



RELEASES FROM THE USE OF PRODUCTS

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This report is fully compatible with OECD PRTR TF RESOURCE COMPENDIUM OF PRTR RELEASE ESTIMATION
TECHNIQUES PART IV: SUMMARY OF TECHNIQUES FOR RELEASES FROM PRODUCTS, Version 1, 5th October 2010

FOREWORD

The aim of the report is to identify relevant releases to the environment from the use phase of end-products, to present techniques to quantify the releases, as well as to support the work of the OECD PRTR Task Force by providing information on how to include these releases into PRTRs if they so wish. The PRTRs include at the moment mainly information reported by the industry.

While restrictions given to releases to the environment from industrial activities, transportation and agriculture have lead to decreased releases from these sources, there are other sources that may still have considerable releases even with increasing trends. According to many studies, the proportional and actual releases from the use of products have increased during the past decades due to the continuously growing number of chemicals and products in use. This means, that a large part of the national total releases of certain substances may already be product based, however, not known well enough. Based on this a Nordic initiative was taken by the Nordic PRTR Group to support the completion of information in the national PRTRs with existing information of sources, such as products, that currently not are included in the PRTRs.

The 36th OECD Joint Meeting on Chemicals Committee and Working Party on Chemicals, Pesticides and Biotechnology decided in 2004 to include work on releases from products in the 2005-2008 work programme of the Task Force on PRTRs. The 39th Joint Meeting agreed on the continuation of this work that would aim at development of tools and methods to help countries in incorporation of information on releases from products into their PRTRs, if they so wish. At the 42nd Joint Meeting the draft structure of the study was agreed upon. The study was funded by the Nordic Council of Ministers and the work carried out at the Finnish Environment Institute. The drafting of the Resource Compendium has been supported by valuable comments by both the OECD Task Force on PRTRs and Task Force on Exposure Assessment.

At the March 2008 meeting of the OECD Task Force on PRTRs, it was agreed to also undertake a survey on the present status on information of releases from products that is available in PRTRs or other inventories and studies in OECD member countries. The results of this survey are included in this Resource Compendium.

The Resource Compendium comprises information on the current knowledge on releases from products and an estimation of the quantities released, as well as legislation and other initiatives to restrict the releases. Case studies concerning product groups from which chemical releases identified to be relevant are annexed to the Resource Compendium. The main information sources for this report were studies carried out in the Nordic countries, i.e. Denmark, Finland, Iceland, Norway and Sweden, for which quantification of releases from the use of products have also been made using the methods provided in this report. Information from studies in other countries and the related literature has been included as far as it was possible¹. However, an increasing number of new information related to releases from products is published every month. Due to this fact the OECD PRTR Task Force decided to keep the Resource Compendium as a “living document” to allow updating it with the latest information during the next years.

¹ until December 2009

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GLOSSARY

Organizations

AKE	Finnish Vehicle Administration
AMAP	Arctic Monitoring and Assessment Programme
AQSIQ	General Administration of Quality Supervision, Inspection and Quarantine of China
CPA	Clean Production Action group in the US
CPSC	U.S. Consumer Product Safety Commission
DG SANCO	Health and Consumer Protection Directorate-General of the European Commission
DMU	Danish Environmental Research Institute
DSB	Swedish Directorate for Civil Protection and Emergency Planning
EC	European Commission
ECB	European Chemical Bureau
ECC	European Consumer Centres Network
ECHA	European Chemicals Agency
EEA	European Environment Agency
EEC	European Economic Council
EMEA	European Medicines Agency
ESPA	European Stabiliser Producers Association
EuPC	European Plastics Converters Association
EU	European Union
EVIRA	Finnish Food Safety Authority
EWG	Environmental Working Group in the US
HCWH	Health Care Without Harm
HBN	Healthy Building Network in the US
HELCOM	Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area
ICCA	International Council of Chemical Associations
ICCM	International Conference on Chemicals Management
IFCS	Intergovernmental Forum on Chemical Safety
ILA	International Lead Association
ILZSG	International Lead and Zinc Study Group
IVL	Swedish Environmental Research Institute
IPEN	International POPs Elimination Network
ISO	International Organization for Standardization
KemI	Swedish Chemicals Agency
KLIF	Norwegian Climate and Pollution Agency
MST	Danish Ministry of the Environment
NCM	Nordic Council of Ministers
NGO	Non-governmental Organizations
OECD	Organisation for Economic Development
OEWG	Open-Ended Working Group (in the US)
SAICM	Strategic Approach to International Chemicals Management
SNV	Swedish Environmental Protection Agency
SYKE	Finnish Environment Institute
TEM	Ministry of Employment and the Economy, Finland
TUKES	Finnish Safety Technology Authority
VALVIRA	Finnish Supervisory Authority for Welfare and Health
WHO	World Health Organisation
UNECE	United Nations Economic Commission for Europe,

UNEP
UNFCCC

United Nations Environmental Programme
United Nations Framework Convention for Climate Change

Concepts

API	Active pharmaceutical ingredient
Article (in REACH)	An object which during production is given a special shape, surface or design that determines its function to a greater degree than does its chemical composition
BEST	Better Environmental Sustainability Targets
CE	Conformité Européene (product marking to confirm compliance with EU Product Directives)
CEPR	Centre for Emergency Preparedness and Response
CLP	EU regulation on Classification, labeling and packaging
CLRTAP	Convention for Long-Range Transboundary Air Pollution
CPD	Construction Products Directive
ECA	Electrically conductive adhesives
EF	Emission factor
ELV	End-of-life vehicles (EU Directive)
EPR	Extended Producer Responsibility
EMEP	European Monitoring and Evaluation Programme
GADSL	Global Automotive Declarable Substance List
GDSN	Global Data Synchronisation Network
GHS	Globally Harmonized System (GHS) for classification and labelling
GPC	Global Product Classification of chemicals
GPHIN	Global Public Health Intelligence Network
GPS	Global Product Strategy
GPSD	General Product Safety Directive
HPV	High Production Volume
IMDS	International Material Data System
IMERC	Interstate Mercury Education and Reduction Clearinghouse in the US
IPP	Integrated Product Policy in the EU
IUCLID	International Uniform Chemical Information Database
LIPASTO	Calculation system for traffic exhaust emissions and energy consumption (Finland)
LCA	Life-cycle analysis
MSDS	Material safety data sheet
NA	Not available
NEC	Net Emissions Ceilings (EU Directive on NEC)
NLFWWI	National Lead Free Wheel Weight Initiative
ORRChem	Swiss Ordinance on Risk Reduction related to Chemical Products
OSPAR	Oslo Paris Convention on the protection and conservation of the marine environment of the North-East Atlantic
PCFV	Partnership for Clean Fuels and Vehicles (UNEP)
PPCPs	Pharmaceuticals and personal care products
ppm	Parts per million
PRTR	Pollutant Release and Transfer Register
REACH	EU regulation concerning registration, evaluation, authorisation and restriction of chemicals
RET	Release Estimation Technique
RAPEX	Rapid alert system for non-food consumer products in the EU
RCGC	Responsible Care Global Charter

RoHs	Use of certain hazardous substances in electrical and electronic equipment (EU Directive)
Sb	Antimony
SRD	Source Ranking Database (by USEPA)
SIN List	Substitute It Now
SLI	Starting, Lighting and Ignition (batteries)
SPIN	Substances in Preparations in the Nordic Countries
SVHC	Substances of very high concern
VECAP	European voluntary emissions control action programme
WEEE	Waste Electrical and Electronic Equipment (EU Directive)
WFD	Water Framework Directive
WSSD	World Summit on Sustainable Development
WWTP	Wastewater Treatment Plant

Chemicals and substances

APEO	Alkylphenol ethoxylate
As	Arsenic
BBP	Butyl Benzyl Phthalate
BDE	Bromodiphenyl ether (deca-/penta-/octa-)
BFR	Brominated Flame Retardants
BMDBM	Butyl methoxydibenzoylmethane
BP3	Benzophenone-3
Ca	Calcium
CCA	Chromated copper arsenate
Cd	Cadmium
CMR	Carcinogenic, mutagenic or toxic to reproduction (reprotoxic)
CO	Carbon monoxide
Cr	Chromium
Cu	Copper
DBP	Di-n-butyl phthalate
DDT	Dichloro-diphenyl-trichloroethane
DeBDE	Deca-Bromodiphenyl ether
DEHB	Di (2-ethylhexyl) phthalate
DIDP	Di-isodecyl phthalate
DINP	Diisononyl phthalate
DMF	Dimethylfumarate
DNOP	Di-n-octyl phthalate
DODP	Dodecyldiphenylphosphine
DHTMAC	Bis(hydrogenated tallow alkyl) dimethyl ammoniumchloride
DSDMAC	Disterayldimethylammonium chloride
DTDMAC	Ditallow dimethyl ammonium chloride
EHMC	Ethylhexyl methoxycinnamate
FTOH	Fluorotelomer alcohols
HBCD or HBCDD	Hexabromocyclododecane
HCB	Hexachlorobenzene
HCBD	Hexachlorobutadiene
HCH	Hexaclorocyclohexane
Hg	Mercury
LA	Lead Arsenate
LAS	Liquid Ammonium Sulfate
NH ₃	Ammonia
Ni	Nickel

MBC	Methylbenzylidene camphor
MCPA	2-Methyl-4-chlorophenoxyacetic acid
MCCP	Medium-chained chlorinated paraffin
NMVOC	Non-methane volatile organic compound
NO _x	Nitric oxides
NP/NPE	Nonylphenol/nonylphenol ethoxylate
OBDE or octa-BDE	Octabromodiphenylether
OPs	Organophosphates
PAH	Polycyclic aromatic hydrocarbon
Pb	Lead
PbHAsO ₄	Lead arsenate (LA)
PbCO ₃	Lead carbonate, cerussite
PbO	Lead oxide
PbS	Galena, Lead sulfide
PbSO ₄	Lead sulphate, anglesite
PBB	Polybrominated biphenyls
PBDE	Polybrominated diphenyl ethers
PBT	Persistent, bioaccumulative and toxic
PCB	Polychlorinated biphenyl
PCDD/F	Polychlorinated dibenzodioxin/furan
PCN	Polychlorinated naphthalene
PCP	Pentachlorophenol
PeCB	Pentachlorobenzene
PE	Polyethylene
PBDE or penta-BDE	Pentabromodiphenylether
PFAS	Perfluoroalkyl substances
PFCs	Perfluorinated chemicals
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulphonate / Perfluorooctanesulfonic acid
PM	Particulate matter
POP	Persistent Organic Pollutants
PVC	Poly Vinyl Chloride
SAC	Tin-silver-copper solder
SCCP	Short-chained chlorinated paraffin
Sn	Tin
SO ₂	Sulphur dioxide
SVHC	Substances of very high concern
TBBPA	Tetrabromobisphenol A
TBT	Tributyl tin
vPvB	Very persistent and very bioaccumulative
Zn	Zinc

EXECUTIVE SUMMARY

Scope

The scope of this document is to identify relevant releases to the environment from the use phase of end-products, to present techniques to quantify the releases, as well as to provide information on how to include these releases into PRTRs if they so wish.

Background

Since 2003 the Nordic PRTR Group has paid attention to the lack of product use related information in PRTR registers, and has carried out four projects to collect available information on releases from products. Information presented in this Resource Compendium has been compiled in these projects funded by the Nordic Council of Ministers' (NCM) subgroups Product and Waste Group (2008-2009) and Chemicals Group (2010). To this, a survey funded by the OECD was carried out to collect information of activities in the OECD member countries. The case study on nonylphenols and nonylphenol ethoxylates was funded by the Swedish Environmental Protection Agency (Naturvårdsverket).

The Norwegian Climate and Pollution Agency KLIF, the Danish Environmental Research Institute DMU, the Swedish Chemicals Agency KemI and the Swedish Environmental Research Institute IVL provided valuable comments and material available from their earlier studies. Material and comments were received also from Mr Andy Bush from the International Lead Association, Mr Stellan Fisher from KemI, Ms Jaana Heiskanen from the Finnish Environment Institute and Ms Louise Sörme from Statistics Sweden.

The Nordic PRTR Group acted as the Steering Group for the projects funded by the NCM as well as in compiling the Resource Compendium: Mr Lars-Petter Bingh from the Norwegian Climate and Pollution Agency, Ms Ingrid Ededahl from the Swedish Environmental Protection Agency, Ms Camilla Trolle from the Danish Ministry of the Environment and Ms Kristina Saarinen from the Finnish Environment Institute.

The work was carried out at the Finnish Environment Institute SYKE by the Air Emissions Team: Mr Tommi Forsberg, Ms Piia Häkkinen, Ms Päivi Lindh, Ms Johanna Mikkola-Pusa, Ms Emma Nurmi, Ms Heli Rimppi and Ms Kristina Saarinen. The Case Study on nonylphenols and nonylphenol ethoxylates was carried out at the Swedish Environmental Protection Agency IVL by Ms Katarina Hanson and Ms Tina Skårman.

Material and methods

The Resource Compendium consist of information that was available by the end of 2009. Material from different studies carried out in the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) has been the main source of this document. Information on the work in Japan, the Netherlands and the USA has been included as far as material was available. Also, information from the work carried out by international organizations and references found in the literature has been included where possible. During the process to compile information it was noted, that an increasing amount of new information related to releases from products is published every month and that also the level of knowledge is growing rapidly.

Results

Though accurate quantification of releases from the use-phase of products is not yet routine work in the countries, there is a clear indication that a large part of the national total releases of certain substances may be product based in many countries. As the use volume of products has increased over time, the share of product use related releases is growing while releases from the other sources have more or less become reduced due to restrictions implemented. Also, the spatial distribution of releases from products has expanded globally.

Substances in products can be chemically bound to other material in the product thus resulting to negligible releases to the environment while those chemicals less tightly bound may be released even in normal use conditions. At the moment, health effects of chemicals released from products are better known than the quantities and effects of chemicals released to the environment. Many hazardous substances used in products have been substituted with other chemicals that not always have proved to be safer. Reduction of chemical releases can be achieved through international conventions restricting the releases, through national legislation as well as by taking voluntary initiatives and setting consumer demands on safe chemical content of products. However, the national restrictions vary between countries.

A wide range of products are identified to have possible releases of hazardous chemicals to the environment. However, information on the concentration of chemicals in products is not always available, and even less information is available on possible releases and release rates. Even the companies selling the products do not always have knowledge of their chemical content nor the quantity of the chemicals. There exist currently few methods to quantify the releases from the use of products, and for those RETs (Release Estimation Techniques) that exist, the uncertainties may be high. Also, more precise information is needed about the release mechanisms and the affecting factors. However, there are already some information systems, such as product registers, which contain some relevant data to enable qualification of releases in certain cases.

Based on information collected during the study, it is also likely that in many cases the product groups and relevant releases may be country-specific due to the use of different product groups or product types, which have different chemical contents, or due to differences in the use and disposal practices of products as well as due to different national restrictions.

Thus, there is sufficient information available regarding releases from the use of certain product groups to enable inclusion of some chemical releases to the national PRTRs, if countries so wish.

According to material reviewed in this study, the following end-product groups have been identified to have environmentally relevant chemical releases during their use-phase. Please note, that the list below is not exclusive/exhaustive due to the fact that in general only little information is available on the chemical contents of products and even less on concentrations released from the use phase of these products:

- Building and construction products
- Electrical and electronic products
- Furniture
- Nanoproducts
- Packages and plastic bags
- Pesticides

- Pharmaceuticals, personal care and cleaning products
- Textile and leather products
- Toys and low-cost jewellery

In addition to the product groups listed above, two chemical specific case studies, one on lead and the other on nonylphenols, were carried out in the Nordic projects, to identify product groups from which lead and nonylphenol releases to the environment can be likely during their use-phase. Lead and nonylphenol were selected as examples of such chemicals, for which there exist information regarding their releases, and which releases not always are included in the regular inventories maintained by countries. For instance, the reported trends of releases of lead to the air have been generally declining since the ban on leaded gasoline in the beginning of the 1990s. However, these trends seldom include releases of lead from the use phase of other not banned products, and might therefore not in all cases reflect the true trends. For nonylphenols, it has been discovered only recently that the releases from textiles to water may be significant and that the trend may also be increasing.

A short overview of the results from the case studies is provided in Table E.1 below while the case studies can be found in Annex I to this Resource Compendium.

Table E.1. Overview of results of the case studies related to releases from the use phase of end-products

Chemical oriented case studies	
Lead	Releases from ammunition (shots and bullets), fishing equipment (weights), lead containing paint, and lead sheets used in roofing and flashings. The use of lead in products has to some extent been restricted, but there are still lead containing products in use.
Nonylphenols & -ethoxylates	In the Nordic countries, the major releases originate in textiles and cleaning agents. Other sources include paints, adhesives, pesticides and veterinary medical products.
Product oriented case studies	
Building & construction products	Releases include heavy metals (e.g. lead in lead sheets and paint), wood impregnation agents (e.g. CCA) and different additives (e.g. plasticizers) in materials. The use of PVC plastics in construction and building products has increased. Though the use and thus also releases of certain hazardous substances have ceased, there may be large amounts released due to the previous extensive use (e.g. PCBs in sealants and caulk).
Electronic and electrical equipment	Releases include flameretardants used in the plastic casing and printed circuit boards, heavy metals (Pb, Hg) from solders and different components. Where such equipment is used, elevated concentrations of flameretardants have been measured in indoor air and dust. Discarded electronic equipments often end up for disassembly or destruction in developing countries and the metals recovered may be used e.g. to make low-cost jewellery. The use volume if these products is increasing.
Furniture	Releases of flame retardant (e.g. from mattresses and the foam in furniture), surface coating (e.g. dirt repellent carpets) and anti-mould agents (e.g. in couches).
Nanoproducts	No information of releases from the use of nanomaterial in products has been identified. However, nanomaterial are widely used in different every day products, and new nanoproducts are entering the market.
Packages and plastic bags	Releases include e.g. phthalates and heavy metals from PVC plastics, perfluorinated compounds used from oil resistant food packaging.
Pesticide	Pesticide releases from the use of crop protection and wood protection agents, pipes, paints and carpets.
Pharmaceuticals and personal care products	Relevant releases may occur in cases where wastewater discharges are not lead through wastewater treatment plants to the receiving waterbodies: e.g. antibiotics, hormones, disinfectants and detergents.
Textile and leather products	Releases include nonylphenols, heavy metals and perfluorinated compounds.
Toys and low cost jewellery	More information on health effects is available than on releases to the environment. Releases to the environment may occur if products left in direct contact with the environment. Low cost jewellery: releases of lead, cadmium and nickel. Plastic toys: heavy metals, additives (e.g. phthalates).

Information on release estimation techniques have been presented where documented methodologies were found. In addition, during the Nordic projects on releases from the use of products, default methodologies were derived for nonylphenol and nonylphenol ethoxylate and for lead releases from certain product groups.

A quantification of releases from the use of products in the Nordic countries on basis of the methods presented in Chapter 8 is provided in Annex 6 "Quantification of releases from the Nordic countries".

A proposal for products to be included in PRTR registers, after country or region specific considerations, is presented in this report (Table 27 in Chapter 8).

TO THE READER

When reading the report it needs to be born in mind that

1. The lists of chemicals and product groups presented in this study are not comprehensive, but reflect information that was available during the study period until December 2009.
2. Quantification of releases from products is a new and developing area and therefore the data, calculation methods and conclusions presented in this study would need to be updated as new research results become available. In addition, uncertainties for the existing RETs are high. Country-specific use conditions and practices need to be considered when selecting products into PRTRs.
3. New initiatives to restrict or register releases from products are under way, e.g. in the European Union and at international level, for instance in the UNEP.
4. Releases from the historical use of products may still play an important role.

CHAPTER 1

INTRODUCTION

1.1 Scope of the document

The scope of this Resource Compendium is to collect existing information on releases to the environment from the use phase of products, and to identify substances for which a significant part of the releases originate from the use of products (Figure 1). Where information on methodologies to quantify the releases was available, this information is also provided in this document. The Compendium also provides information on activities by countries and different organizations in their efforts on identifying, quantifying and restricting releases to the environment from the use of products.

The document aims at identification of product groups and relevant chemical releases to the environment that are not yet covered by the regular inventories, and thus draws attention to less well-known sources. The outcome of the work can be used to show decision makers an indication of areas where further actions are needed to reduce releases, and to provide information to OECD countries to support them in inclusion of releases from the use phase of end-products into their inventories and PRTRs, if they so wish.

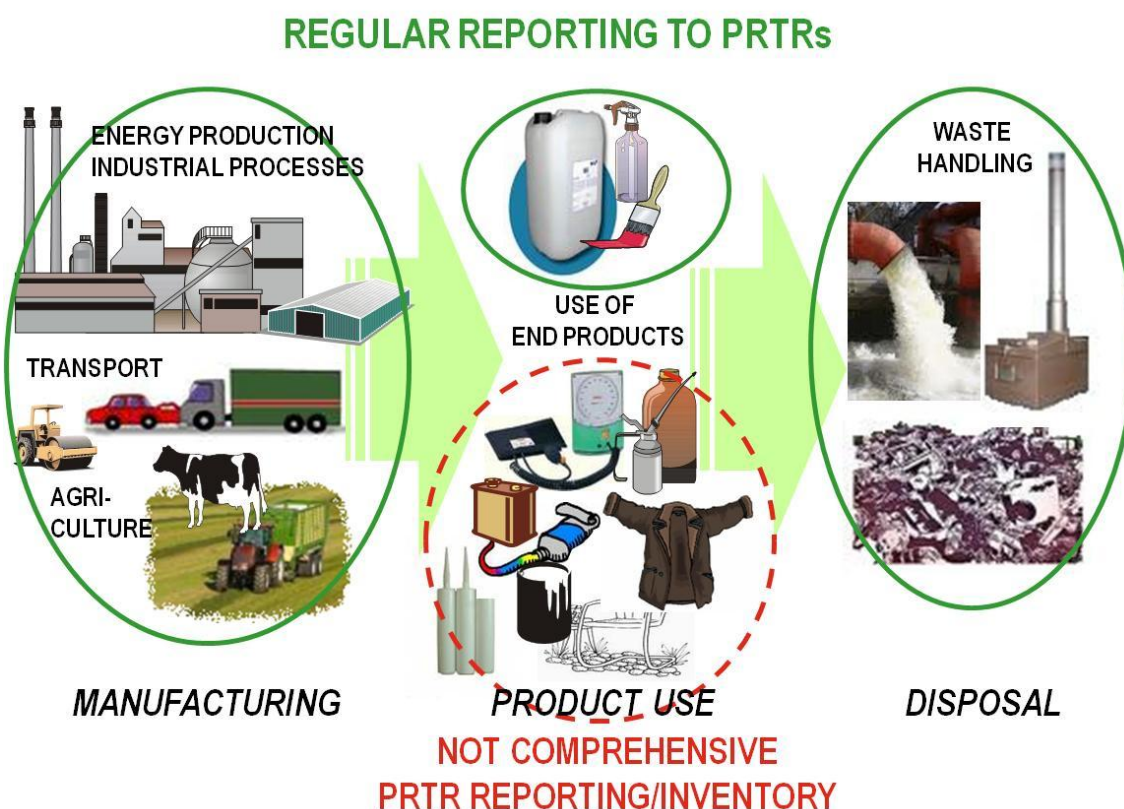


Figure 1. Scope of the Resource Compendium of PRTR RETs, Part 4: Summary of Techniques for Products: Releases from the use-phase of end-products that are not yet included in the PRTRs or in other inventories

1.2 Releases from the use phase of end-products covered in this document

The Resource compendium is restricted to releases originating from the use phase of end-products that are not yet covered by existing data collection activities or reporting efforts. Also, the main focus has been on identification of product related releases that have an impact on the environment, although information on health impacts have also been addressed as an indication of possible environmental releases.

In general, it can be concluded that there is more information available on possible health impacts of many products than on environmental impacts from the use of products. In many cases it can also be concluded that there are no or only negligible direct releases from the use of these products to the environment.

The release sources already covered by the PRTRs include mainly industrial activities such as energy production, industrial processes, storage and handling activities, mining, intensive life-stock farming and aquaculture, as well as waste and wastewater handling.

Information on releases from diffuse sources such as transport, residential combustion, and agriculture will also be included as part of the PRTRs by some countries, for instance in the European Union. These diffuse sources are already included in the reporting obligations under international air emission conventions, such as the United Nations Framework Convention on Climate Change and UNECE Convention of Long-Range Transboundary Air Pollution.

Releases related to the use of products are to some extent already covered by the above-mentioned international conventions. Such releases are not addressed in detail in this document, i.e. non-methane volatile organic compounds (NMVOC) releases from the use of solvent containing products and particle releases from brake and tyre wear in road transportation.

This document neither covers sources that already are covered by other inventories, as presented below:

1. Covered by PRTRs:

- the use of fuel products and substances in energy production, transportation
- the use of products and substances in the manufacturing industries
- the use of pesticides and fertilizers in intensive life-stock farming
- product based releases from landfills, wastewater treatment and waste incineration

2. Covered by other inventories (e.g. the UNFCCC and UNECE CLRTAP):

- the use of fuel products and tyre and brake wear in transportation
- the use of solvent containing products emitting non-methane volatile organic compounds (NMVOCs) to the air

Also POP and heavy metal emissions from the use of products are under the existing reporting obligations of for instance the UNECE CLRTAP, but as the existing inventories of these chemicals currently not always cover the use of products, information on these releases, where available, is included in this document.

3. Releases identified to only have health impacts but not impacts on the environment. Available information of these sources has been included while not going deeply into the release mechanisms and methodologies.

1.3 Methodology

Information sources

The Resource Compendium is mainly based on the contribution of Nordic research institutes and authorities, which provided information on their existing studies and inventories on releases from the use of products. Information on release estimation techniques for releases from the use phase of end-products was collected, where available.

In addition, a survey was carried out in OECD Member countries on existing information on releases from the use phase of end-products. Responses to this survey are included in this report. The results of the survey are presented in Chapters 2.2 and Annex 3.

The information was completed by a literature survey, going through international conventions and legislation texts, as well as from recent international workshop publications. It is likely that other relevant material not identified during the study, exists, as a full search of scientific articles was not carried out, and that should be taken into account when making conclusions of further work in this area.

Identification of products with relevant releases

The selection of product groups for this compendium covered the following criteria:

- Are releases of a substance/chemical from the use of the product likely?
- Does the product have widespread use, and is it high volume use?
- Can the releases from use of the product reach the environment in relevant volumes?

The criteria was developed to evaluate whether potential releases from the use of a product could be considerable.

The work also aimed to collect data on the geographical scope of the problem, where possible. However, during the work it became obvious that it was not possible to achieve this target due to the limited information sources. The case studies therefore present the information that was achievable for the study and also areas where it is not possible to draw further conclusions without additional information.

Based on available information it can be concluded that, at the moment, knowledge of releases from the use of products is restricted to certain product groups and substances. Furthermore, there is not much knowledge of the actual contribution of releases from the use phase of end-products to the total releases of most substances/chemicals. However, there is a clear indication that a large part of the national total releases of certain substances may already originate in the use of products.

1.4 Structure of the document

The Resource Compendium provides information of activities by countries and different organizations in their efforts to identify, classify and quantify information and to restrict releases arising from the use of products (Chapters 2-4).

Information on likely releases generated during the use of products is compiled in Chapter 5. Chapter 6 provides a general introduction to release patterns and Chapter 8 introduction to available release estimation techniques for releases from the use phase of end-products as well as a list of potential product groups for inclusion into national PRTRs. Product group and chemical specific release estimation technique information is provided in the eleven case studies in Annex 1.

Issues to be taken into account when considering the inclusion of releases from products into PRTR registers as well as recommendations on product groups to be included are compiled in Chapter 8.

1.5 Case studies

Eleven case studies have been conducted as a part of the work. Out of these two are related to specific chemicals and are nine product group -based. The chemical oriented Case study 1 (Lead) and Case study 2 (Nonylphenol and nonylphenoethoxylates) compile information on relevant chemical releases from the use-phase of end-products.

The other nine case studies deal with product groups that are likely to have chemical releases to the environment:

- Case study 3: Products used in the construction and building sector
- Case study 4: Electrical and electronic equipment
- Case study 5: Furniture
- Case study 6: Nanoproducts
- Case study 7: Packages and plastic bags
- Case study 8: Pharmaceuticals, personal care and cleaning products
- Case study 9: Pesticides
- Case study 10: Textile and leather products
- Case study 11: Toys and low-cost jewellery

1.6 Quantification of releases from the use of products in the Nordic countries

Quantification of releases from the use of products in the Nordic countries (Denmark, Finland, Norway and Sweden) using the methods presented in this Compendium (Chapter 7.4) can be found in Annex 6.

CHAPTER 2

AN OVERVIEW OF INVENTORIES FOR RELEASES FROM PRODUCTS

2.1 Overview of existing inventories on releases from products

Some countries already carry out annual inventories on releases from products and there is an increasing number of research projects and international work to explore these releases. Current information on releases from the use phase of end-products can be roughly divided into five categories according to the type of information sources available during the study.

1. Information on quantified releases with documented release estimation techniques used for mandatory regular reporting to international conventions (Chapter 2, Table 1).
 - This information includes air emission estimates from certain product groups for certain substances already included in the regular inventory work in most of the OECD Member countries. The release estimation techniques used for quantification of releases are published in the guidebooks for the conventions under which the inventories are carried out (e.g. UNECE CLRTAP). The chemicals and product groups covered by the inventories are non-methane volatile organic compounds (NMVOCs) from the use of solvents, mercury from dental amalgam and heavy metals from tyre and brake wear.
2. Information on quantified releases with documented national release estimation techniques in inventories carried out by certain countries on products and chemicals relevant for that country (Chapter 2, Table 2 and Annex 2).
 - This information includes actual quantified release estimates to air, water and land. Documentation of the release estimation techniques are either published or non-published. These inventories exist for instance in Japan, Korea, the Netherlands and Norway.
3. Information on quantified releases and related information on release estimation techniques, inventories carried out by industry associations or research groups (Chapter 5).
 - This information includes calculated actual release estimates to air, water and land by the industry branch, product groups or by regions. Documentation of the release estimation techniques is usually published. For example, the International Lead Association (ILA) has carried out inventories on lead and nickel releases and there are several research projects in Denmark, Norway and Sweden. A comprehensive study on the releases of DEHP covering the whole life-cycle is carried out in the EU Risk Assessment Programme (Kemi, 2001).
4. Information on quantified releases and related information on release estimation techniques by different groups working with chemicals risk assessment (Annex 4).
 - This information includes often worst-case release estimates to air, water and land. Documentation of the release estimation techniques is published. For example, the OECD Task Force on Exposure Assessment has prepared several emission scenario

documents for the total life cycle of a number of products. However, in these estimates, it is not always possible to identify the part of releases that is related to the use phase of products.

5. Indication on the evidence or likelihood of releases from the use phase of a product: this type of information is available from the literature or from non-governmental organizations, but often carries no remarks on the magnitude of releases to the environment, nor information on available release estimation techniques (Chapter 5).

Table 1. Examples of chemicals from certain product groups that are already included in regular inventory work² for emissions into the air.

1. Product groups printed in *italics* fall under the scope of this project. If this data already exists in the national inventory, it can be incorporated in the PRTRs (product groups 2, 6, 7, 8, 9, 12, 13 and 14) – NOTE that the existing information mainly covers only NMVOC releases but that there are also other likely releases (e.g. heavy metals and POPs) from the same product groups not yet included in any inventory.
2. Product groups not printed in italics are also indicated to have releases during their use but these releases are included under other sources (indicated in the brackets) in the reporting of inventories, than under the use of products (product groups numbers 1, 2, 4, 5, 9, 10, 11 and 15).

Product group	As	Cd	Cr	Cu	HCb	HCH	Hg	Ni	NMVOC ²⁾	NH ₃	PAH-4	Pb	PCDD/F	PFC	PM	Zn
1. Releases from accumulator and battery (waste)		x						x				x				
2. Brake and tyre wear (road transport)	x	x	x	x			x				x	x			x	x
3. <i>Building products, DIY(do-it-yourself)</i>									x							
4. Car care products (car manufacturing)									x							
5. Chlorinated chemicals use (industry)						x										
6. <i>Cooling agents in household use</i>														x		
7. <i>Electronic products (use)</i>							x									
8. <i>Firework</i>	x	x	x	x								x			x	
9. <i>Household products</i>									x							
10. Fertilizer/pesticide use (agriculture)					x	x				x					x	
11. Surface treatment (in the industry)									x			x				
12. <i>Paint application (industry, domestic use)</i>									x							
13. <i>Pharmaceuticals and personal care products</i>									x							
14. <i>Tobacco smoking</i>	x	x	x	x			x				x	x	x		x	
15. Treatment/impregnation of wood (industry)									x							

² UNECE CLRTAP (F-gases, NMVOC, NH₃, particles, heavy metals, POPs), UNFCCC (F-gases, NMVOC) and EU NECD (NMVOC, NH₃), methodology according to the EMEP Corinair Inventory Guidebook (EEA, 2009)

Table 2. Examples of national inventories of releases from products in certain countries (I = inventory exists). Note that the list is not comprehensive.

Product group	As	BFR	Cationic tensiores musk compounds	Cd	Cr	Cu	DDT	DeBDE	DEHP	HBCD	HCH	Hg	MCCP	NP NPE	Octa-BDE	NH3	PAH	Pb	PeCB	PFAS/PFOS	SCCP/	TBT TFT
Ammunition	I					I								I				I				
Asphalt																	I					
Batteries, accumulators	I			I														I				
Brake blocks						I												I				
Building and construction		I											I								I	
Cables																					I	
Cleaning agents			I											I		I						
Cosmetics			I																			
Electronic products		I					I				I	I										
Fertilizer use (agriculture)				I		I						I				I						
Fire extinguishers																				I		
Fireworks	I				I	I												I				
Flame retardants								I		I					I				I			
Fishing gear and weighs						I												I				
Instruments for measuring												I										
Keels of sailboats																		I				
Lead sheets																		I				
Light sources												I										
Pesticides						I								I								
Pipes						I																
PVC-plastics									I													
Steel products					I																	
Textiles																				I		
Surface treated products					I	I			I				I	I			I	I			I	I
Tooth filling												I										
Treated wood	I			I	I	I											I					I
Vehicle parts				I																		

2.2 Inventories, programmes and projects on releases from products

2.2.1 Regular inventory work

Releases from products have been in the 2005-2008 work programme of the Task Force on PRTRs with the aim at development of tools and methods to help countries to incorporate information on releases from products into their PRTRs, if they so wish.

According to the responses to the survey made to OECD countries (Table 3) four OECD member countries indicated to currently have information on releases from the use of products in their national PRTR or other inventory and five more countries were planning to include this information. Three countries had plans to include new products and four countries new chemicals in their systems. Detailed documentation of the survey and the responses is provided in Annex 3.

The four countries carrying out regular inventories on releases from products, i.e. Japan, Korea, the Netherlands and Norway, have partly different product groups included in their inventories. The Japanese inventory on product related releases includes the following product groups: pesticides, paints and adhesives, medical products, cleaning agents and cosmetics, and foam blowing agents. The Korean inventory includes batteries, several household products, and light sources. The Netherlands' inventory includes wood protection agents, fireworks, shooting clays, lead slabs, fishing tackle, and pesticides. The Norwegian inventory includes wood impregnation agents, paints, pipes, pesticides, ammunition, tooth fillings, lighting sources, granulated rubber, textile impregnation agents, cleaning agents, electrical and electronic products, and construction products. Detailed information on the content of these inventories is provided in Annex 2.

In addition, all countries that are parties either to the UNFCCC or UNECE CLRTAP have information of at least air emissions of NMVOC compounds from the use of solvents.

Table 3. Inventories carried out by countries on releases from the use of products (other than already included in the existing inventories)

PRODUCT INFORMATION IN PRTRs OR OTHER INVENTORIES					PLANNING TO INCLUDE			
Country	Currently included		Planning to include		New products		New chemicals	
	YES	NO	YES	NO	YES	NO	YES	NO
Belgium		x		x		x		x
Chile		x	x		x		x	
Czech Republic		x		x				
Denmark		x						
Finland		x	x		x		x	
Japan	x					x		x
Korea	x							
The Netherlands	x				x		x	
Norway	x		x			x		x
Sweden		x	x			x	x	
Turkey		x	x			x		x
Switzerland		x		x				
USA		x		x		x		x
UK		x		x				

Inventories on lead and nonylphenols

According to replies to the questionnaire sent to OECD countries four countries (Japan, Korea, the Netherlands and Norway) currently carry out inventories on product related releases of lead and five more countries collect some information on these releases, while three countries had product related legal restrictions on lead (Table 4).

Only Norway³ carries out inventories on product related releases of nonylphenols and also Sweden had some information on these releases. Seven countries had product related legal restrictions on nonylphenols (Table 5).

More information on legal restrictions for product related releases in countries is presented in Chapter 3.2.

Table 4. Information on regular or study-based national inventories on releases from lead containing products (industrial sources excluded), estimated releases and their contribution to total lead releases in the country. NA = information not available, activity data = statistical or other data used in quantification of the releases.

Product containing lead	Country	Lead release (kg)	Contribution	Year	Remarks (the information below was provided by countries as reply to the survey)
Alloys with lead	Sweden	NA	NA	2005	Activity data 800 t
Ammunition	Netherlands	5400	NA	2005	Emission factor 3.93 g/bullet before 1993; 6.86 g/bullet after 1993
	Norway	201000 to soil	NA	2006	Lead content 60%
	Sweden	NA	NA	2005	Activity data 580 t
	USA	NA	NA		AP-42 (federal facilities with firing ranges)
Boat keels	Sweden	NA	NA	2005	Activity data 1000-2000 t
Brake wear	Netherlands	2400 to air, 1300 to water, 1400 to soil	7% air, 1% water and soil	2006	
Corrosion protection paints	Norway	1360 to soil	NA	2006	Emission factor 10% of use
Electronics	Sweden	NA	NA	2005	Activity data 500 t
Fishing gear	Netherlands	30000	NA	2005	Emission factor 1.8 g/inhabitant
	Norway	47500 to water	NA	2006	Water 25%, waste 50% ³⁾
	Sweden	NA	NA	2005	Activity data 400t
Wear of current contact on electrical trains	Netherlands	60 to water	NA	2005	
Glass, crystal, cut glass	Sweden	NA	NA	2005	Activity data 70 t
Lead acid batteries	Korea	45871545.9 to waste	NA	2005	
	Norway	0	NA	2006	Emission factor 60% ³⁾
	Sweden	NA	NA	2005	Activity data 2000 t
	USA	NA	NA		AP-42 (only facilities under TRI)
Lead sheet (roofing)	Belgium	7305	NA	2005	Emission factors for 8 building types, distribution factors for environmental compartments
	Netherlands	21000	NA	2005	Emission factor 5 g/m ² for house roofing, 0.124 g/m ² for industrial roofing
	Sweden	0	NA	2005	Activity data 0 t
	Switzerland		NA		
Lead pipes	Belgium	806	NA	2005	
Oil losses on roads	Netherlands	19 to water, 1 to soil	Minor	2005	
Paints	Japan	83302	NA	2006	Emission factor 2% of lead in pigment; 18% for traffic paint
	Norway	corrosion of paint	NA	2006	Emission factor 10% ³⁾
	Sweden	NA	NA	2005	Activity data 30 t
Pavement wear	Netherlands	110 to water	0.1%	2005	

³ Norway carries out two regular inventories on releases from products: the inventory by KLIF (SFT 2009) targets hazardous substances from all sources while the inventory by Statistics Norway (Kittelsen et al. 2008) generates indicators.

Plastics	Norway	NA	NA	2006	
	Sweden	NA	NA	2005	Activity data 20 t
Sand from sand blasting	Norway	1000 to soil	NA	2006	
Tyre wear and brake wear	All parties to CLRTAP	70 to air, 1300 to water 1400 to soil	0.1-0.5%	2005-2006	
Wheel balance weights	Sweden	NA	NA	2005	Activity data 900 t
Wood impregnation	Norway	NA	NA	1995-2006	
X-ray protection	Sweden	NA	NA	2005	Activity data 70 t

Table 5. National inventories and studies on releases from nonylphenols containing products (industrial sources excluded), estimated releases in the country

Product containing NPs	Country	NP release (kg)	Year	Remarks
Adhesives	Sweden	NA	2006	Activity data 1.46 tonnes (NP/NPE)
Cleaning agents	Norway	2700 to water	2005	Emission factor 90%
	Sweden	NA	2006	Activity data 3.34 tonnes (NPE)
Granulated rubber (synthetic grass fields)	Norway	9 to water	2005	
Motor and other oil	Sweden		2006	Activity data 1.77 t (NPE)
Paints	Sweden	NA	2006	Activity data 13.24 t of NP/NPE + as bonding agent in paints and glue 8.72 t (NP/NPE)
Pesticides	Sweden	NA	2006	Activity data 1.81 tonnes NPE
Polishers	Sweden	NA	2006	Activity data 1.86 tonnes (NPE)

2.2.2 Research programmes and projects on releases from products

Regular national inventories on releases from products are carried out by Norway⁴, Japan, the Netherlands and Korea (Annex 2). In addition, information on releases from products is included in numerous research projects, models or other programmes that are carried out in many OECD countries. Some examples of this work is provided below.

In Belgium, an environmental input-output model is underway to map the most polluting production and consumer chains. In addition to the environmental effect of industrial processes, the model also includes environmental impacts from the use-phase of products.

In Sweden, a governmental research programme, ChEmiTecs⁵, is running from 2007 to 2012 with the goal to improve the understanding of releases of organic substances from articles and to clarify and determine the magnitude of this problem. The work is carried out in collaboration with authorities, producers and downstream users by the Swedish Environmental Protection Agency, Swedish Environmental Research Institute, Stockholm University, Royal Institute of Technology and Umeå University. The programme focuses on selection of problematic chemicals, articles and use patterns and also produces release estimates for these articles. Technical and social aspects, which contribute to the identified problems are included as well as analyses of voluntary and legislative reduction strategies. Work carried out in the Chemical (REACH) and Product Policies (IPP, SCP), environmental chemistry, toxicology and engineering, analysis in the nature and results from risk assessment work are taken into account in the work.

In Sweden, several studies on releases from selected product groups have also been carried out at the Swedish Chemicals Agency (KemI)⁶, starting from the pioneer project in 1994-1999 regarding the inflow, stock and emissions of heavy metals from products during their use⁷.

⁴ Product related information is available at <http://www.miljostatus.no/Tema/Kjemikalier/Produkter/#>

⁵ More information of the Swedish ChEmiTecs programme is available from www.chemitecs.se

⁶ Product related information is available at http://www.kemi.se/templates/Page____2887.aspx

In Denmark, several studies have been carried out on the chemical content of various consumer products such as, toys and other children's products, low-cost jewellery, hobby products, cosmetics, pharmaceuticals, nanoproductions. These include risk assessments on the effects of various substances used in products on people and the environment. For instance, the Danish studies on indoor contaminants clearly show that product related releases occur as product use is the only possible source of certain chemical concentrations in house dust⁸.

The Nordic Council of Ministers (NCM)⁹ provided resources for compilation of information related to release estimation techniques for releases from the use of products. The results of the project are presented in this Resource Compendium. The project funded by the NCM also included quantification of releases from the use of products in the Nordic countries (Annex 6).

In Japan, the current studies are related to substances in electrical and electronic products, hazardous chemicals in plastic products as well as to brominated flame retardants and POP compounds from household products. (UNEP 2009c)

Work to identify and estimate health impacts and releases to the environment from the use of products is under way in some African countries, China, India, Peru and Thailand where experts have estimated certain releases from selected articles for their region (UNEP 2009c). For instance, product related effects on human health and the environment in African countries have been studied related to the trade of products containing lead, cadmium and mercury. In India, releases from toys, jewellery, paints and electronic products are studied, while risk management studies on PFOS compounds are carried out in China.

2.2.3 Comparability of release data

When comparing information on release data presented in the different inventories, studies or research programmes on releases from the use of products, it can be seen that the results may differ significantly. In many cases only the results of calculations are presented without any documentation or justification of the methodology. Neither is it clearly stated how the concept "product use" is understood: whether the release estimates cover the whole life-cycle of the product or which parts of the life cycle are included, or if the data represents the use phase of products (i.e. after the product has left manufacturing and before it is taken into waste management¹⁰). Thus it is difficult to conclude whether there are actual differences in the data presented, and if the differences represent the real differences, such as for instance, different use practices or differences in the chemical contents of a given product.

⁷ http://www.ts.mah.se/utbild/tm7026/Metaller_i_stad_och_land_NV_02.pdf

⁸ The publications are available at <http://www.mst.dk/Udgivelser/OversigtOverRapporter/>

⁹ Nordic Council of Ministers <http://www.norden.org/en>

¹⁰ For instance, releases to all environmental compartments from the manufacturing of batteries till the disposal and waste treatment can be included in one estimate, while the other estimate may give air emissions from incineration of batteries in household waste or releases to soil from the abandonment of batteries in the nature. Releases covered by the current Nordic study on releases from the use of products would cover only releases from the use of batteries, such as from possible leakages due to unintentional breakages of batteries or (if such would occur) evaporative releases during the use.

Reasons that may explain the differences in the results of the different inventories can thus be found in

1. Completeness of the inventories: Product species or product groups included in or excluded from the different inventories are not defined or explicitly listed in the documentation of the inventory, therefore it is not possible to conclude if the products included in the different inventories have been the same.
2. Differences in the methodologies: It cannot be concluded how well the emission factor used in the calculations represents the actual emission rates due to lack of documentation. The values used as release rates in the different inventories can be different even for similar products, and the uncertainties of these emission rates may be high. However, the estimates of the different emission rates can also present actual differences in the chemical content or structure of a product or the tendency to releases.
3. Differences in how well the calculations represent the actual use of the given product: Statistical data should be available in a correct form to match the release rate used as an emission factor. It may be difficult or even impossible to retrieve representative activity data for calculation of product use related releases as this type of data is often not collected by statistical authorities. In many cases expert estimates are used instead of calculations based on statistical data, and the related uncertainties may be high.

CHAPTER 3

WORK AND TOOLS TO RESTRICT RELEASES FROM PRODUCTS

3.1 International and regional work

International organizations such as UNEP, WHO and UNECE (Table 6) carry out work related to the management of chemicals used in products. Work carried out at more regional level is presented in Table 7.

Table 6 Work by international organizations on releases from end products

Orga-niza-tion	Policy framework/ Convention/ Protocol	Target group	Aim	Actions
UNEP/ WHO	SAICM (ICCM)	Chemicals	Sound management of chemicals by 2020	
WHO	IFCS	Chemicals	Develop and promote strategies on sustainable chemicals management	Implementation of SAICM
UNEP	Stockholm Convention	POPs	Eliminate or reduce production, sale, use and release	National Implementation Plans, new candidates
	Mercury Program	Hg	Reduce emissions, including the use of mercury containing products	
UN	Basel Convention	Chemicals	Disposal of hazardous waste	
UN ECE	Heavy Metals Protocol (CLRTAP)	Pb, Hg, Cd	Reduce emissions to 1990 level	Phase out of leaded petrol, reducing emissions of mercury containing products
	POPs Protocol	POPs	Eliminate discharges, emissions and losses	Waste management, reducing emissions, new candidates
OECD	Product and chemical safety programmes	chemicals	Share information	Tests, reports, guidance manuals

3.1.1 SAICM

The Strategic Approach to International Chemicals Management (SAICM) adopted in 2006 in Dubai by the International Conference on Chemicals Management (ICCM) and endorsed by the UNEP Governing Council aims to achieve sound management of chemicals throughout their life-cycle so that by 2020 chemicals are used and produced in ways that lead to the minimization of significant adverse effects on human health and on the environment. The overarching policy strategy in the SAICM work focuses to ensure that information on chemicals throughout their life cycle is available for all stakeholders. The information should, where appropriate, also include products. According to the SAICM Global Plan of Action, articles and products containing hazardous substances should all be accompanied by relevant information for users, workplaces and at disposal sites, which means that new measures need to be global in order to be effective. (SAICM 2006, 2009)

In connection to the SAICM work, an informal international workshop on stakeholders' information needs on chemicals in articles was held in January 2009 to start a dialogue at the international level to get a better picture of chemicals in articles and the related problems.

The work includes collecting the different stakeholders' needs for information related to products and establishing a working group on chemicals in articles within the SAICM and ICCM2 framework. To support the work, case studies are carried out on selected product groups (building products, electronics, textiles and toys).

3.1.2 IFCS

Intergovernmental Forum on Chemical Safety (IFCS) is a mechanism to develop and promote strategies and partnerships between national governments, intergovernmental and non-governmental organizations with the purpose to provide policy guidance, develop strategies, foster understanding and promote policy support. IFCS contributes to the implementation of SAICM. (IFCS 2009)

3.1.3 UNEP Convention on Persistent Organic Pollutants (Stockholm Convention)

The Stockholm Convention on Persistent Organic Pollutants administered by UNEP was adopted in 2001 and it came into force in 2004. The Convention is aiming to eliminate or reduce the production, sale, use and release as well as unintentional formation of POPs¹¹, and is implemented through National Implementation Plans. All sources of chemicals are covered, including the use of products. An exception has been granted for DDT to control malaria. (Convention 2009, Steiner et al. 2003)

3.1.4 UNEP Mercury Program

The UNEP mercury program was established in 2003, based on a voluntary action, to reduce global mercury releases and the associated risks to humans and the environment. An internationally binding convention to reduce the global releases of mercury is under way, and the aim is to work on prioritized areas on industrial sources, on trade and use of mercury and mercury containing products as well as on waste handling. (UNEP 2009b)

3.1.5 Basel Convention

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal came into force in 1992 and is ratified by 172 countries. The target is to protect the environment from the inappropriate disposal of toxic waste (including discarded products) that include hazardous chemicals.

3.1.6 UNECE Convention on Long Range Transboundary Air Pollution

The UNECE CLRTAP has several protocols related to the restriction of chemicals released from products. Releases from products covered by the VOC protocol are quite well known while product use related releases falling under the Heavy Metals and Persistent Organic Pollutants Protocols are not yet included in all national inventories.

Heavy Metals Protocol

The Protocol on Heavy Metals under the UNECE Convention on Long-Range Transboundary Air Pollution was adopted in 1998. The Protocol is aiming for limiting emissions of lead, mercury and cadmium. The Parties to the protocol have to reduce their emissions for these metals below their 1990 levels. Besides cutting emissions from industrial sources the

¹¹ The first stage of implementation targets the twelve most toxic POPs (pesticides: aldrin, dieldrin, endrin, DDT, heptachlor, chlordane, mirex and toxaphene; industrial chemicals: HCB and PCBs; industrial byproducts: PCDD/F). New candidates considered include penta-BDE, chlordecon, hexabromo-biphenyl, lindane, PFOS, alfa-HCH, beta-HCH, PeCB and octa-BDE.

Protocol also includes phasing out of leaded petrol and measures for reducing emissions from other products like mercury containing batteries. The protocol includes measures for management of other mercury containing products like electrical components, measuring devices, fluorescent lights, paint, pesticides and dental amalgam. (UNECE 2009a)

Protocol on Persistent Organic Pollutants

The Protocol on Persistent Organic Pollutants (POPs) under the UNECE Convention on Long-Range Transboundary Air Pollution was adopted in 1998. The Protocol aims to eliminate any discharges, emissions and losses of certain pesticides, industrial chemicals and byproducts/contaminants. For some POPs the production and use is banned while the use of others is restricted and these will be phased out later stage. The Protocol also includes dealing with wastes of the eliminated POPs and obligates the Parties to reduce their emissions below the 1990 levels. Work to identify new candidate chemicals is underway (UNECE 2009b).

3.1.7 OECD

OECD has several work areas related to releases from the use of products, for instance the work on the management of perfluorinated chemicals (PFCs), pesticides, biocides and nanoproducts, as well as in the field of environmental exposure assessment and related to the PRTRs.

Extended Producer Responsibility (EPR), also known as “Product Stewardship” is a concept for products, which extends its impacts beyond the emissions and effluents generated by the extraction or manufacturing processes to the management of the product once it is discarded. It is based on the premise that the primary responsibility for waste generated during the production process (including extraction of raw materials) and after the product is discarded, is that of the producer of the product. Costs related to pollution and to consumption of resources and energy, as well as to disposal, are subsidized by the government and are therefore not reflected in the price of the product. EPR corrects that imbalance by internalising these externalities, and in doing so, shifts these costs from government and taxpayers to producers and consumers. EPR can be implemented in regulatory or voluntary forms. OECD has published several reports since 1994, and in 2001 a Guidance Manual for Governments on information about issues and potential benefits associated with EPR (OECD, 2009b).

The purpose of OECD’s Co-operation programme on the Investigation on Existing Chemicals (HPV Chemicals Programme) is to share the burden among Member countries. The countries and the chemical industry collect information, test and carry out initial assessment of high volume chemicals in order to identify those for which further action is necessary (OECD, 2009c).

3.1.8 European Union

In the European Union, work is carried out to assess risks related to product safety as well as to implement related legislation (Table 7).

Risk assessment work

The EU carries out risk and safety assessments for products to ensure the safe use to the consumers and has established agencies and committees of independent scientific experts to conduct the assessments.

The Scientific Committee on Consumer Safety works on risks related to non-food consumer products (e.g. cosmetics, toys, textiles and clothing as well as personal care and household products). The work of the Committee on Health and Environmental Risks targets to pollutants with possible negative impacts on health and the environment (e.g. the toxicity and eco-toxicity of chemicals). The Committee on Emerging and Newly-Identified Health Risks works on emerging or newly identified health and environmental risks (e.g. antimicrobial resistance, nanotechnology and medical devices). Harmonised risk assessments on substances related to the REACH legislation are carried out by European Chemicals Agency (EU 2009b).

Legislation

An overview of EU legislation related to chemicals in products is compiled in Table 7.

The recent EU REACH¹² regulation ((EC) No 1907/2006) requires the manufacturers and importers to take responsibility for the use of chemical substances and to improve the information flow on hazardous substances in different product groups throughout the supply chain. If an article¹³ contains a substance which is intended to be released during normal use conditions and if the substance is manufactured more than one tonne per year per manufacturer/importer, the substance need to be registered. The registration includes information about the toxicity of the substance and its use in the article. If the article contains substances of very high concern (SVHCs¹⁴), the manufacturer or importer is obliged to notify the presence of the substance in an article and provide information on the concentration¹⁵. This is not required if the exposure to humans or the environment can be avoided under normal use conditions or if the substance has already been authorised for the specific use. If an article contains SVHCs at a concentration of more than 0.1% by weight, the supplier has to provide sufficient information (at the minimum the name of the substance) to the recipient (i.e. industrial/professional users and distributors) of the article, on substances at any quantity, to allow safe use. Information must be provided to consumers upon request within 45 days. REACH does not apply to waste, but recycled materials that become secondary products are included in the regulation.

Table 7. Overview of EU legislation related to chemicals in products

Legislation no.	Legislation name	Abbreviation	Aim
2001/95/EC	General Product Safety Directive	GPSD	Safety of products placed on the market
2009/251/EC	Decision on dimethylfumarate		Restriction of dimethylfumarate (DMF) in consumer products (e.g. leather furniture and footwear)
88/378/EEC and 2009/48/EC	Toys Directive		Safety of toys
89/106/EEC	Construction Products Directive	CPD	Safety of construction products

¹² REACH, Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals came into force in the EU Member States in 2007. Note that Annex XVII of REACH replaces the earlier Limitations Directive 76/769/EEC.

¹³ Article = an object, which during production is given a special shape, surface or design that determines its function to a greater degree than does its chemical composition

¹⁴ SVHCs include substances found to be carcinogenic, mutagenic or toxic to reproduction, persistent, bioaccumulative and toxic (PBT) or very persistent and very bioaccumulative (vPvB) as well as those for which there is scientific evidence for similar concern (ECHA 2009b; ECHA 2008). They are listed on the so-called Candidate list for authorization (ECHA 2009a), which is regularly updated. (Art 57)

¹⁵ When exceeding 0.1 weight-% and more than 1 tonne per year

76/768/EEC and (EC) No 1223/2009	Cosmetics Directive and Regulation		Safety of cosmetic products (e.g. fragrances, UV filters and heavy metals)
2005/32/EC and 2009/125/EC	Energy-Using Products Directive	EuP	Ensure the free movement of energy-using products on the market, as well as to increase protection of the environment, energy efficiency and the security of energy supply
(EC) No 1907/2006	Registration, Evaluation, Authorisation and Restriction of Chemicals	REACH	Improve information flow on substances in products through the supply chain Reach Annex 17 (chemical specific restrictions, examples: As+Cr in treated wood; Pb containing paint, varnish etc.)
(EC) No 1272/2008 (67/548/EEC and 1999/45/EC)	Classification, Labelling and Packaging of substances and mixtures	CLP	Harmonize the classification and labelling of hazardous chemicals in the EU area (replaces the dangerous preparations and substances directives)
(EC) No 440/2008	Regulation for test methods		Test methods for REACH
2000/60/EC	Water Framework Directive	WFD	Reduce the pollution of ground and surface waters by reducing releases of certain priority hazardous substances
98/8/EC and new Regulation	Biocidal Products Directive and new Regulation	BPD	Biocidal products on the market (e.g. disinfectants, preservatives and pest control products)
91/414/EEC and (EC) No 1107/2009; 2009/128/EC	Plant protection products Directive and new Regulation; Framework Directive on sustainable use of pesticides		Plant protection products (e.g. herbicides, insecticides and fungicides) on the market
(EC) No 850/2004	POPs regulation	POP	Protect human health and the environment from persistent organic pollutants subject to the Stockholm Convention or the UNECE CLRTAP POPs Protocol
2002/95/EC and 2002/96/EC	Restriction of the use of certain Hazardous Substances in Electrical and Electronic Equipment; and Waste Electrical and Electronic Equipment	RoHS and WEEE	Restrict of certain hazardous substances (Pb, Hg, Cd, Cr(VI), PBB, PBDE) in electrical and electronic equipment; reduce environmental impact of electronic waste and optimize collection, re-use and recycling
2000/53/EC	End-of-Life Vehicles	ELV	Reduce amount of hazardous waste, increase recycling and re-use of end-of-life vehicles (Pb, Hg, Cd, Cr(VI))
2006/66/EC	Directive on batteries & accumulators and waste batteries and accumulators		Maximize separate collection of waste batteries and accumulators and increase recycling level (Hg, Cd, Pb)
94/62/EC	Directive on packaging and packaging waste		Production, recycling and re-use of packaging waste (Pb, Cd, Hg, Cr(VI))
98/70/EC	Directive on the quality of petrol and diesel fuels		Reduce pollution from vehicles (Pb, S)
98/83/EC	Directive on the quality of water intended for human consumption		Protect human health from contamination (e.g. heavy metals) of water intended for human consumption; water distribution system (e.g. pipes, solders and joints)
84/500/EEC and 69/493/EEC	Directive relating to ceramic articles intended to come into contact with foodstuffs; and Directive relating to crystal glass		Migration of Pb and Cd from ceramic articles; defines the characteristics (e.g. Pb content) of crystal glass
86/278/EC	Directive on the protection of the environment when sewage sludge is used in agriculture		Use of sewage sludge in agriculture (Cd, Cu, Ni, Pb, Zn, Hg, Cr)

(EC) No 466/2001, 88/344/EEC and 88/388/EEC	Directives on the contaminants in foodstuffs; extraction solvents used in the production of foodstuffs and food ingredients; and flavourings for use in foodstuffs		Level of contaminants (e.g. Pb, Cd, Hg) in foodstuffs; use of extraction solvents in production of foodstuffs and food ingredients; content of flavourings in foodstuffs (As, Pb, Cd, Hg)
96/82/EC	Directive on the control of major-accident hazards involving dangerous substances		Prevention of major accidents involving dangerous substances (e.g. fluorine and lead alkyls)
89/391/EEC	Directive on the introduction of measures to encourage improvements in the safety and health of workers at work		Prevention of occupational risks, protection of safety and health

3.1.9 Regional organizations

Overview of European regional organizations that target to decrease chemical releases from products are listed in Table 8.

The Helsinki Commission (HELCOM), working on the protection of the marine environment of the Baltic Sea, has recommendations related to prevention of releases of hazardous substances from any sources, including those from the use of consumer products (HELCOM 2009).

The OSPAR Commission, works on the protection and conservation of the marine environment of the North-East Atlantic, including prevention of releases of hazardous substances from diffuse sources, such consumer products (OSPAR 2009).

The Arctic Monitoring and Assessment Programme (AMAP) gives guidance on prevention of pollution of the Arctic region, including releases from products (AMAP 2009).

Table 8. Regional restrictions relating to releases from products

Convention/Programme	Target	Region
HELCOM	Marine environment	Baltic Sea
OSPAR	Marine environment	North-East Atlantic
AMAP	Arctic environment	Arctic region

3.2 National legislation

Many countries have legislation either addressing the chemical content of end products or related to certain product groups as shown in Table 9 (by country) and Table 10 (by product group). For the EU region, only national legislation in EU Member States that exceeds the EU legislation has been included while EU wide legislation is presented in Table 7.

Table 9. National legislation concerning chemical content of products or product use

Country	Restriction
Australia	Safety and information standards under the Trade Practices Safety Act from 1974 (IFCS 2006).
Canada	- Hazardous Products Act from 1969 administered by the Health Canada (IFCS 2006) http://laws-lois.justice.gc.ca/PDF/Statute/H/H-3.pdf - Ban on manufacture of polybrominated diphenyl ether (PBDE); prohibits the use, sale, offer for sale and import of those PBDEs that meet the criteria for virtual elimination under CEPA 1999 http://www.ec.gc.ca/CEPARRegistry/regulations/detailReg.cfm?intReg=108

	Provincial legislation: Ontario's Toxics Reduction Act (Bill 167) is a part of the province's Toxics Reduction Strategy, target to reduce toxics in the air, water, land and consumer products, includes tracking and evaluating the current uses and releases of toxics (Ontario 2008, 2009)
Chile	Pb content in paint and petrol
China	China RoHS (Pb, Hg, Cd, Cr (VI))
Denmark	General national ban on certain Pb containing products in Denmark.
Finland	- Hunting Act (1993/615) prohibits the use of Pb containing shots for hunting waterfowls (since 1996). - Restrictions by the Consumer Agency for indoor use of Pb containing candle wicks
Japan	- Law for Ensuring the Implementation, Recovery and Destruction of Fluorocarbons Concerning Specified Products (restriction on vehicle air conditioning unit). - Standard for elution of lead from dish and toy is established under the food sanitation law.
Korea	Pb compounds (De Minimis Limit 0.06% for metal accessories for children, since June 2011).
Netherlands	The use of Pb in ammunition for sports prohibited since 2004.
Norway	Product Control Act to prevent damage to health and disturbances to the environment caused by products. Applies to manufacture, import, marketing, use and handling of products and consumer services. Product Regulations on the manufacture, import, export, sale and use of chemicals and other products hazardous to health and the environment. Restricted substances and preparations include e.g. PCBs, Pb, Hg, Cd, NP/NPE and PFOS and restricted product groups e.g. textiles, jewelry, impregnated wood, toys, batteries, vehicles, electrical and electronic equipment, paints and varnishes. (SFT 2009b)
Sweden	- Non-Toxic Environment is one of the environmental quality objectives: newly manufactured products should not contain substances of very high concern, i.e. persistent, bioaccumulative, carcinogenic, mutagenic, toxic to reproduction; endocrine disrupting; severely allergenic; Hg, Cd and Pb. Products already existing must be handled so that the substances are not released into the environment. (Keml 2006b; Konsumentverket 2006) - Environmental Code and Product Safety Act: companies placing products on the Swedish market are responsible for ensuring that the articles are not harmful for human health or the environment and to replace the chemicals that pose risks with safer alternatives. (Keml 2009b) - Chemical Products and Biotechnical Organisms Ordinance and Chemical Products Ordinance are based on the Environmental Code (Konsumentverket 2006). - In addition to EU legislation, there are specific national restrictions concerning Hg, Cd and trichloroethylene (Chemical Products (Handling, Import, and Export Prohibitions) Ordinance (1998:944) and Chapter 5 of the Chemical Products and Biotechnical Organisms Regulations (KIFS 2008:2) (Keml 2009h): - General national ban on Hg and products containing Hg (from 1.6.2009): placement of Hg, Hg containing compounds, preparations and articles on the market, use of Hg, professional exportation of Hg and articles containing Hg from Sweden. The ban does not concern items already in use, but these are not allowed to be placed on the market, exported from Sweden or to be refilled with new Hg. Exceptions due to harmonized EC legislation include e.g. light sources and other electrical and electronic products, batteries and vehicles. Time-limited exceptions for analyses chemicals, certain instruments, equipment and certain use of amalgam. Transition period to industry until 2013. (Keml 2009b) - Chemical Products Ordinance: products containing cadmium used as surface treatment, stabilizer or colorant are not allowed to be sold or imported. There are exemptions to this rule. (Keml 2009b)
Switzerland	Ordinance on Risk Reduction related to the Use of certain particularly dangerous Substances, Preparations and Articles (Ordinance on Risk Reduction related to Chemical Products (ORRChem) of 18 May 2005).
Turkey	Legislation addressing substances in products
United States	- Toxic Substances Control Act (1976): US EPA has the right to prohibit the manufacture, processing or distribution of a substance for a particular use or particular use above a certain concentration if the use results in an unreasonable risk to people (IFCS 2006). - The Federal Hazardous Substances Act bans the use of hazardous substances e.g. in toys (IFCS 2006) - California's Safe Drinking Water and Toxic Enforcement Act (1986) provides annual lists of appr. 775 chemicals "known to cause cancer or reproductive toxicity", it is required that businesses provide warnings (label, signs, distributed or published notices) when a product, drinking water or workplace is exposing people to the chemicals on the list, if the exposure levels exceed a "no observable effect level" divided by 1,000. Due to this some products in the California market are labeled as "This product contains chemicals known to the state of California to cause cancer or reproductive toxicity".(Massey et al. 2008) - In 2008, Bills A.B. 1879 and S.B. 509 in California set a framework for a "green chemistry" program to

	reduce/phase out toxic substances in consumer products and the environment and to manage information on toxic chemicals. Authorities can regulate chemicals in consumer products by developing a program to identify and prioritize chemicals of concern and to analyze safer alternatives. Toxics Information Clearinghouse established for increasing consumer knowledge on risks related to everyday chemicals (Whetzel 2008; Massey et al. 2008). - Many US states have restrictions on the use of mercury in articles. E.g. Massachusetts requires manufacturers to identify and label Hg containing components of their products and the amount of Hg in them and selected mercury containing products will be phased-out; Maine has banned the use of Hg and Washington has a Hg reduction legislation. (Massey et al. 2008, Costner et al. 2005). - In 2004 penta- and octa-BDE were taken off the market by a voluntary agreement by the industry. Several states have banned these substances by law. Legislation for the use of safer cleaning products in public buildings, and legislation requiring toxics use reduction for large user segments. (McPherson et al. 2004; Sharp & Lunder 2004).

Table 10. National restrictions for product groups (for EU Member States beyond EU legislation)

Product group	Restriction	T= Total ban ¹⁶ R=Restriction	Region	Year	Chemicals included
Ammunition	Use of Pb shots banned for hunting waterfowl	T	Finland	1996	Pb
	Manufacture, import, export, sale and use of Pb shots is banned (including target ranges)	T	Norway	2005	Pb
	Restrictions on the use of Pb shots for clay target shooting	R	Denmark, Sweden		Pb
	Restrictions for the use of Pb in ammunition for rifles	R	Sweden	2008	Pb
Cable sheathing	Prohibition on Pb cable sheaths for ground cables below 24 kV	T	Denmark		Pb
Candle wicks	Pb in candle wicks banned	T	US, Australia, Denmark		Pb
	Restrictions for indoor use	R	Finland		Pb
Capacitors and transformers	Prohibition on the use of ballast capacitors containing PCB	T	Norway	2005	PCBs
Dental amalgam	General national ban for Hg containing products	T ¹⁷	Sweden	2009	Hg
Electrical and electronic equipment	General national ban for Hg containing products	T	Sweden	2009	Hg
	China RoHS	R	China		Pb, Hg, Cd, Cr (VI), PBB, PBDE
Fishing gear	Certain use of Pb sinkers prohibited	T	UK		Pb
	Use of Pb in fishing equipment is banned in national parks	T	Canada		Pb
	Total ban on the use of Pb in fishing equipments	T	Denmark		Pb
	Voluntary restriction on the use of Pb sinkers in certain fresh waters	R	Sweden		Pb
Glasses and glazes	Tableware Act	R	California		Pb
	Use of Pb in gasoline banned for in-road vehicles	T	USA	1996 (1990)	Pb

¹⁶ Can include exemptions

	Restriction on the Pb and Cd released from glazed ceramics and glassware	R	Canada	1971 revised 2005, 2009	Pb, Cd
	Restriction on Pb released from kettles	R	Canada	1974 (pending amendment 2010)	Pb
	Use of Pb solder in food cans is prohibited	T	USA		Pb
	Use of Pb foil wrappers banned	T	US		Pb
	Prohibition on the import and marketing of Pb containing security/safety seals	T	Denmark		Pb
	Toxin-Free Toddlers and Babies Act to ban the use of bisphenol-A in baby bottles	T	California	2009	bisphenol-A
	Voluntary industry initiative to stop using bisphenol-A in baby bottles	T	USA	2009	bisphenol-A
	Prohibition on the sale, advertising or importing into Canada of polycarbonate baby bottles that contain BPA	T	Canada	2010	BPA
Paint	Sale of Pb containing residential paints banned	T	USA	1978	Pb
	Limit values for the Pb content of paint	R	USA	2009	Pb
	Ban on the use of Hg containing paint	T	USA	1991	Hg
	Limit values for the Pb and Hg content in surface coating materials	R	Canada	1976 amendments 2005	Pb, Hg
Pesticides	Use of Pb arsenate as insecticide banned	T	US	1988	Pb
PVC plastics	Import and marketing of the use of Pb compounds in e.g. PVC cables, gutters, pipes, roofing and windows (general national ban on Pb)	T	Denmark	2003	Pb
Radiation shielding	Restriction on the Pb content of radiation shielding (including cathode-ray tubes)	R	Norway		Pb
Roofing and flashings	Use of Pb around windows and chimneys is banned (general national ban on Pb)	T	Denmark	2000	Pb
Sealants and caulk	Ban on new use of PCBs (including double glass windows)	T	Norway	1980	PCBs
Textile and leather	Proposed a law to ban the use of Cr(VI) in leather products intended for more than temporary contact with skin	T	Germany		Cr (VI)
Toys	Law to ban the use of certain phthalates in toys and child care articles	T	California	2009	DINP, DEHP, DBP, DIDP, DNOP, BBP
	Limit values for the Pb content of toys	R	USA	2009	Pb
	Limit values for the Pb content of children's jewellery	R	California	2007	Pb
	Proposed a law to ban on the use of Cr(VI) in leather toys	T	Germany		Cr (VI)
	Hazardous Products Act limits the amount of Pb in children's jewellery and other non-toy children's products (e.g. furniture)	R	Canada	1970	Pb
	Hazardous Products Act limits the amount of Sb, As, Cd, Se, Ba, and Pb used in children's toys	R	Canada	1970	Sb, As, Cd, Se, Ba, Pb
	Limit values for the Pb content of toys (not jewellery)	R	China		Pb
Vehicles	Prohibition on the import and marketing of Pb containing brake linings	T	Denmark		Pb

	Voluntary National Lead Free Wheel Weight Initiative	R	US		Pb
Water pipes	Prohibition on the import/ marketing of Pb containing solder for use in plumbing and sanitation (except for Zn sheets)	T	Denmark		Pb
Weights	Ban on Pb containing curtain weights (general national ban on Pb)	T	Denmark	2000	Pb

In addition to product group related restrictions listed in Table 10, several products fall under other EU legislation, such as the REACH and POP Directives. Examples of this type of products and chemicals are PCB use in capacitors and transformers, lead use in paint, sealants, lacquer and varnishes, lead containing glazes, enamels and pigments on certain ceramics, as well as arsene and chromium use in wood treatment.

3.3 Work by the Industry

The industry carries out voluntary initiatives regarding the use of chemicals in products and their possible releases. Examples of this type of work can be found, for instance, in the apparel, electronic and building industries (Table 11).

Table 11. Examples on industry initiatives on releases from products

Organization/ area	System	Target
International Council of Chemical Associations ICCA	Global Product Strategy GPS	Product stewardship information, reporting to the public
	Responsible Care and Responsible Care Global Charter RCGC	Effective management of chemicals
	Global initiative for HPV chemicals	Testing of chemicals and assessment of possible hazardous properties
Cefic	Confidence in Chemicals and HPV Chemicals	Chemical properties, impacts
Construction industry and IVL in Sweden	BASTA	Database for 13,000 registered materials that meet the requirements of health and environmental properties
Industry	Restricted substances lists (for health, safety and the environment)	Lists of substances prohibited / restricted or preferred in the products

3.3.1 Responsible Care and Responsible Care Global Charter (RCGC)

The Responsible Care Programme (RCGC), started in 1985, is a global voluntary initiative for sustainable development by the chemical industry (International Council of Chemical Associations, ICCA), which has been implemented in 53 countries. The RCGC commits companies to work together to enhance the health, safety and environmental performance of their products. It focuses on effective management of chemicals, greater industry transparency and greater global harmonization of the national programmes. (Responsible Care 2009)

3.3.2 Global Product Strategy (GPS)

The Global Product Strategy (GPS), linked to the RCGC programme, enhances product stewardship within the chemical industry along with suppliers and customers. The aim of the programme is to ensure the benefits of the products while improving the protection of human health, safety and the environment. GPS includes sharing of best practices, risk management of chemicals and greater transparency of the industry.

3.3.3 Confidence in Chemicals and the global initiative on HPV Chemicals

The Confidence in Chemicals initiative was launched by the chemical industry in 1998 as part of the Responsible Care programme, and is aiming to inform the stakeholders about the effects of chemicals and the precautions taken to ensure the safety of products. The work is coordinated by the CEFIC (European Chemical Industry Council). The aim of the programme is to speed up the testing of HPV chemicals¹⁷, by completing data sets and hazard assessments for approximately 1000 HPV chemicals in partnership with the OECD HPV Chemicals Programme (Chemical Industry 2009, ICCA 2009a; Finer 2006).

3.3.4 Voluntary Emissions Control Action Programme (VECAP)

Voluntary Emissions Control Action Programme (VECAP) is a global chemical management programme implemented in the Asia-Pacific region, Europe and North America. VECAP's mission is to increase the awareness of chemical handling processes throughout the value chain with increasing understanding of chemicals management beyond existing legislation, promoting and facilitating dialogue between the industry, regulators and stakeholders and by raising the awareness of all personnel throughout the supply chain. (VECAP, 2010)

3.3.5 BASTA project on construction and building products

The Swedish Construction Federation, the Swedish Environmental Research Institute IVL and the four largest construction companies in Sweden have a joint project, BASTA, funded by the EU's environmental fund LIFE. The project aims at phasing out construction and building products containing hazardous substances by developing a new classification system for these products based on their chemical content. The BASTA database contains currently approximately 13,000 registered materials self-declared by suppliers that meet the safety requirements set for health and environmental properties of the products. The substances to be registered must not be carcinogenic, mutagenic, toxic to reproduction, persistent in the environment or bioaccumulative. (BI 2003)

3.3.6 Restricted and preferred substances lists

Different industry sectors (e.g. electronic, automotive and apparel) have created lists of substances prohibited, restricted or preferred in their products. The companies need this information in planning their future projects. For instance, the car industry jointly operates the a material data system IMDS¹⁸ (see Chapter 4.5.3) helping to trace hazardous substances through all parts of cars. Examples of companies that maintain this type of databases are General Motors, Phillips, Ericsson, Nokia, Motorola, Scania, Wal-Mart and Volvo. For instance Scania¹⁹, keeps a list of chemicals divided into those that should not to be used in any condition and to those that can be used under limited circumstances. Wal-Mart has

¹⁷ HPV chemicals = chemicals produced in more than 1000 tonnes per year per producer

¹⁸ IMDS, International Material Data System

¹⁹ Swedish company producing trucks, buses and engines

made a Preferred Chemical Principles policy for product ingredients that indicates that the company favors products not containing carcinogens, mutagens or reproductive toxicants and those that are not persistent, bioaccumulative or toxic to the environment. The company has already identified three priority chemicals to be phased out by Wal-Mart (pesticides and nonylphenol ethoxylates) and is developing a screening tool to identify other chemicals of concern. (Peltonen 2005b, Massey et al. 2008)

3.4 Work by NGOs

Non-governmental organizations (NGO) carry out a number of projects and programmes concerning the health, safety and environmental impacts of releases from products (Table 12).

At international level, there are some groups involved in work with harmful impacts of products. For instance, Health Care Without Harm (HCWH) is an international coalition in more than 50 countries where health care professionals and environmental organizations work on restricting and preventing pollution from health care sector products.

In the USA and Canada there are several NGOs working in the field. Examples of these are the Clean Production Action (CPA) group working on green chemicals, sustainable materials and environmentally preferable products. The CPA also runs a Safer Products Project as a public support for the use of these chemicals. The Environmental Working Group (EWG), has projects related to hazardous chemicals in consumer products. The Healthy Building Network (HBN) is working on transforming the market of building materials to advance the best environmental, health and social practices. The Ecology Center of Ann Arbor tests chemicals used in cars and child seats for selected substances (antimony, arsenic, bromine, chlorine, chromium, cobalt, copper, lead, mercury, nickel and tin). The test results rating these products, as well as the full reports are available to the customers in a web page and database. (CPA 2009, HBN 2009, Massey et al. 2008)

In the Nordic countries, for instance in Sweden, the Swedish Society for Nature Conservation has carried out significant work in this field, for instance in testing releases of hazardous substances from products, e.g. textiles and shoes²⁰.

Table 12. Examples of NGO work related to releases from products

Country	NGO	Scope
International	Health Care Without Harm (HCWH)	Prevention of pollution in health care sector
Sweden	Swedish Society for Nature Conservation	Tests for textiles and shoes for the content of hazardous substances
USA and Canada	Clean Production Action (CPA)	Green chemicals, sustainable materials and environmentally preferable products
	Environmental Working Group (EWG)	Hazardous chemicals in consumer product, maintains Skin Deep database
	Healthy Building Network (HBN)	Building materials
	Ecology Center of Ann Arbor	Consumer Action Guide to Toxic Chemicals in Cars and child seats

²⁰ <http://www.naturskyddsforeningen.se/in-english/>

CHAPTER 4

INFORMATION SYSTEMS ON CHEMICALS IN PRODUCTS

4.1 Existing information systems on substances and end-products

Although information about the properties of individual chemicals can be received from the chemicals manufacturers, for example through the material safety data sheets, it is often difficult to receive information on the chemical content of products. Related to products, the variability of regulations in different countries and the lack of enforcement are challenges for this flow of information.

At the UNEP IFCS, work initiated by Japan and Sweden has been started to create a global system to collect information on chemicals in products. In this chapter, information is provided of some of the existing systems that include information on the chemical content of products, classification and labeling as well as life-cycle analysis data (examples of these systems are given in Table 13).

Table 13. Examples of existing information systems on substances and end-products

System	Maintenance	Information
Classification and labeling systems		
Globally Harmonized System (GHS)	UN	Classification and labeling of physical properties and toxicity of chemicals
Classification, Labelling and Packaging of substances and mixtures (CLP)	EU	Implementation of the GHS in the EU
SIN List (Substitute It Now)	ChemSec (International Chemical Secretariat)	Chemicals that fulfill the criteria of substances under the REACH, a tool for the work in substituting hazardous chemicals by safer alternatives in everyday products
Environmental labeling	National, UN, EU, ISO standard	Environmentally friendly products
National hazardous chemicals lists	EU Member States	Hazardous chemicals
Rapid alert system for non-food consumer products (RAPEX)	EU	Alert and information exchange on hazardous products
Life cycle assessment and Integrated Product Policy		
LCA and IPP	EU	Environmental impacts
Information on chemicals and substances		
Material Safety Data Sheet (MSDS)	International	Properties of chemicals
International Uniform Chemical Information Database (IUCLID)	EU	Properties of chemicals (contains the registration dossiers submitted by industry to ECHA under the REACH)
Product registers (i.e. registers containing information on chemical products)		
National product registers	E.g. Denmark, Finland, Norway and Sweden, United Kingdom, Cyprus, Switzerland	CAS numbers, product use volumes and area of use In the Nordic product registers by DK, FI, NO, SE also substances and mixtures
Interstate clearing houses and databases (IMERC)	USA	Mercury added products information systems, open to public
International Material Data System (IMDS) with Global Automotive Declarable Substance List (GADSL)	Vehicle manufacturers	Information on substances in vehicles in the supply chain.
Global Data Synchronisation Network (GDSN)	LANSA	Platform for companies to manage their product information

Cosmetics safety database (Skin Deep)	Environmental Working Group (EWG), USA	Information on safety on cosmetics and personal care products by researchers
Product safety work		
National product safety organizations	E.g. Canada, Denmark, Finland, Germany, Norway, Sweden, USA	Increase awareness to end-users of products
Database on product safety	Ecology Center of Ann Arbor	Tests results of chemicals used in cars and child seats
Database on product safety	Swedish Chemicals Agency	PRIO risk reduction database > 4,000 substances.
Source Ranking Database (SRD)	US EPA	Ranking of indoor pollution sources e.g. carpets, rugs, furniture, pharmaceutical preparations, soap and other detergents, paints, cosmetics and personal care products, coatings, pesticides, wall coverings, cleaning agents, textile finishes and flooring for phthalates, lead, tributyltin, adipates, NPEs etc.

4.2 Classification and labeling systems

4.2.1 Environmental labelling

Chemicals

Globally Harmonized System (GHS) for classification and labelling of chemicals

The United Nations' GHS is a standardized system for international communication about chemical hazards. The purpose of GHS is to document information on the physical properties, toxicity and exotoxicity of chemicals as well as to enhance the protection of human health and the environment during handling, transport and use of chemicals. In the GHS system chemicals are classified based on the type of hazardousness (for example acute toxicity, carcinogenicity, reproductive toxicity, explosivity and acute environmental toxicity) with symbols (pictograms), signal words and hazard statements, also precautionary statements as well as product and supplier identification information are included. The aim of this information is to protect workers and the environment. (Massey et al. 2008, GHS 2009).

In the EU, GHS is implemented by the CLP regulation (EC) No 1272/2008 (Classification, Labelling and Packaging of substances and mixtures). The objective of the regulation is to determine which properties of substances and mixtures should lead to being classified and properly identified as hazardous. The properties include physical hazards, hazards to human health and to the environment. CLP will be applied in stages and it will eventually replace the old directives. The CLP regulation applies to all chemicals but the labelling requirement concerns only substances and preparations classified as hazardous. Unlike in REACH, there is no tonnage limit. The role of the European Chemicals Agency (ECHA) is to provide industry with technical and scientific guidance and tools on how to comply with the obligations laid down by the regulation. (CLP 2009)

Products

An eco-label for a product is often awarded by a third party to products or services meeting specified environmental performance criteria or standards.

ISO standards for eco-labelling

Voluntary eco-labeling is carried out according to ISO 14020 series Environmental labels and standards at three levels (ISO 2009; GEN 2004):

- Type I environmental label on a product is awarded based on life cycle assessment by a third party. Examples of eco-labels are the German Blue Angel, the European Union Flower and the Nordic Swan.
- Type II environmental self-declaration is developed by the producer, for example the "Energy Star".
- Type III environmental declarations provide quantified environmental data of product based on life cycle assessments by a qualified third party. Examples are report cards and information labels.

European Eco-label -The Flower

The EU Eco-label certification scheme assists consumers to identify environmentally friendly products and services, excluding food and medicine. There are currently 23 product groups including several hundred products that have over 300 licenses to use the label. The label cannot be granted to products containing substances or preparations/mixtures classified as toxic, hazardous to the environment, carcinogenic, mutagenic or toxic to reproduction (CMR), or to those included in Article 57 of the REACH regulation (ChemicalWatch 2009c). (Eco-Label 2009)

Nordic Eco-label -The Swan

The Nordic Eco-label by the Nordic Council of Ministers is meant to increase awareness on the environmental impacts of products and services and to direct consumption, marketing, product development and manufacture to a less harmful direction regarding the environment. The criteria are the same in all Nordic countries and include life-cycle assessment of the product considering consumption of natural resources and energy; harmful releases to air/water/soil, noise, smell; waste production and recycling. Products for which the manufacturers apply for the label are being checked by samples, certificates and control visits. The label is usually valid for three years after which the criteria are revised and the license has to be reapplied. The label is available for approximately 70 product groups and services including, for instance, button cell batteries, motors, lighting, washing-up liquids, washing machines, furniture and hotels. (SFS 1993, 2009).

German Eco-labels -The Blue Angel, Öko-Tex Standard 100

The Blue Angel is awarded by the German Environmental Label Jury to products, which are environmentally friendlier than other products serving the same purpose. Approximately 10,000 products and services in 80 product categories carry the Blue Angel eco-label. Examples of product groups are paints and varnishes wall papers, paper products, solar panels, low-noise appliances, heating systems as well as certain services such as wet cleaning of textiles. The basic award criteria for the different product groups are valid for a 3-4-year period, and the award of the label is preceded by a life cycle assessment (The Blue Angel 2009a, b,c & 2009d).

Öko-Tex Standard 100 is a globally uniform testing and certification system for textile raw materials, intermediate and end products at all stages of production to ensure their safety regarding harmful chemicals to health. A tested textile product is allocated to one of the four Öko-Tex Product classes based on its intended use. The issued certificate applies one year at a time and can be renewed when required. (Öko-Tex, 2009)

American Eco-label (The Green Seal)

The Green Seal environmental certification standard covers more than 40 product categories, for example paints and coatings, household cleaning products, hand soaps and cleaners, paper towels and printing and writing paper. Services that carry the label are e.g. cleaning services and lodging properties. The label is awarded to products certified after accurate testing and evaluation, including on-site plant visits. (Green Seal 2009a & b)

4.2.2 National lists of hazardous substances

Countries have established lists for hazardous or undesirable substances. The lists are periodically reviewed and updated according to changes in the selection criteria. As examples of the lists, information of the Danish and Norwegian lists is presented below. In addition to the national lists, EU wide lists of hazardous substances are valid in the Member States.

Denmark published the first list of undesirable substances in 1998 and has revised it since on an ongoing basis. If the chemicals or products containing these chemicals are used for commercial purposes in Denmark, they must be reported to the Danish Product Register. The selection of substances to the list is based on their undesirable effects. Candidates for the list are for example carcinogens, mutagens, reproduction toxins and substances being toxic to aquatic life. The list includes about 70 substances and groups of substances, and provides information on chemicals, the use of which should either be reduced or stopped in the long term.

Norway has three lists of hazardous substances. The list of priority substances includes approximately 30 substances and groups of substances, including POP compounds (e.g. SCCPs and PFOS) and heavy metals (e.g. Pb, Hg and Cd). Releases of certain ecological toxins will be eliminated or substantially reduced by 2000, 2005 or 2010. Releases and use of substances that pose a serious threat to health or the environment will be continuously reduced with a view to eliminating them within one generation (by the year 2020). Priority is given to substances that have low biodegradability, which bioaccumulate and have a serious long-term impacts on health, or are highly toxic to the environment. The observation list of 250 substances includes examples of substances that are particularly hazardous to health or the environment and are used in such amounts that they may present a risk at national level. The list of dangerous substances includes approximately 3,500 substances, which also fall under the EU classification.

4.3 Life Cycle Assessment (LCA) and Integrated Product Policy (IPP)

Life Cycle Assessment supports decision-making by describing interactions between the product and the environment. LCA is used in environmental labeling. Integrated Product Policy (IPP) is a general policy framework within the EU based on the life cycle approach, with the target to minimize environmental impacts of products during all phases of the product's life cycle.

4.4 Material Safety Data Sheets

Material Safety Data Sheets (MSDSs) are intended for the safe management of substances and contain information on the physical properties, toxicity, reactivity, storage, disposal and health effects as well as on safe use and potential hazards of a certain material or product. The MSDSs are primarily intended for occupational use, not for consumers, and they are country and supplier specific.

4.5 Product registers

4.5.1 Nordic countries

The Nordic countries established a joint online database in 2002 on the use of chemical substances in products on the Nordic market (Substances in Preparations in the Nordic Countries, SPIN²¹). SPIN is based on data from product registers from Denmark, Finland, Norway and Sweden. The declaration requirements vary between countries. The Danish and Swedish product registers contain information on the highest proportion of products on the market. Foodstuffs and medicinal products are exempted from the product registers in all countries. There are no requirements to declare solid processed articles and thus chemicals in textiles, chipboard, etc. are not included in the registers. However, if the articles are produced in the Nordic countries, the raw materials used may be declared. SPIN was financed by the Nordic Council of Ministers Chemicals Group.

4.5.2 Other European countries

In addition to the Nordic countries also Cyprus, Switzerland and the UK have product registers. Belgium and the Netherlands have Poison Information Centres, and Austria and Iceland carry out registering of material safety data (MSDS) sheets. Estonia collects information on HPV chemicals. France, Italy, Poland and Slovakia collect information on chemical substances and preparations in their national registers.

4.5.3 Industry

The International Material Data System (IMDS) is an online database of the automotive industry, designed to provide communication of information through the production supply chain. IMDS lists over 8,000 substances. It does not provide information to the consumers.

The Global Automotive Declarable Substance List (GADSL), included in the IMDS, contains 111 substances expected to be present in a vehicle. These substances are listed as "prohibited" or "declarable".

²¹ <http://195.215.251.229/DotNetNuke/default.aspx>

The Global Data Synchronisation Network (GDSN) is a platform for companies to manage information on chemical ingredients of products provided by the suppliers. To ensure products are classified correctly and uniformly, GDSN uses GS1 Global Product Classification (GPC), a system that provides buyers and sellers a common language for grouping products in the same way, everywhere in the world (GDSN, 2010, Massey et al. 2008)

4.6 Product safety work and other information exchange systems

There are both international and national information exchange systems regarding products that may bear risk to health, safety or the environment.

Product safety work can be organized by the government or based on the contribution of consumer organizations. Competent government bodies responsible for this work include, for example, health and product supervising authorities, authorities supervising chemicals and food products as well as customs authorities. Consumer protection authorities and plant production inspection authorities follow product properties. Information on the national organization of product safety work in the different countries is presented compiled in Table 14.

4.6.1 Rapid alert system for non-food consumer products (RAPEX)

RAPEX is an EU system facilitating a rapid information exchange on preventing and restricting the use and marketing of products that pose a serious risk to the health and safety of consumers. All member states use the RAPEX system for detecting and notifying dangerous products and for ensuring follow-up actions. The number notifications has gradually increased from year 2004 for instance, in 2008 the number of consumer products that were withdrawn from the market through the RAPEX system was 16 % higher(1,866 notifications) than in 2007. Also, recently it has been noticed that businesses recall their unsafe products more often than they did some years ago. Products with the most frequent notifications in 2008 were toys and child-care articles (498), electrical products (169), motor vehicles (160), all accounting together 53 % of the total amount of notifications. <The number of notifications for textile products was 140. Countries that made most of the notifications in 2008 were Germany (205), Spain (163), Slovakia (140), Greece (132) and Hungary (129), representing together 50 % of the total. The number of notifications on Chinese made products increased from 52 % in 2007 to 59 % (909 notifications) in 2008. (RAPEX 2009, EU 2009a)

"RAPEX-CHINA" application

The "RAPEX-CHINA" application (established in 2006) provides the Chinese authorities access to information on the Chinese products labeled as dangerous in the RAPEX system. The cooperation is conducted in the form of Memorandum of Understanding between the Health and Consumer Protection Directorate-General of the European Commission (DG SANCO) and the General Administration of Quality Supervision, Inspection and Quarantine of China (AQSIQ). Based on information provided in the system, the Chinese authorities have increased restrictive measures on their markets. AQSIQ has until now investigated 669 notifications, from which 53 % (352 notifications) resulted in preventive or restrictive measures. (RAPEX-CHINA 2009, EU 2009a)

Table 14. Examples of product safety work

Country	Organization	Examples of product groups
Canada	Global Public Health Intelligence Network GPHIN	
China	RAPEX-CHINA	Chinese products labeled as dangerous in the RAPEX
EU	Rapid Alert System for non-food consumer products (RAPEX) of products that pose danger to health and safety of consumers	Toys, child-care articles, electrical products, and motor vehicles, textile products etc.
Denmark	Danish Safety Technology Authority	Baby products, electrical products and fireworks
	Danish Consumer Agency	
	Danish Consumer Ombudsman	
	Danish Consumer Council	
Finland	Safety Technology Authority and Ombudsman	Furniture, toys, textiles and cosmetics
	Safety Technology Authority	Technical products (including electrical appliances, pressure and measuring equipment, rescue service equipment and CE-labeled construction products)
	Food Safety Authority	Products in contact with food/drink +pesticides/fertilizers
	National Supervisory Authority for Welfare and Health	Chemical products (e.g. cleaning agents, detergents and biocides)
	National Agency for Medicines	Pharmaceuticals and healthcare products
	The Finnish Vehicle Administration	Vehicle components and traffic equipment
	The Finnish Consumers' Association	
	The Consumers	
France	Consumer Safety Watchdog	
	Health Watchdog	
	French Agency for the Safety of Health Products	
	French Food Safety Agency	
	Federal Union of Consumers	
	Confederation for Consumer Affairs, Housing and Quality of Life	
Germany	The Federal Office of Consumer Protection and Food Safety	Plant protection products and medicinal products
	The Federal Institute for Risk Assessments	Foods, substances (e.g. cosmetics) and products
	The Federal Institute for Occupational Safety and Health	
	The Federation of German Consumer Organisations, the "Stiftung Warentest" and the "Verbraucherinitiative e.V."	
Netherlands	National Institute for the Safety of Food and (consumer) Products VWA	
Norway	Directorate for Civil Protection and Emergency Planning (DSB)	Central responsibility, distributes specified tasks to the below listed agencies
	Consumer Ombudsman	
	Food Safety Agency	
	Labour Inspection Authority	
	Public Roads Administration	
	Radiation protection agency	
	KLIF Climate and Pollution Agency (RAPEX)	
	Consumer Council	
Sweden	Swedish Consumer Agency	
	The Swedish Consumer's Association	
	The Swedish Consumer Coalition	
Thailand	Platform on Chemicals Safety	
United States	Federal Trade Commission	
	The Consumer Product Safety Commission	
	Department of Consumer Affairs (in the States)	

	Household Products Database	Car products, pesticides, products used in gardens, personal care, home maintenance, arts&crafts, pet care, home office etc.

4.6.2 Global Public Health Intelligence Network (GPHIN)

Global Public Health Intelligence Network (GPHIN) is an internet-based warning system on information about significant public health events, including exposure to chemicals and issues relating to the safety of products. GPHIN was developed by the Public Health Agency of Canada and is managed by the Agency's Centre for Emergency Preparedness and Response (CEPR) (GPHIN 2004).

4.6.3 Nordic countries

Denmark

The Danish Safety Technology Authority (Sikkerhedsstyrelsen), the Danish Consumer Agency and the Consumer Ombudsman control product safety related issues. The Danish Consumer Council, an umbrella organization, is the main national consumer organization in Denmark.

Finland

The Safety Technology Authority (Tukes) and the Consumer Ombudsman have the surveillance of consumer products, technical products and equipment as well as chemicals, explosives and fireworks on the market (Tukes 2009). Tukes also maintains a list of dangerous products on their website and tests on randomly selected products to identify possible safety risks. It is the customs' duty to supervise consumer products imported outside the European Economic Area²². Construction products that are not CE-labeled are supervised by the Ministry of the Environment. The Finnish Food Safety Authority (Evira) controls products that are in contact with food or drink as well as pesticides and fertilizers. The National Supervisory Authority for Welfare and Health (Valvira) and the Finnish Environment Institute control the enforcement of chemicals legislation, authorization of biocides and the regulation of detergents while the National Agency for Medicines has the responsibility regarding pharmaceuticals and healthcare products on the market. The Finnish Vehicle Administration (AKE) carries out surveillance of vehicle components and traffic equipment. There are two national consumer organizations, Finnish Consumers' Association (Kuluttajyhdistys) and the Consumers (Kuluttajat) (EC 2009b).

Norway

The Directorate for Civil Protection and Emergency Planning (Direktoratet for samfunnssikkerhet og beredskap, DSB) is the supervising authority together with the Consumer Ombudsman. The Consumer Council is the main national consumer organization in Norway. Besides product safety, these organizations work with fire, electrical and chemical safety as well as emergency legislation issues. (TEM 2009; EC 2009b)

Sweden
The Swedish Consumer Agency (Konsumentverket) is the supervising authority while the fieldwork is carried out by national consumer organizations, including the umbrella organizations The Swedish Consumers' Association (Sveriges Konsumenter) and the

²² i.e. EU Member States, Norway, Iceland and Liechtenstein

Swedish Consumer Coalition (Sveriges Konsumenter i Samverkan). The Swedish Chemicals Agency (KemI) carries out research and follow-up work on chemicals in articles/products. KemI publishes information on national product use related issues such as product types dangerous for the environment, imported and domestic produced products and top ten lists of the most common types of products and chemicals. KemI publishes the Commodity Guide which contains information on materials and substances that may be included in commodities on the Swedish market. KemI has developed a risk reduction tool, Prio, including a database containing more than 4,000 substances. The hazardous substances are divided into those that should be phased-out and to prioritized risk reduction substances. Prio shows if the substance is included in the REACH candidate list or prioritized in the Water Framework Directive. The Agency's restricted substances database contains information on prohibitions and restrictions of substances and the classification database contains approximately 3,300 substances . (KemI 2004b, EC 2009b)

4.6.4 Other European Countries and the EU

Germany

The Federal Office of Consumer Protection and Food Safety, the Federal Institute for Risk Assessments and the Federal Institute for Occupational Safety and Health are the main federal agencies working on product safety issues . There is no central supervisory authority for consumer protection in Germany. The 16 federal states are responsible for enforcement of legislation. There are also government-funded private organizations working alongside the government bodies. The Federation of German Consumer Organisations, the "Stiftung Warentest" and the "Verbraucherinitiative e.V." are national consumer organizations working at federal or regional level in Germany. The Federation of German Consumer Organisations is a non-governmental umbrella organization for 41 consumer associations and has an integrated network with 16 consumer advice centers in the federal states. (EC 2009b)

France

The Consumer Safety Watchdog and the Health Watchdog are independent administrative authorities working on product safety issues. In addition, there are specialized agencies, like the French Agency for the Safety of Health Products and the French Food Safety Agency, working on consumer protection. National consumer organizations include the Federal Union of Consumers and the Confederation for Consumer Affairs, Housing and Quality of Life. (EC 2009b)

EU

The European Consumer Centres Network (ECC-Net) is a EU wide network designed to help consumers in cross-border cases (ECC-Net 2009).

4.6.5 The United States

The Federal Trade Commission has the surveillance of product safety issues at the federal level and the States have a Department of Consumer Affairs. The Consumer Product Safety Commission is an independent agency working on product safety. A number of non-governmental organizations are also working on the issue. The U.S. Consumer Product Safety Commission (CPSC) is charged with protecting the public from unreasonable risks of serious injury or death from thousands of types of consumer products under the agency's jurisdiction. The CPSC is committed to protect consumers from products that pose fire, electrical, chemical, or mechanical hazard or can injure children. The CPSC's work to ensure the safety of consumer products, has contributed significantly the 30 percent decline in the rate of deaths and injuries associated with consumer products over the past 30 years.

Currently 13 states are included in the Interstate Mercury Education and Reduction Clearinghouse (IMERC). Seven states have adopted a legislation that requires companies selling mercury-added products to submit information to the Mercury-Added Products Database, a collaborative program of IMERC. The database is open to the public and it provides information on the amount and purpose of mercury in consumer products as well as identification of mercury-added products and their manufacturers. The authorities use the database to identify product categories posing high risks. An Interstate Chemicals Clearinghouse for sharing information on different products is currently under negotiation.

Source Ranking Database (SRD) developed by the US EPA is designed for risk-based ranking of over 12,000 potential indoor pollution sources by the hazardousness of the chemical and the use environment of the product. It is a tool to identify product or material categories or products containing certain chemicals. The database includes different consumer products, building materials and furnishings that contribute indoor air pollution. Product categories include, carpets, rugs, furniture, pharmaceutical preparations, detergents and cleaning agents, paints, cosmetics and personal care products, coatings, pesticides, wall coverings, , textile finishes and flooring. Chemicals in the database include phthalates, lead, tributyltin, adipates, and nonylphenols and nonylphenol ethoxylates, for example. (USEPA 2009b, Massey et al. 2008)

The U.S. Consumer Product Safety Commission (CPSC) has the responsibility to protect the public from unreasonable risks of serious injury or death from thousands of types of consumer products. The CPSC's work to ensure the safety of consumer products - such as toys, cribs, power tools, cigarette lighters, and household chemicals – has been regarded to have contributed significantly to the 30 percent decline in the rate of deaths and injuries associated with consumer products over the past 30 years.

The Household Products Database contains information to consumers on over 5000 common household products and their health and safety aspects. The database is maintained under the US Department of Health and Human Services. (HHS, 2009).

4.6.6 Thailand

Thailand maintains a database o chemical safety (Platform on Chemicals Safety²³).

²³ www.chemtrack.org

CHAPTER 5

OVERVIEW OF LIKELY RELEASES FROM THE USE PHASE OF PRODUCTS

5.1 Estimates of likely trends of product use related releases

Information on releases that are likely to occur during the use of certain products is presented under this chapter. Note that the compiled information cannot be regarded complete but only reflects information that was available during the preparation of the Resource Compendium.

Table 15 compiles available information on such end-products from which releases may occur and for which there exist methodology to quantify the releases. It is also indicated whether these releases are included in regular national inventories or inventories under international conventions.

Table 15. Examples of releases from the use phase of end-products (RET = release estimation technique, (x) = research projects/certain countries/unpublished)

Product group	Examples of end-products	Substance	Effect in end-product	Releases to	RET exists	Regular inventory
Ammunition	Lead shots and bullets	As, Pb	Operational	Soil, water	x	(x)
	Tracer bullets (military)	HCBs	Operational	Soil, water	(x)	(x)
Biocides	Impregnated wood ²⁴	HCBs	Used as fungicide, pesticide	Air	x	(x)
		PCBs		Air	x	(x)
		PCNs		Air	x	(x)
		PFOA		Air	x	(x)
		HCBs		Air	x	(x)
		As, Cr, Cu		Soil, Water	x	
	Seed, sorghum and crops protection	HCB, HCBd	Fungicide	Air	x	(x)
Building and construction	Pipes	Pb, Hg, Cu	Fungicide	Water	x	(x)
	Roofing and flashings	Pb	Material	Water	x	(x)
	Roofing	DEHP	Additive	Air, water, waste	(x)	
		Cu	Material	Stormwater, soil		
	Facades, wall claddings, roofs	Cr, Ni	Steel structures	Soil, water	x	(x)
	Floor and wall material	NP/NPE, PCB, Pb, phthalates	Softener (phthalates)	Water	(x)	(x)
Cables and wires		PCBs, phthalates, DEHP	Plasticizer	Soil, water	(x)	(x)
Capacitors and transformers	Electrical distribution, lighting ballasts, motor start capacitors, transformers	PCBs	Dielectric fluids	Air	x	(x)
	Gyroscopes, transformers	HCBs, PCNs	Hydraulic fluids	Air	x	(x)
Collector shoes		Pb	Inbound in material	Air, soil	x	(x)
Cleaning products	Laundry detergents, dry cleaning, car care products, paint and varnish removers	NPs/NPEs	Surfactant (tenside)	Water	(x)	(x)
	Cleaning agents, car waxes	PFOS	Surfactant	Air	x	(x)

²⁴ Most of wood preservative active ingredients listed in column "Substance" are no longer permitted in the EU.

Product group	Examples of end-products	Substance	Effect in end-product	Releases to	RET exists	Regular inventory
	Floor polish		Surfactant	Air	x	(x)
	Dishwashing car care		As a rine-aid	Air	x	(x)
	Soap, cleaning agents	LAS, NH ₃	Surfactants, effective alkaline	Water, air	(x)	(x)
	Cleaning agents	Phthalates, PFOA	Solvent, surfactant	Water	(x)	(x)
Dental products	Dental amalgam	Hg	Dental fillings	Air, water	x	x
	Toothpaste	Triclosan	Antimicrobial agent	Water	(x)	(x)
Electrical equipment	Batteries, accumulators	Pb, Cd, Hg	Operational	Soil, water	x	(x)
	Switches and relays	Hg		Air	x	(x)
	TV sets, computer monitors	PCB, PBDE, Pb	Dielectric fluid in transformers	Air	x	(x)
	Solders, circuit boards	BFRs, Pb		Water	x	(x)
Fishing gear	Weights, keels	Pb	Operational	Water	x	(x)
Food handling	Treating fruit	HCBDs	Fumigant	Water	(x)	(x)
Furniture	Furniture foam and textiles, mattress	HBCD, PBDEs	Flame retardant	Air	x	(x)
		PFCs	Coating	Air	x	(x)
	Plastic furniture	Phthalates	Plasticizer	Water	(x)	(x)
		Pb, organotins	Stabilizers	Soil, water		
	Carpets	Formaldehyde	Finishes	Air	(x)	(x)
		Phthalates	Plasticizer			
		Organotins	Stabilizer	Water	(x)	(x)
		PBDEs	Flame retardants	Air		
		PFCs	Dirt repellent coating	Air		
		Pesticides	pesticide	Water	(x)	(x)
	Leather couches and armchairs	Cr	Tanning	Water		
		Dimethylfumarate	Anti-mould agent			
	Wooden furniture	Formaldehyde	Adhesive	Air		
		Pb, Hg	Paint	Air	x	(x)
Household appliances	Refrigerators, washing machines, air humidifiers	Silver	Antibacterial agent	Air	x	(x)
		NH ₃	Refrigerant gas			
	Tablewear, glasswear	Pb	Coloring element	Soil		
Jointing, sealing filling and buildingmaterial, lubricants, hydrylic and heat transfer	Hydraulic and heat transfer fluids, lubricants	PCBs, Pb	Flame retardant , plasticizer	Water		
		BFRs	Flame retardants	Air		
	Insulating materials	Formaldehyde		Air		
	Sealants and caulk	PCBs, Pb	Flame retardant , plasticizer	Air	x	(x)
Lighting	Fluorescent and energy saving lamps	Hg	Operational	Air, soil	x	(x)
Low-cost jewellery		Pb, Cd, Sb	Recycling	Soil	x	(x)
Measure& control equipment	Thermometers	Hg	Operational	Soil, water	(x)	(x)
Pyrotechnic	Pyrotechnic smokes (military)	HCBs	Operational	Air	x	(x)
	Firework	heavy metals	Pigment	Air	x	x
Photograph	Photographic applications	Silver, PFOS	Operational (Ag)	Water		
Radiation shielding	Computer glass and television screens	Pb	Operational	Air	(x)	(x)
Personal care products (including cosmetics, perfumes and hygiene products)	Sunscreens and lotions	EHMC, MBC, OC, BMDBM, BP3, siloxanes	UV filters, preservatives	Water	(x)	(x)
	Lotions, soaps and shampoos	Phthalates	Solvent, binding fragrances	Water	(x)	(x)
	Nail polish and hair sprays		Plasticizer	Water	(x)	(x)

Product group	Examples of end-products	Substance	Effect in end-product	Releases to	RET exists	Regular inventory
	Soap, shampoo, hair dye, make up	NPs/NPEs	Surfactant	Water	(x)	(x)
	Shampoo	PFOS	Surfactant	Air	x	(x)
		Musk xylenes	Fragrances	Air	x	(x)
		Parabens	Preservatives			
Pharmaceuticals	Folklore medicine	Hg	Operational	Water	(x)	(x)
	Spermicides	NPs/NPEs	Operational	Water	(x)	(x)
Surface coatings (e.g. paint) and adhesives	Paint	Pb	Pigment	Air	x	(x)
	Ships, furniture, walls, ceiling	PCBs	Plasticizer, flame retardant	Water	x	
		SCCPs	Plasticiser	Water, soil, Air	x	(x)
	Marine primer, roadmarking, fire-retardant paints	Cr	Pigment	Air	x	(x)
		Hg	Additive	Air	x	(x)
Textiles	Sail and industrial protective clothing, lorry tarpaulings	SCCPs	Flame retardant	Water		
		Phthalates, PFOA	Surfactant	Water	(x)	(x)
	Terry towels, t-shirts, children's overalls	NPs/NPEs	Detergent (tenside)	Water	x	(x)
	Leather products, fabrics	DMF	Solvent, dye intermediate	Water	(x)	(x)
Toys	Plastic toys	Phthalates	Softening agent	Water	(x)	(x)
	Other toys	Pb	Paint, pigment	Water	(x)	(x)

The trend of releases from certain products being generally decreasing or increasing can be estimated on basis of restrictions already implemented on the use of certain products or chemicals in products or due to the fact that the use volume of certain products is increasing or decreasing. Estimates of such trends are presented in Tables 16 and 17. Information on product related legislation can be found in Chapter 3.

Table 16. Product groups where releases can be assumed to cease or decline due to restrictions

Product group	Chemical	Release trend	Affecting factors
Ammunition (shots)	Lead	Declining	Prohibitions on the use of Pb containing shots in wetland (e.g. in Finland). Restrictions on the use of Pb shots in shooting ranges (e.g. in Sweden and Denmark). A general national ban on shots containing lead in Norway.
Cable sheathing	Lead	Declining	Prohibitions on certain types of Pb cable sheaths (e.g. in Denmark)
Candle wicks	Lead	Almost ceased	Pb candle wicks banned in many countries, voluntary industry initiative to remove them from the EU market.
Capacitors and transformers	PCBs	Almost ceased	The use of PCBs have been banned in most of the countries. Old PCB containing devices may still be found.
Dental amalgam	Mercury	Declining	A general national ban for Hg containing products e.g. in Norway and Sweden
Electrical and electronic equipment	Lead	Slowly declining	Restrictions in the RoHS EU on the Pb content of electrical and electronic products.
	Mercury	Slowly declining	Ban for Hg containing products in the EU
Fishing gear	Lead	Declining	The use of Pb sinkers has been prohibited in certain areas in many countries (e.g. UK and Canada). Total ban on Pb containing fishing equipment in Denmark. Voluntary restrictions e.g. in Sweden.
Glasses and glazes	Lead	Slowly declining	Restrictions on the Pb content of glasses and glazes. A national ban on the import and marketing of Pb containing glazes, enamels and pigments on certain ceramics in Denmark.

Leaded gasoline	Lead	Almost ceased	Use of Pb in gasoline has been banned in most countries since the 1990's. Pb in gasoline is still allowed for certain uses in aviation and off-road vehicles.
Packaging	Lead	Some uses ceased, others declining	Use of Pb in solders of food cans, wine capsules, foil wrappers and security seals is prohibited in many countries.
	Bis-phenol-A	Slowly declining	Ban on the use of bisphenol-A in food containers, including baby bottles, in California. There is also a voluntary industry initiative to stop using bisphenol-A in baby bottles in the United States.
Lead containing paint	Lead	Almost ceased	The use of certain Pb compounds in paint (especially in residential paint) has been banned in many countries. These may still be used in developing countries. There are also restrictions for Pb content of paint.
	Mercury	Almost ceased	The use of Hg containing paint has been banned in many countries, still found in old applications.
	PCBs	Almost ceased	The use of PCB containing paint has been banned in most countries, but these may still be found e.g. in old buildings.
Pesticides	Lead	Declining	Pb containing pesticides have been banned, e.g. the use of PbHAsO ₄ as insecticide (the USA)
PVC plastics	Lead	Declining	Voluntary industry initiative in the EU for ceasing the use of Pb as stabilizer in PVC plastics. Restrictions on Pb content of PVC plastics. A general national ban on Pb containing products, including plastic profiles, in Denmark.
Radiation shielding	Lead	Declining	Restrictions on the Pb content of cathode-ray tubes. The use of monitors with cathode-ray tubes is declining due to shifting into flat panel technology where less Pb is used compared to cathode ray tubes.
Roofing and flashings	Lead	Slowly declining	A general ban on certain Pb containing products, including the use of Pb flashings in Denmark. The use of Pb roofing and flashings continues in some countries and there are historical stocks.
Sealants and caulk	PCBs	Declining	PCB use in sealants and caulk has been banned in almost all countries, but they may still be found in many old buildings.
Textile and leather	Chromium(VI)	Slowly declining	There is a proposal for prohibiting the use of Cr ⁶⁺ in certain leather products in Germany.
	PFOS	Declining	Use of PFOS in manufacturing of textile is prohibited in the EU, other PFCs may be used as alternatives . PFOS still used in some countries outside the EU.
	Dimethyl-fumarate	Slowly declining	The EU has banned the use of DMF as anti-mould agent.
	Azo-colourants	Declining	Restrictions on the use of certain azocolourants in textile.
Thermometers	Mercury	Declining	The use of Hg in products has been prohibited in many countries.
Toys	Phthalates	Slowly declining	Restrictions on the use of certain phthalates in children's products in the EU area. There is also a ban on the use of those phthalates in toys and child care articles in California.
	Lead	Slowly declining	Restrictions on the Pb content of toys in many countries. Imported toys may still have too high Pb content. There are also restrictions on the Pb content of children's jewellery, e.g. in California and Canada.
	Chromium(VI)	Slowly declining	There is a proposal for prohibiting the use of Cr ⁶⁺ in leather toys in Germany.
Treated wood	CCA	Declining	Ban of the use of CCA for impregnating wood, e.g. in the EU.
Underwater weight	Lead	Slowly declining	Restrictions on the use of Pb in yacht keels.
Vehicles	Lead	Declining	Restrictions on the use of Pb in vehicle parts e.g. in the EU. Prohibition on the import and marketing of Pb containing brake linings in Denmark. Voluntary industry initiative to cease the use of Pb in wheel weights in the US.

Water pipes	Lead	Almost ceased	Restrictions on the use of Pb in water pipes, joints and solders in the EU and many countries. Prohibition on the import and marketing of Pb containing solder for the use in plumbing and sanitation in Denmark.
Weights	Lead	Slowly declining	Restrictions and prohibitions on Pb content of weights, e.g. Pb containing curtain weights are banned in Denmark.

Table 17. Product groups where releases are assumed to be increasing due to restrictions

Product group	Chemical	Trend description/affecting factors
Fluorescent lamps	Hg	The use of fluorescent "energy saving" lamps has increased.
Pharmaceuticals and personal care products	Different chemicals	The use of pharmaceuticals and personal care product has increased significantly and a large number of different chemicals are used in them.
Surface treated coating	Perfluorinated chemicals	Increased use of other fluorinated chemicals in stain, water and oil repellent coating of products after the phase out of PFOS (e.g. FTOH). Increased use of all-weather clothing.
Products from recycled material	Different chemicals	Increased use of recycled products may increase the product related releases.
Nanoproducts	Possible hazardous chemicals associated with nanomaterials	The use of nanomaterials is expected to increase.
Electrical and electronic products	Flame retardants	Due to restrictions on PBDEs, the use of other brominated flame retardants (e.g. TBBPA and HBCD) can increase. The amount of electronics has increased significantly in recent years.
Textile and leather products	Heavy metals, NMVOCs, POPs, Alkylphenols	Restrictions and bans on chemicals.

5.2 Product groups with likely releases (not included in other inventories)

Product groups that have relatively high releases during their use include building material, textile, furniture and electronic equipment. The tendency for high releases is based on the fact that while these products have a relatively long residence time, their use volumes also are high.

Product groups that have been identified as potential sources of releases during their use-phase are listed in Table 18 in alphabetic order. Note, that product groups or chemicals already included in other inventories are excluded from the list. It also needs to be kept in mind that the list cannot be exclusive due to the fact that little information is available on chemical contents of products and even less on concentrations released from the use phase of these products.

More detailed information of specific product groups, such as construction and building products, electrical and electronic products, furniture, nanoproducts, pharmaceuticals and personal care products, textiles, as well as toys and low-cost jewellery, is available in the annexes of this Resource Compendium, dedicated to each of these product groups. Detailed information of lead and nonylphenol releases related to product use is also provided in the Annexes.

CHAPTER 6

GENERAL INTRODUCTION TO RELEASE PATTERNS

6.1 Relevant releases from the use of products

Information on chemical releases during the use of end-products is at the moment insufficient and in many cases of poor quality. Quantification of releases from product use is challenged due to the fact that there is not always sufficient information available on the chemical contents of products, neither on the release mechanisms of chemicals. In addition, the increased recycling of material to prepare new products further complicates this difficult task. From certain types of products that are used for very long periods, for instance buildings, chemicals may be released during decades, and because of this delay, information on chemicals used at the time of the construction work may have been lost.

Chemical releases from products are known to occur during the normal use of products through various mechanisms and environmental routes (Konsumtverket 2006, Jensen & Knudsen 2006, Kemi 2004a, 2009d, Peltonen 2005).

To determine if the release of a chemical from the use of a product is relevant for the environment, some background information is needed on the chemicals and their bioavailability, estimates on possible release rates with affecting factors (as explained under Chapter 3.2), as well as on the volume and use patterns of the products.

Based on this information conclusions can be drawn on whether releases of a chemical are significant enough to carry out quantification of the actual releases into the environment.

Chemicals and their bioavailability

Firstly, it is important to identify if chemicals with environmentally harmful properties that are likely to be released during the use of a product, and, if the chemicals are released in such concentrations and volumes that may cause harmful impacts on the environment. Information on where and how the products are used helps to assess the likelihood of releases during the use phase of the products.

Knowledge of the environmental bioavailability of a chemical can be used when determining the environmental significance of possible releases as this may vary greatly according to the form of dispersal. For example, the largest release can be in a form that has the lowest bioavailability and the smallest release can be in a form that has the highest bioavailability (Kemi 2004a).

Knowledge of the release recipients is needed to select the proper release estimation technique and to assess the shares of the release between the different environmental compartment (air, water, land/soil).

Factors affecting the volume of releases

To estimate the tendency of a chemical to be released during the use of a product, knowledge is needed on how the chemical is bound to the other material in the product. The releases are affected by the properties of both the chemical and product material as described below under Chapter 3.2 Release mechanisms.

The release concentration rates of a chemical vary depending on the environmental conditions and compartment to which chemicals are released as well as on the use patterns (intended/unintended) of the product, possible breakdown of the product and wearing as explained in Chapter 3.2.

Even if the release concentration of a chemical be low, the volume of products used may be large. The use volume is affected by the number of products as well as the frequency and duration of the use of the product.

When and where to expect releases – spatial and temporal distribution of releases

The technical service lives of products vary from several decades to short periods. Releases may occur first a long time after the products are taken into use, and be distributed evenly over the entire service life of the product or occur under a specific period during the use of the product.

Generally, releases from the use of a product are most likely to occur

- during the first use of a product
- when carrying out maintenance of the product
- due to wearing, exposure to heat or light or other ageing of the product

A product may be transferred between different countries in the world during its life-cycle, even the different parts of a single product can be manufactured in different countries. Products such as electronics, textiles, toys and jewellery, mercury thermometers and paints could be produced in China and India and marketed in Africa, Europe and United States. In addition, the disposal of products can take place in the country where it is used or the used products can be shipped to other countries where the product parts can be recycled and used in new items. Some chemicals remain in the product through the supply chain and end up in unexpected places. However, some product groups may present health or environmental problems due to inadequate waste handling and recycling practices, the lack of organized and controlled waste treatment and related legislation in developing countries. This is the case, for instance for electronic products. Due to the lack of information on the chemical content of the product, people in different countries (including manufacturers, repair personnel, consumers and recycling workers) can be exposed to hazardous chemicals in products (Agarwal 2009, Osibanjo 2009, Calabria 2007, McCarthy 2007, ChemicalWatch 2009c, Peytermann 2007).

When looking at releases from the use phase of end-products, it is important to pay attention to the fact that although the national surveillance of chemicals in products would be well organized, follow-up of chemicals in imported products may be challenging.

Also, the use place of the product may vary from stable (e.g. buildings), to mobile (e.g. packaging material) or be variable (e.g. use of consumer products).

Over time, releases can be transported away from their original release site. Certain chemicals from the use of products, for instance brominated flame retardants, can be long-range transported in the air for thousands of kilometers and chemicals in suspended particulate matter can end up in surface waters and soil far from their original site and be released to the environment from the particles only a longer period after being released from the product material matrix.

Chemicals that are present in the product intentionally

If the properties of certain chemicals are needed to give the product the desired properties, these products are designed to retain the presence of the chemicals during the service life. For instance, the functioning of batteries depends on certain heavy metals in the material, and therefore it is not likely to have high releases of these metals during the use of batteries. Another example on this type of products is refrigerant gases in low-temperature apparatus. High releases from these types of products can be expected mainly during apparatus breakdowns and due to unmanaged waste handling.

Chemicals that are present in the product unintentionally

Substances with functions that are relevant only during the manufacturing phase of a product can be expected to result in higher emission rates if these substances remain present in the product after it has entered the market. During the manufacturing of products chemicals may be embedded in the product as unwanted remains, such as pesticide residues in textiles from the manufacturing phase of natural fibres, or solvent residues in fresh print products. The volume and quality of residual chemicals in the product vary and reliable information for a certain batch of a product can be retrieved accurately only by laboratory measurements.

Chemicals intended to be released from the products

The proper functioning of a product may require either that the chemicals are released in the desired manner, such as ink from ball point pens or colour cartridges, heavy metals during a fireworks display or propellant gas when using a fog horn, as well as different scent giving agents from, for instance, erasers or toys.

6.2 Release mechanisms and affecting factors

Release mechanisms and release rates of chemicals from the use-phase of end-products are affected both by the properties of the chemical present in the product and the product itself. At molecular level, the release volume depends on the concentration and properties of the chemical, the properties of the matrix to which it is bound, as well as on the type of bond between the chemical and the matrix.

Generally, low potential releases can be expected for a low release tendency chemical in a metal alloy. Examples of products from which high releases are likely are small molecular chemicals in a porous polymer material or chemicals with high vapour pressure.

A simplified scheme of the main factors affecting generation of releases from products during their use phase is provided in Figure 2.

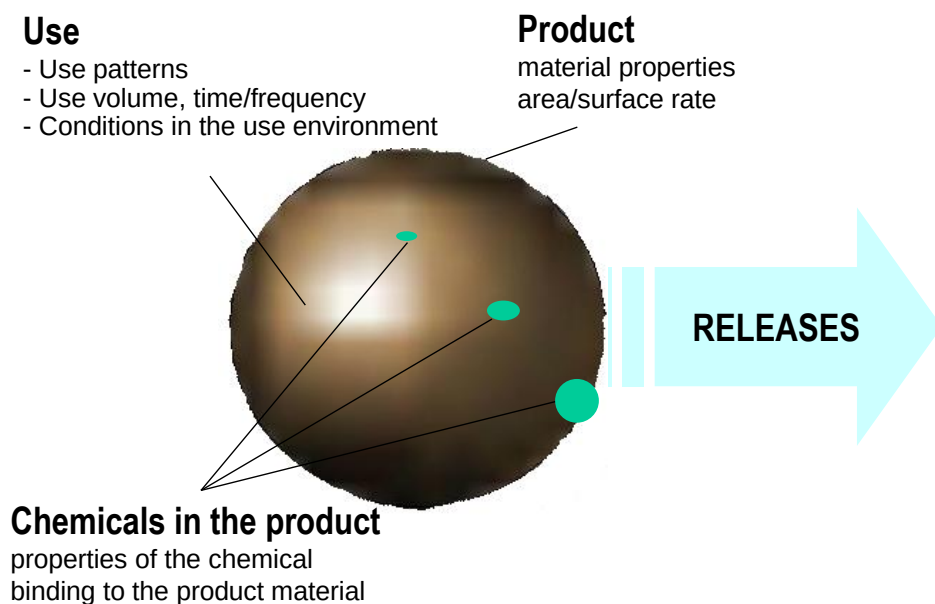


Figure 2. Simplified diagram on factors influencing releases of chemicals from the use of products

Factors that have an impact on the release tendency during the use of a product

1 Chemical and physical factors

Releases from the use of a product are impacted by chemical and physical factors related to both the product material and the substances in the product.

The structure of the product can be simple or it can be composed of a large number of materials, such as plastic, metal, glass, ceramics, textile or leather. Note, that the properties of the product matrix can change due to aging or wearing of the product.

Chemical and physical factors of the product that impact releases during the use of the product include, for instance

- density and porosity of the material(s),
- product surface area/volume ratio,
- properties of the chemicals in the product, such as vapour pressure, water solubility, melting point, and
- bond type between the chemical and the matrix material

2 Environmental factors and use practices

The properties of the product matrix may change due to environmental conditions under which the product is used. For instance, exposure to heat under the sun or from a radiator increases the release rate of NMVOC compounds, as well as when electronic devices warm up during their use. Environmental conditions and sharp changes in them impact the generation of releases, for instance, ambient temperature and pressure, humidity and exposure to factors causing wearing such as wind, light (ultraviolet radiation), abrasion or chemical reactions, including oxygenation and corrosion.

In cases where the product is used against its planned original use conditions, releases may be caused by conditions that were not taken into account in the design of the product. For instance, chemicals in a product which was not designed for wet conditions, are likely to be dissolved when getting into contact with water.

Release mechanisms

1 Migration

Chemicals can be transported out of the product material by migration, for instance through volatilisation into the surrounding atmosphere, through dissolution into the surrounding water or through diffusion into a solid material. For instance, when the local equilibrium on the material surface layer is lowered due to evaporation of a volatile chemical into the atmosphere, the equilibrium concentration in the material is restored through migration. Liquid chemicals are usually more mobile than solid chemicals.

The migration velocity in a matrix is affected by the volatility or solubility of the chemical into the given matrix as well as by the diffusion velocity, which is affected by the concentration and mobility of the chemical.

Chemicals in adhesives or jointing material, such as PCB in sealants for building material, can migrate into the surrounding concrete and further into the environment, and chemicals from packaging are known to migrate into food. Some chemicals, for instance certain phthalates used as softeners in plastics and halogenated flameretardants, have higher tendency for migration than others (Keml 2004a).

2 Chemical reactions

The release potential of a chemical depends on how the chemical is bound to the product material matrix. The setting-strength of the chemical depends on the properties of both the chemical and the material.

In the manufacturing process of a product the purpose is to restrict possible releases by selecting chemicals and materials of low vapour pressure and water solubility to ensure that the chemicals that are needed to support the properties of the product remain there till the end of the life cycle. If the material is not intended to be exposed to water, e.g. certain colorants in paper, there may also be water-soluble additives present.

Substances that are chemically bound in the matrix of the product material can be expected to remain in the product until the disposal phase of the product, unless physical wear of the product occurs. It is known that chemical reactions leading to releases are usually initiated by physical wearing or abrasion of the product material.

Chemical reactions may take place with substances that have been present in the product material from the start, or between substances that have been formed in degradation processes and between substances that have migrated to the material over time (e.g. water, oxygen). For example, lead oxide is formed on the surface of metallic lead (such as lead flashings on chimneys and lead shot) due to oxygenation processes. Isocyanate releases are generated through heating of polyurethane foam plastic (e.g. by ironing). 2-ethylhexanol can be released to air from flooring material when the adhesive between the carpet and concrete is broken down by reaction between the adhesive chemicals and moisture. (Keml 2004a).

Chemicals used as additives in the product have more tendency to be released than those that are chemically bound to the material. Examples of additives are colouring agents, biocides, flameretardants, softeners, antistatic substances, blowing agents. Releases of these chemicals depend on the properties of the matrix and the chemical (i.e. the size of the molecule, solubility in the matrix, vapour pressure and water solubility) as well as on the manner of use of the product.

3 Mechanical wear

Chemicals can be an integral part of the material of the product or bound in the cover, for instance in the surface treatment material, or in the binding material, such as glue. The size of the chemical molecule also has an impact: smaller molecules can move around the material by diffusion, e.g. plasticizers, flameretardants and biological agents.

Mechanical processing, abrasion, wear or break down of the material causes releases in particle form. Particle releases differ from molecular releases because the physical effects of the particles may override the chemical effects as they may stay inside the particles and their impact to the surrounding environment will be thus delayed (Keml 2004a).

CHAPTER 7

GENERAL INTRODUCTION TO RELEASE ESTIMATION TECHNIQUES

7.1 Principles in estimation of releases from products

An inventory of a chemical from the use-phase of end-products should cover all relevant releases of the given chemical during the period of the actual use of the products.

Identify all relevant products

The total releases of a chemical may consist of releases from the use of several products as shown in Figure 3. The inventory of a chemical should identify all products with relevant releases of the given chemical from the different product groups and provide estimates of releases to air, water and soil.

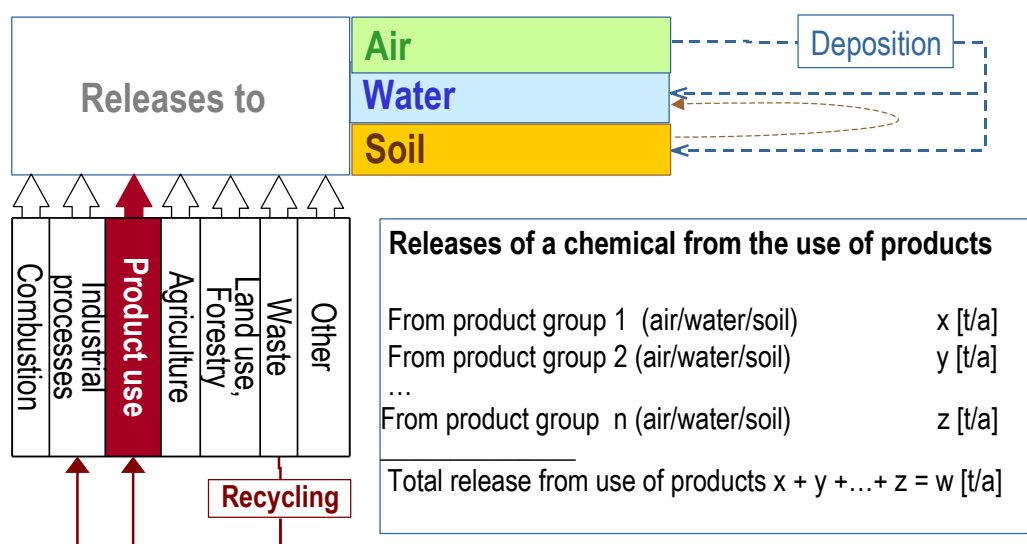


Figure 3. Total releases of a chemical to the environment from the use of end-products

Avoid double-counting

To quantify releases related to the use phase of end-products, it is essential to identify the period in the life-cycle of a product, between the point of time the product has left the manufacturing process (which is generally already covered by regular reporting to PRTRs) and the point of time when the product enters waste treatment (which is generally also covered by PRTRs), to prevent double-counting of releases.

In some cases, potential releases from the product use may already be covered in the inventory for the agriculture sector, as for instance, the use of pesticides might be allocated there. Other examples are releases from tire and brake wear, which may already be accounted for under the inventory of transport releases, and combustion of fuels allocated under the energy sector inventory. Thus only releases that are generated during the actual use of the product should be considered.

Releases from waste not to be included

Attention needs to be paid to the fact, that in many countries, where organized waste management does not yet take place, releases from the use of products may be understood to cover also releases from the disposal of products. The reason for summing up releases from use phase and waste disposal phase is thus related to deficiency in the local waste management system and the related legislation. It should, however, be kept in mind that releases from discarded products cannot be reported under the product use category in PRTRs.

Releases from discarded products should be estimated separately from releases from the use of products, and reported under the waste category in PRTRs, either as diffuse releases or as point source releases from landfills, wastewater treatment plants and waste incineration plants.

7.2 Issues to consider when selecting products into the inventory

When selecting products to be included into the inventory, the following issues need to be considered:

- Are the products used in your country?
- Do the chemicals in the products have environmentally harmful properties?
- Where and how are the products used?
- Is it possible that the harmful chemicals are released to the environment in your country? Is it possible that the chemicals are released during the use of the product or would these chemicals be released only during the manufacturing or waste handling phase of the life cycle of the product?
- Are the releases already included into the current inventory and reporting systems?

7.3 Quantification of releases

Basic equation

The general equation (Equation 1) for quantification of releases can be applied also to releases from the use of products. For the calculation, an estimate of product use related release rate (emission factor)²⁵ is needed. The emission factor needs to be estimated separately for the different environmental compartments (i.e. air, water and soil). Statistical data (activity data)²⁶, which fits the release rate needs to be available to enable calculation of the releases.

Equation 1. General equation for quantification of releases

$$E = Ef \cdot A$$

²⁵ i.e. release concentration levels, e.g. "mg of a chemical/kg of product consumed" or "% of the chemical content of in the products consumed"

²⁶ Activity data can be, for instance, data on use volume of a product (number of products and their use volumes), or production volume of a product / content of the chemical to be quantified in the products)

E = Release of chemical
Ef = Emission factor
A = Activity data

The equation can be modified according to data that is available for the quantification of releases. Activity data can be composed of various factors. For instance, the number of products used and the content of the given chemical in the product establish together sufficient activity data to be used with an emission factor that represent the release rate of the chemical from the product. In case emission factors are not given separately to releases to air, water and soil, factors representing the distribution of releases between the different environmental compartments (air, water, soil) can be added to the equation.

Selection of an emission factor

When selecting release estimation techniques and the emission factor for calculation of releases from the use phase of products, it is advisable to compile information on the chemical content of the given products used in your country. This information is then compared to the assumptions in the release estimation techniques.

Attention needs to be paid to the following issues:

- does the release estimation technique and the emission factor represent the chemical composition of products used in your country
- does the emission factor represent the general use patterns of the product in your country

Selection of activity data

Activity data that corresponds the rate of activity indicated by the selected emission factor, needs to be available for the quantification of releases.

For example, if the emission factor is related to the share of the chemical to be evaporated from the total content of that chemical in the product, the emission factor may be given as mass unit of the evaporated rate of the chemical per mass unit of the total chemical content. Thus the activity data needs to represent the estimated total chemical content in all corresponding products in your country. The preparation of suitable activity data needs to involve an inventory of the volume of the given products in your country as well as data on the content of the given chemical in these products.

An alternative may be to obtain directly the amount of the given chemical in all products. This type of information may be available in product registers. However, in some cases it may be possible to receive the total volume of an effective chemical included in all products but not the content of the chemical in different products.

Quantifying releases over the years

When quantifying releases from the use of products over different years, the following information on the release patterns is useful:

- 1 In cases where the release rate can be considered relatively even over time it can be assumed that the release from the use phase of these products are distributed evenly over the entire service life of the product (examples: particles and heavy metals from vehicle tyre wear during driving and some biocides from the use of treated wood). The annual releases can then be calculated by dividing the total chemical releases by the number of years.

- 2 In cases where the releases are not high and are gradually ceasing over the years it can be assumed that releases occur during a specific period. The number of years under which the releases are included into the inventory needs to be determined case by case for each product/chemical combination.
- 3 In cases where the main part of releases from the use of the product is generated during the first use of the product, it can be assumed that all releases occur during the year when the product is sold to the market. For instance, volatile organic compound releases from paint application can be assumed to occur in the year when the paint is sold to the consumer.

The third method in the list above is the simplest one and is often applied to all cases.

It is possible that accumulation occurs if the substance has a residence time longer than one year and the total number of products in use is high. The cumulative quantity of the chemical can be estimated by multiplying the residence time (i.e. number of years the product has been in use) of the chemical with the quantity added in a year. For this calculation, information of the historical volumes of the use of a chemical in a product, as well as the consumption of the products, is needed.

If the product has already been used for a longer period of time at a relatively constant consumption, it can be expected that the maximum cumulative quantity of the chemical already has been reached. Chemicals that are not very persistent can be assumed to degrade over time. The degradation rate depends on the chemical. To simplify calculations, it can be assumed that when a steady state has been reached with a relatively constant annual consumption, the annual quantity added equals the removal of the chemical.

7.4 Overview of existing release estimation techniques for products

Release estimation techniques presented in Tables 18 - 23 are based on information provided by the OECD countries as well as from the literature. Information provided in these tables is not comprehensive and it is likely that additional RETs exist that were either not identified during the project, or that are not yet published.

Release estimation techniques are presented in the tables as follows:

- RETs for heavy metals: Mercury (Hg) in Table 18 and for chromium (Cr), copper (Cu) and arsenic (As) in Table 19
- RETs for lead (Pb) in Table 20
- RETs for nonylphenols (NP) and nonylphenol ethoxylates (NPE) in Table 21
- RETs for brominated flame retardants (BRF) in Table 22
- RETs for persistent organic compounds (POPs) in Table 23

Table 18. Examples of release estimation techniques available to quantify Hg releases from products

Product	Release	Equation	Emission factor	Reference
Electrical equipment containing mercury	Air	$E = Ef \cdot A$	0.0019 t/population of 10^6 (Western Europe)	EMEP (2000b) ref. WS Atkins (1997)
	Air	E = Hg emission (t) Ef = Emission factor (t) A = Population in the country	0.0003t/ population of 10^6 (Eastern Europe)	
	Air Annual emissions due to breaking or leakage within one year from consumption.	$E = Ef \cdot Df \cdot S \cdot A$ E = Hg emission(mass unit) Ef = Emission factor for all groups 5% Df = Distribution factor for a given group: batteries 1%, measuring and control equipment 5%, electrical equipment 1% light sources 5% S = Share during the first year 5% during the next 10 years 0.05% annually A = Mass of total Hg in all Hg containing products i	5% distribution factors for product groups	Kindbom & Munthe (2007)
	Air	$E = Ef \cdot A$	1.5%	Cain et al. (2007)
	Water	E = Hg release(mass unit) Ef = Emission factor A = Mass of mercury in products	1%	
	Thermometers Air	$E = Ef \cdot A$	10%	Cain et al. (2007)
	Thermometers Water	E = Hg release (mass unit) Ef = Emission factor A = Mass of Hg in products	1%	
	Air Hg containing instruments	$E = Ef \cdot A$ E = Hg emission (kg) Ef = Emission factor A = Mass of Hg in products	0.35 kg/kg (35 %)	SFT (2004)

Table 18 continued

Product	Release	Equation	Emission factor	Reference
Measurement and control equipment	Air	$E = Ef \cdot A$	0.0044 t/population of 10 ⁶ (Western Europe)	EMEP (2000b) ref. WS Atkins (1997)
	Air	E = Hg emission (t) Ef = Emission factor (t) A = Population in the country	0.0013 t/population of 10 ⁶ (Eastern Europe)	
	Air	$E = Ef \cdot A$	1.5% (except thermometer)	Cain et al. (2007)
	Water	E = Hg release (mass unit) Ef = Emission factor A = Mass of Hg in products	1% (except thermometers)	
	Air Annual emissions due to breaking or leakage within one year from consumption.	$E = Ef \cdot Df \cdot S \cdot A$ E = Hg emission (mass unit) Ef = Emission factor for all groups 5% Df = Distribution factor for a given group: batteries 1%, measuring&control equipment 5% electrical equipment 1% , light sources 5% S = Share during the first year 5% during the next 10 years 0.05% annually A = Mass of total Hg in all Hg containing products	5% distribution factors for product groups	Kindbom & Munthe (2007)
Batteries	Air, leakage	$E = Ef \cdot A$	0.0002t/ population of 10 ⁶ (Western Europe)	EMEP (2000b) ref. WS Atkins (1997)
	Air, leakage	E = Hg emission (t) Ef = Emission factor (t) A = Population in the country	0.00004t/population of 10 ⁶ (Eastern Europe)	
	Air Annual emissions due to breaking or leakage within one year from consumption.	$E = Ef \cdot Df \cdot S \cdot A$ E = Hg emission (mass unit) Ef = Emission factor for all groups 5% Df = Distribution factor for a given group: batteries 1%, measuring & control equipment 5% electrical equipment 1% , light sources 5% S = Share during the firstyear 5% during the next 10 years 0.05% annually A = Mass of total Hg in all Hg containing products	5% distribution factors for product groups	Kindbom & Munthe (2007)

Light sources	Air as HgO when a warm lamp is broken	$E = Ef \cdot A$ E = Hg emission (t) Ef = Emission factor (t) A = Population in the country	0.0005 population of 10 ⁶ (Western Europe)	EMEP (2000b) ref. WS Atkins (1997)
	Air		0.0003 population of 10 ⁶ (Eastern Europe)	
	Air	$E = Ef \cdot A$	10%	Cain et al. (2007)
	Water	E = Hg release (mass unit) Ef = Emission factor A = Mass of Hg in products	1%	
	Air, as HgO when a warm lamp is broken. Annual emissions due to breaking or leakage within one year from consumption.	$E = Ef \cdot Df \cdot S \cdot A$ E = Hg emission (mass unit) Ef = Emission factor for all groups 5% Df = Distribution factor for a given group: batteries 1%, measuring & control equipment 5% electrical equipment 1%, light sources 5% S = Share during the 1 st yr 5% during the next 10 years 0.05% annually A = Mass of total Hg in all Hg containing products	5% distribution factors for product groups	Kindbom & Munthe (2007)
	Air	$E = Ef \cdot A$	0.21 kg/kg (21 %)	SFT (2004)
	Water		0.06 kg/kg (6 %)	
	Soil	E = Hg release (kg) Ef = Emission factor A = Mass of Hg in products	0.04 kg/kg (4 %)	
Dental amalgam	Water	$E = Ef \cdot A$ E=Hg emission (kg) Ef= kg emitted per person A= number of persons	60 µg/24 h and person	Skare&Engqvist 1994 Sörme & Lagerkvist 2002

Table 19. Release estimation techniques to quantify Cr, Cu and As releases from products

Product	Release	Equation	Emission factor	Reference
As, Cr and Cu from wooden toys	Treated wooden play structures to soil	$E = Ef \cdot A$ E = heavy metal emission (kg) Ef = emission factor (kg/kg) A = amount of substance used (proportion in CCA) (kg)	0.01 kg/kg (1 %)	SFT (2004)
As, Cr and Cu from wooden furniture	Soil	Distribution between air, water and soil: 0 % to air 0 % to water 30 % to soil during 30-50 years (1 % per year for 30 years).	0.01 kg/kg (1 %)	SFT (2004)
CCA-treated wooden structures	Soil	$E = Ef \cdot A$ E = heavy metal emission (kg) Ef = emission factor (kg/kg) A = amount of substance used (proportion in CCA) (kg)	ca. 0.01 kg/kg (1 %)	Braunschweiler et al. 1996, Shibata et al. (2007), Ansen et al. (2000); SFT (2004)

Cr from paint, varnish etc.	Soil	$E = Ef \cdot A$	0.1 kg/kg (10 %)	SFT (2004)
Cu and TBT from antifouling paint	Water	E = heavy metal emission (kg) Ef = emission factor (kg/kg), 100 kg/kg A = mass of Cu in paint/fungicides (kg/t)*use of pesticide (t)	0.81 kg/kg (81 %)	SFT (2004)
	Soil		0.09 kg/kg (9 %)	
Cu from fungicide	Soil		100 kg/kg (100 %)	SFT (2004, 2009b)
Cu roofs	Stormwater and soil	$E = Ef \cdot A$ E = Cu emission (g) Ef = g emitted per square meter A =number of square meters	2.0 g/m ² per year	He et al, 2001 Sörme & Lagerkvist, 2002
Cu pipes and taps	Wastewater	$E = Ef \cdot A$ E = Cu emission (g) Ef = g Cu emitted per person A =number of persons	1,9 g/person and year	Sörme et al., 2001. Sörme & Lagerkvist, 2002

Table 20. Release estimation techniques to quantify Pb releases from products

Product	Release	Equation	Emission factor	Reference
Lead sheet	Water, soil	$E = Ef \cdot A$ E = Pb emission (kg) E_f = emission factor (g/m ²) or (%) A = area of Pb sheet (m ²) or amount of Pb in the sheet (kg)	5 g/m ² (corrosion rate), to water 0,008 %, to soil 0,006 %	Tukker et al. (2001)
	Roofing, water, soil	$E = Ef \cdot Df \cdot A$ E = Pb emission (in solid form) (kg) Df = division factor: Df-Soil: 0.3 residential buildings 0.8 utility buildings; Df-Water 0.15 residential buildings 0.2 utility buildings	5 g/m ² (run-off rate),	Wilson (2003), Van Hyfte & Callebaut (2007)
	Flahings, water, soil	Ef = run-off factor for Pb (g/m ²) A = exposed area of Pb roofing (m ²)	0.88 g/m ² (run-off rate),	
Lead pipes	Waste-water	$E = Ef \cdot A$ E = Pb emission (mg) Ef = emission factor (mg/capita) A = capita in a given year	1.014 mg/capita	Tukker et al. (2001)
Paint	Soil	$E = Ef \cdot A$ E = Pb emission (kg) Ef = emission factor (kg/kg) A = population in a given year	0.1 kg/kg (10 %)	SFT (2004)

Table 21. Release estimation techniques to quantify nonylphenol (NP) and nonylphenol ethoxylate (NPE) releases from products

Product	Release	Equation	Emission factor	Reference
Plastic toys Plastic packages	Storm water	$E = Ef \cdot A$ E = NP release (kg) Ef = emission factor A = used amount of plastics annually (m ²) The weight of PVC plastics can be assumed to be 2000 g for an area of 1 m ² with a thickness of 1.5 mm, no distinction between product groups.	2.78*10 ⁻¹² kg/m ² (hard plastics) 4.64*10 ⁻¹² kg/m ² (soft plastics)	Hansson et al. (2008)
Concrete	Storm water	$E = Ef \cdot A$ E = NP release (kg) Ef = emission factor, mg/m ² A = surface of construction (m ²)	0.2 mg/m ²	Hansson et al. (2008)
Wall and floor coverings	Storm water	$E = Ef \cdot A$ E = NP release (kg) Ef = emission factor (kg/m ²) A = used amount of plastics annually (m ²) The weight of PVC plastics can be assumed to be 2000 g for an area of 1 m ² with a thickness of 1.5 mm, no distinction between product groups.	2.78*10 ⁻¹² kg/m ² (hard plastics) 4.64*10 ⁻¹² kg/m ² (soft plastics)	Hansson et al. (2008)
Paints and varnishes	Wastewater	$E = Ef \cdot A$ E = NP release (kg) Ef = emission factor (kg/kg) A = chemical content in paints (t/a)	0.005 kg/kg (0.5 %)	Hansson et al. (2008)
Adhesives	Wastewater		0.01 kg/kg (1 %)	Hansson et al. (2008)
Plastic toys	Water	$E = Ef \cdot A$ E = NP release (kg) Ef = emission factor (kg/m ²) A = used amount of plastics annually (m ²) The weight of PVC plastics can be assumed to be 2000 g for an area of 1 m ² with a thickness of 1.5 mm, no distinction between product groups.	2.78*10 ⁻¹² kg/m ² (hard plastics) 4.64*10 ⁻¹² kg/m ² (soft plastics)	Hansson et al. (2008)
Additives in pesticides	Soil	$E = Ef \cdot A$ E = NP release (kg) Ef = emission factor (kg/kg) A = used amount of NPEs in pesticides (import + manufacturing – export) (kg)	0.85 kg/kg (85 %)	Hansson et al. (2008)
	Surface waters		0.1 kg/kg (10 %)	
	Air		0.05 kg/kg (5 %)	

Pharmaceuticals	APIs to wastewater	$E = D * F_e * F_p * C_{WWTP} * F_f$ E = API release (mass unit) D = Daily dose consumed per inhabitant (mg inh ⁻¹ d ⁻¹) F _e = Fraction of parent compound excreted after metabolism (%) F _p = Percentage of market penetration (%) (proportion of population daily treated with the specific drug substance; default 0.01) C _{WWTP} = Capacity of a local WWTP (population equivalent) F _f = Fraction of residue in effluent (%)		EMEA (2006)
	NPEs to soil	$E = Ef \cdot A$ E = NPE release (kg) Ef = emission factor (kg/kg) A = amount of NPEs in the medicine (import + manufacturing – export) (kg)	0.85 kg/kg (85 %)	Hansson et al. (2008)
	NPEs to water		0.1 kg/kg (10 %)	
	NPEs to air (veterinary medicinal products)		0.05 kg/kg (5 %)	
Detergents and auxiliaries in textile & leather products	Water	$E = Ef \cdot A$ E = NP release (kg) Ef = emission factor (kg/t) A = import – export of textiles (tonnes)	0,250 kg/t	Hansson et al. (2008)
Cleaning products, cosmetics and hygiene products	Wastewater	$E = Ef \cdot A$ E = NPE release (kg) Ef = emission factor (kg/kg) A = amount of NPE (import + manufacturing – export of cleaning agents) (kg)	0.9 kg/kg (90 %)	Hansson et al. (2008)
	Air		0.0025 kg/kg (0.25 %)	
Car care products, detergents, cleaners	Water	$E = Ef \cdot A$ E = NP release (kg) Ef = emission factor (kg/kg) A = used amount of product	0.2 kg/kg (20 %) not connected to WWTPs; 0.28 kg/kg (28 %) connected to WWTPs	SFT (2004)
	Soil		0.136 kg/kg (13.6 %)	
Textiles	Wastewater	$E = Ef \cdot A$ E = Emission (kg) EF = Emission factor (g/person) A = number of persons	0.7-1.6 g NP _{eq} /person and year	Månsson et al, 2008
Cleaning agents	Wastewater	$E = Ef \cdot A$ E = Emission (kg) EF = Emission factor (g/person) A = number of persons	0.1 g NP _{eq} /person and year	Månsson et al, 2008

Table 22. Release estimation techniques to quantify releases of BFRs from products

Product	Release	Equation	Emission factor	Reference
Furniture foam and textiles	Air	$E = Ef \cdot A$ E = BFR release (kg) Ef = emission factor (kg/kg) A = amount of BFR in the product (kg)	0.05 %	SFT (2004, 2009)
	Water		0.05 % (with WWTP) 0.7 % (without WWTP)	
Insulating material in construction work	Air		0.05 %	SFT (2004, 2009)
	Water		0.05 % (indoor use) 0.7 % (outdoor use)	
Flame retardants in textiles	Air		0.05 %	SFT (2004, 2009)
	Water		0.05 % (indoor use) 0.7 % (outdoor use)	
Enclosures and monitors	Air		0.05 %	SFT (2004, 2009)
	Water		0.05 % (indoor use) 0.7 % (outdoor use)	

Table 23. Release estimation techniques to quantify releases of POPs from products

End-product group	Re-release	Equation	Emission factor	Reference
DEHP from vinylproducts	Air (indoor)	$E = Ef \cdot A$ E = DEHP emission (g) Ef = Emission (factor g/m ²) A = surface area of the product	9.5 mg/m ² /a	Sandström (2002)
DEHP from roofing	Water and soil		0.985 g/m ² /a (general) 2,31 g/m ² /a (graveled roofs)	Sandström (2002)
DEHP from cables in the soil	Soil	$E = Ef \cdot A$ E = DEHP emission (mass unit) Ef = Emission factor (%) A = DEHP content in the cable	1.2%/a	Sandström (2002)
PCBs from transformers	Leaks	$E = Ef \cdot A$ E = PCB emission (kg) Ef = Emission factor (kg/t) A = Activity data	Default volume of leaks 0.06 kg/t Emission factor to air: 0	EMEP (2000a) ref. TNO (1995)
			Default volume of leaks 0.3 kg/t Emission factor to air:0	EMEP (2000a) ref. USEPA (1997)
			Default volume of leaks 0.3 kg/t Emission factor to air 0.06 kg/t	EMEP (2000a) ref. Belarusian report (2000)
			Default volume of leaks 0.006-0.5 g/capita/year Recommended emission factor 0.13 g/capita/year	EMEP(2000a) ref. Berdowski et al. 1997)

PCBs from capacitors	Leaks	$E = Ef \cdot A$ E = PCB release (kg) Ef = Emission factor (kg/t) A = Number of capacitors * proportion of products with leaks	0.06 % 1.6 % (large capacitors)	Annema et al. (1995)
			Volume of leaks expected 1.6 kg/t Emission factor to air: none	EMEP (2000a) ref. TNO (1995)
			Volume of leaks expected 4.2 kg/t Emission factor to air: none	EMEP (2000a) ref. USEPA (1997)
			Volume of leaks expected 2.0 kg/t (leaks) Emission factor to air 0.8 kg/t	EMEP (2000a) ref. Belarusian report (2000)
PCBs from sealants	Air	$E = Ef \cdot A$ E = PCB emission (kg) Ef = Emission factor (kg/t) A = amount of PCB in product (t/a)	83.6 kg/t	Breivik et al. (2002b)
PCBs from surface coatings and adhesives	Air	$E = Ef \cdot A$ E = PCB emission (kg) Ef = Emission factor (kg/t) A = amount of PCB in product (t/a)	80 kg/t	EEA (2005)
PAHs from treated wood	Air	$E = Ef \cdot A$ E = PAH release (kg) Ef = Emission factor (kg/kg) A = amount of PAH in product (kg)	0.01 kg/kg (1%)	SFT (2004)
	Soil		0.02 kg/kg (2%)	
HCBd from chlorinated solvents	Air	$E = Ef \cdot A$ E = HCBd emission (mass unit) Ef = Emission factor (mass/mass) A = amount of HCBd in the solvent	3 ng/ml	ENGO (Tilman 2003)
	Air		0,2 kg/t	SYKE 2008
HCB from fungicides, herbicides and algacides	Air	$E = Ef \cdot A$ E = HCB emission (mass unit) Ef = Emission factor (%) A = HCB content in biocides	40% of HCB volume applied during field use	EMEP (2005).
		$E = Ef \cdot A$ E = HCB emission (mg) Ef = Emission factor (mg/ha) A = area of land treated (ha)	50-150 mg/ha (total arable land and permanent crop) per year	EMEP (2005).
		$E = Ef \cdot A$ E = HCB emission (mg) Ef = Emission factor (mg/ha) A = area of land treated (ha)	100 mg/ha (arable land and permanent crops)	EMEP (2005).

		$E = Ef \cdot A$ E = HCB emission (t) Ef = Emission factor (mg/ha) A = volume of HCB field application (t)	0.40 t/t (field application) 0.20 t/t (greenhouses)	EMEP (2005).
		$E = Ef \cdot A$ E = HCB emission (t) Ef = Emission factor (mg/ha) A = volume of HCB field application (t)	0.50 t/t (<0.1% of total fungicide consumption)	EMEP (2005).
MCCPs from cables and wires	Air	$E = Ef \cdot A$ E = MCCP release (kg) Ef = Emission factor (kg/kg) A = amount of MCCP in the product (kg)	0.0025 kg/kg (0.25%)	SFT (2004, 2009a)
	Water		0.0325 kg/kg (3.25%)	
	Soil		0.015 kg/kg (1.5%)	
MCCPs from building and construction products	Air	$E = Ef \cdot A$ E = MCCP release(kg) Ef = Emission factor (kg/kg) A = amount of MCCP in the product (kg)	0.0025 kg/kg (0.25%)	SFT (2004, 2009b)
	Water		0.0325 kg/kg (3.25%)	
	Soil		0.015 kg/kg (1.5%)	
SCCPs from paint and anticorrosive coating	Soil and water	$E = Ef \cdot A$ E = SCCP release (kg) Ef = Emission factor (kg/kg) A = SCCP volume in paints (t/a)	0.165 kg/kg (16.5%)	SFT (2004)
Cationic surfactants, DTDMAC, DSDMAC, DHTDMAC from car care products (washing agents, wax etc.) and other products	Water	$E = Ef \cdot A$ E = Surfactant emission (kg) Ef = Emission factor (kg/kg) A = amount of the specific cationic surfactant in the product (kg)	0.2 kg/kg (20%)	SFT (2004)
	Soil		0.4 kg/kg (40%)	
Detergents from soaps	Waste-water	$E = \frac{A \cdot 10^6}{Y \cdot 365}$ E = Detergent discharge (g) A = Volume of applied detergent (t/a) Y = Population of area or number of people consuming the detergent	The maximum authorised concentration in finished cosmetic products is given in EU Directive 76/768/EEC concerning cosmetic products Annex III Part 1 (List of substances which cosmetic products must not contain except subject to the restrictions and conditions laid down). Due to the high number of chemicals listed in the Annex only reference to the document is provided here.	EC (2003b)

Musk compounds from the use of detergents and cosmetics	Waste-water	$E = E_f \cdot A$ E = musk releases (kg) E _f = emission factor (kg/kg) A = amount of musk compounds in the product (kg)	0.2 kg/kg (20%) not connected to WWTPs; 0.008 kg/kg (8%) connected to WWTPs	SFT (2004)
	Soil		0.36 kg/kg (36%)	
Substances used in sunscreens (e.g. EHMC, MBC, OC, BMDBM, BP3, siloxanes)	Water	$E = U \cdot D \cdot N \cdot C$ E = Release of the substance (kg) U = Average daily use (average dose application multiplied by average full body surface and number of daily uses; default 20*2 g) D = Duration of a sun-bathing period (default 5 days) N = Number of tourists in the area C = Proportion of sunscreens washed off during swimming and bathing (default 25 %)	0.25 kg/kg (25%)	Danovaro et al. (2008)

CHAPTER 8:

REPORTING OF RELEASES FROM THE USE OF PRODUCT TO PRTRs

8.1 Current status of information on releases from products in the PRTRs

At the moment, diffuse releases, under which releases from the use of products fall, are not included in any PRTR system worldwide. However, national inventories on air emissions of certain chemicals released from the use of certain product groups are carried out on basis of reporting requirements to international air emission protection conventions. Such inventories include, for instance, emissions of non-methane volatile organic compounds (NMVOCs) from the use of solvent containing products under UNECE CLRTAP and UNFCCC conventions. Air emissions of heavy metals and certain persistent organic compounds (POPs) of certain product groups are included in inventories reported under the UNECE CLRTAP as well as ammonia emissions from the use of fertilizers. Releases of fluorinated greenhouse gases (F-gases, i.e. HFCs, PFCs and SF₆) from the use of products are included in the inventories reported under the UNFCCC.

A summary of the existing release inventories is compiled in Table 24. To build up a comprehensive picture on releases from products, national data already produced under the existing inventory processes should be collected and presented in the PRTRs.

Table 24. Existing inventories on releases from the use of products (JP=Japan, KR=Korea, NL=The Netherlands, NO=Norway)

Chemicals	Products	Environmental compartment	Countries
NMVOC	Solvent containing products ²⁷	A	Parties to UNECE CLRTAP National inventories in JP, KR
Heavy metals and particles	Tyre and brake wear ²⁸ , dental amalgam ²⁹ , fire work ¹² , cigarette smoking ¹² , light sources ¹³ , paint ¹² , treated wood ¹² , fertilizer use ³⁰ + various other products not generally included in inventories to CLRTAP	A, W, S	Parties to UNECE CLRTAP (NO also additional sources to CLRTAP reporting) National inventories in JP, KR National studies DK, SE
	Lead sheet and pipes	A, W, S	National inventories in BE, NL and regional inventories by the industry
	Fishing gear	W	National inventories in NL, NO
	Ammunition	W,S	National inventories in NL, NO
	Accumulators and batteries ¹²		Parties to UNECE CLRTAP National inventories in KR
Nitrogen	Fertilizer use ¹⁵	A, W, S	Parties to UNECE CLRTAP
POPs	Pesticide and fertilizer use ¹⁵ , treated wood (air) ¹² , tyre wear (air) ¹³	A, W, S	Parties to UNECE CLRTAP National inventories in JP
Chlorinated chemicals	Use of chemicals ¹²	A	Parties to UNECE CLRTAP National inventories in JP
F-gases	Refrigerant gases, various other products ³¹	A	Parties to UNFCCC
POPs, heavy metals	Various products (referred to in the annexed case studies)	A, W, S	National studies DK, JP, NL, NO, SE, USA

²⁷ CLRTAP: Included under the solvent and other product use sector

²⁸ CLRTAP: Included under the transport sector

²⁹ CLRTAP: Included under the waste sector

³⁰ CLRTAP: Included under the agriculture sector

³¹ UNFCCC: Included under sector: consumption of halocarbons and SF₆

8.2 Product groups proposed to be included in PRTRs

Based on information collected during the preparation of this document, there are likely releases from the use of certain products. Although chemicals released from products may have environmentally harmful properties, it may be that these chemicals are not released in such volumes or concentrations, or under such conditions that the releases might be relevant to the environment. Existing stocks of old products still in use need also be taken into account when quantifying releases from the use of products. The use of recycled products is increasing, and this may increase releases of different chemicals from the use of products, as well as also complicate the quantification of releases.

As the work on quantifying releases is resource demanding and as quantification of releases from product use is a relatively new area in many countries, the aim is to identify those products that most likely have relevant releases from their use. Releases from products already included in existing inventory processes are excluded from the presentation in the Resource Compendium, as well as products from which the harmful releases may not be relevant for the environment. For instance, air emissions from a number of products, such as solvent containing products and pesticides, are already included in regular inventory work, while releases from the same products to soil and water may not be included in any existing inventory. Releases from products to wastewater treatment plants or to landfills are already included in PRTRs.

Releases to water, and especially to soil from many products, such as, car care products, may be highly harmful if released directly to the environment. Note, that though releases of flame retardants present in many product groups are harmful to the environment, direct releases to the environment may be rare.

Results from the exposure work on harmful chemicals from the use of products carried out at the Swedish Chemicals Inspectorate (KemI) has been taken into account when preparing the conclusions. KemI prepares annually exposure indexes that are chemical specific and prepared for the following environments: "surface water", "air", "soil", "WWTP" and "humans". The work is based on information available in the Swedish Product Register (KemI 2005, KemI 2006; SNV 2003).

For the purpose of the Resource Compendium, the relevance of releases from the use of different products was considered in comparison with exposure information from KemI and other information collected in the case studies as presented in Tables A5.1 and A5.2 in Annex 5. The product groups presented in the Case Studies (Annex 1) were divided into the two groups below. Both groups include products with releases that are proposed to be taken into PRTRs, but especially for the second group of products, country-specific consideration of the relevance of releases is recommended.

1. Products that have relevant direct releases to the environment (Table 25)
2. Products from the use of which releases are not generally lead to the environment but from which possible direct releases to the environment are harmful (Table 26)

1 Products groups with relevant releases to the environment (Table 25)

Based on information collected during the preparation of this document it can be concluded that the following product groups have relevant releases to the environment from their use phase and that these releases are not yet included in regular inventory work:

- ammunition and fishing gear (lead), direct releases to the environment if left in soil or water

- building products (heavy metals, POPs and nonylphenols), direct releases to soil and water
- car and boat care products (nonylphenols), if releases lead directly to the soil
- electrical and electronic equipment containing mercury, direct air emissions
- pesticides, fungicides and antifouling agents: direct releases of heavy metals to soil and water

Table 25. Product groups with relevant releases directly to the environment

Product group	Description of releases	Relevance of releases to the environment
Ammunition and fishing gear	Lead released from ammunition and fishing equipment including lead containing weights, gun powder, explosives	Relevant lead releases if the products remain in soil or water. Prohibitions for the use or use conditions in some countries.
Building & construction products	Releases include heavy metals (e.g. lead in lead sheets, pipes and paint), wood impregnation agents (e.g. CCA) and different additives (e.g. plasticizers) in materials. The use of PVC plastics in construction and building products has increased but restrictions are applied in many countries on the use of Pb as stabilizer in PVC plastics. Though releases of certain hazardous substances have ceased, there may be large stocks left due to the previous extensive use (e.g. PCBs in sealants and caulk). Leaded sheets used in roofing and flashings as well as in pipelines may cause direct releases to the environment, bans in some countries while leaded constructions remaining in old buildings. Paint application releases lead and nonylphenols in addition to NMVOCs.	Relevant heavy metal, POP and NP/NPE releases if lead directly to soil.
Car and boat care products	Releases include windscreen washing agents, car shampoo, coolant, antifreezing agents, underbody compounds inclusive stone hit gards and fuel dope.	Relevant NP/NPE and cationic surfactant releases when lead to soil (not generally included in regular inventories).
Electronic and electrical equipment	The use volume has increased significantly over the years. Major releases include flameretardants used in the plastic casing and printed circuit boards, heavy metals (Pb, Hg) from solders and different components. Elevated concentrations of flameretardants have been found in indoor air and dust. Discarded electronics end often up in developing countries for disassembly or destruction. Metals recovered may be used e.g. to make low-cost jewellery. Heavy metals from light sources (energy saving lamps) and batteries, PCBs from capacitors and transformers.	Mercury emissions relevant to air from the use of Hg containing electronic products (partly included in regular inventory work), but bans for these products already exist in some countries. Also bans for PCB use in most of the countries. Direct releases to the environment from abandoned products are not relevant in countries with organized collection and treatment of EE waste. Direct releases may, however, enter soil through leakage and breakage of batteries, measurement equipment, capacitors, transformers or light sources.
Pesticide	Pesticide releases originate in the use for crop and vegetable protection leading to heavy metal and POP releases. Restrictions and bans for many pesticides (e.g.	Air emissions included mainly in routine inventory work, releases to soil and water not generally. Use of

	Pb, As) in many countries.	environmentally harmful chemicals in pesticides is declining.
Textiles	Heavy metals and organic compounds from washing of textile products	Releases to waterbodies and soil may be relevant in areas where the wastewater is not lead to the receiving water body through WWTPs.

2 Product groups from which releases are not generally lead to the environment (Table 26)

Releases from pharmaceuticals and personal care products³² as well as from toys and low-cost jewellery mainly have health impacts and are generally not released directly to the environment but rather to wastewater treatment plants or landfills. There are exceptions to these, for instance substances from the use of sunscreens are released directly to water, and should thus be considered to be included in PRTRs under releases from product use.

The relevance of releases from textile and leather products, furniture and packaging material to the environment depends on whether there are direct releases to waterbodies (e.g. washing of carpets by a lake or sea without a connection to the sewer network to a wastewater treatment plant) or to soil (e.g. furniture in garden or packages left in the environment). The relevance of direct releases from these products should be considered against country-specific conditions (the relevance of releases is based on the product types and their local use practices as well as on the local product-specific legislation, wastewater treatment and waste handling practices).

Table 26. Product groups from which releases are not generally lead to the environment

Product group	Description of releases	Relevance of releases to the environment
Furniture	Releases of flame retardants (e.g. from mattresses and the foam in furniture), surface coating (e.g. dirt repellent carpets) and anti-mould agents (e.g. in couches). Plastic furniture may release phthalates and heavy metals, wooden furniture heavy metals and formaldehyde.	Relevant to the environment only if there are direct releases to the soil from use in open air.
Packaging and plastic bags	Releases include e.g. phthalates and heavy metals from PVC plastics, perfluorinated compounds used from oil resistant food packaging. Bans for lead and bisphenol-A in food packaging in most countries.	Relevant releases to the environment if the products left in soil and not delivered to organized waste management.
Pharmaceuticals and personal care products	Releases relevant to the environment if wastewater discharges are not lead to the receiving waterbody through wastewater treatment plants: e.g. antibiotics, hormones, disinfectants and detergents. The use of PPCPs is increasing as well as the number of chemicals included in the products.	Not released directly to the environment except NMVOCs and F-gases, which already are included in regular inventories and products like substances in sunscreens which have direct releases to water not generally covered by other inventories.
Textile and leather products	Releases include substances remaining in the product from the raw material cultivation (e.g. pesticide use in cotton fields), manufacturing (e.g. nonylphenols and heavy metals) and finishing (e.g.	Releases may be relevant to health. Relevance to the environment depends on whether direct releases to waterbodies occur (e.g. washing of

³² except for sunscreen products

	perfluorinated compounds) phase of the products. Use of PFOS, dimethylfumurate and axocolourants prohibited in many countries.	carpets in the open air without connection to the sewerage system).
Toys and low cost jewellery	Plastic toys have been found to contain heavy metals and different additives, such as phthalates, all having at least health effects. Releases from low cost jewellery related to the high contents of heavy metals (Pb, Cd, Ni) in the products, which have proven health effects.	Relevant to health but not to the environment.

The relevance of releases from nanoproducts is still unclear. A wide range of nanoproducts are in different every day use, and new nanoproducts enter the market frequently, while there are only few studies on the environmental effects of substances at nano scale.

The list of products with relevant releases during their use phase, presented in Table 27, can be used when selecting product groups to be included into national PRTRs. The respective release estimation techniques are presented in Tables 18 -23 in Chapter 5.

The likelihood of releases needs to be considered case-by-case at the national level, taking into account the country specific conditions such as

- product types used in the country, their chemical composition and likelihood to release chemicals
- country-specific use patterns of the products with conclusions of the relevance of releases
- existing restrictions or bans on products and/or chemicals in the products
- use volume of the product and assessment of the relevance of releases to the environment
- likelihood of direct releases to the environment from the use of the product

Table 27. Product groups and releases proposed for inclusion to PRTRs

Product group	Release	Environmental compartment	RET exists
Biocides (POP emissions and other existing release data to be transferred to PRTRs)			
Antifouling paints	Cu	Soil, water	Cu
Fungicides, herbicides, algaecides	Cu	Soil	Cu, HCB
Pesticides	Chemicals and remains as impurities in pesticides: HCB, HCBd, NP/NPE (DDT) (permethrin)	Soil	HCB, Cu, NP/NPE
Building and construction			
Adhesives	NPE, PCB	Water	NPE, PCB
Backfill material when lead to soil	SCCP	Soil	-
Cleaning agents (when lead to soil)	NPE	Soil	NPE
Colouring agents and paint	NPEs, SCCPs, Cr, Pb, antifouling: Cr, TBT	Water, air	NPEs, SCCPs, Cr, Pb, TBT
Concrete constructions	NP/NPE, MCCP, PCB	Water	NP/NPE, MCCP
Floor and wall covering (plastic)	NP/NPE, PCB, Pb, phtalates	Water	NP/NPE
Insulating material	BFR	Air, water	BFR
Jointing compounds if lead to soil	phtalates, PAH, BFR	Soil, water , air	BFR
Roofing, flashings, pipes	Pb, Cr, Ni, Cu	Soil, water	Pb, Cu
Sealants, fillers when lead to soil	PCB, MCCP, PCN	Soil	MCCP, PCB
Surface coating, paints	PCB, SCCP	Soil, water	PCB, SCCP

Wood preservatives and impregnation agents	PAH, Cr, As, Cu	Soil	PAH, CCA: Cr, As, Cu
Car and boat care products (NMVOC emissions and other existing release data to be transferred to PRTRs)			
Coolants, if released to soil	anti-foulants, corrosion inhibitors, buffering and pH agents, heavy metals	Soil	-
Antifreezing agents if lead to soil	glycols, additives	Soil	
Car shampoo and car care products if lead to soil	NP/NPE, Cationic surfactants (DTDMAC, DSDMAC, DHTDMAC), detergents	Soil, water	NP/NPE, Cationic surfactants (DTDMAC, DSDMAC, HTDMAC), detergents
Underbody compounds, stone hit guards if lead to soil	TBT from antifouling paint	Water, Soil	TBT
Anti-knock agent if released to soil	MMT, iron pentacarbonyl, solvents	Soil	-
Electrical and electronic products (F-gas emissions and other existing release data to be transferred to PRTRs)			
Batteries	Hg, Pb, Cd (breakage/leakage from batteries manufactured earlier)	Air, water	Pb, Hg
Cables and wires	MCCPs, BFRs, PCB, phthalates	Air, water, soil	MCCPs, DEHP
Electrical equipment containing mercury	Hg (breakage/leakage)	Air, water	Hg
Enclosures and monitors	BRFs, PCB, PBDE	Air, water	BRFs
Light sources (breakage)	Hg (breakage/leakage)	Air, water, soil	Hg
Transformers, capacitors (leaks)	PCBs, HCBs, PCNs	Air, water, soil	PCBs
Fishing and hunting			
Ammunition, gun powder, explosives (if to soil)	Pb, (HCBs from tracer bullets)	Soil, water	Pb
Fishing gear, lead containing weights and impregnation agents in fishing nets	Pb	Water	Pb
Packages and plastic bags (in cases where left in the environment)			
Plastics (leach out e.g. plastic bags, if to soil)	phthalates, heavy metals HDPE, PCB, PAH	Soil	
Packaging material, if released to soil	BPA, NP/NPE	Soil	NP/NPE
Personal care products (in cases of direct releases to the environment)			
Detergents, cosmetics (in cases of direct releases to the environment)	NPEs, musk compounds, PFOA/PFOS, LAS, NH ₃ , phthalates, triclosan, heavy metals	Water	NPE, musk compounds
Pharmaceuticals (in cases of direct releases to the environment)	APIs, NPEs	Water, Soil, Air	NPEs, APIs
Sunscreens	E.g. EHMC, MBC, OC, BMDMB, BP3, siloxanes	Water	General method
Textile, leather, furniture (in cases of direct releases to the environment)			
Carpets (if washed outside a sewerage system)	formaldehyde, phthalates, heavy metals, PFCs pesticides	Water	
Furniture foam and textiles	BFRs	Air, water	BFRs
Plastic furniture when releases directly to soil	phthalates, heavy metals	Soil	
Textiles (if washed outside a sewerage system)	HCB, BFRs, DMF, triclosan, NP, alkylphenols	Air, water	BFRs, NP
Wooden furniture (open air use when releases directly to soil)	PAH, formaldehyde, heavy metals, PFOA, HCB	Soil	Cr, Cu, As

CHAPTER 9:

CONCLUSIONS

Releases from product use

The basic assumptions at the beginning of this project were that both the use and the number of products are increasing, and that thus the share of releases from product use from the total releases is growing compared to industrial and other diffuse sources, and that also the global distribution of product related releases is rapidly expanding.

Sources that already are included in the reporting to PRTRs, i.e. product manufacturing, distribution and waste handling, were excluded from the scope of the Resource Compendium, and the efforts were concentrated on collecting information on releases generated during the actual use phase of end-products.

Based on the collected information it is evident that there are releases of hazardous chemicals to the environment from the use of certain product groups. In addition to air emissions that already are covered by the inventories submitted to international air protection conventions, there are relevant product use related releases of heavy metals and persistent organic pollutants, mainly to the soil and waterbodies, but also to the air.

Buildings are likely to be one of the main sources of direct releases to the environment not generally included in the existing inventories. In addition, car and boat care products, pesticides and the use of lead containing ammunition and fishing gear and mercury containing electrical and electronic equipment were identified to be relevant sources of direct releases. Textile and leather products, furniture and packaging material may have direct releases to the environment, if maintained or kept in open air without transferring the releases to a sewer network or landfill. This is also true for pharmaceuticals, personal care products as well as toys and low-cost jewellery, which generally only have health impacts.

A list of products proposed for inclusion into PRTRs is presented in Table 27 under Chapter 8.2. It is recommended that the relevance of releases from the proposed products is assessed against country-specific conditions.

Global issues related to releases from the use of products

Though international and national work to restrict releases from the use of products is under way, no harmonized global approach concerning releases to the environment yet exists. It was observed that especially in countries where organized waste management practices and related legislation has not yet been implemented, releases from products are understood to cover also releases from waste handling, for instance disassembling of products for recycling purposes.

In a growing scale, the life-cycle of a product can be divided between different countries in the world, even the different parts of a single product can be made in different countries. For example, electronics, textile and toys that are produced in the Far East are used worldwide. Also, the used products can be shipped to other countries where the product parts can be recycled and used in new items. It is important to pay attention to the fact that although the national surveillance of chemicals in products would be well organized, follow-up of chemicals in imported products may be challenging. There is need for an internationally harmonized approach for both information sharing and legislation.

Some chemicals follow the product through the supply chain and end up where not expected. There may also be stocks of old products from which releases still occur.

Health and environmental impacts

More information is available on the health effects on releases from products compared to the actual environmental releases from the use of products. Though chemicals in products may impact both health and the environment, those chemicals that have health effects do not always end up in the environment. For instance, releases from pharmaceutical and personal care products usually end up in sewage³³, which is lead to purification in wastewater treatment plants and releases from toys or low-cost jewellery do not enter the environment unless deliberately or undeliberately abandoned there and not taken to landfills.

Differences in the release levels from the use of products

Between the countries, there may also exist actual differences in the releases from products, due to the fact that release patterns and volumes differ largely in global respect. This is due to the use of different product groups and product types, and the chemical contents in the products. Also the use patterns and use volumes of similar products may vary between countries. International, regional or national restrictions or bans on certain products and/or chemicals in the products as well as voluntary initiatives by the industry or consumer demand all have their effect on the releases from the use of products.

Decreases in certain product use related releases

In some countries the releases from certain product groups are already decreasing, even drastically, due to restrictions implemented on import, export or use of certain products with releases of environmentally hazardous chemicals. As an example, lead releases were cut drastically in the early 1990s in many countries due to the ban of leaded gasoline³⁴. A similar phenomenon with the remaining lead releases in Norway was the ban on leaded bullets in hunting in 1995. After this, lead releases in Norway decreased additionally by over 80 per cent. Significant decreases are likely to have been reached also concerning other chemicals that have been regulated in the last decades, however, there is little information of quantification of these releases and their cuts.

³³ For instance in the Nordic countries, wastewaters in the urban areas as well as in most cases also in the sparsely populated areas are lead either to municipal wastewater treatment plants or to property specific wastewater treatment systems.

³⁴ The transport sector was a dominating sector of lead releases in Europe, the USA and Canada until mid-1990. The use of leaded gasoline was banned and the releases of lead were decreased generally by over 90 percent in the countries.

Lack of routine inventory work and comparability of data

Routine inventories on releases to the environment from the use of products are carried out only in a few countries, namely in Japan, the Netherlands³⁵, Norway, and South Korea. In addition, regional inventories on releases from certain products and chemicals have been produced by the industry.

When comparing information on emission data presented in the different inventories, studies or research programmes on releases from the use of products, it can be seen that the results differ significantly. Often only the results are presented without documentation or justification of the methodology or explanation of products or activities³⁶ included or excluded. Thus it is difficult to conclude if there are actual differences in the releases due to, for instance, different use practices or differences in the chemical contents of a given product, as described above.

³⁵ Excluding use of solvents, which is included in the regular inventory programmes in countries that report these releases under the UNFCCC and UNECE CLRTAP Conventions reporting programmes.

³⁶ Unlike the scope of this project (i.e. releases from the use phase of products) releases from products are often understood to cover the whole life-cycle of a product or at least several parts of it.

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ANNEXES

ANNEX 1: CASE STUDIES ON SELECTED PRODUCT GROUPS

Case Study 1: Lead releases from the use phase of end-products

Case Study 2: Releases of nonylphenol and nonylphenol-ethoxylates from the use phase of end-products

Case Study 3: Releases from the use phase of end-products in the construction and building sector

Case Study 4: Releases from the use phase of electrical and electronic equipment

Case Study 5: Releases from the use phase of furniture

Case Study 6: Releases from the use phase of nanoproducts

Case Study 7: Releases from the use phase of packages and plastic bags

Case Study 8: Releases from the use phase of pharmaceuticals, personal care and cleaning products

Case Study 9: Releases from the use phase of pesticides

Case Study 10: Releases from the use phase of textile and leather products

Case Study 11: Releases from the use phase of toys and low-cost jewellery

ANNEX 1

CASE STUDIES ON SELECTED PRODUCT GROUPS

Case Study 1:

Lead releases from the use phase of end-products

CASE STUDY 1: LEAD RELEASES FROM THE USE PHASE OF END-PRODUCTS

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1 Introduction

The aim of this case study was to identify such applications of the use phase of lead containing end-products that may lead to releases into the environment, to collect information of the mechanisms leading to possible releases and to document possible release estimate techniques for these sources. The study was carried out as a literature review and data were compiled mainly from studies carried out in the Nordic Countries but also from other countries' information sources, scientific reports and articles as well as other literature.

Lead

Lead (Pb) is a soft, bluish gray metal with standard atomic weight of 207.2 g/mol and classified as a heavy metal. Natural lead is composed of four different stable isotopes. Lead is a naturally occurring element coming from the Earth's crust and rarely found in nature as a metal. It occurs usually in ore with zinc, silver and copper, the main lead mineral being galena (PbS), which contains 86.6 % lead. Other common minerals are cerussite (PbCO₃) and anglesite (PbSO₄).

Wide use of lead is primarily due to its low melting point, high density and corrosion resistance properties. Lead is also malleable, which makes it easy to work with, and it does not fracture. Lead has a melting point of 327.5 °C and a boiling point of 1749 °C. Metallic lead is resistant to corrosion. When lead is exposed to air or water, it will form films of lead sulphate, lead oxide and lead carbonate, which will protect the metal against corrosion. Lead can form alloys with other metals, e.g. tin, copper and aluminium.

References: ATSDR 2007, Black 2005, Wikipedia 2009a

Production and use

Lead used by the industry comes as a "primary" lead from mined ores or as a "secondary" lead from recycled scrap metal and batteries. Lead is mined in more than 40 countries including China, Australia, United States, Peru, Mexico, Canada, Morocco, Ireland, Kazakhstan, India, South Africa, North Korea and Sweden. United States, Australia and China account for more than half of the whole primary lead production. Today, most of the lead comes from recycled lead-acid batteries. Other important sources include old lead sheets and pipes from demolition and refurbishment of buildings and also old cable sheathing. In 2007 global lead metal production was 8,127 kilotonnes and lead metal usage was 8,137 kilotonnes.

Lead is present in various products typical applications being accumulators, ammunition, weights, constructional uses (sheets and pipes), cable sheathings and pigments.

Pure lead is only used for a few applications due to its softness. In metallic applications, lead is often alloyed with antimony, copper, calcium or silver. Lead can also be used as an alloying element in alloys of copper or tin. Lead and lead alloys are commonly found in storage batteries, pipes, ammunition, weights, cable sheathings and radiation shields. Compilations of identified current and former end-uses of lead and lead compounds are presented in Appendix I.

As can be seen from Figure 1, the largest use of lead is in batteries, out of which vehicle accumulators are the most important. Rolled or extruded lead comprises a variety of

products, out of which lead sheets in buildings cover 80 %, radiation shielding material 10 % and sound proofing 3 %.

For lead compounds, the largest current application is leaded glass used for radiation shielding, cathode ray and fluorescent tubes and electrical glass. Commercially most important applications of lead compounds are as additives to cathode ray tubes and PVC-plastics. Of lead alloys, lead-tin solder is the most widely used. Information of the distribution of the international lead consumption in different end-use applications in 2003 is presented Figure 2.

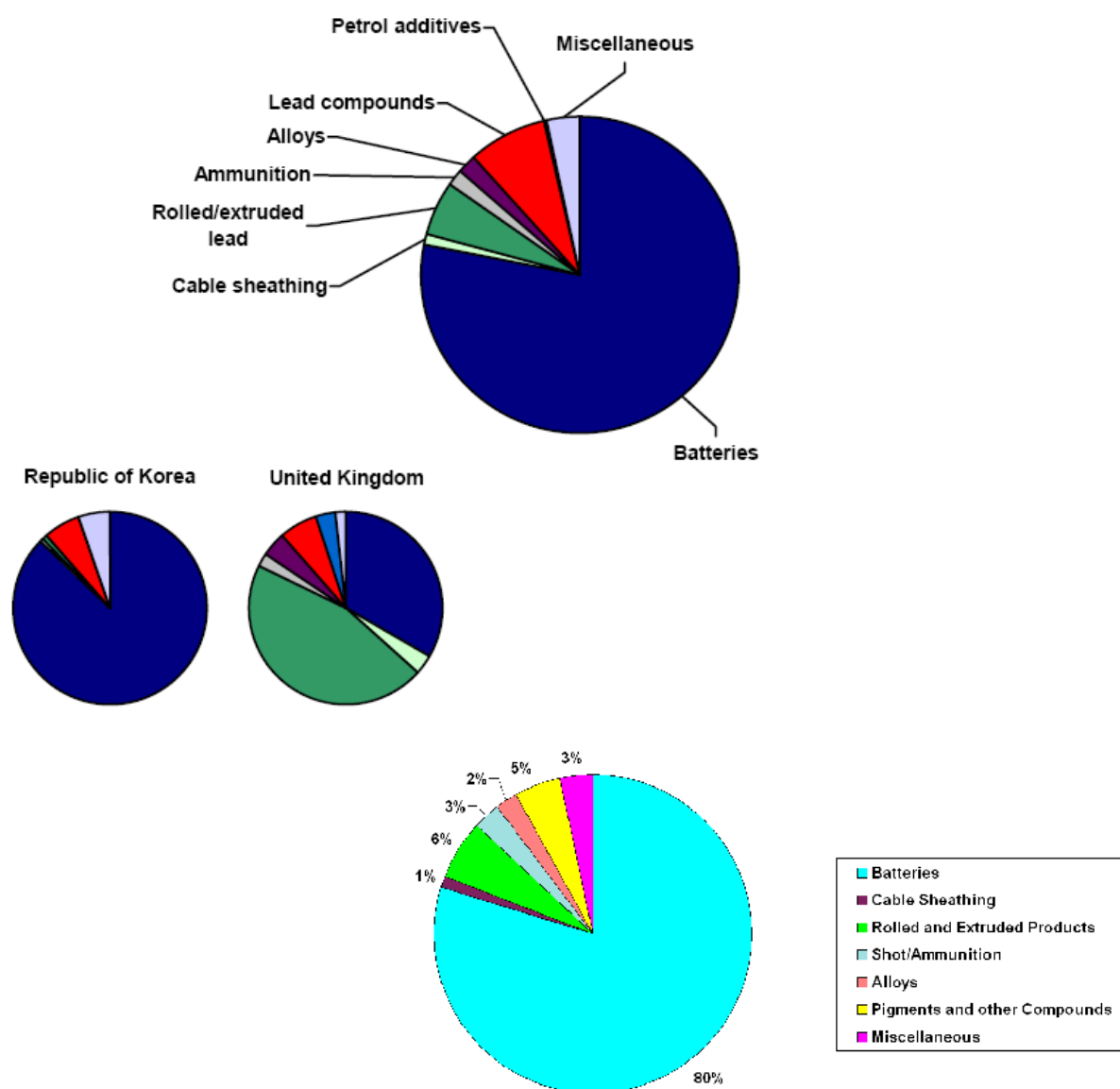


Figure 1. Distribution of the international lead consumption in different end-use applications in 2003 and 2007 by the ILZSG member countries (86 % of the total global lead consumption) (above); examples from two countries on the distribution of lead for manufacturing processes of different applications (below) (UNEP 2008a ref. ILZSG; ILZSG 2008b)

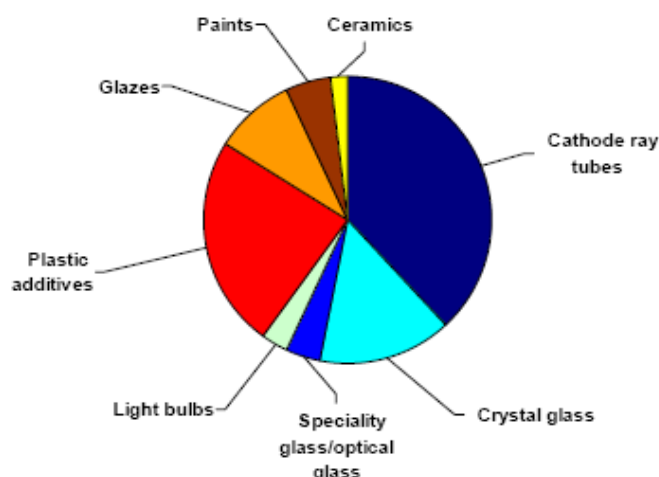


Figure 2. Distribution of the international consumption of lead compounds in different end-use applications in 2001 by the ILZSG "Western World" member countries; lead compounds used in batteries and petrol additives are not included (UNEP 2008a)

Trends in the use of lead containing products

From 1970 to 2003, the proportion of lead containing batteries has increased, whereas the use of lead in cable sheathing and petrol additives has decreased. There are differences in the consumption of lead for first-use (refined lead) between different countries and regions reflecting their industry structures (Table 1), for instance, in the United Kingdom the proportion of rolled/extruded lead (46%) is high due to the use of lead in the construction sector (roofing and roof flashing) and in the Republic of Korea batteries (87%) are the biggest usage area of lead due to extensive car industry (Figure 1). In addition, relatively high consumption of lead for ammunition (6.4%) can be found in Italy, which is the major producer of ammunition in Europe.

Table 1. Consumption of lead by first-use in different countries in 2003 by the ILZSG (UNEP 2008a)

Application area	Percentages of total lead consumption (first use) in 2003					
	Rep. of Korea	China	Italy	United Kingdom	India	Mexico
Batteries	87.2	79.5	81.1	33.3	77.0	85.6
Cable sheeting	0.7	1.9	0.6	3.3	4.2	0.2
Rolled/extruded lead (mainly sheets)	0.8	1.9	0.0	45.6	0.0	0.0
Ammunition	0.0	0.0	6.4	2.3	0.0	0.0
Alloys	0.1	0.0	0.3	4.1	6.1	1.2
Lead compounds	6.1	10.0	7.5	6.4	10.7	6.0
Petrol additives	0.0	0.0	0.0	3.3	0.0	2.4
Miscellaneous	5.2	6.8	4.2	1.8	2.0	4.6
Total	100	100	100	100	100	100
Total (1000 tonnes Pb/year)	349	1,183	236	247	142	259

The distribution of lead consumption for the first-uses in a country may differ significantly from that of lead in traded end-products, but it is often difficult to get exact information for the consumption of lead by end-use due to extensive import and export.

The use of lead as petrol additive phased out in most countries worldwide in 1990-2000. Lead sheets are still widely used in the construction sector, but the use of lead pipes for domestic water has significantly decreased in the last decades.

Lead in the environment

In the environment lead is mainly bound to particles:

- In the air lead has a relatively short residence time, from hours to weeks, and occurs mainly as lead compounds.
- In the aquatic environment lead can occur as ion or as organic complexes with dissolved humus material. It can also attach to colloidal particles, particles of clay or remains of organisms.
- In the upper soil layer lead is bound tightly to soil particles and small amounts can end up in rivers and lakes along with the soil particles during rainfall and erosion. It is unlikely that lead would move into groundwater, unless the rainwater coming to soil is acidic or soft. Movement of lead from soil to the water body depends on the type of the lead compound and the properties of the soil. Clay, silt, iron and manganese oxides and soil organic matter can bind lead. The mobility of lead in soil is affected by soil pH, humic acids and the amount of organic matter
- Lead is bioaccumulative in most organisms, but it does not enrich in the food chain.

Environmental exposure to lead from end products can occur for instance from lead bullets or sinkers from hunting and fishing, wheel balance weights or lead-based paint. The use of lead containing items like shots and sinkers can result in dispersal of metallic lead in some areas. The use of other types of products containing lead, for instance wheel balance weights, can result in more concentrated environmental impacts affecting possibly in local

soil and water. The most important environmental effect of lead in end products is probably the wide-spreading poisoning of waterfowl from ingested lead shots and sinkers and the impact on their predators. Contamination of the migrating waterfowls has a transboundary effect.

The phase out of lead as petrol additive in most countries has reduced lead emissions and continuing reduction of the use of leaded gasoline will further decline the deposition of lead affecting to the levels in forest soil. In an Indian study, the response from the phase out of leaded gasoline can be seen in various environmental components, most clearly in the urban air and river concentrations (10-20%), while the remaining lead exposure in tree leaves and urban children blood is still higher (40-70%) (Figure 3).

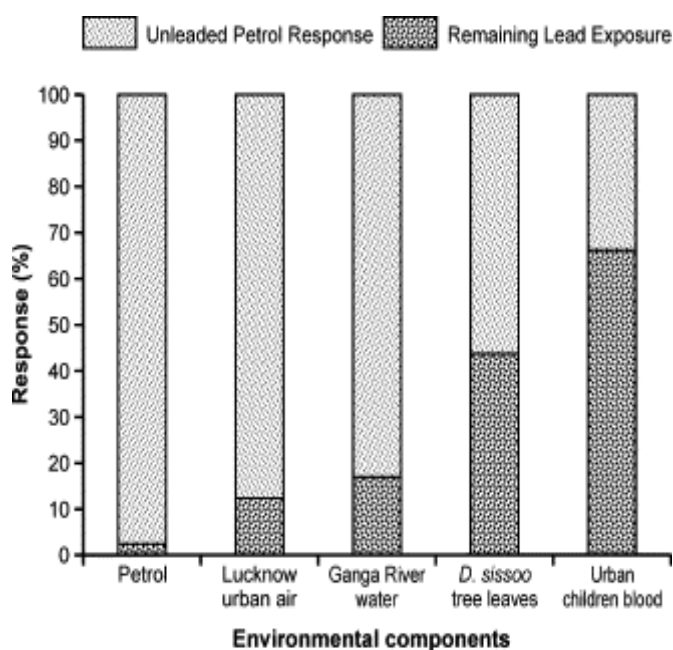


Figure 3. Diagram showing response (%) resulting from switch to unleaded petrol for lead in the various components of Indian environment (Singh AK and Singh M 2006)

Information of health effects of lead is provided in Appendix III.

References: ATSDR 2007, ILZSG 2008a, Keml 2007, Thornton et al. 2001, Tukker et al. 2001, UNEP 2008a, Wikipedia 2009a, Wilson 2003

2 Restrictions on lead in end products

The use of lead has been banned in many products by different national legislations. For instance, in the EU area restrictions have been implemented since 1989 in paints and for leaded gasoline in during the period of 1980-2000.

Ammunition

Restrictions for the use of lead shots and bullets have been introduced in 20 countries by the year 2002. Many countries have banned the use of lead shots for hunting in wetlands. Some countries also have restrictions on lead shots used in forests and other terrestrial

environments. The Agreement on the Conservation of African-Eurasian Migratory Waterbirds is aiming for the phase out of lead shots used for hunting in wetlands.

Nordic countries

- Denmark and Sweden have also restricted the use of lead shots for clay target shooting.
- In Finland the use of lead shots in hunting of waterfowl has been prohibited since August 1996
- Norway banned the manufacture, import, export, sale and use of lead shots, including target ranges in 2005
- In Sweden, a restriction for the use of lead in ammunitions for rifles came into force at the beginning of the year 2008. Lead containing cartridges are not allowed to be used in shooting, hunting over wetlands or hunting over shallow parts of open water. This does not concern shooting ranges if the used bullets are properly managed. Different techniques for diminishing the use of lead in ammunition have been considered. These include tax or change, tradable quotas, deposit-refund system, subsidies for alternative materials, subsidies for retrieval of bullets and subsidies for cleaning up contaminated sites. From these, tax and subsidies for bullet retrieval seems to be the most promising. According to the Swedish Environmental Code, anyone operating in an activity where there is a risk of the area becoming polluted if the ammunition and its rest are not collected in a proper way, is responsible for an after-treatment of the area. The costs of bullet retrieval can be high, but using the tax revenue to subsidies the retrieval arrangements can diminishes them. The bullets should be collected and stored in a way that they are not spread to soil or water. Subsidies could be given to ensure bullet retrieval arrangements.

Batteries

EU Directive (2006/66/EC) on batteries and accumulators and waste batteries and accumulators is aiming to maximize the separate collection of waste batteries and accumulators and to increase the recycling level. The Directive includes labelling requirements for batteries and accumulators containing more than 0.004 % of lead by weight. There is no prohibition on lead containing batteries. The EU Directive (2000/53/EC) on end-of-life vehicles currently exempts lead containing batteries.

Toys

Restrictions on the use of lead in articles intended or subject to the use by children are given at least in the European Union, the USA, Canada and China. Also, variations of the ISO 8124 Toys Safety Standard have been adopted in many countries, including Japan, Australia and New Zealand.

The European Union Directive (88/378/EEC) on the safety of toys includes safety criteria for articles defined as toys as well as bioavailability limits for eight substances, including lead (not exceeding 0.7 µg of lead per day). There are 21 exemptions for articles not considered as toys, e.g. fashion jewellery for children. The new Toys Directive (2009/48/EC) is aiming at improving the safety of toys and will replace the old directive. The migration limits for lead are 13.5 mg/kg in dry, brittle, powder-like or pliable toy material, 3.4 mg/kg in liquid or sticky toy material and 160 mg/kg in scraped-off toy material. Toys are also regulated under the RoHS³⁷ Directive of electrical and electronic equipment.

³⁷ RoHS =Restriction of the use of certain Hazardous substances in electrical and electronic equipment

In the United States, lead content in surface paint should not exceed 0.009 w-% (90 ppm). The use of paint containing more than 0.06 % (600 ppm) of lead by weight is prohibited in children's jewellery. New standards coming into force on 14 August 2009 require that any article designed or intended for the use of children at age of 12 or younger must not contain more than 300 ppm of lead by weight in any part of the item. In California, a limit value of 0.06 % is set for the lead content of base metal in children's jewellery by law starting from September 2007. The lead content of surface paint used in toys and other children's products is lowered to maximum of 0.009 % (90 ppm) of lead by weight. The Consumer Product Safety Commission has also used the value as a guideline for children's jewellery and has proposed it as a federal regulation. A regulation for the adult's jewellery took effect on March 2008 in California. According to the U.S. Consumer Product Safety Commission, accessibility of lead to acid leaching, which simulates the dissolving of lead when ingested, must not exceed the value of 175 µg. Some U.S. importers test their products but they may have difficulties to meet the standards.

The Chinese government has limit values for the lead content of toys, but not for jewellery.

Nordic countries

- There is a ban on lead in decorative purposes in Denmark by legislation from 2000
- There are no limit values for lead used in jewellery in Finland but toys should not contain lead more than 90 mg/kg (with 30 % analytical correction)

National consumer agencies can also give limit values, e.g. in Finland toys should not contain lead more than 90 mg/kg (with 30 % analytical correction). The Chinese government has set limit values for the lead content of toys (no information of the allowed lead concentration) but not for jewellery. In the United States, the use of paint containing more than 0.06 % (600 ppm) of lead by weight is prohibited in toys. New standards coming into force on 14 August 2009 require that any article designed or intended for the use of children at age of 12 or younger must not contain more than 300 ppm of lead by weight in any part of the item. The lead content of surface paint used in toys and other children's products is lowered to maximum of 0.009 % (90 ppm) of lead by weight. In Canada, the Hazardous Products Act and the Children's Jewelry Act limit the amount of lead in toys and children's jewellery.

There have been many recalls of children's products containing too high amounts of lead, e.g. a massive recall of 1.7 million units in the U.S. in 2007. Since the recall, some retailers and toy companies have voluntarily strengthened the guidelines for the permissible amount of lead and increased testing of the products. However, recalled items can end up sold in outlets, online or exported to countries with lacking regulations on lead in children's articles.

References: Consumer Agency 2008, EC 2009, van Engelen et al. 2006, Fairclough 2007, ICCM2 2008, Massey et al. 2008, UNEP 2008a,b

Electrical and electronic equipment

Restrictions on the use of lead in electrical and electronic equipment have been given at least in the European Union and China.

The European RoHS directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (2002/95/EC) prohibits the import and sale of products containing six compounds including lead by more than 0.1 weight-% for individual parts. This covers new articles and their spare parts put on the market in the EU starting from first of

July 2006 with certain exceptions. The exceptions currently include e.g. the use of lead in glass of cathode ray tubes, electronic components and fluorescent tubes; as an alloying element at certain levels as well as certain solders (see Chapter 3.3.4) and electronic ceramic parts. According to the Directive, lead must be replaced by other alternatives in electrical and electronic equipment. The Directive also allows exemptions to the ban if the replacement of lead is technically or scientifically impractical or if its the negative consequences to health, environment or safety overcome the benefits of the ban. The Directive does not require labelling or submission of information, but the manufacturer or supplier has to ensure that the product is in compliance with the RoHS.

The Chinese Restriction on Hazardous Substances (China RoHS) applies only to electronic devices (not electrical), but it contains fewer exemptions compared to the EU RoHS Directive. The China RoHS is based on labelling requirements using symbols to identify if the product contains one or more of the six targeted toxic substances. The symbol also includes number of years during which the item is guaranteed not to release toxics under normal use. In product instructions more detailed information is required. The China RoHS also requires testing of the articles while EU RoHS relies on self certification by the manufacturer or importer.

Various countries have recycling programs for electronic waste, aiming to reduce releases of lead and other toxic metals to the environment. For example, in British Columbia, the electronics are collected, sorted and treated for recycling or burning at a smelter. The financial costs of the program are covered by a levy on new electronics. The program, however, does not include all electronics and there is a concern over the possible effects, which the processing of e-waste in a smelter could have on air pollution. In the EU, electrical and electronic products should be collected, properly handled and recycled. The retailers are obligated to receive these products free of charge and to provide storing, sorting and forwarding of these items. Electrical and electronic waste has also been exported from EU countries to developing countries although this is largely prohibited. During the transport, the appliances can be broken, which reduces the recycling of the components.

In the United States the export of most old electronics, like cell phones and circuit boards, is not regulated, because the US EPA considers them to be non-hazardous. There are currently no restrictions for new electronic products, but there are regulations requiring reporting to the TRI.

References: Black 2005, EC 2002, Fairclough 2007, George-Cosh 2007, Massey et al. 2001, 2008, SFT 2008, UNEP 2008a

Cables and wires

In the Nordic countries there are restrictions for lead in cable sheathing:

- Leaded cable sheaths for electrical ground cables below 24 kV are banned in Denmark.
- Norway has restricted the use of lead containing cable sheathing.

Vehicles

In the European Union the Directive (2000/53/EC) on end-of-life vehicles restricts the use of lead in materials and components of vehicles. Vehicles with lead-containing materials and components shall not be put on the market after the beginning of July 2003. Exemptions currently include e.g. lead in batteries, vibration damping and pyrotechnical initiators for airbags. (UNEP 2008a.)

The use of lead in wheel balance weights will phase out in Europe due to the Directive (2000/53/EC) on end-of-life vehicles according to which vehicles with lead containing wheel balance weights shall not be put on the market after the beginning of July 2003.

In the U.S. there are currently no federal regulatory controls governing the use of leaded wheel weights but the National Lead Free Wheel Weight Initiative (NLFWWI) created by the U.S. EPA enhances the voluntary transition towards the manufacture, distribution, sale and use of unleaded wheel weights.

Nordic countries

- Denmark has prohibited the import and marketing of lead containing brake linings

Cosmetics

In the EU the Directive (76/768/EEU) with its amendments (2000/6/EU and 2000/11/EC) prohibits the use of lead and lead compounds in cosmetics marketed within the European Community. The ban does not include lead acetate when it is used in hair treatment products. New regulation ((EC) No 1223/2009) will replace the old directive. (UNEP 2008a.)

Packaging

In the EU the Directive (94/62/EC) on packaging, the sum concentration of lead, cadmium, mercury and hexavalent chromium in packaging or packaging component must not be over 100 ppm by weight starting from 30 June 2001 (UNEP 2008a).

Drinking water and food

There are restrictions in many countries on the use of lead material (including pipes, solders and joints) in drinking water systems. The restrictions generally involve new applications and do not require replacement of old installations.

- The World Health Organisation has recommended that drinking water should not contain lead more than 50 µg/l.
- The EU Directive (98/83/EC) on the quality of water intended for human consumption restricts the lead content of drinking water. According to the Directive, the water intended for human consumption as a principal should not exceed lead level of 10 µg/l. In the United Kingdom the limit value is currently 25 µg/l, but it will be lowered down to 10 µg/l in 2013.
- The EU Regulation (466/2001) on contaminants in foodstuff sets limits for lead between 0.02 and 1.5 mg/kg wet weight with lowest limit found in cow's milk and the highest in mussels. According to the EU Directive (88/344/EEC), extraction solvents used in the production of food must not contain more than 1 mg/kg of lead. EU Directive (88/388/EEC) relating to flavourings for use in foodstuffs restricts the lead content of flavourings to maximum of 10 mg/kg.

Possible alternatives for lead-tin solders include alternative alloys (e.g. tin-silver-copper solder (SAC) with 95.5 % of tin, 3.9 % of silver and 0.6 % of copper) and polymer formulations (e.g. electrically conductive adhesives (ECAs).

In the United States, the exporters of intact or broken cathode-ray tubes that are going to recycling must notify the U.S. EPA and get a permission from the importing country

Nordic countries

- Denmark has prohibited the import and marketing of lead containing solder alloys for the uses in plumbing and sanitation, except for soldering zinc sheets.

References: IVL 2008, Kemi 2008, UNEP 2008a, GEPA 2000

Leaded glass and ceramics

EU Directive (69/493/EEC) related to crystal glass does not restrict the use of lead, but prohibits the marketing of crystal glass on the basis of its lead content. The content of lead in crystal glass must be 24 % or more and in full-crystal glass 30 % or more.

There are restrictions on the use of lead in articles intended to be in contact with food, e.g. the Tableware Act from California in the United States and the EU Directive (84/500/EEC) relating to ceramic articles intended to come into contact with foodstuffs. According to the Directive, lead must not be transferred from the article above the limit value, which depends on the vessel used. The maximum permitted quantity of lead is 0.8 mg/dm² for vessels that cannot be filled or vessels that can be filled but the maximum internal depth (measured from the lowest point to the upper rim) of the vessel is 25 mm. The limit value is 1.5 mg/l for cooking ware and vessels used for packaging and storage with more than three litres capacity. The limit value is 4.0 mg/l for other items that can be filled. Also the ceramics industry is aiming at voluntary phasing out of lead containing glazes.

Nordic countries

Denmark has prohibited the import and marketing of lead containing glazes, enamels and pigments on certain ceramic products. Exemptions include e.g. glazes, enamels and pigments used for art and handicrafts that are assumed not to be used in contact with foodstuff. Also the import and marketing of products for decorative use containing metallic lead is banned.

Pigments and paints

There are restrictions on the use of lead containing paint and lead has been eliminated from paints in many countries. By 1960 lead compounds were virtually eliminated in sectors such as household paints in the developed countries. The restrictions may vary in different countries. Many countries have prohibited the use of lead carbonate ("white lead") paint while allowing the use of "red lead" for anticorrosion purposes and lead chromates for exterior surfaces. Some countries have a total ban on residential paints while others have voluntary agreements for avoiding the use of lead-based paints in toys and household painting. The sale of leaded paint was banned in the EU in 1989. The Annex XVII of the REACH regulation ((EC) No 1907/2006) prohibits the use of lead carbonates and lead sulphates in paints. Exemptions include the use in restoration and maintenance of historic buildings, structures and interiors.

In the United States the sale of lead containing residential paints was banned in 1978. According to the ban, the use of paint containing more than 0.06 % (600 ppm) of lead by weight is prohibited in toys, furniture, interior and exterior surfaces as well as structures used by consumers. The new standard coming into force on 14 August 2009 requires that the lead content of surface paint for furniture, toys and other children's products is lowered to

maximum of 0.009 % (90 ppm) of lead by weight. There may still be lead in old paints of buildings constructed before the ban. The number of homes in the United States containing old lead paint has been estimated to be as high as 38 million. These were mainly built when lead containing paints were used. The US EPA has set a rule according to which renovators of homes must take precautions to avoid exposing children to lead paint.

Plastic additives

The European Stabiliser Producers Association (ESPA) and the European Plastics Converters Association (EuPC) have voluntarily decided to reduce the consumption of lead stabilizers comparing to the 2000 level, 15 % by 2005, 50 % by 2010 and 100 % by 2015. In 2007 the replacement of lead stabilizers was extended from EU15 to EU27. The reduction of the use of lead stabilizers was 52.3 % (66,552 tonnes) in the period of 2000-2008. Calcium organic stabilizers are used as a substitute for lead stabilizers.

Nordic countries

- The Danish government banned the import and marketing of lead compounds by the year 2003 in products including PVC cables, gutters, pipes, roofing and windows. Electrical cables incorporated into products that contain lead stabilizers as well as elastomers containing lead as heat stabilizers are still allowed to be imported and marketed. In

Solders

Some lead containing solders are currently exempted from the European Union RoHS Directive (2002/95/EC). These include high melting temperature type solders, which are tin-lead solders with more than 85 % of lead; solders used in sewers, storage and storage array systems (until 2010) and also solders used in network infrastructure equipment for switching, signalling, transmission and as network management telecommunication. The use of lead solder in food cans is banned in the United States.

Leaded curtain weights are banned in Denmark by a general legislation on lead containing products from 2000.

Other products

United Kingdom has prohibited the use of lead sinkers above 0.06 g and below 28.35 g of weight in fresh water. The use of lead in fishing equipments is also banned in the national parks of Canada.

Nordic countries

- There is a total ban on the use of lead in *fishing equipment* in Denmark. The ban covers both angling and commercial fishing, but it is only partly implemented due to the lack of commercially sustainable alternatives.
- Sweden has introduced voluntary restriction on the use of lead *sinkers* in certain fresh waters
- Lead used in *roofing and flashing* around windows and chimneys is banned in Denmark by a general legislation on lead containing products from 2000.
- Denmark has banned the import and marketing of lead containing *security / safety seals*.

International work

The World Summit on Sustainable Development (WSSD) in 2002 called for a phase out of lead in gasoline and in paint, in order to protect children's exposure to lead. Paint is considered the second major source of exposure after leaded gasoline, the phase out of which has almost been achieved.

Lead in paints was also one of the topics discussed at the ICCM2 where development of information systems on chemicals in products was discussed.

The International Forum on Chemical Safety (IFCS) has established a Global Partnership aiming to the phase-out of the manufacture and sale of paints containing lead and to eventually eliminate risks from lead containing paint under the auspices of the ICCM. Proposed actions include national standards as well as an international labelling and certification scheme.

Lead hydrogen arsenate is included in the REACH Candidate list of substances of very high concern (SVHC). Lead chromate, lead chromate molybdate sulfate and lead sulfochromate yellow have been proposed to also be included in the list.

References: ChemicalWatch 2009, ECHA 2009a, b, ICCM2 2009

National initiatives

Many countries have national restrictions to control releases and also to reduce the use and exposure to lead as presented in Table 2. Limits on specific products or product groups are more widely used than general bans on lead, which have been implemented only in few countries.

Table 2. Restrictive measures for lead releases(UNEP 2008a)

TYPE AND AIM OF MEASURE		STATE OF IMPLEMENTATION
Production and use phases of life cycle and/or releases from sources that mobilize lead from raw materials		
POINT SOURCES	Apply emission-control technologies to limit emissions of lead from combustion of fossil fuels and processing of mineral materials	Implemented in many countries
	Prevent or limit the release of lead from industrial processes to the wastewater treatment system	Implemented in many countries
	Require use of best available technology to reduce or prevent lead releases	Implemented in some countries, especially OECD countries
PRODUCTS	Prevent or limit products containing lead from being marketed nationally	General bans implemented in a few countries only. Bans or limits on specific products are more widespread, such as gasoline and paint. In EU the use of lead has been restricted or prohibited for use in electric and electronic equipment as well as in vehicles
	Limit the allowed contents of lead in commercial food-stuffs and feed.	Implemented in some countries, especially OECD countries. WHO guidelines used by some countries
Disposal phase of life cycle		
Prevent lead in products and process waste from being released directly to the environment, by efficient waste collection		Implemented in many countries, especially OECD countries
Prevent lead in products - especially batteries - and process waste from being mixed with less hazardous waste in the general waste stream, by separate collection and treatment		Implemented in many countries
Prevent or limit lead releases to the environment from incineration (and possibly other treatment) of household waste, hazardous waste and medical waste by emission control technologies		Likely implemented in all countries where organised waste treatment is taking place.
Set limit values for allowable lead contents in sewage sludge and other organic waste products used for land application		Implemented in a number of countries
Set limit values for lead in solid incineration residues used for road-building, construction and other applications		Implemented in some OECD countries

In the United States, lead is listed as one of the six criteria pollutants. There are no restrictions for lead in products but many end-uses of lead have been phased-out in the past 25 years.

Nordic countries

- Denmark has established legislation for general restriction of lead and lead products in 2000. This covers a ban on the import and marketing of products with more than 100 mg/kg (ppm) of lead of their homogenous components. This includes both metallic lead and lead compounds with some exemptions.
- Products containing lead and lead compounds more than 2500 mg/kg (0.25 %) are classified as hazardous waste in Finland. Also an unofficial limit value of 1500 mg/kg has been used for lead containing sealants. Limit value of 300 mg/kg and reference value of 60 mg/kg have been used for contaminated soils.
- According to the Swedish objective of "A Non-Toxic Environment", new finished products could be lead-free by the year 2010. Articles already containing lead must be handled so that there is no releases to the environment. In many products used in Sweden the use of lead has reduced, including pigments in paint, plastic additives, crystal, cable sheathing, electronics and shot. In products like batteries, boat keels, fishing equipment, lead containing alloys, weights and radiation shielding, the use of lead has not yet decreased.

References: Järvinen et al. 2003, Keml 2007, Rantio et al. 2001, Renner 2007, UNEP 2008a

3 The use of lead in products and releases from the use phase of lead containing end-products

This chapter includes information on such end-products that contain lead from which it is likely that releases occur during their use-phase. Possible releases during the use phase of these end products is estimated under each subchapter.

Estimates of the shares of total lead releases in Europe between the different source categories and environmental media are presented in Table 3.

Table 3. Estimates of European lead emissions (Van Hyfte and Calleaut, 2007)

	Water (kg Pb/year)	Air (kg Pb/year)	Soil (kg Pb/year)	Total (kg Pb/year)
Industry	174,858	704,493	0	879,351
Combustion processes industry	0	102,000	0	102,000
- Power production	0	78,000	0	78,000
- Others	0	24,000	0	24,000
Households	295,664	62,047	199,491	557,202
- Residential heating	0	61,943	0	61,943
- Corrosion of lead sheets	22,459	0	164,703	187,162
- Domestic wastewater	70,630	0	34,788	105,418
- Lost fishing sinkers	202,575	0	0	202,575
- Other sources	0	104	0	104
Waste management	173,214	15,169	0	188,383
- Sewage treatment plants	144,840	0	0	144,840
- Waste incineration	10,846	15,169	0	26,015
- Landfills	17,528	0	0	17,528
Agriculture	8	119	275,700	275,827
- Use of manure, fertilisers, ... on agricultural soil	0	0	275,700	275,700
- Other sources	8	119	0	127
Traffic	40,838	32,059	108,412	181,309
- Tyre wear	29,079	1,884	16,418	47,381
- Exhaust fumes (road, air, navigation)	0	12,244	0	12,244
- Loss and corrosion of wheel weights	4,860	0	32,670	37,530
- Wear of collector shoes (rail transport)	3,941	15,867	52,043	71,851
- Other sources	2,958	2,064	7,281	12,303
Miscellaneous sources	1,800,392	0	23,450,657	25,251,049
- Sewage system - overflows	77,793	0	0	77,793
- Sewage system - separate sewage systems	73,839	0	0	73,839
- Use of Pb-containing ammunition	1,648,760	0	23,450,657	25,099,417
TOTAL	2,484,974	915,887	24,034,260	27,435,121

A compilation of lead products and their anticipated releases during the use phase is presented in Table 4. A compilation of emission factors for lead releases in the use-phase of products is presented in Appendix IV.

Table 4. Lead products and their anticipated releases during the use phase. (Note: A blank cell indicates that there is currently no information on the issue)

End-product	Releases likely	Health effects	RET	Included in regular inventories
Lead batteries	No (or accidental leakages)	Yes	No	No
Cable sheathing	Water, soil	No information	Yes	No
Lead solders in electronics and food cans	Air, water if left in the environment	No information	Yes	No information
Ammunition (shots and bullets)	Soil, water	Yes	Yes	National inventories: Norway, Sweden
Weights in fishing gear	Water	No information	Yes	National inventories: the Netherlands, Norway, Sweden
Underwater weight applications (e.g. yacht keels)	Water	No information	Yes	National inventories: Norway
Wheel balance weights	Soil	No information	Yes	National inventories: Germany
Collector shoes	Air	No information	Yes	UNECE CLRTAP
Petrol additives	Air, water, soil	No information	Yes	UNECE CLRTAP
Propeller shaft grease	Water	No information	Yes	National inventories: the Netherlands
Tyre and brake wear	Air, soil	No information	Yes	UNECE CLRTAP
Terne plate, bronzes, steels and aluminium alloys, bearings		No information		No information
Other weights - balance weights in lifts - balance weights in furniture - pianos - windmill wings - ventilators, - analytical instruments - diving belt weights - yacht keels -curtain weights	No (if subject to moisture and/or abrasion: soil)	No information	No	No
Lead sheets (used e.g. for roofing) and flashings	Soil, water	No information	Yes	National inventories: the Netherlands
Radiation shielding	No information	No information	No information	No information
Lead pipes and lead solders in pipes	Water, soil	No information	Yes	National inventories: the Netherlands
Lead comes	No information	No information	No information	No information
Additives in sealants and caulk	Soil, water	No information	No information	No information
Low cost jewellery	No information	Yes	No information	No information
Leaded glass, table wear and decorations	No information	Yes	No information	No information
Pigments and paints containing lead	Air, soil	Yes	Yes	National inventories: Japan Nordic countries
Plastic additives	Air, soil	No information	No information	No information
New Year's tin	Air, water	Yes	No information	In some countries
Firework	Air, soil	No information	Yes	UNECE CLRTAP

3.1 Consumer products

3.1.1 Lead-containing batteries

Lead has not been used in significant amounts in disposable (i.e. primary) batteries, therefore the term "battery" refers here to rechargeable (i.e. secondary) batteries.

The most important use of lead is in the use of lead-acid batteries to store electrical power. Approximately 80 % (about 6,500 kilotonnes in 2007) of the consumption of lead is for batteries. As much as 97 % of lead-acid batteries are recycled.

Leaded batteries include:

- SLI (Starting, Lighting and Ignition) batteries used in almost all cars, commercial vehicles and motorcycles that have petrol and diesel engines. This is the major application of lead-acid batteries.
- Traction (motive) batteries used to power vehicles e.g. wheel chairs, cleaning machines, airport vehicles, automatic guided vehicles, fork lift trucks and golf carts/caddies.
- Standby (stationary) and storage batteries to provide emergency electricity in the case of power failure for e.g. computer systems, telecommunications, security items, medical devices, railways and emergency installations.
- Consumer batteries used in small electrical products.

Both metallic lead and lead compounds are used in lead-acid batteries. Lead alloy is used as grid material and lead oxide paste as active material. The most used alloy has been lead-antimony (0.75-5 % Sb), but the modern alloys of starter batteries are lead-calcium-(tin) systems (up to 0.1 % Ca, 0-0.5 % Sn).

In the literature, no emissions are reported from the use of lead-acid batteries. Leakages to the environment will probably take place in the disposal phase of the batteries when they are broken, crushed and different components like pastes of lead oxides and sulphates, other metals, acids and plastics are separated. Lead from vehicle batteries is in a plastic container, thus releases from these batteries is considered negligible.

There are environmental certificates for lead battery manufacturers, e.g. the Better Environmental Sustainability Targets (BEST) in India. The voluntary certificate requires implementation of a collection programme and the facilities have to meet minimum emission standards for used batteries.

References: ATSDR 2007, ILZSG 2008b, Perappadan 2008, Thornton et al. 2001, Tukker et al. 2001, UNEP 2008a,b, van Sprang et al. 2008

3.1.2 Toys and low cost jewellery

Plastic toys include lead and lead is used in the leather parts of toys or in paints applied on toys for children. Although the use of lead-based paint has been prohibited around the world, it is still used in many countries and can be found for instance in imported toys. It may also be found in older antique toys and collectibles passing down through generations.

Primary lead alloys are nowadays rarely used in jewellery due to regulations, however, recycled lead is used instead. If the jewellery contains also copper and tin, the lead is probably from lead solder used in circuit boards. Low cost jewellery can also contain antimony, which is used to harden lead in batteries. Lead alloys are used in low cost

jewellery because there is plenty of lead and it is inexpensive compared to for instance to zinc alloys. Lead is easy to work with due to its low melting point. The jewellery are usually coated with a thin layer of another metal, commonly a mixture of gold, palladium and silver. Results from lead analysis of tested peaces of jewellery are presented in Appendix II.

Inexpensive jewellery are imported mainly from China, where manufacturers get a large part of the lead they use from electronic waste (so-called e-waste) including computers and other electronic articles and their parts discarded in developed countries and shipped to China. There lead and usable parts are stripped from the waste and sold to alloy makers, who provide it to jewellery manufacturers. The finished items are finally exported back to developed countries and sold in discount stores and malls, especially to children and teenagers.

Hobby and office products such as crayons and chalk can also contain lead. For instance the Swedish Chemical and Consumer Agencies found in their analysis of imported crayons migration values of lead exceeding more than 20 times the limit value of EU Toys Directive.

Given the high neurotoxicity of lead to young children, especially inexpensive jewellery items pose a potential threat especially to children. There have also been few cases where a child has died due to acute lead poisoning from ingested jewellery. In one incident, the jewellery was found to contain over 99 % of lead by weight. In recent studies in the U.S. inexpensive metallic jewellery were analysed and almost all of the items assayed were heavily leaded, exceeding 80 % lead by weight (average 44%). The results of the studies are presented in Appendix II. In Finland, randomly selected low cost jewellery from different stores were tested resulting in almost half of the jewellery turning out to be hazardous waste with high levels of cadmium and lead varying from 5 to 20.3%.

References: CDC 2007, Consumer Agency, 2008, EC 2009, van Engelen et al. 2006, Fairclough 2007, Helsingin Sanomat 2008, ICCM2 2008, Keml 2007, Maas et al, 2005, Massey et al. 2008, UNEP 2008a, van Arsdale et al. 2004, Weidenhamer & Clement 2007, Yost & Weidenhamer 2008

3.1.3 Leaded glass, ceramics, tableware and decorations

Lead oxide (PbO) has been added to glasses and glazes since ancient times as it improves the appearance of glass by increasing the refractive index, which makes the glass more sparkling. Lead oxide also decreases the melting temperature of the glass, which makes the glass softer and thus improves the cutting properties. The lead oxide content of crystal glass can be 6-32 % by weight. Full crystal glass contains 24 % or more of lead oxide while cheaper "semicrystal" glass contains 14-24 % of lead oxide. Lead crystal is used in many products including tableware (e.g. stemware, decanters and serving platters) and decorations (e.g. art objects, picture frames and lighting fixtures). Smaller additions of lead are made to some optical glass like binoculars and telescopes, and to ophthalmic glass for spectacles.

The use of lead compounds for glazing has a long history. Leaded glazes are still used in a wide range of products like tableware, wall and floor tiles, decorative items and some sanitary ware (e.g. toilets and washbasins) for a smooth, clear and scratch-free finish with good chemical durability. Lead also stabilizes decorating colours. Lead is added to the glaze as lead bisilicate frit. Lead compounds are also added to some enamels used on metals and glasses. In some countries lead containing enamels and glazes are still used.

Pewter is a tin based alloy that has been used for centuries for ornamental purposes and tableware. It can contain up to 50 % of lead. Leaded pewter is no more manufactured in significant amounts, but old pewter products may still be in use.

Leaded tableware can contaminate food and drink when the lead is dissolved. Very small amounts of lead can leach out of lead crystal vessels and lead-glazed ceramic ware during use, especially on exposure to organic acid. Such articles manufactured in the Western World are tested to ensure that leaching rate is acceptably low.

Nowadays lead is added to glazes in a frit form, which desolubilises and detoxifies the lead compounds, therefore lead in the glassware is part of an inert matrix, isolating lead from the environment.

Lead concentrations in old ceramic ware and ceramic ware produced outside the Western World may still be high enough to cause health risks. These items should not be used unless they are tested and proofed to be safe. There are lead test kits for home use on the market.

High concentrations of lead were found in a Finnish study on old ceramic tableware, where lead was found to be released in the leaching test at concentrations exceeding the maximum allowed concentration (4 mg/l) by 60 and 720 times. Even in the new tableware lead was found to be released and the limit value for children (0.05 mg/dm³).

References: Kuningaskuluttaja 2008a,b, Thornton et al. 2001, Tukker et al. 2001, UNEP 2008a,b, Van Sprang et al. 2008

3.1.4 Leaded pigments and paints

Many lead compounds are strongly coloured and highly durable, so they have been used in paints, pigments and even cosmetics. Lead compounds are also used as drying agents in paints. Typical lead contents in paints ready for use are 0.1-0.5 %. Lead compounds can also be found as pigments in wallpapers.

Lead compounds were widely used in pigments and paints before 1950, but later their use has significantly been reduced due to alternatives. Lead based paints are still widely manufactured and sold for use in many developing countries including China and India. Apart from domestic paint, lead based paint is still used in e.g. bridges, automobile parts and ships. The International POPs Elimination Network (IPEN) has studied the lead concentration in new decorative paints available and used in 10 developing countries and India. Of all the samples, 53 % were found to have lead concentration over 90 ppm and 50 % more than 600 ppm. The overall average lead concentration in decorative paints was 18220 ppm. The average new paint lead concentration in the ten developing countries ranged from 4091 ppm to 38970 ppm. For seven of the countries, the average was greater than 10000 ppm.

At present lead compounds are mainly used for a few specific applications like paints for historic building and artists' colours for restoration work. Also paints used for corrosion protection of steel, road markings and warning signs may still contain lead. Lead may be present as a natural impurity in a large number of raw materials used in the paint sector. According to the International Lead and Zinc Study Group, use of lead in pigments comprises 2 % (about 990 kilotonnes in 2007) of the global lead consumption. For instance in Japan, releases of lead and lead compounds from paint (non-targeted type of business) were estimated to be 112,562 kg in 2005.

Powdered lead metal has been used in paints for heavy duty corrosion protection. White lead, a mixture of lead carbonate, lead hydroxide and sometimes lead oxide, was widely used for white paint until the 1950's and may still be found in the walls of old buildings. Red lead was used besides for its colour as an anticorrosive pigment in rust inhibiting primers and it may still be used in many countries. Calcium plumbate pigment gives a good corrosion resistance for galvanised steel. Basic lead silicate has been used in cathodic electrodeposition primers for vehicles. Chrome yellows and molybdate oranges are lead chromate, molybdate and sulphate containing pigments, which are still in modern use. Lead chromate pigments represent approximately 1 % of total worldwide use of lead.

Lead can be released to environment as paint chips and dust when the old paint starts to deteriorate and during renovation, repairing and demolition. Dust can also result from the normal wear of paint, especially around doors and windows, and create an invisible film on the surfaces. After released to the air, lead particles can later settle in dust. The dust can be resuspended through e.g. cleaning. Lead from exterior paint can leach into soil and also be transferred to houses and other buildings.

No release estimation techniques for lead releases to the environment were documented though these releases are possible.

References: ATSDR 2007, BC Green Building Code 2007, CDC 2007, Cone 2008, ICCM2 2008, IFCS 2008, ILZSC 2008, Japan 2007, Järvinen et al. 2003, SFT 2007&2009, Thornton et al. 2001, Toxics Link 2009, Tukker et al. 2001, UNEP 2008a, b, US CPSC 2001

3.1.5 Plastic additives

Lead is used as stabilizer in plastics to protect the plastic from external factors, such as UV-radiation and heat and to improve the electrical and mechanical properties of the material. All lead stabilizers are generally based on nine different lead compounds. Lead stabilizers are only used in PVC plastics because their functioning mechanism is not relevant to other thermoplastics. In thermoplastics (e.g. polyethylene PE and polyvinyl chloride PVC) lead is used to prevent the material from degrading rapidly during manufacture and use and thus extending the lifetime of the product.

The main applications of lead stabilizers are in the construction industry, where they are principally used in rigid PVC products like building profiles such as window frames, electrical conduits, doors and conservatories; pipes, guttering and pipe fittings; and other products including rigid sheet and roof linings used outside. Lead compounds are also used in flexible vinyl cable for insulation of the wires as well as for foils and films. The largest use of lead stabilizers in cable insulation is for interior wiring of buildings, but they are also used e.g. in cars and household appliances. Lead has also been used as an additive in plastic bags to improve pigment and degradability properties.

Lead contents of PVC are in the range of 0.5–2.5 % lead. It has been estimated that approximately 3.2 million tons of lead were present in all the PVC products in use in 2000, and that about 156,000 tonnes of lead are used each year for the global production of PVC plastics. Lead stabilizers account for almost 70 % of all the PVC stabilizers in Europe. In 2000, the consumption of lead stabilizers in Europe was a total of 112,000 tonnes i.e. 70% of all PVC stabilizers, divided between pipes and gutters (40 t), cables (17 t) and profiles (57 t).

When the plastic is exposed to substances like sunlight, air, and detergents the chemical bond between the lead and plastics breaks down forming dust. Lead stabilizers can be released from the vinyl plastics during their use. The migration of lead from rigid PVC products is very low. However, lead is released from vinyl window blinds into the air and has been found to leach into water from PVC pipes, but quickly falling to a low level thereafter.

No release estimation techniques for lead releases to the environment were documented though these releases are possible.

References: CDC 2007, SFT, 2008, van Sprang et al. 2008, Thornton et al. 2001, Tukker et al. 2001, 2002, UNEP 2008, Vinyl2010 2009, Wilson 2003

3.1.6 New Year's tin and fireworks

New Year's tin may contain up to 90 % of lead. Lead from New Year's tin can get to the body through skin or from hands to mouth and to the digestion system. Lead vapours can be released when melting the tin.

Also fireworks contain heavy metals, including lead. Lead in the fireworks can have impact on the environment. It is difficult to estimate the amount of lead released into the air and also to identify the long-term effects in the environment that are specifically due to lead in the fireworks. Short-term effects can be seen soon after the fireworks as increased level of lead particles in the air. Recently, lead has been replaced in many firework products by aluminium.

No release estimation techniques for lead releases to the environment were documented though these releases are possible.

References: SYKE 2003, 2004

3.1.7 Weights

Lead can be found in balance weights in lifts, furniture, curtains, pianos, windmill wings, ventilators and analytical instruments, too. Uses of lead weights out of water are not expected to release more than a minimal amount of lead unless subject to regular abrasion.

References: Thornton et al. 2001, UNEP 2008a

3.2 Machinery, electronics and construction products

3.2.1 Cable sheathing

Lead is used as an impermeable protective sheathing material for power cables (including petrochemical industry and undersea) as well as in underground high voltage cables. Lead sheathing is used to protect the cable from moisture and corrosion. Nowadays the main application of leaded cable sheaths is undersea cables. In some other applications the use of lead sheathing has been reduced because aluminium sheaths and foils have replaced lead.

According to International Lead and Zinc Study Group, the use of lead in cable sheathing comprises 1 % (about 80 kilotonnes in 2007) of the global lead consumption. Use of lead in cable sheathing has decreased due to environmental concerns and alternative materials.

Concerns about lead in cable sheathing relate to possible corrosion. Small amounts of lead may dissolve during the use. The amount of lead dissolved during use depends on the composition of the water, corrosion rates in seawater being low. Also the material in which the cable is buried has an effect on the dissolving of lead. Tests from harbours around the world have shown losses of lead in a range of 2-15 μm annually. General corrosion rates of lead in different waters have been reported to be 2-20 μm per year. Some corrosion problems with underground cable sheathings have arisen because of an accumulation of water from incompletely cured concrete. This can be avoided by laying the cables in a bed of sand or gravel to ensure good drainage and allowing air to penetrate.

The influence of cable lead sheaths on the environment is considered relatively low, since most lead-sheathed cables have outer layers, which isolate them from the environment precluding any possibility of corrosion. This applies also for old cables left in the soil or on the seabed.

Release estimation techniques

According to Tukker et al. (2001), corrosion factor of 0.008 %/year can be used for all metallic applications of lead including cable sheathing.

The annual emission can be calculated as follows:

$$E = E_f \cdot A$$

E = emission (kg) to soil and water

E_f = emission factor ($8 \cdot 10^{-7}$ kg Pb / kg cable sheathing)

A = Weight of the cable sheathing (kg)

References: Blaskett and Boxall 1990, ILZSC 2008b, Thornton et al. 2001, UNEP 2008a, van Sprang et al. 2008

3.2.2. Lead comes

Lead comes have traditionally been used for stained glass windows for instance in churches and cathedrals. Nowadays stained glass windows are used widely also in modern homes. Lead comes, which consist of H- and U-shaped extruded sections of lead, hold together pieces of coloured glass. The joints are soldered together. Modern equivalent of lead comes is a flat self-adhesive extruded lead tape, but lead comes are still used as well.

No information is available in the literature of releases from leaded comes.

Reference: Thornton et al 2001

3.2.3 Lead pipes

Lead pipes have been used for instance in Central Europe. The use of lead in water pipes is phasing out due to health concerns and better alternatives (copper, plastics). No new lead pipes have been installed in most countries for over 30 years. Lead pipes might still be present in old buildings and distribution systems installed before the 1930's. Lead piping is still in use also in chemical industry, because of the excellent corrosion resistance of lead.

Although lead water pipes were displaced by copper, lead solder was still used in plumbing until the 1980s. The use of lead solder in pipes for potable water has been phased out, but there may still be lead solders used in copper pipes that have been installed before 1987.

The main sources of lead in drinking water are lead service pipes and household plumbing. The solubility of lead depends on the acidity and temperature of water as well as length of exposure to water. Acidic, soft water causes continuous slow corrosion, while in hard water (i.e. water containing dissolved lime compounds) some corrosion can occur initially, but a protective layer is quickly formed on the inside of pipes preventing further corrosion. Carbon dioxide or organic matter in water can increase the corrosion rate.

Lead pipes can slowly corrode in soil though the corrosion is very localized and the rate low. Lead releases tend to be rapidly bound by soil particles thus travelling only short distances. British experiments have shown that the corrosion rates of lead pipes in most of the British soils are 2.5-10 μm annually. The lowest corrosion rates were found in well-drained sandy soils, chalk and moist normal clay. In moist acid clay much higher annual corrosion rates were found; 150-170 μm for pure lead and 80-520 μm for lead-tellurium alloy. Even greater rates were found in wet acid peat. The corrosion rates were quite constant only slightly increasing with time.

Lead can be released to drinking water besides pipes also from lead-tin solder and brass fittings used in pipes. It was thought that the amount of lead leached into the water from the solder would be negligible, but later even small amounts of lead have been found detrimental to health. Lead can also be evaporated at small amounts during application of solder

Release estimation techniques

In the Netherlands, emissions of lead from water pipes made of lead to sewer have been estimated based on measurements in residential areas. Converted to emission factors, results were 1014 mg/capita of corrosion of lead per year in 1990 and 906 mg/capita in 1993. It was assumed that in the Netherlands 15 % of the houses still contained water pipes made of lead in 1990. Elsewhere in Europe the percentage might be different, so these emission factors represent solely the Dutch situation.

Emission of lead from water pipes can be calculated as follows:

$$E = E_f \cdot A$$

E = emission (kg)

$$E_f = 1.014 \cdot 10^{-3} \text{ kg/capita} \cdot (\text{share of the houses containing lead pipes (\%)} / 15)$$

A = population

For the calculation of emissions for other countries than the Netherlands, information is needed about the share of houses still containing lead pipes. However, the total stock of old lead pipes present is very difficult to estimate

References: BC Green building code 2007, GEPA 2000, Thornton et al. 2001, Tukker et al. 2001, UNEP 2008a

3.2.4 Lead solders in electronics, cars and food cans

The largest use of solders is in electronic industry and the lead-tin solder is the most widely used solder type. Lead-tin solder has been used for attaching the electronic components to printed circuit boards. Lead solders have also been used in cars, plumbing (Chapter 3.16) and food cans. Nowadays most of the food containing cans are lead-free.

The proportion of lead in the solder varies in different applications. The melting point of the alloy is 183 °C if the proportion is 63 % of tin and 37 % of lead. The low temperature means that the processes are not so sensitive to temperature change and also there is less strain on the materials and equipment. This makes lead-tin solder very durable and reliable.

When melting lead-tin solder, lead vapour is formed. The vapour contains small particles of lead, which can be inhaled. Lead can also be evaporated at small amounts during application of solder.

Release estimation techniques

The corrosion factor of 0.008 %/year can be used for lead alloys including solders. Releases from the use of lead containing alloys are considered to be negligible and most of the releases are expected to take place in the disposal of products.

References: ATSDR 2007, Black 2005, EC 2002, Keml 2007, Thornton et al. 2001, Tukker et al. 2001, UNEP 2008a

3.2.5 Radiation shielding in electronic and construction industries

Lead is used to provide protection from certain types of radiation, most commonly gamma and X-rays. High density, low absorption of neutrons and good optical properties makes lead an effective shielding material. Significant quantities of lead are used in the nuclear power industry, hospitals, dental surgeries and laboratories.

For radiation shielding purposes, both metallic lead (lead sheets) and leaded glass is used:

- Typical applications of lead sheets are containers for radioactive materials and linings for rooms containing X-ray equipment. In the United States 27 % of the lead sheet consumption goes to radiation shielding and in Japan the proportion is as high as 70 %.
- Leaded glass is used for viewing X-ray equipment and radioactive materials from behind a safe screen
- Leaded glass is used in the electronics for cathode ray tubes in television sets and computer monitors to protect viewers from the X-rays produced by the tube. In the future, the cathode ray tube technology will phase out and be replaced by flat panel technology, which do not produce X-rays. Flat panels, especially plasma display panels, also contain leaded glass, but for different purpose and much lower concentrations per panel compared to cathode ray tubes.

Releases of lead from the use of lead sheets for radiation shielding are expected to be negligible. The largest releases will probably take place in the waste handling stage.

References: Fairclough 2007, Thornton et al. 2001, Tukker et al. 2001, UNEP 2008a,b, van Sprang et al. 2008

3.2.6 Lead sheets in roofing and flashings

One important application of lead is the use of lead sheets mainly in building and construction industry where they have been used as e.g. in cladding, guttering and roof parapets. Lead sheets are also used in some extent in the chemical industry.

Applications of lead sheets:

- Most of the lead sheets are used for flashings and weatherings to provide watertight seals and resistance to wind lift. They are used to cover joints where roofs and walls meet in structures like chimney stacks, windows and abutments.
- Lead sheets can be used for complete roofing systems, sections of roofs and for cladding of vertical surfaces. Roofing and cladding are used both for their aesthetic appeal and functional properties (e.g. durability and weatherproofing). They have been traditionally used for cathedrals and other historic buildings, but also for modern constructional uses.
- Layers of lead can also be placed into walls as a part of a sound insulation system or used for damp proofing. Lead is excellent for noise attenuation due to its high density. Lead sheets are usually bonded to a surface of other material e.g. plywood for support.
- Radiation shielding (see Chapter 3.3.5)
- Lead is also used in the linings of reaction vessels and tanks as well as other pieces of chemical plant for its corrosion resistance properties. It is also occasionally used in the tanks and vessels of building industry for its maintenance free properties. This is nowadays a minor application of lead sheets due to synthetic materials.

Lead sheets have been used especially in Central Europe, mainly in the United Kingdom, the Netherlands, Belgium, Ireland Germany and France . More than half of the lead sheet in the EU are used in the UK. In North America, lead sheets are used in small amounts in building construction, e.g. as maintenance-free waterproof membranes, but not in roofing. In Japan, 30 % of lead sheets are used for sound insulation and the rest in radiation shielding (Chapter 3.15).

Due to the slow corrosion of lead, releases to the environment may occur. There is evidence that lead due to run-off can dissolve into rainwater or be abraded during the roof lifetime.

When lead sheet is exposed to air, it rapidly forms a layer of oxide on its surface. This reacts further with water to form lead hydroxide and with carbon dioxide forming lead carbonate, which has very low solubility and gives good protection. Leaded roofs in areas subject to high levels of sulphur dioxide have very good stability due to the formation of lead sulphate layer, which has very low solubility in both water and dilute sulphuric acid. Corrosion rate might be accelerated, if there are lichens on tiled roof. Also if the design of the roof allows condensation to occur underneath, corrosion might happen. The combined use of lead and aluminium roofing is not recommended in marine environment, because the corrosion of lead can accelerate the corrosion of aluminium. Fresh metal surface can only be exposed under normal conditions through small cracks in the protective layer resulting from temperature variations. Patination oils can be used for added protection of the lead surface.

The amount of rainfall, temperature and pH controls the run-off rate. Rainwater is mildly acidic (e.g. carbonic, sulphuric and nitric acids) and might thus dissolve some of the corrosion products. Also the alloy composition of the lead sheet has an effect on the run-off rate. Flashings installed on roofs have lower run-off rate than lead sheet test samples due to orientation of the sheet, shelter effects, evaporation rates and the alkalinity of the building material (bricks, cement and roofing tiles).

Releases from the use of lead sheets for soundproofing is expected to be negligible. The largest releases will probably take place in the waste handling stage.

Release estimation techniques

Corrosion of lead of 5 g/m² of exposed area per year is usually used to estimate the emission of lead from lead sheets. It has also been stated that this approximated corrosion rate might be above the actual rate, because it is based on old measurements (possibly on thinner lead sheets) and because corrosion might also decline in time due to the formation of metal oxides and sulphides.

Releases of lead to the environment from lead sheets can be calculated as follows (van Hyfte and Callebaut 2007):

$$E = E_f \cdot A$$

E = emission of lead (in solid form) (kg)

E_f = run-off factor for lead (kg/m²) per year

A = exposed area of leaded roofing (m²)

The equation does not take into account that corrosion may decrease during time.

According Dutch estimations, 50 % of the lead sheet is used in residential buildings and 50 % in utility buildings. Approximately 25 % of the total amount of lead sheet used in residential buildings and 20 % of the lead sheet in utility buildings is exposed to atmosphere and water. If it is assumed that the exposed area is 25% of the total area of lead sheet, this leads to annual emissions of 120-150 tonnes of lead in the Netherlands. When taking into account the annual emissions and the estimated total stock of lead sheet used in buildings, the corrosion rate of 5 g/m² implies an emission factor of 0.008-0.01 % of the lead stock per year. In their study to estimate the emissions of lead from lead sheets used in buildings in the EU15³⁸, If an emission factor of 0.008 %/year is used and assumed that 75 % of the run-off of lead will end up in the soil (50 % will be emitted directly to soil and 50 % will end up in the sewage system from which 25 % of the sludge will be applied as a fertilizer on land). This results an emission of 0.006 % of lead to soil from the stock of lead sheet in the EU.

Van Hyfte and Callebaut (2007) made difference between the emissions from roofing and flashings and also with emissions from residential and utility buildings. Most of the emissions from lead sheet comes from flashings, which account from 85 % to 95 % of the total area. Roofing accounts only from 5 % to 15 % of the total area. The average mass per unit area of the sheet is estimated to be from 13.6 kg/m² to 18.1 kg/m². Another run-off rate (Wilson 2003) of flashings is 0.88 g/m² and that of roofing is 5 g/m². The division factor of emissions to soil from residential buildings is 0.3 and 0.15 to surface water (assuming an average connection rate of 85 % to the sewage system) In utility buildings the division factor for soil is 0.80 and that for the sewage system is 0.20. The emissions to the water compartment will not reach the surface water directly.

References: Van Hyfte and Callebaut 2007, van Sprang et al. 2008, Thornton et al. 2001, Tukker et al. 2001, Wilson 2003

³⁸ EU15 = Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom.

3.2.7 Lead in sealants and caulk

Lead has been used as a hardener in elastic polysulfide sealants and caulk in buildings. The use of lead in sealants decreased after the mid of 1970's when manganese (Mn) based hardeners were developed, but lead has also been found in sealing materials in buildings constructed in the 1980's. According to the literature the amount of lead used in polysulphide sealants have been up to 5 % of total sealant use. No information of releases from the use is available.

References: ATSDR 2007, Finnish Ministry of the Environment 2008, ref. Pyy & Lyly 1998

3.3 Fishing gear and ammunition

3.3.1 Weights in fishing gear

Lead-containing weights are used as sinkers and fishing net weights. It has been estimated that from 2,000 to 8,000 tonnes of lead have been loosed with fishing equipment used for both angling and commercial fishing in the EU area.

Underwater applications of lead will very slowly corrode. Weight loss is estimated to be of the order of 2–25 mg/cm² of exposed area per year (corrosion rate of 2-20 µm/year). Corrosion rate of 0.008 % has been assumed for fishing sinkers lost in inland waters. It has also been stated, that the corrosion rate will decrease in time, so the first year may be the most important. Lost fishing sinkers comprise 15% of the estimated lead emissions to water for EU15.

Lead weights for commercial fishing nets need to be replaced regularly, perhaps every 6 months. Weight loss would not only be from corrosion, but abrasion on the sea bed. This would result in lead falling to the sea bed where slowly dissolving and eventually becoming incorporated into sediments.

Small lead weights might get ingested by waterfowl, which causes intoxications, enhances the mortality rate and debases the breeding of these birds. or may also be dissolved into water through corrosion.

Small lead weights are banned in certain areas because of the risk of birds ingesting them.

Release estimation techniques

The number of lost sinkers can be derived from population ratios as extrapolation factor using information in the Dutch and Danish studies (van Hyfte and Callebaut 2007): 1-3 kilotonnes of fishing sinkers is assumed to be lost annually to inland waters in the EU area (EU15)³⁹. The annual loss of lead in the environment can be considered constant, with a yearly corrosion rate of 0.008 %. Thus emission to the water/sediment would total 0.03 kilotonnes per year.

³⁹ EU15 = Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom.

It is estimated that the average lead loss from sinkers per one angler could be 0.8 kg per year and that 1 % of the lead in the lost sinkers is corroded in the first year. The corrosion rate will decrease in time, so the first year is the most important.

A rough estimate of lead releases to water can be calculated as follows:

$$E = E_f \cdot A$$

E = emission (kg)

$E_f = 0.01$

A = amount of lead in sinkers lost / year (kg) (could be e.g. the number or volume of weights sold)

The equation is assuming that lead is dissolved only in the first year.

References: van Hyfte and Callebaut 2007, Thornton et al. 2001, Tukker et al 2001, UNEP 2008a

3.3.2 Ammunition

The use of lead in ammunition comprises 3 % (about 240 kilotonnes in 2007) of the global lead metal consumption. Lead is used in ammunition because of its high density giving the ammunition more power and longer range and also with minimal abrasion to the gun. The major application of lead in ammunition is lead shots used for shotguns. Other applications include bullets used for rifles and pistols and also lead pellets. Shots are estimated to account approximately 90 % of the yearly consumption of lead in ammunition in the European Union (EU15⁴⁰ area) while bullets and pellets account only 10 %. The biggest consumers of lead in ammunition in year 2003 were Germany, France, United Kingdom, Spain and Italy. Besides ammunition, lead shots (fine lead shots) are also used for alloys in steel and brass industry.

Lead shots can result in significant inputs of lead to soils, surface waters and sediments. It has been shown that the lead load from ammunition can be much higher than that caused by the air deposition in locally contaminated areas. According to the European Lead Industry studies, around 70% of lead releases to water in and 97% of lead releases to soil in Europe originate from ammunition, while there are no lead releases from ammunition into the air.

Possible substitutes for lead shots that are less toxic to animals and in the environment include for instance steel, bismuth and wolfram (tungsten). Copper can be used as substitute for lead bullets. However, also copper bullets can give rise to locally contaminated areas.

Lead from ammunition end up in the nature and the weathering of lead bullets and shots has led to heavily contaminated soils at shooting ranges. From contaminated soil lead might drift to groundwater and cause health risks if this water is used as drinking water. Also waterfowl can dredge up lead shots from the bottom mud resulting in acute poisoning and debases the breeding of these birds. The weathering products depend on soil properties, the most important of which is soil pH. It has been demonstrated that in acid sandy soil the transformation products are soluble and may be mobile in the soil, while in soils with a high pH and/or a high content of organic matter the transformation products are only sparingly soluble. Oxidation of lead to Pb^{2+} , precipitation of sparingly soluble lead compounds

⁴⁰ EU15 = Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom.

(carbonates, sulphate and phosphates) and retention of lead by soil components are important processes for the transformation of metallic lead into lead compounds in soil.

The amount of lead from lead shots is significantly higher than from lead bullets and also spreads wider than from lead bullets. Many countries have set restrictions or bans for the use of lead shots. For instance in Sweden this ban has been effective for many years in wetland hunting, but still a significant cause of death for wild ducks, geese, swans and eagles is lead poisoning. Birds of prey that eat seabirds can be poisoned by lead. Recent international studies have shown that also land-living birds, like doves, cranes and gallinaceous birds, peck lead shots, which may cause intoxication.

Release estimation techniques

The weathering rate at which lead is transferred and entered the environment has been estimated to be approximately 1 % per year and the initial weathering rate of lead containing ammunition to be 0.2-2 % annually. Most studies have used a worst case corrosion rate of 1 % per year. Corrosion is highest during the first years decreasing to about half of the initial rate after two to three years. After that the corrosion rate will gradually decrease in time. There can be differences in the corrosion rates of different shooting activities, e.g. clay target shooting and hunting. In Sweden it has been observed that an average of 4.8 % of metallic lead in the pellets has been transformed to lead carbonate and lead sulphate in the soil in a period of 20-25 years.

Rough estimates for lead release to the *soil* can be calculated as follows:

$$E = E_f \cdot A \cdot 0.01$$

E = emission

A = number of leaded bullets shot annually

E_f = volume of lead in the bullets shot annually (the yearly corrosion of lead from ammunition is assumed to be 1% of lead from the stock of ammunition in the environment)

Rough estimates for lead releases to *air, soil and water*:

$$E = \sum_a \left[\sum_b (E_f \cdot A \cdot D_f) \right]$$

E = emission of lead (in solid form)

a = different activities in which lead containing ammunition is used

b = different types of lead containing ammunition used per activity (a)

E_f = emission factor (amount of lead per ammunition unit per type:

Clay target shooting: 26 gPb/shot shell

Hunting: 32 gPb/shot shell, 7 gPb/centerfire rifle/pistol/revolver,

3.93 gPb/bullet >1993 and 6.86 gPb/bullet >1993

A = amount of lead containing ammunition used per activity (a) and type (b)

D_f = distribution factor; distribution of the emitted lead to different compartments (air, soil, water): soil 0.85 and water 0.15 (1% of Pb dissolutes annually)

Activities marked with (a) include: hunting (dry land and wetland), clay target shooting (trap and skeet), sporting clays and other target shooting (indoors and outdoors). Activities

marked with (b) include: shotgun (shots) and rifle cartridges (bullets) for hunting and shot shell cartridges for clay target shooting.

The amount of lead emitted to the environment depends on the average weight of lead per round used. Cumulative emissions can be calculated by including both current and historical emissions of leaded ammunition.

References: Cao et al. 2003, Hansen et al. 2004, ILZSG 2008b, Jørgensen and Willems 1987, Keml 2008, Lin et al. 1995, Naumanen et al. 2002, SFT 2009, van Sprang et al. 2008, Thornton et al. 2001, Tukker et al. 2001, UNEP 2008a, b

3.4 Other sources

3.4.1 Collector shoes in rail transport

NOTE: This source is already included in the reporting to UNECE CLRTAP and does therefore not directly fall under the scope of this project. However, the information is presented to enable completing possible lacks in national inventories.

It is estimated that collector shoes used in rail transport contain 10% of lead. Lead is released to the environment due to the wear of collector shoes. 20 % of the released lead ends up in air, 5 % in water and 65 % in soil. 10 % of the dust will attach to the train surface and will be caught by the washing system.

Release estimation techniques

Releases of lead from collector shoes can be estimated using an emission factor of 10 mg/kWh and information about the consumption of electricity in rail transport.

Releases to water from collector shoes can be calculated as follows:

$$E = E_f \cdot A \cdot C$$

E = emission (kg)

$E_f = 10 \cdot 10^{-6}$ kg dust/kWh

C = 10%, lead content of collector shoes

A = consumption of electricity in rail transport (kWh) per year

Shares of releases to air: 0.2, water 0.05 and soil 0.65. The remaining 10% of the lead dust will not reach the environment but will attach to the train surface and will be caught by the washing system.

Reference: van Hyfte and Callebaut 2007

3.4.2 Petrol additives

NOTE: This source is already included in the reporting to UNECE CLRTAP and does therefore not directly fall under the scope of this project. However, the information is presented to enable completing possible lacks in national inventories.

Organic lead compounds were added to petrol since 1920's to improve the performance at low cost. The lead compounds used were tetraethyl lead and tetra methyl lead. Lead improves the efficiency of the petrol by acting as an anti-knocking agent. Lead also acts as a

lubricant on the valve seats. The use of lead additives in petrol ceased between 1990-2000 in many countries. Petrol additives used to be the major source of lead emissions into the air due to use of leaded petrol in road transportation.

Tetraethyl lead can still be used in petrol for off-road vehicles and for some propeller-driven aircrafts (so called AVGAS). For instance Norway and Sweden have estimated these releases resulting in 2.5 tonnes in Norway and 5 tonnes in Sweden in 2002.

The use of lead in petrol has drastically decreased in recent decades all over the world. Regulations on the amount of lead in air came into force in year 2000. The EU Directive (98/70/EC) on the quality of petrol and diesel fuels prohibits the marketing of leaded petrol. Exemptions include petrol for aircraft (small propeller planes). The sale of leaded petrol ceased in the majority of countries in 1990-2000. The UNEP Partnership for Clean Fuels and Vehicles (PCFV) is monitoring globally the development on phasing out of leaded petrol. In August 2008 there were two countries (Democratic People's Republic of Korea and Myanmar) that use only leaded petrol and seven countries using both leaded and unleaded petrol. There were also few countries from which there were no data. The majority of the countries still using leaded petrol are in the Asia-Pacific region. In Canada leaded petrol was removed from the market in 1990 (Ontario 2008), In the United States in 1996 and in the EU in 2000. The ban does not include fuel used in aircraft, race cars and non-road engines like farm equipment engines and marine engines.

Release estimation techniques

In Europe the maximum content of lead in petrol was around 0.4 g/l in the 1990's and was limited to 0.15 g/l by year 2001 in most of the countries. In the 1980's the lead content of petrol was generally around 0.7 g/l. In some countries, higher levels of lead are permitted.

The emission of leaded petrol can be calculated as follows:

$$E = E_f \cdot A$$

E = emission (kg)

E_f = emission factor (kg/l), e.g. 0.7 g/l

A = amount of leaded petrol consumed annually (l)

References: ATSDR 2007, LIPASTO 2009, PCFV 2008, Thornton et al. 2001, UNEP 2008a, b

3.4.3 Propeller shaft grease

Propeller shaft grease is used for greasing sterntube glands in boats. This grease contains about 1.7 % lead. Lead from propeller shaft grease is directly released to the surface water.

Release estimation techniques

It is estimated, that a boat with a greased sterntube⁴¹ gland uses about 152.2 kg grease per year and that about 60 % of the grease will be emitted in the surface water. Because the lead content of the grease is 1.7 %, emission factor of 1.6 kg lead per boat with greased sterntube gland can be used. Emission factor of 1.28 kg per boat per year, which does not require the

⁴¹ Sterntube = propeller shaft tube

knowledge of the amounts of boats with greased sterntube gland, is used for instance in the Dutch emission inventory.

Emission of lead to water can be calculated as follows (Van Hyfte and Callebaut 2007):

$$E = E_f \cdot A$$

E = emission (kg)

$E_f = 1.6 \text{ kg/boat/year} \cdot (\text{amount of boats with greased sterntube gland} / \text{total amount of boats})$

A = amount of boats

Reference: van Hyfte and Callebaut 2007

3.4.4 Tyres and brake linings

NOTE: This source is already included in the reporting to UNECE CLRTAP and does therefore not directly fall under the scope of this project. However, the information is presented to enable completing possible lacks in national inventories.

Lead is used in tyre and brake wear of vehicles. Breaks and tyres are a source of metal emissions, including lead, as the break linings and tyre treads wear down.

Release estimation techniques

In a Swedish study, emissions of lead from brake linings were found to be about one tenth of lower in 2005 compared to levels in 1998. This implies that manufacturers have reduced the lead concentrations of brake linings. Also the lead emissions from tyre treads in 2005 were lower than in those measured in 1995, but this may be due to lack of data.

Lead emissions into the air from tyre and brake wear can be calculated as follows (van Hyfte and Callebaut 2007) or alternatively using emission factors applied in the Nordic countries' emission inventories (Appendix 4):

$$E = E_f \cdot A$$

E = emission (kg/year)

$E_f = \text{emission factor for dust per vehicle (mg dust/km)}$

A = amount of kilometres travelled per vehicle type (km)

The lead content of dust emitted from tyre wear is estimated to be 0.016 % and from brake wear 0.005 %. The emission factors of tyre wear were calculated based on total emission of dust per tyre and the number of tyres per vehicle. The emission factors for brake wear were taken from literature.

References: Fountain 2007, Hjortenkrans et al. 2007, UNEP 2008b

3.4.5 Underwater weight applications

Other weights used in underwater applications include diving belt weights and yacht keels might contain lead. Yacht keels, like other underwater applications, will slowly corrode.

Release estimation techniques

For underwater applications, weight loss due to corrosion is estimated to be of the order of 2-25 mg/cm² of exposed area per year. The assumed corrosion rate is 2-20 µm/year. (Thornton et al. 2001.)

Emission of lead to water can be calculated as follows:

$$E = E_f \cdot A$$

E = emission (kg)

$E_f = 0.135 \text{ mg/m}^2 \cdot \text{number of days when the product is in water}/365$ (mean of weight loss results/a)

A = exposed area (m²)

References: Thornton 2001, UNEP 2008b

3.4.6 Wheel balance weights

NOTE: For emissions to air, this source is already included in the reporting to UNECE CLRTAP and does therefore not directly fall under the scope of this project. However, the information is presented to enable completing possible lacks in national inventories.

Most balance weights in vehicles contain lead. According to a German report, each car is equipped with 10 weights of 20-25 g, which sums up to 200-250 g lead per car. In the Swedish study the average weight of balance weights made of lead in one car is 163 g for passenger cars and 367 g for trucks. In the U.S., average weight of wheel weights in a car wheel is 2.5 oz (about 71 g). An amount of 28,000 tonnes of lead were used in the production of wheel weights in the U.S. in 2003, and 65,000 tonnes were attached to vehicles.

Leaded weights have not been used in new cars manufactured after 2003.

Lead from wheel balance weights in vehicles ends up in the environment, when weights are lost and pulverised by traffic. Lead emissions occur also due to the surface corrosion of the balance weights. Releases from lead wheel balance weights are expected to be minimal unless subjected to regular abrasion. The corrosion rate can be reduced by using plastic coated weights.

Release estimation techniques

Releases from balance weights in vehicles can be estimated based on the average number of balance weights for the various types of vehicles, the estimation of the share of lost weights and the corrosion rate. It is estimated that 1 % of the vehicles lose balance weights from one tyre during the life of the tyres, and that the average weight of balance weights made of lead in one car is 163 g for passenger cars and 367 g for trucks (Table 5). From this, emission factors for the loss of balance weights can be calculated to be 107.2 mg lead/passenger car and 285.5 mg lead/truck per year.

Table 5. Emission and corrosion factors for Pb releases from wheel balance weights for different vehicles (Hillenbrand et al. 2005)

Vehicle type	EF (mg/vehicle)	Korrosion EF (mg/vehicle)
Mopeds	26,8	5,5
Motorcycles	53,6	11,0
Passenger car	107,2	21,9
Busses	429,0	87,6
Trucks and lorries	285,5	60,6
Trailers	285,5	60,6
Other vehicles	115,0	23,6

Releases of lead to the *soil* from the loss of balance weights can be calculated as follows:

$$E = E_f \cdot A$$

E = emission (kg)

E_f = annual corrosion of lead: $4.075 \cdot 10^{-4}$ kg / tyre (passenger cars) or $5.243 \cdot 10^{-4}$ kg / tyre (trucks)

A = amount of tyres purchased annually and balanced with lead weights

The equation includes the assumption that 1% of leaded weights is lost annually. In the U.S., it has been estimated that 3 % of the wheel weights get lost along roadways.

Releases of lead to *water and soil* from the corrosion of balance weights can be calculated as follows:

$$E = E_f \cdot A$$

E = emission (kg)

E_f = $2.19 \cdot 10^{-5}$ kg / vehicle per year (passenger cars) or $6.06 \cdot 10^{-5}$ kg / vehicle per year (trucks)

A = amount of vehicles with lead balance weights / vehicle type

A corrosion rate of 7.3 g/m²/year has been used for calculating the releases of lead from corrosion of wheel weights. In Germany it has been measured, that the area of balance weights exposed to corrosion is 30 cm² in a passenger car and 83 cm² in a truck. This leads to emission factors of 21.9 mg lead/passenger car and 60.6 mg lead/truck per year. In another study it was estimate that 0.088 g of lead is released through corrosion during the vehicles lifetime of 12 years. This was considered to be an underestimation, because of the assumption that the surface area of balance weights per vehicle is 10 cm², when it should be at least 32 cm². Releases of lead from the loss of balance weights have been estimated by collecting balance weights by the roadsides. In New Mexico (USA), annual lead deposition at one intersection in Albuquerque was 50-70 kg/kg.

References: Christen 2006, Hillenbrand et al. 2005, Lohse et al. 2001, Root 2000, Steil 1999/2000, Thornton et al. 2001

3.5 Minor applications of lead and lead compounds in products

Releases from these applications are considered to be unlikely or alternatively very small. No release estimation techniques were available for these sources.

Bitumen

Lead compounds can also be found in bitumen used in roofing, wall covering and flooring. No information on possible releases from the use has been documented. Releases possible during waste handling.

Reference: SFT 2007

Candle wicks

Leaded candle wicks are banned in the United States, Canada, Australia and Denmark. They are also restricted for indoor use in Finland. There is a voluntary agreement between European manufacturers to remove leaded candle wicks from the EU market. Lead containing candle wicks can be found in some scented or gel candles. When the candles are lit, the lead vapour is released to the air. Releases are also possible during waste handling.

References: Keml 2007, UNEP 2008a

Capsules for wine bottles

Lead capsules are prohibited by a 1990 European Directive. The use of lead foil wrappers on wine bottles is also banned in the United States. Tin, plastic or aluminium has replaced lead. No information on possible releases from the use has been documented. Releases possible during waste handling.

References: Thornton et al. 2001, UNEP 2008a

Lead strips for tennis racquets

Lead strips are used for the customization of tennis racquets. They were formerly added by the manufacturer to increase weight. No information on possible releases from the use has been documented. Releases possible during waste handling.

Reference: Wikipedia 2009a

Lead powder

Lead powder has been used in some plastics for protection of radiation and in some paints protecting steel from corrosion. No information on possible releases from the use has been documented. Releases possible during waste handling.

Reference: Thornton et al. 2001

Pesticides and fertilizers

Lead arsenate, basic lead arsenate and lead arsenite were used as herbicides, insecticides and rodenticides before 1960's. They were especially used to control pests in fruit orchards. The use of lead arsenate as insecticide was banned in 1988 in the United States and there have been no lead containing pesticides in the country since 1992. Releases can occur to both air and soil.

Phosphate fertilisers can be contaminated with lead. Also e.g. sewage sludge and manure used as fertiliser can contain lead originated from other products, like lead sheets and water pipes. Use of lead contaminated fertilisers results to lead releases to the environment.

References: ATSDR 2007, Tukker et al. 2001, UNEP 2008a

Pharmaceuticals and nutritional products

Lead contamination can be found e.g. in calcium or bismuth based pharmaceuticals and nutritional products. Releases from the use of these products will end up to wastewater treatment plants if the sewerage system is connected to these plants.

References: Kauffman et al. 2007

Security seals

Lead has been used in security seals, where it could be replaced by aluminium or plastic. No information on possible releases from the use has been documented. Releases possible during waste handling.

References: Thornton et al. 2001, UNEP 2008b

Semiconductors

Lead-based semiconductors (e.g. lead-telluride, lead selenide and lead antimonide) are used in solar energy cells and infrared detectors. No information on possible releases from the use has been documented. Releases possible during waste handling.

Reference: Wikipedia 2009a

Statues and sculptures

Lead is still used in making statues and sculptures. No information on possible releases from the use has been documented. Releases possible during waste handling.

Reference: Wikipedia 2009a

Terne plate

Terne plate is a thin steel plate coated with mixture of lead and tin, out of which e.g. 80 % is lead. They are used for instance in petrol tanks of vehicles. Lead gives the product resistance to corrosion while steel gives mechanical strength and durability.

The corrosion factor of 0.008 %/year can also be used for lead alloys including terne plates, brasses and bronzes. However, the releases can be considered negligible. Most of the releases are expected to take place in the disposal of products.

References: Thornton et al. 2001, Tukker et al. 2001 UNEP 2008b, Wikipedia 2009c

Bronze, steel and aluminium used in car manufacturing

In modern alloys of copper, steel and aluminium, lead is added to improve the machinability. The lead addition of aluminium alloys is less than 4 % and these alloys are mainly used for automotive industry. Aluminium casting alloys can contain up to 0.35 % (typically 0.1 %) of lead. Steels can also contain up to 0.35 % of lead. Lead has been reported to improve the machinability of steel by 30 %. Bronzes can contain from 1.5 % to 3.5 % of lead.

No information on possible releases from the use has been documented. Releases possible during waste handling.

Reference: Thornton et al. 2001

Bearings

Lead-tin based alloys are one type of bearings with advantage of good lubrication and low cost. Also bronzes, with up to 20 % of lead, are used in bearings in heavy-duty application. Aluminium-lead alloy is also one type of bearing material. The number of lead-based

bearings used is very small compared with other metals. Lead-tin-antimony alloys have been used as pieces for typesetting in letterpress printing

No information on possible releases from the use has been documented. Releases possible during waste handling.

References: Thornton et al 2001, Tukker et al. 2001

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5 Appendixes to the Case Study on Lead

5.1 Appendix I Information on lead and lead compounds

Table A1.1. Former and current uses of lead compounds (ATSDR 2007)

Compound	Uses
Lead acetate	Dyeing of textiles, waterproofing, varnishes, lead driers, chrome pigments, gold cyanidation process, insecticide, anti-fouling paints, analytical reagent, hair dye
Lead azide	Primary detonating compound for high explosives
Lead bromide	Photopolymerization catalyst, inorganic filler in fire-retardant plastics, general purpose welding flux
Lead chloride	Preparation of lead salts, lead chromate pigments, analytical reagent
Lead chromate	Pigment in industrial paints, rubber, plastics, ceramic coatings; organic analysis
Lead fluoborate	Salt for electroplating lead; can be mixed with stannous fluoborate to electroplate any composition of tin and lead as an alloy
Lead iodide	Bronzing, printing, photography, cloud seeding
Lead molybdate	Analytical chemistry, pigments
Lead nitrate	Lead salts, mordant in dyeing and printing calico, matches, mordant for staining mother of pearl, oxidizer in the dye industry, sensitizer in photography, explosives, tanning, process engraving, and lithography
Lead oxide, black	Storage batteries, ceramic cements and fluxes, pottery and glazes, glass, chromium pigments, oil refining, varnishes, paints, enamels, assay of precious metal ores, manufacture of red lead, cement (with glycerol), acid-resisting compositions, match-head compositions, other lead compounds, rubber accelerator
Lead phosphate	Stabilizing agent in plastics
Lead styphnate	Primary explosive
Lead sulfate	Storage batteries, paints, ceramics, pigments, Electrical and other vinyl compounds requiring high heat stability
Lead sulfide	Ceramics, infrared radiation detector, semi-conductor, ceramic glaze, source of lead
Tetraethyl lead	Anti-knock agent in aviation gasoline

Sources: Boileau et al. 1987; Carr 1995; EPA 2001

Table A1.2. Metallic lead applications and the extent of current use (UNEP 2008a)

Application	Extent of current use
Metallic lead	
Batteries (lead is actually present in batteries in both metallic form and as lead compounds)	General - principal application of lead
Cable sheathing (mainly underground and undersea cables)	General
Sheets for roofing/flashings in building	General - regional variation
Sheets for corrosion protection in chemical industry	General
Lead comes of stained glass windows	General - regional variation
Ammunition (lead shot, rifle bullets, etc.)	General - lead shot for certain applications banned or restricted in many countries
Brass used for taps, fittings, etc. (copper alloys with typically 2-3% lead)	General
Bronzes for fittings, bearings, etc. (typically 2-25% lead)	General
Steel and aluminium alloys for drilling, boring and turning, etc. (typically <0.35%)	General
Bearings made of tin-lead alloys	General

Table A1.3. Lead compound applications and the extent of current use (UNEP 2008a)

Application	Extent of current use
Lead compounds	
Solders (lead-tin alloys for electronics, cans, electric light bulbs, auto radiators and plumbing)	General, in the process of being substituted in some countries
Hot dip galvanising (zinc with up to 1% lead)	General
Weights for fishing tools and anchors	General
Balancing weights for vehicles, windmills, rotors, etc.	General, restricted in some countries for vehicles
Plating (in particular of gasoline tanks)	General
Yacht keels/ballast	General
Pipes and joints for water supply and drain	Not used in most countries for new water supply installations. May, however, be present in installations in older buildings in many countries
Radiation shielding (sheets, clothing, films, etc.)	General
Tin-lead alloys (pewter) for organ pipes, lead soldiers, figures, ornaments, tableware, etc.	General
Tank linings, pumps, valves, pipes, and heating and cooling coils in chemical operations using sulphuric acid or sulphate solutions	General
Printing type	More or less phased out by technology changes
Candle wicks	Candle wicks containing lead have been banned in Australia, U.S.A., Canada and Denmark and are also restricted for indoor use in Finland. They are in reality also removed from the market in the EU due to a voluntary agreement between European manufacturers (Hansen <i>et al.</i> , 2004a).
Capsules or foil wrap for wine bottles	Not used in most countries - banned or restricted in many countries
Weights for scuba diving	General
Other marginal applications: Curtain weight, security seals, fuses, lead powder for some corrosion protective paints, lead hammers, truncheons, battery cable clamps, anodes for zinc and manganese electroplating)	General
Dental amalgams	Reported in Burkina Faso's submission, 2005 but in general lead is not used for amalgams
Jewellery	Reported from the U.S.A. (Maas <i>et al.</i> 2005)
Gasoline additives (tetraethyl lead and tetramethyl lead)	Phased out in most countries, but still in use in about 26 countries (by June 2006)
PVC stabilisers (many compounds)	General
Pigments for paints and artistic paints (lead chromates and molybdates, calcium plumbate, white lead)	White lead banned or restricted in several countries. Other lead pigments only restricted in a few countries.
Pigments for plastics (lead chromates and molybdates)	General
Rust-inhibitive primers (red lead)	General
Drying agent in varnish and paint (lead naphthanate)	General for some paint types - phased out for many applications in some countries
Hardening agent in polysulphide rubber	?
Glass of cathode ray tubes of TV-sets and monitors	General - until recently the main application of lead compounds - is being phased out by technology changes
Other uses as glass (optical glass, filter glass, crystal glass, plasma display panels, fluorescent lamps, light bulbs, etc.)	General

Application	Extent of current use
Lead compounds	
Glassing and enamel (porcelain, tile, ceramics, enamelled iron, etc.)	General, different types are applied
Ceramic elements in electronics (piezo-electric devices, capacitors, etc.)	General
Automotive brake linings (lead sulphite)	General - banned or restricted in some countries
Explosives (lead styphnate, lead azide)	General
Fireworks	General - banned or restricted in some countries
Laboratory chemicals	General
Antiseptics	Mentioned by Japan's submission (2005)
Makeup (such as the eyeliners or shades for the eyelids)	Mentioned by Mexico's submission (2005)
Remedies used as treatment for diarrhea	Mentioned by Mexico's submission (2005)
Other marginal applications: Lubricants for demanding industrial applications, components of specialty lamps, pyrotechnical initiators for airbags, superconductors	General

5.2 Appendix II to the case study on lead: Lead in low-cost jewellery

Table A2.1 Nitric acid extractable lead, accessible lead, and lead content of the coatings of nine jewellery items (Yost & Weidenhamer 2008)

Sample code	Sample type ^a	Nitric acid extractable Pb (µg) per bead	Accessible Pb (µg) per bead			Total accessible Pb (µg)		Estimated Pb content (%) of coating
			1 h	2 h	3 h	Per bead	Per item	
P36	B	30.8	17.8	3.00	2.25	23.0	69.0	14
P41	B	32.5	10.2	2.25	1.50	14.0	336	6.9
P32B	E	34.8	17.5	3.50	1.75	22.8	91	3.5
P33	B,E	42.6	16.2	2.50	2.00	20.8	1290	4.8
P40	B	76.2	39.8	6.50	2.50	48.8	975	10
P70	B	99.9	7.75	1.25	0.00	9.00	216	11
M106	B,E	145	30.8	4.00	3.50	38.2	956	13
M105	N	176	22.0	2.50	3.50	28.0	1090	23
P61	E	195	3.00	0.75	0.00	3.75	7.5	Lost

Samples are arranged on the basis of increasing nitric acid extractable lead.

^a B = bracelet; E = earring; N = necklace.

Table A2.2. Summary of lead analyses for all tested pieces in Weidenhamer & Clement (2007)

	No. pieces	No. assays	Mean % Pb	Lead content, wt%					
				<0.06%	0.06–3%	3–10%	10–50%	50–80%	>80%
Anklet	1	1	0.02	1	0	0	0	0	0
Bracelet	46	62	50.2	21	1	0	5	8	27
Earrings	15	16	30.1	8	1	1	0	2	4
Hair	5	5	35.9	2	1	0	0	0	2
Accessories									
Key Chain	35	36	60.5	8	3	0	0	2	23
Necklace	21	24	11.4	20	1	0	0	0	3
Pin	5	6	47.6	3	0	0	0	0	3
Ring	4	4	63.1	1	0	0	0	1	2
Other	7	9	47.9	3	1	0	0	0	5
Total	139	163	44.0	67	8	1	5	13	69

Table A2.3. Acid leachable lead content of selected pieces in Weidenhamer & Clement (2007)

Sample type	Extraction time (h)	Lead extracted (µg)	Total lead extracted (µg)
Bracelet charm	1	156	770
	2	226	
	3	388	
Bracelet charm	1	418	2286
	2	707	
	3	1161	
Bracelet charm	1	173	1123
	2	324	
	3	626	
Bracelet charm	1	0	4
	2	0	
	3	4	
Bracelet link	1	215	1079
	2	388	
	3	476	
Bracelet charm	1	192	242
	2	39	
	3	11	
Pin charm	1	26	41
	2	10	
	3	5	
Pin charm	1	31	151
	2	44	
	3	76	
Key chain charm	1	23	730
	2	192	
	3	515	
Key chain charm	1	6	91
	2	26	
	3	59	

Table A2.4. Summary of results from combined dull-coated and non-coated surface wipe experiments by lead exposure category (Maas et al. 2005)

Jewelry Type	Sample size	Mean Pb in wipe (μg)	Percent LE ($<1.0\mu\text{g}$)	Percent ME ($1.0-10.0\mu\text{g}$)	Percent HE ($10.0-50.0\mu\text{g}$)	Percent VHE ($>50.0\mu\text{g}$)
Anklet/ring	1	0.06	100.00	0.00	0.00	0.00
Bracelet	24	11.86	33.33	41.67	16.67	8.33
Bracelet/earring	1	0.15	100.00	0.00	0.00	0.00
Earring	4	2.30	25.00	75.00	0.00	0.00
Necklace	38	5.53	28.95	57.89	10.53	2.63
Pendant	15	7.29	20.00	46.67	33.33	0.00
Ring	14	541.97	35.71	28.57	21.42	14.29

LE= low exposure, ME= moderate exposure, HE= high exposure, VHE= very high exposure

5.3 Appendix III to the Case study on lead: Emission factors for the different lead containing products

End-product	Product type	Emission factor (Ef)	Release media	Country	Reference
Batteries		60 % lead		Norway	SFT 2004
		7.7E-01 pounds / 1000 pounds of lead in batteries	Air	United States	EPA's Compilation of Air Emission Factors (AP-42) document
Cable sheathing		0.008 %/year (corrosion)	Soil, water	The Netherlands	Tukker et al. 2001
Lead solder		0.008 %/year (corrosion)		The Netherlands	Tukker et al. 2001
Ammunition		1 %/year	Soil	Denmark, Norway	Jørgensen and Willems 1987
		3.93 g/bullet (until 1993)	Soil	The Netherlands	Official limits for lead content
		6.86 g/bullet (after 1993)	Soil	The Netherlands	Official limits for lead content
	Federal facilities that have firing ranges	1.2 pounds lead air emissions / 2,000 pounds of bullets fired	Soil, air and water	United States	EPA's Compilation of Air Emission Factors (AP-42) document
Weights in fishing gear		0.01	Water	Norway	Miljøgifter i produkter 2002
		1.8 g/inhabitant	Water	The Netherlands	Expert judgement
Wheel balance weights	Passenger cars (loss of balance weights)	$4.075 \cdot 10^{-4}$ kg/tyre	Soil	Germany	Hillenbrand et al. 2005
	Passenger cars (corrosion of balance weights)	$2.19 \cdot 10^{-5}$ kg/vehicle/year	Soil	Germany	Hillenbrand et al. 2005
	Trucks (loss of balance weights)	$5.243 \cdot 10^{-4}$ kg/tyre	Soil	Germany	Hillenbrand et al. 2005
	Trucks (corrosion of balance weights)	$6.06 \cdot 10^{-5}$ kg/vehicle/year	Soil	Germany	Hillenbrand et al. 2005
Tyre wear	Private cars	0.552 g/mill.km	Air, water, soil	Finland and Norway	Finnish and Norwegian Informative Inventory Reports under the UNECE CLRTAP 2008
	Light duty vehicles, vans	0.720 g/mill.km	Air, water, soil	Finland and Norway	Finnish and Norwegian Informative Inventory

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					Reports under the UNECE CLRTAP 2008
	Heavy duty vehicles, busses and lorries	2.970 g/mill.km	Air, water, soil	Finland and Norway	Finnish and Norwegian Informative Inventory Reports under the UNECE CLRTAP 2008
	Motorcycles	0.276 g/mill.km	Air, water, soil	Finland and Norway	Finnish and Norwegian Informative Inventory Reports under the UNECE CLRTAP 2008
	Passenger cars; light duty vehicles; mopeds and motor cycles	9.4 mg/kg	Air, water, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
	Heavy duty vehicles (retread tyres)	9.5 mg/kg	Air, water, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
Brake wear	New private cars and vans	38.16 g/mill.km	Air, soil	Finland and Norway	Finnish and Norwegian Informative Inventory Reports under the UNECE CLRTAP 2008
	Old private cars and vans	38.02 g/mill.km	Air, soil	Finland and Norway	Finnish and Norwegian Informative Inventory Reports under the UNECE CLRTAP 2008
	Heavy duty vehicles	40.96 g/mill.km	Air, soil	Finland and Norway	Finnish and Norwegian Informative Inventory Reports under the UNECE CLRTAP 2008
	Branded	13854 ppm, wt (years 1980-1998)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		12090 ppm, wt (year 1999)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		10327 ppm, wt (year 2000)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		8563 ppm, wt (year 2001)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		6800 ppm, wt (year 2002)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		5037 ppm, wt (year 2003)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		3273 ppm, wt (year 2004)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		1510 ppm, wt (from year 2005)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
	Independent suppliers	11381 ppm, wt (years 1980-1998);	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP

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					2008
		9783 ppm, wt (year 1999)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		8185 ppm, wt (year 2000)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		6587 ppm, wt (year 2001)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		4989 ppm, wt (year 2002)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		3391 ppm, wt (year 2003)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		1793 ppm, wt (year 2004)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
		155 ppm, wt (from year 2005)	Air, soil	Sweden	Swedish Informative Inventory Report under the UNECE CLRTAP 2008
Terne plate		0.008 %/year (corrosion)		The Netherlands	Tukker et al. 2001
Bronzes, steels and aluminium alloys		0.008 %/year (corrosion)		The Netherlands	Tukker et al. 2001
Bearings					
Petrol Additives		0.7 g/l (beginning of 1980's)	Air, water, soil	Finland	LIPASTO (2009)
		0.4 g/l (1980-1986?)	Air, water, soil	Finland	LIPASTO (2009)
		0.15 g/l (from 1986)	Air, water, soil	Finland	LIPASTO (2009)
Propeller shaft grease		1.6 kg/boat/year multiplied by the amount of boats with greased sterntube gland and divided by the total amount of boats	Water	The Netherlands	Van Hyfte and Callebaut 2007
Collector shoes		$1 \cdot 10^{-6}$ kg/kWh	Soil (65 %), water (5 %), air (20 %)	The Netherlands	Van Hyfte and Callebaut 2007
Other weights		0.135 kg/m ² (mean value of 2-25 mg/cm ²) multiplied by number of days the product is in water and divided by 365	Water		Thornton et al. 2001
Lead sheets	Houses	5 g/m ² /year;	Water, Soil	The Netherlands	Special study and international literature; in Tukker et al. 2001 and Thornton et al. 2001
		0.008 %/year (0.006 %/year to soil)	Soil, water	The Netherlands	Tukker et al. 2001
		Based on building types	Water	Belgia	Engelen et al. 2006
	flashings	0.88 g/m ² /year	Soil, water	EU15	Wilson 2003

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Lead pipes		1014 mg/capita (year 1990) multiplied by share of the houses containing lead pipes (%) and divided by 15	Water	The Netherlands	In Tukker et al. 2001
		Based on building types	Water	Belgium	Engelen et al. 2006
Pigments and paints	Pigment	2 %	Air	Japan	Japan Paint Manufacturers Association
	Traffic paint	18 %	Air	Japan	Japan Paint Manufacturers Association

ANNEX 1

CASE STUDIES ON SELECTED PRODUCT GROUPS

Case Study 2:

**Releases of nonylphenol and nonylphenol
ethoxylates from the use phase of end-products**

CASE STUDY 2: NONYLPHENOL AND NONYLPHENOL ETHOXYLATE RELEASES FROM THE USE PHASE OF END-PRODUCTS

Content

- 1 Introduction
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- 3 General information on releases
 - 3.4 Sources of emissions and discharges
 - 3.5 Releases in the Nordic countries
- 4 NP/NPE releases from the use of end-products
 - 4.1 Textiles
 - 4.1.1 Restrictions
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 - 4.4.3 Releases and release mechanisms
 - 4.4.4 Release estimation techniques
 - 4.5 Concrete
 - 4.5.1 Restrictions
 - 4.5.2 Use
 - 4.5.3 Releases and release mechanisms
 - 4.5.4 Release estimation techniques
 - 4.6 Pesticides and veterinary medical products
 - 4.6.1 Restrictions
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5.2.2 Use

5.2.3 Releases and release mechanisms

5.2.4 Release estimation techniques

5.3 Cosmetics and hygienic products

5.3.1 Restrictions

5.3.2 Use

5.3.3 Releases and release mechanisms

5.3.4 Release estimation techniques

5.4 Aircraft deicer

5.4.1 Restrictions

5.4.2 Use

5.4.3 Releases and release mechanisms

5.4.4 Release estimation techniques

5.5 Leather

5.5.1 Restrictions

5.5.2 Use

5.5.3 Releases and release mechanisms

5.5.4 Release estimation techniques

5.6 Electronic components

5.6.1 Restrictions

5.6.2 Use

5.6.3 Releases and release mechanisms

5.6.4 Release estimation techniques

6 References

1 Introduction

Scope

The present study gives a general overview for nonylphenol and nonylphenol ethoxylates concerning production and use, emission sources, environmental fate, behaviour and effects. The most important end product groups are identified according to legislation, use, release mechanism and estimation techniques.

The overall aim of this study is to compile the available information of the nonylphenols and nonylphenol ethoxylates from the use phase of end products. This project is performed as a literature study with the focus on the Nordic countries. The major scopes of this project are:

Identification of the most important end products that may contain NP/NPE

Description of the use of NP/NPE in different groups of end products and the estimation of the volumes

Description of the release estimation techniques for identified groups of products, if available

Description of release and release mechanisms of NP/NPEs to the environment

What are Nonylphenols and Nonylphenol Ethoxylates

Nonylphenol is an organic compound of the wider family of alkylphenols, specifically a member of a subgroup called long-chain alkylphenols, containing octyl- or nonylphenol, their ethoxylates, and p-dodecylphenol (SOCOPSE, 2008).

Long-chain alkylphenols are characterised by having either a straight alkyl chain or a branched alkyl group connected to the phenol. The nomenclature of nonylphenols is somewhat inconsistent. For example it can be reported as alkylphenol, NP/NPE, NP or NP_{equivalents}. This may result in difficulties in interpretation of the data.

According to the Swedish Chemical Agency (KemI), the following CAS numbers should be used:

- 104-40-5: straight nonylchain in para position
- 25154-52-3: straight nonylchain, but not necessarily in para position
- 84852-15-3: branched nonylchain in para position

According to ECB (2002), CAS-no 25154-52-3 previously included all "nonylphenols", but has been redefined to only contain the nonylphenol with a straight alkyl chain, and others have been assigned new CAS numbers. The term "nonylphenol" is, however, still used as a general term for all nonylphenols (Remberger et al., 2004). In Figure 1 structures of straight nonylphenol, branched nonylphenol and nonylphenol ethoxylate are presented.

NPs are lipophilic, which means that they may bioaccumulate in aquatic species. NP is classified as very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment. NP/NPEs have been found to exert estrogenic effects in aquatic organisms.

NP/NPE may enter the aquatic environment through storm water systems, wastewater or directly to the surface water. Nonylphenols are strongly absorbed to particles in soils, sludges (in wastewater treatment plants) and sediments. NPEs degrade relatively easily, by bacteria, to form short-chained NPEs and NP. A minor part of NP/NPE is emitted to the atmosphere.

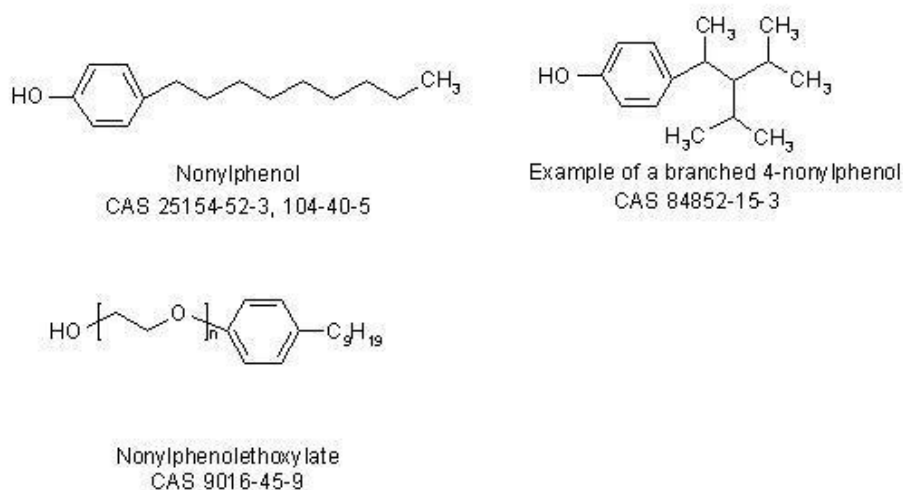


Figure 1. Structures of nonylphenols and their ethoxylates

Data sources

No new data will be generated in this project. Information from databases, scientific reports and other literature will be compiled.

For some of the product groups included in this report, recent data concerning the emissions of NP/NPEs and the emission factors is missing. Information from the EU Risk Assessment Report (ECB, 2002) has been used as one data source. The EU Risk Assessment on NP/NPEs is based on data from 1994-1997. Since then, new legislation (2003/53/EC) on the use of NP/NPEs in products has come into force. There have also been several national voluntary agreements toward decreasing usage of these chemicals. Thus, the data in the risk assessment report may not be as relevant today, in regard to e.g. content of NP in typical formulations and the total volumes used in EU.

The Swedish products register contains information of approximately 145 000 chemical products which are manufactured in or imported to Sweden. The Swedish Chemicals Agency (KemI) is responsible for the database. It is important to point out that the Swedish products register does not contain the information about the content of chemical substances in goods (e.g. textiles) and the information about products that are directly imported to Sweden, by private persons.

Data from the products register with regard to the activity- and industry codes for five nonylphenols and nonylphenols ethoxylates has been performed by KemI (KemI, 2008). The amounts of NP and NPE exported from Sweden have been excluded from the total uses. Thus only the quantities that actually were used in Sweden were compiled (import + manufacturing – export).

Information of the content of single products could not be provided, due to confidentiality. In cases when three or fewer manufacturers or importers were together behind a specific data, the information concerning total uses of NP/NPEs in products from the products register was not handed out. For these product groups, only information with regard to the function- and industry codes was given. Table 1 shows the specific compounds that were included in the data from the products register (KemI, 2008).

Table 1. Nonylphenols (NPs) and nonylphenol ethoxylates (NPEs) for which data from the products register were compiled (KemI, 2008).

	CAS No	Name
NP	104-40-5	Phenol, 4-nonyl-
	11066-49-2	Phenol, isononyl-
	25154-52-3	Phenol, nonyl-
	84852-15-3	Phenol, 4-nonyl-, branched
	90481-04-2	Phenol, nonyl-, branched
NPE	127087-87-0	Poly(oxy-1,2-ethanediyl), .alpha.-(4-nonylphenyl)-.omega.-hydroxy, branched
	26027-38-3	Poly(oxy-1,2-ethanediyl), .alpha.-(4-nonylphenyl)-.omega.-hydroxy-
	37205-87-1	Poly(oxy-1,2-ethanediyl), .alpha.-(isononylphenyl)-.omega.-hydroxy-
	68412-54-4	Poly(oxy-1,2-ethanediyl), .alpha.-(nonylphenyl)-.omega.-hydroxy-, branched
	9016-45-9	Poly(oxy-1,2-ethanediyl), .alpha.-(nonylphenyl)-.omega.-hydroxy-

The SPIN database⁴² (Substances in Preparations in Nordic Countries) was used to obtain data on usage of NP and NPE in chemical products in the other Nordic countries. This database is based on data from the products registers in Norway, Sweden, Denmark and Finland.

The SPIN database contains information on the quantities of chemicals in products used and produced in the Nordic countries. The quantities that are exported from the Nordic countries are included in the total use of a specific chemical. This means that data from SPIN database is not directly comparable with the data from the Swedish products register. The information from SPIN database may however be useful to illustrate which groups of products used in the Nordic countries that may contain NP/NPEs.

Other databases and alternative release estimation techniques

If a national products register is not available, other data sources can be used to obtain data on production, import and export of products. In Europe products are classified according to the CN (combined nomenclature) with numerous subdivisions. Data on national production can be obtained from national statistics authority. Information on exports and imports specified according combined nomenclature (CN) is supplied by the national Foreign Trade statistics. These data are collected by the national Customs Department⁴³. Data on the direct import of chemical products and goods by private persons is not supplied by the national Customs Department.

To be able to calculate the emissions the average concentration of NP/NPE in the product group needs to be known. This information is for example available in the EU Risk Assessment Report (ECB, 2002). The emissions factors are given in section "**4.1.4 Release estimation techniques**". The following formula can be used:

$$E = A * C * E_f$$

⁴² <http://195.215.251.229/fmi/xsl/spin/SPIN/maininfo.xsl?-db=SPINstof&-lay=SpinNavn&-max=1&-findall>

⁴³ <http://www.scb.se/>

E= emission (kg)

A = the total used amount of the product within the country (import + manufacturing – export)

C = concentration of NPE in the product

E_f - emission factor

2 Production and use of NPs/NPEs

The use of NP/NPE has decreased during the last decades in the Nordic countries, due to new legislation and voluntary phase-out agreements.

The main uses of nonylphenol are in production of nonylphenol ethoxylates and production of resins plastics and stabilisers (ECB, 2002; Kemi, 2007).

NPEs are used in a large variety of chemical products, including residential and commercial cleaning products such as detergents, shampoos, and surface cleaners. They are also used in pesticides and spermicides. Industrial uses of NPEs are as detergents, emulsifiers, wetting agents, and dispersing agents in textile processing. Other industrial uses are in paint and protective coatings, the manufacturing of plastics, pulp and paper production, oil extraction, metal processing, leather manufacturing, and building and construction.

General use of nonylphenols and nonylphenol ethoxylates is illustrated in Figure 2. It is important to point out that the import/use of goods (e.g. textiles) that may contain NF/NPEs is not presented in Figure 2. The use of goods containing NP/NPE is considered as an important source of NP to the environment.

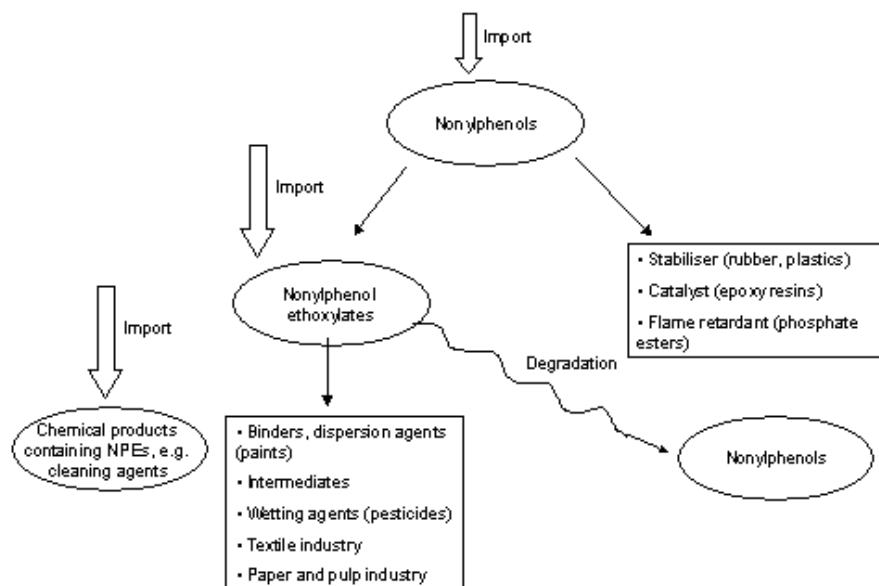


Figure 2. General use of nonylphenols and their ethoxylates (Remberger et al., 2004). The use of goods that may contain the NP/NPE (e.g. textiles) is not illustrated in this figure.

Due to new legislation and a voluntary phase-out of NP/NPEs in chemical products during the last decades, there has been a significant decrease in the use of these substances in the

EU countries. NPEs are however, still widely used in large concentrations in products manufactured in countries outside the EU. NPE can therefore enter the EU market since it is not prohibited to import products containing NPE.

3 General information on releases

3.1 Sources of emissions and discharges

Releases of NP from production processes of NP derivatives are estimated to be low. As a result, only a small amount of NP enters the environment directly. The primary source of NP in the environment is considered to be NPEs, which can degrade by bacteria into NP after being released to the environment (OSPAR, 2002).

Nonylphenols may also enter the environment by leakage or migration from products that contain these substances, e.g. plastics or paints. The main compartments to which releases of NP/NPEs occur are to receiving waters (rivers, lakes, seas) via industrial and municipal wastewater and wastewater treatment plants, and to a smaller extent, to the air (OSPAR, 2002).

Nonylphenol is considered to be destroyed during combustion processes (Remberger et al., 2004).

Nonylphenol equivalents

To be able to relate NPE with NP, NPE needs to be transformed to NP_{equ}. This can be done by using the molar weight for the substances. The molar weight for NP is 220 g/mol and for NPE with eight ethoxy-groups 572 g/mol. The use of NPEs with different chain lengths and some examples of transformation of NPE to NP_{equ} are shown in Table 2 (Månsson et al., 2008).

Table 2. Examples of uses of NPEs with different number of ethoxy groups together with transformation to NP_{equ}.

Use	Products	Number of ethoxy groups	NP _{equ}
Detergents	Cleaning agents, degreasing products	<10	m* = 8 NP:NPE ≈ 2:5 10 kg NPE ↔ 4 kg NP _{equ}
Emulsifiers	Cosmetics	10-30	m* = 20 NP:NPE ≈ 1:5 10 kg NPE ↔ 2 kg NP _{equ}
Dispersing agents	Paint, biocides	30-80	m* = 40 NP:NPE ≈ 1:10 10 kg NPE ↔ 1 kg NP _{equ}

* = number of ethoxy groups

3.2 Releases in the Nordic countries

NPs/NPEs can be emitted from the use phase of end products. In the Nordic countries, the most important product groups that contribute to the emissions of NP/NPEs water and wastewater systems are textiles and cleaning agents. Paints, adhesives, pesticides and veterinary medical products, concrete, metal working products and plastics gives a smaller contribution. Other potential sources are leather, paper, aircraft deicer, photo chemicals and electronic components.

The use of NP/NPE is limited in the Nordic countries due to legislation and voluntary phase-out agreements.

4 NP/NPE releases from the use of end products

NP/NPEs are used in a large number of different product groups. The product groups that contribute the most to the emissions of NP/NPEs to the environment differ between urban and rural areas. In an urban area and its suburbs, emissions of NP/NPEs from e.g. textiles and cleaning agents are considered as most important. In rural areas, the use of agricultural pesticides is a significant source of NPE to background sites (soil and surface water). Below follows a compilation of the most imported groups of products identified in this study from which releases of NP/NPE may occur.

Emissions of NP/NPE from end products can be estimated based on two alternative methods:

- National data from the products register on used amount of NP/NPE in a specific chemical product group multiplied with an emission factor. Data on the content of chemical substances in goods and the direct import of products and goods by private persons will not be obtained from the products register.
- National data on production, import and export of a product group (direct import by private persons not included) multiplied with average concentration and an emission factor.

Quantification of NP/NPE emissions from use phase of end products is difficult since the information on emission factors, concentrations and usage is incomplete.

4.1 Textiles

4.1.1 Restrictions

According to the EU directive (2003/53/EC), NP and NPE are prohibited to be placed on the market or used as substances or constituents of preparations at concentrations of 0.1 percent by weight or higher in textiles and leather processing except for processing with no release into waste water and systems with special treatment where the process water is pre-treated to remove the organic fraction completely prior to biological waste water treatment (degreasing of sheepskin).

4.1.2 Use

Due to restrictions given in EU directive (2003/53/EC) the use of NPE in the textile industry in the Nordic countries is limited. On the other hand it is not prohibited to import textile products that contain NPE. In Sweden the trade organisation "Textile importers" have recommended to their members a limit value of 250 mg/kg NPE in textiles (Ranner, 2008).

In countries outside the EU, NPEs are still commonly used in the textile industry. The production of textiles includes several steps of washing where NPEs can be used as a

detergent (tenside) and auxiliaries (e.g. dispersing agents used for dyeing, emulsifiers, spinning lubricants) and remaining NPEs can be found in textile end products (EC, 2003).

4.1.3 Releases and release mechanisms

According to recently published results of chemical analysis of NPEs in textiles in Sweden, it is stated that high concentrations of NPEs can be found in towels, t-shirts, overalls and underwear (Hök 2007, Testfakta 2007, Prevodnik 2008 and GP 2008). The results from the four different investigations are summarised in Table 3. In Table 3 it can also be seen that the number of the analysed samples are low and the concentrations varies greatly. As a consequence the calculated average value may be uncertain. Furthermore, the results indicate that the recommendation given by the Swedish trade organisation is not fully followed in Sweden.

Table 3. Summarised results from the four different investigations concerning concentrations of NPE in textile products (Hök 2007, Testfakta 2007, Prevodnik 2008 and GP 2008). Values are given with two significant digits.

	Concentration of NPE mg/kg*	Concentration of NPE mg/kg**
average	470	250
max	10600	1300
min	1.6	1.6
median	63	58
Number of samples	49	48

*) Outlier included. Values below detection limit excluded.

**) Outlier excluded. Values below detection limit excluded.

The results indicate that NPEs used in the textile industry can be found in the end products (for example towels, home-textiles and clothes). It can also be assumed that other textile products may contain NPE. When textile products are washed NPEs are transferred to either wastewater treatment plants (WWTP) or the environment. When NPE enters the wastewater system or the environment it is degraded by bacteria to form NP. This process takes place both in anaerobic conditions in the sludge in WWTP and in natural sediments.

4.1.4 Release estimation techniques

According to Månsson et al. (2008) the emission of NPE to wastewater treatment plants can be calculated as follows:

$$E = A * E_f;$$

E= emission (kg)

A= import-export of textiles (tonnes). Data on import and export can be obtained from national Foreign Trade statistics.

E_f= 0.250 kg/tonnes (share of NPE emitted to WWTP). The emission factor is based on analysis results from Hök 2007, Testfakta 2007, Prevodnik 2008 and GP 2008. Average concentration (outlier excluded).

If products register data are not available the formula given in chapter "Other databases and alternative release estimation techniques" can be used.

4.2 Cleaning agents

4.2.1 Restrictions

According to the EU directive (2003/53/EC), the nonylphenol and nonylphenol ethoxylate are prohibited to be placed on the market or used as substances or constituents of preparations at concentrations of 0.1 percent by weight or higher in:

industrial and institutional cleaning except for controlled closed dry cleaning systems where the washing liquid is recycled or incinerated and cleaning systems with special treatment where the washing liquid is recycled or incinerated
domestic cleaning

4.2.2 Use

NPEs are a group of substances which earlier were widely used as tensides in formulations such as vehicle detergents and different cleaning agents. NPEs may still be used in products for e.g dry cleaning, in detergents, car care products, cleaning agents, paint and varnish removers.

In Norway, an 82 % reduction of the total use of NPEs was achieved during the period 1995-2000. The use has further decreased by about 40% between 2000 and 2002 and was approaching zero in 2005 (OSPAR, 2006).

In Denmark, the use of nonylphenol and its ethoxylates in cleaning materials has been on the decline for a number of years as a result of a voluntary agreement from 1987 between the Association of Danish Cosmetics, Toiletries, Soap and Detergent Industries (SPT) and the Danish Environmental Protection Agency. This agreement included elimination of NPEs in the products of the companies organised in SPT. Approximately 60-80 % of these companies were supplying household cleaning materials, and to a smaller extent industrial cleaning products (Miljöministeriet, 2007).

In Sweden the reduction of NPEs used in cleaning agents was more than 90% during the period 1990-1999. The industrial use of NPEs as cleaning agents has decreased further with about 30 – 40% by 2003 (OSPAR, 2006).

Table 4 shows the use of NPEs in cleaning agents in Sweden 2006 (Products register, 2008).

Table 4. Registered quantities of NPEs in different cleaning agents in Sweden 2006 (Products register, Keml 2008).

Function code	Products	NPE 2006 (tonnes)
R10	Cleaning/washing agents, other	2.1
P10	Polishing agents	1.6
R10100	Degreasers (cold degreasing, de-waxing, de-polishing)	0.74
R10150	General cleaning/washing agents (floor wash, basic cleaning) inclusive concentrate	0.51
B18100	Car care products and boat care products	0.28
M10	Paint and varnish removers	0.19
O27900	Surface treatment, other	0.14

4.2.3 Releases and release mechanisms

The use of cleaning products that contain NPEs results in releases of NPEs to the wastewater system and the sludge in WWTP (ECB, 2002).

During the use phase of cleaning products a small amount of NPEs may be emitted to the atmosphere (ECB, 2002).

4.2.4 Release estimation techniques

The emission of NPE to air and wastewater treatment plants can be calculated as follows:

$$E = A * E_f;$$

E= emission (kg)

A= national activity data containing used amount of NPE (import + manufacturing – export) in cleaning agents (kg).

E_f = emission factor (0.0025 kg/kg to air and 0.9 kg/kg to wastewater) (ECB, 2002).

If products register data are not available the formula given in chapter "Other databases and alternative release estimation techniques" can be used.

4.3 Paints and printing inks

4.3.1 Restrictions

There is no legislation concerning uses of NPE in paints in any of the Nordic countries. The decrease in releases that has occurred during the last decades depends on voluntary agreements between the authorities and industries, importers and the Paint and Printing Ink Manufacturers Associations.

4.3.2 Use

NPE may be used in the preparation of paint resin (PVA-polyvinyl acetates). Nonylphenol ethoxylates are also used as a paint mixture stabiliser. A typical formulation may contain 0.6-3% NPE (ECB, 2002). Products that may contain NP/NPEs are mainly paints used to wet room floors, water-based paints and varnishes for indoor use mostly, printer's ink, concrete floor paint, metal coating and some anti-corrosive paints (Andersson and Sörme, 2007).

NP/NPEs are used in the formulation of inks for laser mixture stabiliser jet printers and the formulation of chemicals for use with lithographic printers (RPA, 1999).

According to the Swedish products register, during 2006, approximately 11 tonnes NP and 2.6 tonnes NPEs were registered as used in paints and varnishes in Sweden. Additionally, 3.8 tonnes NPEs were used in pigments pastes and other colouring agents and 8.7 tonnes as binding agents for paints and adhesives. The use of NPE in pigment to paint and printing inks in Sweden was confidential (KemI, 2008).

In 2006 in Finland registered use of approximately 130 tonnes NPEs and 3 tonnes NP in paints, lacquers and varnishes in the Nordic Product Register. The corresponding volumes for Norway were 0.8 tonnes NPE and 1 tonne NP (SPIN, 2008).

Based on the registrations in the Danish Product Register (2004), nonylphenol and nonylphenol ethoxylates are not used as additives for the production of paints and lacquers in Denmark but are present in imported products or semi-manufactured articles (Miljöministerier, 2007).

The total stock of NPEs build-in in paints in Sweden have been estimated to <1200 tonnes, (117 tonnes NPEs as an average for 1999-2002 in paints was supplied each year and the lifetime of the paint applied on the buildings, the re-paint interval, is approximately 10 years) (Palm et al., 2005).

4.3.3 Releases and release mechanisms

There are several possible release pathways of NP/NPEs from paints. The most important are the leakage from painted and varnished surfaces and from the cleaning of painting equipment.

The release of NPE from use of printing inks is assumed to be negligible (ECB, 2002).

It is also possible that NP/NPEs may in small amounts evaporate to the air during application of e.g. water-based paints on house facades, which may result in higher atmospheric emissions of NP/NPEs in residential areas. Results from a screening study performed in Sweden (Remberger et al., 2004) showed, however, that NP was detected only in two of 20 air samples but in almost every water, sludge and sediment sample, which indicate that air is not a major pathway for NP/NPEs to the environment.

The NPEs that are released to the environment may enter the storm water system and further the WWTP (in cases where the storm water system is connected to the WWTP), where it is accumulated in the sludge and to a large extent degraded to nonylphenol. A fair assumption is that <1% of alkylphenols and alkylphenol ethoxylates used in paints is released to WWTP (Månsson et al., 2008).

NP and NPEs are still used in paints and varnishes in the Nordic countries. The large stock of NPEs build-in paints in the communities as a result of historical uses, may also contribute to the importance of paints as a possible emission source of NPEs to the environment.

4.3.4 Release estimation techniques

The emissions of NPE from paints to wastewater may be estimated using the total amount of NPE used in paints and varnishes annually multiplied by emission factor 0.005 (0.5%) (ECB, 2002).

$$E = A * E_f$$

E= emission (kg),

A= national activity data containing NPE used in paints (import + manufacturing – export), (kg)

E_f= emission factor 0.005 kg/kg (share of NPE emitted into wastewater).

Emission factor for NP/NPEs to the air is estimated in the literature to be zero (ECB, 2002).

If products register data are not available the formula given in chapter "Other databases and alternative release estimation techniques" can be used.

4.4 Adhesives

4.4.1 Restrictions

There is no legislation concerning the use of NP/NPEs in adhesives in the EU.

4.4.2 Use

NPEs are used in glues as water-based adhesive for end use in different industry sectors such as the textile industry, but also in the pulp and paper industry, in printing-works, in the construction industry and in the plastic products industry. According to the Swedish adhesives industry, the use of NPEs in water-based adhesives was reduced by 98% between 1995 and 1999 (HELCOM, 2002).

According to the registrations in the Swedish products register, 1 tonne NPE and 0.46 tonnes NP were used in water-based adhesives and other adhesives in 2006 in Sweden (KemI, 2008). Historical use of adhesives may also contribute to higher total stock of NP/NPE in the communities.

4.4.3 Releases and release mechanisms

Minor emissions of NPEs used in adhesives may occur when equipment is cleaned. According to Andersson and Sörme (2007) approximately 1% of all adhesives used in Sweden may enter the wastewater.

Adhesives are not considered as a major emission source of NP/NPEs to the environment. Historical use may constitute a possible source and depends on the size of the volumes of NP/NPEs build-in in different products in the communities.

4.4.4 Release estimation techniques

If 1% of all the adhesives used were to enter the wastewater, then the total emission of NP/NPE to WWTP would be as follows:

$$E = A * E_f$$

E = emission of NP/NPE to the wastewater (kg)

A = national activity data containing the use of NP/NPE in adhesives (import + manufacturing – export), (kg)

E_f = emission factor 0.01 kg/kg

If products register data are not available, the formula given in chapter "Other databases and alternative release estimation techniques" can be used.

4.5 Concrete

4.5.1. Restrictions

There is no regulation of NPEs usage as concrete agents in EU today. However, the suppliers have on a voluntary basis reduced/stopped the usage of this kind of products.

4.5.2 Use

NPEs may be used in very small amounts as concrete modifiers. The concrete modifier helps to form small air bubbles that reduce the strain on the concrete material during freezing periods (Björklund et al., 2007).

Because of historical use there are possible large stocks of NPEs build-in into the technosphere. Concrete that contain NPEs has earlier been used mainly in specific constructions, such as harbour construction and bridges (Månsson, et al., 2008).

There are no data available on quantities of NP/NPEs used as concrete modifiers in Sweden and the other Nordic countries (Products register and SPIN, 2008).

4.5.3 Releases and release mechanisms

Leakage of NPEs from concrete constructions is a possible source of releases to the environment. The NPEs are thought to enter the storm water system in residential areas and may end up in the wastewater treatment plants.

4.5.4 Release estimation techniques

Recently, 30-day leakage tests of NPE from concrete construction were performed in a Swedish study. If it is assumed that the emission of NPE is constant during a 40-year period and that the average thickness of the concrete construction is 0.2 m, the estimated emission of NPEs from concrete to urban storm water is 0.2 mg/m² and year (Björklund et al., 2007). The total emission of NPE from concrete may be estimated by using the following formula:

$$E = A * E_f$$

E = emission of NPE from concrete to storm water (kg)

A = surface of concrete constructions (m²)

E_f = emission factor to urban storm water, 0.2*10⁻⁶ kg/m² and year

4.6 Pesticides and veterinary medicinal products

4.6.1 Restrictions

According to the EU directive (2003/53/EC), NP/NPEs may not be placed on the market or used as a substance or constituent of preparations in concentrations equal or higher than 0.1 % by mass for purposes as emulsifier in agricultural teat dips and co-formulants in pesticides and biocides.

4.6.2 Use

NPEs are used in the agriculture sector, acting as a wetting agent in pesticide formulation in order to improve the efficiency of spraying and reduce the amount of active ingredient that otherwise would be applied. NPEs may also be incorporated as dispersants and emulsifier or added to the spray tank at the time of application.

NPEs are also used as an additive in veterinary medicinal products, such as surfactants in teat dips and as an aid in control of mastitis. There are two main types of teat dips that may contain NPEs, isodophores (approximately 5% NPE) and chlorohexanes (less than 1% NPE in formulations) (ECB, 2002).

Since 1997 in Sweden and Denmark, approval is no longer given to new agricultural pesticides if they contain NPEs. In Norway corresponding approval measures were taken after year 2000 (HELCOM, 2002).

According to the registrations in the Swedish products register (KemI, 2008), NPEs were used in quantities of 0.31 tonnes in biocide products and 1.5 tonnes in plant protection agents in 2006. Among the other Nordic countries (2006), Denmark registered use of 1.7 tonnes NPEs in biocides (pesticides for non agricultural uses) and approximately 15 tonnes in plant protection products (agricultural pesticides) (SPIN, 2008).

4.6.3 Releases and release mechanisms

The use of NPEs in agricultural pesticides is of concern due to their additional contribution to background concentrations in soil and water. During spraying, parts of the agricultural pesticides may be distributed into the soil, where NPE is degraded into NP. NP is persistent and strongly bound to soil particles and could, depending on e.g. soil structure and soil scope, to some extent be transported from soil to surface waters (HELCOM, 2002).

A part of NPEs used as surfactants in teat and sheep dips may eventually be applied to land as a result of spreading of sewage sludge (RPA, 1999).

4.6.4 Release estimation techniques

According to ECB (2002) partition of NPEs between the environmental compartments from the use of pesticides and surfactants in the agricultural industry is 5% to air, 10% to surface water and 85% to soil. The annual emission may be calculated using the formula:

$$E = A * E_f$$

E - emission of NPEs (kg)

A - national activity data containing used amount of NPE in pesticides and surfactants (import + manufacturing – export), (kg)

E_f - emission factor (0.05 kg/kg to air, 0.1 kg/kg to water and 0.85 kg/kg to soil)

If products register data are not available, the formula given in chapter "Other databases and alternative release estimation techniques" can be used.

4.7 Metal working fluids, lubricating oils

4.7.1 Restrictions

According to the EU directive (2003/53/EC), NP/NPEs may not be placed on the market or used as a substance or constituent of preparations in concentrations equal or higher than 0.1 % by mass for purposes of metal working except for uses in controlled closed systems where the washing liquid is recycled or incinerated.

4.7.2 Use

NPEs are used in the metal extraction, refining and processing industries in the formulation and usage of cutting and drilling oils (ECB, 2002). NPEs may also be used in the metal working industry as emulsifiers, in metal cleaning aids and in anti-mist additives (Huntsman, 2007). Para-Nonylphenol (4-nonylphenol) is used in the preparation of lubricating oil additives. In Table 5, registered quantities of NPEs in the metal working products in the Swedish products register for 2006 are summarised (KemI, 2008).

Table 5. Registered quantities of NPEs in the metal working products, 2006 (KemI, 2008).

Function code	Products	Use of NPE 2006 (tonnes)
K60	Cutting fluids	1.3
S45110	Base oils	1.5
M15500	Surface treatment of metals, other	0.75
G05400	Galvano-technical agents, other	0.59
S45180	Motor oils	0.29
S45300	Other lubricants	0.07
M15400	Rust removers	0.01
S45150	Gear oils	Confidential*
H10100	Hydraulic fluids, hydraulic oils	Confidential*
R20200	Corrosion inhibitors	Confidential*
R20900	Anti-corrosion materials, other	Confidential*
S40300	Slip agents for modelling metal	Confidential*

*Three or less manufacturers or importers behind a specific data

Among the other Nordic countries (2006), Denmark reported uses of NPEs in product groups: cooling agents for metal processing >1.8 tonnes, lubricants approximately 80 tonnes and metal surface treatment remedies approximately 93 tonnes (SPIN, 2008).

4.7.3 Releases and release mechanisms

During normal usage of the metal working fluids, the spills are not intended to reach the wastewater treatment plants. These products are to be collected and disposed of properly. Incorrect uses of metal working oils may, however, result in some releases directly to the waste water system (approximately 5% of the total usage) and thus represent a possible emission source of NPEs to the environment (Månsson et al., 2008). NPEs may also be

emitted to soil and surface water through spills and leaks of oils, mainly during industrial use or accidents.

4.7.4 Release estimation techniques

The annual emission of NPEs from the use of metal working oils may be calculated using the formula:

$$E = A * E_f$$

E - emission of NPEs to wastewater (kg)

A - national activity data containing used amount of NPE in metal working oils (import + manufacturing – export), (kg)

E_f - emission factor (0.005 kg/kg to wastewater based on the data from Månsson et al., 2008)

Emission factors to soil and surface water were not found in the literature.

If products register data are not available, the formula given in chapter "Other databases and alternative release estimation techniques" can be used.

4.8 Plastics

4.8.1 Restrictions

There is no legislation in the EU concerning uses of NPE in plastics. The decrease in emissions depends on voluntary agreements between the authorities and industries, importers and other organisations.

4.8.2 Use

NP and NPEs are used as antioxidants and plasticizers in some plastic products. Plastics types that may contain and emit NP/NPEs are PVC, polystyrene, epoxy, PET and polypropylene (Björklund et al., 2007). It is difficult to find information on the total amount of plastics used in building industry that may contain NP/NPEs. It is likely that this application was phased out 20-25 years ago. Today's values are probably on a level of approximately <0.1%.

Nonylphenol is also used as an accelerator or cutting agent in the hardening components in some epoxy resins. Cutting agents are added to polymer resins in concentrations of 0.5-3% of the total resin. Epoxy may be used in e.g. paints and varnishes, fillers, glues and floor covering products (ECB, 2002).

Beside the plastics used in building industry, NP has also been found in food contact plastics and baby toys (36 of totally 207 samples). Highest levels and frequencies of NP were obtained in polyvinyl chloride wrapping film and gloves but also in polystyrene disposable cups. NP was also found in a few polypropylene, polycarbonate and styrene-butadiene products, though it was not detected in polyethylene or polyvinylidene chloride products (Yoko et al., 2000).

According to the registrations in the Swedish products register (Kemli, 2008), 0.14 tonnes NPE and 0.41 tonnes NP were used in floor covering materials and another 0.33 tonnes NP in joint-less floors in 2006. Another 0.01 tonnes NP was used as curing agents in plastics.

Among the other Nordic countries, Norway registered use of 0.3 tonnes NPE and 0.8 tonnes NP in joint-less floors. Finland reported use of 0.1 tonne NP in fillers (SPIN, 2008).

4.8.3 Releases and release mechanisms

Products that contain plastics are a possible emission source of NP/NPEs to the environment. However the emissions from rigid plastics occur through a very slow process and the NP/NPEs are added to plastics material in very small amounts, which together result in very small total input to the environment (Månsson et al., 2008).

Approximately 60% of all plastics in the building industry are assumed to contain NP/NPEs. A migration study of alkylphenols from different indoor materials showed that PVC was the largest source of emission of these substances to the air in new build houses (Björklund et al., 2007).

Migration of NP from plastic tableware and food containers to fatty food simulants, n-heptane, has been examined in a study performed by Tomohiko et al., (2002). NP was detected from 16 food-contact plastics out of 50 tested samples. Especially high amounts of NP were released from 5 samples (21-2485 ng/cm²), e.g., disposable cup, dish and cap of food container made of polystyrene or polypropylene.

4.8.4 Release estimation techniques

The emission of NP/NPEs from plastics materials to storm water has been estimated to be:
2.78 ng/m² *year from hard plastics and;
4.64 ng/m² *year from soft plastics (Björklund et al., 2007)

The annual emission may be calculated using the formula:

$$E = A * E_f$$

E - emission of NP/NPEs from plastic materials to storm water (kg)

A - amount of plastics used annually (m²). The assumed weight of 1 m² PVC with thickness of 1.5 mm is 2000 g (Björklund et al., 2007)

E_f - emission factor to storm water, 2.78*10⁻¹² kg/m² from hard plastics, 4.64*10⁻¹² kg/m² from soft plastics

5 Other groups of products

In this chapter products that contain NP/NPEs, but are considered as a less important or negligible source of emissions are presented.

5.1 Cosmetics and hygienic products

5.1.1 Restrictions

According to the EU directive (2003/53/EC), nonylphenol and nonylphenol ethoxylate may not be placed on the market or used as a substance or constituent of preparations in concentrations equal or higher than 0.1% by mass for the following purposes: cosmetic products or other personal care products except for spermicides.

5.1.2 Use

NPEs are thought to be used as a surfactant in some cosmetic formulations (ECB, 2002). Products in which NPEs may be included are soaps, shampoos, hair dyes, make-up and other hygienic products (Andersson and Sörme, 2007).

The knowledge of the new legislation (EU directive 2003/53/EC) among the suppliers is still considered to be poor. Consumer products that include NP/NPEs may still be found on the market (Andersson and Sörme, 2007).

The Danish cosmetics and soap industry has removed all nonylphenol ethoxylates (NPEs) from their products. There is also a Swiss Government ban on all NPEs and the UK Soap and Detergent Industry Association has recommended a voluntary phase out of all NPEs by its members (WWF, 1999).

In Sweden, approximately 10 kg NPEs is annually used in spermicides (Andersson and Sörme, 2007). Spermicides are hygienic products that are not comprised in the Directive 2003/53/EC.

5.1.3 Releases and release mechanisms

The use of cosmetic and hygienic products that contain NPEs may result in releases of NPEs to the wastewater system and further degrading to NP in the sludge in WWTP (ECB, 2002).

During the use of cleaning products a small amount of NPEs may be emitted to the air (ECB, 2002).

5.1.4 Release estimation techniques

NP/NPEs used in cosmetic products are not included in the Swedish products register. The Swedish Medical Products Agency supplies a register including cosmetic products. Unfortunately the register does not include product information on substance or quantity level.

If products register data are not available, the formula given in chapter "Other databases and alternative release estimation techniques" can be used.

5.2 Photochemicals

5.2.1 Restrictions

Regulations in some EU countries require that commercial photo developers do not discharge products such as wetting agents to the sewer. The chemicals have to be collected and disposed of properly.

5.2.2 Use

NPEs are used as wetting agents in the development of photographic film. NPEs may be used in products intended both for home use by the amateur photographers and in some professional products. The concentration of NPEs in these products is 3-5% (ECB, 2002). NP/NPEs may also be used in x-ray film.

In Sweden the use of NPE in photo chemicals and film hardeners registered in the national products register was confidential for year 2006 (KemI, 2008). No data on uses in products registers for the other Nordic countries was available (SPIN, 2008).

5.2.3 Releases and release mechanisms

The use of photo chemicals that contain NPEs may result in releases of NPEs to wastewater systems. Commercial photo developers have to collect the chemicals containing e.g. NPEs without discharging to the sewer. Small amounts of chemicals resulting from e.g. carryover of solution to wash tanks may, however, get discharged directly to the sewer. Also, home hobbyists may contribute to discharge of NP/NPEs to the sewer (ECB, 2002).

Compared to other NP/NPEs sources, such as textiles and cleaning agents, emissions from photo chemicals may be considered as a minor/negligible source to wastewater (Månsson et al., 2008).

5.2.4 Release estimation techniques

No specific information on the releases of NPEs from photo chemicals was found in the literature.

5.3 Paper

5.3.1 Restrictions

According to the EU directive (2003/53/EC), nonylphenol and nonylphenol ethoxylate are prohibited to be placed on the market or used as substances or constituents of preparations at concentrations of 0.1 percent by weight or higher in manufacturing of pulp and paper.

5.3.2 Use

NPEs are used in the pulp industry in defoamers in the wet end of paper manufacture, where they help to ensure even dispersion of the defoaming agents. The NPE are also used in retention aids in order to help disperse the actual retention agents. According to the ECB (2002), the concentration of NPEs in these products may be up to approximately 1%.

There were no uses of NP/NPEs in paper and pulp industries registered in the national products registers in the Nordic countries during 2006 (SPIN, 2008).

5.3.3 Releases and release mechanisms

It is difficult to estimate if NPEs used in the pulp and paper industry eventually will end up in the paper or be emitted from the paper during the manufacture processes. According to Andersson and Sörme (2007) NPEs do not end up in paper to a large extent and thus paper products are not likely to constitute an important emissions source of NPEs to the environment.

5.3.4 Release estimation techniques

No specific information on the releases of NPEs from paper and pulp industry was found in the literature.

5.4 Aircraft deicer

5.4.1 Restrictions

There are no restrictions in the EU.

5.4.2 Use

Alkylphenol ethoxylates are used as additives in aircraft deicers, e.g. in countries as the USA. Proprietary additives make up about 1–5% of deicer fluids (Erickson, 2003).

No information about the use of deicers that contain alkylphenol ethoxylates in the Nordic countries could be found. There was no registered data on uses of NPEs in aircraft deicers for any of the Nordic countries (Keml, 2008; SPIN, 2008).

5.4.3 Releases and release mechanisms

The NPE used in aircraft deicers may enter the environment by runoff from airports and end up in the surface water system. The largest input to the environment may probably occur after an intense aircraft deicing application event. Also, at airports, deicing may occur only a few times a year, and the amount of runoff, even if concentrated, is limited to these occasions during the cold periods of a year.

In a study performed by Corsi et al. (2003), NP/NPEs have been identified in three of nine different formulations of aircraft deicer and anti-icer fluids (ADAF). In the field study at General Mitchell International Airport, Milwaukee, USA, NPE (n = 1-15) and NP were detected in airport runoff. Samples were collected from two airport outfalls, from the receiving stream, and from an upstream reference site during intensive ADAF application events. NPEs were measured at concentrations up to 1190 µg/l in airport outfall samples, up to 77 µg/l in samples from the receiving stream and less than 5.0 µg/l from the upstream reference. The field data suggest that NP is generated through degradation of NPEs from airport runoff.

5.4.4 Release estimation techniques

No specific information on the releases of NPEs from aircraft deicer was found in the literature.

5.4.5 Impacts of releases

Biota living in streams near airports may be exposed to concentrations of nonylphenols that could be toxic, even if it is for a short period of time during the aircraft deicing application event (Erickson, 2003).

5.5 Leather

5.5.1 Restrictions

According to the EU directive (2003/53/EC), NP and NPEs are prohibited to be placed on the market or used as substances or constituents of preparations at concentrations of 0.1 percent by weight or higher in textiles and leather processing except for processing with no release into waste water and systems with special treatment where the process water is pre-

treated to remove the organic fraction completely prior to biological waste water treatment (degreasing of sheepskin).

5.5.2 Use

NPE are thought to be used in the wet degreasing of hides in the leather industry (ECB, 2002). Information from the leather industry indicates that almost half of NPE usage attributed to them is exported for use outside the EU (EPA, 1999).

5.5.3 Releases and release mechanisms

No specific information on the releases of NPEs from the use of leather products was found in the literature.

5.5.4 Release estimation techniques

No specific information on release estimation technique of NPEs from the use of leather products was found in the literature.

5.6 Electronic components

5.6.1 Restrictions

There are no restrictions in the EU.

5.6.2 Use

In the electrical engineering sector, NPEs are reported as being used in fluxes in the manufacture of printed circuit boards, in dyes to identify cracks in printed circuit boards and as a component of chemical baths used in the etching of circuit boards. NPE may also be used in cleaning products used to clean electrical components (ECB, 2002).

5.6.3 Releases and release mechanisms

No specific information on the releases of NPEs from the use of electronic components was found in the literature.

5.6.4 Release estimation techniques

No specific information on release estimation technique of NPEs from the use of electronic components was found in the literature.

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ANNEX 1

CASE STUDIES ON SELECTED PRODUCT GROUPS

Case Study 3:

Releases from the use phase of end-products in the construction and building sector

CASE STUDY 3:

RELEASES FROM THE USE PHASE OF END-PRODUCTS IN THE CONSTRUCTION AND BUILDING SECTOR

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1 End products with likely releases during the use phase

There are about 50,000 different products used by the construction industry in the various building activities. Construction and building products covered by this study include the materials used for the structures (e.g. concrete, sealants and insulation materials), for the different functions in the buildings, such as pipes and cables, measuring equipment and devices, as well as for the exterior and interior covering (e.g. roofing, flooring and wall materials) and to finish surfaces (e.g. paint and wallpaper).

Many of the substances used in construction and building products have been found to be detrimental for both the environment and human health, leading to restrictions of their production, sale and use. There have been many studies mainly about the health risks of building products to construction workers and the residents of the buildings, but also about the environmental risks of releases to soil, air and water. Information on hazardous substances in construction and building products is important because of the large volume and relatively long life of the articles. It needs also to be borne in mind that the possible existence of the different hazardous substances depends greatly on the construction year of the building.

In the construction and building sector polychlorinated biphenyls (PCBs) were in the earlier years used in sealants, flooring, paint, plaster and concrete. PCBs have also been used as plasticizers in polyvinyl chloride (PVC) plastics, neoprene and in other chlorinated rubbers. Dioxins and furans can be found as impurities in PCBs. PCBs have been transferred to the surrounding environment and building materials over the years but PCB contamination can still be found in older buildings, although the majority of the old sealants have been replaced at least once. It has been estimated that the replacement of contaminated window panes as well as the removal and storage of PCBs have cost a total of 37 million Euros in the EU.

Polyvinyl chloride (PVC) has replaced many construction and building products traditionally made of wood, metals, ceramics and textiles. These include exterior sidings, window frames, pipes, floor tiles, wall coverings as well as cable sheathings. Flexible PVC products, such as flooring, roofing membranes and wall coverings, contain phthalates. Phthalates can also be found in paint and varnish, jointing materials, and wallpapers. PVC plastics used in construction and building products can also contain other substances, e.g. lead, cadmium, organotins and bisphenol A.

Non-methane volatile organic compounds (NMVOCs) are released from solvents used in paints, paint strippers, varnishes and adhesives. They are also released from roofing (e.g. asphalt and tar and membrane roofing), sealants, wood preservatives, floor materials (e.g. levellers and sealants) and PVC plastics. Formaldehydes, classified as NMVOCs and emitted for instance from composite and pressed wood products and insulating material, were a big concern of indoor air quality in the early of the 1990s. NMVOC emissions to air from the use of these products do not fall under the scope of this project as they are already covered by the regular reporting under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP), UN Framework Convention on Climate Change and the EU Net Emission Ceilings Directive. Therefore these emissions are omitted from the conclusions presented in the main report for the study (Study on Releases from Products).

Asbestos has been used widely in construction and building materials in the past, especially as a fire and heat resistant material and insulation material. It can be found, for example, in pipe and furnace insulation materials; cement and bitumen roofing, shingles, sidings, air shafts, water and drainage pipes; millboard, cardboard; floor tiles, plastic and rubber carpets, plastic wallpaper; paints and other coatings; sealants and adhesives, caulk and plaster; coated steel sheets; fire doors, stoves and stovepipes. Asbestos fibres can be released to the air through renovation of old buildings and deterioration of products containing asbestos.

Different chemicals and compounds have been used widely among the construction and building products for various purposes over the years (Table 1).

Table 1. Use of different substances in construction and building products and their likely releases during use phase. Explanations: Releases to: the environmental compartment is in brackets if releases are considered minor, e.g. (air); RET = Release estimation technique, Yes = exists, (Yes) = not published/only in certain countries; NA = information not available)

End-product group	Substance	Releases to	RET	Included in regular inventories
Jointing, sealing and filling materials, concrete and plaster	PCBs	air, soil, water	Yes	(Yes)
	Lead	NA	NA	NA
	NPs/NPEs	water	Yes	(Yes)
	Phthalates (e.g. DBP)	NA	NA	NA
	Bisphenol A	NA	NA	NA
	SCCPs	(air, soil and water)	No	(Yes)
	PAHs	NA	NA	NA
	PCNs	NA	NA	NA
	Arsenic	NA	NA	NA
	BFRs	NA	NA	NA
	DEHP	NA	NA	NA
	Asbestos	NA	NA	NA
Insulating material	BFRs (e.g. HBCD and pentaBDE)	air, water, soil	Yes	(Yes)
	HxBB	NA	NA	NA
	PCBs	NA	NA	NA
	Organotins	NA	NA	NA
	Formaldehyde	NA	NA	NA
	PAHs	NA	NA	NA
	Asbestos	NA	NA	NA
Roofing, flashings and other exterior structures	Lead	soil, water	Yes	(Yes)
	Organotins	NA	No	No
	Chromium	soil, water	No	No
	Copper	soil	Yes	(Yes)
	BFRs	NA	No	No
	Phthalates	NA	No	No
	Bisphenol A	NA	No	No
	Asbestos	NA	No	No
	DEHP	soil, water	No	No
Pipes and cables	Lead	water, (air)	Yes	(Yes)
	Copper	water, soil	Yes	(Yes)
	Organotins	NA	No	No
	Mercury	NA	No	No
	BFRs (e.g. PBDEs)	NA	No	No
	DEHP	soil	Yes	(Yes)

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Case Study on Construction and Building Sector Products

End-product group	Substance	Releases to	RET	Included in regular inventories
Building and construction products	MCCPs	air, water, soil	Yes	(Yes)
Wooden materials	Chromium	soil	Yes	(Yes)
	Copper	soil	Yes	(Yes)
	Arsenate	soil	Yes	(Yes)
	Organotins	NA	No	No
	PAHs	air, soil	Yes	(Yes)
	PCP	NA	No	No
	PCNs	NA	No	No
	HCB	NA	No	No
	Heptachlor	NA	No	No
	Lindane	NA	No	No
	Chlordane	NA	No	No
	Formaldehyde	NA	No	No
Wall and floor material	Phthalates (e.g. DBP and DEHP)	air, soil and water	Yes	(Yes)
	Bisphenol A	NA	No	No
	Organotins (e.g. TBT)	NA	No	No
	Cadmium	NA	No	No
	Lead	NA	No	No
	NPs/NPEs	water	Yes	(Yes)
	BFRs (e.g. decaBDE and pentaBDE)	NA	No	No
	HxBB	NA	No	No
	Mirex	NA	No	No
	PCBs	NA	No	No
	PAHs	NA	No	No
	Chlorinated paraffins	NA	No	No
Surface coatings and adhesives	PCBs	air	Yes	(Yes)
	NPs/NPEs	water	Yes	(Yes)
	Lead	air, soil and water	Yes	(Yes)
	Mercury	NA	No	No
	Cadmium	NA	No	No
	Chromium	soil and water	Yes	(Yes)
	Copper	soil and water	Yes	(Yes)
	Arsenic	NA	No	No
	Barium	NA	No	No
	Organotins	NA	No	No
	Phthalates (e.g. DBP)	NA	No	No
	Bisphenol A	NA	No	No
	PFCs (e.g. PFBS and FTOH)	NA	No	No
	BFRs (e.g. decaBDE and pentaBDE)	NA	No	No
	SCCPs	soil and water	Yes	(Yes)
	HCB	NA	No	No
	Asbestos	NA	No	No
	TBT	water, soil	Yes	(Yes)

References: BC Green Building Code 2007, EEA 2009, Häkkinen & Ruohomäki 1992, Kemi 2007, 2009; Majjala & Nippala 2002, SAICM 2009, SFT 2007; US EPA 2009b,c.

2 Use and substances in construction and building products

2.1 Jointing, sealing and filling materials

Lead and other metals

Lead has been used as a hardener in elastic polysulfide sealants and caulk in buildings. The use of lead in sealants decreased after the mid-1970s when manganese (Mn) based hardeners were developed, but lead has also been found in sealing materials in buildings constructed in the 1980's. Polysulphide sealants usually contained 1-2 % of lead oxide. The amounts of lead used in polysulphide sealants have been up to 5 %. Arsenic compounds can be found in filling materials.

PCBs

PCB-containing sealants have been used in the earlier decades on a large scale in Northern Europe and the USA. It was discovered in the 1990s that the jointing materials used in prefabricated buildings and double glazed windows in Germany, Sweden and Finland may be a significant source of PCBs. The use environment may differ in the different countries, for instance, in Finland PCB containing sealants have mainly been used outdoors or in some cases in office or store buildings, while in Germany they have mostly been used indoors.

PCBs have been used as plasticizers in polysulfide-based two-component elastic sealants in the joints between concrete blocks. The perimeters of doorways, windows and valves as well as masonry expansion joints may earlier have been sealed using PCB-containing sealants for air- and watertight structures, as well as roofing plate structures and wooden siding panelling. Elastic sealants have also been used in some cases to replace plaster in sealing brick and stone elements.

The amount of PCBs added to the sealants depends on temperature, with lower temperatures requiring more plasticizers. This is why the concentration of PCBs can vary greatly even for the same materials. There are a number of different commercial PCB mixtures that have been used as plasticizers in elastic sealants. The most used commercial PCB containing sealants were 50-60 % chlorinated. Products based on thiokol polysulfide usually contain PCB as plasticizer, the amount of PCBs in these products has been reported to be 7-25 %. PCBs were probably not used as plasticizers below a concentration of 10 g/kg in order to maintain the elasticity of the sealants. In Germany the sealants contained an average of 15 % of PCBs with a range of 1-50 %, in Finland 10-20% by weight and in Sweden 20%.

The global use of PCBs in polysulfide sealants started in the 1950s and continued until the end of the 1970s while the biggest use of PCBs in construction and building materials was in 1960-1970:

- In Germany PCB containing polysulphide sealants were manufactured between 1955 and 1972 and used until 1975 with an approximate volume of 20,000 tonnes per year.
- In the United States, PCB-containing caulk was used from the 1950's until the 1980s. Buildings that were built in the 1980's are less likely to contain PCBs.
- In Switzerland, one third of all investigated polysulfide joint sealants from buildings constructed between 1966 and 1971 contained more than 10 g/kg of PCBs, while no joint sealants containing this amount were identified in buildings constructed before 1955 or after 1978. Still today 50-150 tonnes of PCBs can be found in joint sealants in buildings.
- In 1969, 5 tonnes of PCBs were used in sealants, 25 tonnes in paints, 5 tonnes in varnishes and 1.5 tonnes in adhesives in Finland. In addition, there may have been PCBs in imported products. In double glazed windows PCB-containing sealants were used from 1960 until the end of the 1970s and it is possible that these windows have been recycled and reused.
- In Norway, PCBs have been used in the sealants of double glazed windows that were produced from 1965 to 1975 and half of the estimated amount (100 tonnes) of them had been disposed by the year 2000. Sealants accounted for 22 %, additives in plaster 38 %, sealants of double glazed windows 17 % and paint 6 % of the total amount of 120 tonnes of all PCB containing products left in use in Norway at the end of year 2006 (Figure 1). In 2008, the proportions were 15 %, 62 %, 10 % and 5 %, respectively.
- In Sweden, PCB-containing sealants were used from 1956 to 1973 and today 150-600 tonnes of PCBs still remain in sealants in the buildings and 35 tonnes in double glassed windows.
- In Denmark there are approximately 235 tonnes of PCBs left in buildings.

Remaining PCBs in buildings

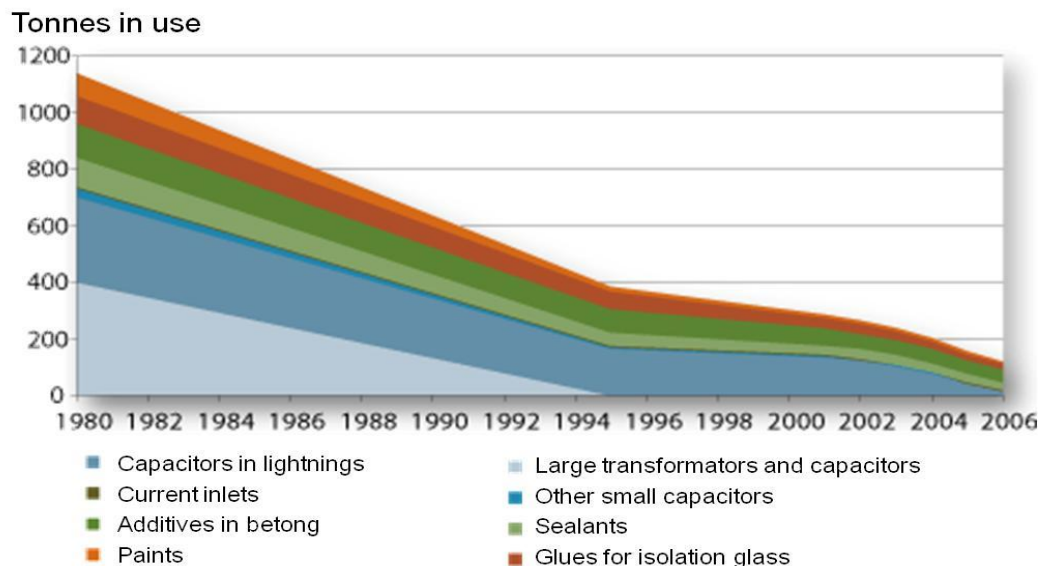


Figure 1. Use of PCB-containing construction and building products in Norway (SFT 2008)

Nonylphenols

Cutting agents in epoxy resins contain NPs in concentrations of 0.5 - 3%. In Finland, 0.1 tonnes of NPs were reported for the use in fillers in 2006. There are possibly large stocks of NPE-containing concrete due to historical use.

Other POP compounds

Short-chained chlorinated paraffins (SCCPs) have been used as additives in fillers or sealers (e.g. polysulphide, polyurethane, acrylic and other polymers) in the building industry. In 2005 in the EU25, 75-100 tonnes of SCCPs were used in sealants and adhesives. In Norway, 12.4 tonnes of SCCPs were used as softeners, and as flame retardants in plastics in 1995. In 2006, there were no registered product containing SCCPs in Norway, but 17-22 tonnes of MCCPs were used as softeners and flame retardants in plastics and 46 tonnes in sealing and insulation materials and adhesives in 2006. These do not include imported products. SCCPs act as plasticizers to achieve the desired hardness and elasticity of the material. They can also add flame-resistant properties to the sealant. The SCCPs used in fillers and sealants appear to have chlorine contents in the range of 56 - 65% by weight. MCCPs and PCNs have been used in sealing compounds.

Phthalates can be found in jointing materials, for instance, dibutyl phthalate (DBP), as a plasticizer in sealants and caulk. Bisphenol A is used in filling foams.

Polycyclic aromatic hydrocarbons (PAHs) are present in jointing and filling materials and brominated flame retardants (BFRs) are used in jointing materials.

References: Benthe et al 1992, BiPRO 2007, ECB 2000, Finnish Ministry of the Environment 2004b, 2008, Healthy Building Network 2006, Hellman et al. 2003; Johannesson 1999, Kiinteistölehti 2004, Kohler et al. 2005, Kontsas et al. 2004, Maijala & Nippala 2002, NICNAS 2009, Peeters Weem 2007, van de Plasche et al. 2002, Priha et al 2005, Pyy & Lyly 1998, Rantio et al. 2001, SFT 2002, 2005, 2007, 2008, 2009b, c, Sundahl et al. 1999, TemaNord 2004, 2007; Tuhkanen et al. 2007, US EPA 2009a, Weis et al. 2003, 2004b, Åstebro 1999, Öberg 1996.

2.2 Concrete and plaster

Metals

Barium sulphate is added to concrete to improve its radiation shielding properties.

PCBs

PCBs have been used in concrete and plaster where they are added in polyvinyl acetate (PVA) mixtures and used as softeners and to improve the fire resistance, flexibility and erosion resistance of the material. In roughcast, which is a type of plaster, PCBs have been used as plasticizers. Roughcast was developed for outdoor use, but because of its durability, it has also been used indoors e.g. in gyms and corridors.

Nonylphenols

NPEs can be used in small amounts as concrete modifiers to help the formation of small air bubbles and thus reducing the strain during freezing. NPE-containing concrete was used in the past mainly in specific structures, such as harbours and bridges. NPs are also used as an accelerator or cutting agent in the hardening components of certain epoxy resins, which are used e.g. in fillers.

References: Andersson et al. 2004; ADSTR 2007, Environment Australia 2001, Finnish Ministry of the Environment 2008, IVL 2008, SFT 2007, Thornton et al. 2001, 2002, Tuhkanen et al. 2007; US EPA 2008, Weis et al 2003

2.3 Insulating material

Metals

Organotins can be found in polyurethane foams.

POP compounds

The isolation materials polyurethane (PUR), expanded polystyrene (EPS) and extruded polystyrene (XPS) contain flame retardants. Hexabromocyclododecane (HBCD), for example, has been used in materials made of EPS foam and XPS used in insulation. XPS is usually used for insulation boards that are used under roads, railways and buildings. XPS is the main plastic product flame retarded with HBCD or HBDD (in Europe 1 - 2% HBDD). EPS has similar uses as XPS and HBCD is the only substance that can be used for fire protection of EPS. Penta-BDE can be used in the polyurethane foam of sound insulation panels, for example. Hexabromobiphenyl (HxBB) has been used as a flame retardant in insulating materials. The use of HBCDD in building materials accounted for 85% of the total use in products in Europe in 2002. Approximately 30 tonnes of brominated flame retardants (including HBCDD) were used for insulation materials in Norway in 2006. The concentration of HBCDD in plastics is 0.5 - 7% depending on the type of plastic. In the 1970s, urea-formaldehyde insulation materials were widely used in thermal insulations. In addition, bisphenol-A has been used in insulation materials. In Sweden, only XPS going to export (4% the produced XPS) contains HBCD. HBCD may be present in imported flame retarded products.

MCCPs and PCBs have been used in insulating materials, including fibreglass, foam, felt and cork. Formaldehyde can be found in foam (urea-formaldehyde foam insulation UFFI) and fibreglass insulation materials. PAH compounds can be found in water insulators

References: Andersson et al. 2004, Costner et al. 2005, EC 2003, Keml 2007, Finnish Ministry of the Environment 2006; 2009c, Kiinteistölehti 2004; Remberger et al. 2004, SFT 2009b, Sharp & Lunder 2004, US EPA 2008; US EPA 2009c

2.4 Roofing, flashings and other exterior structures

Lead and other metals

Lead sheets are used in the building and construction industry in roofing, flashings, cladding, guttering and roof parapets both traditionally in cathedrals and other historic buildings, but also for modern construction uses. Lead compounds can also be found in bitumen used in roofing. Significant quantities of lead sheets are used in nuclear power plants, hospitals,

dental surgeries and laboratories. In the United States 27 % of the lead sheet consumption goes to radiation shielding and in Japan the proportion is as high as 70 %.

Layers of lead can also be placed into walls as a part of a sound insulation system or used for damp proofing. Lead is excellent for noise attenuation due to its high density. The sheets are usually bonded to a surface of other material e.g. plywood for support.

Lead sheets can also be used in the building and construction industry for radiation shielding purposes. They have been used e.g. in the linings for rooms containing X-ray equipment to provide protection from certain types of radiation, most commonly gamma and X-rays.

Leaded window comes have traditionally been H-shaped and U-shaped extruded sections of lead holding together pieces of coloured glass. These have been used for stained glass windows, e.g. in churches and cathedrals. Nowadays stained glass windows are used also in modern homes. The modern equivalent of lead comes is a flat self-adhesive extruded lead tape that can be applied to glass window, but lead comes are still used as well. Stainless steel products have been used for outdoor applications including e.g. facades, wall claddings and roofs. Lead stabilizers have also commonly been used in rigid PVC products exposed to light, such as window frames and guttering to extend the lifetime of the product.

Lead sheets have been used especially in Central Europe, mainly in the United Kingdom, the Netherlands, Belgium, Ireland Germany and France. The UK uses over half of the lead sheets in the EU. In North America, lead sheets are used in small amounts in building construction, e.g. as maintenance-free waterproof membranes, but not in roofing. In Japan, 30 % of lead sheets are used for sound insulation and the rest in radiation shielding. Organotins have been used as stabilizers in PVC building sidings especially in the United States.

Organotins have mainly been used as stabilizers in vinyl roofing materials, rigid films and clear rigid construction sheeting.

In Sweden, measurements have been carried out for copper releases from roofing material.

Chromium is used in stainless steel products (304 and 316 stainless steel used in outdoor applications for facades, wall claddings and roofs both in urban and marine environments).

POP compounds

Flexible PVC products, containing phthalates, have been used in roofing membranes. Bisphenol A can be found in PVC roofing. Flame retardants are used in plastics (other than PVC) and bitumen used in roofing and DEHPs are released from roofing.

References: Costner et al. 2005, Ekstrand et al 2001, Hoffmann et al. 2004, Keml 2001, Miljöförvaltningen 2003, Odnevall Wallinder et al. 2002, SFT 2007, Sörme and Lagerqvist 2002, Thornton et al. 2001, 2002, Tukker et al. 2001, van Sprang et al. 2008; Wilson 2003

2.5 Pipes and cables

Metals

Lead pipes were used in the past, as well as lead solder in copper piping. Lead pipes have been used for instance in Central Europe. Lead stabilizers have commonly been used in rigid PVC products exposed to light, e.g. pipes, to extend the lifetime of the product. In addition,

organotin compounds have been used as stabilizers in PVC water pipes. Mercury and copper have been used as fungicide in pipes.

The use of lead in water pipes is phasing out due to health concerns and better alternatives (copper, plastics). No new lead pipes have been installed in most of the European countries for over 30 years, but large amounts are still present in old buildings and distribution systems installed before the 1930's. Lead piping is still in use in the chemical industry, because of the excellent corrosion resistance of lead. Although lead water pipes were displaced by copper, lead solder was still used in plumbing until the 1980s.

POP compounds

PBDEs have also been used as flame retardants in the plastics of waste water pipes and in rubber made foamed pipes for insulation. DEHP releases have been identified from cables in soil.

References: BC Green building code 2007; Costner et al. 2005, Keml 2003, Kiinteistölehti 2004, Miljöförvaltningen 2003, Sharp & Lunder 2004, Thornton et al. 2001, 2002

2.6 Wooden material

Metals

Chromium(VI), copper and arsenic have been used as a wood preservative in CCA (chromated copper arsenate). Chromium in the form of chromates (chromated copper arsenate, CCA) and chromium(VI) oxide has previously been used in large quantities within the wood industry to protect wood against fungi and insects. Chromium acts as a mordant or fixative whereby it permanently fixes toxic elements (arsenate, borate, fluoride, copper, etc), which prevent the growth of wood-destroying organisms. End products made from CCA-treated wood include electric power transmission and telecommunications poles, fence poles, terrace boards, decks, hand railings and underground railway sleepers. CCA-treated wood has also been used in bridges, residential and other buildings and earth retaining structures. The use of CCA in wood preservation has declined globally in recent years due to many restrictions (see Chapter 5).

Organotin compounds have been used as preservatives and antifoulants on wood surfaces.

Organic compounds

PCNs have been used as a fungicide in wood preservation and hexachlorobenzene (HCB) wood preservative (fungicide). Heptachlor has been used for protection of plywood against decaying and termites. Also lindane and chlordane have been used for wood protection. Pentachlorophenol (PCP) and other chlorinated phenols have been used as wood preservatives in the past to prevent the growth of the decay fungus, e.g. in electrical poles. The use of PCP has been limited in the United States since 1984 to applications such as wooden utility poles, railroad ties and wharf pilings.

Formaldehyde has been used in the production of composite or pressed wood products made with adhesives containing urea-formaldehyde (UF) resins used indoors or phenol-formaldehyde (PF) resins used outdoors. The products include plywood, particle board and fibreboard used in panelling, wall covering, furniture and in membrane roofing. Nowadays the formaldehyde levels of building products have been reduced, but imported plywood may still contain high amounts of formaldehyde.

Impregnated wood may contain PAHs.

References: ADSTR 200, Bailey 2001, Barber et al. 2005, BC Green Building Code 2007, Costner et al. 2005; ECB 2005, ECU 2008, Finnish Ministry of the Environment 2006, Helweg et al. 2004, KemI 2009, Peeters Weem 2007, van de Plasche et al. 2002, SFT 2009a, US EPA 2009c,d, Ympäristökatastrofit 2009

2.7 Wall and floor material

Metals

Lead and cadmium have been used as stabilizers in PVC plastics against heat and light in concentrations from 0.5 to 2.5%. Lead compounds can also be found in bitumen used in wall covering and flooring as well as in wallpapers.

In the United States the use of PVC plastics in construction and building products accounts for 75% and in the European Union for 60% of all vinyl consumption. A large proportion of PVC products used in the construction and building sector are imported. The use of lead as a vinyl stabilizer is greater in Europe than in the United States, accounting for almost 70 % of all the PVC stabilizers.

Organotins, especially tributyltin (TBT), can be found in PVC flooring.

PCBs

PCBs have been found in some acrylic plastic based floor materials, which were used in factories, institutional kitchens and also, for example, in balconies in Sweden. PCBs were also used for plastic floors at least in Germany and Norway. According to a recent Swedish study PCB-containing floor finishes may be a significant source of PCBs in residential buildings.

Nonylphenols

NPs/NPEs are used as antioxidants and plasticizers in PVC, polystyrene, epoxy, PET and polypropylene plastics used in the building industry. NPs are also used as an accelerator or cutting agent in the hardening components of certain epoxy resins, which are used e.g. in floor coverings. Concentrations of 0.5-3 % of cutting agents (containing NPs) are added to the epoxy resins. Approximately 60 % of all plastics that are used in the building industry may contain NPs/NPEs, but the current amount of plastics containing NPs/NPEs in the building industry can be assumed to be less than 0.1 %. In Sweden, 0.14 tonnes of NPEs and 0.41 tonnes of NPs were registered for use in floor coverings and 0.33 tonnes of NPs in joint-less floors in 2006. In Norway, 0.3 tonnes of NPEs and 0.8 tonnes of NPs were registered for use in joint-less floors in 2006.

Other POP compounds

Flame retardants are used in plastics (other than PVC) and bitumen in wall covering and flooring. Hexabromobiphenyl (HxBB) has been used as a flame retardant in plastics. Mirex has been used as flame retardant in plastics and rubber until 1978 in some countries. Decabromodiphenyl oxide (deca-BDE) has been used in building and construction products

made of high impact polystyrene (HIPS) and penta-BDE in polyurethane foam (used to make imitation wood).

Flexible PVC products containing phthalates have been used in flooring and wall coverings since the 1950's and nowadays the construction and building products account for the largest use of vinyl applications. Dibutyl phthalate (DBP) has not been used in significant amounts in PVC, but it has been used in vinyl floors in high amounts and in concentrations of as high as 60%. DEHP has been used in PVC building products, such as floor coverings and floor tiles. Bisphenol A can be found in PVC wall covering and flooring.

Chlorinated paraffins can be found as fillings in PVC coatings of walls, floors and ceilings, as well as in wall papers. PAH compounds may be present in plastic coatings of walls, floors and ceilings.

References: ATSDR 200, Costner et al. 2005, Environment Australia 2001, Finnish Ministry of the Environment 2006, IVL 2008, SFT 2007; KemI 2003, Kiinteistölehti 2004, Miljöförvaltningen 2003, McPherson et al. 2004, Rudel et al. 2008, Sharp & Lunder 2004, SFT 2007, 2009a, TemaNord 2004, Thornton et al. 2001, 2002, Tuhkanen et al. 2007

2.8 Surface coatings and adhesives

Lead and other metals

Lead compounds have been used as pigments in paint. Lead is still used in some ceramic glazes, e.g. wall and floor tiles. Leaded pigments and paints with a typical concentration of 0.1 to 0.5% were widely used before 1950 after which their use reduced significantly due to a rapid move to safer alternatives. They were almost eliminated by 1960 in household paints. There may still be lead in paints on old buildings.

Organotins can also be found in glass coatings.

Mercury has been used in exterior and interior latex paints as a fungicide. Mercury found in buildings is usually metal mercury. Before mercury-containing interior paint was banned, it was the third largest use application of mercury in the United States. Cadmium has been used for pigments in paints as well as chromium(III) and chromium(VI) (hexavalent chromium). Chromium compounds have also been used for rust protection. Barium (Ba) has been used as a pigment and a corrosion inhibitor in paints and arsenic compounds have been used as pigments in paints and wallpapers. Copper and tributyltin (TBT) have been used in antifouling paints. Mercury has been added to paints at least in the United States.

PCBs

PCB-containing surface coatings include paints, varnishes, waxes, adhesives for waterproof wall coatings and floor carpets as well as flame-retardant coatings on ceiling tiles, and walls especially in industrial and public buildings because of their anti-corrosive properties and as plasticizer (softener) or to improve their attachment properties, permanence and flexibility as well as fire and moisture resistance properties. Dedusting agents as well as laminating and impregnating agents have also contained PCBs.

In addition, they have been commonly used in concrete surfaces of cellars, stairways and walls, in public buildings like schools and barracks. Besides walls and floors, PCBs can also be found in the surface of metallic containers and pipes.

PCBs were added either directly to the paint as an additive or with the resins used in the paints, resulting in concentrations up to 10% . PCBs have been used in the surface coatings at least in Finland, Germany, Norway and Canada.

Nonylphenols

Nonylphenol ethoxylates (NPEs) have been used in the manufacture of paints, lacquers, varnishes and adhesives. They have been used in the manufacture of polyvinyl acetate (PVA) paint resins as well as a paint mixture stabilizer. Products containing NPs/NPEs include e.g. paints used on wet room floors, water-based paints and varnishes used mostly indoors, paints for concrete floor, metal coating and certain anti-corrosive paints. NPEs are used in glues as water-based adhesives e.g. in the construction industry. NPs are also used as an accelerator or cutting agent in the hardening components of certain epoxy resins, which are used e.g. in paints and varnishes and glues.

NPs/NPEs are still used in paints and varnishes in the Nordic countries with a typical concentration of 0.6-3 %. Approximately 11 tonnes of NPs and 2.6 tonnes of NPEs were registered for used in paints and varnishes and 8.7 tonnes of NPEs as binding agents for paints and adhesives in Sweden in 2006, about 130 tonnes in Finland and 3 tonnes in Norway. NPs and NPEs are not used in the production of paints and lacquers in Denmark but may be found in imported or semi-manufactured products. The historic use also represents a large stock of NPEs in paint. The use of NPEs in water-based adhesives has reduced by 98 % in 1995-1999 in Sweden.

Other POP compounds

PFCs have been used in various building materials. PFOS-related substances have been used in paints, varnishes and adhesives. For example, perfluorobutane sulphonate (PFBS) has been used in paints. Fluorotelomers (FTOH) have been used in the surface treatment of building materials, e.g. tiles and flooring.

Hexachlorobenzene (HCB) has been used as a solvent in paints and plastics and trichloroethylene (TCE) in glues.

Flame retardants are used in wallpapers, paints and other coatings, for example, deca- and penta-BDEs are used in industrial protective paints and lacquers.

SCCPs have been used in glues and coating materials in the building industry. In paint and coating applications along with the use as a plasticizing agent, SCCPs can also be used to improve the water resistance, chemical resistance and the non-flammability of paints in concentrations of 60-65% wt or at proportions of 1-10% in paints based on resins. The paints are mostly solvent based and are used mainly in industrial/specialist applications such as marine primer paints, fire retardant paints and paints for road markings. In 2005 in the EU25, 50-75 tonnes of SCCPs were used in paints and coatings and for instance in Norway, 3 tonnes of SCCPs were used for paints and rust protection in 1995. In 2006 there were no registered products containing SCCPs in Norway, but MCCPs were used 2.1 tonnes for paints and varnishes. MCCPs have been used as binders in two component adhesives.

Phthalates can be found in paint and varnish as well as wallpapers. Dibutyl phthalate (DBP) has not been used in significant quantities in PVC, but it has been used in coatings and adhesives . DEHP has been used in coatings (paint) and adhesives. Bisphenol A has been used in paint and varnish.

References: ADSTR 1999, 2007, 2008a, BC Green Building Code 2007, BiPRO 2007, Breivik et al. 2002 b, Brunn Poulsen et al. 2005, Costner et al. 2005, DEQ 2003, ECB 2000, ECY 2008, Environment Australia 2001, Finnish Ministry of the Environment 2004a, 2006; Healthy Building Network 2006, IVL 2008, Keml 2006, Kiinteistölehti 2004; Maijala & Nippala 2002, NICNAS 2009, SFT 2004, 2007, 2009b, Sharp & Lunder 2004, Thornton et al. 2001, 2002, Tuhkanen et al. 2007, UNEP 1999, US EPA 2009e

3 Releases to the environment

There are several factors affecting the releases from construction and building products. These include environmental conditions such as temperature and precipitation, condition of the building products (for instance age and renovations) and properties of the chemicals and substances released (e.g. leaching, evaporation). The location of the building also has an impact on releases through the related environmental conditions.

Some construction and building products and materials are in direct contact with the outdoor environment, some are only in direct contact with indoor air, and some are in direct contact with both. The products can be placed under or inside other materials, e.g. pipes. They can also be between other materials, e.g. sealants and insulation foam or on top of other materials, e.g. flooring, roofing and paint. When used indoors, the chemicals can be released to outdoors, e.g. via ventilation systems.

Releases to soil from construction and building products can be mainly found in the close neighbourhood of the building. Substances can also leach to water and soil or volatilize into air or be transported to a longer distance in dust. The substances can also contaminate the surrounding products, especially porous material.

Information on estimated concentrations of different chemicals in construction and building products and their emission rates and release periods is presented in Table 4. The production period and region of the products can also be found in the table, as well as the region for use and the possible replacement of the harmful chemicals. Detailed background for the information in the table is presented in Annex I.

The global distribution of substances released from the use phase of construction and building products depends on where the materials have been used and the distance the released substances are spreading. Releases of PCBs from joint sealants have been measured at least in Northern Europe and in the United States.

Table 3. Releases of substances from the use phase of construction and building products (includes only substances and product groups from which information is available; blank cells indicate that no information is currently available)

Product group	Substance	Concentration of the substance in the product (rough estimate)	Use volume of the substance	Release rate (rough estimate)	Production period	Use period	Release period	Region for production	Region for use	Possible replacement
Jointing, sealing and filling materials, concrete and plaster										
Polysulphide sealants and caulk	PCBs	7-25 % (maybe not below 10 g/kg), 0.5-5 % in window sealants	100-500 tonnes/country	Atmospheric releases of PCBs from sealants: 8.36 tonnes/year (if a total ⁴⁴ of 100 tonnes is in use); less than 1 % in air, 1-2 % in soil, 1 % in rainwater drainage	1950-1970	1950-1970/80 (biggest use in 1960-1970)	Continuous (weathering) and during renovations	USA, UK, Europe, Japan, SU/USSR and China (all PCB mixtures)	Europe and North America (at least)	Chlorinated paraffins, phthalates, polyurethanes
Sealants and adhesives	SCCPs		75-100 tonnes in EU25 in 2005							
Polysulphide sealants	Lead	usually 1-2 % (up to 5 %)			-1975?	-1980 (biggest use before 1970's)	Continuous (weathering) and during renovations			Manganese
Epoxy resins used in fillers	NPs/NPEs	0.5-3 % of cutting agents containing NPs	0.1 tonnes of NPs used in fillers in Finland in 2006							
Plaster	PCBs				1950-1970?	1950-1970 (biggest use in 1950-1960)	During renovation and if starting to deteriorate			
Insulating materials										
Insulating (UFFI) fibreglass	Form-aldehyde					Biggest use of UFFI in the 1970's (USA)	Continuous (decreasing with time)			

⁴⁴ Total = use from previous years and current year

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Product group	Substance	Concentration of the substance in the product (rough estimate)	Use volume of the substance	Release rate (rough estimate)	Production period	Use period	Release period	Region for production	Region for use	Possible replacement
EPS and XPS insulation materials	HBCD	0.5-7 % depending on the type of plastic. European XPS contains 1-2 %								
Roofing, flashings and other exterior structures										
Lead sheets	Lead						Continuous (weathering)		Central Europe, mainly in the UK, the Netherlands, Belgium, Ireland Germany	Aluminium, lead-clad steel, rubber backed metal, galvanised steel, zinc, copper
PVC-plastics used e.g. in roofing	Phthalates	Up to 60 %			1936- (PVC)	1950's- (PVC)		USA (PVC)		
PVC-plastics used e.g. in window frames and guttering	Lead	0.5-2.5 %							More in Europe than in the USA	Organotins, calcium-zinc, calcium based
Pipes										
Lead pipes and solder in copper pipes	Lead					-1930, -1987 (solders)	Continuous (corrosion)			Copper, PVC
PVC-plastics used in pipes	Lead	0.5-2.5 %							More in Europe than in the USA	Organotins, calcium-zinc, calcium based
Wooden materials										
CCA impregnated wood	Chromium			1-2 % to soil						
Composite and pressed wood products	Formaldehyde					-1990's?	Continuous (decreasing with time)			

Resource Compendium Part IV: Releases from the Use of Products –
Case Study on Construction and Building Sector Products

Product group	Substance	Concentration of the substance in the product (rough estimate)	Use volume of the substance	Release rate (rough estimate)	Production period	Use period	Release period	Region for production	Region for use	Possible replacement
Wall and floor materials										
PVC-plastics	Phthalates	Up to 60 %			1936- (PVC)	1950's- (PVC)		USA (PVC)		
PVC-plastics	Lead	0.5-2.5 %							More in Europe than in the USA	Organotins, calcium-zinc, calcium
Epoxy resins used in floor coverings	NPs/NPEs	0.5-3 % of cutting agents containing NPs	Approximately 0.1-1 tonnes used in 2006 in Nordic countries for floor coverings							
Surface coatings and adhesives										
Paint and other coatings (e.g. floor finishes)	PCBs	5-10 % in paints	500-2500 tonnes/country in the 1950s-1970s	Atmospheric releases of PCBs from paint: 8 tonnes/year (if a total of 100 tonnes in use)	1952-1975 (Norway)		During renovation and when starting to deteriorate		At least in Finland, Germany, Norway and Canada	Chlorinated paraffins (in floor finishes)
Paints and coatings	SCCPs	1-10 % in paints	50-75 tonnes in EU25 in 2005							
Paints, varnishes and adhesives	NPs/NPEs	0.6-3 % of NPEs in paints, 0.5-3 % of cutting agents	Amounts used vary by country	Releases to wastewater: less than 1 % of NPs/NPEs from paints						
Paint	Lead	0.1-0.5 %			-1960?	-1978 (biggest use before 1950's)	During renovation and when starting to deteriorate			Zinc, titanium dioxide
Latex paint	Mercury					-1991 (USA)	During renovation and when starting to deteriorate		USA (at least)	
Paint	Chromium			0.03-13 tonnes in Denmark in 1999			During renovation and when starting to deteriorate			

3.1 Jointing, sealing and filling materials

PCBs

PCBs are present in buildings as solid particles or as vapour. The concentration of PCBs in air is generally much greater in urban areas than in rural areas. High PCB concentrations have been found in the outdoor and indoor air, soil surrounding buildings and also in the concrete and polymer materials near the PCB source. According to studies, PCB emissions are mainly due to indoor air contamination. PCB releases to air from construction and building products are likely to spread to the environment during renovation bound in dust as well as due to weathering products. PCBs in the soil around the buildings are most likely due to natural weathering of building products. PCBs are found to mobilize as complexes with dissolved organic matter leaching from the caulking. In Northern countries like Finland the lifetime of polysulphide sealants is from 20 to 30 years due to weather conditions.

It has been found that indoor air PCB concentrations remain even after the removal of all PCB-containing sealants, likely due to off gassing from secondary sources like wallpaper and carpets.

The highest concentrations of soil PCB levels may be found on the side of the buildings in contact with the most severe weathering conditions (e.g. the south side exposed to sun) showing the impact of weathering on sealants⁴⁵. Cleanup techniques have been developed to minimize the releases of PCBs to the surrounding environment during replacement of the sealants. It is estimated that less than 1 % of the PCBs from sealants ends up in the air, 1-2 % in the soil, 1 % in the rainwater drainage and 95 % will be collected as hazardous waste

Other POP compounds

SCCP releases from the use in sealing compounds is likely to be minimal due to low vapor pressure of the substance.

References: Andersson et al. 2004, ATSDR 2000; ECB 2000, Finnish Ministry of the environment 2008, Herrick et al. 2007, Jamshidi et al. 2007, Jansson et al. 1997, Johannesson 1999, Kannan 2000, Kiinteistölehti 2004, Kotsas et al. 2004, Priha et al. 2005, Rantio et al. 2001, Sundahl et al. 1999, Weis et al. 2003, Åstebro 1999

3.2 Concrete and plaster

PCBs

PCBs can be transferred also from PCB containing products to the material it is in contact with, e.g. concrete or wood. This secondary contamination affects significantly the indoor air PCB levels. Concrete structures next to polysulfide sealants may have PCB concentrations that correspond to a fraction of a millesimal of the concentrations of the sealants and the highest values (28 mg/kg) in a study decreased rapidly with increasing distance. Also migration of PCBs from concrete to new sealant has been reported after the sealant has been replaced.

⁴⁵ Average PCB levels in a Finnish study: south 16.6 mg/kg; west 2.00 mg/kg; east 2.39 mg/kg; north 3.96 mg/kg (Priha et al 2005)

NPEs

NPEs can be released from concrete through leakage and enter the storm water system and wastewater treatment plants in concentrations of 0.2 mg/m² in Sweden

References: Benthe et al. 1992, IVL 2008, Pyy and Lyly 1998

3.3 Insulating material

HBCD

Flame retardants used in XPS and EPS can be released to the environment during the use of the product. HBCD is an additive flame retardant and thus it is not chemically bound to the polymer. This is why HBCD can be emitted from polymer products by diffusion. If the product has a long service life (ca. 50 years for XPS boards), releases can occur during the whole lifetime of the product. Also, wearing of building materials is one possible release mechanism.

The leaching of HBCD from products can be expected to be higher in urban areas due to population density and thus consumption. Indications of elevated HBCD concentrations have been found in the air, sediments and possibly in the depositions of urban environment compared to background levels. This could result from diffuse releases from the use of polymer products, such as building materials. The release rates can be expected to decline with time, if the predominant release mechanism is solid phase diffusion.

For additive flame retardants, it is estimated that 0.05 % of the substance will annually leach from the material to the air. The so called worst case emission factors for leaching of BFRs to the water; 0.05 % for indoor use and 0.7 % for outdoor use.

References: Remberger et al. 2004, 2006, SFT 2004, 2009b

3.4 Roofing, flashings and other exterior structures

Lead

Due to slow corrosion of lead, releases to the environment may occur. There is evidence that lead due to run-off can dissolve into rainwater or be abraded during the roof lifetime.

When lead sheet is exposed to air, it rapidly forms a layer of oxide on its surface. This reacts further with water to form lead hydroxide and with carbon dioxide to form lead carbonate, which has very low solubility and gives good protection. Leaded roofs in areas subject to high levels of sulphur dioxide have very good stability due to the formation of lead sulphate layer, which has very low solubility in both water and dilute sulphuric acid. The corrosion rate might be accelerated if there are lichens on a tiled roof. Also if the design of the roof allows condensation to form underneath the roof, corrosion might occur. The combined use of lead and aluminium roofing is not recommended in marine environments, because the corrosion of lead can accelerate the corrosion of aluminium.

The amount of rainfall, temperature and pH controls the run-off rate. Rainwater is mildly acidic (e.g. carbonic, sulphuric and nitric acids) and might thus dissolve some of the

corrosion products. Also the alloy composition of the lead sheet has an effect on the run-off rate. Flashings installed on roofs have lower run-off rate than lead sheet test samples due to orientation of the sheet, shelter effects, evaporation rates and the alkalinity of the building material (bricks, cement and roofing tiles).

The releases of lead from the use of lead sheets for soundproofing and radiation shielding are expected to be negligible and the largest releases from these products will probably take place in the waste handling stage.

Chromium

Some chromium releases from the use phase of stainless steel products (304 and 316 stainless steel used in outdoor applications for facades, wall claddings and roofs both in urban and marine environments) have been reported. Releases of chromium to soil and water may occur through corrosion of iron, steel, aluminum and copper.

The release rates of chromium have been estimated from as-received (pickled and skin passed) 304 and 316 stainless steel during a one-year field exposure in an urban environment in Stockholm, Sweden and also through complementary exposures in artificial rain. The steels in question are used in outdoor applications for facades, wall claddings and roofs both in urban and marine environments. Release rates from 304 stainless steel were 0.25–0.3 mg Cr/m² and 0.35–0.4 mg Cr/m² from 316 stainless steel. There was no observed direct effect of rain intensity on the metal release rate. Surface conditions had a major influence on the release rate, indicating a non uniform corrosion attack. The release rate of chromium was significantly faster from an abraded surface than from an as-received surface. The release rate of chromium from abraded surfaces increased substantially with decreasing pH. Release rates determined during laboratory exposures in artificial rain were comparable with release rates determined during field exposures in natural rain. Based on this information an estimation has been made of annual dissipation of 200 kg chromium to the environment from the use phase of products containing 304 and 316 stainless steels. The estimate includes the assumptions that stainless steel in-use stock was twenty times greater than the annual use, 10% of that stock is located outdoors and the average thickness of the steel was 1 mm.

In Norway, no emissions of chromium from steel products or lead from lead metal products used in building materials have been detected.

Copper

In Sweden, measurements have been carried out to quantify releases of copper from roofing material.

DEHP is found to leach from roofing material.

References: Ekstrand et al 2001, Hoffmann et al. 2004, Johnson et al. 2006, Keml 2003, Miljöförvaltningen 2003; Odnevall Wallinder et al. 2002, SFT 2004, Sörme and Lagerqvist 2002, Thornton et al. 2001, Tukker et al. 2001; van Hyfte and Callebaut 2007, Wilson 2003

3.5 Pipes and cables

Lead

The main sources of lead in drinking water are lead service pipes and household plumbing. The solubility of lead depends on the acidity and temperature of water as well as length of exposure to water. Acidic, soft water causes continuous slow corrosion, while in hard water (i.e. water containing dissolved lime compounds) some corrosion can occur initially, but a protective layer is quickly formed on the inside of pipes, preventing further corrosion. Carbon dioxide or organic matter in water can increase the corrosion rate. Lead pipes can also slowly corrode in soil though the corrosion is very localized and the rate low. Lead releases tend to be rapidly bound by soil particles thus travelling only short distances. Lead can also be released to drinking water, not only from pipes, but also from lead-tin solder and brass fittings used in pipes. In the past, it was thought that the amount of lead leached into the water from the solder would be negligible, but more recently, even small amounts of lead have been found to be detrimental to health. Stabilizers used in PVC pipes, for instance lead and organotins, have been found to leach from the pipes into drinking water.

Lead can also be evaporated to air at small amounts during application of solder.

British experiments have shown that the corrosion rates of lead pipes in most of the British soils are 2.5-10 μm annually. The lowest corrosion rates were found in well-drained sandy soils, chalk and moist normal clay. In moist acid clay, much higher annual corrosion rates were found; 150-170 μm for pure lead and 80-520 μm for lead-tellurium alloy. Even greater rates were found in wet acid peat. The corrosion rates were quite constant, only slightly increasing with time.

Copper

In Norway, releases of copper from pipes to water have been estimated to be 25 tonnes annually since 1997.

DEHP

DEHP has been found in cables buried in the soil.

References: Costner et al. 2005, Keml 2003, Miljöförvaltningen 2003; SFT 2004, Thornton et al. 2001, 2002

3.6 Wooden material

Chromium

Releases of chromium to the environment from the use phase of end products are attributed to the use of impregnated wood. The CCA-treated wood products are typically outdoor applications and thus in direct contact with soil and/or water and subject to rainfall. The releases from impregnated wood are largely to soil and the available information shows that the chromium does not migrate to any significant extent from the area around the treated wood.

Releases of chromium from existing residential wood structures (such as play sets and decks) treated with chromated copper arsenate (CCA), occur incrementally over time. The quantities of chromium released from impregnated wood depend on many factors, including exposure to water and rain. Leaching of chromium into the aquatic environment primarily takes place during the first few years. Even though only small quantities of wood are impregnated with chromium today, releases will continue to occur in the future. This is due to the long lifetime of impregnated wood. It has been estimated that impregnated wood for building, construction and outdoor applications has a functional lifetime of approximately 40 years. It is also estimated that an additional ten years should be added to this period because a lot of impregnated wood is reused. The functional lifetime of impregnated wood varies greatly. For example, building components may have functional lifetimes of 100 years, whereas fence poles, terrace boards, etc., may have functional lifetimes of 30–40 years. The majority of the chromium impregnated into the wood is converted into chromium (III), and any chromium (VI) released to soil will also be rapidly converted.

In several studies an emission rate of 1–2% of the chromium in the wood to soil and the aquatic environment has been presented. According to laboratory studies on the removal of chromium (and the other constituents of CCA) from treated wood samples up to 1% removal of chromium was found in leaching experiments. According to another study chromium (along with arsenic) leached from an in-service CCA-treated deck exposed to rainfall over a three-year monitoring period amounted to 1.4% of the chromium initially present in the CCA-treated wood. (Shibata et al. 2007) An estimate given for annual global dissipation of chromium from the use phase of treated wood is 7 Gg (7,000 tonnes) from a rough estimate of stock (10 years' flow), with an assumption of 70 % wood in contact with water, using the same release rate of 1% as in the studies above.

In addition, chromium and arsenate can leach to soil and PAH compounds can be emitted to air.

Organic compounds

Releases of PCPs from treated wood have been found on soil and water.

Products containing PF resins emit significantly lower amounts of formaldehyde than products containing UF resins. The formaldehyde level of indoor air depends on several factors, including temperature, relative atmospheric humidity, ventilation and on other formaldehyde sources, such as furniture and cigarette smoke. The amount of formaldehyde released from construction and building products decreases with time.

References: Costner et al. 2005, Braunschweiler et al. 1996, ECB 2005, ECV 2005, Hansen et al 2000; Helweg et al. 2004, Hoffmann et al. 2004; Johnson et al. 2006, Keml 2009, SFT 2007, Shibata et al 2007, US EPA 2009c

3.7 Wall and floor material

POP compounds

Phthalates are not chemically bonded to the PVC plastic and they can thus leach out of the product into air, water and soil over time. Indoor air has been found to have significantly higher concentrations of phthalates than outdoor air. This is due to their abundance in building materials and consumer products. Phthalates have also been found to be present in

higher concentrations on dust particles than in vapour phase due to their low vapour pressure.

DEHP has been found to be released to air from PVC flooring.

In a study in Sweden, PVC was found to be the major source of releases of NPs/NPEs to the air in newly built houses. Because the releases from rigid plastics occur very slowly and NPs/NPEs are added to products in very small amounts, the releases to the environment are also considered to be small.

References: Costner et al. 2005; IVL 2008, Kemi 2003, Miljöförvaltningen 2003, Thornton 2002

3.8 Surface coatings and adhesives

Surface coatings and adhesives can contaminate wide areas when they deteriorate, due to the large area and thin layer of the application. Paint chips can end up in the environment surrounding buildings or be washed into the drainage. The life time of paint applied on buildings is approximately 10 years in the Nordic Countries.

NPs

The most important releases of NPs/NPEs during the use of paints and varnishes are the leakage from treated surfaces as well as from cleaning of the equipment. Adhesives are not considered as a major source of NPs/NPEs to the environment, although minor releases may occur during cleaning of the equipment. It has been estimated that less than 1 % of NPs/NPEs from paints and approximately 1 % of NPEs from adhesives is released to the WWTPs in Sweden.

After being released to the environment, NPEs can end up in the storm water systems and the wastewater treatment plants (WWTPs). In WWTPs NPEs are accumulated in the sludge and a large part of NPEs degrades into NPs. Air is not identified to be a major pathway of NPs/NPEs to the environment, although small amounts can also evaporate to the air during application of paint, resulting in higher atmospheric emissions of NPs/NPEs in residential area.

PCB releases occur from PCB-containing paint application.

SCCPs

SCCP releases from paints and sealing compounds are considered negligible. The low vapor pressures of chlorinated paraffins mean that volatilization from the finished painted surface is likely to be low, and the low water solubility means that leaching from the paint during use is likely to be minimal. Further, for some applications such as marine paints, the chlorinated paraffin-containing paint is used as a primer and is subsequently covered with a top coat of a different type, thus further minimizing the possibility of leaching.

Lead and chromium

Lead can be released to environment, e.g. as paint chips when the old paint starts to deteriorate. After being released to the air, lead particles can later settle in dust. Releases of

chromium to soil and water may also occur from surfaces painted with paints containing chromium pigments.

Use of chrome pigments in paint caused releases to water of about 0.03-13 tonnes in 1999 in Denmark.

References: BC Green Building Code 2007, ECB 2000, EMEP 2005, Hoffmann et al. 2004, IVL 2008; Kiinteistölehti 2004

4 Release estimation techniques

There are some estimation techniques found in the literature for estimating the releases of different substances from the use phase of construction and building products (Table 4). These include the study by Breivik et al. (2002b) to estimate the releases of PCBs from different applications, the case study on NPs and NPEs by IVL (2008), the release estimations of PCBs presented in the EMEP/CORINAIR Atmospheric Emission Inventory Guidebook and the annually reported data on releases of certain prioritized hazardous substances from products by the Norwegian Climate and Pollution Agency, KLIF.

Table 4. Emission factors for different chemicals released from construction and building products

End-product group	End-product	Substance	Emission factor (E_i)	Release media	Reference
Building and construction products		MCCPs	0.0025 kg/kg MCCP in product (0.25 %)	Air	SFT (2004, 2009b)
			0.0325 kg/kg MCCP in product (3.25 %)	Water	
			0.015 kg/kg MCCP in product (1.5 %)	Soil	
Jointing, sealing and filling material	Sealants	PCBs	83.6 kg/t	Air	Breivik et al. (2002b)
Concrete and plaster	Concrete	NPEs	0.2 mg/m ²	Storm water	IVL (2008)
Insulating material		BFRs	0.05 %	Air	SFT (2004, 2009b)
			0.05 % (indoor use), 0.7 % (outdoor use)	Water	
Roofing, flashings and other exterior structures	Lead sheets	Lead	5 g/m ² (corrosion rate), 0.008 %, 0.006 % to soil	Water, soil	Tukker et al. (2001)
	Lead sheets used for roofing in residential / utility buildings		5 g/m ² (run-off rate), 0.3/0.8 (division factor to soil), 0.15/0.2 (division factor to surface water)		Wilson (2003), Van Hyfte & Callebaut (2007)
	Lead sheets used for flashings in residential / utility buildings		0.88 g/m ² (run-off rate), 0.3/0.8 (division factor to soil), 0.15/0.2 (division factor to surface water)		
	Roofing material	DEHP	0.985 g/m ² (clean surface) 2.31 g/m ² (unclean surface)	water, soil	Miljöförvaltnin gen 2003
		Copper	0.2 g/m ²	soil	Sörme and Lagerqvist 2002
Pipes and cables	Lead pipes	Lead	1.014 mg/capita	Wastewater	Tukker et al. (2001)

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	Cables in soil	DEHP	1.2%	Soil	Miljöförvaltnin gen 2003
Wooden material	CCA-treated wooden structures	Chromium, copper, arsenate	ca. 0.01 kg/kg (1 %)	Soil	Braunschweil er et al. (1996), Shibata et al. (2007) and Hansen et al. (2000); SFT (2004)
	Treated wood	PAHs	0.01 kg/kg PAHs in product (1 %) 0.02 kg/kg PAHs in product (2 %)	Air Soil	SFT (2004)
Wall and floor coverings	Hard plastics	NPs/NPEs	2.78*10 ⁻¹² kg/m ²	Storm water	IVL (2008)
	Soft plastics		4.64*10 ⁻¹² kg/m ²		
	PVC products	DEHP	0.0095 g/m ²	Air	Miljöförvaltnin gen 2003
Surface coatings and adhesives	Paint	PCBs	80 kg/t	Air	EMEP/CORIN AIR Atmospheric Emission Inventory Guidebook (2005)
	Paints and varnishes	NPEs	0.005 kg/kg (0.5 %)	Wastewat er	IVL (2008)
	Adhesives	NPs/NPEs	0.01 kg/kg (1 %)	Wastewat er	
	Paint and anticorrosive coating	SCCPs	0.165 kg/kg (16.5 %)	Soil and water	SFT (2004)
	Paints, varnishes etc.	Chromium	0.1 kg/kg (10 %)	Soil	
	Paints	Lead	0.1 kg/kg (10 %)	Soil	
	Antifouling paints	Copper, TBT	0.81 kg/kg (81 %)	Water	
			0.09 kg/kg (9 %)	Soil	

According KLIF (SFT 2008), there are no data available to calculate the PCB releases from construction and building products in Norway directly. The releases can be calculated using data from the phasing out of PCB-containing products and their waste handling.

The releases of MCCPs from products in Norway are estimated to be 5% of the amount used, with 5% distributed to air, 65 % to water and 30% to soil. This would result in emission factors of 0.0025 kg/kg (0.25 %) to air, 0.0325 kg/kg (3.25 %) to water and 0.015 kg/kg (1.5%) to soil. There are no differentiations between the product groups (SFT 2004, 2009).

4.1 Jointing, sealing and filling material

PCBs from open use applications to air

Breivik et al. (2002b) have derived emission factors for emissions of 22 individual PCB congeners from open use applications. The emission factors for all open usage were derived based on experiments with atmospheric releases from sealants containing PCBs. The emission factors are presented in Table 5 for open use cover sealants, concrete and plaster, surface coatings and adhesives and plasticizers in PVC plastics. There was not enough

information available to allocate the amount of certain PCB mixtures to specific applications. The calculations are based on a study by Persson et al. (1997) of experiments with atmospheric releases from PCB-containing sealants. The results are presented in temperature of 20 °C. The sum of the emission factors of 22 PCB isomers results in 83.6 kg/t of PCBs used in a year.

Table 6. Emissions factors for 22 individual PCB congeners to air. 1 (open) stands for open system applications (Breivik et al. 2002b)

PCB No.	Chemical structure	<i>ef</i> (usage) 1 (open) 20 °C
5	2,3-DiCB	2.56E-02
8	2,4'-DiCB	2.71E-02
18	2,2',5-TriCB	6.75E-03
28	2,4,4'-TriCB	6.75E-03
31	2,4',5-TriCB	6.88E-03
52	2,2',5,5'-TetCB	4.03E-03
70	2,3',4',5-TetCB	1.01E-03
90	2,2',3,4',5-PenCB	1.09E-03
101	2,2',4,5,5'-PenCB	1.10E-03
105	2,3,3',4,4'-PenCB	1.49E-04
110	2,3,3',4',6-PenCB	6.70E-04
118	2,3',4,4',5-PenCB	2.08E-04
123	2',3,4,4',5-PenCB	2.27E-04
132	2,2',3,3',4,6-HexCB	3.21E-04
138	2,2',3,4,4',5'-HexCB	2.31E-04
149	2,2',3,4',5',6-HexCB	4.44E-04
153	2,2',4,4',5,5'-HexCB	2.92E-04
158	2,3,3',4,4',6-HexCB	2.66E-04
160	2,3,3',4,5,6-HexCB	3.46E-04
180	2,2',3,4,4',5,5'-HepCB	7.45E-05
194	2,2',3,3',4,4',5,5'-OctaCB	1.58E-05
199	2,2',3,3',4,5,5',6'-OctaCB	3.80E-05

All units in (w/w) year⁻¹.

PCB emissions to air from open application during one year can be calculated as follows (Breivik et al. 2002b):

$$E(t) = U_{current}(t) \cdot EF$$

where

E(t) = Emissions from usage of PCB products (tonnes)

U_{current}(t) = Amount of PCB in use at the beginning of year, before losses (tonnes)

EF = emission factor for use

The amount of PCB in use in these applications (*U_{current}*) in one year can be calculated as follows (Breivik et al. 2002b):

$$U_{current}(t) = U_{rem}(t-1) + U_{new}(t)$$

$$U_{new}(t) = C(t) \cdot \mu(t)$$

$$U_{rem}(t) = U_{current}(t) \cdot (1 - af_s - af_f - ef) - D_{new}(t)$$

where

$U_{rem}(t)$ = Amount remaining in use at the end of year, after losses (tonnes)

$U_{new}(t)$ = Amount added to use during year (tonnes)

$C(t)$ = Total consumption in year (tonnes)

$\mu(t)$ = Use factor (fraction of total consumption of PCBs)

af_s = Factor for accidental releases to soil

af_f = Factor for accidental releases from fires

D_{new} = Amount that is disposed from use at the end of the year

The use factor (μ) describes the fraction of total consumption of PCBs, which is used during one year.

Because temperature affects the emissions and the emission patterns of PCBs, the emission factors increase with increasing temperature. The volatilization of PCBs varies greatly between different congeners. Breivik et al. (2002b) emphasizes that the emission factors of the study are highly uncertain due to lack of data.

4.2 Concrete and plaster

NPEs from concrete to storm water

According to IVL (2008), the annual releases of NPEs from concrete to storm water can be calculated by using equation:

$$E = A \cdot E_f$$

E = emission (kg)

A = surface of construction (m²)

E_f = emission factor, 0.2 * 10⁻⁶ kg/m²

4.3 Insulating material

BRFs from insulating material to air, soil and water

The annual releases of BRFs from insulating material to air, soil and water can be estimated by using equation:

$$E = A \cdot E_f$$

E = emission (kg)

A = amount of BRF in the product (kg)

E_f = emission factor (kg/kg)

The emission factors are according to KLIF (SFT 2004, 2009), 0.05 kg/kg to air, 0.05 kg/kg to water (indoor use) and 0.7 kg/kg to water (outdoor use).

4.4 Roofing, flashings and other exterior structures

Heavy metal and POP releases

The corrosion rate of 5 g lead/m² of exposed area per year can be used to estimate the emission of lead from lead sheets. The approximated corrosion rate might be above the actual rate, because it is based on old measurements, possibly on thinner lead sheets, and because corrosion might also decline in time due to the formation of metal oxides and sulphides. (Tukker et al. 2001; Thornton et al. 2001)

The annual releases of lead to the environment from lead sheets can be calculated as follows:

$$E = A \cdot E_f$$

where

E = emission of lead (in solid form) (kg)
E_f = run-off factor for lead (kg/m²)
A = exposed area of leaded roofing (m²)

The equation does not take into account that corrosion may decrease during time.

According to Dutch estimations, 50% of the lead sheet is used in residential buildings and 50 % in utility buildings. Approximately 25% of the total amount of lead sheet is used in residential buildings and 20 % of the lead sheet in utility buildings is exposed to atmosphere and water. (Van Hyfte and Callebaut 2007)

If it is assumed that 25% of the total area of lead sheet is exposed to corrosion, this leads to annual emissions of 120-150 tonnes of lead in the Netherlands. When taking into account the annual emissions and the estimated total stock of lead sheet used in buildings, the corrosion rate of 5 g/m² implies an emission factor of 0.008-0.01 % of the lead stock per year. In the study to estimate the emissions of lead from lead sheets used in buildings in the EU15⁴⁶, Tukker et al. (2001) used the emission factor of 0.008 %/year and assumed that 75% of the run-off of lead will end up in the soil (50 % emitted directly to soil and 50 % ending up in the sewage system from which 25% of the sludge is applied as fertilizer on land). This results in an emission of 0.006 % of lead to soil from the stock of lead sheet in the EU.

In the Dutch estimates, a distinction was made between emissions from roofing and flashings and emissions from residential and utility buildings. Emissions from lead sheet come mainly from flashings, which account for 85 % to 95 % of the total area while roofing accounts for only 5% to 15% of the total area. The average mass per unit area of the sheet is estimated to be from 13.6 kg/m² to 18.1 kg/m². According to another report (Wilson 2003), the run-off rate of flashings is 0.88 g/m² and that of roofing is 5 g/m². Dutch division factors for releases to soil and water are: to soil from residential buildings 0.3 and to surface water (assuming an

⁴⁶ EU15 = Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom.

average connection rate of 85% to the sewage system) 0.15. In utility buildings the division factor for soil is 0.80 and that for the sewage system is 0.20. Discharges to water will not reach the surface water directly. (Van Hyfte and Callebaut 2007)

Copper releases to soil can be estimated using the equation above and the Swedish estimates of 2.0 g/m² released per year from roofing material. (Ekstrand et al 2001; Sörme and Lagerqvist 2002)

According to Swedish measurements, DEHP is released to the environment from roofing material. The equation above can be used in the calculations with the following emission factors: 0.985 g/m² from clean surface and 2.31 g/m² from not clean surfaces to water and soil of the DEHP content of the roofing material annually (Miljöförvaltningen 2003 and Keml 2003).

4.5 Pipes and cables

Lead releases from pipes to water

In the Netherlands, lead releases to sewers from water pipes made of lead have been estimated on the basis of measurements in residential areas. Emission factors derived from measurements are 1014 mg/capita of corrosion of lead per year in 1990 and 906 mg/capita in 1993. In the Netherlands 15 % of the houses still contained water pipes made of lead in 1990. Elsewhere in Europe the percentage might be different, so these emission factors need to be revised according to national conditions. (Tukker et al. 2001) In addition, the removal efficiency of the WWTP for lead needs to be taken into account if the wastewater receives wastewater treatment before release to receiving waters.

Emission of lead from water pipes to the sewer can be calculated as follows:

$$E = A \cdot E_f$$

where

E = emission (kg)

$E_f = 1.014 \cdot 10^{-3}$ kg/capita · (share of the houses containing lead pipes (%) / 15)

A = population

Copper releases from pipes and taps

According to studies in Stockholm, Sweden, copper can be released from water pipes and taps to wastewater. The equation above can be used to calculate these releases using the following release factor: 1.9 g Cu/person per year (Sörme et al 2001, Sörme and Lagerkvist 2002).

DEHP releases

According to Swedish measurements, DEHP is released to the environment from cables buried in soil. The equation above can be used in the calculations with an emission factor of 1,2% of DEHP in the cable material (Miljöförvaltningen 2003 and Keml 2003).

4.6 Wooden material

Heavy metal and PAH releases from treated wood to air, water and soil

Heavy metal releases from treated wood structures to the environment can be roughly estimated by using equation:

$$E = A \cdot E_f$$

where

E = emission (kg)

A = amount of substance used (proportion in CCA) (kg)

E_f = emission factor (kg/kg)

The emission factor for chromium can be estimated to be 0.01 kg/kg (1%) based on the studies by Braunschweiler et al. (1996), Shibata et al. (2007) and Hansen et al. (2000).

According to KLIF (SFT 2004), the releases of arsenic, chromium and copper from wood preservation are estimated to be 0 % to air, 0 % to water and 30 % to soil over a time period of 30-50 years (1% per year for 30 years).

Releases of PAH compounds from wood protection can be estimated using the same equation and assuming the emission factor to be 1% (1/3) to air, 2% (2/3) to soil and 0% to water from the content of PAH compounds in the product. (SFT 2004)

4.7 Wall and floor material

POP compounds from plastic products

Releases of NPs/NPEs from plastics to storm water can be calculated by using equation (IVL 2008):

$$E = A \cdot E_f$$

where

E = emission (kg)

A = used amount of plastics annually (m²)

E_f = emission factor, $2.78 \cdot 10^{-12}$ kg/m² from hard plastics and $4.64 \cdot 10^{-12}$ kg/m² from soft plastics

The weight of PVC plastics can be assumed to be 2000 g for an area of 1 m² with a thickness of 1.5 mm (IVL 2008).

DEHP from PVC products

According to Swedish measurements, DEHP is released to the environment from PVC products. The equation above can be used in the calculations with an emission factor of 0.0095 g/m² (Miljöförvaltningen 2003 and KemI 2003).

4.8 Surface coatings and adhesives

POP and heavy metal releases from paint application

The annual atmospheric releases of PCBs and NP/NPEs as well as SCCPs from paint can be calculated by using equation:

$$E = A \cdot E_f$$

where

E = emission (kg)

A = chemical content in paints (t/a)

E_f = emission factor

PCB emissions are usually calculated by using emission factors, but for open applications, such as sealants and paint, these are very uncertain due to the complex process of PCB evaporation from different formulations. A default emission factor of 80 kg/t may be used for PCB-containing paint application and the amount of PCBs in paints (tonnes) can be used as an activity data. (EEA 2005)

Releases of NPs/NPEs from paints or adhesives to WWTPs can be calculated by emission factors of 0.005 kg/kg for paint (share of NPE emitted to wastewater) and 0.01 kg/kg for adhesives. NPE emission factor for emissions to air from paint application is estimated to be zero. The amount of NPs/NPEs used in paints or adhesives (import + manufacturing – export) (kg) can be used as an activity data. (IVL 2008)

Releases of SCCPs from paint and anticorrosive coatings can be calculated by assuming that 1/3 (33%) of the amount used is released to the environment and that the releases are divided equally between soil and water (50:50). This would result in an emission factor of 0.165 kg/kg (16.5 %) to soil and water. Consumption of SCCPs in paints and coatings can be used as activity data. (SFT 2004)

Releases of heavy metals, for instance chromium and lead, to soil from the use of paints are estimated to be 10% of the amount used. The releases of copper and TBT from antifouling paints are estimated to be 90% of the used amount of paints. The releases are assumed to be divided between water (90%) and soil (10%). This results in emission factors of 0.81 kg/kg (81%) to water and 0.09 kg/kg (9%) to soil.

5 Restrictions

5.1 Regional legislation

European Union

There are some restrictions in the European Union relating to releases from the use of construction and building products, for instance in the Annex XVII of the EU REACH Regulation (EC No 1907/2006). The Construction Products Directive is concentrated on product safety issues. There are currently no restrictions for the use of NPEs in paint, adhesives, concrete or plastics in the EU legislation.

Construction Products Directive

The EU Construction Products Directive (89/106/EEC) is aiming for free trade in construction products and for the safety of the use phase of buildings. This does not include manufacture, working environment or waste. The safety requirements are done by standardisation bodies.

Test methods used for measuring emissions of substances from construction materials are standardized, including examining which product groups can be excluded from testing. The Directive does not include preventing leakage of hazardous substances and it does not directly improve the declarations of substances hazardous to the environment and health in construction products. The requirements are applied to the building, not the construction products, which are governed by the following standardisation. The Biocides Directive targets wood preservation agents and thus preservation agents in the building products (masonry preservatives).

EU REACH Regulation

Annex XVII of the EU REACH Regulation (EC) No 1907/2006) includes restrictions on the manufacture, placing on the market and the use of certain dangerous substances, preparations and articles.

Cement

According to Annex XVII of the EU REACH Regulation, cement and cement-containing preparations containing more than 0.0002% dry weight of soluble chromium(VI) may not be placed on the market. Exemptions include controlled closed and totally automated processes.

Arsenic

According to Annex XVII of the EU REACH Regulation, arsenic compounds (CCA) may not be used in the preservation of wood, and the wood so treated may not be placed on the market. The Annex prohibits the use of CCA-treated wood in residential or domestic constructions, applications that are likely to result in repeated skin contact, including play structures, marine waters, for agricultural purposes other than for livestock fence posts and structural uses, in any application where the treated wood may come into contact with intermediate or finished products intended for human and/or animal consumption. It does not apply to existing structures. An exception is wood to be used in industrial installation where "the structural integrity of the wood is required for human or livestock safety and skin contact by the general public during its service life is unlikely". Wood treated with arsenic compounds that was in use before 30 September 2007, or that was placed on the market may remain in place and continue to be used until it reaches the end of its service life. The Directive therefore restricts the marketing and use of both the CCA chemical as well as timber treated with CCA, and will also apply to imported treated wood and waste wood in re-use.

Asbestos

According to the Annex XVII, the manufacture, placing on the market and use of asbestos fibres and articles containing intentionally added fibres is prohibited. The use of articles containing asbestos fibres that were already installed and/or in service before January 2005 is permitted to continue until disposal or end of the service life.

Lead

According to the Annex XVII, lead carbonates and sulphates shall not be placed on the market or used as substances or mixtures intended for use as paint. Exemption can be granted for the use of white lead and sulphates of lead in paint in restoration and maintenance works of art and historical buildings and their interiors.

Mercury

According to the Annex XVII, mercury compounds may not be placed on the market, or used, as substances or in mixtures in the preservation of wood.

Pentachlorophenol (PCP)

According to the Annex XVII, PCP shall not be placed on the market or used as a substance, or as a constituent in other substances; or in mixtures in a concentration of 0.1 % or greater by weight.

Cadmium

According to the Annex XVII, cadmium may not be used to give colour to articles manufactured from e.g. PVC, or to colour paint. If the paints have a high zinc content, the residual cadmium concentration must be lower than 0.1 % by weight. Articles or components of articles manufactured from the substances and mixtures coloured with cadmium shall not be placed on the market if their cadmium content (expressed as Cd metal) is greater than 0.01 % by weight of the plastic material. Cadmium may also not be used to stabilize mixtures or articles manufactured from vinyl chloride, including floor and wall coverings; tubes pipes and fittings; swing doors; coating of steel sheet used in construction. The cadmium content in these articles must exceed 0.01 % by weight of the polymer. Exemption is granted to articles colored or stabilized with cadmium for safety reasons.

Creosote

According to the Annex XVII, creosote shall not be placed on the market, or used, as a substance or in mixtures for the treatment of wood. Exemptions include industrial installations, except inside buildings.

Organostannic compounds (organotins)

According to the Annex XVII, dioctyltin (DOT) compounds shall not be used after 1 January 2015 at concentration greater than 0.1 % by weight of tin in wall and floor coverings.

Pentabromodiphenyl ether (penta-BDE) and octabromodiphenyl ether (octa-BDE)

According to the Annex XVII, articles or their flame-retarded parts containing pentabromodiphenyl ether (pentaBDE) or octabromodiphenyl ether (octaBDE) at concentrations higher than 0.1 % by mass must not be placed on the market. This does not apply to articles that were in use before 15 August 2004.

Perfluorooctane sulfonate (PFOS)

According to the Annex XVII, PFOS shall not be placed on the market, or used, as substance or in mixtures in concentrations of 50 mg/kg (0.005 % by weight) or greater.

POPs regulation

The Regulation (EC) No 850/2004 on persistent organic pollutants (POPs) is prohibiting, phasing out, or restricting the production, placing on the market and use of substances subject to the Stockholm Convention or the UNECE CLRTAP POPs Protocol. The POPs regulation also concerns placing on the market of articles containing POPs. Prohibited substances (Annex I) include e.g. aldrin, mirex, PCBs and DDT.

5.2 National legislation

Lead has been eliminated from paints in many countries. The sale of lead-containing residential paints was banned in the United States in 1978. Mercury-containing paints have not been used in the United States since 1991. There are restrictions in many countries on

the use of lead in pipes for drinking water systems. The restrictions generally involve new applications and do not require replacement of old installations.

The use of asbestos in new constructions has been banned in many developed countries, including EU, Australia, New Zealand and Japan. Asbestos is still used in USA and in some developing countries, like India and China. In the United States, asbestos continues to be used, e.g. in cement asbestos pipes. As of January 1, 2004, new CCA-treated wood is no longer manufactured for residential uses in the United States.

Nordic countries

- Paints containing lead and lead compounds at concentrations more than 2500 mg/kg (0.25%) are classified as hazardous waste in Finland. An unofficial limit value of 1500 mg/kg has been used for lead-containing sealants.
- The Danish government banned the use of lead compounds by the year 2003 in products including PVC cables, gutters, pipes, roofing and windows.
- Denmark has also prohibited the import and marketing of lead-containing solder alloys for use in plumbing and sanitation, except for soldering zinc sheets.
- Lead used in roofing and flashing around windows and chimneys is banned in Denmark by a general legislation on lead-containing products from 2000.
- In Norway, new use of PCB was banned in 1980. PCB-containing double glass windows must be handled as hazardous waste. Re-use and selling of PCB-containing glasses is prohibited and the importers and producers of PCB-containing double glass windows are obligated to arrange collection systems for disposed products.

References: ATSDR 2007, BC Green Building Code 2007, EC 1988, 2004, 2006, 2009, IFCS 2006, IVL 2008, Järvinen et al. 2003, Rantio et al. 2001, SFT 2005, 2008, Shibata et al. 2007, TemaNord 2004, Thornton 2002, UNEP 2008a,b, US EPA 2009e

5.3 Industry initiatives

There are some voluntary industry initiatives related to the use of substances in construction and building products, e.g. the industry agreements in the EU to reduce the use of NPEs in paints, concrete and plastics. The Swedish Construction Federation, the Swedish Environmental Research Institute and the four biggest construction companies in Sweden had a joint project called BASTA, funded by the EU's environmental fund LIFE. The project was aiming at phasing out construction and building products containing hazardous substances by developing a new classification system of construction products based on the chemical content of the products with a number of requirements. The BASTA system includes a database, currently containing approximately 13,000 registered materials self-declared by suppliers, that meet the requirements of health and environmental properties (Massey et al. 2008). The substances to be registered must not be carcinogenic, mutagenic, toxic to reproduction, persistent in the environment or bioaccumulative.

In Norway, builders and renovators have a checklist of the possible hazardous substances present in construction and building products by product group. There is also a checklist for the possible substitution of products with hazardous substances. Everyone who plans to use products with substances that may pose a threat to health or the environment has a responsibility to evaluate whether it is possible to use an alternative with minor hazard. The quality, lifetime, maintenance and costs of the possible substitutes should be taken into account. The user of the product should check whether the product contains hazardous substances that are included in the Norwegian priority list and should also check the warning symbols and R-phrases found in the safety data sheet. Checking for possible new

alternatives should be a continuing process. The manufacturer is also responsible for the proper disposal of hazardous construction, renovation and demolition waste. According to the revised action plan of Norway to reduce PCB emissions, the building owners also have a responsibility for the proper waste management of PCB-containing construction waste.

There are eco-label criteria relating to the use of hazardous substances in construction and building products. The Nordic eco-label, the swan, includes criteria for chemical building products, such as glues, sealants, filling materials as well as paints and varnishes (outdoor applications). According to the criteria, the limit value for the formaldehyde content in these products is 200 ppm and that for certain heavy metals (cadmium, lead, chromium(VI), mercury, arsenic, barium (except barium sulphate), selenium and antimony) is 100 ppm. The chemical building products must not contain nanometals, nanocarbon or nanofluoro compounds unless it can be proved that they do not pose a hazard to the environment or health. The products must not also contain e.g. PBT (persistent, bioaccumulative and toxic) and vPvB (very persistent and very bioaccumulative) organic substances, organotin, phthalates, APEO compounds (alkylphenol ethoxylates and their derivatives), halogenated organic compounds, and bisphenol A.

References: BI 2003, IVL 2009, Massey et al. 2008; SFT 2007, 2009b,c, Ymparistomerkki 2008

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7 Appendixes to the Case Study on Building and Construction Products

7.1 Appendix I: Comparison of PCB concentrations measured in different studies

Jointing materials

Pyy and Lyly (1998) studied the release of PCBs in prefabricated buildings constructed between 1965 and 1970 in suburbs of Helsinki, Finland. The study included polysulfide sealants, material surrounding the sealants and the soil near the buildings. The sealant types included original old sealants, replaced sealants, new sealants on top of the old ones (measured from the original sealants) and new sealants added next to the old ones. The authors found PCBs from all these sealants. In new sealants that had not contained PCBs before placed in the buildings, the PCBs detected had been absorbed from the surrounding materials. The highest PCB concentration was from the original sealants and the lowest from the added sealants (Table A1.1).

Table A1.1 Comparison of PCB releases from polysulfide sealants investigated in different studies

Study	Country	PCB conc. (mg/kg)			Source
		Min.	Max.	Mean	
Pyy & Lyly (1998)	Finland	3,300	67,000	24,000	Old sealants
		3,300	54,000	25,000	New sealants added on top of the old ones
		73	2,500	810	Replaced sealants
		4.4	89	47	New sealants added next to the old ones
Sundahl et al. (1999)	Sweden	47,000	81,000		Old sealants
Hellman & Puhakka (2001)	Finland	8,300	108,700		Old sealants

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Herrick. et al. (2004)	U.S.	70.5	36,200	15,645	Old and new caulking
Kohler et al. (2005)	Switzerland	20.0 (detection limit)	550,000		Not specified

Sundahl et al. (1999) studied the PCB levels of sealants, concrete near sealants, soil and indoor air of an eight storey building in Göteborg, Sweden. The samples were taken from 30 year old sealants that were in bad condition. The authors found the sealants to contain PCBs from 4.7 to 8.1 % (Table A1.1). Probably the concentration had been higher, but PCBs had leaked to soil and air over the years. Hellman and Puhakka (2001) found in their study, that the PCB concentration of sealants was highest at the northern side of the building, indicating that weathering is less efficient there due to sunlight and other climatic conditions (Table A1.1).

Herrick et al. (2004) studied the PCB concentrations of buildings in Greater Boston area in United States that likely contained polysulfide caulking material installed in 1970's. The samples were taken from the sealants of 24 buildings including schools, hospitals and other public buildings. Some of the buildings had reconstruction underway and old caulking was being removed, in others, the caulking had already been replaced and the rest had old deteriorated caulking. The authors reported that 13 of the 24 buildings had caulking materials with detectable PCB concentrations. From these 13 buildings eight had PCB levels higher than 50 ppm (Table A1.1).

Kohler et al. (2005) conducted a nation-wide study of PCB levels in polysulfide sealants and indoor air in public buildings constructed between 1950 and 1980 in Switzerland. From total of 1348 samples of sealants 646 (48 %) contained PCB. From these 279 (21 % of all samples) had PCB concentrations higher than 10 g/kg and 568 (42 % of all samples) had PCB concentrations higher than 0,050 g/kg. Most of the samples had PCB levels above 0.1 g/kg and the maximum was 550 g/kg (Tables A1.1 and A1.2). Low chlorinated PCB mixtures were found from 10 %, medium chlorinated from 70 % and high chlorinated from 20 % of the samples.

Table A1.2 Distribution of PCB concentrations of joint sealants (Kohler et al. 2005)

PCB content [g/kg]	number of samples [n]	percentage [%]
<d.l. ^a	702	52
>d.l.	646	48
d.l. to <0.05	78	5.8
0.05 to <0.1	50	3.7
0.1 to <1	122	9.1
1 to <10	117	8.7
10 to <100	150	11.1
>100	129	9.6
total	1348	100

^a d.l.: detection limit; for most of the samples, the limit of detection for individual PCB congeners was 0.002 g/kg or lower and 0.02 g/kg for total PCB content.

Concrete and plaster products and surface coatings

Andersson et al. (2005) studied the use of PCBs in plaster of 46 official and residential buildings constructed between 1950 to 1980 in Bergen, Norway. The samples were taken from plaster of facades (35 samples), paint (five samples) and surface soil (43 samples). The paint samples contained some plaster and the PCB concentration of paint was probably too high due to contamination (Table A1.3).

Table A1.3 Comparison of PCB releases from plaster and paint investigated in different studies (ND = non-detected)

Study	Country	PCB conc. (mg/kg)			Source
		Min.	Max.	Mean	
Weis et al. (2003)	Germany	15,000	47,000		Roughcast
				110,000	Flame retardant
Andersson et al. (2004)	Norway	ND	290		Plaster
		ND	1940		Paint
Tuhkanen et al. (2007)	Finland			102,900	Paint

Weis et al. (2003) studied the PCB levels of roughcast as well as in flame retardant coating used in sound insulating ceiling panels (Table A1.3). Tuhkanen et al. (2007) studied PCB containing paints in buildings constructed before year 1972 in Finland. From 17 objects 11 contained PCBs and every fourth of the samples had more than 50 mg/kg of PCBs (Table A1.3). The highest PCB concentrations were found in concrete floor of cellar facilities of school buildings. High amounts were also found in paints used for wooden floors.

Soil surrounding buildings

In the studies of Pyy and Lyly (1998) and Hellman and Puhakka (2001) concentrations of PCBs were found also in soil near the buildings in all the samples. The samples were taken from different depth and from different distance from the buildings. The authors found that from all the sample depths the concentrations of PCBs were higher near the buildings and lower away from the buildings (Table A1.4). The PCB levels of soils were lower than that of sealants in both studies.

Table A1.4 Comparison of PCB releases from soils investigated in different studies and the sample depth and distance from the building

Study	Country	PCB conc. (mg/kg)			Depth (cm)	Distance (m)
		Min.	Max.	Mean		
Pyy & Lyly (1998)	Finland	5.8	300	87	0-10	0.1
		2.1	21	5.6	0-10	2
		0.5	21	8.4	0-10	5-20
		1.5	26	11	10-30	0.1
		0.26	1.6	0.84	10-30	2
		0.089	1.3	0.43	10-30	5-20
Hellman & Puhakka (2001)	Finland	0.03	6.62			
Andersson et al. (2004)	Norway	ND	320		0 - 5	
Priha et al. (2005)	Finland	0.11	26.9			
				6.83	top soil	2
				0.52	top soil	3-10

In the study of Andersson et al. (2004) in Norway, the soil samples were collected from 0 - 5 cm depth adjacent to the buildings (Table A1.4). They noted that the site which had the highest concentration had possibly been contaminated by PCB from double glazing windows, which had been stored at the location of the sampling. If that sample had not been included in the study, the maximum PCB concentration would have been 41 mg/kg. The authors found that the PCB concentration of soil was higher than that of plaster due to high organic matter content retaining the PCBs. According to Jamshidi et al. (2007), the concentration of POPs in soil is usually highly influenced by the organic matter content of the soil.

Priha et al. (2005) studied the PCB concentrations of soils surrounding 11 buildings built in 1960's in Finland. The polysulfide sealants of the buildings had been replaced within one to three years of the study. The variance of PCB concentrations was high (Figure A1.1, Table A1.4).

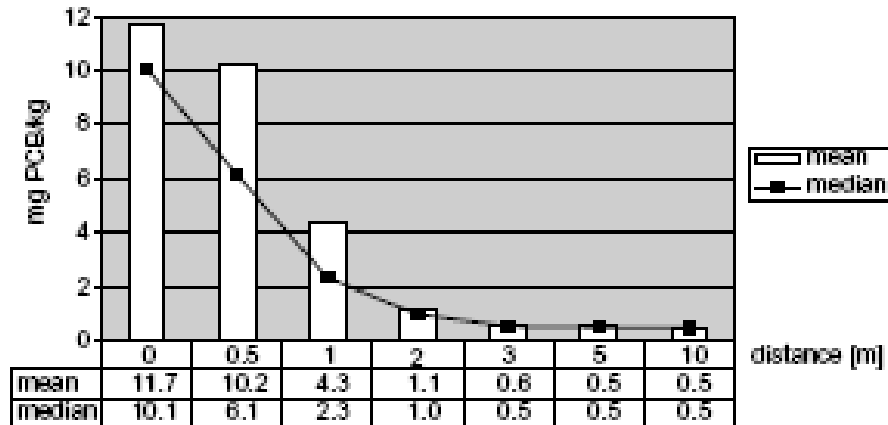


Figure A1.1. PCB in top soil within different distance from the buildings (Priha et al. 2005)

Indoor and outdoor air

Kohler et al. (2005) studied 160 samples of indoor air. The mean PCB concentration in indoor air was $0.79 \mu\text{g}/\text{m}^3$. Indoor releases of PCBs have been found to be higher than outdoor releases due to secondary PCB contamination. The PCB concentration in indoor air depends on e.g. air-exchange rate, type of PCB mixture, surface area of the sealants, temperature of the construction material and the room temperature (Kohler et al. 2005). Kohler et al. (2005) found a slight correlation between indoor air PCB concentration and room temperature. Sundahl et al. (1999) found a similar correlation between indoor air PCB concentration and outdoor temperature with higher PCB levels due to higher temperature. It is evident that the temperature has an effect to evaporation of PCBs from the sealants. Johannesson (1999) reported 20 times higher indoor air PCB concentration compared to the background level and four times higher compared to the average daily intake of PCBs by food. The elevated concentrations were due to leakage from outdoor sealants.

Residents and workers

In some studies high PCB levels have been measured in residents of PCB containing buildings and construction workers. Priha et al. (2005) studied the PCB concentrations in the blood serum of residents and workers of buildings in Finland, where PCB containing sealants had been used and replaced. They found no significant difference in the blood PCB levels of the residents and a control group. The PCB levels in the blood of the workers removing old sealants were higher than that of the residents. Kontsas et al. (2004) studied the PCB concentrations in the blood serums of workers renovating sealants of prefabricated buildings in Finland. The authors found that the PCB blood levels of the workers were higher compared to that of a control group. Gabrio et al. (2000) studied the PCB blood levels of teachers from three PCB contaminated schools and two control schools in Germany. PCBs were found in indoor air and in the sealants and walls of the contaminated schools. The

authors concluded that the PCB concentrations of blood of teachers were slightly increased compared to the teachers from the control schools.

ANNEX 1

CASE STUDIES ON SELECTED PRODUCT GROUPS

Case Study 4:

Releases from the use phase of electrical and electronic equipment

CASE STUDY 4

RELEASES FROM THE USE PHASE OF ELECTRICAL AND ELECTRONIC EQUIPMENT

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 - 7.1 Appendix I Studies on the chemical releases from EEE products

1 End products with likely releases during the use phase

According to the definition in the RoHS Directive, electrical and electronic equipment (EEE) are dependent on electric currents or electromagnetic fields in order to work properly as well as equipment for the generation, transfer and measurement of such currents and fields. Examples of EEEs include monitors, computers, cellular phones, batteries and lighting, as well as measuring equipment. In addition to EEEs this study also includes information on thermometers using mercury and printing inks used in printers and photochemicals.

EEEs are composed of a variety of components, including semiconductors, printed circuit boards, wiring, switches and plastic casings, cathode ray tubes or liquid crystal displays.

EEE products can contain many toxic substances, for instance metals such as lead, mercury, beryllium, cadmium, antimony, lithium and other environmentally hazardous substances (Table 1) such as brominated flame retardants (BRFs), PFOS and PVC plastic additives. It has been estimated that approximately 22 kg of different chemicals are used in the manufacturing of a personal computer and a 17" cathode-ray-tube monitor. However, it is challenging to receive information on the chemical content of electrical products though also many of the substances used in new equipment are suspected of being toxic to the environment.

Traditionally used flame retardants in electronics have been polybrominated diphenyl ethers (PBDEs) or sometimes tetrabromobisphenol A (TBBPA). The electronics industry has been since the 1970's one of the largest consumers of PBDEs., one of the most widely used PBDE being deca-BDE. Octa-BDE has been commonly used in ABS plastic, but after it was banned, other alternative flame retardants have been used. PCBs, Mirex and hexabromobiphenyl (HxBB) have also been used as flame retardants in electrical equipments. Studies also indicate that consumer products, including electronics, are the most likely source of polybrominated diphenyl ethers (PBDEs) in the environment, animals and people. The concentrations of PBDEs are higher in the indoor dust than in food, water, air or soil. Substances used in older equipment (e.g. PCBs and mercury) are problematic especially in the waste disposal phase, but also in the use phase e.g. through recycling and re-use.

References: EC 2002, Eco-design guide 2009, Keml 2007, Lassen et al. 2006, Massey et al. 2008, McPherson et al. 2004, Ministry of the Environment 2006, Osibanjo 2009, SFT 2007& 2008b, Sharp & Lunder 2004, Tietokone 2009, Webster et al. 2009

Table 1. Use of different substances in electrical and electronic products and their likely releases during use phase. Explanations: Releases to: the environmental compartment is in brackets if releases are considered minor, e.g. (air); RET = Release estimation technique, Yes = exists, (Yes) = not published/only in certain countries; NA = information not available) A blank cell indicates that there is currently no information on the issue.

End-product	Substance	Releases to	RET	Included in regular inventories
Enclosures and monitors (e.g. TV-sets, computers and printers)	PBDEs (e.g. deca- and octa-BDE), TBBPA, HBCD	Air, water	Yes	(Yes)
	BRFs			
	Lead		(Yes)	(Yes)
Solders and printed circuit boards	Lead		(Yes)	(Yes)
	Beryllium		No	No
	PBDEs (e.g. deca-BDE), TBBPA	Air, water	(Yes)	(Yes)
	NPs		No	No
	Other metals		No	No
Electrical equipment (e.g. switches and relays)	Mercury	Air, water	Yes	(Yes)
	PBDEs	Air, water	(Yes)	(Yes)
Measuring and control equipment (e.g. thermometers)	Mercury	Air, water	Yes	(Yes)
	PBDEs	Air, water	(Yes)	(Yes)
Cables and wires	PBDEs (e.g. deca-BDE)	Air, water	(Yes)	(Yes)
	Phthalates (e.g. DINP)		No	No
	PTFE		(Yes)	(Yes)
	MCCPs	Air, water, soil	Yes	(Yes)
	PCBs, PCNs		(Yes)	(Yes)
Batteries and accumulators (primary and secondary)	Cadmium		(Yes)	(Yes)
	Lead		(Yes)	Yes
	Mercury		Yes	(Yes)
	Lithium		(Yes)	(Yes)
	Other metals		No	No
Capacitors and transformers	PCBs	Air	Yes	(Yes)
	PCNs		(Yes)	(Yes)
	HCBd		(Yes)	(Yes)
Lighting	Mercury	Air, water, soil	Yes	(Yes)
	PBDEs	Air, water	(Yes)	(Yes)
	PCBs		(Yes)	(Yes)
	BRFs			
Household appliances (e.g. refrigerators, washing machines and air humidifiers)	Silver	Water	No	No
Others (photographic applications, heatsink, springs)	Silver		No	No
	Beryllium		No	No
	NPs/NPEs	Water	(Yes)	(Yes)
	PCBs		(Yes)	(Yes)
	Chromium, cadmium		No	No

2 Use and chemicals in electrical and electronic products

2.1 Enclosures and monitors

Enclosures for TV-sets are usually made of high impact polystyrene (HIPS), acrylonitrile butadiene styrene (ABS) or copolymers such as PC/ABS, PPE/HIPS and PPE/PS. Monitors of personal computers are usually made of ABS and PC/ABS. PC or PPE makes the plastic less flammable.

Flame retardants

- *Brominated flame retardants* are used in plastic casings, keyboards and other devices.
- *HBCD* was earlier used as a flame retardant in certain HIPS plastics for electronic devices, such as VCR covers in concentrations between 0.5 and 7 % depending on the type of plastic, accounting for 5% of the total use of HBCD in products in Europe in 2002. HBCD may be present in imported flame retarded products.
- *PBDEs* have replaced HBCDs partly as a flame retardant e.g. in hair dryers, curling irons and coffee makers, which can contain up to 15 % of PBDEs
 - *Deca-BDE* (in concentrations of 5-30 % by weight) has earlier been used mainly as flame retardant in the enclosures of electronic equipment made of HIPS, e.g. in computers, television sets, printers, scanners, and copy and fax machines, for instance both in the USA and Canada accounting approximately 80 % of the total use of deca-BDE in the country. The enclosure of an LCD panel TV-set may contain nearly as much flame retardants (in the back cover) as a CRT TV-set, due to a larger screen size. In Europe, copolymer enclosures with non-halogen organo-phosphorous flame retardants are used instead. Alternatives to deca-BDE include bis(pentabromophenyl) ethane and ethylene bis(tetrabromophthalimide).
 - *Octa-BDE* is used in ABS plastics of monitors, TV enclosures, mobile phones and copy machine parts.
- *Tetrabromobisphenol A (TBBPA)* is used as a flame retardant in ABS plastics used for enclosures of computers, televisions, monitors and other electronic products. For instance, cameras imported to Sweden contained approximately 0.7 tonnes of TBBPA in 1991

Display protection

- *Lead* can be found in cathode-ray-tube (CRT) glasses of TV and computer monitors where it is used to protect viewers from the X-rays produced by the tube. Flat panels, especially plasma display panels, also contain leaded glass, but for different purpose and much lower concentrations per panel compared to cathode ray tubes. CRTs are being replaced by flat panel technology which do not produce X-rays.
- *Mercury* is used in fluorescent lamps for flat panel displays

References: Betts 2008, ChemicalWatch 2009, Eco-design guide 2009, Keml 2007, Lassen et al. 2006&2008, Massey et al. 2008, McPherson et al. 2004, Remberger et al. 2004, Sharp & Lunder 2004, Van Sprang et al. 2008, Thornton et al. 2001, UNEP 2008a

2.2 Solders and printed circuit boards

Printed circuit boards

- *Beryllium* can be found in the circuits as beryllia circuit substrate
- *Copper, iron, nickel, tin, lead, aluminium, zinc, gold, silver and palladium* and their oxides can be found in printed circuit boards (Figure 1)
- *Nonylphenol ethoxylates (NPEs)* have been used in fluxes in the manufacture of printed circuit boards, in dyes to identify cracks in printed circuit boards and as a component of chemical baths used in the etching of circuit boards.
- *PBDEs* have been used as a flame retardant in circuit boards
- *TBBPA* is used as a flame retardant in epoxy resins in printed circuit boards and printed wire boards of computers and other electronic products. TBBPA is the dominating flame retardant in electronic products for instance in Norway.

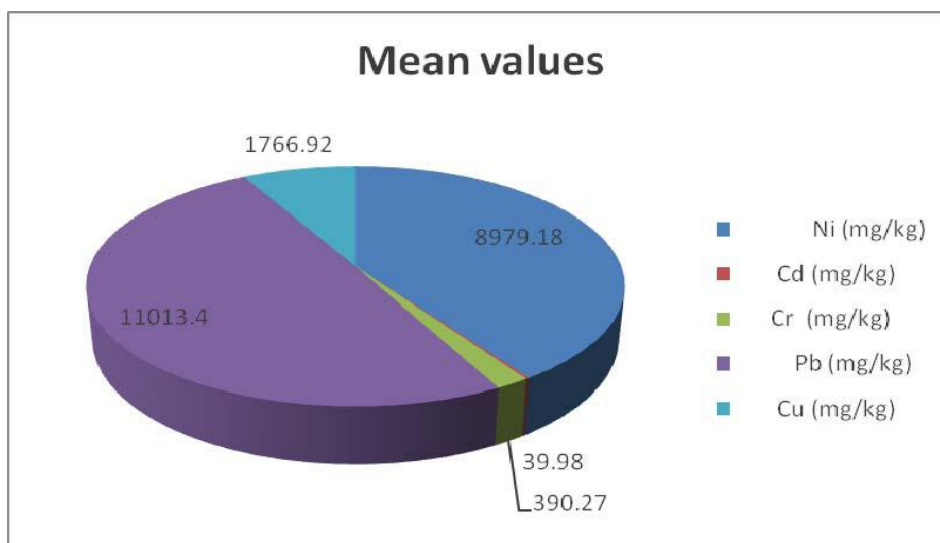


Figure 1. Mean concentrations of heavy metals in a computer mother board.

Solders

- *Lead* is often used in solders in electrical and electronic equipment.

References: Eco-design guide 2009, IVL 2008, McPherson et al. 2004, Osibanjo 2009 Sharp & Lunder 2004

2.3 Electrical equipment containing mercury and plastic parts

The global *mercury* demand in electrical and electronic devices was 140 tonnes in 2005. In 2008, mercury consumption of switches, relays and related articles in EU-15 was estimated between 0.3 - 0.8 tonnes annually. For instance, tilt switches usually contain 0.5-10 g of mercury per switch. Mercury is often present in old equipment. Electrical equipment, which can contain mercury include

- switches, contacts, relays, arc rectifiers
- thermostats, thermoregulators, laboratory equipment
- medical devices
- motion and level sensors, alarm equipment and certain clock types

Plastics used in connectors, switches and other internal parts are usually made of "engineering plastics" such as thermoplastic polyesters (PBT/PET) and polyamide (PA). This equals 60% of total plastics consumption in EEEs.

Flame retardants

- *Brominated carbonate oligomers and brominated epoxy oligomers* are the most widely used flame retardants in PBT/PET plastics and polybrominated styrenes or brominated polystyrenes in PA plastics in EEEs. Halogen free alternatives based on organic phosphinates have been recently developed.
- *Deca-BDE* has been used for these two plastics, but in lesser extent, still contributing 10% of the global flame retardant consumption in PBT/PET and 6% of PA consumption in EEEs.
- *PBDEs* have been used as flame retardants in electrical connectors, fuses and switches, as well as in underground junction boxes

References: EEA 2000b, Eco-design guide 2009, Lassen et al. 2008, Maijala & Nippala 2002, Maxson 2006, Ministry of the Environment 2004, Sharp & Lunder 2004

2.4 Measuring and control equipment

The global *mercury* demand in measuring and control equipment was 150 tonnes in 2005 and in EU-15 between 7 - 17 tonnes annually. Mercury is used in measuring equipment and devices including

- thermometers (consumer products containing 0.5-1.5 g Hg and laboratory/industry products containing 1-20 g Hg with an average of 2-4 g Hg per device)
- pressure measuring devices: barometers (consumer products containing 60-75 g Hg and laboratory/industry products containing up to 1.1 kg Hg), manometers (containing 70-140 g Hg) and sphygmomanometers (containing 85-100 g Hg)
- hygrometers and hydrometers
- tensiometers, gyrocompasses and electrodes.
-

PBDEs have been used as a flame retardant in smoke detectors.

References: Lassen et al. 2008, Maijala & Nippala 2002, Ministry of the Environment 2004, Sharp & Lunder 2004

2.5 Cables and wires

- *Polytetrafluoroethylene (PTFE)* has been often used in the coating of wires.
- *Flame retardants*: certain types of wires and communication cables with insulation made of polyolefins (PP and PE) have contained deca-BDE as a flame retardant. PBDEs have been used in PVC wires and cables, as well as in rubber cables. MCCP is also used as flame retardant.
- *Plastics and rubber* are used as insulation material in cables and wires. Earlier PCNs and thereafter PCBs were used for the purpose in cables, before they were replaced by *phthalates* (like DINP) in the PVC plastics of cables and wires.
- *Chlorinated paraffins*, e.g. MCCPs have been used as softeners in cables and wires.

References: Lassen et al. 2006, Peeters Weem 2007, van de Plasche et al. 2002, SFT 2004, 2007, 2009a, Sharp & Lunder 2004, UBA 2007, US EPA 2009

2.6 Batteries and accumulators

An electrical battery is a combination of one or more electrochemical cells used to convert stored chemical energy into electrical energy. Batteries may be used once and discarded (primary batteries), or recharged for years (secondary batteries) as in standby power applications. Miniature cells are used to power devices such as hearing aids and wristwatches; larger batteries provide standby power for telephone exchanges or computer data centers.

Many chemicals in batteries and accumulators are corrosive, poisonous or both and may leach out of the product. The global mercury demand in batteries was 400 tonnes in year 2005 and in EU-15 between 7 -25 tonnes annually. As an example, the manufacture of high mercury content batteries in China is now shifting to lower mercury designs though there still continues to be a significant trade in mercuric oxide batteries.

Dry cell batteries have the electrolyte immobilized as a paste, with only enough moisture in the paste to allow current to flow. These batteries include

- *Carbon zinc, alkaline manganese, NiMH and lithium* chemical systems, most of these being non-rechargeable batteries.
- *Mercury, lead, cadmium, copper and manganese* are other substances used in dry cell batteries. Mercury is no longer added to standard primary batteries, but it can be found in button cell batteries and cylindrical or rectangular batteries.
- Mercury oxide batteries are no longer manufactured in the EU, but they can still be used in various countries and contain approximately 30-40 % of mercury.
- Small quantities of mercury is alloyed with the zinc for the purpose of controlling corrosion and providing current carrying capability to batteries with zinc anodes. These contain also low percentages of cadmium and lead for improvement in strength and ductility.
- In a Nigerian study of imported dry cell batteries the average lead content was 1051 mg/kg (42-3170 mg/kg) and that of cadmium 107.7 mg/kg (4.6-410 mg/kg) of the dry cells. Even batteries that had labels indicating zero content of these metals had high concentrations of lead and cadmium.
- Button cell batteries contain an average of 2.5-3.0 g of mercury in weight (1%) , these will be replaced by mercury-free button cells in the next years
- Larger zinc-carbon cylinders contain an average of 50 g mercury and alkaline batteries an average of 33 g of mercury per battery.

A wet cell battery has a liquid electrolyte. Wet cells were a precursor to dry cells and are still used as a learning tool for electrochemistry and in automobile batteries as well as in industry applications for standby power for switchgear, telecommunication or large uninterruptible power supplies, but in many places batteries with gel cells have been used instead. *Lead-acid or nickel-cadmium* cells are used in wet cell batteries

Accumulators that can contribute to releases to the environment include mainly rechargeable batteries such as a lead-acid battery.

References: EEA 2000b, Eco-design guide 2009, HS 2006, Lassen et al. 2008, Maxson 2006, Osibanjo 2009, Wikipedia 2009

2.7 Capacitors, transformers and heat exchangers

Capacitors

PCBs (for instance Aroclors 1016, 1221 and 1254) were used as a dielectric insulating material in closed system applications in electrical equipment such as electrical capacitors and transformers as well as in electrical motors and electric magnets mainly before the 1990's. Small capacitors containing PCBs are reported to have a use-life expectancy ranging from 10 to 15 years and large capacitors from 20 to 25 years. It is estimated that around 15 % of historically produced PCBs may still be in use on a global scale most of it remaining in long-lived closed systems. It is estimated that especially in developing countries, large quantities of PCB-containing electrical equipment may still be in use. In Norway, capacitors for lighting accounted 13 %, other small capacitors 6 % and electrical bushings 2 % of the total amount of 120 tonnes of all PCB containing products in use in Norway in 2006.

A PCB containing capacitor is typically a completely sealed metal can, filled with the PCB-containing dielectric fluid, with two electrical leads or contacts. They have been used especially in bigger buildings like schools and public houses and were common in oil burners. Also some old electronic machines and devices as well as components of devices that have been removed from use may contain PCBs.

Capacitors possibly containing PCBs can be divided as follows:

into large power capacitors (high voltage and power factor correction capacitors) and small capacitors (motor start and ballast capacitors)

- Large power high voltage and power factor correction capacitors typically contain 11 kg of PCBs from the approximate total of 54 kg of weight while power factor correction capacitors produced in the former Soviet Union have two typical sizes containing 10 kg of PCBs in a 28-35 kg capacitor and 19 kg of PCBs in a 54-60 kg capacitor.
- Motor start capacitors are used with single phase motors for starting torque. They have been used in electric motors of cars and down-well water pumps, but also in common household electrical appliances including power tools, refrigerators, cookers, microwave ovens, washing machines, dishwashers, clothes dryers, hair dryers, ventilating fans, air conditioners and televisions.
- Ballast capacitors (light ballasts) are found in fluorescent, mercury, and sodium containing light poles and other lighting fixtures used outdoors and indoors in bigger buildings like hospitals and warehouses as well as in neon lights. In the Nordic countries mercury containing lighting fixtures were used between 1960-1980 and PCB containing ballast capacitors manufactured before 1980 were used in public

buildings. Ballast capacitors typically contain 0.05 kg of PCBs in a total weight of 1.6 kg.

Transformers

Transformers are used for electric power transformation in power transmission lines and in units receiving, using and producing electricity, e.g. power stations, mines, railways and equipments of ammunition industry. PCBs such as Aroclors 1242, 1254 and 1260 were used between 1929 and 1988 as dielectric fluids in transformers. Service life of transformers containing PCBs can be greater than 30 years. PCNs predated PCBs in dielectric fluids of transformer and capacitor.

Heat exchange systems and pumps

PCBs have been used in hydraulic heat exchange systems and pumps.. Hexachlorobutadiene (HCBd) has been used as a solvent for heat transfer liquids, transformer and hydraulic fluids but the use has ceased in the last decades.

References: DEQ 2003, EEA 2000a, van der Honing 2007, Maijala & Nippala 2002, Rantio et al. 2001, Steiner et al. 2003, Peeters Weem 2007, van de Plasche & Schwegler 2003, SFT 2005, SYKE 2008, UNEP 1999, Weis et al. 2003

2.8 Light sources

Mercury containing lamps (discharge lamps) typically consist of a phosphorous coated glass tube filled with mercury vapour and of electrodes at both ends of the tube. The global mercury demand in lighting was 120 tonnes in 2005 and in EU-14 between 11 -15 tonnes annually during the latest decade. In Norway, 173 kg of mercury were used in lighting in 2006 while the use was 130 kg in 1995.

- Fluorescent lamps (tubes and compact fluorescent lamps (CFLs) are used e.g. in indoor lamps, office lights, laptop computers and other appliances and they contain mercury as tiny drops, solid amalgam or mercury/iron pellets. The Hg content in these lamps varies between 5-10 mg/lamp. The use of fluorescent lamps is increasing in the EU due to removing discharge lamps from the market. However, it is expected that LED light sources will replace them.
- High-intensity discharge (HID) lamps (mercury vapour, metal halide, high- and low-pressure sodium and low-pressure mercury discharge) are usually used in security lighting, street and other outdoor lights as well as warehouses.
- Cold cathode lamps (ultraviolet and neon) are used in e.g. skin tanning equipment, medical and laboratory applications and lighted signs.

In the wires, *arsenic* is often present.

Infrared light detectors include *mercury-cadmium-telluride (MCT)*.

PBDEs have been used as a flame retardant in lighting panels and lamp sockets.

Some light ballasts have contained *PCB*-containing asphaltic resin (potting material) as insulating material.

References: DEQ 2003, EEA 2000b, Keml 2009b, Lassen et al. 2008, SFT 2009a, b, c, Sharp & Lunder 2004

2.9 Household appliances

Refrigerators and washing machines

The ionic form of *silver* is used in refrigerators and washing machines for its antibacterial effect. Some washing machines have a function that releases silver ions to the washing liquid. With washing temperatures of 60 °C or higher, the silver function of the washing machine is not needed because the high water temperature itself has a bactericidal effect

Electrical motors

In electrical motors PCBs have been used in some specialized fluid cooled motors. PCBs can be found in electric fluid cooled separating magnets.

Reference: KemI 2009

2.10 Other products

Photographic and printing applications

- *Beryllium* can be found in cameras.
- *Silver* has been used in photographic applications but the use has been reduced significantly with shifting to digital photography technique.
- *Nonylphenol ethoxylates (NPEs)* are used as wetting agents in the development of photographic film and in the formulations of printing inks for laser mixture stabilizer jet printers and in the formulation of chemicals for the use with lithographic printers. Approximately 3.8 tonnes of NPEs were registered for use in pigment pastes and other coloring agents in Sweden in 2006.
- *PCBs* have also been used for film casting solutions for electrical coatings

Other

- *Beryllium* has been used as a heatsink compound and as an alloy material in springs
- *Cadmium* is used in electroplating
- *Hexavalent chromium* has also been used for surface treatment because of its corrosion resistance properties

References: DEQ 2003, Eco-design guide 2009, IVL 2008, KemI 2002 & 2009c, Steiner et al. 2003

3 Estimation of releases

Likely releases from the use of different EEEs is presented in the chapters below and emission factors and release rates are collected in Table 2 after the product specific presentations.

3.1 Enclosures and monitors

Electronic products emit chemicals through off-gassing into indoor air from where they settle in dust. It can be estimated that approximately 75 % of the BFRs used in electrical and

electronic products are added to the material reactively and the rest 25 % are used as an additive. The releases of reactive BFRs to the air are considered to be negligible.

Those substances that are applied as an additive are more likely released from the product to the surrounding environment. For additive flame retardants, it can be estimated that 0.05 % of the substance will annually leach from the material to the air. The so called worst case emission factors for leaching of BFRs to the water; 0.05 % for indoor use and 0.7 % for outdoor use.

Oil droplets, from e.g. cooking, can produce a thin, sticky film on nearly all indoor surfaces. This organic film can trap indoor chemicals, such as PBDEs.

- HBCD is an additive flame retardant and thus it is not chemically bound to the polymer and can thus be emitted from polymer products by diffusion. If the product has a long service life, releases can occur during the whole lifetime of the product. The leaching of HBCD from products can be expected to be higher in urban areas due to population density. For instance in Internet cafes and offices, high levels of flame retardants have been detected. The release rates can be expected to decline with time, if the predominant release mechanism is solid phase diffusion.
- PBDEs have been detected in house dust but the mechanism for the releases is unknown. In the USA, furniture and television have been identified as the main sources of PBDEs in house dust. It is estimated that PBDE is volatilized due to direct partitioning between the PBDE in polymer and dust, and through physical weathering. Volatilization is assumed to be increased by heating.
- Deca-BDE is simply mixed in with the plastic during manufacture and may thus leach out from the product. It has low volatility but can be released through weathering or abrasion.
- The releases of lead from the use of lead sheets for radiation shielding are expected to be negligible. The largest releases will probably take place in the waste handling stage.

References: Betts 2008, Costner et al. 2005, Remberger et al. 2004, SFT 2004, 2009a, Sharp & Lunder 2004, Tukker et al. 2001, Thornton et al. 2001, Webster et al. 2009

3.2 Solders and printed circuit boards

TBBPA used in printed circuit boards is mainly added to the material reactively. This means that the substance is chemically bound to the material and is thus less likely to be released from the product to the environment. No information is neither found in the literature about the releases from the use of NPEs in printed circuit boards.

References: IVL 2008, SFT 2009a

3.2.1 Electrical equipment containing mercury

The estimated mercury emissions to air from the use-phase of mercury containing products (batteries, measuring and control equipment, electrical equipment and light sources) in the EU were 14 tonnes in 2005. Emissions to the air were assumed to occur by breaking or leakage and within approximately ten years. It is known that releases of mercury to the air vary according to temperature .

References: Kindbom & Munthe 2007

3.2.2 Measuring and control equipment

Emissions to air from the use of measuring and control equipment have been estimated to total 1.8 tonnes in Eastern European countries and 0.5 tonnes in Western European countries in 1995.

Reference: EEA 200b

3.2.2 Cables and wires

Releases of MCCPs from cables and wires end up to air, water and soil without relevant differences between the different products.

Reference: SFT 2004

3.2.3 Batteries and accumulators

Releases of substances from batteries can be expected to happen primarily in the disposal phase. In the use phase releases may occur from old products through leakage. The "black mix" of disposed dry cell batteries has been used for darkening blackboards in classrooms in Africa. This can lead to indoor releases of heavy metals.

Reference: SYKE 2008, Osibanjo 2009

3.2.5 Capacitors and transformers

The major source of PCB releases comes from leaks of PCB containing dielectric fluids from large electrical transformers and capacitors that are in poor condition and/or are poorly maintained. PCB emissions during normal operation of transformers and capacitors are considered to be negligible.

The European emission estimates for the year 1990 indicate that, along with fragmentizing operations, as much as 94 % of PCB emissions originate from leaks from capacitors and transformers. It is unlikely that electrical equipment containing PCBs would be a significant source of any other pollutants. It is estimated that approximately 0.06 % of the total amount of PCBs in transformers are spilled per year. For large capacitors, a rough spillage rate of 1.6 % has been presented.

Reference: Annema et al. 1995, EEA 2000a

3.2.6 Light sources

The releases of mercury from the use of light sources happen primarily if the lamp is broken. When the fluorescent lamp is lit, the mercury is vaporised into gas as the temperature rises. When the lamp cools down, the mercury is transformed to tiny drops and possibly also to amalgam. If a cold lamp is broken, the mercury drops fall to the floor with the pieces of the lamp. If a warm lamp is broken, gaseous metallic mercury (HgO) is released into the air of the room. Also, if the small drops of mercury are not cleaned off, they can slowly evaporate.

It can be estimated that approximately 25 mg of mercury per capita is annually released from braking of mercury containing lamps. In Norway this results to an annual emission to air of about 100 kg of mercury.

Reference: KemI 2009b, SFT 2009a

3.2.7 Household appliances

From the washing machine, silver ion particles can be transferred to textiles and to waste water. The volume of silver released from electrical and electronic products varies between the different equipment and uses. Releases from textiles are presented in a separate Case Study.

Reference: KemI 2009c

3.2.8 Other products

NPEs can be released to the wastewater system during the use of photochemicals. Commercial photo-developers have the obligation to collect the chemicals. Small amounts of NPEs may however be released to the sewers e.g. when washing the tanks. However, releases of NPs/NPEs from the use of printing inks as well as from the use of photo chemicals are considered to be negligible.

Reference: IVL 2008

Resource Compendium Part IV: Releases from the Use of Products –
Case Study on Electrical and Electronic Equipment

Table 2. Releases of substances from the use phase of electrical and electronic products

Product group	Substance	Concentration in product (rough estimate)	Example of the use volume of the chemical	Release rate (rough estimate)	Remark
Enclosures and monitors	HBCD	0.5-7 % (depending on the type of plastic)			
	PBDEs	Up to 15 %			
	Lead (in CRT)	Up to 1.8 kg			
Electrical equipment	Mercury	0.5-10 g (tilt switches)	0.3-0.8 tonnes/year (EU)	0.77 tonnes Hg (W-Europe 1995), 0.125 tonnes Hg (E-Europe 1995)	EEA 2000b
Measuring and control equipment	Mercury	0.5-1.5 g (medical thermometers); 1-20 g (industrial thermometers); 70-140 g (manometers); 60-75 g (consumer barometers); 1.1 kg (laboratory barometers); 85-100 g (sphygnomanometers)	7-17 tonnes/year (EU)	1.81 tonnes Hg (W-Europe 1995), 0.5 tonnes Hg (E-Europe 1995)	Thermometers: digital electronic thermometers and heat sensitive thermometers based on liquid crystals (EEA 2000b)
Batteries and accumulators	Mercury	2.5-3 g (button cell batteries); 50 g (zinc-carbon cylinders); 33 g (alkaline batteries); 30-40 % (mercury-oxide batteries)	7-25 tonnes/year (EU)	0.09 tonnes Hg (W-Europe 1995), 0.015 tonnes Hg (E-Europe 1995)	Mercury-oxide batteries: zinc-air, silver-oxide and lithium batteries EEA2000b
Capacitors and transformers	PCBs	11 kg (large capacitors); 0,05 kg (ballast capacitors)		0.06 % spilled; 1.6 % for large capacitors	Used in 1929-1988 in Europe (Kindbom&Munthe 2007)
Light sources	Mercury	Up to 5 mg in compact fluorescent light; up to 10 mg in fluorescent light	120 tonnes globally in 2005; 11-15 tonnes/year (EU)	0.21 tonnes Hg (W-Europe 1995), 0.121 tonnes Hg (E-Europe 1995); 25 mg/capita/year	Halogen and LED lamps EEA 2000b

4 Release estimation techniques

Release estimation techniques for quantifying releases of different chemicals from the use phase of electrical and electronic products are presented in Table 3. These include results from different studies as well as from the EMEP/CORINAIR Atmospheric Emission Inventory Guidebook and the annually reported data on releases of certain prioritized hazardous substances from products by the Norwegian Climate and Pollution Agency, KLIF (earlier SFT).

Table 3. Emission factors for different chemicals released from electrical and electronic products

End-product	Substance	Emission factor (E _f)	Release to	Reference
Enclosures and monitors	BFRs	0.05 %	Air	SFT (2004, 2009a)
		0.05 % (indoor use), 0.7 % (outdoor use)	Water	
Instruments (e.g. meters)	Mercury	0.35 kg/kg (35 %)	Air	SFT (2004)
Electrical equipment	Mercury	0.0019 tonnes per million population (Western Europe)	Air	EEA (2000b) ref. WS Atkins (1997)
		0.0003 tonnes per million population (Eastern Europe)	Air	
		5% (initial), 0.5%, distribution factors for different product types for breakage	Air	Kindbom & Munthe (2007)
Switches and relays	Mercury	1.5%	Air	Cain et al. (2007)
		1%	Water	
Measurement and control equipment	Mercury	0.0044 tonnes per million population		EEA (2000b) ref. WS Atkins (1997)
		0.0013 tonnes per million population		
		1.5% (except thermometer)	Air	Cain et al. (2007)
		1% (except thermometers)	Water	
		5% (initial), 0.5%, distribution factors for different product types for breakage		Kindbom & Munthe (2007)
Thermometers	Mercury	10%	Air	Cain et al. (2007)
		1%	Water	
Cables	MCCPs	0.0025 kg/kg (0.25 %)	Air	SFT (2004, 2009a)
		0.0325 kg/kg (3.25 %)	Water	
		0.015 kg/kg (1.5 %)	Soil	
Batteries	Mercury	0.0002 tonnes per million population		EEA(2000b) ref. WS Atkins (1997)
		0.00004 tonnes per million population		
		5% (initial), 0.5%, distribution factors for different product types for breakage		Kindbom & Munthe (2007)
Capacitors	PCBs	1.6 kg/t (leaks)		EEA (2000a) ref. TNO (1995)
		4.2 kg/t (leaks)		EEA (2000a) ref. USEPA (1997)
		2.0 kg/t (leaks) 0.8 kg/t (releases to air)	Air	EEA (2000a) ref. Belarusian report to EMEP (2000)
Transformers	PCBs	0.06 kg/t (leaks)		EEA (2000a) ref. TNO (1995)
		0.3 kg/t (leaks)		EEA (2000a) ref. USEPA (1997)
		0.3 kg/t (leaks) 0.06 kg/t (releases to air)	Air	EEA (2000a) ref. Belarusian report to EMEP (2000)

		0.006-0.5 g/capita/year (leaks)		EEA (2000a) ref. Berdowski et al. (1997)
Light sources	Mercury	0.0005 tonnes per million population		EEA (2000b) ref. WS Atkins (1997)
		0.0003 tonnes per million population		
		10%	Air	Cain et al. (2007)
		1%	Water	
		5% (initial), 0.5%, distribution factors for different product types for breakage		Kindbom & Munthe (2007)
		0.21 kg/kg (21 %)	Air	SFT (2004)
		0.06 kg/kg (6 %)	Water	
		0.04 kg/kg (4 %)	Soil	

4.1 Enclosures and monitors

The annual releases of additive flame retardants from electrical and electronic products to air, soil and water can be estimated by using equation:

$$E = A \cdot EF$$

E = emission (kg)

EF = emission factor (kg/kg of flame retardant in the product)

A = amount of flame retardant used in the product (kg)

The emission factors according to KLIF (SFT 2004, 2009a) are 0.05 kg/kg to air, 0.05 kg/kg to water (indoor use) and 0.7 kg/kg to water (outdoor use).

4.2 Electrical equipment containing mercury

Releases of mercury from electrical and electronic products can be calculated by a simple method as follows (EEA 2000b):

$$E = EF \cdot A$$

E = Atmospheric emission of mercury (t)

EF = Emission factor (0.0019 tonnes per million population (Western Europe) 0.0003 tonnes per million population (Eastern Europe)

A = Population

A more detailed methodology would require information on the mass of mercury in a product per year and the amount of products consumed annually. Using the method by Kindbom & Munthe (2007), release estimates from the use phase of different groups of electrical equipment can be derived as follows: first, the amount of mercury in electrical equipment⁴⁷ in a given year is multiplied by the distribution factor for the share of products in each group estimated to be subject to breaking and then by the release factor for the product group. Distribution factors established for the following product groups are: batteries 1%, measuring and control equipment 5%, electrical equipment 1% and light sources 5%. The release factor of 5% is then used for all of these groups. It is also assumed that 5% out of the total release is emitted to air during the first year and 0.5% during the next 10 years annually. The shares of releases to water and soil were not estimated in this study.

⁴⁷ available from e.g. a product register or mass balance

$$E = D_f \cdot EF \cdot Sa \cdot A$$

E = Atmospheric emission of mercury (kg)

D_f = Distribution factor for a given group: batteries 1%, measuring and control equipment 5%, electrical equipment 1% and light sources 5%

EF = Emission factor for all groups 5% of mercury in product

Sa = Share of releases to air during the first year 5%, during the next 10 years 0.05% annually

A = Activity data (mass of mercury (kg) in the products, i.e. mass per product types and the number of these products per year)

The method by Cain et al. (2007) is a substance flow analysis giving releases to air (emission factor 1.5% of mercury in the product) and to water (1% of mercury in the product). For thermometers Cain proposes the following emission factors: 10% to air and 1% to water. The Norwegian method (SFT, 2004) for instruments containing mercury, such as meters uses the emission factor of 0.35 kg/kg (35%) to air. Both of these methods use the equation below:

$$E = EF \cdot A$$

E = Release of mercury (kg)

EF = Emission factor (kg/kg mercury in product)

A = Mass of mercury in products(kg)

4.2 Measurement and control equipment

In addition to the methods provided above for mercury containing electrical and electronic products, the following methods for measuring and control equipment are presented (EEA 2000b):

$$E = EF \cdot A$$

E = Atmospheric emission of mercury (kg)

EF = Emission factor (0.0044 tonnes per million population (Western Europe) 0.0013 tonnes per million population (Eastern Europe))

A = Population (mill. Inhabitants)

4.3 Cables and wires

The annual releases from cables and wires to the environment can be estimated by using equation:

$$E = A \cdot EF$$

E = emission (kg)

A = amount of the substance used in the product (kg)

EF = emission factor (kg/kg)

According to KLIF (SFT 2004, 2009a), releases of MCCPs from products are estimated to be 5 % of the used amount of MCCPs in products, with 5 % distributed to air, 65 % to water and 30 % to soil. This would result to emission factors of 0.0025 kg/kg (0.25 %) to air, 0.0325

kg/kg (3.25 %) to water and 0.015 kg/kg (1.5 %) to soil. There are no differentiations between the product groups.

4.4 Batteries

The simple method for mercury releases from batteries provided by the EEA (2000b)

$$E = EF \cdot A$$

E = Atmospheric emission of mercury (kg)

EF = Emission factor (0.0002 tonnes per million population (Western Europe) 0.00004 tonnes per million population (Eastern Europe))

A = Population (mill. Inhabitants)

Capacitors and transformers

Breivik et al. (2002b) have derived emission factors for emissions of 22 individual PCB congeners from small capacitors, partially closed applications and closed applications (transformers and large capacitors). The emission factors for small capacitors and nominally closed systems were assumed to be the same as for closed systems. The emission factors are presented in Table 4, with categories 2, 3 and 4 small capacitors, partially closed applications and closed applications respectively.

Table 4. Emissions factors for 22 individual PCB congeners (Breivik et al. 2002b)

PCB No.	Chemical structure	ef (usage)	
		1 (open)	2,3,4
		20 °C	20 °C
5	2,3-DiCB	2.56E-02	5.22E-06
8	2,4'-DiCB	2.71E-02	7.12E-04
18	2,2',5-TriCB	6.75E-03	1.18E-04
28	2,4,4'-TriCB	6.75E-03	1.18E-04
31	2,4',5-TriCB	6.88E-03	8.55E-05
52	2,2',5,5'-TetCB	4.03E-03	6.47E-05
70	2,3',4',5-TetCB	1.01E-03	1.01E-05
90	2,2',3,4',5-PenCB	1.09E-03	1.81E-06
101	2,2',4,5,5'-PenCB	1.10E-03	1.29E-05
105	2,3,3',4,4'-PenCB	1.49E-04	5.26E-07
110	2,3,3',4',6-PenCB	6.70E-04	5.46E-06
118	2,3',4,4',5-PenCB	2.08E-04	1.38E-06
123	2',3,4,4',5-PenCB	2.27E-04	1.26E-07
132	2,2',3,3',4,6-HexCB	3.21E-04	9.55E-07
138	2,2',3,4,4',5'-HexCB	2.31E-04	1.07E-06
149	2,2',3,4',5',6-HexCB	4.44E-04	2.28E-06
153	2,2',4,4',5,5'-HexCB	2.92E-04	2.09E-06
158	2,3,3',4,4',6-HexCB	2.66E-04	2.61E-07
160	2,3,3',4,5,6-HexCB	3.46E-04	5.14E-09
180	2,2',3,4,4',5,5'-HepCB	7.45E-05	1.38E-07
194	2,2',3,3',4,4',5,5'-OctaCB	1.58E-05	3.38E-09
199	2,2',3,3',4,4',5,5',6'-OctaCB	3.80E-05	9.69E-09

All units in (w/w) year⁻¹.

According to EMEP/Corinair Emission Inventory Guidebook (EEA 2000a), leaks of PCBs from capacitors and transformers can be calculated with two different methods:

Transformers:

$$E = EF \cdot A$$

E = Atmospheric emission of PCBs (g)

EF = Emission factor (g/per capita)

A = Activity data (population, inhabitants)

Capacitors and transformers:

$$E = EF \cdot A$$

E = Atmospheric emission of PCBs (kg)

EF = Emission factor (kg/t)

A = Activity data (PCB in electrical equipment)

Berdowski et al. (1997) in EEA (2000a) calculated emissions of PCBs originating from leaks from transformers and capacitors for each European country in 1990. As shown in Table 4 the evaporation rate decreases when the level of chlorination of the PCB congeners increases. This means that leakages from capacitors are estimated to evaporate more quickly than from transformers.

A more detailed methodology would involve a statistical data of the number of transformers and capacitors in a country and an analysis of the proportion of transformers and capacitors containing PCBs, as well as the share of PCBs in the product that has the potential to leak (EEA 2000a).

4.7 Light sources

The following methods have been presented for mercury releases from light sources:

A simple method according to the EEA (2000b):

$$E = EF \cdot A$$

E = Atmospheric emission of mercury (kg)

EF = Emission factor (0.0005 tonnes per million population (Western Europe) 0.0003 tonnes per million population (Eastern Europe))

A = Population (mill. Inhabitants)

The method by Cain et al. (2007) is a substance flow analysis to quantify releases to air (emission factor 10% of mercury in the product) and to water (1% of mercury in the product).

The Norwegian method (SFT, 2004) for light sources uses the emission factor of 0.21 kg/kg (21%) to air, 0.06 kg/kg (6%) to water and 0.04 kg/kg (4%) to soil.

Both of these emission factors can be applied to the equation below:

$$E = EF \cdot A$$

E = Release of mercury (kg)

EF = Emission factor (kg/kg of mercury in the products)
A = Mass of mercury in products (kg)

5 Restrictions

5.1 International and regional restrictions

EU RoHS Directive

EU Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) prohibits the import and sale of products containing lead, mercury, chromium(VI), polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE) by more than 0.1 weight-% and cadmium by more than 0.01 % by weight for individual parts. This covers new articles and their spare parts put on the market in the EU starting from first of July 2006 with certain exceptions.

The Directive includes large and small household appliances; IT and telecommunication equipment; consumer and lighting equipment; electrical and electronic tools (not large-scale stationary industrial tools), toys, leisure and sports equipment, automatic dispensers, electric light bulbs, and luminaires in households. The Directive does not include equipments used for specific military purposes, medical devices as well as monitoring and control equipment.

According to the Directive, the six substances must be replaced by other alternatives in electrical and electronic equipment. The Directive also allows exemptions to the ban if the replacement is technically or scientifically impractical or if its negative consequences to health, environment or safety overcome the benefits of the ban. The Directive does not require labelling or submission of information, but the manufacturer or supplier has to ensure that the product is in compliance with the RoHS.

The exceptions currently include e.g. the use of mercury in fluorescent and other lamps at certain levels; the use of lead in glass of cathode ray tubes, electronic components and fluorescent tubes, as an alloying element at certain levels, certain solders and electronic ceramic parts; the use of certain cadmium plating and the use of hexavalent chromium as an anti-corrosion in certain types of refrigerators.

Two product groups that are included in the Directive 2002/96/EC on waste electrical and electronic equipment (WEEE), medical devices used in health care as well as monitoring and control equipments and devices (e.g. switches and relays), are not included in the RoHS Directive. The RoHS Directive is currently under revision on among other things on including these two product groups in the Directive. Also the current exemptions and possibility of adding hazardous substances to the Directive are under consideration.

References; Black 2005, EC 2002, UNEP 2008a, Konsumentverket 2006, Lassen et al. 2008, Massey et al. 2008, Tukes 2008, UNEP 2008a

EU REACH regulation

Annex XVII of the EU REACH regulation ((EC) No 1907/2006) includes restrictions on the manufacture, placing on the market and use of certain dangerous substances, preparations and articles.

Mercury containing measuring devices

According to the Annex XVII of the REACH regulation products that must not be placed on the market include fever thermometers and other measuring devices intended for sale to the general public (e.g. other thermometers, manometers, barometers and sphygmomanometers). Exemptions include measuring devices older than 50 years (on 3 October 2007) and barometers (until 3 October 2009). The restriction is also not applied to measuring devices that were in use before 3 April 2009. The Commission will review the availability of safer alternatives by 3 October 2009 and based on that, it will consider extending the restriction to measuring devices used in healthcare and other professional uses. The export of mercury will be prohibited starting from 2011.

Reference: EC 2009a, b

Perfluorooctane sulfonate (PFOS)

Annex XVII of EU REACH Regulation prohibits the distribution and use products containing 1 µg/m² or more PFOS of the coated material. Exemptions include the use of PFOS in photographic coating in the production of processors because there is yet no alternative available.

Reference: EC 2009b, UBA 2007

Pentabromodiphenyl ether (penta-BDE) and octabromodiphenyl ether (octa-BDE)

According to EU REACH Regulation Annex XVII, articles or their flame-retarded parts containing pentabromodiphenyl ether (pentaBDE) or octabromodiphenyl ether (octaBDE) at concentrations higher than 0.1 % by mass must not be placed on the market. This does not apply to articles that were in use before 15 August 2004.

There are no restrictions for the use of NPEs in electronic components in the EU legislation

Reference: EC 2009, IVL 2008

Cadmium

According to EU REACH Regulation Annex XVII, cadmium may not be used to give colour to articles manufactured from e.g. PVC. Articles or components of articles manufactured from the substances and mixtures coloured with cadmium shall not be placed on the market if their cadmium content (expressed as Cd metal) is greater than 0,01 % by weight of the plastic material. Cadmium may also not be used to stabilize mixtures or articles manufactured from vinyl chloride, including insulation for electrical wiring. The cadmium content in these articles must exceed 0.01 % by weight of the polymer. Exemption is granted to articles colored or stabilized with cadmium for safety reasons.

Reference: EC 2009

Electrical equipment in vehicles

EU Directive 2000/53/EC on end-of-life vehicles (ELV) is designed to increase recycling and to reduce pollution (Massey et al. 2008). The ELV prohibits the use of lead, mercury, cadmium and hexavalent chromium materials and components of vehicles put on the market after 1 July 2003 (EC 2000). The ELV currently exempts e.g. lead containing batteries and solder as well as mercury containing discharge lamps and instrument panel displays.

References: Lassen et al. 2008; EC 2000

Batteries and accumulators

According to EU Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators, all batteries and accumulators with mercury content of more than 0.0005 % by weight as well as portable batteries and accumulators with cadmium content of more than 0.002 % by weight, are prohibited to place on the market. This includes also those incorporated into appliances. Exemptions include button cell batteries containing mercury 2 % or less by weight as well as portable batteries and accumulators used in emergency and alarm systems, medical equipment or cordless power tools. No prohibition on lead containing batteries was introduced.

References: EC 1991, 2006, Lassen et al. 2008, UNEP 2008b

EU POPs regulation

The EU Regulation (EC) No 850/2004 on persistent organic pollutants (POPs) is prohibiting, phasing out, or restricting the production, placing on the market and use of substances subject to the Stockholm Convention or the UNECE CLRTAP POPs Protocol. The POPs regulation also concerns placing on the market of articles containing POPs. Prohibited substances (Annex I) include e.g. aldrin, mirex, PCBs and DDT.

References: EC 2004

5.2 National legislation

The Chinese Restriction on Hazardous Substances (China RoHS) applies only to electronic devices (not electrical), but it contains fewer exemptions compared to the EU RoHS Directive (Massey et al. 2001). The China RoHS is based on labelling requirements using symbols to identify if the product contains one or more of the six targeted toxic substances. The symbol also includes number of years during which the item is guaranteed not to release toxics under normal use. In product instructions more detailed information is required. The China RoHS also requires testing of the articles while the EU RoHS relies on self certification by the manufacturer or importer.

In the United States, authorized use of PCB containing transformers is still allowed. There are also no restrictions on the existing use of PCB containing switches, cables, electromagnets, voltage regulators, circuit breakers and re-closers. In the United States, the exporters of intact or broken cathode-ray tubes that are going to recycling must notify the U.S. EPA and get a permission from the importing country.

Canadian government has proposed to prohibit the manufacture, use, sale, offer for sale and import of certain new electrical and electronic products that contain nona- and decaBDE by concentrations higher than 0.1 % by weight. This would widen the existing ban on the use of polybrominated diphenyl ether (PBDE) containing flame retardants in products, which now includes penta- and octaBDE.

Some countries also require that photo chemicals have to be collected and taken care of.

Nordic countries

In Norway, PCB containing capacitors in light ballasts were prohibited to use starting from 2005. Exemptions include mercury in fluorescent lamps. According to the Norwegian (and EU) regulations, a lamp must not contain more than 5 g of mercury. This limit value will be revised in 2010.

Sweden prohibited the professional manufacture and sale of certain mercury-containing instruments (e.g. thermometers) and electrical components at the beginning of 1990's. Also the export of mercury, mercury compounds and preparations containing mercury was banned. A general national ban, which will widen the present ban on mercury and products containing mercury is starting from the beginning of June 2009 (See Chapter 2.3 of the main report). Exceptions due to harmonized EC legislation include e.g. light sources and other electrical and electronic products, batteries and vehicles. The Swedish Chemicals Agency's regulations will specify certain time-limited exceptions for certain instruments and equipments.

References: ChemicalWatch 2009, DEQ 2003, Fairclough 2007, IVL 2008, Keml 2004, SFT 2005, SFT 2009a,c, SYKE 2008, UNEP 2008b

5.3 Industry initiatives

The Joint Industry Guide for Material Composition Declaration for Electronics Products (JIG) is designed to facilitate information flow across the supply chain, including customers, product recyclers and other stakeholders. JIG contains a standardized list of materials that has to be provided if they are present in products and components. The list includes 15 materials and substances subject to bans or restrictions and nine materials and substances that can not be banned or restricted, but are relevant to the material declarations.

Electronic Product Environmental Assessment Tool (EPEAT), administrated by Green Electronics Council, is a voluntary system for exchanging information between the manufacturers and purchasers of computers and monitors. EPEAT was designed for large-volume purchasers, but it can also be used by consumers. Through EPEAT, the manufacturers can show that their products meet the environmental criteria. They have to pay a fee and sign an agreement with EPEAT to verify that their information is accurate. EPEAT test certain number of the products for verification. The product register is available in a free online database. The product records show the rating of the product for each criteria and how the product is meeting the standard.

Some companies have created lists of substances restricted or banned in their products. For example, Microsoft has provided its suppliers a list of substances restricted in hardware and batteries sold to the company. The suppliers are provided a list of substances they must disclose, if used above certain threshold. The company is aiming to phase-out the use of substances posing a risk or threatened risk to health and the environment in its consumer

hardware electronics. It has also developed a procedure for identifying and restricting additional substances. The company is planning to phase-out the use of brominated flame retardants and phthalates by the end of year 2010.

Sony Ericsson has also created lists of banned and restricted substances in order to manage the use of substances and materials in their products. The list was gathered based on legislation and the requirements of customers, NGOs and other stakeholders. With the regularly updated list, the company also wants to be prepared for upcoming legislation. Sony Ericsson has phased out by far the use of halogenated flame retardants in boards, casings and cables; the use of PVC; the use of chlorinated polymers as well as the use of nickel in surface applications. The company is also planning to phase out the remaining use of halogenated flame retardants, beryllium and antimony compounds as well as bisphenol-A residues found in polycarbonate and epoxy. Sony Ericsson's material declarations database system calculates the legal and environmental compliance for each component and for the entire products. The environmental declarations can be downloaded from web to identify the presence of individual substances in a specific product. Sony Ericsson has also created "green" products containing e.g. bioplastics and recycled plastics.

Also, Dell has a restricted substances list. The company has listed e.g. halogenated plastics and PVC for phase out. Dell's all applications are free of PBDEs and the company has also phased out the use of all other brominated flame retardants (including TBBP-A and HBCDD) in plastic parts since June 2006. The company has also restricted or eliminated other substances (including asbestos, cadmium, SCCP, chromium(VI), lead, mercury and PCBs) from certain applications. Dell has a restricted materials specification to inform the manufacturers about the required material restrictions. The company is also committed to recycling and reuse.

Many manufacturers have started to phase out the use of deca-BDE in their products, e.g. Hewlett-Packard Company, Sony, IBM, Ericsson, Apple, and Intel. The main factors affecting to their decision have been eco-labels, customer requirements and preparing for ROHS and other legislation. Some companies replaced deca-BDE in their products as early as 1990s. The companies have not usually specified the used substitutes, but typically copolymers with halogen-free organo-phosphorous compounds have been used for enclosures and other large parts. Alternative brominated flame retardants have been used for the small parts (less than 25 g) e.g. in connectors and switches.

Some companies (e.g. Apple, Toshiba and NEC) have started to replace flammable materials with nontoxic flame resistant materials, like metal, polyphenylene sulphide plastics and biobased plastics. European manufacturers ceased the addition of mercury in alkaline batteries in 1992.

References: Costner et al. 2005, Dell 2009, Lassen et al. 2006, Massey et al. 2008, McPherson et al. 2004, Osibanjo 2009, Paska 2009, Sony Ericsson 2009

Recycling and re-use of electrical and electronic products

Electrical and electronic products should not be disposed with other waste because they may contain hazardous substances. This also includes mercury containing fluorescent lamps. They should be collected, properly handled and recycled. Various countries have recycling programs for electronic waste, aiming to reduce releases of lead and other toxic metals to the environment. For example, in British Columbia, the electronics are collected, sorted and treated for recycling or burning at a smelter. The financial costs of the program are covered

by a levy on new electronics. The program, however, does not include all electronics and there is a concern over the possible effects, which the processing of e-waste in a smelter could have on air pollution.

The electronics should not be disposed off with normal garbage. In many countries, e.g. Norway, the retailers are obligated to receive electrical and electronic products free of charge and to provide storing, sorting and forwarding of these items. According to an investigation by the Norwegian Climate and Pollution Agency, KLIF, in 2008, 71 % of the retailers of electrical and electronic products do not inform their customers about the correct waste handling and only third of all small electronic appliances are delivered to proper treatment. In a follow up study in 2009, it was found that 39 % of the retailers still do not meet the information duty. Electrical and electronic waste has also been exported from Norway to developing countries although this is largely prohibited. During the transport, the appliances can be broken, which reduces the recycling of the components.

In the United States the export of most old electronics, like cell phones and circuit boards, is not regulated, because the US EPA considers them to be non-hazardous. There are currently no restrictions for new electronic products, but there are regulations requiring reporting to the TRI.

Guidelines are needed for recycling of materials to ensure that flame retardants used in electronic products are not continually put into new products. Most recycling of personal computers is conducted in China, India and Africa.

References: George-Cosh 2007, Fairclough 2007, Massey et al. 2008, McPherson et al. 2004, SFT 2008b, SFT 2008b, 2009c

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7 Appendixes

7.1 Appendix I: Studies on the chemical releases from electrical and electronic products

Mortensen (2005) studied the emissions of chemical substances from electrical and electronic products in use and the possible health risks in Denmark. The test included equipments like printer, computer, television, batteries, mobile phone and lamp that were new or had been in use for a short time. Several substances were tested (e.g. VOCs, isocyanates, brominated flame retardants and organic tin compounds). All of the tested products were emitting substances when in use. Especially formaldehyde was emitted at high amounts from a number of products. Also brominated flame retardants (nona- and decaBDE) were emitted, but small amounts. The types of substances and the emitted amounts were generally reduced with time.

The Safety Technology Authority of Finland (Tukes) tested 63 electrical and electronic equipments in Finland in year 2007 (Tukes 2008; HS 2008). The test included household appliances, consumer electronics and lighting fixtures. Two of the tested products, a dvd-player (lead in solder) and an air humidifier (lead in conducting wire insulator), had too high amounts of lead and were prohibited to deliver to stores. The test also showed that there

were still many products, which had been put on the market before the RoHS Directive came into force in July 2006.

ANNEX 1

CASE STUDIES ON SELECTED PRODUCT GROUPS

Case Study 5:

Releases from the use phase of furniture

CASE STUDY 5

RELEASES FROM THE USE PHASE OF FURNITURE

Content

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- 2 Use and substances in furniture products
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1 End products from which there are likely releases during the use phase

Furniture

Furniture often consists of a combination of many different materials, including wood, plastic, foam rubber, textile, leather, glass and metals. The products include couches, chairs, tables, bookshelves, beds as examples. Furniture textiles, including curtains, upholstery and mattresses, as well as carpets are included in this case study. More information on textiles and leather products is available in the separate case study on textiles.

A variety of chemicals are used in the materials included in furniture as shown in Table 1:

- Flame retardants are used in the furniture textiles, such as in couches, mattresses, carpets and cushions
- Polybrominated diphenyl ethers (PBDEs) can be found in the foam paddings and in carpet backing. Studies indicate that consumer products, including furniture, are the most likely source of PBDEs to the environment as these concentrations have been measured to be high especially in indoor air. The use of flame retardants has increased as a result of the replacement of less flammable natural materials by more combustible synthetic materials.
- Perfluorinated chemicals (PFCs), such as PFOS are found in many common products including furniture upholstery and stain-proofed carpets where they have been used as an oil-, water- and stain resistant coatings.
- Furniture may also contain heavy metals, such as arsenic, lead and mercury. These compounds are commonly found in paint pigments and in PVC plastics. Chromium is found in tanned leather and wooden furniture. Carpets are often protected against dust mites, bacteria, moulds and fungi by using different chemicals and pesticides.

Table 1. Use of different substances in furniture products and their likely releases during the use phase. Explanations: Releases to: the environmental compartment is in brackets if releases are considered minor, e.g. (air); RET = Release estimation technique, Yes = exists, (Yes) = not published/only in certain countries; NA = information not available) A blank cell indicates that there is currently no information on the issue.

Use category	Substance	Releases to	RET	Included in regular inventories
Leather furniture	Chromium (in tanning)		No	No
	Anti-mould agents (e.g. dimethylfumarate)		No	No
Wooden furniture	Formaldehyde (in adhesive)	Air	No	No
	Heavy metals (in paint)	Soil, water, air	No	No
	Chromium, copper and arsenic (in impregnated wood)	Water, soil	Yes	(Yes)
Plastic furniture	Phthalates (PVC)	Air	No	No
	Heavy metals (e.g. lead and organotins)		No	No
Furniture foam and textiles	Flame retardants (e.g. HBCD, PBDEs)	Air	Yes	(Yes)
	PFCs	Water	No	No
Carpets	Formaldehyde	Air	No	No
	Phthalates (PVC)	Air	No	No
	Organotins (PVC)		No	No

	Flame retardants	Air	No	No
	PFCs	Water	No	No
	Pesticides (e.g. permethrin)	Air	No	No

References: Allsopp et al. 2001, Betts 2008, Bull & Foxall 2009, Costner et al. 2005, Keml 2009a, Sharp & Lunder 2004

Use and substances in furniture products

2.1 Leather furniture

Leather furniture is most frequently (80-90% of products) upholstered in chromium-tanned leather (3-5 w-% Cr_2O_3), to make it feel softer and more supple than leather tanned using vegetable agents. Leather products tanned with chromium include e.g. sofas and chairs. The products will contain chromium during their whole lifetime.

Dimethylfumarate (DMF) has been used as an anti-mould agent in leather furniture, like couches and armchairs. Producers use DMF as a biocide to protect the furniture from mould, which can cause deterioration of leather during storage and transportation in a humid climate. DMF can also be placed in sachets inside the furniture. DMF evaporates from the sachets impregnating the leather. Dimethylfumarate has been used in imported products, especially in Chinese made furniture.

References: EU 2009, Hoffmann et al. 2003, Johnson et al. 2006

3.1 Wooden furniture

Composite wood products treated with urea-formaldehyde resin are likely to be among the most significant sources of airborne formaldehyde in the home environment. Medium density fiberboard (MDF) is the highest formaldehyde-emitting composite wood product and it is widely used in building materials and furniture. Particle board and hardwood plywood are two additional types of compressed wood made with formaldehyde-based glue. Urea-formaldehyde glue is widely used in composite wood products because of its low price and transparency. Formaldehydes are classified as NMVOC-compounds, which are included in regular inventory work.

Heavy metals are used in furniture materials as follows:

- Arsenic is widely used as a preservative in pressure treated wood in order to preserve wood from decay. The most common arsenic formulation is Chromated Copper Arsenate (CCA), which consists of chromium, copper and arsenic. Up to 70% of global arsenic production is used in the industry of preservation of wood as CCA (more information in the Case Study for Building and Construction Products). Arsenic compounds are also used to make special glass, paints and metals, which are possible elements of furniture.
- Today only small quantities of wood are impregnated with chromium but there is potential for significant chromium emissions from the existing impregnated wood items because of their long lifetime.
- Mercury has been used in paints both as pigment and fungicide. Mercury compounds are now banned, however, old surfaces, such as furniture painted with these supplies still exist.

- Lead is found in a large array of consumer products, including paint (as a pigment). The use of lead in specific products is restricted for example in the EU (Lead case study) and in the USA. In developing countries lead is more commonly found in products, e.g. paints, which are used in furniture.

Furniture paint can also contain phthalates.

References: Costner et al 2005, HBN 2001, Hoffmann et al. 2003, LEF 2009, Madsen & Gibson 2008, Pollution in people 2006, Pritchard 2007, Toxics Link 2009, USEPA 2009

3.2 Plastic furniture

PVC is used in furniture for making imitation leather and furniture film. Inflatable furniture and water beds are made of soft PVC while unplasticized polyvinyl chloride (u-PVC) is used in manufacturing garden furniture. PVCs can also be used in e.g. work chairs to cover the armrests.

Furniture made of soft PVC plastics contains phthalates. Di(2-ethylhexyl) phthalate (DEHP) and di-isononyl phthalate (DINP) are used nearly exclusively as a plasticizer in PVC plastics to soften them in the production of consumer goods, e.g. furniture. PVC products can contain heavy metals, e.g. lead, used as stabilizers.

References: AHT 2003a, European Communities 2003, Greiner et al. 2006, Harmon 2001, LEF 2009, Pollution in people 2006

2.3 Furniture foam and textiles

Chemical coatings are commonly applied to the fabric of chairs and couches to make them stain resistant or fire retardant. The use of flame retardants varies in the different materials. Wool does not need flame retardants due to its lower capacity to ignite.

- Decabromodiphenyl ether (deca-BDE or BDE 209) is commonly used as flame retardant in high impact polystyrene (HIPS) and textiles used for furnishings and upholstery such as sofas, office chairs and curtains as well as in car, plane and train seating. About 10 % of the decaBDE produced is used in the textile industry.
- Penta-BDE is used in mattresses and mattress pads, seat cushions, upholstery furniture in couches and chairs, and carpet padding and underlay made of polyurethane foam. Polyurethane foam typically contains 10-30 % pentaBDE by weight
- Hexabromocyclododecane (HBCD) has been used in upholstered textiles made of polymer matrices for cotton or cotton containing textile mixtures, e.g. in upholstery and mattresses. The use of HBCD (range 0.5 to 7% w-%) in back coating of textiles accounted for 10 % of the total use of the substance in products in Europe in 2002.
- Perfluorinated chemicals (PFCs), e.g. perfluorinated surfactants, perfluorooctanyl sulfate (PFOS) and perfluorooctanoic acid (PFOA), have been used for oil-, water- and stain resistant coating in furniture upholstery. Furniture textiles are one of the imported products that probably contain PFCs. Accordingly, imported products (e.g. furniture) that have been treated with PFCs are assumed to account for the largest proportion of PFCs transported to Sweden. For example, PFOS are no longer used for waterproofing of textiles in Europe or in the United States. There are still countries using PFOS in textiles, e.g. China, which also imports fluorine containing textile finishing agents from other countries.

- HBCD may be present in imported flame retarded products. Penta-BDE is no longer used in EU and the US. Deca-BDE is still used in North America. There is evidence that penta-BDE is produced in China and may enter other countries in imported furniture.

References: AHT 2003b, Betts 2008, Costner et al. 2005, HI Pages 2008, Kemi 2006, 2009a, Massey et al. 2008, McPherson et al. 2004, Remberger et al. 2004, Sharp & Lunder 2004, Wakefield 2007

2.4 Carpets

Most industrially manufactured carpets contain different chemical additives, which are either impregnated during the manufacture of the carpet fiber or are used in surface treatments of the final product:

- Deca-BDE is commonly used in styrene rubbers in carpet backing and penta-BDE in carpet padding and underlay made of polyurethane foam.
- PFCs, e.g. PFOS and PFOA, are found in stain-proofed carpet. PFCs have been used in 3M's Scotchgard fabric and carpet protectors as well until 3M made a decision on phasing out the manufacture of products including PFCs in 2000.
- Perfluorobutane sulphonate (PFBS) has been used for impregnating carpets
- Some carpets are backed up with PVC and may thus contain phthalates and heavy metals such as organotins, especially tributyltin (TBT)

Carpets are often protected against dust mites, bacteria, moulds and fungi by using different chemicals. Pesticides are applied to carpets prior to sale in order to prevent infestations of insects and dust mites. Anti-mould agents are used to prevent the growth of mould in the product. They may be present in the finished product or be supplied in separate bags. It is estimated that approximately 80 % of most people's exposure to pesticides occurs indoors.

- Organotins can be used as pesticides in carpets though they are mainly used in PVC as stabilizers.
- Permethrin, which is a synthetic pyrethroid is used as an anti dust mite chemical in carpets.
- Triclosan (5-chloro-2(2,4-dichlorophenoxy) phenol) has been used as an antibacterial agent in carpets.
- Formaldehyde is also used as an antiseptic, germicide and fungicide. Some carpets contain formaldehyde, which can contribute to domestic exposure. Formaldehydes are classified as NMVOC-compounds, which are included in regular inventory work.

References: 3M 2009, Allsopp et al. 2001, Costner et al. 2005, Greiner et al. 2006, Kemi 2006, 2009a, McPherson et al., Remberger et al. 2004, Sharp & Lunder 2004

3 Estimation of releases

Substances can migrate, leach out of or otherwise escape from furniture during normal use. Chemicals used in furniture have also been found in high concentrations in indoor air and household dust as well as in human blood and tissues. In the environment, these chemicals can be found in fish, birds and marine mammals in addition to sewage sludge, surface water and sediments.

3.1 Leather furniture

Though it is known that dimethylfumarate can penetrate from leather to clothes and skin of people, there is no information about the releases to the environment.

Reference: EU 2009

3.2 Wooden furniture

The following chemicals may have releases to the environment from the use of wooden furniture:

- Products containing urea-formaldehyde adhesive tend to have very high formaldehyde emissions, which continue for several years after manufacture. Heat and humidity accelerate the vaporization of formaldehyde, particularly in case of new products. High concentrations have been measured in several studies.
- Arsenic leaches out from wooden furniture into soil and also rubs off from the wood into people or animals.
- Chromium and chromium compounds are stable compounds with high melting and boiling points, which means that chromium emissions to air are primarily associated with thermal processes. Chromium(III) compounds are relatively insoluble in water but some chromium(VI) compounds are more soluble. Thus, chromium emissions to water may occur in the form of leaching from impregnated wood. The above-mentioned conditions for solubility of chromium compounds also apply in connection with chromium emissions to soil. During the use phase, impregnated wood emits chromium to the environment. The quantities emitted depend on possible exposure to water. It is estimated that 1-2 % of the chromium content of impregnated wood is emitted to soil and the aquatic environment annually.
- Household dust is contaminated from the lead paints when small particles become airborne during sanding while repainting indoors. Lead can then be inhaled or ingested, especially by children, who tend to have frequent hand-to-mouth contact.

References: Greiner et al. 2006, Hoffmann et al. 2003, Madsen & Gibson 2008, Pollution in people 2006, Toxics Link 2009

3.3 Plastic furniture

The following chemicals may have releases to the environment from the use of plastic furniture:

- Phthalates which have the highest concentrations (appr. 90w-%, 300-600 ppm) of the substances measured in household dust. They are not chemically bound to the plastic. DEHP leaches out during use, exposing consumers and causing emissions to the air and waterways. DEHP is the predominant substance (appr. 80 w-%) of these and also widely met in the environment.
- DINP. In a European Commission risk assessment report it has been estimated that adults are exposed to DINP released from furniture mainly by inhalation, whereas for infants and babies dermal contact and ingestion may be significant exposure routes added to that. Releases to indoor air are estimated at about 40 µg/m³ and internal exposure from furniture and building materials together 8.3 µg/kgd for adults and 42.6 µg/kgd for infants and new-borns.
- Lead: PVC products can release lead under conditions where the products are abandoned to conditions enhancing leach out.

Reference: AHT 2003a, Costner et al. 2005, European Communities 2003, Greiner et al. 2006

3.4 Furniture foam and textiles

Flame retardants used in textiles can be released to air and water during use of the product:

- The indoor and environmental concentrations of PBDEs have been increasing over time. PBDEs mix with house dust as foam furniture degrades. Although the exact mechanism is still unclear, releases are related to volatilization, direct partitioning between the PBDE in polymer and dust, and in physical weathering which is considered the most likely way of releases. Volatilization is assumed to be increased by heating. Oil droplets, from e.g. cooking, can produce a thin, sticky film on nearly all indoor surfaces and this organic film can trap indoor chemicals, such as PBDEs. Numerous studies have shown that the indoor environment contains higher levels (in some studies ten times higher, i.e. up to 10 ppm) of toxic fire retardants than are found outside. There have been associations between PBDE found in house dust and bromine containing foam furniture.
- Deca-BDE may leach out from the products.
- HBCD is an additive flame retardant and thus not chemically bound to the polymer, and can be emitted from polymer products by diffusion. Washing of textiles is one possible release mechanism. If the product has a long service life, releases can occur during the whole lifetime of the product. The leaching of HBCD from products can be expected to be higher in urban areas due to population density and thus consumption
- According to KLIF (SFT 2009), for additive flame retardants, it can be estimated that 0.05 % of the substance will annually leach from the material to the air. The so called worst case emission factors for leaching of BFRs to the water; 0.05 % for indoor use and 0.7 % for outdoor use.
- PFOS concentrations measured in outdoor air have been found low.

References: Betts 2008, Bull & Foxall 2009, Costner et al. 2005, Remberger et al. 2004, Sharp & Lunder 2004, Webster et al. 2004, 2009

3.5 Carpets

The chemicals in carpets may persist for long periods, since carpets are often sold with long-term pest proof guarantees. No information was found on pesticide releases from the use of carpets to the environment.

PFCs are released into the environment from fabric and carpet protectors as active ingredients or breakdown products of the product material while formaldehyde is not likely to enter the environment, at least not in significant volumes.

References: Allsopp et al. 2001, Bull & Foxall 2009, Greiner et al. 2006; Massey et al. 2008

Table 2. Releases from the use phase of furniture products

Use category	Substance	Concentration (rough estimate)	Release media and rate (rough estimate)
Leather furniture	Chromium	3-5 % (water)	water
	Anti-mould agents (e.g. dimethylfumarate)		water
Wooden furniture	Formaldehyde		air
	Heavy metals		1-2 % per year of chromium to soil and water
Plastic furniture	Phthalates		water
	Heavy metals		water, soil
Furniture foam and textiles	Flame retardants	10-30 % of pentaBDE	water
	PFCs		air
Carpets	Formaldehyde		0.5-7.6 ppm in one study (water)
	Phthalates		water
	Heavy metals	48 ppm (max) of tributyl tin in one study	water, soil
	Flame retardants	0.5-7 % HBCD	water, air
	PFCs		air
	Pesticides	0.05-78 ppm permethrin in one study	water, air

4 Release estimation techniques

No methodologies that would especially target releases to the environment from use of furniture were found in the literature. However, information from KLIF and the study by Hoffman et al. (2003) in estimating heavy metal releases from wooden products can be used in quantifying some releases (Table 3).

Table 3. Emission factors for different substances released from furniture

End-product group	Substance	Emission factor (E_f)	Release media	Reference
Wooden furniture (impregnate)	Chromium, copper, arsenate	0.01 kg/kg (1 %)	Soil	SFT (2004)
	Chromium	1-2%	Water, soil	Hoffman et al., 2003
Furniture foam and textiles	BFRs	0.05 %	Air	SFT (2004, 2009)
		0.05 % (indoor use), 0.7 % (outdoor use)	Water	

4.1 Wooden furniture

The annual releases from treated wooden furniture to the environment can be roughly estimated by using equation:

$$E = A \cdot E_f$$

E = emission (kg)

A = amount of substance used (proportion in CCA) (kg)

E_f = emission factor (kg/kg)

According to KLIF (SFT 2004), the releases of arsenic, chromium and copper from wood preservation are estimated to be 0 % to air, 0 % to water and 30 % to soil during time period of 30-50 years (1 % per year for 30 years).

According to Hoffman et al. (2003) releases to water or soil from impregnated wooden structures amounts annually 1-2 w-% of the chromium content (kg) in the wood.

4.2 Furniture foam and textiles

The annual releases of additive flame retardants from furniture foam and textiles to air, soil and water can be estimated by using equation:

$$E = A \cdot E_f$$

E = emission (kg)

A = amount of the flame retardant used in the product (kg)

E_f = emission factor (kg/kg)

The emission factors are according to KLIF (SFT 2004, 2009), 0.05 kg/kg to air, 0.05 kg/kg to water (indoor use) and 0.7 kg/kg to water (outdoor use).

5 Restrictions

5.1 International and regional restrictions

Pesticides and anti-mould agents

According to EU Directive (91/414/EEC) on plant protection products and Directive (98/8/EC) on biocidal products; pesticides, including insecticides and anti-mould agents have to be approved for sale and use in the EU area (Keml 2009b). Biocidal products containing dimethylfumarate (DMF) are not authorised for use in the production of goods in the EU (EU 2009). Manufacturers outside EU may still be using DMF along with other unauthorised substances.

The EU has adopted an emergency Decision (2009/251/EC) to ban the placing on the market of DMF containing products. Products containing this substance, above the maximum limit of 0.1 mg/kg of product or part of the product, will be recalled and withdrawn from the market (EC 2009a). The decision was made after several member states, including France, Finland, Poland, Sweden and the UK, reported through the EU RAPEX system (Rapid alert system for non-food consumer products) exposure of consumers to the substance (EU 2009). The decision came into force at the beginning of May 2009 and it was continued until 15 March 2011. It has been proposed to be included in the REACH Appendix XVII.

Annex XVII of the EU REACH regulation ((EC) No 1907/2006) includes restrictions on the manufacture, placing on the market and use of certain dangerous substances, preparations and articles.

Perfluorooctane sulfonate (PFOS)

The EU prohibited the use of PFOS in the manufacture of textiles in year 2007 (Massey et al. 2008). Annex XVII of the REACH regulation prohibits the marketing of textiles and other coated materials containing 1 µg/m² or more PFOS of the coated material (EC 2006). According to Keml (2009b), PFOS have largely been replaced by other highly fluorinated substances, which may also pose a risk to the environment and human health due to some of them being persistent and bioaccumulative.

Pentabromodiphenyl ether (penta-BDE) and octabromodiphenyl ether (octa-BDE)

According to Annex XVII of the REACH regulation, articles or their flame-retarded parts containing pentabromodiphenyl ether (penta-BDE) or octabromodiphenyl ether (octa-BDE) at concentrations higher than 0.1 % by mass must not be placed on the market (EC 2006, 2009).

Tris (2,3 dibromopropyl) phosphate, tris(aziridinyl)phosphin oxide and polybrominated biphenyls (PBB)

According to the Annex XVII, the substances shall not be used in textile articles, such as garments, undergarments and linen, which are intended to come into contact with the skin. These articles may not be placed on the market. (EC 2009)

Cadmium

According to Annex XVII, cadmium shall not be used as a stabilizer in articles manufactured from vinyl chloride, including: fittings for furniture, coachwork or the like; impregnated, coated, covered or laminated textile fabrics; as well as imitation leather (EC 2009).

Short-chained chlorinated paraffins (SCCPs)

The Annex XVII bans the marketing and use of SCCPs in concentrations greater than 1 % for fat liquoring of leather in the EU (EC 2006).

Organostannic compounds (organotins)

According to the Annex XVII, dioctyltin (DOT) compounds shall not be used after 1 January 2015 in textile articles intended to come into contact with the skin at concentration greater than 0.1 % by weight of tin (EC 2010).

5.2 National restrictions

Before the EU wide decision on dimethylfumarate (DMF), some countries introduced national bans on DMF containing products. France adopted a year-long ban on the import and placing on the market of DMF containing seating and footwear in December 2008 (EU 2009). Also, recalls of seating, footwear and packaging that visibly contain DMF, are required.

Belgium prohibited the placing on the market of DMF containing articles and products in January 2009. Spain is also preparing measures on DMF.

5.3 Industry initiatives

IKEA

The IKEA Concept is to offer functional, well designed home furnishings at a low price and thus affordable to as many people as possible (IKEA 2009c). At the same time, the company aims at minimizing the use of harmful chemicals and substances in their furniture production (IKEA 2009a). All IKEA products comply with the chemical restrictions in the EU REACH regulation.

IKEA is continually working with chemicals and is trying to phase-out the use of questionable substances. For example, the company set a ban on PVC (1991) except for some lighting cables, on all organic brominated flame retardants in furniture (2000) and on formaldehyde emitting paints and lacquers on all products (1993) (IKEA 2009a). The concentrations of chemicals such as formaldehyde and phthalates are tested in a third-party accredited test laboratory in order to ensure they do not exceed the requirements (IKEA 2009b). The laboratory is certified annually by external auditors. Suppliers are also required to have their product tested by a third party.

Herman Miller

Herman Miller Inc. designs furniture and related services. The company's products include office, healthcare and residential furniture (Herman Miller 2009a). Herman Miller has specified environmental sustainability targets, e.g. aiming at zero VOC emissions by the year 2020 (Herman Miller 2009e). The company has invested in the eco-friendliness of their products by creating e.g. an "Indoor Air Team" to monitor the gaseous emissions of their products and a "Design for the Environment Team" to develop environmentally sensitive design standards for their products. (Herman Miller 2009d.)

Herman Miller has adopted the McDonough Braungart Design Chemistry (MBDC) Cradle to Cradle Protocol in designing the products and thus studies material chemistry and chemical safety (Herman Miller 2009c). Several Herman Miller furniture products have received the MBDC Cradle to Cradle Certification, including chairs and storage furniture (Herman Miller 2009b). Many of their products have a Greenguard Certification as well (Herman Miller 2009f).

Environmental product certifications

Greenguard Indoor Air Quality label

Greenguard Environmental Institute (GEI) is an independent, non-profit and ANSI (American National Standards Institute) authorized standard developer, which establishes indoor air standards for indoor products, environments and buildings (GEI 2008a). Furniture (systems furniture, seating, individual case goods, desks, tables and movable walls) may be labeled with the Greenguard Indoor Air Quality Certified label if they meet the Greenguard standards for low-emitting products (GEI 2008c).

Products are tested for formaldehyde, volatile organic compounds (VOCs), respirable particles, ozone, carbon monoxide, nitrogen oxide, and carbon dioxide emissions (GEI 2008b). There are threshold limit values for these substances (GEI 2005). At the moment, there are over 3,000 Greenguard Indoor Air Quality Certified furniture products (GEI 2008d).

Cradle to Cradle Certification

MBDC is a product and process design firm dedicated to changing the design of products and services worldwide by implementing eco-effective design principles (MBDC 2009). The firm has created the Cradle to Cradle Certification program, the aim of which is to create eco-friendly and safe products. The program directs manufacturers towards material optimization, i.e. utilizing environmentally healthy and safe materials, waste elimination by material reutilization (eliminating cradle to grave products) and energy efficiency (MBDC 2007, 2009). If a candidate product achieves the necessary certification criteria, it is certified as a Basic, Silver, Gold or Platinum product and can be branded as Cradle to Cradle Certified (MBDC 2007).

Substances, such as phthalates, toxic heavy metals, pigments, dyes, colorants, halogenated organics and PVC in the product must be reported during the certification process at any concentration (MBDC 2008). The usage of PVC in the certified product is forbidden and the heavy metal (lead, mercury, cadmium and chromium(VI)) content is restricted to 1,000 ppm for metal products and 100 ppm for other products. The total VOC emission threshold limit value is 0.5 mg/m³ for Gold and Platinum products.

All chemicals and materials in the product are classified and scored for their impact on human and environmental health (MBDC 2008). For both the human and environmental health criteria, there are established limit values for determining hazards. For example, toxic heavy metals (antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, mercury, nickel etc.) as well as organohalogens (chlorine, bromine or fluorine bond) are classified as substances with high risk and they should be phased out in the production within a limited time period.

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ANNEX 1

CASE STUDIES ON SELECTED PRODUCT GROUPS

Case Study 6:

Releases from the Use Phase of Nanoproductions

CASE STUDY 6

RELEASES FROM THE USE PHASE OF NANOPRODUCTS

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1 End products with likely releases from the use phase

Nanomaterials are defined as chemicals, compounds, or components that attribute their function to their extremely small size - within the range of 1 to 100 nanometers ($\text{nm} = 10^{-9} \text{ m}$). Nanotechnology studies the creation and use of structures, devices and systems that have different properties and functions due to their small size and the ability to manipulate and control material on atomic scale.

Nanoparticles can have very different properties compared to the same substances used at large scale. Differences are related to the surface area per unit of mass which increases when the size of the particle decreases and the quantum effects which are greater the smaller the particle. The composition of these materials can be carbon- or metal-based, dendrimers or composites while their chemical, optical, electrical and magnetic properties differ from those of the larger particles of the same materials.

Nanomaterials have been used commercially starting from 1930's and their use is expected to grow continuously. Materials already been in use for a longer period include silver in photographic film, carbon black in car tyres, and silicon oxide as a thickener in paints. The most commonly used nanomaterials include silver, calcium carbonate, titanium dioxide and liposomes in addition to zinc, aluminium, cerium, and silicon oxides; metals, nanoclays, polymers, dendrimers, nitrides, carbon black, fullerenes, single-(SWCNT) and multi-walled (MWCNT) carbon nanotubes.

More than 50% of nanoproducts are currently manufactured in the USA while East Asia (China, Taiwan, Korea and Japan) produces around 30% and the European countries (UK, France, Germany, Finland, Switzerland, Italy, Sweden) rough 15% of the products the remaining 5% being manufactured in other locations. Today there are more than 800 different products on the market manufactured in 21 countries and the number is growing rapidly (Table 1).

Little information is currently available on the environmental or even health effects of nanoproducts. Also methods for identifying nanomaterials in the environment are still under development.

Table 1. Number of nanoproducts in the market in 2008 (Nanotechnology Project 2009)

Product group	2008
Health and fitness	502
Home and garden	91
Electronics and computers	56
Food and beverage	80
Automotive	52
Appliances	43
Goods for children	31
Other products	18

References: ChemicalWatch 2009b, KemI 2008&2009a&2009b, Nanotechnology Project 2009, Nike 2009, OECD 2008, Suomalainen & Hakkarainen 2008, USEPA 2007

2 Use of nanomaterials in products

2.1 Vehicles

Nanomaterials in vehicles are alkene-based nanocomposites or nanotubes which are used to make lighter and more durable body structures. Nanomaterials can also be used in paints and coatings for protection of surfaces from scratches to improve the waterproof and stain resistance properties. They can also be used in windows to prevent reflections.

References: Suomalainen&Hakkarainen 2008

2.2 Electrical and electronic equipment

Nanotechnology has contributed to the development of electrical and electronic equipment, especially in information technology. The development of smaller and more efficient products has required development and handling of components at nano scale, for instance in structures designed for saving information, in the processors of the appliances, in flash memories of mp3-players and in photographic papers for printers as well.

References: Suomalainen&Hakkarainen 2008

2.3 Building and domestic appliances

Refrigerators, washing machines and air or water filters can contain nanoparticles as silver ions for antibacterial purposes. Also doorknobs, watches, tableware, furniture and textiles can be found with silver containing coatings.

Calcium carbonate has been used in polyvinyl chloride (PVC) window profiles to increase the impact strength. Windows can be treated also with other nanoparticles to provide self-cleaning surfaces. Nanoparticles are used in paints and in wood impregnating agents to increase their durability.

Nanotechnology has been used in the structure of accumulators of some tools and in the manufacture of LED (Light Emitting Diode) –lights.

Titanium dioxide filters used in air purifiers designed to remove toxic gases like formaldehyde, benzene and ammonia utilize nanotechnology. Ceramic nanoparticles of titanium and aluminium dioxides have been used in the coatings of frying pans to prevent the food from burning.

References: Keml 2008, Suomalainen&Hakkarainen 2008

2.5 Textiles

Nanoparticles have been used in textiles to fabricate stain resistant, antibacterial, weatherproof, odour neutralization and other materials. The most used nanoparticles in textiles are silver, palladium and titanium dioxide. Coatings can be added to textiles by spraying or soaking.

Though the use of nanomaterials in textiles is still very low, techniques to handle fibres at nanoscale exist.

References: Kemi 2009b, Suomalainen&Hakkarainen 2008

2.5 Sports equipment

Products using carbon fibres can potentially be improved by making them lighter and more durable by using nanotubes or fullerenes. Sports equipments where nanotechnology has been used include tennis rackets, skis and ski waxes, hockey sticks, snowboards, bicycles and fishing tackle.

References: Kemi 2008, Suomalainen&Hakkarainen 2008

2.6 Pharmaceuticals and personal care products

Nanotechnology can be applied to develop the drug delivery systems of pharmaceuticals to more affective which enables penetration where traditional products can not enter. For instance, nanoliposomes are used to improve the effect of different substances by carrying them deeper into the skin. Silver has been used in medical products such as patches and ceramic particles in scratch resistant spectacles. Nanoparticles in insecticides are used to replace toxic additives and preservatives.

Nanoparticles used in cosmetic products include titanium, zinc and their oxides, carbon nanostructures, silicon oxide, gold, keratin, crystals as well as different carrying agents like liposomes. Titanium dioxide and zinc oxide have been used for decades as UV-filters in sunscreens, but only in the recent years the size of their crystals has been reduced to nano scale. Nanoscale fullerene has been used in cosmetics and potassium phosphate as well as proteins in toothpastes for protection of damaged teeth.

References: Kemi 2008, Suomalainen&Hakkarainen 2008

2.7 Food supplies

Nanoparticles are claimed to improve the properties of many food supplies. For example, there is a drink on the market in the United States that contains only water and nanosilver and is claimed to help the immune system of the body to resist bacteria. However, this may risk the normal intestinal bacterial growth and the immune system of the body.

Mycelles, which are small balls made from fatty acids that can penetrate the cell membrane, are naturally present in the cells. These are used in some groceries and dietary supplements to improve the absorption of vitamins and other compounds in the body.

Nanomaterials in the packaging material can be used to indicate bacteria or contamination of the food. The structure of the packaging material can also be strengthened with nanocomponents thus reducing the demand of the material.

References: Kemi 2008, Suomalainen&Hakkarainen 2008

2.8 Other products

Nanoparticles can be used as insecticides or to replace toxic additives and preservatives as well as different chemicals. They have been used in paints and wood impregnating agents e.g. for durability. Windows can be treated with nanoparticles for self-cleaning surface.

References: Suomalainen&Hakkarainen 2008

3 Releases to the environment

Nanotechnology is believed to help reducing the consumption of raw materials and energy providing more efficient and accurate technical solutions though there is little knowledge about their environmental and health effects. There is also lack of suitable methods for identifying these materials in the environment.

Nanomaterials can absorb into different materials and many are known to act as catalysts. Nanoparticles have been found to be released from products through wearing and washing. However, they are unlikely released from products like electrical and electronic equipment or sports equipment where the nanotubes are usually attached to epoxy resins.

Releases to soil

Nanoparticles can be absorbed tightly to soil because of their surface area and they can easily spread in the soil due to their small size. The properties of the nanomaterial (e.g. size, form, chemistry and modification) effect greatly on the behaviour in the soil while the properties of the soil and the environment affect the movement of materials. For example, nanomaterials can transform in the soil surface by photoreactions.

It can be estimated that because of the large surface area of nanoparticles, nanomaterials of organic origin may degrade relatively fast in the environment, however, due to lack of data, no generalizations can be made. The molecular form of the material, for instance in fullerenes and tubes may enhance the breakdown of material. Fullerenes have been noticed to be taken up by wood-decaying fungi. Some nanomaterials are even designed to be biodegradable, like polymers used in drug transport. Many substances used in nanomaterials are, however, inorganic (e.g. ceramics) or metals and metal oxides that are not expected to biodegrade.

Studies have shown reduction in the survival of the bacteria exposed to even small concentrations of nanoparticles for a short period. Some bacteria have been found not to tolerate certain nanoparticles, like silver, copper oxide and zinc oxide, resulting to toxicity even at low levels. It has also been stated that nanoparticles could aggregate together or bind to silt and organic matter in the environment, resulting to reduced toxicity. There are ongoing studies on this subject.

Air emissions

Nano-sized particles are relatively short-lived in the atmosphere because they are easily combined to form larger secondary particles. The larger particles can stay from days to weeks in the air and can be easily deposited. Some nanoparticles are modified to reduce the aggregation thus dispersing more easily and having longer lifetime. However, recent studies indicate that certain nanoparticles could be harmful for animals and humans when inhaled.

Many nanoparticles have been reported to be photoactive.

Wastewater discharges

Waterborne nanoparticles sediment more slowly than corresponding larger particles and they can also easily absorb to sediment particles due to their high surface area to mass ratio. Nanoparticles can be subjected to biotic and abiotic (including hydrolysis and photocatalyzed reactions in the surface waters) degradation in the water and also be exposed to sunlight. These reactions may alter their properties and behaviour in the environment. Some insoluble nanoparticles can be stabilized in the aquatic environment, which slows down their removal from the water. Dissolved organic matter can increase the mobility of the carbon nanotubes.

Nanoparticles used in personal care products are washed down the drain and end up in the waste water treatment plants from where the substances can enter aquatic environments. Also the particles used e.g. in clothing can be released through washing process.

References: IFCS 2008, Kemi 2008, Simpson 2009, Suomalainen and Hakkarainen 2008, USEPA 2007

4 Release estimation techniques

It is not possible to present emission factors or detailed methodologies for estimation of releases from the use of nanoproducts due to the fact that little is currently known about the release mechanisms or releases from nanoproducts to the environment. This is even true for health impacts, which are generally much better known than environmental effects for products and substances.

However, the general formula for estimating releases can be used when information on released concentrations of substances become available.

$$E = A \cdot E_f$$

where E = emission [mass unit]
 A = activity data (e.g. import – export of products or annual consumption of products)
 E_f = emission factor (i.e. share of the chemical to be released)

5 Restrictions

5.1 International and regional restrictions

First regulations on nanoproducts have been introduced only recently as well as obligations to manufacturers to label items containing nanoparticles. Often the companies selling the products do not know if the product contains nanomaterials. The European Parliament has now decided that nanomaterials used as ingredients in substances, mixtures and articles must be labelled and the Commission review all relevant legislation within the next years.

The proposal for the new Cosmetics Regulation addresses nanoproducts. According to the proposal, nanomaterials can be used in cosmetics, unless the use of a particular nanomaterial for a particular product category has been assessed to be unsafe. Nanomaterials that are used as colorants, preservatives or UV filters have to be approved before the Regulation comes into force. When listing the ingredients on a product label, nanomaterials must be labeled by the word "(nano)" after the ingredient's name. There are concerns that the definition of a nanomaterial will result to some of them not complying with the Regulation due to lack of data to assess if they are insoluble or biopersistent. The proposal was approved by the Members of the Parliament in 24 March 2009 and it will still need an approval from the Council.

There are also registration and notification requirements considered for nanomaterials under the EU REACH regulation on registration, evaluation, authorisation and restriction of chemicals. In cases where there exist no information on the environmental and health hazards of nanoparticles, the EU classifications of the corresponding larger particles are used. The European Parliament wants in its resolution all nanomaterials to be considered as new substances. A database on nanomaterials in agricultural products, food, medicine and silver in consumer products is under preparation for public use by 2011.

The OECD has groups working on issues concerning health and environmental risks, testing methods and physical and chemical properties relating to intentionally manufactured nanomaterials.

Nanomaterials are also discussed under the UNEP Strategic Approach to International Chemicals Management (SAICM).

5.2 National legislation

Many national studies and testing programmes, for instance in the Nordic countries, are currently exploring issues relating to nanoproducts and the results will feed updating of the REACH regulation and the work in the OECD.

Chinese Taipei has a labelling system for the use of nanoparticles in consumer products.

5.3 Industry initiatives

Information of industry initiatives on nanomaterials used in their products is currently vague. As an example, Nike currently restricts the use of nanomaterials within apparel, footwear and equipment product lines for any chemicals incorporating nanomaterials that may leach or release chemicals or particles during wear unless safety data are available and acceptable.

References: ChemicalWatch 2009a,c, IFCS 2008, KemI 2009a,b, Nike 2009, Suomalainen & Hakkarainen 2008

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ANNEX 1

CASE STUDIES ON SELECTED PRODUCT GROUPS

Case Study 7:

Releases from the Use Phase of Packages and Plastic Bags

CASE STUDY 7

RELEASES FROM THE USE PHASE OF PACKAGES AND PLASTIC BAGS

Content

- 1 End products with likely releases during the use phase
- 2 Use and substances in packages and plastic bags
 - 2.1 Packages
 - 2.2 Plastic bags
- 3 Releases to the environment
 - 3.1 Packages
 - 3.2 Plastic bags
- 4 Release estimation techniques
 - 4.1 Packages
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- 5 Restrictions
 - 5.1 International and regional restrictions
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 - 7.1 Appendix I Information of the environmental impacts and energy consumption of packaging material

1 End products from which there are likely releases during the use phase

According to the EU Directive (94/62/EC) packaging is defined as "all products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer". Non-returnable items are also considered as packaging.

A variety of different materials are used in packaging purposes. These include PVC (polyvinyl chloride) and other plastics, paper packages, cardboards, glass, wood, metal cans and containers. Packages are used for the storage and transport of products. In addition to these purposes, plastic bags are also used as shopping bags to carry items from shop to home or in re-use purposes such as garbage bags. More than half of plastic bags are reused, for instance in Norway more than 80% of the one billion pieces used annually.

Packaging products and plastic bags may contain different chemicals as shown in Table 1. PVC packages contain phthalates as plasticizers and heavy metals as stabilizers. Packages can also contain flame retardants, oil resistant coatings and heavy metals.

Table 1. Use of different substances in packages and plastic bags and their likely releases during use phase.

End-product group	Substance	Releases to	RET	Included in regular inventories
Plastic packages	Phthalates (e.g. DEHP)	Water	No	No
	Organotins	Water	No	No
	NPs/NPEs	Water	Yes	No
	Triclosan	Water	No	No
Cans and containers, bottles	Bisphenyl-A (BPA)	Water, waste, air	No	No
Polyurethane foam packages	penta-BDE	Water	No	No
Paper packages	Fluorotelomer alcohols, FTOH	Water, air	No	No
Plastic bags	Lead	Water	No	No
	Triclosan	Water	No	No

References: EC 1994, SFT 2009

2 Use and substances in packaging and plastic bags

2.1 Packages

A laminate for vacuum packaging is usually made from 17-18 different layers composing of polyethylene and polyamide (nylon), but also polyethylene terephthalate (PET) and polyurethane glue can be used in the material. Bisphenol A (BPA) is used in the production of polycarbonate plastic and epoxy resins in packaging that are lining food and beverage containers. BPA can also be found e.g. in baby bottles⁴⁸.

⁴⁸ Canada banned the use of BPA in baby bottles in 2008, also Denmark and several states in the US have implemented this ban in 2010.

PVC-plastics used in many packaging materials such as food packaging and bottles, includes additives, for instance plasticizers and stabilizers.

- Phthalates are used as plasticizers in soft PVC plastics. DEHP has been used in packaging film and sheets.
- Penta-BDE has been used as a flame retardant in polyurethane foam packaging materials.
- Organotins have been used as stabilizers in PVC packages, e.g. in food packaging and cellophane wraps, to extend the life time of the product.
- Nonylphenols (NPs) and nonylphenol ethoxylates (NPEs) are used as antioxidants and plasticizers in PVC, polystyrene, PET and polypropylene plastics. NPs are also used as an accelerator or cutting agent (at concentrations of 0.5-3 %) in the hardening components of certain epoxy resins. NPs are found in food contact plastics, e.g. in PVC wrapping film and polystyrene disposable cups.
- Perfluorinated chemicals (PFCs), such as fluorotelomer alcohols (FTOH) are used in oil and water resistant coatings of paper packages for foodstuff. PFCs have been at least used in packages intended to be used in microwave ovens and packages for animal food. The market for the use of PFCs in packages is expected to grow.
- Triclosan has been used as an antimicrobial agent in food packages.

References: Costner et al. 2005, IVL 2008, Keml 2002, 2006, Lang et al. 2008 UBA 2009, SFT 2009, Sharp & Lunder 2004, Steiner et al., 2003

2.2 Plastic bags

There are several different types of plastic bags on the market and their consumption and re-use varies greatly between different countries. Plastic bags are made of low (PE-LD/LDPE) and high (PE-HD/HDPE) density polyethylene with additives.

Phthalates and flame retardants are not used in plastic shopping bags. Additives to LDPE include:

- Fillers and stabilizers (e.g. clay and clay minerals, bauxite, dolomite, lime, olivine, slate, salt, sand, ferro-manganese and calcium sulphate)
- Pigments and additives for greater degradability (e.g. chromium, iron, zinc and lead)
- Triclosan has been used in garbage bags for preservative purposes.

References: SFT, 2008, USEPA 2008

3 Releases to the environment

3.1 Packages

Phthalates and heavy metal can leach out from the PVC plastics. BPA can be released from packaging materials and has also been found in household dust. Fluorotelomer alcohols (FTOH) have been found to migrate from the packages into foodstuff.

According to the studies by IVL (2008), releases from rigid plastics occur very slowly and as nonylphenols and nonylphenolethoxylates (NPs/NPEs) are added to products in very small

amounts, releases to the environment are also considered to be small. However, high amounts of NPs have been found to be released from food contact plastics into fatty food.

References: IVL 2008, Keml 2006, Lang et al. 2008

3.2 Plastic bags

Plastic bags are generally found abandoned in the environment. High Density Polyethylene (HDPE) bags are thin and light, and can thus easily be blown away or be broken. In the environment, plastics can photodegrade into smaller parts and absorb persistent organic pollutants (POPs), such as PCBs and PAH. This is estimated to happen in the Great Pacific Garbage Patch. Marine animals may mistake the partly degraded plastics as food (e.g. jellyfish) and suffocate or starve to death when eating them.

In a Norwegian study, plastic shopping bags were found to be more environmentally friendly than paper bags due to lower water and energy consumption during the manufacturing. Recyclable plastic bags have been found to be more environmentally friendly than recyclable paper bags and degradable plastic bags. The results of the study are presented in Annex I (Tables A1.1, A1.2 and A1.3).

References: SFT, 2008

4 Release estimation techniques

4.1 Packages

According to IVL (2008), the annual releases of NPs/NPEs from plastics to storm water can be calculated by using equation:

$$E = A \cdot E_f$$

E = emission (kg)

A = used amount of plastics annually (m²)

E_f = emission factor, 2.78*10⁻¹² kg/m² from hard plastics and 4.64*10⁻¹² kg/m² from soft plastics

The weight of PVC plastics can be assumed to be 2000 g for an area of 1 m² with a thickness of 1.5 mm (IVL, 2008). The same equation can also be applied to other substances if the emission factors are known.

The same equation can be used for estimating releases of other chemicals to the environment, when the release rates are known. In cases where no estimation for the releases rate is available, the chemical content, available from e.g. material safety data sheets, can be applied together with a coefficient that indicates the portion of the amount of the chemical in the product that would be released to the environment. The principles for estimation of releases is explained in Chapter 7 in the Study on Releases from Products.

5 Restrictions

5.1 International and regional restrictions

European Union

The EU Directive 94/62/EC on packaging and packaging waste restricts the concentration of heavy metals in packaging materials. According to the Directive, the sum of concentration levels of lead, cadmium, mercury and hexavalent chromium in packaging or packaging component must not exceed 100 ppm by weight. Packaging made of entirely from lead crystal glass is exempted from the rule.

The EU Directive 84/500/EEC relating to ceramic articles intended to come into contact with foodstuffs is restricting the use of lead and cadmium in these items, including food packages. According to the Directive, lead and cadmium must not be transferred from the article above the limit value, which depends on the vessel used. The limit value is 1.5 mg/l of lead and 0.1 mg/l of cadmium for vessels used for packaging and storage with more than three litres capacity. There are no restrictions for the use of NPEs or BPA in plastics in the EU legislation.

REACH regulation

Cadmium

According to Annex XVII, cadmium shall not be used as stabilizer in packaging materials (bags, containers, bottles, lids) manufactured from vinyl chloride.

References: EC 1984,1994, IVL 2008, UNEP 2008a,b

5.2 National legislation

Packages

California is the eighteenth state, which has introduced a legislation called the Toxin-Free Toddlers and Babies Act (Senate Bill 797) to completely ban the use of bisphenol-A (BPA) in baby bottles. The Act is sponsored by the Environmental Working Group (EWG) and it prohibits the manufacture, sale and distribution of bottles and cups designed for children under three years of age that contain more than 0.1 ppb of BPA. Similar Bills have been introduced also in Washington, Minnesota and Connecticut. Canada is also planning to ban the use of BPA in baby bottles.

There is no legislation in the US, which would completely ban the use of BPA in all baby product packaging including foods, but the US Congress has introduced a federal legislation called Ban Poisonous Additives bill, which is aiming at stopping the use of plastics containing BPA in reusable food and drink containers. These include baby bottles and other food and drink packaging. Renewable year long waivers might be granted in cases where alternative packaging is not available.

The six biggest baby bottle companies in the US have decided to stop using BPA in baby bottles after the Attorneys General of three states urged them to stop using this chemical, which have been linked to health problems of infants. The companies made their decision even though the Food and Drug Administration's (FDA) safety assessment concluded that an adequate margin of safety exists for the current exposure levels of BPA from food contact uses for infants and adults. Also the Canadian federal government lists the hormone-disrupting chemicals as toxic substances and to ban the use of polycarbonate baby bottles.

References: ChemicalWatch 2009a

Plastic bags

In a Swedish study it was observed that a ban on plastic bags is not desired because there is a need for them in the waste management, either as shopping bags or bought bags.

In many countries (e.g. Spain and the state of California in the United States), stores are not allowed to give plastic shopping bags for free.

References: IVL 2008, SFT 2008

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7 Appendixes

7.1 Appendix I Information of the environmental impacts and energy consumption of packaging material

Table A1.1. Comparison of the environmental impacts of recyclable plastic bags, biodegradable plastic bags and recyclable paper bags (SFT 2008)

	Summary of LCA analysis results from 3 types of bags		
	Carrying capacity 1000 paper bag equivalents		
	Recyclable plastic bags (HDPE)	Biodegradable plastic bags	Recirculated paper bags
Total energy use (MJ)	763	2070	2622
Consumption of fossile fuels (kg)	14.9	41.5	23.2
Waste amount (kg)	7.0	19.2	33.9
Greenhouse gas emissions (t of CO ₂ eqv)	0.04	0.18	0.08
Consumption of fresh waster (litre)	220	3850	3800

Table A1.2. Environmental impacts of different kinds of plastic bags used in Australia (SFT 2008)

Type of bag		Weight of bag (g)	Annual ghg emission (kg of CO ₂ eqv)	Annual energy consumption (MJ)
HDPE bag	Disposable	6	6.08	210
Paper bag	Disposable	42.6	11.8	721
50% recirculated HDPE ¹	Disposable	6	4.79	117
LDPE bag ²	Disposable	18.1	29.8	957
Biodegradable bag, based on starch	Disposable	12.5	6.61 ³	61.3
Solid polypropylene (PP) bag	Reusable, 3 years	250	1.1	38.8
PP fiber bag	Reusable, 2 years	65.6	1.96	46.3
PP fiber bag, nylon based	Reusable, 2 years	50.3	1.96	46.3
Knitted HDPE bag	Reusable, 2 years	130.7	0.628	18.6
Cotton bag	Reusable, 1 years	125.4	2.52	160
LDPE reusable bag	Reusable, 3 months	35.8	2.43	78

1) This bag is common in many countries but only little used in Norway, some direct import occurs.
2) This bag corresponds not directly with LDPE bags which are more common i the daily goods commerce in Norway.
3) Continues to break down to CO₂

Table A1.3. Comparison of the energy consumption and greenhouse gas emissions of paper, HDPE and LDPE bags (SFT 2008)

Bag	Energy consumption (Mg/kg)	Emissions (g CO ₂ /kg)	Weight/bag (g)	Releases/bag (g)	Energy consumption/ bag (MJ)
Paper (30% recirculated paper)	50.6	222	51.8	11.5	2.6
HDPE bag	87.9	2153	6	12.9	0.5
LDPE bag	89.3	2303	15	34.5	1.3

ANNEX 1

CASE STUDIES ON SELECTED PRODUCT GROUPS

Case Study 8:

Releases from the use phase of pharmaceuticals, personal care and cleaning products

CASE STUDY 8

RELEASES FROM THE USE PHASE OF PHARMACEUTICALS, PERSONAL CARE AND CLEANING PRODUCTS

Contents

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 - 7.3 Appendix III: Concentration of UV filters in two Swiss lakes

1 End products with likely releases during the use phase

The scope of the case study is to provide information on likely releases from the use phase of pharmaceutical, personal care and cleaning products, PPCCs. The number of various products in these sectors is high and only some of these products and their releases can be presented in this case study as examples of the broad product groups. The product groups studied more closely are compiled in Tables 1a and 1b.

Non Methane Volatile Organic Compound (NMVOC) emissions to air from the use of these products as well as mercury from dental amalgam do not fall under the scope of the project as they are already covered by the regular reporting under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP), UN Framework Convention on Climate Change and the EU Net Emission Ceilings Directive. Emissions of fluorinated gases, for instance PFCs are also included under the reporting to the UNFCCC. Therefore these substances were not in the focus of the conclusions of this document.

The term pharmaceuticals, personal care and cleaning products (PPCCs) is a very broad group of chemical products and includes any products used for personal health and cosmetic reasons as well as veterinary care products used for the growth or health of livestock. These include prescription and over-the-counter therapeutic drugs, veterinary drugs, fragrances, cosmetics, sunscreen products, diagnostic agents and nutraceuticals (e.g. vitamins) and hygiene products like soaps, shampoos and lotions.

PPCCs are produced and used in large quantities and the number of these products on the market is continuously growing. The ingredients in these products comprise thousands of different substances, which can be released to the environment during the use of products. These substances have been found to enter the surface waters through discharges from waste water treatment plants. Many substances are not completely removed by wastewater treatment. Some releases of PPCCs may also enter the environment directly, for instance from the use of sunscreens. There is increasing concern over the impacts that these direct releases may have on aquatic organisms. Recent studies have shown that certain chemical substances used in PPCCs are accumulating in the water environment with the potential for harmful environmental and human effects. (Läkemedelsverket 2004, US EPA 2009).

Table 1a. Use of different substances in PPCCs and cleaning products and their likely releases during the use phase Explanations: Releases to: the environmental compartment is in brackets if releases are considered minor, e.g. (air); RET = Release estimation technique, Yes = exists, (Yes) = not published/only in certain countries; NA = information not available)

Product group	Substance	Releases likely	RET	Releases included in regular inventories
Pharmaceuticals	Active ingredients (e.g. antibiotics, hormones and anti-inflammatory ingredients)	Water, soil, air	Yes	(Yes)
	Ethylene oxide	Water	(Yes)	(Yes)
	Formaldehyde	Water	(Yes)	(Yes)
	Mercury	Water	No	No
	Phthalate	Water	No	No
	NPs/NPE	Water, soil, air	Yes	No
Cosmetics and hygiene products	NMVOCs	Air	Yes	Yes
	UV filter substances	Water	Yes	No
	NPs/NPEs	Water, soil, air	No	No
	NMVOC (including formaldehyde)	Air	Yes	Yes
	PFC	Water	No	No
	Paraben	Water	No	No
	Triclosan	Water	No	No
	Siloxanes	Water	No	No
	Phthalate	Water	No	No
	Musk xylene and other fragrances	Water, Air	Yes	No
	Aluminium	Water	No	No
	Azo-colourant agents	Water	No	No
	EDTA	Water	No	No
Dental care products	p-dichlorobenzene	Air	(Yes)	(Yes)
	Mercury (amalgam)	Water	Yes	No
Household cleaning and car care products	Triclosan	Water	Yes	No
	2-aminoethanol	Water	No	No
	NPs/NPE	Water, soil, air	Yes	(Yes)
	PFCs	Water	Yes	Yes
	n-alkylbenzenesulfonic acid (LAS)	Water	No	No
	N,N-dimethyldodecylamine n-oxide (AO)	Water	No	No
	Bis(hydrogenated tallow)dimethylammonium chloride (DAC)	Water	No	No
	p-dichlorobenzene	Air	No	No
	Poly(oxyethylene)alkyl ether (AE)/-octylphenol ether (OPE)	Water	No	No
	Cationic surfactants (DTDMAC, DSDMAC, DHTDMAC)	Water, soil	Yes	(yes)

Table 1b. Harmful substances likely to be released from the use phase of PPCCs (includes only substances and product groups from which information is available; blank cells indicate that no information is currently available)

End-products	Substance	Concentration of the substance in the product (rough estimate)	Example of the use volume	Note
Pharmaceuticals	NPEs	<1 % or 5 % depending on the product		
Sunscreens	UV filters	0.1-10 %	10,000 tonnes annually	
Spermicides	NPs		Sweden: 10 kg annually	
Additives	Phthalates	<10 %		
Polish	PFCs	<0.1 %		Possible replacement with silicones

2 Use of substances in pharmaceuticals, personal care and cleaning products

Pharmaceuticals

Pharmaceuticals and medical products include products that are used to combat specific diseases or to treat wounds or illness. The global consumption of pharmaceutical products in human medicine is substantial (SFT 2009b). Also a large number of pharmaceuticals are used in veterinary medicine. The same substances may sometimes also be used in foodstuffs. For example, there were approximately 7,600 pharmaceutical products in the Swedish market in 2004 (Carlsson et al. 2006b). From these approximately 7,200 were intended for humans and approximately 400 for veterinary use (Läkemedelsverket 2004). Amongst all the above mentioned products there were about 1,200 active substances and 1,300 excipients. The use of substances as excipients in pharmaceuticals is relatively small in proportion to the total use of these substances (Läkemedelsverket 2004).

In addition, especially in developing countries, counterfeit medicines are used. These are usually manufactured below established standards of quality and may therefore be dangerous to health and ineffective for treatment. Counterfeits are mislabeled with respect to identity or source, can occur for branded and generic products, and may include correct ingredients but fake packaging, or wrong ingredients with or without insufficient active ingredients. Counterfeiting has occurred for all types of products from expensive lifestyle and anti-cancer medicines, antibiotics, medicines for hypertension and cholesterol-lowering drugs, hormones, steroids and inexpensive generic versions of simple pain killers and antihistamines. In developing countries counterfeit medicines are commonly available for the treatment of life-threatening conditions such as malaria, tuberculosis and HIV/AIDS. The US-based Centre for Medicines in the Public Interest predicts that counterfeit drug sales will reach US\$ 75 billion globally in 2010, an increase of more than 90% from 2005. Although precise and detailed data on counterfeit medicines is difficult to obtain, the sales in developing countries are estimated to be between 1 - 30% of legitimate products. The figures vary depending on the geographical area and within countries, i.e. city versus rural areas, city versus city. (WHO 2006)

Cosmetics, hygiene and cleaning products

Cosmetics and hygiene products include lotions, deodorants, perfumes and make up, hair care products, soaps, sunscreens, shampoos and other detergents. Production and consumption of personal care and cosmetic sun products are increasing worldwide and may result in considerable environmental contamination. Information concerning the use volume of some common cosmetic and hygiene products is presented below.

The total volume of cosmetics and hygiene products in the Swedish market is approximately 40,000 tonnes per year (Läkemedelsverket 2004). Approximately 24,000 tonnes of this is water. The average use of cosmetics and hygiene products per person was estimated to be 12 g per day. According to the Medical Products Agency of Sweden (Läkemedelsverket 2004), approximately 7,000 different ingredients are used in cosmetics and hygiene products.

Consumer habits have changed during the past 10-15 years concerning the use of hand soaps. Formerly mainly solid products, made of fatty acids and with few ingredients, were used (Larsen & Andersen 2006). Today the use of liquid or foam products is more widespread. According to the EU Technical Guidance Document (EC 2003b), the typical amount of hand soap used for washing hands is determined to be 0.8 g for solid soap bars with a daily use frequency of 3-6 times. No value has been determined for the use amount of liquid hand soap. Larsen & Andersen

(2006) estimated in their survey the consumption of liquid hand soaps per hand wash to be slightly higher, 1.0 g soap/hand wash.

Sunscreens are designed for external application to the outermost layers of the skin (Giokas et al. 2007). They are typically used outdoors near aquatic environment both at marine coastal areas and inland water areas. Sunscreens are used in significant amounts in tourist areas. Sunscreen cosmetic products have been used for nearly 75 years (Giokas et al. 2007). The global sunscreen product sales exceeded half a billion dollars in 2005. It has been estimated that 10,000 tonnes of UV filters for sunscreens are produced annually for the global market (Salvador & Chisvert 2005).

Mercury containing dental amalgam

The use of mercury containing dental amalgam is declining in many European countries, but there are still many countries where the use is significant. In some countries, the use may have even temporarily increased due to the low cost of the material. In Sweden and Denmark the use of dental amalgam has almost ceased. For example, in Sweden, mercury containing dental amalgam is used in only 2-5 % of all new fillings. The Nordic countries consumed together no more than one tonne of mercury in dental amalgams in 2007. The largest use of mercury in the European Union is in dental care with approximately 90-125 tonnes of mercury used annually while the global mercury demand in dental care was around 270 tonnes in 2005 (Kemi 2009, Lassen 2008, Maxson 2006).

3 Releases to the environment

The releases from PPCCs can be either indirect releases through waste water treatment plants (WWTPs) or direct releases to the environment such as aerosols to the air or sunscreens to water. The sewage systems are not specifically equipped to remove substances included in PPCCs from wastewater. The removal rates vary according to the type of the chemical and the WWTP. PPCCs dissolve easily and do not evaporate at normal conditions. PPCCs can end up to soil for instance through treated sewage sludge used on agricultural land or irrigation with reclaimed water. (USEPA 2009)

The probability of excipients used in pharmaceuticals and other personal care products, including cosmetics and hygiene products, reaching significant effect concentrations in the environment has rarely been studied, although environmental concentrations of these compounds are sometimes measured together with the active pharmaceutical ingredients (Läkemedelsverket 2004, Carlsson et al. 2006b).

3.1 Pharmaceuticals

Pharmaceuticals comprise active ingredients and a number of excipients and additives:

- Active pharmaceutical ingredients (APIs) are the components in medicines that are designed to act for specific purposes. These include e.g. diazepam (tranquilizer), ethinyloestradiol (oestrogen), ibuprofen (analgesic, anti-inflammatory, antipyretic), metformin (antidiabetic) and tetracycline (antibiotic) (Carlsson et al. 2006a).
- Mercury has been used in some folklore medicine, mainly in the developing countries (Lassen et al. 2008).
- Excipients are inactive substances used as carriers for the active ingredients. They are added to the active pharmaceutical ingredients in order to give the finished product desired properties (such as the release and absorption rate of the effective substances,

stability, texture, volume, taste, and colour) (Carlsson et al. 2006b). Typical excipients include solvents, surfactants⁴⁹, lubricants, emulsifiers and antimicrobial preservatives. Examples of excipients and additives are phthalates that are used in the coatings of some medications (Costner et al. 2005) and nonylphenol ethoxylates (NPEs) that are used as an additive in veterinary medical products, e.g. as surfactant in teat dips and as an aid in the control of mastitis (IVL 2008).

In countries with organized waste and waste water management, environmentally relevant chemical releases from the normal use of pharmaceutical products into the environment are not likely. However, unused or outdated pharmaceuticals can be flushed down the drain or thrown away with common waste and, via WWTPs or landfills, may enter the environment (LIF 2009). Some pharmaceuticals can be volatilized into air (USEPA 2009).

Pharmaceuticals having environmental relevance share common properties: they often have high production volumes combined with environmental persistence and biological activity, mainly after long-term exposure. According to the US EPA (2009), as from 2007, over 100 different PPCCs have been identified in environmental samples and drinking water in addition to antibiotics and steroids.

The main environmental exposure pathway for human pharmaceuticals is aquatic exposure i.e. ingestion, followed by excretion (mainly urine or faeces) and disposal through municipal wastewater. Pharmaceuticals are excreted either in their original "parent" form or as metabolites. It is estimated that between 30 and 90% of an administered dose of many pharmaceuticals ingested by humans is excreted in the urine as the active substance. Pharmaceuticals enter aquatic systems by different pathways (Figure 1). Municipal wastewater is the main route for human pharmaceuticals after normal use and disposal of unused medicines. Direct releases of externally applied pharmaceuticals to open waters can happen via swimming, washing and bathing (USEPA 2009, Fent et al. 2006, Cooper et al. 2008)

Some human pharmaceuticals survive biodegradation in WWTPs in their active form and are found in surface waters, ground waters, and drinking water reservoirs. Up to 90% of drug residues may remain in effluent after treatment, although, there is a great variation in elimination rates due to the heterogeneity of pharmaceutical compounds with diverse chemical properties and efficiencies of different WWTPs. Following the wastewater treatment, the effluent containing pharmaceutical parent compounds and metabolites can be discharged from the WWTP directly into aquatic environments. Pharmaceuticals that may have been transformed in the body or during wastewater treatment could be converted back into parent forms. However, once in the environment, pharmaceutical substances can be biologically and physico-chemically degraded and/or mineralized e.g. via photo transformation (reactions to UV light). (Heberer 2002; Velagaleti 1997, Cooper et al. 2008; Fent et al. 2006; Ternes 1998)

Veterinary pharmaceuticals used in aquaculture (prophylactic treatment of aquaculture livestock) are directly released into surface water and highly lipid-soluble pharmaceuticals can bioaccumulate in the fatty tissue of animals, for instance in fish. (Carlson et al. 2006a)

Releases from the use of pharmaceuticals to the terrestrial environment include direct runoff from on-ground fecal material from pets and livestock, prophylactic treatment of terrestrial livestock, the use of sewage sludge as fertilizer and the use of treated wastewater for irrigation. The main environmental exposure route for veterinary medicines is terrestrial exposure. Parent compounds and metabolites are excreted in animal dung and subsequently left or spread on agricultural land.

⁴⁹ Surfactants are compounds that have a dual affinity being both lipophilic and hydrophilic (Wolf et al. 2001). A lipophilic tail group of the molecule links to greasy soil and a hydrophilic polar head group turns it water-soluble and helps disperse and rinse away greasy soil. The balance between these features influences the surfactant application as a detergent, wetter or emulsifier.

From the terrestrial environment, some pharmaceuticals can eventually reach surface water and groundwater, whereas others may be taken up by terrestrial plants. NPEs used in teat dips for cattle can end up in soil as a result of spreading of sewage sludge. It can be estimated that 85% of the NPE releases from veterinary medical products go to the soil, 10% to surface waters and 5% to air (Boxall et al. 2006, IVL 2008).

In one Swedish study it was concluded that there is no acute environmental risks associated with the use of human and veterinary pharmaceuticals, but long-term effects are still possible. In another Swedish study nine out of twelve tested active substances and two out of 27 preservatives in pharmaceuticals were found to have hazardous effects to the aquatic environment. (Läkemedelsverket 2004)

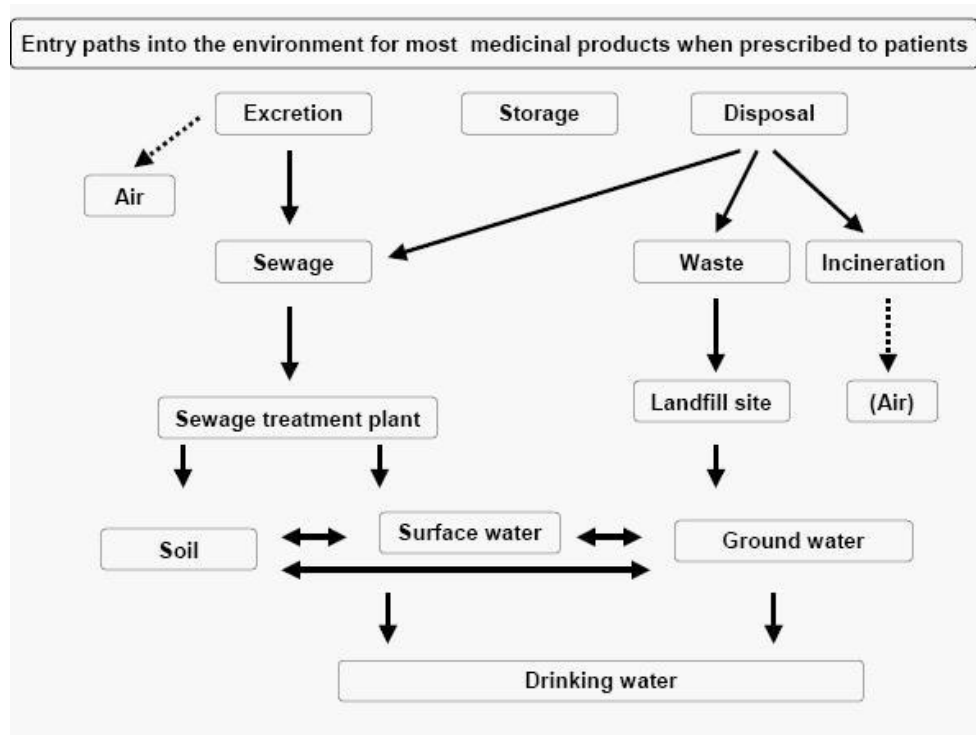


Figure 1. Major routes of pharmaceuticals to the environment (EMA 2006).

3.2 Cosmetics and hygiene products

As a result of the increasing production and consumption of personal care and cosmetic products, releases from cosmetic and hygiene products can be expected to be increasing by volume and by the number of chemicals. Many of these ingredients have been indicated to reach detectable levels in both fresh and seawater systems and to have negative impact on the environment. For example, synthetic musk fragrances have been identified to be bioaccumulative and persistent in the environment. In studies carried out by the Medical Products Agency of Sweden several ingredients in cosmetics and hygiene products were studied for their environmental risks and some were predicted to have adverse effects on the environment. (Danovaro et al. 2008, Läkemedelsverket 2004, Schütt 2008, Simpson 2008; USEPA 2009)

Surfactants, tensides, softeners, additives

A single product usually contains a number of different ingredients, the biggest functional groups being surfactants, mainly tensides, (30%) and softeners or moisture-regulating substances (20%).

The total amount of tensides used in this product group in Sweden is estimated to be approximately 5,000 tonnes annually. (Läkemedelsverket 2004)

Additives, such as fragrances, pigments, preservatives, antimicrobial agents, solvents and plasticizers, are also included in these products:

- Preservatives used in cosmetic and hygiene products include parabens (e.g. methyl paraben) (Brunn Poulsen & Schmidt 2007) and substances that release formaldehyde (Stiens 2008).
- Musk xylenes are used as fragrances e.g. in toiletries (SFT 2009a).
- Azocolourants (i.e. azo dyes and pigments) have been used in cosmetics (VKM 2005).
- Aluminium compounds are often contained in deodorants (VKM 2005).
- EDTA (ethylenediaminetetra-acetate) is an additive found in many cosmetic products.
- Perfluorooctanyl sulphonate (PFOS) related substances have been used in shampoos to improve wetting (Brunn Poulsen et al. 2005; Costner et al. 2005).
- Triclosan (see below)
- Phthalates (see below)
- Nonylphenols (see below)

Triclosan

Triclosan is used as a preservative, antiseptic or disinfectant agent in cosmetic products such as toothpaste, deodorants, soaps, skin care products, mouth washes and shampoos (VKM 2005).

In a study by Rastogi et al. (2007), triclosan was found to be the most used preservative or antimicrobial agent in the studied deodorants, but it was only present in the more expensive product category. Cosmetics account for 99% of the total amount of triclosan in products in the Danish market. The largest amount of triclosan was found in dental care products, including tooth paste. The amount of triclosan in products decreased to half of the volume between 2000 and 2004. (Borling et al. 2006) According to Borling et al. (2006), majority of the products reported as used in Denmark contain 0-2 % of triclosan.

Triclosan containing products end up in the drain and eventually to the WWTP. In WWTP triclosan is not fully removed from the water and can thus be released to the environment. (Samsøe-Petersen et al. 2003)

According to many studies the widespread use of triclosan enhances development of triclosan resistance (VKM 2005) to clinically important antimicrobial agents and thus may present a public health risk.

According to the opinion of the EU Scientific Committee on Consumer Products (SCCP), the use of triclosan in products where it is commonly used, i.e. toothpastes, hand soaps, body soaps/shower gels and deodorant sticks, is safe. According to the SCCP, the use of triclosan in other leave-on products (e.g. body lotions) and in mouthwashes is not considered safe because of the resulting high exposures. (SCCP 2008)

Phthalates and NPEs

Phthalates are used in various personal care products, e.g. nail polish, hair sprays, soaps and shampoos at concentrations usually less than 10%. Dibutylphthalate (DBP), dimethylphthalate (DMP) and diethylphthalate (DEP) are mainly used in cosmetic products as solvents and to bind fragrances in products such as lotions, soaps and shampoos. Phthalates are used in nail polish to reduce cracking by making the polish less brittle and in hair sprays to form a flexible film on the hair and thus avoiding stiffness. (Costner et al. 2005; Hileman 2007; US FDA 2001).

Nonylphenol ethoxylates (NPEs) have been used as surfactants in cosmetic and hygiene products, including e.g. soaps, shampoos, hair dyes and make-up (Brunn Poulsen et al. 2005; Costner et al. 2005; IVL 2008) and nonylphenols (NP) as spermicides, for instance in Sweden the approximate annual use is 10 kg (Costner et al. 2005, IVL 2008).

Substances in sunscreens

The numerous commercial formulations of sunscreens on the market with varying compositions, have been identified to contain 20 or more different chemicals (Giokas et al. 2007; Danovaro et al. 2008).

- UV filters⁵⁰ are the active components in sunscreens because they absorb ultraviolet (UV) radiation and thus protect the human skin from direct exposure to the harmful wavelengths of sunlight (UV-A 320–400 nm and UV-B 280–320 nm). The UV-filters are divided into chemical (e.g. benzophenones, cinnamates, camphor derivatives and anthranilates) and physical (e.g. talc, kaolin, zinc oxide and titanium dioxide) agents, most of them being organic. There are also some nanomaterials used as UV-filters, e.g. nano-titanium dioxide. Concentrations of UV filters in cosmetics vary from 0.1% to 25%. (Danovaro & Corinaldesi 2003, Giokas et al. 2007, Schütt 2008, TemaNord 2005; Buser et al. 2006, Knudsen et al. 2007).
- Other substances in sunscreens include for instance cosmetic lipid base and antimicrobial preservatives, e.g. paraben (Danovaro et al. 2008, TemaNord 2005)
- Siloxanes are widely used in sunscreens (Salvador & Chisvert 2005, Danovaro & Corinaldesi 2003; Schütt 2008)

Unlike other cosmetics products, it is typical for sunscreen products that a significant part of them enters directly into surface waters without passing any WWTPs. Direct input to natural waters from the use phase of sunscreens occurs during swimming and bathing and from containers left in the environment (see examples in Annex III Tables A3.1 and A3.2). The global distribution of releases from the use phase of sunscreens are expected to correlate with the annual tourist densities in both marine coastal areas and inland waters. The use of sunscreens have been prohibited in certain popular tourist areas, like marine ecoparks in Mexico. Up to 10 % of the world's coral reefs would be threatened by sunscreen-induced coral bleaching. Releases may also occur indirectly via WWTPs (when released during showering or washed from textiles). (Schütt 2008, Giokas et al. 2007, Danovaro et al. 2008).

The negative effects of sunscreens are mainly due to UV filters, chemical UV filters, and are generally considered to be more hazardous to the environment than physical filters. Because sunscreens are lipophilic, their UV filters can bioaccumulate in the fatty tissues of certain aquatic animals like fish and birds and they have been found to have impacts on marine bacterial plankton. Sunscreens also cause the rapid and complete bleaching of hard corals, even at extremely low concentrations. This effect is due to organic UV filters, able to induce the lytic viral cycle in symbiotic zooxanthellae with latent infections. Of the ingredients in sunscreens parabens, cinnamates, benzophenones and camphor derivatives in particular are identified to cause complete bleaching of coral reefs even at very low concentrations. Parabens account for approximately 0.5 % of sunscreen ingredients. (Danovaro et al. 2008, Stiens 2008, Simpson 2009; ChemicalWatch 2009b)

⁵⁰ UV filters in sunscreens usually possess single or multiple aromatic structures, sometimes conjugated with carbon-carbon double bonds and/or carbonyl moieties, which are able to attenuate the transmission of energetic solar photons that reach the surface of the Earth (Giokas et al. 2007). UV filters absorb photons and rapidly return to ground state by thermally emitting the energy through a series of vibrational transitions.

Paraben preservatives and some UV filters contained in sunscreens have estrogenic activity or undergo photodegradation, resulting in transformation into toxic by-products with more harmful effects than the parent compounds. For instance, swimming pools may be a significant environmental and human exposure route for substances released from sunscreens, depending on the use and maintenance of the pool. Many of the UV filters and additives used in sunscreens have also been found in human breast milk or have dermatological side effects. (Danovaro et al. 2008, Daughton and Ternes 1999; Schlumpf et al. 2004, Giokas et al. 2007, Schütt 2008, Hany & Nagel 1995)

Substances in cleanser products

Releases to the environment from cleanser products occur mainly through wastewater treatment plants. The proportion of substances discharged with the treated waste water depends on the fate of the chemical substances.

Environmentally relevant releases leading to environmental concentrations approaching effect concentrations (Larsen & Andersen 2006, IVL 2008, Stiens 2008) include:

- NPEs, which degrade in sludge into NPs; small amounts may be emitted to air.
- EDTA, which does not degrade in the WWTPs, and is thus released to the environment. EDTA degrades very slowly and accumulates in the environment, due to binding with heavy metals. Some EDTA compounds can degrade in surface waters via sunlight photolysis.
- Solvents in cosmetic products are emitted to the air. These releases are already covered by regular NMVOC (non-methane volatile organic compounds) inventories reported under the UNECE CLRTAP and UNFCCC.
- Cocamide DEA
- Triclosan
- Phthalates (DBP, DMP and DEP concentrations in cosmetic products are found to be safe) (US FDA 2001).

Soap and shampoo

Soaps, shampoos and other detergents typically comprise a mixture of ingredients, classified according to their function (Table 2). Surfactants, surface-active substances, are the essential cleaning substances, which determine the cleaning and lathering characteristics, as well as, for example mushiness, plasticity and skin compatibility of the product (Wolf et al. 2001). Soaps in the form of liquid and foam have a more complex composition and contain more preservatives than solid products (Larsen & Andersen 2006). The majority of the releases of soap occur at the use phase (EC 2003b). Direct releases to the environment from the use phase of liquid hand soap products are considered to be negligible. Instead the main environmental exposure route will be via waste water treatment plants, but in areas with a limited exchange of water, e.g. the inner part of an inlet, these releases may be significant.

Table 2. Ingredients of a typical soap product (Wolf et al. 2001).

Ingredients	Percent of total
Surfactants	30-70
Plasticizers and binders	20-50
Lather enhancers	0-5
Fillers and binders	5-30
Water	5-12
Opacifying agents	0-3.0
Dyes and pigments	0-0.3
Dyes and pigments	<1

Dental care products

- Mercury is used in the form of amalgam in dental fillings. Dental amalgam contains approximately 40-50% of mercury (Keml 2009, Lassen et al. 2008; Cain et al. 2007; SFT 2004).
- Bisphenol A can be found in the dental sealants (Lang et al. 2008). PFOS-related substances have been used in denture cleaners to improve wetting (Brunn Poulsen et al. 2005; Costner et al. 2005).

The use of mercury containing amalgam in dental care is the largest source of mercury in sewage sludge, as it may be released in the waste water system during dental care procedure, for instance when drilling out a previous filling or carving the excess material from new filling (Kemi 2004, Lassen et al. 2008).

Mercury from the amalgam may also be released to the air. According to model calculations by Cain et al. (2007), approximately 150 kg of mercury are released annually in the U.S. in exhaled breath as a result of dental amalgam fillings.

Dental mercury emissions to air occur mainly through flue gases from crematoria. These releases are already covered by regular mercury inventories reported under the UNECE CLRTAP and UNFCCC.

3.3 Household cleaning products

Household cleaning products contain many of the same substances and additives as cosmetics and hygiene products:

- The use of fluorinated tensides in cleaning products is widespread, as they provide good spreading properties in products like polish. There are no good alternatives for these substances in polish, but silicones may be potential substitutes. Fluorinated (PFOS-related) substances are used as surfactants (tensides) in cleaning agents, including e.g. polish and wax products to improve wetting and leveling, and in cleaning products to improve wetting and as a rinse aid (all-purpose cleaners, window cleaners, dishwashing liquids, car washes). The volume of fluorinated compounds in polishing products is less than 0.1 % (Brunn Poulsen et al. 2005; Costner et al. 2005; Keml 2006).
- NPEs were widely used in cleaning agents in the past and they may still be used in different cleaning products as non-ionic surfactants (tensides) e.g. in laundry detergents, dry cleaning, spot removers, paint and varnish removers, car care products, disinfecting and all-purpose cleaners as well as in cleaners used for electrical components. The use volume of NPEs in cleaning products has decreased in many countries, including Norway, Sweden and Denmark. NPEs are released from cleaning products to wastewater, ending up in the WWTPs and sewage sludge (IVL 2008). During use of the products, a small amount may also be emitted to the air. (IVL 2008, Costner et al. 2005).
- Fluorinated tensides are released from the cleaning products into waste water (Keml 2006).
- Linear alkylbenzene sulphonates (LAS) are one of the most used groups of surfactants in detergents and cleaning agents, both for households and industry. In Denmark the WWTPs have an obligation to report the LAS concentration in sewage sludge. (Niemann et al. 2007).
- Washing powders contain phosphates, sodium carbonate and sodium silicate (Steiner et al. 2003).

4 Release estimation techniques

Information on release estimation techniques presented in the literature for estimating the releases of different substances from the use phase of PPCCs is compiled in Table 3. Note that the list is not comprehensive due to lack of information on methodologies to quantify the releases.

Table 3. Emission factors for different chemicals released from pharmaceuticals, personal care and cleaning products

End products	Substance	Emission factor (E _i)	Environmental compartment	Reference
Car care products	Cationic surfactants (DTDMAC, DSDMAC, DHTDMAC)	0.2 kg/kg of substance used (20 %) (20% not connected to WWTPs)	Water	SFT (2004)
		0.4 kg/kg of substance used (40 %) 80% of wastewater connected to WWTP from which 50% of sludge applied on agricultural soil or other land	Soil	
	NPs/NPEs	0.2 kg/kg (20%) 20% of wastewater not connected to WWTPs	Water	
		0.28 kg/kg (28%) 80% of wastewater connected to WWTPs 35% of NP/NPEs not retained in sludge		
		0.136 kg/kg (13.6%) 80% connected to WWTPs with 34% retained in sludge out of which 50% for agricultural and other land use	Soil	
Cleansers and cosmetics	Substances in soap	Methodology in Chapter 4.2	Water	EU Technical guidance document (2003)
	Musk compounds	0.2 kg/kg (20%) not connected to WWTPs;	Water	SFT (2004)
		0.008 kg/kg (8 %) connected to WWTPs	Soil	
	Substances in sunscreens	0.25 kg/kg (25%)	Water	Danovaro et al. (2008)
Dental amalgam	Mercury	0.0001 kg/kg (0.01%) for new fillings; 0.025 kg/kg (2.5%) for removed fillings	Water, soil	SFT (2004)
Household cleaning agents	Cationic surfactants (DTDMAC, DSDMAC, DHTDMAC)	0.2 kg/kg (20%)	Water	SFT (2004)
		0.4 kg/kg (40%)	Soil	
	NPs/NPEs	0.2 kg/kg (20%) not connected to WWTPs;	Water	
		0.28 kg/kg (28%) connected to WWTPs	Soil	
		0.136 kg/kg (13.6%)	Wastewater	
		0.9 kg/kg (90%)	Air	IVL (2008)
		0.0025 kg/kg (0.25%)	Wastewater	
		0.1 g/person and year	Wastewater	Månsson et al, 2008
Pharma- ceuticals	APIs	Methodology in Chapter 3.1	Wastewater	EMA (2006)
	NPEs	0.85 kg/kg (85%)	Soil	IVL (2008)
		0.1 kg/kg (10%)	Water	
		0.05 kg/kg (5%)	Air	
	Formaldehyde	0.3 (30%)	Water	Japanese PRTR (2005)
	Ethylene oxide	0.93 (93%)	Air	

4.1 Pharmaceuticals

Active pharmaceutical Ingredients (APIs)

A very rough estimate of the local releases of active pharmaceutical ingredients (APIs) to wastewater is derived from the Guideline on the Environmental Risk Assessment of Medicinal Products for Human Use, released by the European Medicines Agency (EMA 2006). Local emission to wastewater of the relevant drug residue can be calculated using the following equation:

$$E_{\text{local}_{\text{water}}} = \text{DOSE}_{\text{ai}} * F_{\text{excreta}} * F_{\text{pen}} * \text{CAPACITY}_{\text{WWTP}} * F_{\text{eff}}$$

where

$E_{\text{local}_{\text{water}}}$	= Local emission to wastewater
DOSE_{ai}	= Daily dose consumed per inhabitant ($\text{mg inh}^{-1}\text{d}^{-1}$)
F_{excreta}	= Fraction of parent compound excreted after metabolism (%)
F_{pen}	= Percentage of market penetration (%)
$\text{CAPACITY}_{\text{WWTP}}$	= Capacity of a local wastewater treatment plant expressed in inhabitants connected to the WWTP (inhabitants)
F_{eff}	= Fraction of the residue remaining in the effluent (%)

The penetration factor (F_{pen}) represents the proportion of the population that is being treated daily with the specific drug substance. A default penetration factor of 0.01 is presented in the document (EMA 2006). The value was derived from a wide range of individual market penetration factors, calculated as follows:

$$F_{\text{pen}} [\%] = \frac{\text{consumption} [\text{mg} * \text{year}^{-1}] * 100}{\text{DDD} [\text{mg} * \text{d}^{-1} * \text{inhab}] * \text{inhabitants} [\text{inhab}] * 365 \text{ d} * \text{year}^{-1}}$$

The calculation of the default factor used German statistics and data from the World Health Organization (WHO) (EMA 2006). Institut für Medizinische Statistik (IMS Health) maintains a data bank "Chemical Country Profil" containing statistics for annual German consumption of approximately 2700 drug substances (EMA 2006). This was considered to be representative for the drug consumption in the EU. Defined daily dose (DDD) values of WHO were available for approximately 1450 drug substances. Data on German population (82 012 000 inhabitants in 2001). Approximately 800 drug substances, on the German market in 2001 with available DDD-value, were taken into account in the evaluation of the penetration factor. In order to calculate F_{pen} for specific substances suitable statistical data are needed.

Nonylphenols and nonylphenol ethoxylates (NPs/NPEs)

According to IVL (2008), releases of NPs/NPEs from surfactants used in veterinary medical products can be calculated by using equation:

$$E = A * E_f$$

E = emission (kg)

A = used amount of NPEs in surfactants (import + manufacturing – export) (kg)

E_f = emission factor, 0.05 kg/kg (5 %) to air, 0.1 kg/kg (10 %) to surface water and 0.85 kg/kg (85%) to soil

Formaldehyde and ethylene oxide

The Japanese PRTR inventory currently includes estimation of formaldehyde and ethylene oxide releases from pharmaceutical products. The methodology is based on information on the use of the products, their chemical content and the assumption that approximately 30% of the amount of formaldehyde is emitted to water and 93% of ethylene oxide is emitted to air. (Japanese Ministry of Economy, Trade and Industry, 2005).

4.2 Cosmetics and hygiene products

Substances in sunscreens

Danovaro et al. (2008) estimated the potential global releases of sunscreens of 4,000–6,000 tonnes/year in areas harboring coral reefs. These are rough estimates based on average daily use of sunscreens and the number of tourists in a typical area. Calculations included:

- An average sunscreen dose application of 2 mg/cm² (suggested by the U.S. FDA) for a full body surface of 1.0 m² (Poiger et al. 2004) results in an average usage of 20 g/application (Danovaro et al. 2008).
- An average two daily applications per tourist on a 5-day travel and a rough estimate of 78 million tourists annually in areas hosting reefs (i.e. 10% of world tourists registered in 2004 according to UNWTO 2007) (Danovaro et al. 2008).
- Annual production of UV filters of 10,000 tonnes (according to Wilkinson 2004) (Danovaro et al. 2008).
- Based on calculation above, 16,000-25,000 tonnes of sunscreens are expected to be used in tropical countries.
- According to the studies by Danovaro et al. (2008), it is estimated that at least 25% of the amount applied is washed off during swimming and bathing.

Poiger et al. (2004) used an average dose of 1 mg/cm² and 1.5 application per day when estimating the average amount of UV filters applied daily by swimmers.

Some researchers have suggested that the dose of sunscreen recommended by the U.S. FDA is much lower than the actual amount used by tourists (Danovaro et al. 2008). This is why dose amounts like 3 mg/cm² and 8 mg/cm² have also been used (Giokas et al. 2007). This would mean that the amount of sunscreen released during bathing or swimming could be far higher than that estimated by Danovaro et al. (2008).

The estimation technique from Danovaro et al. (2008) for areas harboring coral reefs could also be used for release estimations of sunscreens in coastal and inland water areas in general.

Hence, a simple method for estimation of annual releases from sunscreens to water in coastal areas can be presented as:

$$E = U * D * N * C$$

E = Emission

U = Average daily use (average dose application multiplied by the average full body surface and number of daily uses; default value of 20.2 g)

D = Duration of a holiday (default value of 5 days)

N = Number of tourists in the area

C = Proportion of sunscreens washed off during swimming and bathing (default value of 25%)

In the absence of accurate information, default values for U, D and C presented by Danovaro et al. (2008) can be used. The estimates are for on shore regions with coral reefs, but they could be

used for other tourist resorts as well. The number of tourists in certain areas can be found e.g. in the UNWTO statistics.

Mercury from dental care products

The annual releases of mercury to the environment from the use of mercury containing dental fillings can be calculated by using equation:

$$E = A \cdot E_f$$

E = emission (kg)

A = used amount of mercury in fillings (kg)

E_f = emission factor (kg/kg)

According to KLIF (SFT 2004), the releases of mercury from new fillings account for 40% of the consumption (proportion that is lost) and 2.5% of this ends up in water and 2.5% in soil. From removed fillings, 5% ends up in the environment, divided equally (50%) to water and soil. This results to emission factor of 0.0001 kg/kg (0.01%) for new fillings and 0.025 kg/kg (2.5%) for removed fillings.

According to Swedish studies, based on research data from Stockholm City, an emission factor of 60 ug Hg per person can be used in the estimation. The activity data for the equation below is in this case the number of persons (Skare and Engqvist 1994, Sörme and Lagerkvist 2002).

Cleansers and other products

According to the EU Technical Guidance Document (EC 2003b), the releases of a cleanser agent (e.g. soap) emitted to raw waste water can be calculated as follows:

$$E = \frac{X \cdot 10^6}{Y \cdot 365}$$

E = Mass of the cleanser agent released to waste water (g/cap/d)

X = Quantity of the agent (t/year)

Y = Population of area or number of people consuming the cleanser

The releases to waste water could also be estimated based on an average dose of soap, number of daily uses, number of households connected to the WWTP and number of people in a household. The releases from the WWTP to surface waters could be further estimated based on the amount of soap washed off (representing E from the above equation) and the amount of soap recovered from the waste water at WWTP.

$$E = U \cdot W \cdot N \cdot (1-S)$$

E = Emission

U = Average daily use (average dose application multiplied by the number of daily uses)

W = Amount washed off with the waste water

N = Number of consumers (number of households multiplied by the number of people/household)

S = Proportion of soap recovered with the sludge

The annual releases of musk compounds (musk xylene and musk ketone) to the environment from the use of cleansers and cosmetics can be calculated by using equation:

$$E = A \cdot E_f$$

E = emission (kg)

A = used amount of musk compounds in the product (kg)

E_f = emission factor (kg/kg)

According to KLIF (SFT 2004), the releases of musk compounds are divided into systems not connected to the WWTPs (20%) and systems that are connected to the WWTPs (80%). It is also assumed that 90 % of the compounds are retained in the sludge and that 50% of this amount is used for agricultural or other land use. This results to emission factors of 0.2 kg/kg (20%) directly to surface water, 0.008 kg/kg (0.8%) to the surface water through the WWTPs and 0.36 kg/kg (36%) to the soil from the sludge of the WWTPs.

Cosmetics and deodorants

The Japanese PRTR inventory includes the estimation of releases from the use of personal care products such as cosmetics and deodorants. The methodology currently applies to p-dichlorobenzene releases and is based on information on the use of the products, their chemical content and emission factors (not published). (Japanese Ministry of Economy, Trade and Industry, 2005).

4.3 Household cleaning products

According to IVL (2008), releases of NPEs from cleaning products to WWTPs can be calculated by using equation:

$$E = A \cdot E_f$$

E = emission (kg)

A = used amount of NPE (import + manufacturing – export of cleaning agents) (kg)

E_f = emission factor (kg/kg)

The emission factors are estimated by IVL (2008) to be 0.9 kg/kg (90%) to wastewater and 0.0025 kg/kg (0.25%) to air. The same equation could also be used for cosmetics and hygiene product containing NPEs if the activity data and emission factors are known.

Also KLIF (SFT 2004) has calculated releases of nonyl- and octylphenols and their ethoxylates from the use of products for cars and household cleaning products. It is assumed that all releases from the consumption go to wastewaters. According to their estimates, the releases are divided into systems not connected to the WWTPs (20%) and to systems that are connected to the WWTPs (80%). It is also assumed that 35% of the compounds are not retained in the sludge, 34% is retained in the sludge and that 50% of this amount is used for agricultural or other land use. This results to emission factors of 0.2 kg/kg (20%) directly to surface water, 0.28 kg/kg (28%) to the surface water through the WWTPs and 0.136 kg/kg (13.6%) to the soil from sewage sludge from the WWTPs.

KLIF (SFT 2004) has calculated the releases of selected cationic surfactants (DSDMAC, DSDMAC and DHTDMAC) from the use of car care products (e.g. washing agents and waxes) as well as other cleaning products. The releases are divided into water (20%) and soil (80%). It is assumed that 80% of the wastewater goes to WWTPs, 100% is retained in sludge and 50% of this is used in agriculture. This results in emission factors of 0.2 kg/kg (20%) to water, and 0.4 kg/kg (40%) to the soil.

The Japanese PRTR inventory includes the estimation of releases from the use of cleaning products containing surfactants, neutralizers. The methodology currently applies to n-alkylbenzenesulfonic acid, n,n-dimethyldodecylamine n-oxide, bis(hydrogenated tallow)dimethylammonium chloride, poly(oxyethylene) alkyl and octylphenol ethers and nonylphenol ethers. The methodology is based on information on the use of the products, their chemical content and emission factors (not published). (Japanese Ministry of Economy, Trade and Industry, 2004).

5 Restrictions

According to Giokas et al. (2007), the three main regulatory systems on cosmetics products worldwide are the EU Cosmetics Directive, the United States Food and Drug Administration (FDA), and the Japanese legislation.

Besides efforts to design improved UV filters with low toxicity, the maximum permitted concentrations of UV filters have been regulated, trying to reach a compromise between adequate protection and minimal side effects (Giokas et al. 2007). According to Giokas et al. (2007), in most cases, concentrations of up to 10 % of organic UV filters are permitted in sunscreen products. This depends on specific compound and legislation in force. Maximum allowed concentrations of the UV filters permitted in EU can be found in Annex II.

5.1 Regional legislation

European Union

Medicinal products and biocides

According to the EU Directive 2001/83/EC relating to medicinal products for human use, an authorization of the products must include an environmental risk assessment (Fent et al. 2006; EMEA 2006). Environmental assessments of veterinary pharmaceuticals have been required in the EU since 1997 (Boxall et al. 2003).

Disinfectants (e.g. antibacterial hand soap) are considered as biocides (i.e. substances or preparations that are able to destroy, render harmless or combat the effects of harmful organisms) and are therefore covered by the Directive 98/8/EC on biocidal products (SFT 2009b).

Cosmetics Directive

The EU Cosmetics Directive 76/768/EEC, with its amendments restricts the use of substances in cosmetic products.

- The concentration of 26 fragrance chemicals reported as contact allergens (Directive 2003/15/EC) must be listed on the INCI list of ingredients if the concentration of the fragrance chemical is more than 0.01% in rinse-off products and 0.001% in leave-on products (Larsen & Andersen 2006; EC 2003a). This is for ensuring that particularly sensitive consumers can avoid specific fragrance chemicals used in products, and thus reducing the number of cases of allergy (Larsen & Andersen 2006).
- There are currently 27 UV filters permitted by the Cosmetics Directive for commercial use (Giokas et al. 2007; Salvador & Chisvert 2005). From these, 26 are organic and one is inorganic (titanium dioxide). A list of the permitted UV filters can be found in Annex II.
- The Cosmetics Directive prohibits the use of substances classified as category 1 or 2 CMRs (carcinogenic, mutagenic or reprotoxic) according to the old classification system

(ChemicalWatch 2009b). It does not include possible environmental risks (Läkemedelsverket 2004). The manufacturer or the importer has a responsibility to ensure that the product does not pose a threat to the user or the environment.

- EU has prohibited the use of 22 substances in hair dyes (Brunn Poulsen & Schmidt 2007).
- According to the Cosmetics Directive, the maximum allowed concentration of triclosan is 0.3% used as a preservative in cosmetic products (Rastogi et al. 2007; SCCP 2008).

The Directive is being continuously revised and amended with new substances, e.g. Directive 2009/36/EC concerning substances used in hair dyes and the Directive 2009/6/EC concerning the use of diethylene glycol in cosmetic products.

The new Cosmetics Regulation (EC) No 1223/2009 will replace the old Cosmetics Directive in 2013. The new regulation was adopted on 30 November 2009. According to the regulation, nanomaterials can be used in cosmetics, unless the use of a particular nanomaterial for a particular product category has been assessed to be unsafe. The new rules include definition, assessment and labelling requirements of nanomaterials used in cosmetic products (for instance sunscreens). Cosmetic product that contain nanomaterials (e.g. as colorants, preservatives or UV filters) must be notified to the Commission from January 2013. The new Regulation on the classification, labeling and packaging of chemicals (see Chapter 2.4 in the main report) will change the classification of CMRs into categories 1a, 1b and 2. The Cosmetics Regulation prohibits the use of category 1a and 1b CMR substances in cosmetics products with certain exceptions (e.g. there is no suitable alternative available). Also the use of category 2 CMR substances is prohibited, unless the Scientific Committee for Consumer Safety (SCCS) has evaluated it to be safe for use. Substances with endocrine-disrupting properties will be reviewed in the new cosmetics Regulation when criteria for identifying them are available (or at the latest five years after entering to force). The new CMR regulations will apply from December 2010. (EC 2009a, b, ChemicalWatch 2009b)

The revision of the Cosmetics Directive from 2003 prohibits the testing of cosmetic ingredients on animals in the EU (ChemicalWatch 2009b). The ban came into force on 11 March 2009. In addition, the sale of cosmetic products containing ingredients that have been tested on animals will be prohibited. This ban will be phased in and becomes a complete ban in March 2013, taking into account scientific progress on alternatives.

REACH regulation

Nonylphenols and nonylphenol ethoxylates

According to Annex XVII of the REACH regulation, NPs and NPEs may not be placed on the market or used as substances or constituents of preparations at concentrations of 0.1 % by weight or higher in domestic, industrial and institutional cleaning, cosmetic products and other personal care products, as well as used as emulsifiers in agricultural teat dips (EC 2006). Exemptions for industrial and institutional cleaning applications include controlled closed dry cleaning systems and systems with special treatment of the washing liquid. Exemptions for other personal care products include spermicides.

Organostannic compounds (organotins)

According to the Annex XVII, dioctyltin (DOT) compounds shall not be used after 1 January 2015 at concentration greater than 0.1 % by weight of tin in female hygiene products.

Other regulations

The EU Regulation (EC no. 648/2004) on detergents does not apply to fluorinated tensides in cleaning products since they are not sufficiently biodegradable (Keml 2006). Musk xylene is included in the REACH Candidate list of substances of very high concern (SVHC) (ECHA 2009).

5.2 National legislation

The United States

The US Food and Drug Administration (FDA) published guidance for the assessments of human drugs, which says that the applicants in the US are required to provide an environmental assessment report when the expected concentration of the active pharmaceutical ingredient is 1µg/L or higher in the aquatic environment (Fent et al. 2006). This corresponds to about 40 tonnes as a trigger level. Environmental assessments of veterinary pharmaceuticals have been required by the US FDA since 1980 (Boxall et al. 2003).

According to the Fair Packaging and Labeling Act (FPLA), ingredients of cosmetic products sold to consumers must be listed on the label (US FDA 2001). This does not apply to individual fragrance ingredients or products used exclusively by professionals (e.g. in salons).

Nordic countries

The Medical Products Agency of Sweden considered an introduction of an EU wide environmental classification system for pharmaceutical products (Läkemedelsverket 2004). They concluded that the EU rules applied and that it was not legally possible to introduce a mandatory national classification system. A voluntary Swedish classification system for pharmaceuticals was developed in 2004 and it is available in a website (LIF 2009). First classifications were done in October 2005 and the rest will be added to the system by late 2010. Pharmaceuticals that are considered to cause insignificant environmental impact are exempted from the classification according to the EU environmental risk assessment guidelines. These include vitamins, electrolytes, amino acids, peptides, proteins, carbohydrates, lipids, vaccines and herbal medicinal products.

Denmark, Norway and Sweden have prohibited the use of dental amalgams in fillings (Lassen et al. 2008).

5.3 Industry initiatives

The United States

A voluntary US industry initiative requires the companies to list the ingredients in their product, but dyes, preservatives and fragrances are not included (ChemicalWatch 2009c). Information is required to be available in one of the following ways: through a web site, a toll-free number or on product labels. One of the major US cleaning products manufacturers has decided to list all the ingredients used in its home cleaning products and air fresheners, including dyes, preservatives and fragrance ingredients. Details of the specific fragrance formulations will be protected by listing all the ingredients potentially included in the fragrance. The information will be available through all the three ways required in the voluntary initiative by January 2012. The company has also decided that all of its products will be free of phthalates, by ending the use of diethyl phthalate (DEP) in its products, by the summer 2010.

UK and Denmark

There are voluntary agreements in Denmark and the United Kingdom to stop using NPEs in personal care and cleaning products (IVL 2008).

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7 Appendixes

7.1 Appendix I: Pharmaceutical rankings due to risk assessments

A number of environmental risk assessments (ERAs) of human or veterinary pharmaceuticals have been published in recent years for various European countries.

In a recent broad study of Cooper et al. (2008), a web-accessible database called "Pharmaceuticals in the Environment, Information for Assessing Risk" (PEIAR) was built to provide preliminary risk assessment information for commonly prescribed pharmaceuticals. The preliminary risk assessment database contains information on the 200 most commonly prescribed drugs as well as the common antibiotics and lipid regulating drugs that were not within the top 200. Available information was compiled for each pharmaceutical on their physiochemical and environmental properties and toxicity. The information was used to rank the pharmaceuticals and to highlight the compounds that may pose the highest risk to the environment.

Pharmaceuticals with therapeutic effects on the central nervous system were the most commonly ranked for most of the risk rankings (Cooper et al. 2008). They include 23% of the drugs in the database with analgesics, anti-inflammatory drugs and psychotherapeutic drugs. The cardiovascular drug class, which includes 18 % of the drugs in the database, were the second most commonly cited drugs in the rankings. This class includes lipid regulating drugs as well as several other drug types. The anti-infective class of pharmaceuticals, which includes 31% of the drugs in the database, were the third most commonly cited drugs in the rankings.

7.2 Appendix II: UV filters permitted by EU legislation

Table A2.1. Compounds permitted as UV filters and their maximum concentrations according to EU legislation (Salvador & Chisvert 2005)

EU no. ^a	COLIPA no. ^b	Chemical name	INCI name ^c	Key ^d	C _{max} ^e (%)
1.1	S1	4-Aminobenzoic acid	PABA	PAB	5
1.2	S57	<i>N,N,N</i> -Trimethyl-4-(2-oxoborn-3-ylidinemethyl) anilinium methyl sulphate	Camphor benzalkonium methosulphate	CBM	6
1.3	S12	3,3,5-Trimethylcyclohexyl salicylate (<i>homosalate</i>)	Homosalate	HS	10
1.4	S38	2-Hydroxy-4-methoxybenzophenone (<i>oxybenzone</i>)	Benzophenone-3	BZ3	10
1.6	S45	2-Phenylbenzimidazole-5-sulphonic acid and its potassium, sodium and triethanolamine salts	Phenylbenzimidazole sulphonic acid	PBS	8 (as acid)
1.7	S71	3,3'-(1,4-Phenylenedimethylene)bis(7,7-dimethyl-2-oxobicyclo-[2.2.1]hept-1-ylmethane sulphonic acid and its salts	Terephthalylidene dicamphor sulphonic acid	TDS	10 (as acid)
1.8	S66	4- <i>tert</i> -Butyl-4'-methoxydibenzoylmethane	Butyl methoxydibenzoylmethane	BDM	5
1.9	S59	α -(2-Oxoborn-3-ylidene)-toluene-4-sulphonic acid and its salts	Benzylidene camphor sulphonic acid	BCS	6 (as acid)
1.10	S32	2-Ethylhexyl 2-cyano-3,3-diphenylacrylate	Octocrylene	OCR	10 (as acid)
1.11	S72	Polymer of <i>N</i> -{[(2 and 4)-(2-oxoborn-3-ylidene)methyl]benzyl} acrylamide	Polyacrylamidomethyl benzylidene camphor	PBC	6
1.12	S28	2-Ethylhexyl 4-methoxycinnamate	Ethylhexyl methoxycinnamate	EMC	10
1.13	S3	Ethoxylated ethyl 4-aminobenzoate	PEG-25 PABA	P25	10
1.14	S27	Isoamyl 4-methoxycinnamate	Isoamyl <i>p</i> -methoxycinnamate	IMC	10
1.15	S69	2,4,6-Triamino- <i>p</i> -carbo-2'-ethylhexyl-1'-oxy)-1,3,5-triazine	Ethylhexyl triazone	ET	5
1.16	S73	2-(2H-benzotriazol-2-yl)-4-methyl-6-[2-methyl-3-(1,3,3,3-tetramethyl-1-((trimethylsilyl)oxy)disiloxanyl)propyl] phenol	Drometrisole trisiloxane	DRT	15
1.17	S78	4,4'-[[6-[[[(1,1-Dimethylethyl)amino] carbonyl]phenyl]amino]-1,3,5-triazine-2,4-diyl]diimino]bis-bis(2-ethylhexyl) benzoate	Diethylhexyl butamido triazone	DBT	10
1.18	S60	3-(4'-Methylbenzylidene) camphor	4-Methylbenzylidene camphor	MBC	4
1.19	S61	3-Benzylidene camphor	3-Benzylidene camphor	3BC	2
1.20	S13	2-Ethylhexyl salicylate	Ethylhexyl salicylate	ES	5
1.21	S8	2-Ethylhexyl 4-dimethylaminobenzoate	Ethylhexyl dimethyl PABA	EDP	8
1.22	S40	2-Hydroxy-4-methoxybenzophenone-5-sulphonic acid and its sodium salt (<i>sulisobenzone</i>)	Benzophenone-4	BZ4	5 (as acid)
1.23	S79	2,2'-Methylenebis[4-(1,1,3,3-tetramethylbutyl)-6-(2H-benzotriazol-2-yl)phenol]	Methylene bis-benzotriazolyl tetramethylbutylphenol	MBP	10
1.24	S80	2,2'-(1,4-Phenylene)bis-1H-benzimidazole-4,6-disulphonic acid, monosodium salt	Disodium phenyl dibenzimidazole tetrasulfonate	PDT	10 (as acid)
1.25	S81	2,2'-[6-(4-Methoxyphenyl)-1,3,5-triazine-2,4-diyl]bis[5-[(2ethylhexyl)oxy]phenol	Bis-ethylhexyloxyphenol methoxyphenyl triazine	EMT	10
1.26	S74	Methyl 3-[4-[2,2-bis(ethoxycarbonyl) ethenyl]phenoxy]propenyl dimethyl polysiloxane	Polysilicone-15	P15	10
1.27		Titanium dioxide	Titanium dioxide	TiO ₂	25

^a European Union reference number.^b COLIPA (Comitee De Liaison Des Associations Europeens de L'Industries de la Parfumerie, De Produits Cosmetiques et de Toilette) reference number.^c INCI (International Nomenclature for Cosmetic Ingredient) elaborated by COLIPA.^d Key system adopted by authors of this review.^e Maximum authorized concentration in cosmetics (% m/m).

7.3 Appendix III: Concentration of UV filters in two Swiss lakes

Concentrations of UV filter compounds from sunscreens have been detected in aquatic systems. Poiger et al. (2004) conducted a study of occurrence and input of these compounds in two Swiss lakes, lake Zürich and Hüttnersee. The estimated inputs and predicted concentrations of nine UV filters in the two lakes are presented in Table A3.2 and the abbreviations used are presented in Table A3.1 in Annex III. Five compounds were further selected as target compounds for surface water analysis, where the actual concentrations in the lakes were analyzed (Table A3.3 in Annex III). UV filters were detected at low concentrations in water samples from both lakes. The results show, that the actual concentrations were considerably lower than those predicted from estimates of such direct inputs. The highest concentrations (up to 125 ng/l) were found at Lake Hüttnersee. It was included in the study as a worst-case situation with respect to the amount of direct UV filter input in relation to lake volume and water discharge. Concentrations generally increased in summer. This is expected due to direct release from skin during bathing.

Table A3.1. The UV filters and their frequency of listing as an ingredient in selected products (Poiger et al. 2004)

Abbreviation	INCI name ^b	Frequency (%)
BM-DBM	Butyl methoxydibenzoylmethane	81
MBC	4-Methylbenzylidene camphor	54
EHMC	Ethylhexyl methoxycinnamate ^c	53
TDSA	Terephthalylidene dicamphor sulfonic acid	28
OC	Octocrylene	25
EHT	Ethylhexyl triazone ^c	18
PBSA	Phenylbenzimidazole sulfonic acid	12
BP3	Benzophenone-3	9
EHS	Ethylhexyl salicylate ^c	7

^a Further compounds with frequencies <5% were homosalate (3%), benzophenone-4 (2%), and ethylhexyl dimethyl PABA (2%).

^b INCI: International Nomenclature of Cosmetic Ingredients.

^c "Ethylhexyl" replaced the previously used term "octyl".

Table A3.2. Estimation of the average composition and amount of UV filters applied with sunscreen products, inputs and predicted concentrations of UV filters in two lakes, 1998 (OT = EHT, OS = EHS) (Poiger et al. 2004)

UV filter	Average UV filter content in sunscreen products (%) ^a	Amount of UV filters applied (mg/person) ^b	Lake Zurich		Hüttnersee	
			Estimated input in summer, 1998 (kg) ^c	Predicted steady-state concentration (ng l ⁻¹) ^d	Estimated input in summer, 1998 (kg) ^e	Predicted steady-state concentration (ng l ⁻¹) ^d
EHMC	2.4	311	224	71	0.97	266
OC	1.6	212	152	48	0.66	181
MBC	1.5	202	145	46	0.63	173
BM-DBM	1.3	169	122	39	0.52	142
OT	0.9	113	81	26	0.35	96
BP3	0.8	107	77	24	0.33	90
OS	0.6	72	52	16	0.22	60
PBSA	0.5	67	96	30	0.41	112
TDSA	0.1	11	16	5	0.07	19
Total (9)	9.7	1263	966	305	4.2	1139

^a Extrapolated from the composition of the 15 most frequently used products according to survey.

^b Average amount in product $\times 1 \text{ mg cm}^{-2} \times 1 \text{ m}^2$ body surface $\times 1.5$ applications $\times 87\%$ applied.

^c Applied amount $\times 1.44 \times 10^6$ bathers $\times 50\%$ wash-off (lipophilic) or 100% wash-off (hydrophilic compounds, respectively).

^d Input dissolved in annual water discharge (Lake Zurich $3.15 \times 10^9 \text{ m}^3$; Hüttnersee $3.65 \times 10^6 \text{ m}^3$).

^e Applied amount $\times 6200$ bathers $\times 50\%$ (100%) wash-off.

Table A3.3. Concentrations of UV filters in the two Swiss lakes (ng l⁻¹) 1998 (Poiger et al. 2004)

UV filter	Lake Zurich (date)				Hüttnersee (date)		
	April 4	July 8	August 5	October 7	April 27	July 20	September 21
MBC	<2-3	3-22	4-13	- ^a	2-9	9-82	<2-8
EHMC	- ^a	2-26	<2-25	2-3	5-19	4-15	<2-19
OC	<2	<2	<2	<2	<2	3-27	<2-4
BP3	n.a. ^b	<2-4	n.a.	n.a.	n.a.	5-125	9-12
BM-DBM	<20	<20	<20	<20	<20	<20-24	<20

^a Samples contaminated with EHMC or MBC, respectively.^b n.a.: not analyzed.

ANNEX 1

CASE STUDIES ON SELECTED PRODUCT GROUPS

Case Study 9:

Releases from the Use Phase of Pesticides

CASE STUDY 9

RELEASES FROM THE USE PHASE OF PESTICIDES

Content

- 1 End products with likely releases during the use phase
- 2 Use and substances in products
 - 2.1 Insecticides
 - 2.2 Fungicides, herbicides and algaecides
 - 2.3 Additives
- 3 Releases to the environment
- 4 Release estimation techniques
- 5 Restrictions
 - 5.1 International and regional restrictions
 - 5.2 National legislation
 - 5.3 Industry initiatives
- 6 References

1 End products from which there are likely releases during the use phase

This case study is focused on pesticides found in consumer products and those chemical products that are used in households. Wood preservatives are included in the case study on construction and building products. Professional agricultural use of pesticides has been excluded from this study as these releases already are covered by regular inventories in the respective countries. On the market there are also other chemicals registered as pesticides but which are produced and marketed mostly for other purposes, i.e., multi-use chemicals, for instance sulfur, petroleum products (e.g., kerosene, oils and distillates), salt and sulfuric acid. These are not included in this document.

Pesticides

Pesticides⁵¹ are substances used to repel, kill, or control any species designated a "pest" including weeds, insects, rodents, birds, fungi, molds, unwanted plants, bacteria, or other organisms. The family of pesticides includes algaecides, herbicides, insecticides, rodenticides, fungicides, and bactericides.

- *Algaecides* are used to control algae in swimming pools and water tanks.
- *Bactericides* are used to control or destroy bacteria, typically in the home, schools, or on hospital equipment.
- *Fungicides* are used to control fungi.
- *Herbicides* are used to control or kill plants, weeds, or grasses and used as plant growth regulators. Almost 70% of all pesticides used by farmers and ranchers are herbicides.
- *Insecticides* are used to kill or prevent the growth of insects.
- *Rodenticides* are used to kill rats and other rodents or to prevent them from damaging food, crops, or forage.

The term pesticide is used in this document as follows: Pesticides can include both biocides and plant protection products. With the term plant protection products it is referred to products that are used in agriculture, horticulture and forestry to protect the plants from pests. With the term biocides it is referred to products that are used for other purposes than plant protection. Some pesticide products (e.g. fungicides) can be used both as plant protection products or as biocides.

There are a variety of different pesticide products on the market sold for household use to control pests indoors and outdoors from cleaning use to wall papers and textile protection. Household products such as many lawn and garden products, cockroach sprays and baits, rat poisons, pet flea collars, products that kill mold and mildew, and kitchen disinfectants are included as pesticides. In many cases the active chemicals in the pesticide products may have wide-ranging effects on non-targeted species and many of them are persistent organic compounds that remain in the environment and in the food chain.

Pesticides may have high environmental impacts to wildlife as well as to soil, surface and ground water and air in cases where they are not stored, handled or used properly. Pesticides intended for domestic garden use are considered to have secondary poisoning risks. However, because of the need, and being often irreplaceable, they are often sold in small volumes. Applications to domestic pesticide use are in and around the home in

⁵¹ Depending on the purpose of use, pesticides fall either under plant protection legislation or under biocides legislation. The same product can also simultaneously fall under both legislations.

controlling rodents and insects within the house as well as weeds and insects in gardens. For professional uses, for instance in commercial gardens, pesticide use is more controlled. Permits are generally required in cases when working near an open body of water, applying pesticides from an aircraft or using restricted substances. In some countries, the use of pesticides in public spaces may be restricted to professionals.

The wide use of pesticide chemicals in articles and chemical products has raised concerns about the impact and volume of their releases. An example of the world wide pesticide market is presented in Table 1.

Table 1. World Amount of Pesticide Active Ingredient at User Level by Pesticide Type, 2000 and 1999 Estimates (USEPA, 2009b)

Year	Type	World Market	
		Active ingredient (mil lbs)	%
2000	Herbicides	1,944	36%
	Insecticides	1,355	25%
	Fungicides	516	10%
	Other	1,536	29%
	Total	5,351	100%
1999	Herbicides	1,870	37%
	Insecticides	1,232	24%
	Fungicides	475	9%
	Other	1,469	29%
	Total	5,046	100%

As an example of the use patterns of pesticides, information on the general use patterns of pesticides in the USA are presented in Figure 1 and Table 2, and information on pesticide uses in households in Table 3. The scope of this document falls under the use of pesticides outside professional agriculture use, which is already included in regular national release inventories.

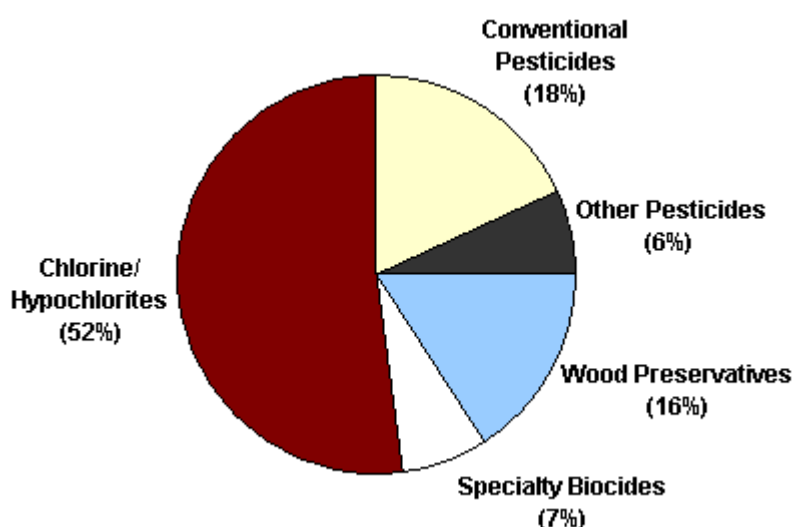


Figure 1. Amount of Pesticide Used in the U.S. by Pesticide Group, 2001 Estimates

(USEPA 2009b)

Table 2. Land in Farms, Land Harvested, Number of Farms, and Farms Using Pesticides in 2003 (M = million) in the USA

	Number of farms in 2003
Land in Farms (acres)	941M
Land Harvested (acres)	311M
Total Number of Farms	2.156M
Total Number of Farms with Cropland	1.661M
Total Number of Farms with Harvested Cropland	1.411M
Number of Farms Using Chemicals for:	
Insects on Crops/Hay	366,000
Nematodes	43,000
Diseases on Crops/Orchards	112,000
Weed/Grass/Brush	685,000
Defoliation/Fruit Thinning	51,000
Any or all of the above	941,000
Any or all of the above plus fertilizer	1,325,000

Table 3. Number of U.S. Households Using Pesticides in 2000

Pesticide Type	U.S. Households
Insecticides	59 Million
Fungicides	14 Million
Herbicides	41 Million
Repellents	53 Million
Disinfectants	59 Million
Any Pesticides	78 Million

Information on the current use and likely releases of different chemicals in pesticides is listed in Table 4. The list is not comprehensive but indicates information found in the literature related to releases from the use phase of these products. Many of these substances have been found to be hazardous to the environment and human health.

In addition to the below mentioned ingredients, pesticides include additives such as solvents, emulsifiers, spreaders, and other substances mixed into pesticide products to increase the effectiveness of the active ingredients, make the product easier to apply, or to allow several active ingredients to mix in one solution. An inert ingredient is simply any ingredient in the product that is not intended to affect a target pest. Inert ingredients can be as much as 99% of pesticide products.

Table 4. Use of some chemicals in pesticides and their likely releases during the use phase.

Product group	Substance	Releases	RET	Included in

		likely		regular inventories
Algaecides	Copper	Soil	Yes	No
Bactericides and fungicides	HCB	Air	(Yes)	Yes
	HCBD	Air, soil, water	(Yes)	Yes
	Mercury	Soil	(Yes)	No
	Organotins	Soil	(Yes)	No
	Copper	Soil	Yes	No
Herbicides	Dioxin	Air	(Yes)	(Yes)
	PFCs	Air	(Yes)	No
Insecticides and rodenticides	Cythion (Malathion)	Soil, water, air	No	No
	DEET	Air, soil, water	No	No
	DDT	Soil, water, air	(Yes)	(Yes)
	Permethrin, piperonyl butoxide	Soil, water, air	No	No
	PCP	Air	Yes	Yes
	PFCs	Air	(Yes)	(Yes)
	Propoxur, TCVP	Soil, water, air	No	No
	Pyrethroids	Soil, water, air	No	No
	Tetramethrin	Soil, water, air	No	No
Additives	NPEs	Air, water, soil	(Yes)	No
	Phthalates	Soil, water	(Yes)	No

Key for Table 4: Releases to: the environmental compartment is in brackets if releases are considered minor, e.g. (air); RET = Release estimation technique, Yes = exists, (Yes) = not published/only in certain countries; NA = information not available) A blank cell indicates that there is currently no information on the issue.

References: Costner et al. 2005, Environment Canada, Pesticide Action Network 2009, Steiner et al. 2003, USEPA 2009a,b

2 Use and substances of pesticides in households

2.1 Insecticides

Insecticides are used to kill or prevent insects from engaging in behavior deemed destructive. The products may be applied in spray or bait form or through slow-released diffusion mechanisms. In recent years, bacterial gene coding for insecticide proteins have been incorporated into various crop plants to cause death to pests that feed on them. It is estimated that about 10,000 species of the more than 1 million species of insects are crop-eating, and of these, approximately 700 species worldwide cause most of the insect damage to human crops, in the field and in storage. Before the 1940s insecticides used were mostly arsenicals, petroleum oils, nicotine, pyrethrum, rotenone, sulphur, hydrogen cyanide and cryolite. After that, synthetic organic insecticides were introduced, the first of them being DDT.

Insecticides can be divided into organic products such as organophosphates, -sulfurs, -tins and -chlorines, carbamates, formamidines, pyrazoles, pyridazines, quinazolines, benzoylureas, pyrethroids and fumigates and inorganic products including, for example, sulphur, fluorides, and heavy metals.

Organic insecticides

Organophosphates (OPs) are derived from phosphoric acid and thus contain phosphorus. They are the most toxic of all pesticides to vertebrates as they affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. Most organophosphates are insecticides. They were developed during the early 19th century, but their effects on insects, which are similar to their effects on humans, were discovered in 1932. Some are very poisonous and were used in World War II as nerve agents. Most OPs are chemically unstable and non-persistent in the environment. Organophosphates are divided into aliphatic, phenyl and heterocyclic derivatives.

- Cythion (Malathion) is an example of an OP and is not persistent but is toxic to fish and honeybees as well as to some domestic plants. It has been sold as a domestic product in many countries.

Organosulfurs (tetradifon, propargine and ovex) have very low toxicity to insects and are used only as miticides.

Organochlorines were commonly used in the past, but many have been removed from the market due to their health and environmental effects and their persistence⁵². Organochlorines include e.g. DDT, hexachlorocyclohexane (HCH), cyclodienes (such as chlordane, aldrin, dieldrin, heptachlor, endrin, mirex, endosulfan and chlordecone) and polychloroterpenes (toxaphene and strobane).

- DDT was used extensively in the 20th century after its effectiveness as a pesticide was discovered. It is still used in developing countries, primarily tropical countries, to fight malaria. Over 80% of the DDT used in 1970-1972 was applied to cotton crops, while the rest was primarily used on peanut and soybean crops.
- Pentachlorophenol (PCP) is used for pest control for instance on almonds and structural pest control. The use of PCP is currently being reduced in many countries.

Organotins are also used as fungicides and in the prevention of acarids, however, the use of is nowadays rather restricted. They inhibit formation of ATP (adenosine triphosphate) and photophosphorylation in chloroplasts.

Dinitrophenols act by uncoupling or inhibiting the formation of ATP.

Carbamates are derivatives of carbamic acid and affect the nervous system by disrupting an enzyme that regulates acetylcholine, a neurotransmitter. The enzyme effects are usually reversible. Carbaryl, thiodicarb, methiocarb, propoxur and carbosulfan are examples of chemicals belonging to this group. The latest arrivals from the 2000's are primicarb, indoxacarb, alanycarb and furathiocarb.

- Propoxur and tetrachlorvinphos (TCVP) are carcinogenic chemicals commonly used in pet products like flea collars. They are considered as domestic products for the retail and use purposes. Propoxur and TCVP are non-poisonous to plants and not absorbed by plant or animals but used to kill plant bugs and aphids or to control household pests and in mosquito abatement.

Formamidines are insecticides used to control OP and carbamate resistant pests.

Pyrazoles, pyridazines, quinazolines and benzoylureas are insecticides which mainly attack the nervous system of insects.

Pyrethroids were developed as a synthetic version of the naturally occurring pesticide pyrethrin, which is found in chrysanthemums. These synthetic pyrethroids are photostable and toxic to the nervous system, and used at very low rates of 0.01 - 0.1 pounds per acre.

⁵² Many of these fall under the UNEP POP Convention.

New pyrethroid pesticides from the last decade include acinathrin, imiprothrin and gamma-cyhalothrin. These have improved properties such as minimal volatility and are thus effective up to 10 days after application. Pyrethroids are widely used in products intended for domestic use. They are extremely toxic to aquatic life and to bees and birds.

- Permethrin is a pyrethroid used as an insecticide in agriculture, home pest control, in forestry and in public health programmes (e.g. head lice control). It is a synthetic pyrethroid and it kills insects by affecting their nervous systems. Approximately 60% of the worldwide permethrin use is on cotton, in addition to insecticide use for corn and wheat. The substance is also widely used in the homes, yards and gardens in the USA.

Insect repellents have in the past included smoke, plants hung in dwellings or rubbed on the skin as the fresh plant or its brews, oils, pitches, tars, and various earths applied to the body. Modern repellents include dimethyl and dibutyl phthalate, benzyl benzoate, N-butyl acetanilide and dimethyl carbase.

- DEET (N,N-diethyl-meta-toluamide) is used worldwide for biting flies and mosquitoes in a variety of formulations including aerosols, spray and creams for application to human skin. DEET containing products are usually sold in concentrations ranging from 10 to 30%.

Fumigants are small, volatile organic molecules that are used to kill insects and their eggs during storage or in buildings. They include ethylene dichloride, hydrogen cyanide, sulfuryl fluoride, chloroethene, ethylene oxide and naphthalene or paradichlorobenzene crystals.

Other diverse insecticide groups:

- Methoxyacrylates, naphthoquinone, pyridine azomethine
- Nereistoxin analogues (thiocyclam, cartap, bensultap and thiocytap-sodium)
- Pyrimidinamines, tetrone acids, sodium tetrabicycarbonate
- Clofentezine, etoxazole
- Perfluorinated compounds

Newly developed insecticides include

- Spinosyns act as crop protection for larvae, termites and other insects
- Phenylpyrazole is used as insecticides e.g. for rootworms and ants.
- Pyrroles
- Nicotinoids act on the central nervous system of insects.

Synergists and activators such as piperonyl butoxide and antibiotics such as abamectin and emamectin benzoate are used as insecticides. Piperonyl butoxide is used as a synergist to increase the effect of pesticides. The substance itself does not have pesticidal properties. It is used in the formulations of permethrin, other pyrethrins and pyrethroids.

Inorganic insecticides

Inorganic insecticides do not contain carbon and are usually white crystals which do not evaporate and are water soluble:

- Sulphur is especially toxic to mites in dust or spray forms.
- Mercury, boron, thallium, arsenic, Paris Green, lead arsenate and cadmium arsenate
- Inorganic fluorides (sodium fluoride, barium fluorosilicate, sodium silicofluoride and cryolite)
- Boric acid in the form of a salt is a non-volatile insecticide which has the longest residual activity of any insecticide
- Sodium borate is a water soluble salt to protect wood from fungi or termites
- Silica gels or silicate dusts act by dehydrating insects

Natural insecticides

Older insecticides of this group are sulphur, tobacco, pyrethrum, derris, hellebore, quassia, camphor and turpentine. Also pyrethrum, nicotine, rotenones, limone (d-limonene) and neems belong to this group.

- Biorational insecticides, mainly derived from plants, have a detrimental or lethal effect on specific target pests (insects, weeds, plant diseases) and are non-toxic to human health and have little or no adverse effects on wildlife and the environment. These include biochemicals (hormones, enzymes, pheromones and insect and plant growth regulators), microbial pesticides (viruses, bacteria, fungi, protozoa, nematodes) and plant-incorporated protectants (e.g. transgenic plants). Examples of biochemicals are pheromones that act through attracting insects to be trapped. Insect growth regulators are chemical compounds that alter growth and development of insects by interfering in the normal mechanisms of development and cause the insects to die before reaching the adult stage. These have few or no effects on humans and the environment. Microbial pesticides are insect disease-causing microorganisms that do not harm other animals or plants. Transgenic plants are genetically altered by artificial introduction of DNA from another organism (genetically modified, GM) to induce insect-resistance.

References: Brunn Poulsen et al. 2005, ChemicalWatch 2009a, Costner et al. 2005, SFT 2009a, Environment Canada 2009, UNEP 2009a, USEPA 2009b and 2009c, Ware and Whitacre, 2004

2.2 Algaecides, fungicides and herbicides

Algaecides

Algae occur in water from fish tanks to swimming pools and reservoirs. Algae require nitrogen, phosphorus and potassium for their growth. Many algaecides are based on copper, which is a toxic heavy metal in the aquatic environment.

Chemicals used to control algae include:

- Copper compounds (e.g. copper chelate) are applied to swimming pools for the control of algae. Copper concentrations in the products are approximately 259 g/kg or 110 g/litre.
- Chlorine compounds
 - benzalkonium chlorides, e.g. Polyquat (n-alkyl-dimethyl benzyl ammonium chloride), concentration in algaecide solution 5%
 - hypochlorite
- Simazine compounds, concentrations in the products are between 500-900 g/kg
- Other compounds:

- Alum (aluminium sulphate) is a coagulant for swimming pools (concentration in products 5%)
- Alkyl ammonium chlorides and amine salts
- Calcium hypochlorite, dose 2.5-5ppm

Fungicides

Plant fungicides are usually applied by spraying or dusting but some types are applied to seeds and soil for the destruction of vegetative spores. Most fungicides that can be bought on retail are in liquid form. In addition some fungicides are applied as a protective coating to seeds before germination. Fungicides used on wood, including creosote, prevent dry rot, and certain compounds are used to make fabrics resistant to mildews.

Most fungicides can cause acute toxicity, and some cause chronic toxicity as well. The function of the earlier applied fungicides was based on contact with the organisms, these including organic salts of iron, zinc and mercury. Also copper compounds, especially copper sulfate mixed with lime and water (Bordeaux mixture), and sulphur have long been used as fungicides. After 1965 they have gradually been replaced by synthetic organic compounds which are systemic fungicides that are absorbed by the affected organism.

Fungicides can be divided into the following groups:

Organotin and mercury compounds

- Cyhexatin and fenbutatin-oxide are fungicides (also used as insecticides for prevention of acarids). They inhibit formation of ATP and photophosphorylation in chloroplasts and can therefore also serve as algaecides. Organotin compounds are banned or restricted in most countries.
- Mercury has been used as a fungicide in pipes and on textiles that are exposed to extreme conditions, e.g. canvas. Phenyl mercuric acetate is no longer used as a paint preservative because it releases elemental mercury into the air.

Carbamates, such as ethylene-bis-dithiocarbamates and thiocarbamates.

Dinitrophenols (binapacryl and dinocap) are used as herbicides, insecticides, ovicides and fungicides. They act by uncoupling or inhibiting the formation of ATP.

Substituted benzenes

- Hexachlorobenzene (HCB) has been used in the past as a fungicide on the seeds of onions, sorghum and crops, such as wheat, barley, oats and rye. HCB may be formed as a by-product during the manufacture of chlorine containing pesticides. HCB is present as a micro contaminant in many pesticides and may thus be left in the product as an impurity in lindane, dacthal (DCPA), PCP, atrazine, simazine, picloram, pentachloronitrobenzene (PCNB, quintozone), chlorothalonil, endosulfan and clopyralid.
- HCB has been used as a fumigant (as a seed dressing and fungicide) for treating grapes, but the use has decreased in many countries.
- Chloroneb and chlorothalonil

Copper and copper compounds have been used as a fungicide for fruits, vegetables and crops. It is also applied to swimming pools for the control of algae (algaecides).

Sulphur has been used in the form of dusts and sprays in concentrations ranging from 0.08 to 0.5%. The use of sulphur as a fungicide has gradually been replaced by copper compounds.

Natural fungicides.

- Many antifungal substances occur naturally in plants and other organisms which have chemical defenses against micro-organisms. These include tea tree oil, cinnamaldehyde as well as jojoba, neem and rosemary oil and also milk.

Herbicides

Herbicides are used to kill unwanted plants either in direct contact where they destroy only the plant tissue or being translocated through the plant, either from foliar application down to the roots, or from soil application up to the leaves. The latter type is effective for perennial plants.

Selective herbicides kill specific targets while leaving the desired crop relatively unharmed. Some of these act by interfering with the growth of the weed and are often synthetic "imitations" of plant hormones. Herbicides which are used to clear areas like industrial sites and railway embankments are non-selective and kill all plant material with which they come into contact.

Most herbicides are applied as water-based sprays using ground equipment e.g. irrigation systems or from airplanes.

Herbicides are also used in forestry, pasture systems, and management of areas set aside as wildlife habitat.

Some plants produce natural herbicides, such as the genus *Juglans* (walnuts).

Herbicides can be divided to the following groups:

Chlorophenoxy acids mimic the natural hormone-like auxins in plants and cause lethal growth abnormalities. These herbicides are selective for broad-leaved or angiosperm plants, and are tolerated by monocots and conifers at the spray rates normally used. These chemicals are moderately persistent in the environment, with a half-life in soil typically measured in weeks, and a persistence of a year or so. The most commonly used compounds are 2,4-dichlorophenoxyacetic acid, 2,4,5-trichlorophenoxyacetic acid, 2-Methyl-4-chlorophenoxyacetic acid (MCPA) and silvex.

Triazines used in agriculture and as soil sterilants are not persistent in surface soils, but are mobile and can cause a contamination of groundwater. Triazines include atrazine, cyanazine, hexazinone, metribuzin and simazine.

Organic phosphorous compounds include glyphosate which interferes with the synthesis of certain amino acids. Glyphosate is not mobile in soils, has a moderate persistence, and is not very toxic to animals.

Organic fluorinated compounds include dioxins and PFCs (PFOS related compounds).

Bactericides

Bactericides are substances targeting to eliminate [bacteria](#). Bactericides are either [disinfectants](#), [antiseptics](#) or [antibiotics](#).

- The most used disinfectants are based on active chlorine or oxygen, on iodine, phenolic substances, cationic surfactants or can also include heavy metals or alkalis.
- Bactericidal antiseptics are germicides such as chlorine or iodine preparations, peroxides, alcohols, weak organic acids, phenolic compounds or cation-active compounds. Some of the antiseptics are corrosive or toxic in nature.
- There are both bactericidal and bacteriostatic antibiotics, the first ones kill while the latter ones slow the growth or reproduction of bacteria. There are also antibiotics having both effects, for instance aminoglycoside antibiotics. Antibiotics that inhibit cell wall synthesis are, for instance, beta-lactam antibiotics, cephalosporins, monobactams and vancomycin. Bacteria killing antibiotics are, for instance, daptomycin, fluoroquinolones, metronidazole, nitrofurantoin and co-trimoxazole.

Disinfectants

Disinfectants are used to destroy microorganisms that are living on non-living objects but that do not necessarily kill all microorganisms. Most disinfectants are potentially harmful to the environment. Alcohols, aldehydes and oxidizing agents are used as disinfectants as well as phenolics and ammonium compounds. Some examples of most commonly used disinfectants are given below:

- Alcohols: ethanol, isopropanol
- Aldehydes: formaldehyde, glutaraldehyde, ortho-phthalaldehyde
- Oxidizing agents: chlorine compounds such as chlorine or chlorine dioxide, oxygen, sodium and calcium hypochlorite, hydrogen peroxide
- Phenolics: phenol, hexachlorophene, thymol
- Quaternary ammonium compounds ("quats"): benzalkonium chloride
- Ultraviolet light
- Sodium bicarbonate

2.3 Additives

Different additives are needed in the pesticides:

- Nonylphenol ethoxylates (NPE⁵³) are used as wetting agents (surfactants) in pesticide formulations to improve the spraying and to reduce the amount of active ingredients. NPEs can also be added as dispersant and emulsifier, or added to the spray tank during application of the pesticide. It is estimated that the use of NPEs in pesticides for non-agricultural use is 1/10 of the total use in agricultural pesticides.
- Phthalates have been used in the manufacture of pesticides.

References: Bailey 2001, Barber et al. 2005, CRC 2009, Costner et al. 2005, EDIS 2009, Finnish Environmental Institute 2007, van der Honing 2007, IVL 2008, Kiinteistölehti 2004, van de Plasche & Schwegler 2003, SFT 2009b, Herbicides 2010, Steiner et al. 2003

⁵³ Forbidden in the EU Area since implementation of the EU REACH Regulation Annex XVII

3 Releases to the environment

Pesticides can be released to the environment during the use of products containing these substances or from direct application to agricultural soils or to other cultivations and also from indoor use. Also household dust has been found to contain these chemicals. According to the screening work carried out in Sweden, releases from pesticides especially to soil can be extremely harmful to the environment (see Study on Releases from Products, Annex 5). Sources of environmental contamination from outdoor use of pesticides are presented in Figure 2.

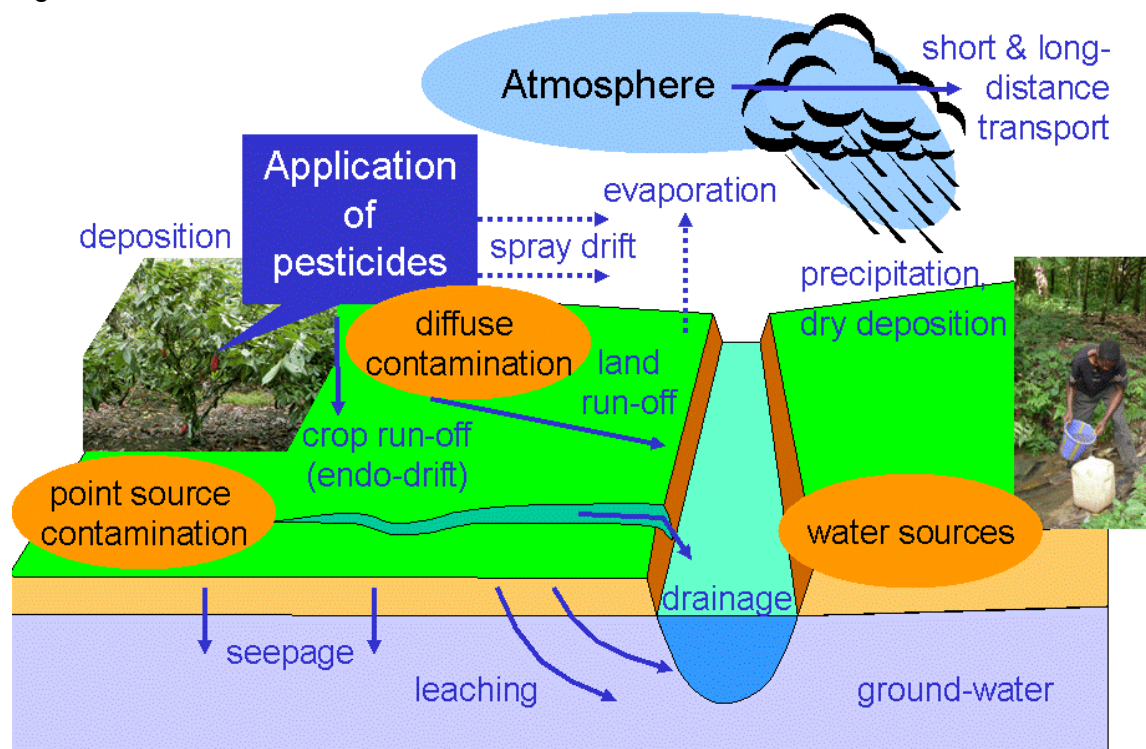


Figure 2. Sources of environmental contamination from pesticides (Wikipedia, 2009)

Algaecides

The use of algaecides to control algal blooms, for instance in swimming pools, is not recommended for environmental reasons and the chemical should only be used in emergency cases and not as a long term solution. Copper-based algaecides can be used for protection of boat bottoms but not applied directly to waterbodies. All copper-based algaecides will damage and in most cases kill algal cells. These toxins can pass through the water treatment filters easier than the intact algal cells. When algaecides are used to treat toxic or odorous algal blooms, the algal cells lyse releasing the toxin/odour into the water body. The intended use of the water directly after treatment for human consumption, stock watering or irrigation needs to be carefully considered. Toxins and odours degrade over time. Although there is little information on the withholding period, it could exceed 14 days for toxin breakdown in lakes. As an example, copper used as algaecide in water reservoirs can affect non-target species (bacteria, fish, zooplankton, other macroinvertebrates) when released to the environment. This can happen if the chemical is added to on-stream water storage and water including the remaining pesticide is discharged downstream to the receiving water body. Risks associated with using copper-based algaecides include accumulation of copper in the sediments,

Herbicides

Herbicides can be transported via surface runoff to contaminate distant water sources or washed off the foliage by precipitation or irrigation onto the soil, and may also be volatilized into the air. Most herbicides decompose rapidly in soils via soil microbial decomposition, hydrolysis, or photolysis. Some are more persistent with longer soil half-lives. Herbicide use has been responsible for killing wildlife including birds, either through direct contact or through vegetation used as feed. Releases to air depend on the vapour pressure of chemicals included in the product as well as on the application method (e.g. spraying).

Insecticides

Many insecticide chemicals have been found in sediments in streams downstream of application areas in all of the watersheds. Insecticides are washed to surface water or to ground water through soil. Releases to air depend on the vapour pressure of chemicals included in the product as well as on the application method (e.g. spraying). For instance NPEs can be released to the environment during spraying. When NPEs are released to the soil, they are degraded into nonylphenols (NPs), which are bound to soil particles and could also be transported to surface waters to some extent. Detectable levels of insecticides, e.g. DDT and permethrin, have been found in household dust and in food in addition to human blood samples, although DDT was banned in the 1970's in many countries. The biological half-life of DDT is approximately eight years

Fungicide

Releases of fungicides to soil are likely. Benzimidazole fungicides are toxic to earthworms which play an important role in thatch decomposition. Many of the newer turf fungicides have low use rates but higher water solubility and lower sorption coefficients than older fungicides and thus present an increased risk to water quality. For example, releases of copper based products to soil can be estimated to be equal to the copper included in the used amount of pesticide. In Norway, 2.2 tonnes of copper was released to soil from the use of pesticides in 2006. Releases from pesticide applications were previously dominated by HCB in Europe, while in North America pesticides have not been considered as a major source of HCB in the environment. The agricultural use of HCB was banned in Europe in the 1970s.

References: Bailey 2001, Barber et al. 2005, Costner et al. 2005, EEA 2005, van der Honing 2007, van de Plasche & Schwegler 2003, SFT 2009b, Sharp & Lunder 2004

Disinfectants

Releases from the use of disinfectants depend on where they are used. However, in many countries, releases from the household use of these products are lead to surface waters through wastewater treatment plants, and in these cases already included in PRTRs.

4 Release estimation techniques

Information on release estimation techniques found in the literature for releases of pesticides are presented in Table 5⁵⁴. The RETs include HCBs, NP/NPEs and copper releases. More detailed description of emission calculation and emission factors can be found in sections 4.1-4.3.

Table 5. Emission factors for different chemicals released from pesticides

End-product group	Substance	Emission factor (E _f)	Releases to	Reference
Fungicides, herbicides and algaecides	HCB	40 % of HCB in the pesticide; 50-150 mg HCB/ha of application of the pesticide 0.4 t/t / 0.5 t/t	Air	EMEP/CORINAIR Emission Inventory Guidebook (2005).
	Copper	1 kg/kg of the chemical in the pesticide (100 %)	Soil	SFT (2004, 2009b)
Additives	NPs/NPEs	0.85 kg/kg of the chemical in the pesticide (85 %)	Soil	IVL (2008)
		0.1 kg/kg of the chemical in the pesticide (10 %)	Surface waters	
		0.05 kg/kg of the chemical in the pesticide (5 %)	Air	

4.1 General methodology

The general equation for quantifying releases to the environment can be used to estimate chemical releases from the use of pesticides:

$$E = A \cdot E_f \cdot c$$

E = emission

A = chemical content of the pesticide (some levels indicated in section 2 of this document, accurate information regarding the specific chemicals is available e.g. from the material safety data sheet (MSDS))

E_f = emission factor (fraction estimated to be released to the environment)

c = coefficient for the fraction to be released to soil (c_s), water (c_w) or air (c_a)

Emissions to air from harmful chemicals in pesticides are dependent on the volatility of the compounds. Ambient air temperature and humidity levels affect the stability of the products. The level of volatility is quantified by the vapour pressure exerted by the chemical in air. The greater the volatility of a pesticide, the more likely the substance will be released to air as a gas. When the vapour pressure exceeds 10⁻³ mmHg, there are likely to be atmospheric releases of the compound. The volatilisation rate can be up to 80 - 90% depending on ambient climatic conditions.

⁵⁴ In addition to these, methods used in emission scenarios related to the EU biocides risk assessment are available at <http://ecb.jrc.ec.europa.eu/biocides/>

Chemicals with a water solubility > 10 ppm are primarily transported as dissolved compounds while hydrophobic compounds end up in soil sediments.

4.2 Fungicides, herbicides and algaecides

According to EMEP/CORINAIR Emission Inventory Guidebook (EEA 2005), a simple methodology for the estimation of releases from pesticide applications is based on the calculation using aggregated emission factors and production statistics. Based on that, the HCB emissions from the use of fumigants can be calculated by using the equation:

$$E = A \cdot E_f$$

E = emission

A = output production (pesticides applied)

E_f = emission factor

Data on use of HCB as a pesticide can be available from national statistical reports. A more reliable methodology is based on emission factors for specific processes, taking into account data on the type and efficiency of control equipment, and the content of HCB in materials.

The estimates for HCB emissions from pesticide application depend on the use rates of HCB-containing pesticides, the HCB content in those pesticides, and the rate of HCB volatilization from the pesticide formulation when it is applied. The emission factor for HCB during field use is 40 % of HCB application. EMEP/CORINAIR Emission Inventory Guidebook (EEA 2005) states that HCB emission factors for pesticide use in agriculture are 50 – 150 mg/ha (total arable land and permanent crop) per year or 100 mg/ha (arable land and permanent crops). According to the same source, HCB emission factors for field application in agriculture are 0.40 t/t (greenhouses 0.20) or 0.50 t/t (< 0.1 % of total fungicide consumption).

The uncertainty of HCB emission calculation consists of uncertainties of emission factors and uncertainties of statistical (production / activity) data (EEA 2005). The first type of uncertainty can be estimated statistically on the basis of experimental data on HCB concentration variability in emissions; the second type depends on the accuracy of statistical data and varies from country to country. On the whole, the precision and accuracy of HCB emissions calculation depends mainly on the quality of emission factors. However, a lack of statistical data for some source categories also results in high level of uncertainty.

The annual releases of copper from the use of pesticides can be calculated by using equation:

$$E = A \cdot E_f$$

E = emission (kg)

A = used amount of copper in pesticides (kg)

E_f = emission factor (kg/kg), 1 kg/kg

4.3 Additives

The annual releases of NPs/NPEs from additives in pesticides can be calculated by using equation (IVL 2008):

$$E = A \cdot E_f$$

E = emission (kg)

A = used amount of NPEs in pesticides (import + manufacturing – export) (kg)

E_f = emission factor (kg/kg)

According to IVL (2008), it can be estimated that 0.85 kg/kg (85 %) of the NPEs releases from pesticides go to the soil, 0.1 kg/kg (10 %) to surface waters and 0.05 kg/kg (5 %) to air.

5 Restrictions

5.1 International and regional restrictions

The Stockholm Convention on Persistent Organic Pollutants (POPs) is aiming to eliminate or reduce the production, sale, use and releases of eight pesticides (aldrin, dieldrin, endrin, DDT, heptachlor, chlordane, mirex and toxaphene). Recently also pesticide chlordecon and pentachlorobenzene, used in the production of pesticides, were added to the Convention. The Stockholm Convention on POPs prohibits the use of DDT, except for disease vector control. The Protocol on Persistent Organic Pollutants under the UNECE Convention on Long-Range Transboundary Air Pollution aims to eliminate any discharges, emissions and losses of 11 pesticides. Recently, also pentachlorobenzene was added to the Protocol.

References: SYKE 2009a, UNECE 2009, UNEP 2009

European Union

Plant protection products and biocidal products

According to EU Directive 91/414/EEC on plant protection products and Directive 98/8/EC on biocidal products; pesticides have to be approved for sale and use in the EU area.

The directive 91/414/EEC on plant protection products regulates placing of plant protection products on the market. The new regulation (EC) No 1107/2009 will replace the old directive starting from 14 June 2011. The regulation is aiming to raise the level of protection and the approval process. It will also allow substituting a problematic product with a safer one. Framework Directive 2009/128/EC on sustainable use of pesticides will regulate the use of pesticides by national action plans of the member states. Currently this only includes plant protection products.

The aim of the biocidal products directive 98/8/EC (BPD) is to harmonise the European market for biocidal products and to provide high level of protection of health and the environment. BPD is regulating the use of 23 different types of biocides, including pesticides. A revised EU biocides regulation will repeal and replace BPD. The proposal for the new regulation would extend the need for authorization to articles and materials treated with biocides. The regulation is scheduled to come into force in 2013.

References: EC 1991, 1998, 2009, ChemicalWatch 2009b, Keml 2009a, b, EUROPA 2009, SYKE 2009b, 2010

REACH regulation

Annex XVII of the EU REACH regulation ((EC) No 1907/2006) includes restrictions on the manufacture, placing on the market and use of certain dangerous substances, preparations and articles. According to the Annex, NPs and NPEs may not be placed on the market or used as substances or constituents of preparations at concentrations of 0.1 % by weight or higher as co-formulants in pesticides and biocides. Mercury and arsenic compounds shall not be used as substances and constituents of preparations to prevent the fouling by micro-organisms, plants or animals of: the hulls of boats; cages, floats, nets and any other appliances or equipment used for fish or shellfish farming; any totally or partly submerged appliances or equipment. Organostannic compounds (organotin) shall not be placed on the market or used as substances and constituents of preparations which act as biocides to prevent the fouling by micro-organisms, plants or animals of: all craft irrespective of their length intended for use in marine, coastal, estuarine and inland waterways and lakes; cages, floats, nets and any other appliances or equipment used for fish or shellfish farming; any totally or partly submerged appliance or equipment.

References: EC 2006

5.2 National legislation

Several school districts in the United States (e.g. Alaska, California, Colorado and Washington) have prohibited the use of pesticides that have been linked to health or environmental damage. Massachusetts has banned the use of pesticides considered known, likely or probable carcinogens, inert ingredients with toxicological concerns or products used for purely aesthetic reasons, in schools or daycares, and also indoors. In New York, school districts have limited the use of pesticides for aesthetic purposes or prohibited the use of certain highly toxic pesticides. California has banned the pharmaceutical use of the pesticide lindane. Illinois and New York have a similar pending legislation. Minnesota has banned the use of the herbicide atrazine.

DDT is no longer used in many countries. For example, it was banned in the United States in 1972 and in Canada in 1985. However, it is still used in many tropical countries for malaria control.

Nordic countries:

- New agricultural pesticides containing NPEs have not been approved for use in Sweden and Denmark since 1997 and in Norway since 2000.
- In Norway, products sold for the control of mosquitoes must contain less than 20 % of DEET.

References: Costner et al. 2005, IVL 2008, Ontario 2008, SFT 2009a

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ANNEX 1

CASE STUDIES ON SELECTED PRODUCT GROUPS

Case Study 10:

Releases from the use phase of textile and leather products

CASE STUDY 10

RELEASES FROM THE USE PHASE OF TEXTILE AND LEATHER PRODUCTS

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1 End products with likely releases during the use phase

Textile and leather products

The scope of this report is to collect existing information on the use phase of such textile and leather products from which there are likely releases to the environment during their use-phase. Home textiles and clothing, leather products, footwear as well as fabrics and leather used in furniture (including curtains) are included, and also carpets.

According to the Standard International Trade Classification (SITC) 65, textiles are defined as products consisting of yarns, fabrics as well as made up textile articles, kitchen linens, and luggage. Clothing is defined under SITC 85 to include garments and accessories, gloves, headwear and neckwear.

Chemicals in textile and leather products

Different substances are used in the manufacture of textiles for bringing special functions and appearance on the final product (Table 1). Chemicals are used in fibre manufacturing as well as for bleaching, improving optical brightness and for dyeing and printing of fabrics. Some substances are used to increase absorption and to reduce shrinkage. Many of these chemicals are rinsed out with detergents and water, but residual levels may still remain in the finished products.

Chemicals used as pesticides in cultivation of raw material for textile, such as cotton, may remain in the fabric until the final product. Chemicals are also used in finished textiles to achieve desired properties in the material, such as to obtain a stiff, soft or shiny surface of the fabric or to improve properties of the material, for instance to make it shrink or crease proof or resistant to make matt finishing or antistatic properties. Chemicals are also used for flame-proofing, to bring oil, water and dirt repellent properties to the surface, to protect the colours from fading in the sunlight, to provide fragrance and to highlight luminous properties of the fabric. In dye pastes used for printing of textiles chemicals can act as preservatives and prevent microbial attack including the growth of bacteria (e.g. in sportswear) and mould (e.g. in outdoor textiles).

In cases where chemicals used in textile enter directly the environment, they may be harmful, e.g. poisonous substances or chemicals with hormone disrupting properties. Chemical substances from the use phase of textile products have been found in the wastewater from washing textiles. In cases where clothes are washed without connection to WWTPs there is a direct risk to the environment.

Geographical distribution

The manufacturing, sales and use chain of textile and leather products as well as the releases from the use phase can be estimated as rather globally distributed. The supply chain of textiles and clothing sectors consists of a number of separate activities from sourcing of raw materials via design and production to distribution and marketing. The sector is increasingly organized as an integrated production network where production is sliced into

specialized activities and each of them located where it can contribute the most to the value of the end product.

Textile manufacturing is labour-intensive and the mass production is concentrated in the developing countries due to low production costs. In the 1960's, less than 15 % of the global textile exports were from developing countries, where as in the year 2000 more than 50 % of the exports occurred from developing countries. The different production stages often take place in different countries and textiles are transported between countries prior to their final sale. Cotton is grown in the Americas, Africa, Asia and Australia, while the biggest production volume of textiles is in the developing countries. The annual global textile markets are worth almost 300 billion Euros. More than 70 % of the textiles are exported to industrialized western countries, EU and the USA being the biggest importers. As an example, approximately 80-90 % of the textiles used in Sweden are imported and most textiles in the Swedish market come from an origin outside of Europe, for example from China, India and Bangladesh.

China ranks first in the world with its annual production capacity of cotton textiles, woollen fabrics, silk fabrics and chemical fibres. It processed 25 % (26,000 kt) and 36 % of the worldwide fibre output in 2004 and 2005, respectively. About 80 % of all the textile and apparel productions are sold in domestic market. The growing domestic demand has resulted in an increase of average fibre consumption level from 4.1 kg/person in year 1980 to 14 kg/person in year 2005. In 2004 and 2005, the total textile industrial output values were US\$ 199.316 billion and US\$ 253.657 billion, respectively, all having a ratio of 11 % to gross domestic product (GDP) of China. China's export of textile and clothing has ranked the first position in the world since 1995. The export value of China's textile industry reached a record US\$ 117.535 billion in 2005 accounting for 15.4 % of China's total industrial export value and 24 % of the global textile trade.

Besides China, other countries where textile industry is important are India, Pakistan and Japan.

The use of chemicals in textile and leather products are presented in Table 1 with information on likely releases to the environment as well as information on whether these releases are included in regular inventory work in the OECD countries..

Table 1. Use of different substances in textile and leather products and their likely releases during the use phase.

Use category	Substance	Releases to	RET exists	Included in regular inventory work
Detergents and auxiliaries	NPEs	Water	Yes	No
Water-, oil-, stain- and wrinkle resistant coatings	PFCs (PFOS), PFNA, FTOH	Water	No	No
	Formaldehyde	Air	No	No
Fire retardant textiles	PBDEs (e.g. HCBd)	Water	No	No
	SCCPs	Water	No	No
	Asbestos	Air	No	No
Plastic coatings	Phthalates (e.g. DEHP)	Water	No	No
	Heavy metals (e.g. Pb, Cd, organotins)	Water	No	No
Antibacterial and anti-mould agents	Silver	Water	No	No
	Triclosan	Water	No	No
	Dimethylfumarate (DMF)		No	No

Dyes and colours	Heavy metals (e.g. Hg, Cd and Pb)	Water	No	No
	Azo-dyes	Water	No	No
Footwear and leather products	Chromium	Water	No	No
	SCCPs	Water	No	No
Other	Heavy metals (e.g. Pb, Cd, organotins)	Water	No	No
	NPEs	Water	No	No

References: Bodin 2008, Chen et al. 2007, Engvall 2007, Keml 2009a,b, Larsen et al. 2000, Nordås 2004, Remberger et al. 2004, Seyoum 2007

2 Use and substances in textile and leather products

2.1 Detergents and auxiliaries

Nonylphenol ethoxylates (NPEs) have been used in the manufacturing of textiles as detergents (tensides) in the washing processes and as dispersing agents for dyeing and printing, and as emulsifiers and spinning lubricants. They have also been used in bleaching, finishing and printing processes for textiles and as non-ionic surfactants in the production of leather. Residual concentrations of NPEs can be found in finished products, such as in home textiles and clothes.

Nonylphenol ethoxylates (NPEs) have been found in high concentrations in terry towels, t-shirts, underwear (GP 2008) and in children's overalls with varying concentrations. In a Swedish study, a total of 20 terry towels purchased from seven different retail stores in Gothenburg area in Sweden were analyzed for the content of possible hazardous chemicals. NPEs were found in every tested towel, with the highest detected concentration being as much as 10,608 mg/kg (1 %) and another notably high concentration being 1,277 mg/kg (0.13 %). Other concentrations were considerably lower.

In the other Swedish studies, 17 t-shirts were purchased from local shops were analyzed for their NPE contents. Concentrations of NPEs were found in every t-shirt except one, the highest concentration being 940 mg/kg. T-shirts with the highest detected concentrations were manufactured either in China or in Turkey. Also 13 different children's overalls were analyzed for NPEs. The highest detected concentrations in the study were 1,200 mg/kg, 990 mg/kg and 970 mg/kg. The results of these three surveys are presented in Appendix I.

Residues of nonylphenolethoxylates are usually found in imported products manufactured outside the EU. It is not prohibited to import textile products containing NPE

References: Costner et al. 2005, Hök 2007, IVL 2008, Keml 2009b, Massey et al. 2008, Prevodnik 2008, Testfakta 2007

2.2 Water-, oil-, stain- and wrinkle resistant coatings

Highly fluorinated substances have been used in the textile industry as impregnating agents for a stain-, oil- and water-repellent coating to prevent oil, water and dirt entering the fabric. Per(poly)fluorinated compounds (PFCs) like perfluorooctane sulphonates (PFOS) and

fluorotelomer alcohols (FTOH) have been used for this purpose. PFCs are mainly telomere based polymers and used in the treatment of waterproof and sun-blocking textiles, car textiles and work clothes, weather clothing, shoes, tents, carpets, upholstery, tablecloths and also bed linens. Polytetrafluoroethylene (PTFE) has been used as membranes in clothing, such as rainwear and functional clothing and perfluorobutane sulphonate (PFBS) for impregnating textiles. FTOH's degradation products include perfluorooctanoic acid (PFOA) and perfluorononanoic acid (PFNA), which can be found in the products. Perfluorononanoic acid (PFNA) is the dominating perfluorinated acid found in textiles. Formaldehyde resins have been used in some textile finishes for wrinkle and stain resistance products. The finishes have been used in fabrics, like rayon, blended cotton, wrinkle resistant 100 % cotton, shrink-proof wool and synthetic blended polymers. Polychlorinated naphthalenes (PCNs) have been used in finishes for certain textiles.

Residual amounts of PFCs have been found in waterproof jackets, children's raincoats and waterproofing sprays and the importance of the market of FTOH in the production of synthetic fibre coatings is estimated to be growing. FTOH has been found in all-weather textiles and impregnation agents; in a Norwegian study, the volume of PFCs used for impregnating textiles was 7-10 tonnes in 2002. In Sweden, imported clothes (mainly work and sport clothes) that have been treated with PFCs are assumed to account for the largest proportion of PFCs transported to the country.

Although PFOS are no longer used for waterproofing of textiles in Europe or in the United States, there are still countries using PFOS in textiles, for instance China, which also imports fluorine containing textile finishing agents from other countries. In a Norwegian, Swedish and Danish joint study, new children's all-weather jackets sold in the Nordic countries in 2005 were tested for unbound fluorochemicals. Fluorotelomers and PFOA were detected in all the clothes. Five out of six jackets had significant amounts of PFOA and some had very high amounts of fluorotelomers. The study did not include chemicals released from repeated washing, drying and wearing.

There is high consumption products made out of water resistant material such as Gore Tex®.

References: Keml 2006, 2009b, Martin 2005, Massey et al. 2008, Peeters Weem 2007, van de Plasche et al. 2002, SFT 2008, 2009b, UBA 2007

2.3 Flame retardants

Flame retardants are used in furniture textiles and also in fabrics for tents. Both deca-BDE and hexabromocyclododecane (HBCD) have been used for this purpose, while HBCD has been the most common of all brominated flame retardant used in textiles. It has also been found in baby care products in concentrations exceeding the limit values for acquiring eco-design labels. The environmental concerns about the use of aromatic brominated flame retardants, especially in Europe, have resulted to a trend towards the replacement of these substances by e.g. HBCD.

In addition, short-chained chlorinated paraffins (SCCPs) have been used as a flame retardant coating on textiles. The applications of SCCPs in textiles include sail cloths, industrial protective clothing and lorry tarpaulins. The major historical use of chlorinated paraffins in textiles was in military tenting, but it is believed that they are no longer used for this application in the EU. The current use of SCCPs in textiles in the EU is very low, with the

majority being used in back coating of textiles. Asbestos has been used as a component in incombustible fabric.

References: Betts 2008, EC 2000, Mortensen et al. 2007, McPherson et al. 2004, NICNAS 2009, Remberger et al. 2004; Sharp & Lunder 2004, Steiner et al. 2003

2.4 Plastic coatings

Plastic coatings are used in textiles for patterns as well as to make the fabric watertight. PVC plastics can be found in clothing, raincoats, shoes and shower curtains and also in artificial leather, e.g. in gloves and bags. PVC plastic coatings contain plasticizers like phthalates (e.g. DEHP and DINP) as well as heavy metals (e.g. cadmium, lead and organotins). Some baby care products intended for children from 0 to 1 years were found to contain more DEHP than the limit value to acquire eco-labels (e.g. EcoTex). Organotins have been used as stabilizers in PVC plastics and can be found in textiles containing polymer parts, such as t-shirts with prints, sanitary napkins, bandaids and diapers. They are also used as fungicides on textiles that are exposed to extreme conditions, for instance in canvas.

References: Babich et al. 2004, Costner et al. 2005, Keml 2009b, Larsen et al. 2000, Tønning et al. 2008

2.5 Antibacterial and anti-mould agents

Anti-bacterial agents are used in sportswear, shoes, sponges and dishcloths. Also triclosan is used as an antibacterial agent for instance in bedding and socks. In addition, some washing machines have a function that releases silver ions to the washing liquid for antibacterial purposes where they are transferred to textiles.

Anti-mould chemicals have been used in outdoor fabrics and in the transport and storage of textiles in humid climate. They may be present in the finished textile or be supplied with the product in separate bags. Dimethylfumarate (DMF) has been used as an anti-mould agent in leather footwear. Producers use DMF as a biocide to protect the products from mould, which can cause deterioration of leather during storage and transportation. DMF can also be placed in sachets inside the shoe boxes. DMF evaporates from the sachets impregnating the leather.

References: EU 2009, Keml 2009b,e, SFT 2009

2.6 Dyes and colours

Metals, including mercury, cadmium (e.g. cadmium chloride) and lead, have been used in some dyes and colours for textiles. Also azocolourants have been used as dyes.

References: Keml 2009b; Larsen et al 2000, NPI 2008

2.7 Footwear and leather products

Footwear consist of a combination of different materials. Most common materials for footwear include textile, leather and plastic. Different chemicals are used in the manufacturing stage to glue, dye, polish and impregnate the products. These substances can also be found in the finished products in addition to chemicals used to improve the stain and water resistance of the products. In addition, the consumers can treat the footwear with different agents to improve their stain and water resistance and for polishing purposes.

Chromium has been used in the tanning of leather. Short-chained chlorinated paraffins (SCCPs) have been used in leather treatment, as well as nonylphenol ethoxylates (NPEs) in the wet degreasing of hides.

Almost half of the NPE containing leather products are exported for use outside EU. The volume of exported goods may be high, for instance most shoes in the Swedish market (population 9 million) are imported (e.g. appr. 20,000 tonnes in 2000).

References: IVL 2008, KemI 2001, 2009b; Larsen et al 2000, NICNAS 2009, NPI 2008

2.8 Other use

Metals (copper, zinc, manganese, aluminium, palladium, mercury, nickel, cadmium and lead) and plastics are used in some parts of clothing, for instance in buttons and zipper.

Synthetic fibres need more antistatic treatment than other fibres.

NPEs are used in glues as water based adhesives for instance in the textile industry.

The use of NPEs in water based adhesives has reduced by 98 % in 1995-1999 in Sweden, with 1.0 tonne of NPEs and 0.46 tonnes of NPs registered for total use in adhesives in 2006 (also other than textile industry included). Historic use may also contribute to the stock of NPEs in adhesives.

References: Bodin 2008, IVL 2008, KemI 2002, 2009b; Larsen et al 2000, NICNAS 2009, NPI 2008

3 Releases to the environment

Some functional chemicals are not always tightly bound to the textile and may thus be washed out or worn over time and consequently dispersed to the environment. Releases of hazardous substances from textiles through the washing processes may harm the aquatic environment. The releases may also disperse to agricultural land through sewage sludge. In a study simulating domestic laundry it was showed that the least washed out substances were chlorinated carriers and substituted toluenes while some phthalates, certain heavy metals and benzene sulphonamides were washed out at relatively high percentages. For most of the substances less than half of the total amount was washed out. For example, for 80 % of the studied aryl amines, the washing out was less than 10 % of the total amount. It was concluded that it is not likely that any significant amounts will be washed out in the following launderings.

Chemicals used as pesticides in cultivation of raw material for textile, such as cotton, may remain in the fabric until the final product. However, little information is available from releases of these substances related to the use phase of end products.

3.1 Detergents and auxiliaries

Nonylphenol ethoxylates (NPEs) are released from textiles during the use and washing of these products and end up either to the wastewater treatment plant or directly to the environment. NPEs cannot be removed by treatment at the WWTPs, but are degraded into nonylphenol (NP) with the help of bacteria in anaerobic conditions. In the waterbodies degradation occurs in the sediments. Approximately 40 % of NPEs degrade completely into NPs, 20 - 64 % end up in the sludge as NPs and the rest 40 % go to the effluent. High concentrations of NPEs have been found e.g. in jeans.

The NP content of sewage sludge measured in Stockholm in 2007 was 0.35 tonnes. It was estimated that this volume corresponded to one third of the total amount of NPs to WWTPs, thus being approximately 1.2 tonnes. From these figures it was calculated that 0.85 tonnes of NPs enter surface waters, assuming that none of the NPs are degraded in the WWTP.

References: Ahel et al. 1994, IVL 2008, Keml 2009b, Loyo-Rosales et al. 2007, Massey et al. 2008, Prevodnik 2008, SVT 2009

3.2 Water-, oil-, stain- and wrinkle resistant coatings

PFCs (e.g. FTOH) can be released from textile products as residues during normal use conditions such as from wearing and washing textiles. PFOS and PFOA are water-soluble and thus mainly emitted to water. PFCs can be released from textiles during washing and end up in the waste water. From the wastewater treatment plants, the compounds are carried by the effluents into rivers and oceans where they are diluted in the water. They can also find their way to the groundwater (e.g. PFOA).

The increasing concentration of FTOH found in the outdoor and indoor air indicates that they can be released from coated products, like carpets. The concentrations measured have been higher indoors than outdoors, although the connection to textiles and carpeting has not been proved. FTOH can be converted into perfluorocarboxylic acids, including PFOA. PFCs have also been found in household dust. Also, PFNA levels in the liver of Canadian polar bears were found to be quadrupling from 1972 to 2001.

Formaldehyde can be released when wearing and washing the textiles. Most of it is released in the washing water, reducing the concentration of formaldehyde in the product. The concentration of formaldehyde resin in textiles varies between the different manufacturers. Humidity and perspiration affects the amount of formaldehyde released from clothing. Formaldehyde can also be found in baby care products, for instance, pillows intended for baby feeding have been found to emit significant amounts of formaldehyde and to exceed the limit value to acquire eco-labels.

According to studies the levels of unbound fluorotelomers in all-weather clothing can be approximately 400 - 1,000 µg/m² of textile. The measurements made for jackets did not include repeated washing, drying and wearing. PFCs concentrations in indoor air have been measured to be 30-570 times higher than that of the outdoor air while the sources for the inside air concentrations are likely to be products, like dirt-repellent carpets.

References: Keml 2006, Kohler et al. 2009, Martin 2005, Massey et al. 2008, NICNAS 2007, SFT 2008, Tønning et al. 2008, UBA 2007)

3.3 Flame retardants

Flame retardants used in textiles can be released to air and water during use of the product. HBCD is an additive flame retardant and thus it is not chemically bound to the polymer. This is why HBCD can be emitted from polymer products by diffusion. However, it is estimated that the releases of HBCD and phthalates to the environment will most likely occur in small amounts due to their low vapour pressure and that most of the content of these substances will remain in the products during their service life, unless exposed to organic solvents or high temperatures for a long time period. If the product has a long service life, releases can occur during the whole lifetime of the product.

Leaching of HBCD from products can be expected to be higher in urban areas due to the population density and thus higher consumption. Indications of elevated HBCD concentrations have been found in the air, sediments and possibly in the depositions of urban environment compared to the background levels. These can result from diffuse releases from the use of polymer products, including textiles. The release rates can be expected to decline with time, if the predominant release mechanism is solid phase diffusion. Releases of SCCPs from textile applications are considered negligible.

References: EC 2000, Remberger et al. 2004, Tønning et al. 2008

3.4 Antibacterial and anti-mould agents

Some washing machines have a function that releases silver ions to the washing liquid for antibacterial purposes where they are transferred to textiles. From textiles, the particles are worn off, which results to diffuse emissions. With washing temperatures of 60 °C or higher, the silver function of the washing machine is not needed because the high water temperature itself has a bactericidal effect.

Dimethylfumarate (DMF) concentrations exceeding five times the EU limit value of 0.1 mg/kg have been found in jeans. DMF can penetrate from the leather to the clothes and into the skin.

References: EU 2009, Keml 2009b,e, SFT 2009, SVT 2009, EU 2009)

3.5 Dyes and colours

Surplus dyes may be released in the washing process. Also, impurities in the dyes (aromatic amines and heavy metals) may enter the sewage water system and azo compounds be cleaved in the WWTP into aryl amines in reductive conditions. Lead and mercury in concentrations exceeding the limit values for eco-design labels have been found in jeans.

References: Keml 2009, Larsen et al. 2000, SVT 2009

3.6 Footwear and leather products

Chemicals used in footwear can be released and spread to the environment. Most of the releases are expected to happen at the disposal phase, in landfills or by combustion.

No information has been found in the literature about releases of NPEs from leather products

References: IVL 2008, KemI 2001

3.7 Other use

Adhesives are not considered as a major source of NPs/NPEs to the environment, although minor releases may occur during cleaning of the equipment. It has been estimated that approximately 1 % of NPEs from adhesives is released to the WWTPs in Sweden.

References: IVL 2008, KemI 2009b, Larsen et al. 2000

4 Release estimation techniques

Release estimation techniques to quantify the releases of the different chemicals from the use of textile and leather products are summarized in Table 4. Methodologies were identified only for releases from textile and leather products containing NPEs as detergents and other auxiliaries and brominated flame retardants.

Table 4. Emission factors for different substances released from textile and leather products

End-product group	Substance	Emission factor (E_f)	Release media	Reference
Detergents and auxiliaries from textiles	NPEs	0.250 kg/tonnes textiles	Water	IVL (2008)
Textiles	NP equivalents	0.7-1.6 g/person and year	Wastewater	Månsson et al, 2008 (data from Stockholm, Sweden)
Flame retardant textiles	BFRs	0.05 %	Air	SFT (2004, 2009b)
		0.05 % (indoor use), 0.7 % (outdoor use)	Water	
Textile cleaning agents	Substances in cleaning agents	0.1 g of the active chemical/person and year	Wastewater	Månsson et al, 2008 (data from Stockholm, Sweden)

Detergents and auxiliaries

According to IVL (2008), releases of NPEs from textiles to WWTPs can be calculated by using the equation:

Annex XVII of the EU REACH regulation ((EC) No 1907/2006) includes restrictions on the manufacture, placing on the market and use of certain dangerous substances, preparations and articles.

Nonylphenols and nonylphenol ethoxylates

According to Annex XVII, NPs and NPEs may not be placed on the market or used as substances or constituents of preparations at concentrations of 0.1 % by weight or higher in textiles and leather processing (EC 2006). Exemptions include processing that has no releases to waste water and systems with a special treatment to remove the organic fraction completely. There are no restrictions for the use of NPEs in adhesives in the EU legislation (IVL 2008).

Pentabromodiphenyl ether (penta-BDE) and octabromodiphenyl ether (octa-BDE)

According to Annex XVII, articles or their flame-retarded parts containing pentabromodiphenyl ether (pentaBDE) or octabromodiphenyl ether (octaBDE) at concentrations higher than 0.1 % by mass must not be placed on the market (EC 2006).

Azodyes

Annex XVII is restricting the marketing and use of azocolourants (Appendix 8) in textile and leather products that may come into direct or prolonged contact with the skin and mouth (EC 2006). These products may not contain more than 30 ppm of the aromatic amines in the finished product. The restriction is applied to textile and leather products like:

- clothing, bedding, towels, hairpieces, wigs, hats, nappies and other sanitary items, sleeping bags
- footwear, gloves, wristwatch straps, handbags, purses/wallets, briefcases, chair covers, purses worn around the neck
- textile or leather toys and toys that include textile and leather garments
- yarn and fabrics intended for consumer use

Annex XVII is also restricting the marketing and use of 'blue azo colourant' (Appendix 9) for colouring of textile and leather products in concentrations above 0.1 % by mass (EC 2006). Appendix 10 of the Annex is related to testing methods of azodyes from textile and leather.

Cadmium

According to Annex XVII, cadmium shall not be used as stabilizer in articles manufactured from vinyl chloride, including apparel and clothing accessories (including gloves), and imitation leather.

Organostannic compounds (organotins)

According to the Annex XVII, dioctyltin (DOT) compounds shall not be used after 1 January 2015 at concentration greater than 0.1 % by weight of tin in textile articles intended to come into contact with the skin; gloves; footwear or part of footwear intended to come into contact with the skin.

Perfluorooctane sulfonate (PFOS)

The Regulation (EC) No552/2009 amending Annex XVII prohibits the marketing of textiles and other coated materials containing 1 µg/m² or more PFOS of the coated material (EC 2009b). According to Keml (2009b), PFOS have largely been replaced by other highly fluorinated substances, which may also pose a risk to the environment and human health due to some of them being persistent and bioaccumulative.

Short-chained chlorinated paraffins (SCCPs)

The Annex XVII bans the marketing and use of SCCPs in concentrations greater than 1 % for fat liquoring of leather in the EU (EC 2006).

Dimethylfumarate

EU has adopted an emergency Decision 2009/251/EC to ban the placing on the market of DMF containing products. Products containing this substance, above the maximum limit of 0.1 mg/kg of product or part of the product, will be recalled and withdrawn from the market. The decision was made after several member states, including France, Finland, Poland, Sweden and the UK, reported through the RAPEX system exposure of consumers to the substance. The decision came into force at the beginning of May 2009.

Biocides

According to EU Directive 91/414/EEC on plant protection products and Directive 98/8/EC on biocidal products; pesticides, insecticides and anti-mould agents have to be approved for sale and use in the EU area. Biocidal products containing dimethylfumarate (DMF) are not authorised for use in the production of goods in the EU. Manufacturers outside EU may still be using DMF along with other unauthorised substances. Also, all products that release silver ions that are used to prevent bactericidal growth, are regarded as pesticides. These products will need an approval to be placed in the market in all the EU countries after the turn of the year 2008/09.

Imported textiles

In the EU, no specific legislation concerning the chemical contents of imported textiles is in force (Hök 2007). Imported textiles, containing hazardous substances that are no longer used in EU, but allowed to be used in other countries, may enter the EU market.

Eco-labels and standards

Eco-labels available for textiles include e.g. the EU "Flower", the Nordic "Swan" and the Öko-tex labelling scheme. Basic information on the EU and Nordic eco-labels can be found in Chapter 2.5.1 of the main report.

The revised criteria of the EU eco-label will ban the use of additive flame retardants, like the brominated flame retardant deca-BDE, in textiles and bed mattresses. The new criteria permits the use of reactive flame retardants. Some EU countries and NGOs have argued that all the halogenated flame retardants should have been prohibited.

Also, the use of biocides in textiles was tightened in the eco-label criteria only to permit the use of "active substances" that are approved for use in "low-risk biocidal products" listed in the Annex 1A of the biocides Directive. The active substances included in the list cannot be substances that are CMR, sensitising, bioaccumulative or those that are not readily degradable. In order to be used in eco-labelled products, biocides have to have specific approval for the use in textiles. Biocides containing active substances listed in Annex 1 for approval in biocidal products and those listed in Annex 1A can be used in mattresses with specific approval. The new criteria for textiles and mattresses will take effect on January 2010 and will apply for four years.

The revised eco-label criteria will also remove the ban on PVC in footwear, but it will be replaced by the inclusion on phthalates DBP, BBP and DEHP on the REACH candidate list for authorization (ChemicalWatch 2009a). Also DNOP, DINP and DIDP will be prohibited by

the new criteria. The new criteria for footwear will take effect on April 2010 and will apply for four years.

Oeko-Tex (or Öko-Tex) Standard 100 is a certification and testing system for harmful substances in textiles, developed in 1992. The international Oeko-Tex Association consists of independent test institutes located around the world. There are currently over 73,000 certificates issued and millions of labelled textile products worldwide. The Oeko-Tex is the best known label for testing harmful substances in textiles.

The tests include substances that are prohibited (e.g. carcinogenic dyes) or regulated (e.g. heavy metals) by law as well as substances that are known to be harmful for health, but have not been regulated or prohibited by law (e.g. pesticides). The tests are based on the intended use of the product.

Tested textile products are divided into four different classes (Oeko-Tex 2009):

- I: Textiles and textile toys for babies and small children up to three years old (e.g. romper suits, bedding and soft toys), accounting 36 % of the tested products
- II: Textiles in direct contact with the skin (e.g. underwear, bed linen, shirts and blouses), accounting 57 % of the tested products
- III: Textiles not intended in contact with the skin (e.g. jackets, coats and interlining materials), accounting 2 % of the tested products
- IV: Furnishing textiles (e.g. table linen, curtains as well as wall and floor coverings), accounting 5 % of the tested products

There are limit values for the tested substances according to the product classes. For example, limit value for lead is 45 mg/kg for class I products and 90 mg/kg for the other products. The Oeko-Tex Association also has a list of active chemical products that are used in textiles and have been assessed to be harmless to human health.

5.2 National legislation

The restrictions of PFOS started in the 1990's from evidence of the chemical's environmental and health risks. The production of PFOS was restricted in the developed countries in year 2005, but they are still used in many countries including China.

In the United States, the California Proposition 65 and the Consumer Product Safety Improvement Act (CPSIA) are also concerning substances used in textiles. In Japan, law 112 for the control of household products containing harmful substances also includes those used in textiles. In China, textile products are covered in the national general safety technical code GB 18401-2003.

Germany has proposed an amendment to its Consumer Goods Ordinance for banning the use of hexavalent chromium compounds from all leather made consumer products. The new law would include articles intended for more than temporary skin contact, e.g. leather gloves. The ban will also be extended to leather toys (See Case study on toys).

Before the EU wide decision on dimethylfumarate (DMF), some countries had introduced national bans on DMF containing products. France adopted a year-long ban on the import and placing on the market of DMF containing seating and footwear in December 2008 (EU 2009). Also, recalls of seating, footwear and packaging that visibly contain DMF, are

required. Belgium prohibited the placing on the market of DMF containing articles and products in January 2009. Spain is preparing measures on DMF.

Nordic countries:

- According to the Swedish Chemical Products Ordinance, clothing and material for clothing are not to be sold if they contain or have been treated with chemical products and may thus be harmful to humans. Companies buying or selling textile products are responsible for that the products are not harmful for human health or the environment. They are also responsible for replacing harmful products with less harmful ones and to provide necessary information.
- Norway has restricted the use of PFOS to 1 microgramme/m².

5.3 Industry initiatives

The Restricted Substances List (RSL), created by the American Apparel & Footwear Association (AAFA), is used to provide the companies information on regulations and laws that restrict or ban certain chemicals and substances in finished textile, apparel, and footwear products globally (AAFA 2009). The RSL includes only those materials, chemicals, and substances that are covered by a regulation or law. The RSL identifies the most restrictive regulation. The focus is on the substances that can be found in finished products at a certain level. Regulations relating to the production processes are not included in the RSL. Also, the California Proposition 65 requirements for labeling and the US EPA requirements for labeling of ozone-depleting compounds are not included in the RSL.

The Apparel and Footwear International RSL Management Working Group (AFIRM) is aiming to reduce the use and impact of harmful substances in the apparel and footwear supply chain. The purpose of the AFIRM group is to provide a forum for cooperation of companies in order to advance the global management of restricted substances in apparel and footwear, sharing information about RSL to the supply chain, discussing concerns and exchanging ideas for improving chemicals management.

Several major retail companies are included in AFIRM group. For example, Hennes & Mauritz introduced its RSL in 1995 and it has been updated regularly. The list includes dyes, pesticides, heavy metals, formaldehyde, APEO (alkylphenol ethoxylates, including nonylphenol ethoxylates), PVC and phthalates. The list of chemicals was gathered by using global legislation and including chemicals of concern, which include carcinogenic (e.g. some dyes), reprotoxic (e.g. some phthalates) and mutagenic (e.g. some pesticides) substances as well as those hazardous to the environment (e.g. APEO).

According to the Swedish Chemicals Agency, the Swedish textile manufacturers are no longer using e.g. brominated flame retardants. Several chlorinated compounds have also been replaced and e.g. nonylphenol ethoxylates, phthalates, mineral oils and highly fluorinated substances are being phased out in the future. Also, the supply of product made from organic cotton as well as eco-labelled products has increased.

References: AFIRM 2009, Betts 2008, BiPRO 2007, Bodin 2008, ChemicalWatch 2009a,b, EC 2003b, 2004, 2006, 2009, EU 2009, IVL 2008, Keml 2009a, b, Larsen et al. 2000, Massey et al. 2008, Oeko-Tex 2009, SFT 2009

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7 Appendixes

7.1 Appendix I: Studies on nonylphenol ethoxylates

Results of the studies by Hök (2007), Prevodnik (2008) and Testfakta (2007) on nonylphenol ethoxylates are found in Tables A1.1-A1.3.

Table A1.1 Concentrations of nonylphenol ethoxylates measured from Terry towels (detection limit 1 mg/kg) (Hök 2007)

Sample number	Purchase site	Nonylphenolethoxylate concentration mg/kg	Sample number	Purchase site	Nonylphenolethoxylate concentration mg/kg
1	IKEA	<1	12	Coop	3.4
2	IKEA	94.6	13	Rusta	2.6
3	Åhlens	2	14	Rusta	2.6
4	Åhlens	6.1	15	Duka	7
5	Jysk	11.1	16	Duka	<1
6	Jysk	239	17	Hemtex	1.6
7	Ellos	517	18	Hemtex	150.7
8	Ellos	190.5	19	ÖB	12.6
9	Ica	1277	20	Lexington	2.2
10	Ica	577		Detection threshold	1
11	Coop	10608			

Table A1.2 Concentrations of nonylphenol ethoxylates measured from T-shirts (detection limit 1 mg/kg) (Prevodnik 2008)

Sample number	Purchase site	Trade mark	Nonylphenolethoxylate concentration mg/kg
1	Intersport	Puma	45
2	Team Sportia	Nike	16
3	Stadium	Soc	<1
4	Stadium	Nike	22
5	NK	Peak Performance	4
6	Naturkompaniet	Tierra	13
7	Cubus	Identity	430

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8	Weekday Hero	Cheap Monday	940
9	Sisters	East West	11
10	MQ	Emilio	63
11	MQ	Zoul	33
12	MQ	Bondelid	43
13	Carlings	Just a Fucking T-shirt	120
14	Pepper	Selected Homme	270
15	Gina Tricot	Gina Tricot	3
16	Filippa K	Filippa K	4
17	Dressmann	Batistini	230

Table A1.3 Concentrations of nonylphenol ethoxylates measured from children's overalls (Testfakta 2007)

Model		NPE conc. mg/kg
Nanook		12
Altitude 8848 Wolfram		52
Polam&Pyret Skiingdress		110
Reima Essen		2
Europriis, Boys&Girls		420
Didriksons Mountain Goat		470
Coop Friends		21
Helly Hansen K Mount Skiingsuit		230
Lindex		970
Polam&Pyret Bävemylon (waterresistant)		580
H&M		1200
Åhlens		420
KappAhl Snow World Explorer		990

7.2 Appendix II: Study on chemicals in textiles

Part of the results of the study by Larsen (2000) on chemicals in textiles are found below in Danish.

Tabel B2.1. Results of ABC and UPH scoring

CAS-nr.	Substance	ABC score	UHP score	Acute toxicity	Irritation	Sensibilization	Organotoxic	Genotoxic	Cancer	Neurotoxic	Reproductive	Notes
3068006	1,2,4-butantriol	0	H	4								
95636	1,2,4-trimethylbenzen	A	H(L)	3	2							1)
85507999	1-(okta cykloymethyl) pyridinchloride	0	0									2)
90131	1-chloronaphthalene	A	H(L)	3								
90120	1-methylnaphthalen	a	H(L)	3	3							
2437798	2,2,4,4-tetrachlorbiphenyl	A	P									like PCB
105679	2,4-dimethylphenol	C	P	2								1)
3207123	2-amino-2-methylpropanol-hydrochloride	0	0									
1892439	2-chlorophenoxy ethanol	0	P	3	3							changed to chlorophenoxy acetic acid
939275	2-ethyl naphthalen	0	H	4								
	2-hydroxy-3-chlorobenzoic acid butylester	0	H									no data, considered analogous to butylbenzoat and chlorobenzoic acid
23287265	2-hydroxy-3-methylbenzoic acid methylester	0	H	4								methyl cresotinat
119368	2-hydroxy-benzoic acid methyl ester	c	P	3	3						3	
91576	2-methylnaphthalen	a	H(L)	3	3							
	Acrylpolymer	C	H									3)
79107	Acrylacid	C	H(L)		3							1)
	Alkanol amine hydrochlorides	0	H(L)	3	2							Ethanolamine
	Alkyl amide thoxylates	b	H	3								
	Alkyl aryl sulfonates (LAS)	B	H(L)	3	3							2)
	Alkylpyridin	0	H	3				4		3		
	Alkylsulfonates	B	H(L)	4	3							
8006131	Aluminiumtriacetate	0	P									3)2)
7360534	Aluminiumtriformate	0	P									3)2)
	Amid-modified esters	0	0									2)
	Aminhydrochlorides	0	P		2							
7727437	Bariumsulfate	b	H									
	Benzimidazol-derivate	0	U	3							1	
	Benzoxazol derivate	0	P									based on classification of phosalon

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CAS-nr.	Substance	ABC score	UHP score	Acute toxicity	Irritation	Sensibilization	Organotoxic	Genotoxic	Cancer	Neurotoxic	Reproductive	Notes
120514	Benzyl benzoate	0	H	3								1)
92524	Biphenyl	C	P		2							1)
7439921	Lead	A	P							(3)		metallic
136607	Butylbenzoate	c	H(L)	3	3							
85687	Butylbenzyl phthalate	C	P				3		3		3 (high dose)	IARC 3
9000117	Carboxymethylcellulose	C	H									3)
108907	Chlorobenzen	B	H									1)
	Chlorifying ethylens	A	U									Chlorethen carc 1, R45 1)
	Chlorphenol	A	H(L)	3								1)
	Cumarins	a	P	2					3		2	
9004539	Dextrin	C	H									3)
111422	Di(hydroxyethyl) amine	C	H	3								considered analogous to diethanolamides
84742	Dibutylphthalate	C	0									3)
95501	Dichlorbenzen, 1,2-	A	H(L)	3	2							1)
541731	Dichlorbenzen, 1,3-	A	H(L)	3								1)
106467	Dichlorbenzen, 1,4-	A	H(L)	3	3							1)
98873	Dichlormethylbenzene	A	P	2	1				3			1) alfa,alfa-dichlortoluen
95738	Dichlortoluen, 2,4-	a	H(L)	3	3 (2)							3 Other dichlorobenzenes are classified Xn R22, some XI 36/38 or 27, but they have other CAS numbers. Even so considered as class 1)
118694	Dichlortoluen, 2,6-	A	H(L)	3	3 (2)							considered as chlortoluen
95750	Dichlortoluen, 3,4-	0	H(L)	3	3 (2)							considered as chlortoluen
111466	Diethylenglycol	C	H(L)	3	3							
117817	Diethylhexylphthalate (DEHP)	A	P	4	3				3		3 (high dose)	IARC 3
84662	Diethylphthalate	C	H	4							4	
3720976	Dihydroxy ethylen urea	0	H(L)	3								4)
68122	Dimethylformamide	A	U	3	3						2	N,N Dimethylformamid
28804888	Dimethylnaphthalene (mixture)	a	0									2)
13747121	Dimethylol-4-metox-5,5-dimethylpropylurea	0	H(L)	3								4)
7327697	Dimethylol-5-oxa-1,3-piperazin-2-on	0	0									
	Dimethylol-carbamate	0	H(L)	3								4)
1854268	Dimethyloldihydroxy-ethylen-urea	b	H(L)	3							3	4)
3883236	Dimethylolethyl carbamate	0	H(L)	3								4)
136845	Dimethylol-ethylen urea	a	H(L)	3								4)
134974	Dimethylolethyl triazon	0	H	4								

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CAS-nr.	Substance	ABC score	UHP score	Acute toxicity	Irritation	Sensibilization	Organotoxic	Genotoxic	Cancer	Neurotoxic	Reproductive	Notes
4913319	Dimethylolmethyl carbamate	0	H									4)
3270744	Dimethylol-propylen urea	a	H(L)	3								4)
140954	Dimethylol-urea	a	H(L)	3								4)
131113	Dimethylphthalate	C	H	4							4	
120616	Dimethylterephthalate	C	H	4	3							
101848	Diphenyloxid	A	H(L)	4	3							
	Distyrylobiphenyl derivative	0	H(L)	3								
533233	Acetic acid-dichlorophenoxy-ethylester	0	P									Classification under 2, 4-D. Salts and esters*
2555499	Acetic acid phenoxyethylester	0	H	4								
140885	Ethylacrylate	C	U	3	3	1						
9004573	Ethylcellulose	0	H									3)
	Fat alcohol sulfates (FAS)	C	H									3)2)
	Fat acid condensation products	0	H									3)
	Fat acid salt	c	H									3)
	Fluorescence silicone polymer	0	H									3)
	Fluorocarbons	0	H									3)
	Fluorocarbon polymers	0	H									3)2)
50000	Formaldehyde	A	P	2		2			3			1)
	Fosfates	0	H									3)
56815	Glycerine	C	H									3)
107222	Glyoxal	C	H	3								1)
87683	Hexachlorobutadien	A	P	2	3			2	3		2	
92693	Hydroxybiphenyl	B	H					4	4			
7440439	Cadmium	A	P	3						(3)		compound 1)
471341	Calciumcarbonat	C	H									3)
10043524	Calciumchlorid	C	H		3							1)
7778509	Kaliumdichromat	A	U	(3)2	2	2		2	2			1)
1332587	Kaolin	C	H									3)
9005258	Potatoe starch	C	H									3)
9000719	Casein	C	H									3)
7440508	Copper	A	H									metallic copper
142712	Copper acetate	A	H(L)	3								
3251238	Copper nitrate	A	P	3	2							
7440484	Cobalt	A	P	2								1)
7440473	Chromium	A	P	2	2	Chrom (IV)	forbindelse					Chromium (IV) compound 1)
	Chromium fat acid complex	a	0	2)								2)
	Qaternary ammonium salt	A	P	2	3							1)

Resource Compendium Part IV: Releases from the Use of Products -
Case Study on Textile and Leather Products

CAS-nr.	Substance	ABC score	UHP score	Acute toxicity	Irritation	Sensibilization	Organotoxic	Genotoxic	Cancer	Neurotoxic	Reproductive	Notes
7439976	Mercury	A	P	2						3		
63148629	Linear polydimethylsiloxams	C	H	4				4				
7786303	Magnesiumchloride	C	H	4				3				3)
108781	Melamine	c	H(L)	4					3			3)
9003081	Melamin formaldehyde	a	H	4								Polymer
93583	Methylbenzoat	0	H(L)	3	3							
28652724	Methylbiphenyl	a	H					4				
9004675	Methylcellulose	C	H									3)
924425	Methylol acrylamide	0	P	3					3			
3370352	Methylol stearamide	C	H									2) methylol-stearamid octadecamamide, N-(hydroxymethyl)
	Metoxydimethylol urea	0	H(L)		3							4)
	N-alkylphthalimider	0	0									2)
20120336	N-methyloldimethyl fosfonopropionamid	0	0									
88120	N-vinylpyrrolidion	c	P	3	2				3			IARC3
91203	Naphthalen	A	P	3	4				3		4	See naphtalenes
	Naphthalin imides	a	0									
7440020	Nikkel	A	P			2			3			1)
100027	Nitrophenol	B	P	3	3					3		4-nitrophenol 1)
9016459	Nonylphenoethoxylates	A	P									Nonylphenoethoxylate is on the list of the Ministry of the Environment on undesired substances, labelled here P 2)
95498	o-chlorotoluen	A	H(L)	3								=2 chlortolouen 1)
4991326	Octadecyl ethylene urea	0	0									2)
	Oleater	c	H									3)
112801	Oleic Acid	c	H									
59507	p-chloro-m-cresol	A	P	3	1	2						4-chloro-3-methylphenol 1)
	Palmitates	c	H									3)
8002742	Paraffin	c	H									3)
25429292	Pentachlorbiphenyl	A	P	4								3) PCB
87865	Pentachlorphenol	A	U	1	-2	2			3			1)
108952	Phenol	C	P	2	2							1)
90437	Phenylphenol	C	H(L)		3							Biphenyl-2-ol 1)
	Phthal acid ester	0	H									1)
	Poly(oxyethylen-oxypropylen) glycolether	0	H									
9003058	Polyacrylamides	0	H									3)
	Polyacryl acid salt	C	H									3)
	Polyacrylat	C	H									3)

Resource Compendium Part IV: Releases from the Use of Products -
Case Study on Textile and Leather Products

CAS-nr.	Substance	ABC score	UHP score	Acute toxicity	Irritation	Sensibilization	Organotoxic	Genotoxic	Cancer	Neurotoxic	Reproductive	Notes
1336363	Polychlorinated biphenyls	A	P							3		Like PCB 1)
	Polyester	0	H									3)
	Polyethoxylates (EO polymer)	c	H									=Polyglycoether
9002884	Polyethylene	c	H									3)
	Polymethylmelamine	0	H									Same as melamin formaldehyde
	Polymetoxymethylol melamine	0	H									
63148629	Polysiloxan-emulsion	b	H									
9009545	Polyurethane	0	H									3)
9003207	Polyvinylacetate	0	H									3)
9002862	Polyvinylchloride	0	H									3)
103651	Propylbenzen	B	H	2								1)
6531313	Propylen urea	0	H(L)	3								4)
	Proteine complex Aluminium salt	0	H									3)
	Protein complex dichromates	a	0									
	Protein complex formaldehyde	0	H									2)
	Protein complex tin	b	0									
	Pyrazolin derivates	0	P	3					4		3	
	Pyrenoxazol derivat	0	0									
121299	Pyretrines (Pyrethrin II)	0	H(L)	3	3							
	Pyretroides	0	P	3	2							2)
4261727	Stearamidomethyl pyridinchloride	0	H	3								
	Stearates	C	H	4	4	4	4	4	4	4	4	3)
57114	Stearin acid	C	H	4	4	4	4	4	4	4	4	
	Stilben derivates (diamino/disulfonates)	b	H	4								
	Styrenpolymer	C	H									3)
	Styrylv derivate	0	U						2			IARC 2A
57501	Sugar	C	H									3)
14807966	Talkum	c	H									Asbestos free 3)
119642	Tetrahydrona phthalene	A	H(L)		3							1)
7580372	Tetrakis(hydroxymethyl) fosfonium acetate	0	0									
124641	Tetrakis(hydroxymethyl) fosfonium chloride, THPC	0	P	2					3			IARC gr. 3
22031170	Tetrakis(hydroxymethyl) fosfonium fosphate	0	0									
55566308	Tetrakis(hydroxyl-	0	P	3					3			IARC gr. 3

Resource Compendium Part IV: Releases from the Use of Products -
Case Study on Textile and Leather Products

CAS-nr.	Substance	ABC score	UHP score	Acute toxicity	Irritation	Sensibilization	Organotoxic	Genotoxic	Cancer	Neurotoxic	Reprotoxic	Notes
	methyl) fosfonium sulfate, THPS											
5395506	Tetramethylol acetylene diurea	0	H(L)		3							4)
7440315	Tin	b	U	2	3					1		1) Tributyl tin
7772998	Tin dichloride	b	H(L)	3			3	3				= Tin II Chloride
7646788	Tin tetrachloride	A	P	2	2							= Tin IV chloride 1)
108883	Toluen	C	H(L)	3								1)
87616	Trichlorbenzen, 1,2,3-	A	P	3								Often mixture of isomers
120821	Trichlorbenzen, 1,2,4-	A	P	2								Data from IRIS
	Trichlorphenol	A	P	3					3			1) 2,4,5-trichlorophenol, CAS.nr. 95-95-4, Xn R22, Xi R36/38 2,4,6-trichlorophenol, CAS.nr. 88-06-2, Xn R22, Xi R36/38, Carc 3 R40
102716	Triethanolamin	C	H(L)	4	3	3	0	4	4	0	0	
1017567	Trimethylolmelamin	0	0									
	Tris-methylol-2-cabamoyl ethylamin	0	H	(L)	3							4)
57136	Urea	C	H(L)	4	3			4				i.e. carbamide
9011056	Urea formaldehyde	a	H									polymer
6834920	Water glas	C	P	2	CAS-nr.	for	dinatriummetasilikat.					CAS number for dinatrium metasilicate. Water glas is normal natriumsilicate
	Vax (polyethene, montana)	c	H									3)
	Wax aluminium salt	0	H									3)
	Wax zirkonium salt	0	H									3)
1330207	Xylen	C	H(L)	3	3							1)
7440666	Zink	A	H									1)
13826885	Zinc fluoroborate	0	H	3								
7646857	Zinc chloride	A	P	2								1)
7779886	Zinc nitrate	a	P	2	2							3)
24887067	Zinc sulfoxylate formaldehyde	0	0									2)
7440677	Zirkoniumsalt	b	H									1)
2) No data found in the RTECS and HSDB databases												
3) Considered based on experience without further data												
4) Dimethyl ... urea compounds considered												
* UPH-points are based on criteria described in chapter B2.3 and paragraph 4 and in references HSDB (1999), RTECS (1999) and Miljø og Energiministeriet (1997)												
ABC points in Table B2.1 are based on criteria in the following chapter and in references: MITI (1992), Verschuren (1997), Nikunen et al. (1990), Howard (1990), Baumann & Herberg-Liedtke (1991), Miljø- og Energiministeriet (1997), Sangster (1989), AQUIRE (1999) Kemikalieinspektionen (1989), Roth (1994), Merck (1983), BODEG (1993), Pedersen et al. (1994), LOGKOW (1994), Damberg & (1997) og Brown (1978), Thygesen (1991), IUCLID (1996), Kemikalieinspektionen (1997) og Brown (1978).												

B2.2 Criteria for ABC scoring system

The ABC scoring system has been applied for substances that are lead in wastewater to a public wastewater treatment plant for biological treatment. A full description of the methodology is presented in , "Tilslutning af industrispildevand til offentlige renseanlæg. Oplæg til vejledning (Miljøstyrelsens spildevandsvejledning), udarbejdet af VKI", april 1997".

The methodology concerns organic substances in three categories of harmfulness (A, B and C) based on their harmfulness to people, biodegradability and chronic and acute impacts in water environment.

ANNEX 1

CASE STUDIES ON SELECTED PRODUCT GROUPS

Case Study 11:

Releases from the use phase of toys and low-cost jewellery

CASE STUDY 11

RELEASES FROM THE USE PHASE OF TOYS AND LOW-COST JEWELLERY

Content

- 1 End products with likely releases during the use phase
- 2 Use and substances in toys and low-cost jewellery
 - 2.1 Plastic toys
 - 2.2 Arts and crafts (Hobby products)
 - 2.3 Balloons
 - 2.4 Other toys
 - 2.5 Low cost jewellery
- 3 Releases to the environment
- 4 Release estimation techniques
 - 4.1 Plastic toys
 - 4.2 Wooden toys
- 5 Restrictions
 - 5.1 International and regional restrictions
 - 5.2 National legislation
 - 5.3 Industry initiatives
- 6 References
- 7 Appendixes
 - 7.1 Appendix I: Articles not regarded as toys
 - 7.2 Appendix II: Children's exposure to hazardous substances Exposure pathways
 - 7.3 Appendix III: Exposure to lead in low cost jewellery
 - 7.4 Appendix IV: Exposure to diisononyl phthalate (DINP)

1 End products with likely releases during the use phase

This study compiles currently information on possible releases from the use of toys and low cost jewellery.

Toys

Toys are a very heterogeneous product group containing both chemical and other products and consisting of many different materials, such as plastics, rubber, textile, leather, metal, wood and paper, and their combinations. These materials may contain many hazardous substances, for instance heavy metals, phthalates, flame retardants and formaldehyde. A toy is defined according to the European Union Toys Directive as “any product or material designed or clearly intended for use in play by children of less than 14 years of age”. Annex I of the Directive provides a list of products that are not regarded as toys (see Appendix I). Data from Toy Industries of Europe shows the division for the major types of toys in Table 1.

Table 1. Market shares of major types of toys according to Toy Industries of Europe (TIE 2006)

Toy Category	Market Share (%)	
	2004	2005
Infant/Preschool	17.2	19.6
Games/Puzzles	13.8	14.5
Dolls	13.9	12.5
Vehicles	11.4	9.4
Outdoor & Sport toys	10.4	10.6
Building Sets	6.4	7.2
Arts & Crafts	5.7	5.8
Plush	5.6	5.7
Action Figures & Accessories	4.2	4.7
Learning & Exploration	1.7	1.7
All other	9.7	8.3
Total	100.0	100.0

According to Stober (2009) toy categories of possible chemical hazard include

- chew toys (e.g. pacifiers and teethers)
- toy cosmetics and jewellery
- arts and crafts and learning materials (e.g. crayons, playdough and paints)
- chemistry sets, cap tapes for gun toys
- electronic toys with batteries
- liquid containing toys
- toys with plastic sections of components
- stuffed toys and toys made of textiles
- playground equipment (e.g. CCA treated wood, lead paint and lead used to line playing fields)
- second-hand toys, hand-me-down old
- unlabeled and unsafe toys

The largest user group of toys are children of all ages. Besides children, adults and pets can also be counted as users of toys. Toys and play itself products serve multiple purposes for

both humans and animals. Toys are generally considered an integral part of a child's development. They provide entertainment while also having an educational role. Toys enhance cognitive behaviour and stimulate creativity, as well as help in the development of physical and mental skills, which are necessary in later life. Children of different age groups handle toys in different manner and thus the exposure pathways differ as well.

Toys are manufactured globally, China being the biggest exporter of toys in the world with a manufacturing base consisting of around 7,500 companies. For instance, approximately 70-90 % of all toys on the market in Europe and the USA are produced in China. With the rising labour costs in China, the toy industry and other labour-intensive sectors may relocate production to other countries that still have a lower cost base. Also, markets for toys continue to grow especially in Latin America, Asia, Indonesia and in the Russian Federation. The international and internet commerce of toys as well has increased recently. The market shares according to regions are presented in Figure 1.

Countries that export toys to countries with demands for the quality of the products have bias towards compliance with the standards. However, for instance the Chinese manufacturers claim that it is difficult for them to fully understand the legislation in the EU where conformity with a certain harmonised safety standard does not necessarily mean the product is in compliance with all applicable safety requirements in the legislation. Ensuring the compliance with existing requirements is further complicated by the fact that the toy supply chain consists of different types of players such as Original Equipment Manufacturers (OEMs), retailers and traders. The biggest OEMs have almost full control over product design, manufacturing and distribution while they have outsourced the production. The retailers play a much weaker role and cannot in a significant way impact the design, supply chain and consequently product safety. Up to 10 % in volume of the toy market are counterfeit products. These are often cheap copies of well-known brands that contain inferior materials and are manufactured with limited regard for safety aspects containing, for instance, more often hazardous chemicals. Often it is the poor children in developing countries that play with cheap toys that leach out the most lead.

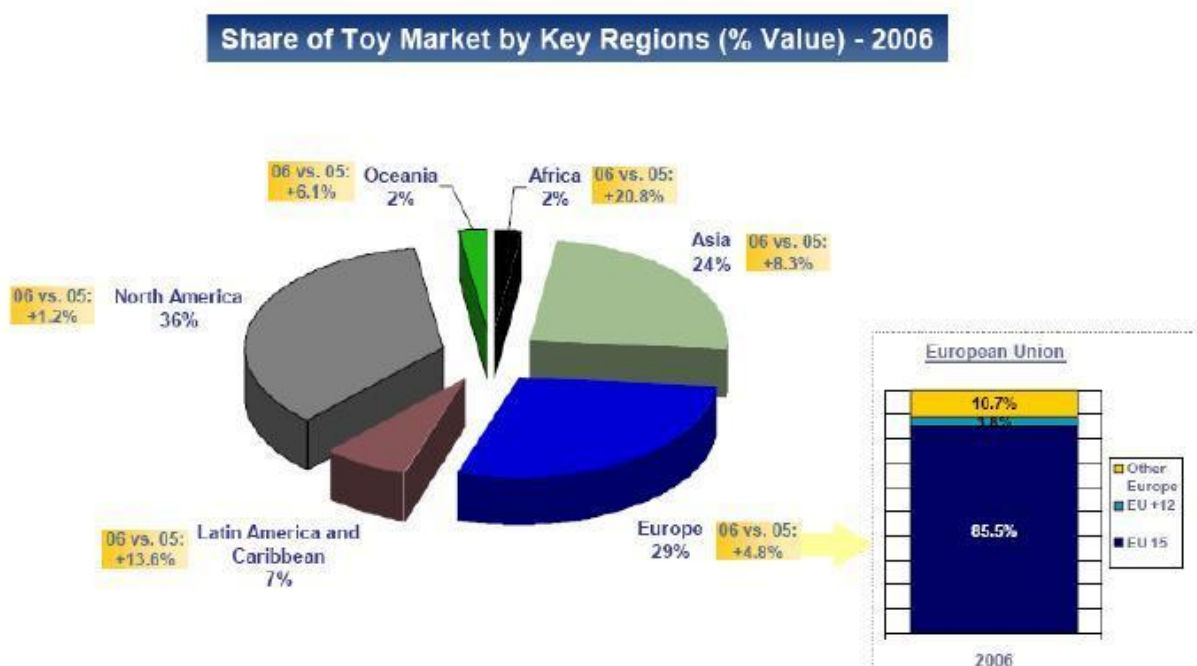


Figure 1. Global toy markets according to ICTI (2007)

References: Agarwal 2009, EC 2008, EC 2008, van Engelen et al. 2006, ICTI 2007, IFCS 2006a, Konsumentverket 2006, Kumar&Pastore, 2007, Stober 2009, WECF 2009

Low-cost jewellery

Low-cost jewellery covers the whole range of different type of metallic, plastic, wooden and textile decorations such as for instance rings, necklaces, bracelets, earrings, piercing jewellerys and ankle chains. The users are from all age groups and genders.

Studies have shown that heavy metal contamination to the skin of persons using inexpensive metal jewellery is a widespread phenomenon, but not much information is available from possible releases to the environment from these products (Table 3). Lead containing low cost jewellery and their toxic effects to young children has received growing attention in the recent years. Many of these pieces of low-cost jewellery are imported from China. Children can be exposed to toxic substances when handling these items.

The global market for low cost jewellery resembles that of toys as shown by the example from jewellery imported to Denmark (Table 2). In the Danish study it was not concluded whether jewellerys bought from a certain country have a larger probability to contain heavy metals but there seemed to be a greater chance of high content of lead in the cheaper metal jewellerys while for cadmium there did not seem to be a direct relation.

A great part of the inexpensive jewellery is imported from China, where manufacturers get a large part of the lead they use from electronic waste (so-called e-waste) including computers and other electronic articles and their parts discarded in the United States and other developed countries and shipped to China. The companies handling e-waste strip lead and other usable parts from it and sell the lead to alloy makers, who provide it to jewellery manufacturers. The finished items are finally sold to developed countries and sold in discount stores and malls, especially to children and teenagers.

Table 2. Import of jewellerys to Denmark ((Strandesen & Brunn Poulsen 2008)

Import from	Precious metal jewellerys	Bijouterie – precious metal	Bijouterie – non-metal	Bijouterie – without precious metal
USA	4.2%	5.5%	0.6%	0.4%
Indonesia	0.4%	0.3%	0.9%	0.3%
China	53.7%	87.9%	37.8%	54.0%
South Korea	2.5%	2.9%	0.6%	2.1%
Japan	3.7%	0.0%	0.0%	0.0%
Taiwan	0.0%	1.3%	1.1%	1.1%
Hong Kong	10.4%	1.8%	5.4%	6.6%
Total	21.912 kg	385,322 kg	380,337 kg	282,229 kg

References: CDC 2006, Fairclough 2007, Maas et al. 2005, Massey et al. 2008, , Strandesen & Brunn Poulsen 2008, Weidenhamer & Clement 2007, Yost & Weidenhamer 2008

Information on the use of chemicals in toys and low-cost jewellery is presented in Table 3 with assesment on likely releases to the environment as well as information on whether these releases are included in regular inventory work in the OECD countries.

Table 3. Use of different chemicals in toys and low cost jewellery and their likely releases to the environment during use phase. Explanations: Releases to: the environmental compartment is in brackets if releases are considered minor, e.g. (air); RET = Release estimation technique, Yes = exists, (Yes) = not published/only in certain countries; NA = information not available)

End-product	Substance	Releases to	RET exist	Included in regular inventories
Low cost jewellery	Lead	No information on releases to the environment	No	No
	Cadmium		No	No
	Mercury		No	No
	Antimony		No	No
	Nickel		No	No
	Azo-dye, which can be reduced to aromatic amines, e.g. benzidine		No	No
Plastic toys	Phthalates	No information on releases to the environment	No	No
	Lead		No	No
	Bisphenol-A		No	No
	BFRs		No	No
	Cadmium		No	No
	Chlorinated paraffins		No	No
	NPs/NPEs	Water	Yes	No
	Organotins	No information on releases to the environment	No	No
	Triclosan		No	No
Other toys (e.g. dolls, cuddly toys, wooden toys, electronic toys, beads, crayons and finger paints)	BFRs	No information on releases to the environment	No	No
	Formaldehyde		No	No
	Lead		No	No
	Phthalates		No	No
	Parabens		No	No
	Aniline		No	No
	Bisphenol-A		No	No
	Cadmium		No	No
	Chlorinated paraffins		No	No
	Chromium, copper, arsenic	Soil	Yes	No
	Organotins	No information on releases to the environment	No	No
	NPs/NPEs		No	No
	PFCs		No	No
	Boron		No	No
	DINP		No	No
Balloons	nitrosatable substances (amines)	Air	(Yes)	No
Additives	Dyes and colouring (e.g. azo-colorants and heavy metals)	No information on releases to the environment	No	No
	Antibacterial agents and preservatives (e.g. triclosan and parabens)		No	No
	Fragrances		No	No
	Flame retardants		No	No

2 Use and substances in toys and low-cost jewellery

This chapter provides information on the use of specific chemicals in toys and low-cost jewellery by product type. The following chemicals that are environmentally harmful have been found in harmful concentrations to health in toys and low cost jewellery (EC 2008):

- brominated flame retardants in toys
- heavy metals or their compounds (antimony, arsenic, cadmium, lead, mercury, nickel, organotins) in paints in toys and children's face paints, crayons, hard PVC plastic toys, in batteries, low cost jewellery
- boron in toys
- NP/NPEs in toys
- formaldehyde in toys
- gammahydroxybutyrate, GHB in jewellery

It has been noted, that when concentrations of hazardous substances to health have been found in toys and the products have been recalled from the market, only 5-20% of the items actually are returned back. The remaining items might be sold online or in low-cost outlets, or exported to countries with less strict regulations.

2.1 Plastic toys

Toys can be made from foam plastics, mainly from polyurethane (PUR), ethylene vinyl acetate (EVA) or polyvinyl chloride (PVC).

Soft plastic toys, such as teething rings, rattles and soft plastic books are made of PVC with the help of plasticizers. DINP has been the principal plasticizer in PVC children's products (concentration often 20-40 % or higher), since di(2-ethylhexyl) phthalate (DEHP) was found to be carcinogenic in laboratory studies in the 1980's. However, the oral exposure to diisononyl phthalate (DINP) from mouthing soft plastic toys is not likely to present a health hazard to children as the estimated average and upper bound exposures from their studies should be below the acceptable daily intake (ADI). Foam plastics can contain phthalates and heavy metals.

Hard PVC plastic toys do not usually contain phthalates, but they can contain heavy metals, such as lead and organotins, used as stabilizers. Lead has been used as a stabilizer in plastic products, also in toys, to stabilize molecules from heat and to give good mechanical properties.

Flame retardants may be added to toys made of plastic and foam plastic. NPs/NPEs are used as antioxidants and plasticizers in PVC, polystyrene, epoxy, PET and polypropylene plastics in toys. Organotins have been found in children's PVC toys, including e.g. face masks, balls, soft toys and food toys.

References: Babich 1998, Babich et al. 2004, Borling et al. 2006, CDC 2007, Costner et al. 2005, CPSC 2001b, France 2001, Hileman 2007, IFCS 2006a, IVL 2008, Konsumentverket 2006, RIVM 1998, WECF 2009

2.2 Arts, crafts and hobby products

Arts and crafts materials here include e.g. crayons, chalks, pencils, pens, paints, inks, erasers, glazes, glues, solvents, playdoh, finger and face paints, pencil cases, toy bags as well as toy cosmetic sets.

These products can contain preservatives like parabens, heavy metals (e.g. lead and chromium), solvents, formaldehyde and phthalates, and different colourants contain different substances. For instance, imported crayons in the USA and Sweden, labelled "non-toxic" have been discovered to contain high concentrations of lead and chromium and lower concentrations of asbestos. In Canada, high levels of lead, arsenic, mercury, cadmium and antimony have been found in children's face paints.

In a Danish study phthalates were found in plastic parts of childrens' school bags and pencil cases as well as in erasers made of PVC.

References: IFCS 2006a, Konsumentverket 2006, Hansen et al. 2008, IFCS 2006a, Massey et al. 2008, Konsumentverket 2006, Svendsen et al 2007, WECF 2009

2.3 Balloons

In a Danish Study of four balloons there were no measurable releases of heavy metals, but all the tested balloons gave off nitrosamines in concentrations exceeding the German limit value of 0.2 mg/kg for the release of nitrosamine substances from balloons. The concentrations were even higher than allowed for soothers and bottle teats and the standardised analysis method could not account for the high concentration of nitrosamine concentrations. The study also demonstrated liberation of carbon disulfide from the four analysed balloons, and of dibutylamine and BHT (antioxidant) from one balloon.

Reference: Nielsen 2007

2.4 Other toys

Toys made of textile can contain impregnation agents as well as toys made of leather tanning agents. In addition, toys may be painted with lead containing paint

Cuddly toys have often been found to contain allergens and brominated flame retardants and plastic dolls with plush and stuffing, wearing jewellery and clothes or containing electronic components, also other hazardous chemicals, for instance heavy metals. These toys may also contain fragrances (e.g. in toy cosmetic sets), phthalates and flame retardants.

Electronic toys can contain brominated flame retardants and the batteries contain heavy metals. Varnishes and paints used in toys may contain lead or other heavy metals.

The glue used in wooden toys may contain formaldehyde and that in children's beads for instance gamma drug (gammahydroxybutyrate, GHB)

The surface treatment of wooden play structures, children's play sets and playground equipment, used outside may include preservatives like CCA (chromated copper arsenate) and lead containing paint.

Rubbery and slimy toys have been found to release chemicals to the air. For instance, in a Danish study, some of the 26 recognized contact allergens regulated by the EU Cosmetics Directive were found. Boron and nickel have also been found from some of these tested toy products.

Toys designed for animals (especially toys for cats and dogs) often have the same appearance as toys designed for children. Plastic toys for pets can contain phthalates, including DINP and DEHP

References: Brandt Nielsen et al. 2005, CDC 2007, Glensvig & Ports 2006, IFCS 2006, Müller et al. 2006, Konsumentverket 2006, Svendsen et al 2005, Vendsen et al. 2005, WECF 2009

2.5 Low cost jewellery

Low-cost jewellery can be made of different materials, including plastic, metal, wood and textiles. They may contain many different heavy metals, e.g. lead, cadmium, antimony, copper, zinc, iron and nickel. The basic material is often brass or steel, but also other metals may have been used. The surface coating, commonly a mixture of gold, palladium and silver, can contain lead. Nickel alloys are often used for the attachment of the surface material to the basic material.

Lead alloy is widely used in low cost jewellery because there is plenty of lead and it is inexpensive compared to for instance zinc alloy. The lead found in jewellery may originate from lead solder used in circuit boards, especially if the jewellery also contains copper and tin. The jewellery can also contain antimony, which is used to harden lead in batteries. In different studies, 40-60% of the items tested have generally included lead of one to three quarters of the weight of the product (Appendix II, Tables A2.1, A2.2, A2.3 and A2.4). Unfortunate accidents have also occurred such as small children dying after having ingested a piece of jewellery containing toxic concentrations of lead. For instance, in the USA, this type of accidents has involved pieces of jewellery containing 39% of lead by weight (with a range of 37-44% in similar products) and 99% in the inner core of the product (range 0.004-67% in similar products). In addition to lead, also cadmium, mercury and nickel have been found in concentration exceeding the health safety limit values (Table 4).

Table 4. Hazardous substances found in adults low cost jewellery (HS 2008a)

Jewellery	Substance	Concentration in the jewellery (%)
Ring	Cadmium (Cd)	22.1 (in a stone)
Earrings	Cadmium (Cd)	21.7
Locket	Lead (Pb)	20.3
	Antimony (Sb)	2.1
Necklace	Lead (Pb)	7 (in stones)
	Antimony (Sb)	6 (in stones)
Earrings	Lead (Pb)	5
	Antimony (Sb)	4.2

References: Fairclough 2007, HS 2008a, 2007a,b, IFCS 2006a, Keml 2002, Maas et al. 2005, Massey et al. 2008, SFT 2009, Strandesen and Brunn Poulsen 2008, Weidenhamer & Clement 2007, Yost & Weidenhamer 2008

3 Releases to the environment

Little information on releases from toys and low cost jewellery to the environment was found during this project and it seems that there are not yet many studies on the possible environmental impacts of releases from the use of these products. The main concern of studies on releases from toys and low cost jewellery have been focused on the health impacts.

However, it can be concluded that in certain conditions chemical releases to the environment are likely. It can also be concluded that besides the chemical composition, the physical design of the toy or a piece of jewellery affects the possible tendency of releases to the environment. Chemicals of possible concern include heavy metals, plasticizers and softeners that are not tightly bound to the material and can thus leach from the product. Other examples of compounds and contaminants in toys are musk compounds, fragrances and allergens in addition to glues, solvents, lacquers, pigments, antioxidants, antimicrobials, flame retardants and stabilizers, even fuels can be contained in toys. The chemical content of toys is often unknown and the concentrations may vary according to market forces, laws and regulations as well as due to consumer concerns. There may also be batch to batch variations in the chemical mixtures.

Information on actual releases to the environment from the type of products that are included under toys and low-cost jewellery were available in three cases: Studies at IVL concerning NP/NPE releases from rigid plastics and in Denmark on health impacts of hobby products, show that if chemicals from the use of products would enter the environment, e.g. through washed off residues from children's hands this would not represent a threat to the aquatic environment.

According to several studies, releases from toys and low cost jewellery to the environment could follow following mechanisms:

- Migration: Toxic metals used in low-cost jewellery can migrate out of the material and lead also out of plastic material. When the plastic is exposed to sunlight or detergents, the chemical bond between the lead and plastics can break down and form dust. When using plastic toys outside, the substances can be released directly to the environment. Phthalates and heavy metals may migrate out of toys or jewellery during normal use conditions.
- Leaching: Plasticizers, softeners and stabilizers added to some plastic toys may leach from the material. Plasticizers, including phthalates like DINP, are not tightly bound to PVC and may thus be released, for instance when exposed to humid conditions, e.g. abandoned in rainfall. Heat, agitation, friction and impaction are conditions increasing the leaching. Arsenic can leach out of CCA treated wooden play structures and weather into the soil.
- Leakage: Leakage of batteries of electronic toys may pose a chemical risk
- Peeling off: Lead paint can peel off the surface.
- Wash-off: Ink and paint can be released to the environment through washed off residues

References: Babich et al 2004, CDC 2007, Hansen et al. 2008, IFCS 2006a, IVL 2008, Konsumentverket 2006, Nielsen 2007, Stober 2009, WECF 2009

4 Release estimation techniques

No methodologies that would especially target releases to the environment from use of toys and low-cost jewellery, were found in the literature. However, information presented in the other case studies can be applied here: the emission factor presented in the Case Study on NPs and NPEs by IVL (IVL 2008) for plastics and information from KLIF (SFT 2004) in estimating heavy metal releases from wooden products (Table 5).

Table 5. Emission factors for different substances released from toys

End-product group	Substance	Emission factor (E_f)	Release media	Reference
Plastic toys	NPs/NPEs	$2.78 \cdot 10^{-12}$ kg/m ² from hard plastics; $4.64 \cdot 10^{-12}$ kg/m ² from soft plastics	Water	IVL (2008)
Wooden toys	Chromium, copper, arsenate	0.01 kg/kg (1 %)	Soil	SFT (2004)

4.1 Plastic toys

According to IVL (2008), releases of NPs/NPEs from plastics to storm water can be calculated by using equation:

$$E = A \cdot E_f$$

E = emission (kg)

A = used amount of plastics annually (m²)

E_f = emission factor, $2.78 \cdot 10^{-12}$ kg/m² from hard plastics and $4.64 \cdot 10^{-12}$ kg/m² from soft plastics

The weight of PVC plastics can be assumed to be 2000 g for an area of 1 m² with a thickness of 1.5 mm. There was no distinction between product groups.

4.2 Wooden toys

The annual releases from treated wooden play structures to the environment can be roughly estimated by using equation:

$$E = A \cdot E_f$$

E = emission (kg)

A = amount of substance used (proportion in CCA) (kg)

E_f = emission factor (kg/kg)

According to KLIF (SFT 2004), the releases of arsenic, chromium and copper from wood preservation are estimated to be 0 % to air, 0 % to water and 30 % to soil during time period of 30-50 years (1 % per year for 30 years).

5 Restrictions

5.1 Regional restrictions

Precaution is needed because of children's exposure to hazardous substances present in toys. It has been observed that, at the moment, information on the chemical content of toys is incomplete and that harmonization of international toy standards is needed due to increasing international trade, internet commerce and differences in toy safety standards. There are also problems with low quality toy donations to developing countries. Use of substances that are likely to cause adverse effects (e.g. lead and mercury) should be phased out from toys. Proper labelling and information sheets of toys are necessary. Women in Europe for a Common Future (WECF) has published a safe toys guide which helps consumers to identify possible chemicals in different toy categories and their possible risks.

The European Union

Within the EU, regulations on toys are harmonized, based on the Toys Directive (88/378/EEC) according to which toys must not contain dangerous chemical substances or preparations within the meaning of Directive 67/548/EEC relating to classification, packaging and labelling of dangerous substances and Directive 88/379/EEC relating to classification, packaging and labelling of dangerous preparations, in amounts which may harm the health of children using them. Toys are also regulated under the Directive 2002/95/EC on the use of certain hazardous substances in electrical and electronic equipment (RoHS). For more information about the RoHS Directive, see the Case study on electrical and electronic products. There are no regulations for the content of hazardous components, e.g. phthalates, in toys for pets.

References: Brandt Nielsen et al. 2005, Van Engelen et al. 2006, IFCS 2006b, Müller et al. 2006, UNEP 2008, WECF 2009

Toys Directive

Directive 88/378/EEC on the safety of toys includes safety criteria for articles defined as toys as well as bioavailability (migration) limits for eight elements released from toys (Standard EN 71-3): antimony, arsenic, barium, cadmium, chromium, lead, mercury and selenium. Standard EN 71-5 on chemical toys covers e.g. plaster, glues, paints and solvents. EN 71-7 on finger paints covers e.g. pigments and preservatives used in the products. EN 71-9 on organic chemical compounds covers e.g. the migration of solvents, preservatives, plasticisers, flame retardants and colorants. There are 21 exemptions in the Directive for articles not considered as toys, e.g. fashion jewellery for children (see Appendix I).

The new Directive 2009/48/EC on the safety of toys adopted in 18 June 2009 will replace the 20 years old Toys Directive from year 1988. It will enhance the safety of toys by new and higher safety requirements to cope with recently identified hazards, especially regarding the use of chemical substances. The Directive will ban the use of substances that are carcinogenic, mutagenic or toxic to reproduction (CMR substances) in accessible parts of the toys. It will also ban the intentional use of certain particularly toxic heavy metals (like lead and mercury) and reduces the limit value of certain substances (including nickel). The use of fragrances that have strong allergenic potential will be prohibited and the ones that are potentially allergenic have to be properly labelled. The new Directive will also improve the

existing legislation regarding the marketing of toys produced in the EU and imported to the EU by strengthening manufacturers' and importers' responsibility for the marketing of toys and enhancing the market surveillance obligations of Member States.

With the CE mark the manufacturer guarantees that the essential safety requirements of the Toys Directive are fulfilled. It does not, however, guarantee the chemical safety of toys.

References: EC 1988, 2008, 2009a, Van Engelen et al. 2006, Konsumentverket 2006

REACH regulation

Annex XVII of the EU REACH regulation ((EC) No 1907/2006) includes restrictions on the manufacture, placing on the market and use of certain dangerous substances, preparations and articles.

Phthalates

Toys and childcare articles containing certain phthalates were prohibited to be placed on the market throughout the European Union by a temporary Decision 1999/815/EC in 1999. This was done after concerns from several Member States (raised in Nordic countries) about phthalates released from toys and ingested by children when chewing plastic toys as well as the possible adverse health effects of these substances (EC 2009b; EA 2005). The prohibition covered six phthalates (di-iso nonyl phthalate (DINP), di (2-ethylhexyl) phthalate (DEHP), dibutyl phthalate (DBP), di-iso-decyl phthalate (DIDP), di-n-octyl phthalate (DNOP) and butylbenzyl phthalate (BBP)) of one or more existing in the article at concentration of more than 0.1 % by weight and intended to be placed in the mouth by children under three years of age. The import of such products was also prohibited.

Despite the concerns over the possible health and environmental risks of phthalates, the EU Risk Assessment report from 2003 indicated that DINP does not pose a risk to human health or the environment. The conclusions were agreed by the member states of the European Union and the European Commission and were subsequently published in the Official Journal of the European Union and on the European Commission's Joint Research Centre website.

A permanent ban was established in 2005 after a series of risk assessments (EC 2009b, 2006). Although, the EU risk assessment on DINP concluded it was safe to use, the Opinion by the Scientific Committee on Toxicity, Ecotoxicity and the Environment in 2004 overruled the report (EA 2005). According to the Annex XVII of the REACH regulation, DEHP, DBP and BBP shall not be used in toys and childcare articles at a concentration more than 0.1 % by mass of the plasticised material. DINP, DIDP and DNOP shall not be used in toys and childcare articles that can be placed in the mouth by children at a concentration more than 0.1 % by mass of the plasticised material. The placing on the market of these products is also prohibited.

Arsenic

The Annex XVII prohibits the use of CCA treated wood in applications that are likely to result in repeated skin contact, including play structures (EC 2006, IFCS 2006a). It does not apply to existing structures that were in use or placed on the market before 30 September 2007.

Creosote

According to the Annex XVII, creosote shall not be placed on the market, or used, as a substance or in mixtures for the treatment of wood. Exemptions include industrial installations, except in toys and in playgrounds. The placing on the market does not apply to wood treated with creosote wash oil before 31 December 2002 and placed on the second-hand market for re-use. (EC 2006)

There are no restrictions for the use of NPEs in plastics in the EU legislation.

References: EC 2009b, 1999, 2005, ECB 2003, Van Engelen et al. 2006, IFCS 2006a, IVL 2008

5.2 National legislation

The US Child Protection Act from 1966, which was later changed to the Federal Hazardous Substances Act (FHSA) bans the use of hazardous substances in toys.

Maine has a legislation adopted in 2008 called Maine's Act to Protect Children's Health and the Environment from Toxic Chemicals in Toys and Children's Products, which will provide list of chemicals of high concern. Manufacturers and distributors will be required to give notification to the state on the use of listed chemicals on "children's products" (broad term including a number of consumer products) sold in the state.

Washington has also a legislation adopted in 2008 called Washington's Children's Safe Products Act, which includes phasing-out of the use of lead, cadmium and phthalates in "children's toys and other products". The law also provides identification of high priority chemicals with high concern for children. The manufacturers are required to make notification to the state of the products that contain these high priority chemicals.

In the United States, the use of paint containing more than 0.06 % (600 ppm) of lead by weight is prohibited in children's jewellery. New standards coming into force on 14 August 2009 require that any article designed or intended for the use of children at age of 12 or younger must not contain more than 300 ppm of lead by weight in any part of the item. In California, a limit value of 0.06 % is set for the lead content of base metal in children's jewellery by law starting from September 2007. The lead content of surface paint used in toys and other children's products is lowered to maximum of 0.009 % (90 ppm) of lead by weight. The Consumer Product Safety Commission has also used the value as a guideline for children's jewellery and has proposed it as a federal regulation. A regulation for the adult's jewellery took effect on March 2008 in California. According to the U.S. Consumer Product Safety Commission, accessibility of lead to acid leaching, which simulates the dissolving of lead when ingested, must not exceed the value of 175 µg. Some U.S. importers test their products but they may have difficulties to meet the standards. The Chinese government has limit values for the lead content of toys, but not for jewellery.

Based on several studies, the U.S. Consumer Product Safety Commission (CPSC) denied the 1998 petition to ban the use of PVC (and thus the plasticizers, including DINP) in toys and other products intended for use by children five years of age and under.

California has introduced a legislation banning the use of certain phthalates in toys and child care articles designed for children under three years of age. The law, which took effect in the beginning of year 2009, prohibits the manufacture, sale and distribution of toys and child care products containing more than 0.1 % of di-(2-ethylhexyl) phthalate (DEHP), dibutyl phthalate (DBP) or benzyl butyl phthalate (BBP). It also bans toys and child care articles that can be put in mouth containing more than 0.1 % of diisononyl phthalate (DINP), diisodecyl phthalate

(DIDP) or di-*n*-octyl phthalate (DNOP). Manufacturers must use the least toxic alternative when replacing these phthalates. Besides EU, at least 14 other countries have prohibited the use of certain phthalates in children's articles.

Germany has proposed an amendment to its Consumer Goods Ordinance for banning the use of hexavalent chromium compounds from all leather made consumer products. The new law would include besides textiles (See Case study on textiles) also leather toys. Canada has the Hazardous Products (Toys) Regulation, which also addresses the chemicals found in toys.

Nordic countries:

- Finland: Products that contain more than 0.25 % (2500 mg/kg) of lead in paint are classified as hazardous waste. There is no limit value for lead as an alloy in products.
- Sweden: According to the Swedish Toy Safety Act and Toy Safety Ordinance, toys must not contain hazardous substances that pose a risk to human health (Keml 2009). The information requirement stated in the Chemical Products Ordinance also applies to toys, e.g. the content of fragrances, preservatives and formaldehyde in Sweden.

Norway and 12 other European countries are controlling the content of heavy metals (e.g. lead and cadmium) in toys for children under three years of age. The toys are checked using a portable heavy metal detector and those containing high concentrations are further analysed in the laboratory. The joint report of the surveillance from the 13 European countries will be published in 2010.

References: Babich et al. 2004, ChemicalWatch 2009, Fairclough 2007, Hileman 2007, ICCM2 2008, IFCS 2006a, IVL 2008, Järvinen et al. 2003, Konsumentverket 2006, Massey et al. 2008, SFT 2009, Weidenhamer & Clement 2007

5.3 Industry initiatives

The Toy Industry Association (TIA) sponsored the first voluntary toy safety standard (ASTM F963) in the United States with the National Bureau of Standard. This standard, taken over by the American Society of Testing and Materials (ASTM) in 1980, has been also used as a basis for toy regulation in other countries. The ISO standard 8124 is a harmonized voluntary standard for international use on safety of toys. Many countries, including China and Korea, have adopted the standard. The ASTM F963 and the ISO 8124 standards, like EN 71, include migration of harmful substances (e.g. heavy metals).

TIA has made a recommendation to the CPSC for a new testing protocol in order to verify the limits for lead in paint and similar surface coatings on toys and children's products (TIA 2009). The limit values are defined in the Consumer Product Safety Improvement Act (CPSIA), which was adopted in 10 February 2009. The CPSIA requires the CPSC to begin the enforcement of new standards for lead and phthalates on children's articles. TIA has also launched the Electronic Certification System (ECS), which is a web-based platform to help the manufacturers and importers of toys to meet the requirements of the CPSIA. ECS is part of the TIA's new Toy Safety Certification Program (TSCP).

In some countries the industry has voluntarily decided not to use phthalates in teethingers, pacifiers and toys intended to be used by children under three years of age. There is an

unregulated "phthalate free" label used in some products. Studies have indicated that some of the labelled products may still contain measureable concentrations of phthalates.

In the US, the industry voluntarily removed CCA treated wood used for residential purposes from the market in 2003. In Japan, the industry voluntarily ended the use of lead paint in toys in 1960.

The Consumer Action Guide to Toxic Chemicals in Toys is a database for consumers, maintained by the Ecology Center of Ann Arbor, a non-governmental organization in Michigan USA. The database contains test results of selected substances for over 1200 products.

There have been voluntary industry initiatives to reduce the use of NPES plastics in the EU.

References: IFCS 2006a, IVL 2008, Massey et al. 2008

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7 Appendixes

7.1 Appendix I: Articles not regarded as toys

Annex I of the Toys Directive 2009/48/EC provides a list of products that are not regarded as toys (EC 2009a):

1. Decorative objects for festivities and celebrations
2. Products for collectors, provided that the product or its packaging bears a visible and legible indication that it is intended for collectors of 14 years of age and above. Examples of this category are:
 - (a) detailed and faithful scale models;
 - (b) kits for the assembly of detailed scale models;
 - (c) folk dolls and decorative dolls and other similar articles;
 - (d) historical replicas of toys; and
 - (e) reproductions of real fire arms.
3. Sports equipment, including roller skates, inline skates, and skateboards intended for children with a body mass of more than 20 kg
4. Bicycles with a maximum saddle height of more than 435 mm, measured as the vertical distance from the ground to the top of the seat surface, with the seat in a horizontal position and with the seat pillar set to the minimum insertion mark
5. Scooters and other means of transport designed for sport or which are intended to be used for travel on public roads or public pathways
6. Electrically driven vehicles which are intended to be used for travel on public roads, public pathways, or the pavement thereof
7. Aquatic equipment intended to be used in deep water, and swimming learning devices for children, such as swim seats and swimming aids
8. Puzzles with more than 500 pieces
9. Guns and pistols using compressed gas, with the exception of water guns and water pistols, and bows for archery over 120 cm long
10. Fireworks, including percussion caps which are not specifically designed for toys
11. Products and games using sharp-pointed missiles, such as sets of darts with metallic points

12. Functional educational products, such as electric ovens, irons or other functional products operated at a nominal voltage exceeding 24 volts which are sold exclusively for teaching purposes under adult supervision
13. Products intended for use for educational purposes in schools and other pedagogical contexts under the surveillance of an adult instructor, such as science equipment
14. Electronic equipment, such as personal computers and game consoles, used to access interactive software and their associated peripherals, unless the electronic equipment or the associated peripherals are specifically designed for and targeted at children and have a play value on their own, such as specially designed personal computers, key boards, joy sticks or steering wheels
15. Interactive software, intended for leisure and entertainment, such as computer games, and their storage media, such as CDs
16. Babies' soothers
17. Child-appealing luminaires
18. Electrical transformers for toys
19. Fashion accessories for children which are not for use in play

7.2 Appendix II: Children's exposure to hazardous substances

Exposure to the chemical is affected by the intended use and reasonably anticipated misuse of the toy. There is also a risk that children playing with toys designed for animals may be exposed to hazardous components (Brandt Nielsen et al. 2005).

Exposure pathways

Chemical exposure to children from toys poses a potential health hazard. The chewing, licking and swallowing behaviour of children can be a common source of toxic releases from toys (Kumar & Pastorre 2007). The wide range of toys results in many different exposure scenarios (Van Engelen et al. 2006). On the basis of Van Engelen et al. (2006), five general exposure scenarios cover the most relevant ways of exposure to chemicals in toys: direct ingestion, mouthing, inhalation via evaporation, inhalation via dust or spray, and skin contact.

Direct ingestion

Direct ingestion of the toy and toy material can be assumed to occur mainly by children under three years of age due to the oral exploration behaviour of this age (Van Engelen et al. 2006).

Mouthing

Mouthing of toys can also be assumed to occur mainly by children under three years of age (Van Engelen et al. 2006). Some toys available on the market are specifically designed to be mouthed, like teething rings. Although some toys may have such dimensions that they cannot be placed in the mouth, the ridges can still be sucked on. Also, some toys intended for children over three years of age are intended to be placed in the mouth.

Inhalation via evaporation

Many toys can release chemicals in the air via evaporation, e.g. the solvent in a felt pen (Van Engelen et al. 2006). The chemical would need to be quite volatile in order to evaporate and to be available for inhalation. That is why this route of exposure is not relevant for elements. This route is less likely to be relevant for systemic exposure if oral exposure also occurs.

Inhalation via dust or spray

Some toys may release significant amounts of dust, like plaster mix and crayons (e.g. when beating out a brush) (Van Engelen et al. 2006). Some toys may also release chemicals in the air via a spraying system, although at present, very few examples of such toys are known.

Skin contact

Most of the toys will at some point contact the skin (Van Engelen et al. 2006). Many toys are handled with the hands and some may also be contacted by other body parts, e.g. foot contact with a canvas on which children may jump as well as arm and leg contact with costumes. Dermal exposure is especially relevant for sensitizing elements like nickel. For systemic exposure, this exposure route is probably not very relevant for elements due to very low dermal uptake.

7.3 APPENDIX III: Exposure to lead in low cost jewellery

Table A2.1 Nitric acid extractable lead, accessible lead and lead content of the coatings of selected jewellery items (Yost & Weidenhamer 2008)

Sample code	Sample type ^a	Nitric acid extractable Pb (µg) per bead	Accessible Pb (µg) per bead			Total accessible Pb (µg)		Estimated Pb content (%) of coating
			1 h	2 h	3 h	Per bead	Per item	
P36	B	30.8	17.8	3.00	2.25	23.0	69.0	14
P41	B	32.5	10.2	2.25	1.50	14.0	336	6.9
P32B	E	34.8	17.5	3.50	1.75	22.8	91	3.5
P33	B,E	42.6	16.2	2.50	2.00	20.8	1290	4.8
P40	B	76.2	39.8	6.50	2.50	48.8	975	10
P70	B	99.9	7.75	1.25	0.00	9.00	216	11
M106	B,E	145	30.8	4.00	3.50	38.2	956	13
M105	N	176	22.0	2.50	3.50	28.0	1090	23
P61	E	195	3.00	0.75	0.00	3.75	7.5	Lost

Samples are arranged on the basis of increasing nitric acid extractable lead.
^a B = bracelet; E = earring; N = necklace.

Table A2.2 Summary of lead analyses for all tested jewellery pieces in study by Weidenhamer & Clement (2007)

	No. pieces	No. assays	Mean % Pb	Lead content, wt%					
				<0.06%	0.06-3%	3-10%	10-50%	50-80%	>80%
Anklet	1	1	0.02	1	0	0	0	0	0
Bracelet	46	62	50.2	21	1	0	5	8	27
Earrings	15	16	30.1	8	1	1	0	2	4
Hair	5	5	35.9	2	1	0	0	0	2
Accessories									
Key Chain	35	36	60.5	8	3	0	0	2	23
Necklace	21	24	11.4	20	1	0	0	0	3
Pin	5	6	47.6	3	0	0	0	0	3
Ring	4	4	63.1	1	0	0	0	1	2
Other	7	9	47.9	3	1	0	0	0	5
Total	139	163	44.0	67	8	1	5	13	69

Table A2.3 Acid leachable lead content of selected low-cost jewellery pieces (Weidenhamer & Clement 2007)

Sample type	Extraction time (h)	Lead extracted (µg)	Total lead extracted (µg)
Bracelet charm	1	156	770
	2	226	
	3	388	
Bracelet charm	1	418	2286
	2	707	
	3	1161	
Bracelet charm	1	173	1123
	2	324	
	3	626	
Bracelet charm	1	0	4
	2	0	
	3	4	
Bracelet link	1	215	1079
	2	388	
	3	476	
Bracelet charm	1	192	242
	2	39	
	3	11	
Pin charm	1	26	41
	2	10	
	3	5	
Pin charm	1	31	151
	2	44	
	3	76	
Key chain charm	1	23	730
	2	192	
	3	515	
Key chain charm	1	6	91
	2	26	
	3	59	

Table A2.4 Summary of results from surface wipe experiments according to lead exposure category (Maas et al. 2005)

Jewelry Type	Sample size	Mean Pb in wipe (µg)	Percent LE (<1.0µg)	Percent ME (1.0-10.0µg)	Percent HE (10.0-50.0µg)	Percent VHE (>50.0µg)
Anklet/ring	1	0.06	100.00	0.00	0.00	0.00
Bracelet	24	11.86	33.33	41.67	16.67	8.33
Bracelet/earring	1	0.15	100.00	0.00	0.00	0.00
Earring	4	2.30	25.00	75.00	0.00	0.00
Necklace	38	5.53	28.95	57.89	10.53	2.63
Pendant	15	7.29	20.00	46.67	33.33	0.00
Ring	14	541.97	35.71	28.57	21.42	14.29

LE= low exposure, ME= moderate exposure, HE= high exposure, VHE= very high exposure

7.4 APPENDIX IV: Exposure to diisononyl phthalate (DINP)

Table A2.5. Migration of DINP from PVC children's products (Babich et al. 2004)

Description	Number tested	% DINP	Migration rate ($\mu\text{g}/10\text{cm}^2/\text{min}$)
Doll's face	2	35.5	3.2
Corner cushion	3	39.4	4.2
Blue seat	6	29.4	2.9
Blue doll	3	25.3	2.7
Yellow duck	3	29.3	6.1
Tub toy	3	35.9	1.1
Book	3	22.2	1.5
Green whale	3	39.3	4.0
Bacon	3	34.2	1.8
Donut	3	29.0	6.8
Egg	3	36.4	3.7
French fries	3	28.9	10.8
Ice cream	3	27.5	2.0
Lettuce	3	27.4	4.6
Pizza	3	32.3	11.1
Spaghetti	3	35.7	4.3
Tomato	2	31.8	6.6
Doll's leg	3	32.8	6.5
Doll's face	1	26.6	2.2
Cape	3	19.5	1.0
Ball (protrusion)	3	26.8	3.2
Doll's face	3	32.2	3.5
Large reptile	1	12.9	2.0
Doll's face	1	30.0	1.6
Mean		30.0	4.1
Median		29.7	3.4
SD		6.2	2.7

Table A2.6. Estimated exposure ($\mu\text{g}/\text{kg}\cdot\text{d}$) to DINP from mouthing soft plastic toys according to different age groups (Babich et al. 2004)

	3–11 Months ^b	12–23 Months	24–36 Months
Mean	0.07 (0.03–0.13)	0.08 (0.04–0.14)	0.03 (0.01–0.06)
Median	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)
95th Percentile	0.44 (0.15–0.82)	0.53 (0.24–0.89)	0.12 (0.04–0.23)
99th Percentile	1.4 (0.74–2.4)	1.5 (0.89–2.3)	0.56 (0.17–1.6)

^a Calculated with Eq. (1). Assumes that DINP was present in 42% of soft plastic toys.

^b Numbers in parentheses are 95% confidence intervals.

ANNEX 2:

NATIONAL INVENTORIES AND ESTIMATES ON RELEASES FROM THE USE OF PRODUCTS

Information of the product related inventories from
Japan, Korea, the Netherlands and Norway

Japanese Inventory on Releases from Products

Japan has information in their PRTR for the years 2001-2006. Product groups included in this inventory are presented in Table A1.1, the share of releases from the use phase of end-products by chemical in 2006 is presented in Table A1.2 and the chemicals included in the Japanese PRTR in Table A1.3. Japan indicated that the following product sources are not included in the estimates: algaecides, plasticizing agent, fire-retarding material and ammunition. The following tables include product related sources (i.e. industrial and fuel combustion sources are excluded).

Table A2.1 Japanese Inventory on releases from the use of products in the PRTR 2001-2006 (industrial and fuel consumption processes excluded)

Product group	Env.com- partment A=air L=soil	Chemical code (see Table A.1.3 for explanation)
Pesticides	A, L	1 Zn, 12,18,20,24,34,35,36,37,38,39,40,43,49 Mg, 50,51,53,57,63,75,76,78,79,81,82,90,92,93,97,98,105, 106,107,108,110,111,122,125,126,129,130,131,136,137,141,142,143,146,147,148,150,151,152,153,154,155, 156,161,165,167,169,170,172,173,174,180,183,184,185,188,189,190,192,193,194,195,196,198,199,204,207 Cu, 214,216,220,224,227,245,246,247,249 Zn, 250,257,267,270,274,275,276,277,278,279,280,281,284,288,289,291,299,301,304,307,308,309,322,324,325, 328,329,330,331,332,333,334,342,348,349,350
Insecticides	A, W, L	18,24,40,43,63,67,139,140,167,185,186,192,193,194,224,254,267,304,307,308,309,326,329,330,350
Adhesives	A	4,5,6,63,102,227,310
Paints	A, L	30,40,43,44,63,69,177,224,227,230,270,272
Anti-fouling agents	A, W	63250304
Medicinal products	A, W	42310
Cleaning detergents and cosmetics (surfactants, neutralizers)	W, L	16,24,47,166,251,307,308,309
Moth repellents and deodorizers	A	140
Tobacco smoke	A	7,8,11,28,108,227,268,299,310
Trains (Engines, Brake Abrasion, etc.)	A	8,11,26 asbestos,40,63,227,268,298,299,310
Foam blowing agents for rigid urethane foam	-	217,85,132
Foam blowing agents for extruded polystyrene	-	232,84
Refrigerants for household refrigeration unit	-	232
Refrigerants for vehicle air conditioning unit	-	232
Refrigerants for household air conditioning unit	-	85

Resource Compendium Part IV: Releases from the Use of Products -
National Inventories and Estimates on Releases from the Use of Products

Table A2.2 Japanese releases from the use phase of end-products by chemical 2006.
Column A = Chemical/compound, column B = Estimated share (%) of total national releases of the chemical Not included: algacides, plasticizing agent, fire-retarding material, ammunition.

A	B
Zn 1	3%
4	55%
5	98%
6	44%
7	8%
8	100%
11	97%
12	7%
16	91%
18	100%
20	100%
24	97%
Antimony 25	0.004%
Asbestos 26	100%
28	94%
30	59%
34	100%
35	100%
36	100%
37	60%
38	100%
39	100%
40	41%
42	36%
43	37%
44	4%
47	92%
Mg 49	100%
50	100%
51	100%
53	100%
57	85%
Cd 60	0.11%
63	52%
67	12%
Cr 68	1%
Cr 69	18%
75	100%
76	100%
78	100%
79	100%
81	100%
82	100%
84	95%
85	95%
90	96%
92	100%
93	12%
94	100%
97	100%
98	100%
99	58%
Co 100	0.07%
102	10%
105	100%
106	100%
107	100%
108	15%
110	98%
111	100%
121	98%

122	100%
A	B
124	19%
125	100%
126	100%
129	100%
130	100%
131	100%
132	85%
136	100%
137	100%
139	61%
140	100%
141	100%
142	100%
143	100%
144	63%
146	100%
147	100%
148	100%
150	100%
151	100%
152	100%
153	100%
154	100%
155	100%
156	100%
161	100%
162	13%
165	100%
166	100%
167	100%
169	100%
170	100%
172	2%
173	100%
174	100%
Hg 175	45%
177	44%
Se 178	12%
180	100%
183	100%
184	100%
185	100%
186	100%
188	100%
189	100%
190	100%
192	100%
193	100%
194	100%
195	100%
196	100%
198	95%
199	100%
204	98%
Cu 207	4%
214	100%
216	100%
217	99%
220	100%
224	59%
227	34%

Pb 230	1%
A	B
Ni 232	0.17%
245	100%
Cu 246	100%
247	100%
Zn 249	100%
250	100%
251	93%
As 252	0.04%
254	0.03%
257	100%
267	100%
268	95%
270	24%
272	0.36%
274	100%
275	100%
276	100%
277	100%
278	100%
279	100%
280	100%
281	100%
283	18%
284	100%
286	68%
288	82%
289	100%
291	100%
Beryllium 294	62%
298	100%
299	92%
301	100%
304	26%
307	97%
308	80%
309	79%
310	96%
Mg 311	0.02%
322	100%
324	100%
325	100%
326	100%
328	100%
329	100%
330	100%
331	100%
332	100%
333	100%
334	100%
342	100%
348	100%
349	100%
350	100%

Resource Compendium Part IV: Releases from the Use of Products -
National Inventories and Estimates on Releases from the Use of Products

Table A2.3 Chemicals in the Japanese inventory

PRTR	CAS No.	Chemicals	
1	-	zinc compounds (water-soluble)	HM
2	79-06-1	acrylamide	VOC
3	79-10-7	acrylic acid	VOC
4	140-88-5	ethyl acrylate	VOC
5	2439-35-2	2-(dimethylamino)ethyl acrylate	VOC
6	96-33-3	methyl acrylate	VOC
7	107-13-1	acrylonitrile	VOC
8	107-02-8	acrolein	VOC
9	103-23-1	bis(2-ethylhexyl) adipate	VOC
10	111-69-3	adiponitrile	VOC
11	75-07-0	acetaldehyde	VOC
12	75-05-8	acetonitrile	VOC
13	78-67-1	2,2'-azobisisobutyronitrile	VOC
14	90-04-0	o-anisidine	VOC
15	62-53-3	aniline	VOC
16	141-43-5	2-aminoethanol	VOC
17	111-40-0	N-(2-aminoethyl)-1,2-	VOC
18	120068-37-3	5-amino-1-[2,6-dichloro-4-	VOC
19	61-82-5	3-amino-1H-1,2,4-triazole;	VOC
20	51276-47-2	2-amino-4-	VOC
21	591-27-5	m-aminophenol	VOC
22	107-18-6	allyl alcohol	VOC
23	106-92-3	1-allyloxy-2,3-epoxypropane	VOC
24	-	n-alkylbenzenesulfonic acid and	VOC
25	-	antimony and its compounds	HM
26	1332-21-4	asbestos	M
27	4098-71-9	3-isocyanatomethyl-3,5,5-	VOC
28	78-79-5	isoprene	VOC
29	80-05-7	4,4'-isopropylidenediphenol;	VOC
30	25068-38-6	polymer of 4,4'-	VOC
31	4162-45-2	2,2'-(isopropylidenebis[(2,6-	VOC
32	96-45-7	2-imidazolidinethione	VOC
33	13516-27-3	1,1'-	VOC
34	76578-14-8	ethyl 2-[4-(6-chloro-2-	VOC
35	25319-90-8	S-ethyl 2-(4-chloro-2-	VOC
36	36335-67-8	O-ethyl O-(6-nitro-m-tolyl) sec-	VOC
37	2104-64-5	O-ethyl O-4-nitrophenyl	VOC
38	40487-42-1	N-(1-ethylpropyl)-2,6-dinitro-3,4-	VOC
39	2212-67-1	S-ethyl hexahydro-1H-azepine-1-	VOC
40	100-41-4	ethylbenzene	VOC
41	151-56-4	ethyleneimine	VOC
42	75-21-8	ethylene oxide	VOC
43	107-21-1	ethylene glycol	VOC
44	110-80-5	ethylene glycol monoethyl ether	VOC
45	109-86-4	ethylene glycol monomethyl ether	VOC
46	107-15-3	ethylenediamine	VOC
47	60-00-4	ethylenediaminetetraacetic acid	VOC
48	12122-67-7	zinc N,N'	HM
49	12427-38-2	manganese N,N'	HM
50	8018-01-7	complex compounds of	VOC
51	85-00-7	1,1'-ethylene-2,2'-bipyridinium	VOC
52	62-44-2	4'-ethoxyacetanilide; phenacetin	VOC
53	2593-15-9	5-ethoxy-3-trichloromethyl-1,2,4-	VOC
54	106-89-8	epichlorohydrin	VOC
55	556-52-5	2,3-epoxy-1-propanol	VOC
56	75-56-9	1,2-epoxypropane; propylene	VOC
57	122-60-1	2,3-epoxypropyl phenyl ether	VOC
58	111-87-5	1-octanol	VOC
59	1806-26-4	p-octylphenol	VOC
60	-	cadmium and its compounds	HM
61	105-60-2	ε-caprolactam	VOC
62	576-26-1	2,6-xenolol	VOC
63	1330-20-7	xylene	VOC
64	-	silver and its water-soluble	HM
65	107-22-2	glyoxal	VOC
66	111-30-8	glutaraldehyde	VOC
67	1319-77-3	cresol	VOC
68	-	chromium and chromium(VI)	HM
69	-	chromium(VI) compounds	HM
70	79-04-9	chloroacetyl chloride	VOC
71	95-51-2	o-chloroaniline	VOC
72	106-47-8	p-chloroaniline	VOC
73	108-42-9	m-chloroaniline	VOC
74	75-00-3	chloroethane	VOC
75	1912-24-9	2-chloro-4-ethylamino-6-	VOC
76	51218-45-2	2-chloro-2'-ethyl-N-(2-methoxy-1-	VOC
77	75-01-4	chloroethylene; vinyl chloride	VOC
78	79622-59-6	3-chloro-N-(3-chloro-5-	VOC
79	119446-68-3	1-[(2-chloro-4-(4-	VOC
80	79-11-8	chloroacetic acid	VOC
81	51218-49-6	2-chloro-2',6'-diethyl-N-(2-	VOC
82	15972-60-8	2-chloro-2',6'-diethyl-N-	VOC
83	97-00-7	1-chloro-2,4-dinitrobenzene	VOC
84	75-68-3	1-chloro-1,1-difluoroethane;	VOC
85	75-45-6	chlorodifluoromethane; HCFC-22	VOC
86	2837-89-0	2-chloro-1,1,1,2-	VOC
87	-	chlorotrifluoroethane; HCFC-133	VOC
88	75-72-9	chlorotrifluoromethane; CFC-13	VOC
89	95-49-8	o-chlorotoluene	VOC
90	122-34-9	2-chloro-4,6-bis(ethylamino)-	VOC
91	107-05-1	3-chloropropene; allyl chloride	VOC
92	86598-92-7	4-chlorobenzyl N-(2,4-	VOC
93	108-90-7	chlorobenzene	VOC
94	76-15-3	chloropentafluoroethane; CFC-	VOC
95	67-66-3	chloroform	VOC
96	74-87-3	chloromethane; methyl chloride	VOC
97	94-74-6	(4-chloro-2-methylphenoxy)acetic	VOC
98	96491-05-3	2-chloro-N-(3-methoxy-2-thienyl)-	VOC
99	1314-62-1	divanadium pentaoxide	VOC

Resource Compendium Part IV: Releases from the Use of Products -
National Inventories and Estimates on Releases from the Use of Products

100	-	cobalt and its compounds	HM
101	111-15-9	2-ethoxyethyl acetate; ethylene	VOC
102	108-05-4	vinyl acetate	VOC
103	110-49-6	2-methoxyethyl acetate; ethylene	VOC
104	90-02-8	salicylaldehyde	VOC
105	102851-06-9	α-cyano-3-phenoxybenzyl N-(2-	VOC
106	51630-58-1	α-cyano-3-phenoxybenzyl 2-(4-	VOC
107	52315-07-8	α-cyano-3-phenoxybenzyl 3-(2,2-	VOC
108	-	inorganic cyanide compounds	VOC
109	100-37-8	2-(diethylamino)ethanol	VOC
110	28249-77-6	S-4-chlorobenzyl N,N-	VOC
111	125306-83-4	N,N-diethyl-3-(2,4,6-	VOC
112	56-23-5	tetrachloromethane	VOC
113	123-91-1	1,4-dioxane	VOC
114	108-91-8	cyclohexylamine	VOC
115	95-33-0	N-cyclohexyl-2-	VOC
116	107-06-2	1,2-dichloroethane	VOC
117	75-35-4	1,1-dichloroethylene; vinylidene	VOC
118	156-59-2	cis-1,2-dichloroethylene	VOC
119	156-60-5	trans-1,2-dichloroethylene	VOC
120	101-14-4	3,3'-dichloro-4,4'-	VOC
121	75-71-8	dichlorodifluoromethane; CFC-12	VOC
122	23950-58-5	3,5-dichloro-N-(1,1-dimethyl-2-	VOC
123	-	dichlorotetrafluoroethane; CFC-	VOC
124	306-83-2	2,2-dichloro-1,1,1-trifluoroethane;	VOC
125	106917-52-6	2',4-dichloro-α,α,α-trifluoro-4'-	VOC
126	82692-44-2	2-[4-(2,4-dichloro-m-toluylo)-1,3-	VOC
127	3209-22-1	1,2-dichloro-3-nitrobenzene	VOC
128	89-61-2	1,4-dichloro-2-nitrobenzene	VOC
129	330-54-1	3-(3,4-dichlorophenyl)-1,1-	VOC
130	330-55-2	3-(3,4-dichlorophenyl)-1-	VOC
131	94-75-7	2,4-dichlorophenoxyacetic acid;	VOC
132	1717-00-6	1,1-dichloro-1-fluoroethane;	VOC
133	75-43-4	dichlorofluoromethane; HCFC-21	VOC
134	96-23-1	1,3-dichloro-2-propanol	VOC
135	78-87-5	1,2-dichloropropane	VOC
136	709-98-8	3',4'-dichloropropionanilide;	VOC
137	542-75-6	1,3-dichloropropene; D-D	VOC
138	91-94-1	3,3'-dichlorobenzidine	VOC
139	95-50-1	o-dichlorobenzene	VOC
140	106-46-7	p-dichlorobenzene	VOC
141	71561-11-0	2-[4-(2,4-dichlorobenzoyl)-1,3-	VOC
142	58011-68-0	4-(2,4-dichlorobenzoyl)-1,3-	VOC
143	1194-65-6	2,6-dichlorobenzonitrile;	VOC
144	-	dichloropentafluoropropane;	VOC
145	75-09-2	dichloromethane; methylene	VOC
146	3347-22-6	2,3-dicyano-1,4-	VOC
147	50512-35-1	diisopropyl 1,3-dithiolan-2-	VOC
148	17109-49-8	O-ethyl S,S-diphenyl	VOC
149	640-15-3	S-2-(ethylthio)ethyl O,O-dimethyl	VOC
150	35400-43-2	O-ethyl O-4-(methylthio)phenyl S-	VOC

151	298-04-4	O,O-diethyl S-2-(ethylthio)ethyl	VOC
152	2310-17-0	O,O-diethyl S-(6-chloro-2,3-	VOC
153	34643-46-4	O-2,4-dichlorophenyl O-ethyl S-	VOC
154	950-37-8	S-(2,3-dihydro-5-methoxy-2-oxo-	VOC
155	121-75-5	O,O-dimethyl S-1,2-	VOC
156	60-51-5	O,O-dimethyl S-(N-	VOC
157	25321-14-6	dinitrotoluene	VOC
158	51-28-5	2,4-dinitrophenol	VOC
159	122-39-4	diphenylamine	VOC
160	102-81-8	2-(di-n-butylamino)ethanol	VOC
161	55285-14-8	2,3-dihydro-2,2-dimethyl-7-	VOC
162	-	dibromotetrafluoroethane;	VOC
163	87-62-7	2,6-dimethylaniline	VOC
164	95-64-7	3,4-dimethylaniline	VOC
165	62850-32-2	S-4-phenoxybutyl N,N-	VOC
166	1643-20-5	N,N-dimethyldodecylamine N-	VOC
167	52-68-6	dimethyl 2,2,2-trichloro-1-	VOC
168	4685-14-7	1,1'-dimethyl-4,4'-bipyridinium	VOC
169	1910-42-5	1,1'-dimethyl-4,4'-bipyridinium	VOC
170	85785-20-2	S-benzyl N-(1,2-dimethylpropyl)-	VOC
171	119-93-7	3,3'-dimethylbenzidine; o-tolidine	VOC
172	68-12-2	N,N-dimethylformamide	VOC
173	2597-03-7	ethyl 2-	VOC
174	3861-47-0	3,5-diiodo-4-	VOC
175	-	mercury and its compounds	HM
176	-	organic tin compounds	HM
177	100-42-5	styrene	VOC
178	-	selenium and its compounds	HM
179	-	dioxins	POP
180	533-74-4	2-thioxo-3,5-dimethyltetrahydro-	VOC
181	62-56-6	thiourea	VOC
182	108-98-5	thiophenol	VOC
183	77458-01-6	O-1-(4-chlorophenyl)-4-pyrazolyl	VOC
184	2636-26-2	O-4-cyanophenyl O,O-dimethyl	VOC
185	333-41-5	O,O-diethyl O-2-isopropyl-6-	VOC
186	119-12-0	O,O-diethyl O-6-oxo-1-phenyl-	VOC
187	13593-03-8	O,O-diethyl O-2-quinoxaliny	VOC
188	2921-88-2	O,O-diethyl O-3,5,6-trichloro-2-	VOC
189	18854-01-8	O,O-diethyl O-5-phenyl-3-	VOC
190	97-17-6	O-2,4-dichlorophenyl O,O-diethyl	VOC
191	2275-23-2	O,O-dimethyl S-2-[1-(N-	VOC
192	122-14-5	O,O-dimethyl O-3-methyl-4-	VOC
193	55-38-9	O,O-dimethyl O-3-methyl-4-	VOC
194	5598-13-0	O-3,5,6-trichloro-2-pyridyl O,O-	VOC
195	41198-08-7	O-4-bromo-2-chlorophenyl O-	VOC
196	26087-47-8	S-benzyl O,O-diisopropyl	VOC
197	1163-19-5	decabromodiphenyl ether	VOC
198	100-97-0	1,3,5,7-	VOC
199	1897-45-6	tetrachloroisophthalonitrile;	VOC
200	127-18-4	tetrachloroethylene	VOC
201	-	tetrachlorodifluoroethane; CFC-	VOC

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National Inventories and Estimates on Releases from the Use of Products

202	11070-44-3	tetrahydromethylphthalic	VOC
203	116-14-3	tetrafluoroethylene	VOC
204	137-26-8	tetramethylthiuram disulfide;	VOC
205	100-21-0	terephthalic acid	VOC
206	120-61-6	dimethyl terephthalate	VOC
207	-	copper salts (water-soluble,	HM
208	75-87-6	trichloroacetaldehyde	VOC
209	71-55-6	1,1,1-trichloroethane	VOC
210	79-00-5	1,1,2-trichloroethane	VOC
211	79-01-6	trichloroethylene	VOC
212	108-77-0	2,4,6-trichloro-1,3,5-triazine	VOC
213	-	trichlorotrifluoroethane; CFC-113	VOC
214	76-06-2	trichloronitromethane;	VOC
215	115-32-2	2,2,2-trichloro-1,1-bis(4-	VOC
216	55335-06-3	(3,5,6-trichloro-2-	VOC
217	75-69-4	trichlorofluoromethane; CFC-11	VOC
218	2451-62-9	1,3,5-tris(2,3-epoxypropyl)-1,3,5-	VOC
219	118-96-7	2,4,6-trinitrotoluene	VOC
220	1582-09-8	α,α,α -trifluoro-2,6-dinitro-N,N-	VOC
221	118-79-6	2,4,6-tribromophenol	VOC
222	75-25-2	tribromomethane; bromoform	VOC
223	3452-97-9	3,5,5-trimethyl-1-hexanol	VOC
224	108-67-8	1,3,5-trimethylbenzene	VOC
225	95-53-4	o-toluidine	VOC
226	106-49-0	p-toluidine	VOC
227	108-88-3	toluene	VOC
228	95-80-7	2,4-toluenediamine	VOC
229	52570-16-8	2-(2-naphthoxy)propionanilide;	VOC
230	-	lead and its compounds	HM
231	7440-02-0	nickel	HM
232	-	nickel compounds	HM
233	139-13-9	nitrilotriacetic acid	VOC
234	100-01-6	p-nitroaniline	VOC
235	628-96-6	nitroglycol	VOC
236	55-63-0	nitroglycerin	VOC
237	100-00-5	p-nitrochlorobenzene	VOC
238	86-30-6	N-nitrosodiphenylamine	VOC
239	100-02-7	p-nitrophenol	VOC
240	98-95-3	nitrobenzene	VOC
241	75-15-0	carbon disulfide	VOC
242	25154-52-3	nonylphenol	VOC/NP
243	-	barium and its water-soluble	HM
244	88-89-1	picric acid	VOC
245	1014-70-6	2,4-bis(ethylamino)-6-methylthio-	VOC
246	10380-28-6	bis(8-quinolinolato)copper; oxine-	HM
247	74115-24-5	3,6-bis(2-chlorophenyl)-1,2,4,5-	VOC
248	563-12-2	S,S'-methylene O,O',O'-	VOC
249	137-30-4	zinc bis(N,N'-	HM
250	64440-88-6	N,N'-	VOC
251	61789-80-8	bis(hydrogenated	VOC
252	-	arsenic and its inorganic	HM

253	302-01-2	hydrazine	VOC
254	123-31-9	hydroquinone	VOC
255	100-40-3	4-vinyl-1-cyclohexene	VOC
256	100-69-6	2-vinylpyridine	VOC
257	55179-31-2	1-(4-biphenyloxy)-3,3-dimethyl-	VOC
258	110-85-0	piperazine	VOC
259	110-86-1	pyridine	VOC
260	120-80-9	pyrocatechol	VOC
261	96-09-3	phenyloxirane	VOC
262	95-54-5	o-phenylenediamine	VOC
263	106-50-3	p-phenylenediamine	VOC
264	108-45-2	m-phenylenediamine	VOC
265	156-43-4	p-phenetidine	VOC
266	108-95-2	phenol	VOC
267	52645-53-1	3-phenoxybenzyl 3-(2,2-	VOC
268	106-99-0	1,3-butadiene	VOC
269	117-84-0	di-n-octyl phthalate	VOC
270	84-74-2	di-n-butyl phthalate	VOC
271	3648-21-3	di-n-heptyl phthalate	VOC
272	117-81-7	bis(2-ethylhexyl) phthalate	VOC
273	85-68-7	n-butyl benzyl phthalate	VOC
274	69327-76-0	2-tert-butylimino-3-isopropyl-5-	VOC
275	112410-23-8	N-tert-butyl-N'-(4-ethylbenzoyl)-	VOC
276	17804-35-2	methyl N-[1-(N-n-	VOC
277	122008-85-9	butyl (R)-2-[4-(4-cyano-2-	VOC
278	134098-61-6	tert-butyl 4-(((1,3-dimethyl-5-	VOC
279	2312-35-8	2-(4-tert-butylphenoxy)cyclohexyl	VOC
280	96489-71-3	2-tert-butyl-5-(4-tert-	VOC
281	119168-77-3	N-(4-tert-butylbenzyl)-4-chloro-3-	VOC
282	95-31-8	N-(tert-butyl)-2-	VOC
283	-	hydrogen fluoride and its water-	VOC
284	12071-83-9	polymer of N,N'-	VOC
285	353-59-3	bromochlorodifluoromethane;	VOC
286	75-63-8	bromotrifluoromethane; halone-	VOC
287	75-26-3	2-bromopropane	VOC
288	74-83-9	bromomethane; methyl bromide	VOC
289	13356-08-6	hexakis(2-methyl-2-	VOC
290	115-28-6	1,4,5,6,7,7-	VOC
291	115-29-7	6,7,8,9,10,10-hexachloro-	VOC
292	124-09-4	hexamethylenediamine	VOC
293	822-06-0	hexamethylene diisocyanate	VOC
294	-	beryllium and its compounds	HM
295	98-07-7	benzylidyne trichloride	VOC
296	98-87-3	benzylidene dichloride	VOC
297	100-44-7	benzyl chloride	VOC
298	100-52-7	benzaldehyde	VOC
299	71-43-2	benzene	VOC
300	552-30-7	1,2,4-benzenetricarboxylic 1,2-	VOC
301	73250-68-7	2-(2-benzothiazolyloxy)-N-	VOC
302	82-68-8	pentachloronitrobenzene;	VOC
303	87-86-5	pentachlorophenol	VOC

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304	-	boron and its compounds	VOC
305	75-44-5	phosgene	VOC
306	1336-36-3	polychlorinated biphenyls; PCBs	POP
307	-	poly(oxyethylene) alkyl ether	VOC
308	9036-19-5	poly(oxyethylene) octylphenyl	VOC
309	9016-45-9	poly(oxyethylene) nonylphenyl	VOC
310	50-00-0	formaldehyde	VOC
311	-	manganese and its compounds	HM
312	85-44-9	phthalic anhydride	VOC
313	108-31-6	maleic anhydride	VOC
314	79-41-4	methacrylic acid	VOC
315	688-84-6	2-ethylhexyl methacrylate	VOC
316	106-91-2	2,3-epoxypropyl methacrylate	VOC
317	105-16-8	2-(diethylamino)ethyl	VOC
318	2867-47-2	2-(dimethylamino)ethyl	VOC
319	97-88-1	n-butyl methacrylate	VOC
320	80-62-6	methyl methacrylate	VOC
321	126-98-7	methacrylonitrile	VOC
322	89269-64-7	(Z)-2'-methylacetophenone 4,6-	VOC
323	100-61-8	N-methylaniline	VOC
324	556-61-6	methyl isothiocyanate	VOC
325	2631-40-5	2-isopropylphenyl N-	VOC
326	114-26-1	2-isopropoxyphenyl N-	VOC
327	1563-66-2	2,3-dihydro-2,2-dimethyl-7-	VOC
328	2655-14-3	3,5-dimethylphenyl N-	VOC
329	63-25-2	1-naphthyl N-methylcarbamate;	VOC
330	3766-81-2	2-sec-butylphenyl N-	VOC
331	100784-20-1	methyl 3-chloro-5-(4,6-	VOC
332	33089-61-1	3-methyl-1,5-di(2,4-xylyl)-1,3,5-	VOC
333	144-54-7	N-methyldithiocarbamic acid;	VOC
334	2439-01-2	6-methyl-1,3-dithiolo[4,5-	VOC
335	98-83-9	α-methylstyrene	VOC
336	108-99-6	3-methylpyridine	VOC
337	61432-55-1	S-1-methyl-1-phenylethyl 1-	VOC
338	26471-62-5	methyl-1,3-phenylene	VOC
339	88-85-7	2-(1-methylpropyl)-4,6-	VOC
340	101-77-9	4,4'-methylenedianiline	VOC
341	5124-30-1	methylenebis(4,1-cyclohexylene)	VOC
342	88678-67-5	O-3-tert-butylphenyl N-(6-	VOC
343	298-81-7	9-methoxy-7H-furo[3,2-	VOC
344	120-71-8	2-methoxy-5-methylaniline	VOC
345	68-11-1	mercaptoacetic acid	VOC
346	-	molybdenum and its compounds	HM
347	470-90-6	2-chloro-1-(2,4-	VOC
348	2274-67-1	2-chloro-1-(2,4-	VOC
349	300-76-5	1,2-dibromo-2,2-dichloroethyl	VOC
350	62-73-7	dimethyl 2,2-dichlorovinyl	VOC
351	6923-22-4	dimethyl (E)-1-methyl-2-(N-	VOC
352	115-96-8	tris(2-chloroethyl) phosphate	VOC
353	25155-23-1	tris(dimethylphenyl) phosphate	VOC
354	126-73-8	tri-n-butyl phosphate	VOC

Korean Inventory on Releases from Products

The Korean inventory of releases from products includes release estimates of the following product groups (A= air, W= water, L=land, T=waste):

- Batteries (19 compounds): heavy metals (As, Cd, Cr, Cu, Pb, Mn, Hg, Ni, Zn) Al, Ba, Sb, Sn thionyl chloride, H₂SO₄, NaOH, KOH, dihexylphosphine oxide
- Household products (144 compounds): VOCs, POPs, acidifying compounds and nutrients
- Illuminators: Hg and its compounds

Table A2.4 Korean Inventory on releases for products, year 2006

Name of chemical / compound	A(kg/year)	W(kg/year)	L(kg/year)	T(kg/year)	Estimate of the completeness of information
[4,4'-(1-Methylethylidene)	0			94555	C
1,1,1-Trichloroethane	10230			859	C
1,1'-Methylenebis[4-	0			308	C
1,3-Butadiene	2			0	C
1,4-Dichlorobenzene	200			0	C
2,4-D	0			10046	C
2,6-Dimethylaniline	0			0	C
2,6-Di-tert-butyl-4-	0			31451	C
2-Ethoxyethanol	408054			0	C
2-Ethoxyethyl acetate	336097			0	C
2-Methoxyethanol	0			0	C
2-propanol	136738			90747	C
2-Propyn-1-ol	185			0	C
3,3'-Dichloro-4,4'-	0			5	C
4,4'-Bisphenol A	0			412	C
4,4'-Methylenedianiline	0			308	C
8-Methoxy-6,7-	0			0	C
Acephate	0			35820	C
Acetaldehyde	0			0	C
Acetic acid	2360			2994	C
Acrylonitrile	502			0	C
Aluminium and it's compound	0			5732353	C
Ammonia	30259			17621	C
Ammonium bifluoride	0			121	C
Aniline	1220			0	C
Antimony and its compounds				25105	C
Arsenic and its compounds				1195	C
Barium and its compounds	0			3346341	C
Benfurcarb	0			7183	C
Benomyl	0			111479	C
Benzene	47			0	C
Benzyl chloride	0			0	C
Benzylidimethyl octadecyl	0			135	C
Boron and its compounds	0			107344	C
Bronopol	0			76	C
Butane	1127350			477	C
Butylbenzyl phthalate	0			2641	C
C.I. acid red 114	0			592	C
Cadmium and its compounds	0			159871	C
Carbaryl	0			20974	C
Carbofuran	0			38180	C
Carbosulfan	0			14300	C
Cartap	0			65445	C
Chlorfenapyr	0			3740	C

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Chlorothalonil	0		110059	C
Chlorpyrifos	0		58034	C
Chromium and its compounds	0		1635	C
Cobalt and its compounds	0		9419	C
Copper and its compounds	0		1532400	C
Cyclohexane	613969		1359	C
Cyfluthrin	0		40518	C
Decamethrin	0		6540	C
Di(2-ethylhexyl) phthalate	0		1414156	C
Diazinon	0		130332	C
Dichloromethane	2860		0	C
Dichlorvos	0		202575	C
Difenoconazole	0		8637	C
Dimethoate	0		36355	C
Dimethylamine	1323		0	C
Diphenylmethane 4,4'-	0		1780	C
Dithianone	0		130099	C
Edifenphos	0		23803	C
Endosulfan	0		182684	C
EPN	0		152408	C
Ethoprophos	0		95786	C
Ethyl acetate	377926		1	C
Ethyl acrylate	0		0	C
Ethylbenzene	46849		16	C
Ethylene	18504		0	C
Ethylene oxide	0		0	C
Fenbutatin oxide	0		3933	C
Fenitrothion	0		252173	C
Fenothiocarb	0		2034	C
Fenvalerate	0		15114	C
Fipronil	0		2174	C
Folpet	0		30617	C
Formaldehyde	859		1	C
Fuming sulfuric acid	0		65	C
Furathiocarb	0		1381	C
Glutaraldehyde	0		47	C
Hexamethylene diisocyanate	0		60	C
Hydrogen chloride	1772		29660	C
Hydrogen fluoride	7		646	C
Hydrogen peroxide	9209		74802	C
Imibenconazole	0		5823	C
Iprobenfos	0		97530	C
Isophorone diisocyanate	0		1400	C
Isoprene	288		0	C
Lead and its compounds	0		45871571	C
Linuron	0		1198	C
Malathion	0		1485	C
Mancozeb	0		137587	C
Manganese and its	0		3018468	C
Mercury and its compounds			5462	C
Methacrylonitrile	0		0	C
Methidathion	0		45854	C
Methyl alcohol	5115261		1363	C
Methyl ethyl ketone	342323		5267	C
Methyl tert-butyl ether	34		6	C
Methylhydrazine	0		0	C
Mixture of trihexylphosphine			161	C
Molinate	0		76681	C
N,N''-1,6-hexanediylbis(N'-	0		2926	C
N,N-Dimethylformamide	0		0	C
N-Alkyldimethylbenzyl	0		0	C

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Naphtha	0		180273	C
Naphthalene	6		5	C
N-	760		5395	C
n-Hexane	144361		28	C
Nickel and its compounds			392635	C
Nitric acid	530		0	C
Nitrilotriacetic acid and its	0		1265	C
Nitrous acid, salts	0		8272	C
o-Toluidine	0		0	C
Paraquat salt	0		1515891	C
Permethrin	0		1490	C
Phenol	91507		0	C
Phenthoate	0		75937	C
Phenylenediamine	0		5413	C
Phorate	0		168014	C
Phosphorus	0		79	C
Potassium bromate	0		28025	C
Potassium hydroxide	0		1904528	C
Propargite	0		20751	C
Propylene	480		0	C
Pyridaben	0		4060	C
Sodium	0		288	C
Sodium fluoride	0		14252	C
Sodium hydroxide	0		5334994	C
Styrene	61427		2	C
Sulfur	0		135323	C
Sulfuric acid	0		43240809	C
Tebufenpyrad	0		1864	C
Tetrachloroethylene	4791		0	C
Tetrafluoroethylene	3215		15	C
Thiodicarb	0		3581	C
Thionyl chloride			52288	C
Thiophanate-methyl	0		109209	C
Thiourea	0		1538	C
Thiram	0		27300	C
Tin and its compounds	0		22714	C
Toluene	4831341		7290	C
Toluene 2,4-diisocyanate	0		410	C
Trichlorfon	0		14331	C
Trichloroethylene	7		656	C
Vanadium and its compounds	0		1024	C
Vinyl acetate	12480		0	C
Xylene(including o-,m-,p-	6224324		38415	C
Zeta cypermethrin	0		9045	C
Zinc and its compounds	0		2646891	C

The Netherlands' Inventory on Releases from Products

Table A2.5 The Netherlands, releases from the use of products included in the PRTR

Product	Release to A= air, W=water, L= land T=waste	List of chemicals released from this product	Years covered
Anaesthetics	A	Dinitrogenoxide	20
Wood protection at houses	A	Pentachlorophenol, dioxins	20
Desinfection of containers	A	Methylbromide	20
Smoking of cigarettes and cigars	A	Fine particles	20
Shooting of clay pigeons	L	Lead	20
Firework	A	Metal containing fine particles	20
Wood protection by creosote oil	A	PAH	20
Corrosion of zinc roofs, drinking water lines, greenhouses zinc protected safety rails and lampposts	A, W	Zn	10
Corrosion of zinc anodes in locks	A, W	Zn	20
Corrosion of lead slabs	A, W	Pb	20
Corrosion of stainless steel	W	Cr, Ni	20
Corrosion of drinking water lines	W	Cu	20
Hunting	W,L	Pb	10
Recreational fishing	W	Pb	10
Use of pesticides	W,L	Pb residues	10
Amount of releases from the use phase of end-products by chemical in 2006			
Name of chemical / Compound	Environmental compartment A= air, W=water, L= land T=waste	Estimate of the completeness of information A = all releases covered B = not all sources covered, please list which C= completeness unknown	Share (%) of total national releases of the chemical
Methyl bromide	A	A	50.00%
Fine particles	A	A	10.00%
PAH	A	A	
Zinc	W	A	
Lead	A,W,L	A	

Norwegian Inventory on Releases from Products

Norwegian inventories of releases from products are available for 1995-2006

(<http://www.miljostatus.no/Tema/Kjemikalier/Produkter/#>)

Table A2.6 Norwegian Inventory for Releases from Products (not all sources covered)

Name of chemical / compound	Environmental compartment A= air, W=water, L= land T=waste	Releases in 2006	Share (%) of total national releases of the chemical
As	L	25,685 ton	90 %
Pb	L, W	244,2 ton	95 %
Dichloroethane	A, W	0,036 ton	2 %
Phtalates		0,309 ton	100 %
Cd	L, W	0,130 ton	13 %
Cu	L, W, A	1114,1 ton	97 %
Cr	L	31,84 ton	89 %
Hg	L, W, A	196 kg	23 %
Medium chained chloorparafins	L, W, A	3,65 ton	100 %
Nonylphenol	W	0,009 ton	100 %
PAH	L, W, A	14,516 ton	6 %
Tetrachloroethylene	A, W	37,225 ton	100 %
Trichloroethene	A, W	48,830 ton	100 %
Cationic tenside	L, W	0,9 ton	Not available
Musk xylen	W, L	385 kg	Not available

Table A2.6 Norwegian inventory on releases from the use phase of end-products 1995-2006

Product	A= air, W=water, L= land T=waste	List of chemicals released from this product
Wood impregnation (telephone poles etc)	L, A	As, Pb, Cu, Cr, PAH
Wood impregnation agents	L	Cu, Cr, PAH, As
Lead shots	L	As,
Mineral fertilizers	L	As, Cu, Hg
Paint and laquer	W	Pb, Cr
Sand from sand blasting	L	Pb, Cr
Fishing tools	W	Pb
Laboratory chemicals	A, W, L	Dichloroethane, Hg, Tetrachloro-ethylene,
Anodes	W	Cd
Cadmium-plated products	L	Cd
Copper metal (incl contact wires for trains)	A, L	Cu
Pipes	W	Cu
Anti fouling paint	L, W	Cu
Impregnated closing nets	W	Cu
Pesticides	L	Cu
Brake blocks	L	Cu
Ammunition	L	Cu
Surface finishing	L	Cr
Materials for tooth fillings	L, A, W	Hg
Light sources	L, A, W	Hg
Measuring instruments	A	Hg
Granulated rubber (synthetic grass fields)	W	Nonyl phenols
Asphalt	W, A	PAH
Polish		PFOS
Impregnation of textiles	A, W	Tetrachloroethylene
Agents for removal of fat from metals	A, W	Tetrachloroethylene, trichloro-ethene
Glue	A, W	Tetrachloroethylene, trichloro-ethene
Cleaning agents	W	Nonyl phenols
EE-equipment	A, W	Brominated flame retardants

Construction materials, insulation	A, W	Brominated flame retardants
Transport	A, W	Brominated flame retardants

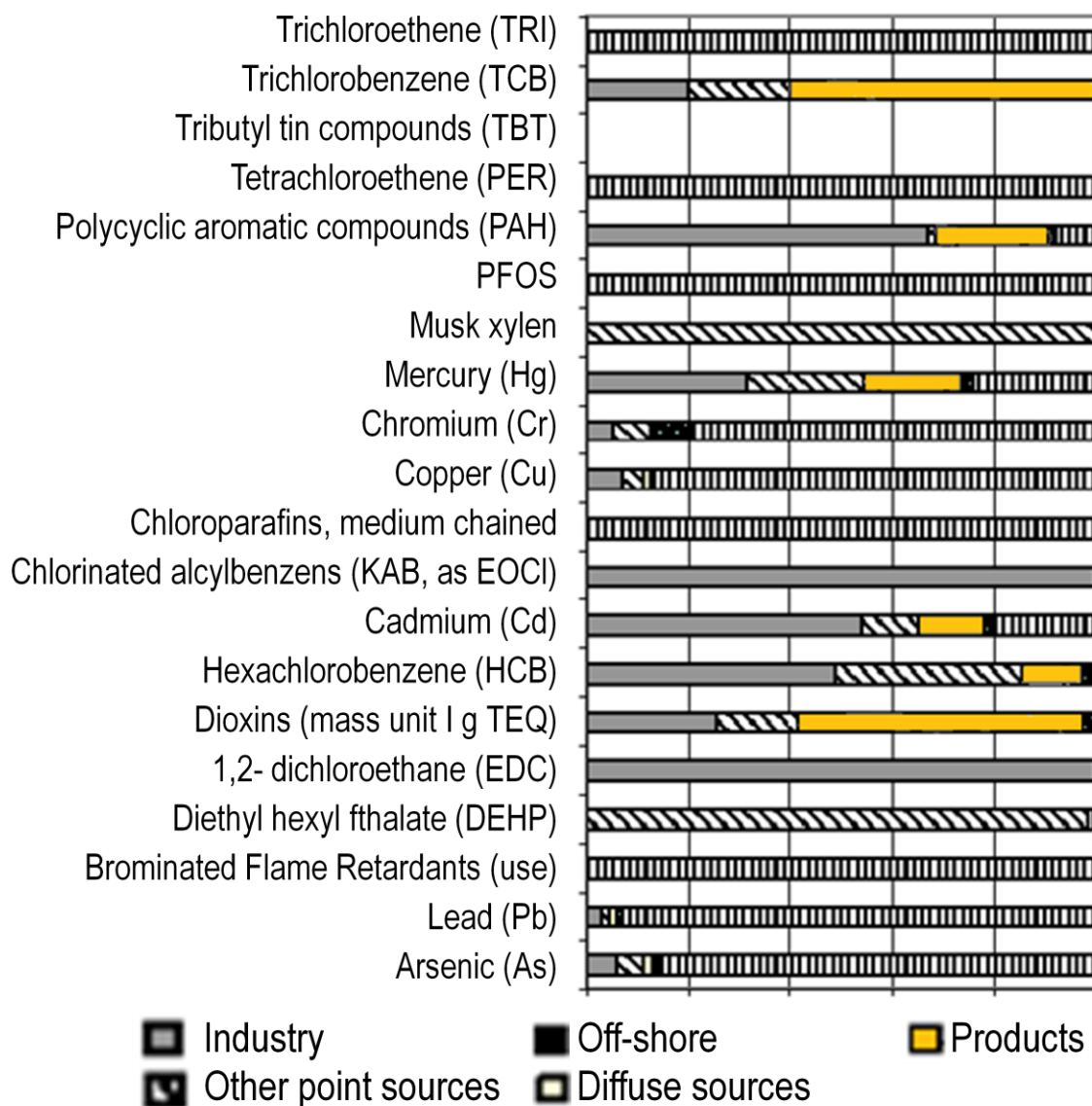


Figure A1. Estimation of the share of products of the total releases by chemical

ANNEX 3

SURVEY TO OECD COUNTRIES ON RELEASES FROM THE USE OF PRODUCTS

QUESTIONNAIRE ON THE INCLUSION OF RELEASES FROM THE USE PHASE OF END-PRODUCTS IN NATIONAL PRTRs

BACKGROUND FOR THIS QUESTIONNAIRE

The 36th OECD Joint Meeting on Chemicals Committee and Working Party on Chemicals, Pesticides and Biotechnology decided in 2004 to include work on releases from products in the 2005-2008 work programme of the Task Force on PRTRs. The 39th Joint Meeting agreed on the continuation of this work that would aim at development of tools and methods to help countries in incorporation of information on releases from products into their PRTRs, if they so wish. At the 42nd Joint Meeting the draft structure of the study was agreed upon. Further, it was agreed at the March 2008 meeting of the OECD Task Force on PRTRs to undertake a survey on the present status on information of releases from products that is available in PRTRs or other inventories and studies in OECD member countries.

The purpose of this questionnaire is to collect existing information on releases from the use phase of end-products in OECD member countries. In this study the use phase of end-products is defined to cover the time after the manufacturing of the end-product and before it will be discarded to become waste destined for recovery or disposal. This definition assumes that releases from industrial operations and waste management are already covered by the PRTRs. Consequently, the use of a product in the manufacturing process is not covered by this study, but the use of the same product by, for instance, consumers is covered.

The questionnaire is sent to the OECD Task Force on PRTRs. However, if you are not the right person to respond to this questionnaire, please kindly forward it to the correct recipient.

Finally, we would like to invite you to provide us with contact information of experts who could help us to achieve more detailed information of your country's situation at a later stage, if appropriate.

We would also appreciate any other comments, experiences, concerns and thoughts related to estimation of releases from products. You could provide these additional views after each group of questions.

SCHEDULE FOR THE SURVEY

You are invited to send your replies to Kristina Saarinen (kristina.saarinen@environment.fi), **by 30 September 2008**. Should you have any questions, please call +358 400 148715. The replies will be analysed and summarised in a report, which will be delivered to the OECD Task Force on PRTRs in March 2009.

CONTACT INFORMATION

Please provide your contact information, since in addition to your written response we may need to interview you by telephone to get your views on certain specific questions. In case you have national studies on releases from the use phase of certain end-products, you can choose to provide these studies or contact information of relevant experts.

Your name:
Your organisation:
Your country:
Your e-mail address:
Your telephone number:
Contact information of relevant experts regarding releases from products:

Thank you for your valuable assistance!

INFORMATION ON RELEASES FROM THE **USE PHASE OF END-PRODUCTS** AVAILABLE IN YOUR NATIONAL PRTR OR OTHER INVENTORY

NOTE: The assumption is that information of NMVOC (volatile organic compounds, excluding methane) emissions from the use of solvents is included in the national inventories, especially for those countries that are party to the UNECE Convention of Long-Range Transboundary Air Pollution. This information should therefore be excluded from the replies provided below.

1A. Do you currently collect information of releases from the use phase of end-products for your national PRTR or other inventory?	☐ NO ☐ YES If, yes, please proceed to question number 2.
1B. Are you planning to start including this information in your PRTR or other inventory in the future?	☐ NO ☐ YES

2A Overview of releases from the use phase of end-products included in your national inventories at the moment

Product	Release to A= air, W=water, L= land T=waste	List of chemicals released from this product	Included in P = PRTR I = Other inventory S = Study	Years covered by the PRTR/ inventory/study

Do you have legal restrictions for releases from the use phase of end-products?
☐ NO ☐ YES If, yes please provide information of the relevant restrictions

Remarks	

2B Amount of releases from the use phase of end-products by chemical in 2006

Name of chemical / compound	Environmental compartment A= air, W=water, L= land T=waste	Release year (preferably 2006 but if other year, please indicate)	Estimate of the completeness of information A = all releases covered B = not all sources covered, please list which C= completeness unknown	Estimate of the share (%) of total national releases of the chemical

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2C Other related information (please tick with X)		
Are you planning to include new products in to the inventory/PRTR? in the next years? If yes, please list which	Yes	No
List:		
Are you planning to include new chemicals in the inventory/PRTR? in the next years. If yes, please list which.		
List:		

QUESTIONS RELATED TO RELEASES OF LEAD FROM THE USE PHASE OF LEAD- CONTAINING END-PRODUCTS

1. Do you currently estimate releases of lead from the use phase of lead-containing end-products in your country? ☐ NO ☐ YES If, yes, please proceed to question number 3.			
2. Are there any legal restrictions on the use of lead in end-products in your country? (E.g. regarding ammunition, wheel balance weights, fishing gear, etc.)			
3. Please fill in possible information from your country regarding the following lead-containing products. If your inventory covers other products not listed in the rows below, please, add them on the next page.			
Lead containing product	Releases included in the PRTR/Inventory/Other study		Reference information
Ammunition	☐ NO ☐ YES	If yes, fill in the following information	
		Emissions per year:	Year:
		Emission factor:	Source of the emission factor
		Activity data:	Source of activity data:
		Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information			
Wheel balance weights	☐ NO ☐ YES	If yes, fill in the following information	
		Emissions per year:	Year:
		Emission factor:	Source of the emission factor
		Activity data:	Source of activity data:
		Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information			
Lead sheets	☐ NO ☐ YES	If yes, fill in the following information	
		Emissions per year:	Year:
		Emission factor:	Source of the emission factor
		Activity data:	Source of activity data:
		Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information			
Lead pipes	☐ NO ☐ YES	If yes, fill in the following information	
		Emissions per year:	Year:
		Emission factor:	Source of the emission factor
		Activity data:	Source of activity data:
		Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information			
Fishing gear	☐ NO ☐ YES	If yes, fill in the following information	
		Emissions per year:	Year:
		Emission factor:	Source of the emission factor
		Activity data:	Source of activity data:
		Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information			
Lead-acid batteries	☐ NO ☐ YES	If yes, fill in the following information	
		Emissions per year:	Year:
		Emission factor:	Source of the emission factor
		Activity data:	Source of activity data:
		Release media (air/water/soil)	Distribution factor to each media (if many recipients):

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Additional information		
Product	<i>Please, fill in the following information</i>	
	Emissions per year:	Year:
	Emission factor:	Source of the emission factor
	Activity data:	Source of activity data:
	Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information		
Product	<i>Please, fill in the following information</i>	
	Emissions per year:	Year:
	Emission factor:	Source of the emission factor
	Activity data:	Source of activity data:
	Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information		
Product	<i>Please, fill in the following information</i>	
	Emissions per year:	Year:
	Emission factor:	Source of the emission factor
	Activity data:	Source of activity data:
	Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information		
Product	<i>Please, fill in the following information</i>	
	Emissions per year:	Year:
	Emission factor:	Source of the emission factor
	Activity data:	Source of activity data:
	Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information		
Product	<i>Please, fill in the following information</i>	
	Emissions per year:	Year:
	Emission factor:	Source of the emission factor
	Activity data:	Source of activity data:
	Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information		

QUESTIONS RELATED TO RELEASES OF NONYLPHENOLS FROM THE USE PHASE OF NONYLPHENOL-CONTAINING END-PRODUCTS

1. Do you currently estimate releases of nonylphenols from the use phase of nonylphenol-containing end-products in your country? ☐ NO ☐ YES If, yes, please proceed to question number 3.		
2. Are there any legal or other restrictions on the use of nonylphenols in end-products in your country?		
3. Please fill in possible information from your country regarding releases of nonylphenols from the use phase of end-products:		
Product	Please, fill in the following information	
	Emissions per year:	Year:
	Emission factor:	Source of the emission factor
	Activity data:	Source of activity data:
	Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information		
Product	Please, fill in the following information	
	Emissions per year:	Year:
	Emission factor:	Source of the emission factor
	Activity data:	Source of activity data:
	Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information		
Product	Please, fill in the following information	
	Emissions per year:	Year:
	Emission factor:	Source of the emission factor
	Activity data:	Source of activity data:
	Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information		
Product	Please, fill in the following information	
	Emissions per year:	Year:
	Emission factor:	Source of the emission factor
	Activity data:	Source of activity data:
	Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information		
Product	Please, fill in the following information	
	Emissions per year:	Year:
	Emission factor:	Source of the emission factor
	Activity data:	Source of activity data:
	Release media (air/water/soil)	Distribution factor to each media (if many recipients):
Additional information		

ANNEX 4

OECD Emission Scenario Documents for the use of certain product groups

Source: OECD Environment Directorate, Chemical safety, Chemicals Hazard/Risk Assessment, Emission Scenario Documents (10.1.2010)

http://www.oecd.org/document/46/0,3343,en_2649_34373_2412462_1_1_1_1,00.html#b

Information provided in the documents printed **in bold** letters fall partly under the scope of this document but cannot be used directly in the work as information on releases from the use phase of products cannot be extracted from the other information.

Published ESDs

Wood preservatives (2004, revised 2009)
Water Treatment Chemicals (2004)
Photographic Industry (2004)
Rubber Additives (2004)
Textile Finishing (2004)
Leather Processing (2004)
Photoresist Use in Semiconductor Manufacturing (2004)
Lubricants and Lubricant Additives (2004)
Automotive spray application (2004)
Metal finishing (2004)
Antifoulants main document (2005)
Insecticides for Stables and Manure Storage Systems (2006)

Kraft Pulp Mills (2006)
Non-Integrated Paper Mills (2006)
Recovered Paper Mills (2006)
Insecticides, acaricides and products to control other arthropods for household and professional uses (2008)
Adhesive Formulation [April 2009]
Formulation of Radiation Curable Coatings, Inks and Adhesives Coating Industry (Paints, Lacquers and Varnishes) [July 2009]
Pulp, Paper and Board Industry [July 2009]
Transport and Storage of Chemicals [July 2009]

Draft ESDs under review (January 2010)

Industrial surfactants (March 2002)

Projects in preparation (January 2010)

Industry surfactants
Printing industry
Coatings industry; paints, lacquers and varnishes
Paper recycling
Blending of fragrance oils into consumer and commercial products
Adhesive formulation
Transport and storage of chemicals
Electronics industry
Insecticides used in households and for professional uses

ANNEX 5: IDENTIFICATION OF PRODUCTS WITH RELEVANT RELEASES TO THE ENVIRONMENT

Table A5.1. Environmentally Hazardous Releases from the Use of Products

The list includes products with releases to the environment during their use. Those printed in ***bold italics*** can be seen to have releases of relevant volumes and concentrations directly to the environment. K = products identified in the exposure index by Keml (Keml, 2005), C= products identified in the Nordic study on releases from the use of products.

Codes for the Remark Column: I = already included in PRTR reporting or other inventory, H = mainly health impacts, W = releases mainly to WWTPs, L = releases mainly to landfills.

Product group	Source	Remark	Release	Media	RET exists
Pesticides, fertilizers etc					
Insecticides	K	I= air	POPs	Soil, water, air	POPs
<i>Fungicide, fungistats (when lead to soil)</i>	K C	I = air	<i>HCB, HCBd, NP/NPE (DDT) (permethrin)</i>	<i>Soil</i> , air	HCB, Cu, NP/NPE, POP(air)
Weed control agents	K	I= air	POPs, NMVOCs	Soil, water	POP
Fish control agents	K		NH ₃ , heavy metals, POPs	Water	
Soil disinfection agent	K		ammonia compounds, NMVOCs	Soil	
Agent stimulating root growth (plants)	K		auxines (organic acids)	Soil	
Building and construction					
Flame retardants	K		minerals, halocarbons, phosphonium salts	Air, water, soil	
Oil removal agents	K	L	cationic polymers	soil	
Propellant gas, cooling agent	K	I=air	CO ₂ , F gas	Air	F gas
Odorizing agent (industry perfume)	K	I=air	NMVOCs	Air	NMVOC
Removing agents for paint, lacquer, varnish	K	I=air	detergents	Air, water	NMVOC (air)
Conservation agents for building stone	K		NMVOC, herbicides	soil	NMVOC
Sludge treatment agents	K		lime, chlorine compounds		
<i>Wood preservatives and impregnation agents (when lead to soil)</i>	K C	I =air	<i>PAH, Cr, As, Cu</i>	Air	PAH, CCA: Cr, As, Cu
Flooring material	K C	H	NP/NPE	soil	NP/NPE
Agents for prevention of sediment building	K		NMVOCs	soil	
<i>Road construction material, concrete</i>	K C		<i>NPE, PCB</i>	soil	
<i>Cleaning agents (when lead to soil)</i>	K C	A/H/W I=air	NPE, NMVOC (air)	soil	NPE, NMVOC(air)
Dust binding agent	K		acrylic polymers, petroleum resins, asphalt emulsions, salts, adhesives	soil	
Foaming agents (for liquids)	K		sodium laureth sulfate, detergents, titanium and zirconium hydroxide	water	
<i>Colouring agents</i> (NMVOCs compounds already included in inventories)	C		<i>NPEs, SCCPs, Cr, Pb</i> antifouling: Cr, TBT	water	NPEs, SCCPs, Cr, Pb, TBT
<i>Jointing compounds if lead to soil</i>	C	L, I= air	<i>phthalates, PAH, BFR</i>	Air, soil	BFR
<i>Sealants, fillers when lead to soil</i>	C	L, I=air	<i>PCB, MCCP, PCN</i>	Air, soil	MCCP, PCB
<i>Backfill material when lead to soil</i>	C	L, I=air	<i>SCCP</i>	Air, soil	
Isolation material	C	L	BRFs	soil	
<i>Roofing, flashings, pipes</i>	C		<i>Pb</i>	<i>Soil, water</i>	Pb
Textile, leather, furniture (when releases directly to water or soil)					
Flame retardants and additives	C	L, W	(penta)-BDE, BRF, HCBd	water	BRF
Removing agents for paint, lacquer, varnish (if not lead to treatment)	K C	(H/W)	detergents		NMVOC
<i>Wood impregnation agents when lead to soil</i>	K C	I= air	<i>PAH, Cr, As, Cu formaldehyde</i>	Air, soil	Cr, As, Cu
Glues	C	L, W	(NPEs)		NPEs
<i>Plastic furniture (in gardens)</i>	C	L, H	<i>phthalates, heavy metals</i>	Soil	
Furniture foam	C	H, L, I	pentaBDE	Air	BRF

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Identification of Products with Relevant Releases to the Environment

Carpets (if washed outside a sewerage system)	C	W, L	formaldehyde, phthalates, heavy metals, PFCs pesticides	Water	
Water/oil/stain/wrinkle resistant coatings	C	W, L	PFC, FTOH, fluorotelomers, formaldehyde	water	
Wooden furniture (in gardens)	C	H; L	Formaldehyde, As (Cr if in water), Pb (in paint particles)	Soil	Cr, Cu, As
Fishing and hunting					
Ammunition,gun powder, explosives (if remains in soil)	C		Pb	Soil	Pb
Fishing gear, lead containing weighs	C		Pb	Water	Pb
Car and boat care (when releases directly to soil or water)					
Windscreen washing medium	K	W, L I=air	NMVOC	Air, Soil	NMVOC (air)
Coolant	K	W, L	anti-foulants, corrosion inhibitors, buffering and pH agents, heavy metals	Soil	
Antifreezing compounds	K	W, L	glycols, additives	Soil	
Car care products, including shampoo	K	W, L I= NMVOC to air	NP/NPE, Cationic surfactants (DTDMAC, DSDMAC, DHTDMAC), NMVOC	Air, Soil	NP/NPE, Cationic surfactants (DTDMAC, DSDMAC, HTDMAC)
Underbody compounds, stone hit gards etc.	K	W, L I=air	Pb, alkyds, bitumen, rubber, wax, solvents	Soil	NMVOC (air)
Anti-knock additive	K	W, L	lead compounds, halogen compounds, solvents	Soil	NMVOC (air)
Pharmaceuticals and personal care products					
Deodorant	K	I=air	NMVOC	Air	NMVOC
Desinfection agents for surfaces in contact with food and animal feed	K	H	NPEs, EDTA, phthalates	Health	NPEs, EDTA phthalates
Propellant gas	K	I=air	CO ₂ , F gas	Air	F gas
Deodorizers	K	I = air	NMVOC	Air	NMVOC (air)
Cleaning agents	K	W, L	Musk compounds, NPEs		Musk compounds,NPEs
Pharmaceuticals		W, L	APIs (ActivePharmaceutical Ingredients), NPEs		APIs, NPEs
Toys, hobby, low-cost jewellery, office					
Softeners	K	H, L	PCB, NP/NPE		NP/NPE
Colour and ink pigments	C	H, L	Pb, azo-colorants, heavy metals		
Glue	K	H, L	(NP/NPE)		NP/NPE
Plastics	C	H, L	phthalates, Pb, bisphenol-A, BFR, Cr, chlorinated paraffins, NP/NPEs, organotins, triclosan		NP/NPE
Low-cost jewellery	C	H, L	Pb, Cd, Hg, Ni, amines, antimony		
Toys, general (leach)	C	H, L	BFR, formaldehyde, Pb, phthalates, parabens, aniline, bisphenol-A, Cd, chlorinated paraffins Cr, Cu, As, organotins, NP/NPEs, PFC, boron, DINP		
Balloons	C	H, L	nitrosatable substances (amines)		
Wooden toys	C	H, L	As (Cr Cu) formaldehyde, Pb		Cr, As, Cu, Pb
Packages and plastic bags					
Packages for foodstuff	K	H, L	FTOH	Health	
Plast (leach out e.g. plastic bags, if to soil)	C	L	phthalates, heavy metals HDPE,PCB, PAH	Soil	
Packaging material, if to soil	C	L	BPA, NP/NPE	Soil	NP/NPE
Electronics and electric equipment					
Electronics (enclosures, monitors, switches, relays)	C	L	Hg + other heavy metals, BFR	Air	Hg, BFR
Cables	K, C	L	MCCPs	Soil	MCCPs
Batteries (leakage during use)	C	L, I=air	Hg	Air	Hg
Measurement&control equipment (breakage)	C	L	Hg	Air	Hg
Capacitors, transformers (old/leach)	C	L, I=air	PCB	Air	PCBs
Light sources (breakage)	C	L	Hg	Air	Hg
Other					

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<i>Impregnation agents in fishing nets</i>	K		antifouling agents, waxes	Water	

Table A5.2 Environmental Relevance of Releases from Products. The table is developed from exposure index work by Kemi (Kemi, 2005).

Codes: l = low, m = medium, h = high, A=air, W= water, S= soil. Products with at least 2 "l"s or one "h" to water/air/soil printed in **bold** are considered in this study to be relevant. Out of these those not yet included into existing inventories are printed in ***bold italics*** and proposed to be included in the PRTs.

Product group	Relevant chemicals	Water	Air	Soil
Textile, leather, furniture				
Conservation medium for textile, paper, leather, rubber and polymers, protection against microbes	pentaBDE	m	l	l
Bleaching agents for textile	NMVOCs	l	l	l
Flame retardants	(penta)-BDE BRF- (A/W), HCBd	l	l	l
Pigments in paints and inks	NMVOCs	l	l	l
Agents used for grinding of textile, paper, leather		l	l	l
Impregnation agents for leather, paper, textile	Dimethylfumarate, Cr	l	l	l
<i>Impregnation agents for wood</i>	<i>PAH(A/S), Cr, As, Cu (S), formaldehyde</i>	m	l	m
Glues	NPEs	l	l	l
Paint and varnish	NMVOCs	l	l	l
Removal agents for paint, lacques, varnish	NMVOCs	l	h	l
Car and boat care				
<i>Radiator fluid</i>	anti-foulants, corrosion inhibitors, buffering and pH agents, heavy metals	m	l	m
<i>Antifreeze agent</i>	glycols, nitrogen compounds, additives	l	m	m
Desinfection agents	NMVOCs	l	l	l
<i>Car care products</i>	NP/NPE, Cationic surfactants (DTDMAC, DSDMAC, DHTDMAC), detergents	l	l	h
Glues	NMVOCs	l	l	l
<i>Car shampoo</i>	<i>NP/NPE (W/S)</i> Cationic surfactants (S)	m	l	m
Oils, lubricants	oil, solvents	l	l	m
<i>Underbody compounds, stone hit guards etc.</i>	Pb, alkyds, bitumen, rubber, wax, solvents	l	m	m
Corrosion inhibitors	e.g. amines, nitrites, phosphates	l	l	l
Windshield washing agents	NMVOCs	l	h	l
<i>Anti-knock additive</i>	MMT, iron pentacarbonyl, solvents	m	m	m
Personal care products				
Desinfection agents for food and animal feed	NPEs (W) EDTA, phthalates	l	l	l
Toilet sanitation agents	NMVOCs	l	l	l
Propellant gas	CO ₂ , F gas	l	h	l
Deodorant	NMVOCs	l	h	l
Deodorizers	NMVOCs	l	h	l
Mouth and dental care products	solvents	l	l	l
Cleaning agents	Musk compounds NPEs (W), NPEs (A)	l	l	l
Window cleaning agents	NMVOCs	l	m	l
Sweeping, boiler cleaning and deliming agents, dishwashing and oven cleaning agents, stain removal agents. Shampoos	NMVOCs	l	l	l
Conditioners and softeners for dish washers, textiles	surfactants	l	l	l
Rubber cleaning agents, waxes, creams for household use	PFC	l	l	l
Optical bleaching agents	NMVOCs	m	l	l
Building and construction				
<i>Wood preservation agents, impregnation agents</i>	PAH (A/S)	m	l	m

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	Cr, As, Cu (W/S)			
Conservation agents for surface treatment	NMVOCs, biocides, heavy metals	l	l	m
Conservation agents for building blocks/stones	NMVOC, herbicides	l	l	h
Antislime agents	chlorine dioxin, POPs	m	l	l
Fire fighting agents	surfactants, solvents, stabilizers	m	m	h
Binders in colours and glues	resins, oils	l	l	l
Bleaching agents	e.g. chlorine, peroxide	l	l	l
Propellant gases	CO ₂ , F gas	l	h	l
Agents for prevention of sediment building	NMVOCs	l	m	m
Industrial perfumes	NMVOCs	l	h	l
Pigments of glazing, enamel and glas	heavy metals, alkydes	l	l	l
Colours and colour regenerators	NPEs, SCCPs, Cr, Pb	l	l	l
Enamel additives, galvanotechnical	cobolt, nickel	l	l	l
Flooring material	NP/NPE (A/S)	l	m	m
Hydraulic oils and agents	oil	l	l	h
Concrete hardening agents	NPE (W), PCB	l	l	m
Sealants	ftalater, PAH, BFR	l	l	m
Putty material	SCCP	l	l	l
Joint sealants, hard putty	PCB (A), MCCP, PCN	l	l	m
Putty material for stone	PCB, MCCP, PCN	m	l	h
Hardeners and anti-hardening agents	resins, solvents	l	m	l
Heat transfer agents, thickening agents, gel forming agents, viscosity regulating agents, ab/adsorption agents	e.g. F-gases, nitrogen, glycols, mineral oils, waxes	l	l	l
Flame retardants	(penta)-BDE, BRF, HCBd	l	l	l
Anti-fog agents	detergents, hydrophilic polymers and gels, titanium dioxide	l	l	l
Condensation draining and preventive agents	NMVOC	l	l	l
Brick work agents, concrete, cement	NPE (W), PCB	l	l	m
Glues	NMVOC (A), NP/NPE	l	l	l
Refrigerants	F-gaser	l	m	l
Drilling- screwing and surface oils, grinding agents	carbonate, bentonite, polymers, salts, calcium chloride, oil	l	m	l
Indicators (pH): ionochromic dyes, metal-organic complexes, aromatic compounds	e.g. heavy metals	l	l	l
Welding and melting products, steel construction	metals	l	l	l
Wall construction material	NPE (W) PCB (concrete)	m	l	m
Inhibitors (protective gases)	nitrogen, argon, helium	l	m	l
Degreasing agents	NMVOC	l	m	l
Wastewater treatment agents	e.g. aluminium chloride, ferrosulphate	l	l	l
Paint, lacquers – indoor use	PCB-luft NP/NPE -vatten	l	l	l
Paint, lacquers – outdoor use (active biological effect)	SCCP (W/S), Cr, Pb (S) NP/NPE-(W) antifouling: Cr, TBT (W/S)	l	l	m
Removal agents for paint, lacquers, varnish	NMVOCs (A/W)	l	h	l
Corrosion removal agents	acids	l	l	l
Dilution agents for colours, thinner	NMVOC (A/W)	l	m	l
Cleaning agents	NMVOC (W/S)	m	l	m
Oil removal agents	solvents	h	m	m
Pyrotechnical products	heavy metals, oxidizers, dextrin, nitrocellulose	l	m	l
Antioxidants, antiozonants, antidrying agents, stabilizers	thiols, phenols	l	l	l
Cast masses	NPE (W), PCB	l	l	l
Dust bindings agents	acrylic polymers, petroleum resins, asphalt emulsions,	m	l	m

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	salts, adhesives			
Friction minimizing agents, lubricants	oils, solvents	l	l	m
Anti corrosion agents	e.g. amines, nitrites, phosphates.	l	l	m
Engraving agents for electronics and glas	ferric chloride, solvents	l	l	l
Surface treatment agents for non metallic products	alkalines, acids	m	l	l
Oxidizing agents	e.g. halogen compounds, e.g. hexavalent chromium compounds	l	l	l
pH-regulating agents, buffer agents	acids, solvents	l	l	l
Foam building agents for fluids	sodium laureth sulfate, detergents, titanium and zirconium hydroxide	m	l	m
Sludge treatment agents	lime, chlorine compounds	h	l	l
Polishing agents	PFC	l	l	m
Biocides				
Fish control agents	NH3, heavy metals, POPs	h	l	l
Insecticides and agents for arthropod prevention	POPs	m	m	m
Plant protection agents	POPs	l	m	h
Fungicides fungistats	POPs	l	l	h
Weed control agents	POPs	m	l	h
Soil disinfection agents	POPs	l	m	h
Fertilizers	nitrogen, heavy metals	l	l	l
Agents stimulating root formation for plants	auxines (organic acids)	m	l	m
Veterinary medicine, shampoo for animals	solvents, heavy metals	l	l	m
Toys, hobby, low-cost jewellery, office				
Softeners (for plastic, rubber, colour.)	NP/NPE	l	l	l
Softeners, elasticity improving agents	PCB, NP/NPE	l	l	l
Flame retardants	minerals, halocarbons, phosphonium salts	l	l	l
Lighter fluid	solvents	l	m	l
Glazing, enamel, paints, ink and glas and their pigment additives	Pb, azo-colorants, heavy metals	l	l	l
Fixation agents	solvents	l	l	l
Foto chemicals	heavy metals, solvents	l	l	l
Glues	NP/NPE (W)	l	l	l
Corrective lacque and fluid(for office use)	solvents	l	m	l
Erasors	rubber	l	l	l
Toners for copy machines and laser writers	solvents, colourants	l	l	l
Print colours	solvents, colourants	l	l	l
Removal agents for colours, lacque, varnish	NMVOcs	l	h	l
Writing ink and printer cartridges	solvents, colourants	l	l	l
Spirit pens	solvents, colourants	l	l	l
Plastic, rubber etc.	phthalates, Pb, Cr, BFR, bisphenol-A, chlorinated paraffins, NP/NPEs, organotins, triclosan	h	l	l
Etching agents	sodium naphtalene, ferric chloride, solvents	m	l	l
Gun powder, explosives	Pb	l	m	l
Packages and plastic bags				
Softeners for plastic, rubber etc	PCB	l	l	l
Flame retardants	minerals, halocarbons, phosphonium salts	l	l	l
Propeller gases	CO2, F gas	l	h	l
Hardeners for plastics	resins	l	l	l
Plastic material	phthalates, heavy metals	m	l	m
Electronics and electric equipment				
Electronics (enclosures, monitors, switches, relays)	Heavy metals, BFR (A)	l	l	l
Jointing material	epoxy, elastomers, mica	l	h	l

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Other				
<i>Impregnation agents for fishing nets</i>	antifouling agents, waxes	h	l	l
Ingredients for taste, vitamins, sweetening agents, food colourants etc	oils, acids, emulsifiers, vegetable gums	l	l	l

ANNEX 6

QUANTIFICATION OF RELEASES FROM THE NORDIC COUNTRIES

ANNEX 6

QUANTIFICATION OF RELEASES FROM THE NORDIC COUNTRIES

Content

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A6.6 Summary

A6.7 References

A6.1 Introduction

A6.1.1 Background of the calculations

Annex 6 of the OECD Resource Compendium on PRTR Release Estimation Techniques, Part 4 Products, presents quantified releases from the use of products for four of the Nordic countries⁵⁵, i.e. Denmark, Finland, Norway and Sweden.

The calculations have been carried out using release estimation techniques (RETs) presented in Tables 18 - 23 of the main report. It should be noted, as indicated in the main report, that the RETs may partly be overlapping, i.e. covering more or less the same products, and it is not always clear, which products are included in each of the release estimation techniques.

The calculation of releases from the use of products are presented in the following order:

- Chapter A6.2 Nordic releases of heavy metals from the use of products: arsenic (As), chromium (Cr), copper (Cu), mercury (Hg) and lead (Pb)
- Chapter A6.3 Nordic releases of nonylphenols (NP) and nonylphenol ethoxylates (NPE)
- Chapter A6.4 Nordic releases of brominated flame retardants (BRF)
- Chapter A6.5 Nordic releases of persistent organic compounds (POPs): Cationic surfactants (DTDMAC, DSDMAC, DHTDMAC), DEHP, Hexachlorobenzene, Short chain chlorinated paraffins, musk compounds

When estimating releases from products, one major problem is the availability of reliable activity data. Information of chemicals used in the production of consumer products in a specific country are likely to be available while the chemical content of imported finished products in the market are seldom known. Therefore rough assumptions have been made for the activity data used in the calculations, and consequently, also the uncertainty of the estimated releases is high. In a number of cases, information on chemical stocks in products already in use was not available, and it was therefore not possible to quantify the releases from these products. In this study, releases are assumed to be generated in the same year as application of chemicals in the finished products instead of gradual releases during a longer time period. The estimates can be improved when more reliable activity data becomes available.

Where possible, the quantified releases are analyzed for their representativeness, by, for instance, comparing the corresponding release data from other sources or comparing the completeness of the different RETs. A summary of release estimates calculated in this study are presented in Table 6A.1. For some RETs no activity data was available and these releases were therefore not estimated (indicated by NE in the table). The release estimates do not cover any specific year or period but the releases for which the activity data were available.

⁵⁵ Information from Iceland was not available for the study.

Resource Compendium Part IV: Releases from the Use of Products -
Quantification of Releases from the Nordic Countries

Table 6A.1. List of product groups and chemicals included in the quantification of Nordic releases.

Release	Product	Air	Soil	Water	year
As					
	CCA treated wood		x		2001-2007
Cr					
	CCA treated wood		x		2001-2007
	paint and varnish		x		2002-2007
Cu					
	CCA treated wood		x		2002-2006
	antifouling paint		x	x	2002-2006
	fungicide		x		2002-2006
	pipes and taps			x	2002-2006
	copper roofing		x (soil and stormwater)		2001
Hg					
	electrical equipment	x		x	2007
	measurement and control equipment	x		x	2007
	batteries	x			2007
	light sources	x	x	x	2007
	instruments	x			2007
	thermometers	NE			
	dental amalgam			x	2007
Pb					
	paint		x		2003
	lead pipes			x	2001
	lead sheet		x		2001
NP/NPE					
	pesticide	x	x	x	2002-2007
	pharmaceuticals	NE	NE	NE	
	car care products		NE	NE	
	textiles			x	2008
	adhesives			x	2006
	paints and varnishes			x	2006
	concrete			x	2006
	cleaning agents			x	2006
	wall and floor coverings			x	1998-2003
BFR					
	insulating material and construction work	x		x	2006
	enclosures and monitors	x		x	2006
Cationic surfactants (DTDMAC, DSDMAC, DHTDMAC)					
	car care and other products		x	x	2005-2007
DEHP					
	vinyl products	x			2006
	roofing		NE	NE	
	cables in the soil		NE		
HCB					
	pesticides	x			1998-2008
PCB					
	transformers	NE			
	capacitors	NE			
	sealants	NE			
	surface coating and adhesives	NE			
SCCP					
	paint	x	x		2006
MCCP					
	cables and wires	NE	NE	NE	
	building and construction	NE	NE	NE	
Musk compounds					
	detergents and cosmetics		x	x	2000

A6.1.2 Statistical information of Nordic countries

Statistical information of the population and *gross domestic product* (GDP) for the Nordic countries is presented in Table 6A.2 and Table 6A.3 to provide some background data for the evaluation of the release rates. The total population in Denmark, Finland, Norway and Sweden is about 25.5 million, representing 5.4% of EU-25 (approximately 470 million) or 7.8% of EU-15 (approximately 320 million). The share of the individual Nordic countries is between 1–2 % of EU-25 and 1.5-2.9% of EU-15.

As the economic and geographical conditions in the Nordic countries are very much alike, and the legislation related to chemicals and products is largely similar, no large differences should be found in releases from the use of products. However, when comparing release estimates from the use of products in the Nordic, it is good to keep in mind that the countries differ by population size, which is often reflected in the total releases (through the RET⁵⁶). The largest Nordic country is Sweden (37% of the total population in the Nordic countries), followed by Finland (22%), Denmark (21%), Norway (19%) and Iceland (1%) (Table 6A.2). Information of the GDP is provided in Table 6A.3.

Table 6A.2. Population (number of inhabitants, Eurostat 2010a).

Year	Denmark			Finland			Iceland			Norway			Sweden			All Nordic Countries		EU-25	EU-15
		% of EU-25	% of EU-15		% of EU-25	% of EU-15		% of EU-25	% of EU-15		% of EU-25	% of EU-15		% of EU-25	% of EU-15	% of EU-25	% of EU-15		
1998	5313577	1,18	1,74	5159646	1,14	1,68	272381	0,06	0,09	4445329	0,99	1,45	8854322	1,96	2,89	5,33	7,85	450898986	306233114
1999	5330020	1,18	1,73	5171302	1,14	1,68	275712	0,06	0,09	4478497	0,99	1,46	8861426	1,96	2,88	5,33	7,85	452121349	307326839
2000	5349212	1,18	1,73	5181115	1,14	1,68	279049	0,06	0,09	4503436	0,99	1,46	8882792	1,96	2,88	5,34	7,84	453217293	308667715
2001	5368354	1,18	1,73	5194901	1,14	1,67	283361	0,06	0,09	4524066	0,99	1,46	8909128	1,96	2,87	5,34	7,83	454912169	310232062
2002	5383507	1,18	1,72	5206295	1,14	1,67	286575	0,06	0,09	4552252	1,00	1,46	8940788	1,96	2,86	5,33	7,81	457029216	312173797
2003	5397640	1,18	1,72	5219732	1,14	1,66	288471	0,06	0,09	4577457	1,00	1,46	8975670	1,95	2,86	5,33	7,78	459287076	314198951
2004	5411405	1,17	1,71	5236611	1,13	1,66	290570	0,06	0,09	4606363	1,00	1,46	9011392	1,95	2,85	5,32	7,76	461734067	316295319
2005	5427459	1,17	1,71	5255580	1,13	1,65	293577	0,06	0,09	4640219	1,00	1,46	9047752	1,95	2,84	5,32	7,75	463897973	318080523
2006	5447084	1,17	1,70	5276955	1,13	1,65	299891	0,06	0,09	4681134	1,00	1,46	9113257	1,96	2,85	5,33	7,76	466025666	319802917
2007	5475791	1,17	1,70	5300484	1,13	1,65	307672	0,07	0,10	4737171	1,01	1,47	9182927	1,96	2,85	5,34	7,77	468480260	321720930
2008	5511451	1,17	1,71	5326314	1,13	1,65	315459	0,07	0,10	4799525	1,02	1,48	9256347	1,97	2,86	5,36	7,80	470618353	323217728
2009	5547088	1,17	1,71	5350475	1,13	1,65	319368	0,07	0,10	4854824	1,03	1,50	9347899	1,98	2,88	5,38	7,84	472216915	324247781

⁵⁶ The RET may be based for example on the population rate.

Table 6A.3. GDP per capita in Purchasing Power Standards (PPS). EU-27 = 100. (Eurostat, 2010b).

Year	Denmark	Finland	Iceland	Norway	Sweden	EU-27	EU-25	EU-15
1998	132	114	140	138	123	100	105	115
1999	131	115	139	145	126	100	105	115
2000	132	117	132	165	128	100	105	115
2001	128	115	132	161	122	100	105	115
2002	128	115	130	155	122	100	105	114
2003	124	112	125	156	124	100	104	114
2004	126	116	131	164	126	100	104	113
2005	124	114	130	176	122	100	104	113
2006	124	114	123	184	123	100	104	112
2007	121	118	122	179	125	100	104	112
2008	120	117	121	191	122	100	103	111
2009	117	111	120	177	120	100	103	111

A6.2 Nordic releases of heavy metals from the use of products

A6.2.1 Releases of Arsenic from the Use of Products

Arsenic releases to soil from wood products treated with CCA (chromated copper arsenate) were estimated using activity data collected from SPIN⁵⁷ and an emission factor derived from the publication by SFT (2004). Part of the activity data in SPIN was confidential but since the use of As for wood treatment was banned in 2006, it is assumed in this project that the data that not included in SPIN because of confidentiality is close to zero. No separation between the use categories, such as, for example, consumer products or railway sleeper, of CCA treated wood has been made, because the activity data is for the total use of CCA.

It should also be noted that since the lack of activity data, release estimate for wood products covers only CCA treated wood applied and used in domestic markets but not imported products. It is also assumed that the applied CCA will release during the first year instead of 30 years since the information on CCA stocks in products were not available, hence, the emission factor used was as large as 30%. The emission factor has been calculated as 30 years multiplied with the annually released arsenic content in CCA, which is assumed to be 1% per year.

⁵⁷ Substances and Preparates in Nordic Countries (<http://195.215.251.229/DotNetNuke/default.aspx>), for details see the main report.

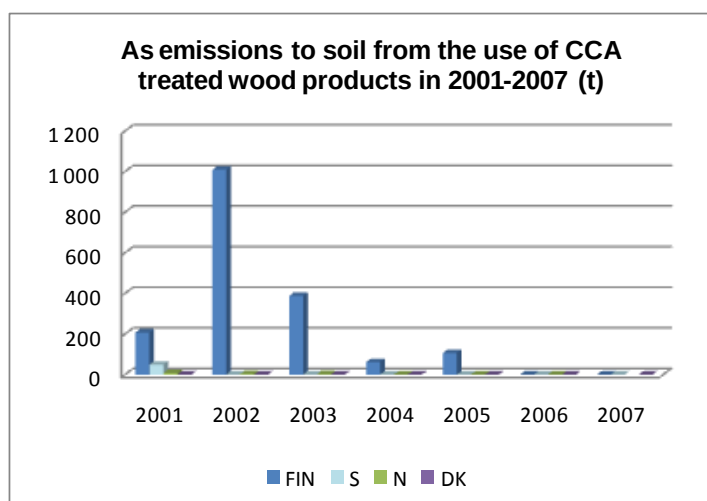


Figure 6A.1. Arsenic releases to soil from the use of CCA treated wood.

According to the calculations made in this project, releases of arsenic to soil from CCA treated wood are negligible since the ban of the use of arsenic in wood treatment in 2006 (Figure 6A1). The import of arsenic containing wood treatment products in the SPIN register fluctuated largely between the years. However, this does not correspond the actual situation where releases to the environment occur gradually during the years.

Statistics of the production of preservative-treated wood in the Nordic countries in 2007 is summarized in Table 6A.4.

Table 6A.4. Statistics of production of preservative-treated wood in the Nordic countries in 2007 (NTR, 2010).

	Denmark	Finland ⁵⁸	Norway	Sweden
Production by commodity (m ³)				
Sleepers	0	16 100	0	20 946
Poles	0	102 900	20 200	69 332
Sawn timber	147 222	257 000	421 700	1 302 319
Fence post + other	IE	IE	22 300	54 697
Joinery	13 075	IE	39 200	28 768
Total	160 297	376 000	503 400	1 476 062
Production by type of preservative (m ³)				
Creosote	0	100 600	18 900	90 725
Water-borne	147 222	275 400	445 300	1 354 122
Light organic solvent preservatives	13 075	0	39 200	391 665
Total	160 297	376 000	503 400	1 476 062
Export				
total (m ³)	233	114 500	35 000	881 104
total (%)	0.1	30%	7%	60%

Comparison to information reported under the E-PRTR and CLRTAP

Releases of arsenic from the use of products are presented in Table 6A.5 Only Norway has reported arsenic releases to soil to E-PRTR in 2007. When comparing this to the calculated

⁵⁸ In addition, in Finland approximately 330 000 – 400 000 m³ of industrially impregnated wood has been produced in 2001-2006. Most of it is used as sawn timber (60%), about 35% as wood poles and the rest as railway sleepers (SYKE, 2010).

arsenic releases from the use of CCA treated wood, attention should be paid to the fact that CCA treated wood may have considerable affect to the soil emissions. However, due to the lack of data on CCA stocks in products, rough assumptions were made for the calculation and the results are highly uncertain. Due to the recent ban on the use of arsenic containing preservatives such as CCA in the Nordic countries, releases of As from the use of CCA treated products will slowly decline over time.

Table 6A.5. Comparison of As releases reported to E-PRTR and CLRTAP.

Country	As 2007 releases reported to E-PRTR (t)			As 2007 releases reported to CLRTAP (t)		As 2004 releases presented in this annex (t)	
	Air	Water	Soil	Air	Water	Air	Water
FIN	0.617	1.82	-	2.717	-	-	60.4*
S	0.771	1.66	-	1.137	-	-	-
N	0.554	0.916	0.174	1.620	-	-	3.3
DK	0.182	0.16	-	0.63	-	-	-

*The release is high due to the high emission factor used (30%).

A6.2.2 Releases of Chromium from the Use of Products

Chromium releases to soil were estimated from the use of wood products treated with CCA and from the use of paint and varnish. Activity data used in the calculations was derived from information collected from SPIN. The emission factor used in the calculation was taken from the publication SFT (2004). The calculated emissions are presented in Figure 6A.2.

In the estimation of chromium releases to soil from the use of CCA treated wood, an emission factor of 30% (SFT, 2004) was used, based on the same assumption as in the calculation of arsenic releases (see chapter A6.2.1). The emission factor has been calculated as 30 years multiplied with the annually released arsenic content in CCA, which is assumed to be 1% per year. Activity data was calculated by proportioning the information on imported amount of arsenic in CCA to the total chemical content in CCA (CCA (type C): 47,5% CrO_3 , 19% CuO , 33,5% As_2O_5). According to the calculations, chromium releases to soil from CCA treated wood are negligible since the ban of the use of arsenic in wood treatment. However, this does not correspond the actual situation where releases of chromium from existing wood products treated previously with CCA (before it was banned) to the environment occur gradually during the years.

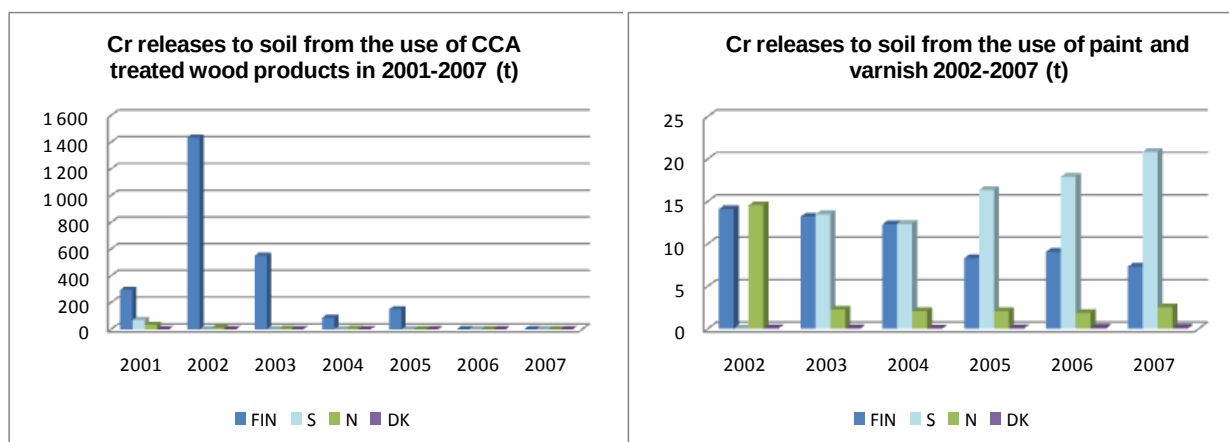


Figure 6A.2. Chromium releases to soil from the use of CCA treated wood and paint and varnish.

Chromium releases to soil from the use of paint and varnishes were also estimated. Since there is a lack of accurate information on the use of paint and varnish in products, the calculation method was simplified in this project. The releases were calculated only for paints and varnishes applied and used in domestic markets. Imported finished products were not included. It was also assumed that the applied paint and varnish will be released during the first year. The applied emission factor was 10% of chromium in the product.

Comparison to information reported under the E-PRTR and CLRTAP

As presented in 0, Nordic countries have not reported Cr releases to soil to E-PRTR in 2007. In this project releases to soil from the use of CCA treated wood and paints were evaluated. Releases estimated for 2007 only contain estimates from the use of paints. The release estimate is insufficient if considering the actual situation where releases to the environment occur gradually during the years from CCA treated wood.

Table 6A.6. Comparison of chromium releases reported to E-PRTR and CLRTAP.

Country	Cr 2007 releases reported to E-PRTR (t)			Cr 2007 releases reported to CLRTAP (t)	Cr 2007 releases presented in this annex (t)		
	Air	Water	Soil		Air	Water	Soil
FIN	13.5	1.76	-	26.713	-	-	7.3
S	11.2	3.31	-	13.173	-	-	20.9
N	0.303	2.81	-	2.256	-	-	2.6
DK	-	0.176	-	1.36	-	-	0.13

A6.2.3 Releases of Copper from the Use of Products

Copper releases to soil were estimated from the use of wood products treated with CCA, antifouling paints that contain copper, and copper-based fungicide. Releases to water were estimated from the use of antifouling paints that contain copper, copper pipes and taps. Releases to soil and storm water from copper roofing were also calculated. Releases occur due weathering of paint and other material during the use phase. The estimated emissions are presented in Figure 6A.3 and the release estimation techniques in Table 6A.6.

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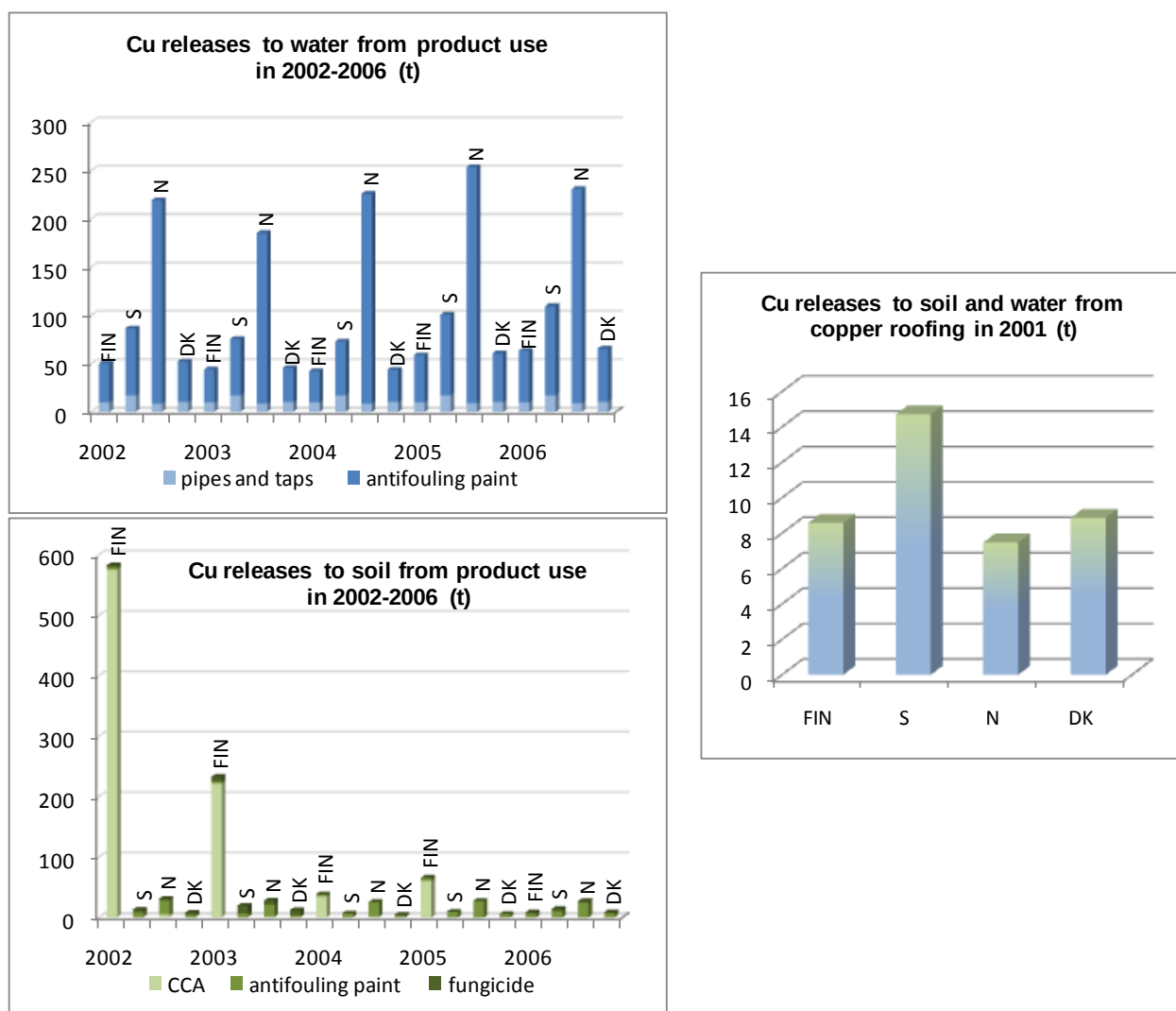


Figure 6A.3. Copper releases to water and soil from product use.

Table 6A.6. Summary of RETs for copper releases to soil and water.

Activity data description		Emission factor	Emission factor reference
CCA treated wood			
	Cu content is calculated by proportioning the information on arsenic contents in wood treatment products in the SPIN register in the chemical content of CCA (CCA (type C): 47,5% CrO ₃ , 19% CuO, 33,5% As ₂ O ₅ , Laine (2005)).	30% of Cu in CCA (soil)	SFT (2004)
Antifouling paint			
	Activity data (copper content in antifouling paint) for Sweden and Denmark was calculated by proportioning the information from Finland (SYKE, 2010a) to the population (Eurostat, 2010a). Activity data for Norway is received from Norwegian Climate and Pollution Agency (Lahti, 2010).	9% of Cu content in antifouling paint (soil) 81% of Cu content in antifouling paint (water)	SFT (2004)
Fungicide			
	Calculated by proportioning the information of copper content in fungicide in Norway to the population of other Nordic countries (Eurostat, 2010a).	100% of copper content in pesticide (soil)	SFT (2004)
Copper roofing			
	Calculated by proportioning the information of releases	2 g/m ²	He et al (2001),

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	from copper roofing in Stockholm to the population (Eurostat, 2010a).	(Soil and Stormwater)	Sörme&Lagerkvist, 2002
Pipes and taps			
	Population (Eurostat, 2010a)	1,9 g/person (water)	He et al (2001), Sörme&Lagerkvist, 2002

In the estimation of copper releases to soil from the use of CCA treated wood the same assumptions were made as in the calculation of arsenic emissions (see chapter A6.2.1). According to the calculations made in this project, copper releases to soil from CCA treated wood are negligible since the ban of the use of arsenic in wood treatment in 2006. However, the releases are even lower at annual basis because of the slow release rate of copper from wood products.

Copper releases from antifouling paint were estimated with a simplified method. The releases were calculated only for antifouling paint applied in domestic markets. The releases were assumed to occur in the year of application.

Comparison to information reported under the E-PRTR and CLRTAP

In this project, copper releases from the use of different products could not be calculated for all recent years due to lack of activity data. Therefore emissions from the use of CCA treated wood and copper roofing were calculated for 2001 for which activity data was available, and emissions from the use of antifouling paint, fungicide and pipes and taps for the year 2006 (Table 6A.7). From the results it can be seen that releases from products may make a considerable contribution to the total emissions in the countries.

As presented in Table 6A.7, none of the Nordic countries reported Cu releases to soil to E-PRTR in 2007.

Table 6A.7. Comparison of Cu releases reported to E-PRTR and CLRTAP.

Country	Cu 2007 releases reported to E-PRTR (t)			Cu 2007 releases reported to CLRTAP (t)	Cu 2001 releases* presented in this annex (t)			Cu 2006 releases** presented in this annex (t)		
	Air	Water	Soil		Air	Water	Soil	Air	Water	Soil
FIN	3.69	10.5	-	61.415	-	IE***	126.9	-	63.5	8.4
S	3.19	9.25	-	50.792	-	IE***	14.7	-	109.6	14.5
N	1.96	12.8	-	21.93	-	IE***	20.5	-	230.8	26.9
DK	-	1.35	-	9.99	-	IE***	8.9	-	65.5	8.7

* Releases from the use of CCA treated wood and copper roofing

** Releases from the use of antifouling paint, fungicide and pipes and taps

*** Releases to stormwater from copper roofing are included in soil releases

A6.2.4 Releases of Mercury from the Use of Products

There are various release estimation techniques (RETs) in the literature for calculating mercury releases to air, water and soil from the use of products. The methodologies for quantification of releases found in the literature cover a variety of product groups such as electrical, measurement and control equipment and instruments, thermometers, batteries and light sources as well as dental amalgam.

The RETs are partly overlapping, i.e. covering more or less of the same products, and it is not always very clear, which products are included in each of the release estimation techniques. For instance, it is not clear if all of the products covered by the more specified RETs for calculating mercury releases are actually also covered by those RETs that use the overall quantity of mercury in products in a given year. The different scope of the methods may explain the different release rates the methods suggest.

For the purpose of the OECD Resource Compendium on RETs for Products, Nordic mercury releases in 2007 from the use of selected products were calculated using the different RETs found in the literature. The calculations are presented below separately for releases to air, water and soil. RETs resulting in the highest and lowest mercury emissions were discarded from the results and those methods giving average emissions were chosen for the comparison of emission rates.

Releases from the use phase of mercury containing products is assumed to occur in cases where the product is accidentally broken or it is not disposed so that it does not enter the organized waste management system and the releases are thus not captured by the PRTRs.

Mercury emissions to air from the use⁵⁹ of products

Emissions to air from the use of electrical, measurement and control equipment, batteries and light sources are presented in Figure 6A.4.

From the literature, three different release estimation techniques were identified for quantification of mercury releases from the use of electrical equipment and measurement and control equipment. For releases from the use of batteries, two RETs were found, and for releases from the use of mercury containing light sources, four RETs. The RETs used for calculation are summarized in Table 6A.8.

Releases of mercury from the use of thermometers were not calculated because the use of such thermometers has ceased to almost zero in the Nordic countries, although some old stocks may still exist.

From Figure 6A.4 it can be seen that the differences between the methods are large.

⁵⁹ Releases from the use phase of mercury containing products is assumed to occur in cases where the product is accidentally broken or it is not disposed so that it does not enter the organized waste management system and the releases are thus not captured by the PRTRs.

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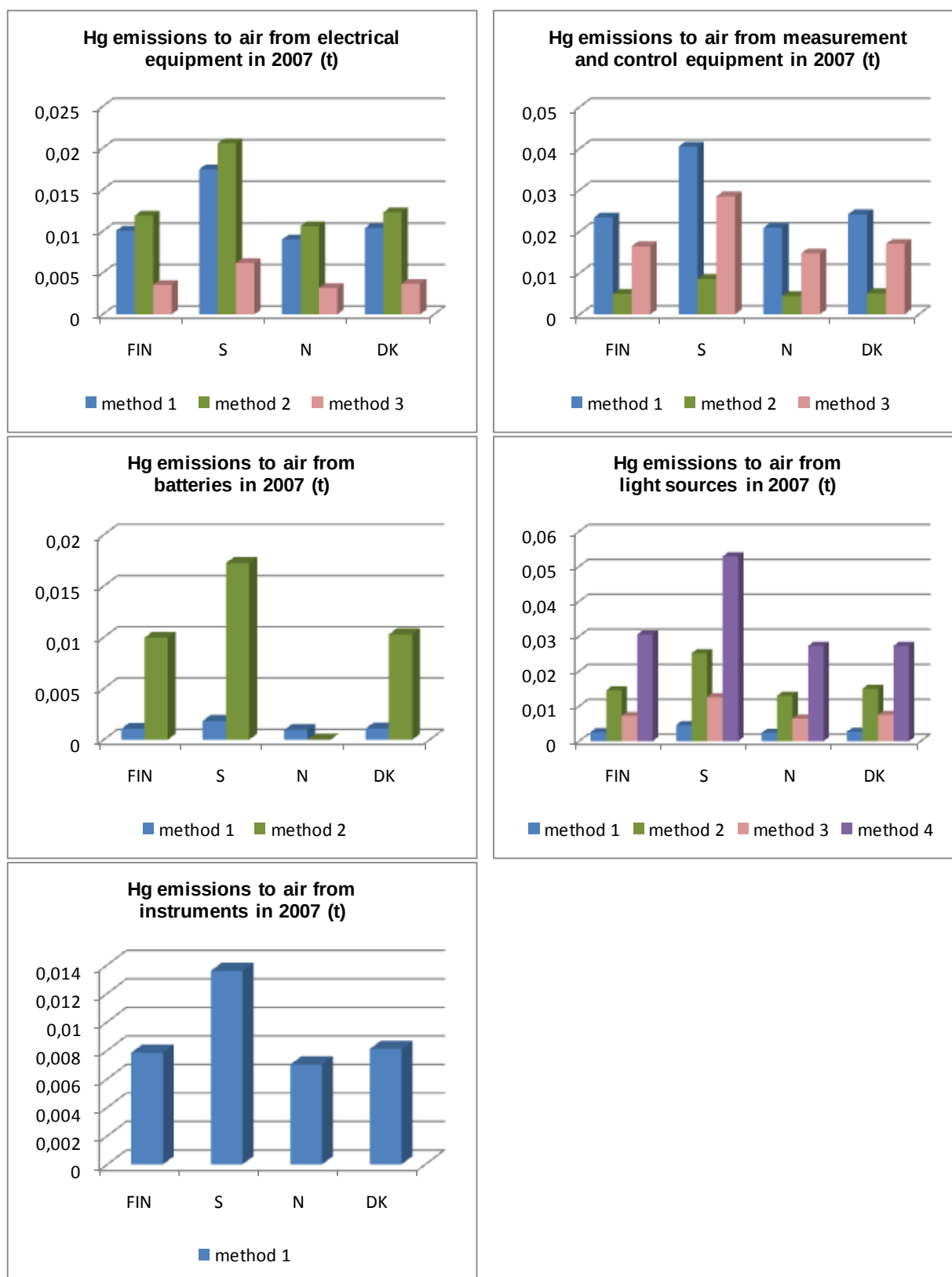


Figure 6A.4. Mercury emissions to air from electrical, measurement and control equipment, batteries, light sources and instruments (calculated with different RETs).

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Quantification of Releases from the Nordic Countries

Table 6A.8. Summary of RETs for mercury releases to air.

Activity data description		Emission factor	Emission reference factor
Electrical equipment			
method 1	Population (Eurostat, 2010a)	0.0019 t/million inhabitants	EMEP (2000b) ref. WS Atkins (1997)
method 2	Calculated based on information of Hg in EE devices in EU-25 (Kindbom&Munthe, 2007) and proportioning figures to population (Eurostat, 2010)	5% of mass of total Hg in all Hg containing products, distribution factor for electrical equipment = 1%	Kindbom&Munthe (2007)
method 3		1.5% of mass of Hg in products	Cain et. Al (2007)
Measurement and control equipment			
method 1	Population (Eurostat, 2010a)	0.0044 t/population of 10 ⁶ (Western Europe)	EMEP (2000b) ref. WS Atkins (1997)
method 2	Calculated based on information of Hg in products in EU-25 (Kindbom&Munthe, 2007) and proportioning figures to population (Eurostat, 2010a).	1.5% (except thermometer)	Cain et. Al (2007)
method 3		5% of mass of total Hg in all Hg containing products, distribution factor for measurement and control equipment = 5%	Kindbom&Munthe (2007)
Hg containing instruments			
method 1	Calculated based on information on Hg content in instruments received from Norway and proportioning figures to population (Eurostat, 2010a)	0.35 kg/kg (35%) of mass of Hg in products	SFT (2004)
Batteries			
method 1	Population (Eurostat, 2010a)	0.0002 t/million inhabitants (Western Europe)	EMEP (2000b) ref. WS Atkins (1997)
method 2	Calculated based on information of Hg in products in EU-25 (Kindbom&Munthe, 2007) and proportioning figures to population (Eurostat, 2010)a.	5% of mass of total Hg in all Hg containing products, distribution factor for batteries = 1%	Kindbom&Munthe (2007)
Light sources			
method 1	Population (Eurostat, 2010a)	0.0005 population of 10 ⁶ (Western Europe)	EMEP (2000b) ref. WS Atkins (1997)
method 2	Calculated based on information on Hg content in light sources received from Norway and proportioning figures to population (Eurostat, 2010a)	10%	Cain et. Al (2007)
method 3		5% of mass of total Hg in all Hg containing products, distribution factor for light sources = 1%	Kindbom&Munthe (2007)
method 4		21%	SFT (2004)
Thermometers			
method 1	Calculated based on information of Hg in products in EU-25 (Kindbom&Munthe, 2007) and proportioning figures to population (Eurostat, 2010).	10% of mass of Hg in products	Cain et. Al (2007)

RETs resulting in the highest and lowest mercury emissions were discarded from the results and those methods giving average emissions (these RETs are bolded in Table 6A.8) were selected for further comparison (Figure 6A.5). Mercury containing instruments were not included because those were assumed to be included in other product categories.

The total mercury emissions from electrical, measurement and control equipment, batteries and light sources to air in 2007 presented in Figure 6A.5 show that the largest source in each of the Nordic countries was measurement and control equipment (approximately 35% of releases), followed by light sources (30%). Releases from batteries and electrical equipment contributed to 15 and 20%. It should be noted, however, that the selection of the method affects the shares between these source categories.

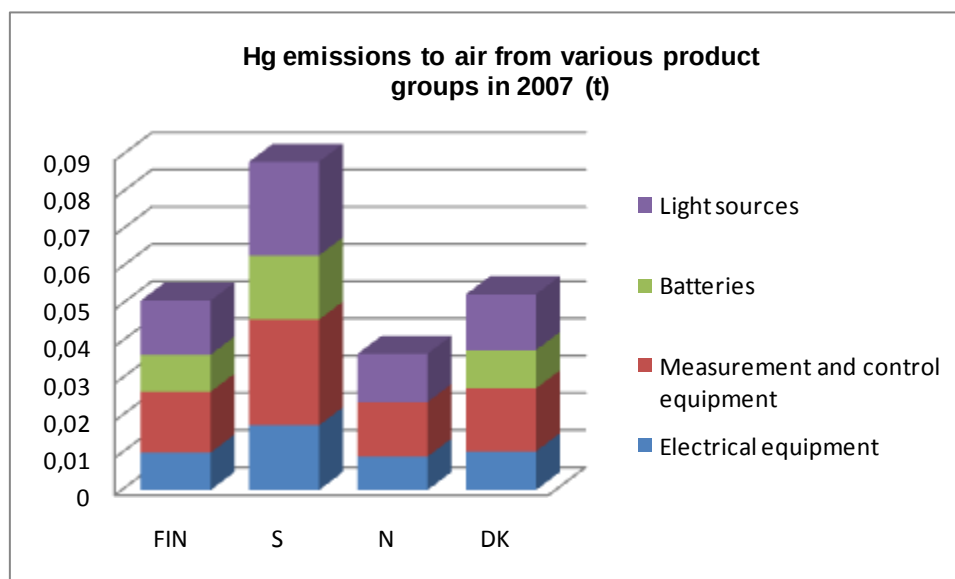


Figure 6A.5. Mercury emissions to air from selected product groups.

Mercury releases to water from the use⁶⁰ of products

Mercury releases to water from the use of electrical, measurement and control equipment, light sources and dental amalgam are presented in Figure 6A.6.

There was only one release estimation technique found for mercury releases to water from the use of electrical equipment, measurement and control equipment and dental amalgam. Two different RETs were found for quantification of mercury releases from the use light sources. The RETs used in the calculation are summarized in Table 6A.9.

Releases from thermometers were not calculated because the use of mercury containing thermometers has ceased in the Nordic countries, although some old stocks may still exist.

Table 6A.9. Summary of RETs for mercury releases to water.

Activity data description		Emission factor	Emission factor reference
Electrical equipment			
	Calculated by proportioning the data on Hg in electrical equipment received from Norway to population.	1%	Cain et. Al (2007)
Measurement and control equipment			
	Calculated based on information of Hg in products in EU-25 (Kindbom&Munthe, 2007) and proportioning figures to population (Eurostat, 2010).	1%	Cain et. Al (2007)
Light sources			
method 1	Calculated by proportioning the data on Hg content in light sources received from Norway to population.	1%	Cain et. Al (2007)
method 2		6%	SFT (2004)

⁶⁰ Releases from the use phase of mercury containing products is assumed to occur in cases where the product is accidentally broken or it is not disposed so that it does not enter the organized waste management system and the releases are thus not captured by the PRTRs.

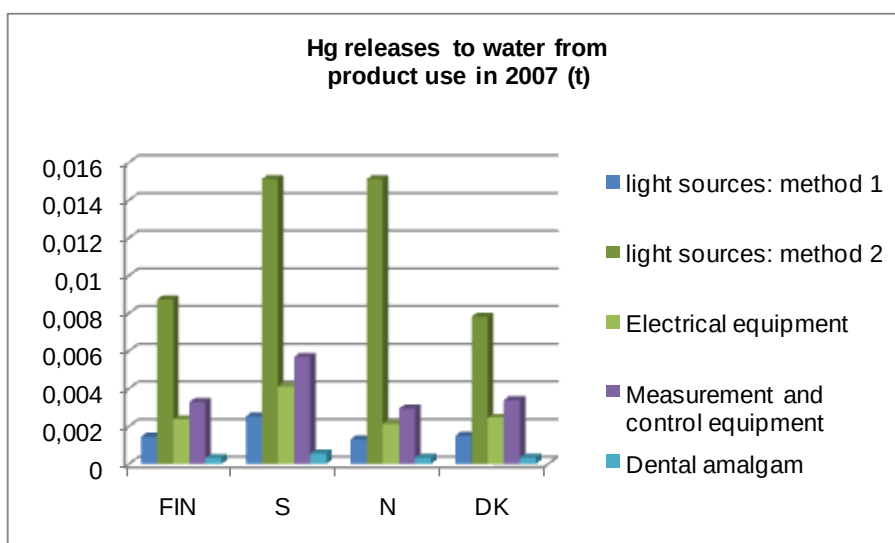


Figure 6A.6. Hg emissions to water from product use.

Figure 6A.6 illustrates that the choice of the calculation method affects the total mercury releases to water from electrical, measurement and control equipment and light sources. If method 1 is selected for light sources the largest source in each of the Nordic countries would be measurement and control equipment (approximately 46% of releases), followed by electrical equipment (33%) and light sources (20%). However, if method 2 is chosen, the corresponding shares are 21%, 15% and 63%. Unfortunately it is unclear whether the method for measurement and control equipment also includes electrical equipment, as this cannot be verified from the description of the methodologies.

Mercury releases from dental amalgam were a minor source in 2007 in the Nordic countries. The use of amalgam fillings has been prohibited in Norway in 2008 and in Sweden in 2009.

Mercury releases to soil from the use⁶¹ of products

Releases of mercury to soil could be calculated only for the use of light sources as this was the only release estimation technique found in the literature. The emission factor of 4% was taken from the publication by SFT (2004). Activity data pertaining to Finland, Sweden and Denmark were calculated by proportioning the data on mercury content in light sources received from Norway to population in the other countries. In Figure 6A.7 mercury releases (2002-2007) to soil from light sources is presented (activity data was available only for these years)

⁶¹ Releases from the use phase of mercury containing products is assumed to occur in cases where the product is accidentally broken or it is not disposed so that it does not enter the organized waste management system and the releases are thus not captured by the PRTRs.

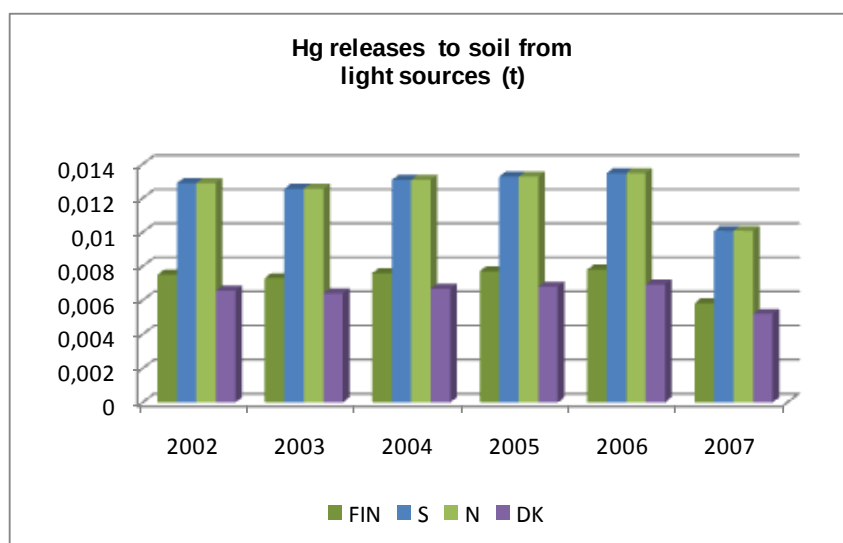


Figure 6A.7. Mercury releases to soil from light sources.

Comparison to information reported under the E-PRTR and CLRTAP

In this project mercury releases to air, water and soil from the use of different products were calculated. The calculated release rates from product use are approximately at the same level as the presently reported releases from other sources than product use in the E-PRTR. As presented in Table 6A.10 none of the Nordic countries reported releases to soil to E-PRTR in 2007.

Table 6A.10. Comparison of Hg releases reported to E-PRTR and CLRTAP.

Country	Mercury releases reported to E-PRTR (t), 2007			Mercury releases reported to CLRTAP (t), 2007		Mercury releases presented in this annex (t), 2007		
	Air	Water	Soil	Air		Air	Water	Soil
FIN	0.453	0.0341	-	0.448		0.051	0.015	0.006
S	0.157	0.0468	-	0.593		0.088	0.025	0.010
N	0.159	0.19	-	0.664		0.037	0.021	0.010
DK	0.237	0.0781	-	1.12		0.053	0.014	0.005

A6.2.5 Releases of Lead from the Use of Products

Lead releases to soil were estimated from the use of paint and lead sheet in roofing and as building material. Releases to water were estimated from lead pipes and from lead sheet used for roofing and as building material. Activity data for the use of lead sheet flashing was not available. The release estimation techniques for lead releases from products are summarized in Table 6A.11.

Table 6A.11. Summary of RETs for lead releases to water and soil.

Activity data description		Emission factor	Emission factor reference
Use of paint			
	SPIN database and information from Sweden and Norway	10% of Pb content in paints (soil)	SFT (2004)
Lead pipes			
	Population (Eurostat, 2010a)	1,014 mg/capita (water)	Tukker (2001)
Lead sheet (building materials)			

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	Calculated based on information of the mass of lead stock in building materials in EU-15 (Tukker, 2001) and proportioning figures to population of Nordic countries (Eurostat, 2010a)	0,006% (soil) 0,008% (water)	Tukker (2001)
Lead sheet (roofing)			
	Calculated based on information of lead content in roofings in Netherlands (Wilson (2003), Van Hyfte & Callebaut (2007)) and proportioning figures to population of Nordic countries (Eurostat, 2010a)	For utility buildings: 1 g/m ² (soil), 4 g/m ² (water) For residential buildings: 1,5 g/m ² (soil), 0,0685 g/m ² (water)	derived from Wilson (2003), Van Hyfte & Callebaut (2007)
Lead sheet (flashings)			
	Activity data not available	For utility buildings: 0,176 g/m ² (soil), 0,704 g/m ² (water) For residential buildings: 0,264 g/m ² (soil), 0,012 g/m ² (water)	derived from Wilson (2003), Van Hyfte & Callebaut (2007)

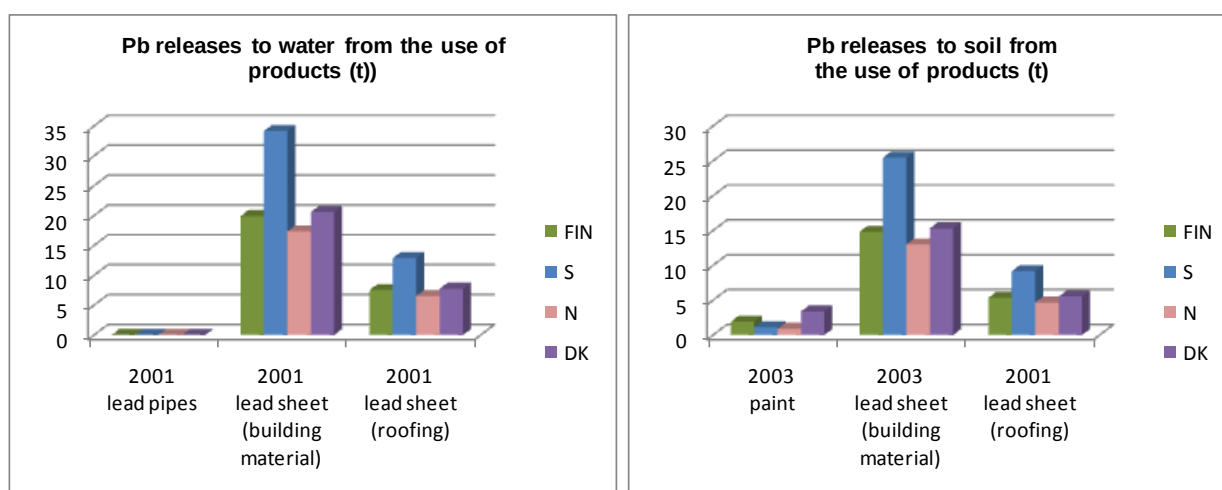


Figure 6A.8. Lead releases to water and soil from the use of products.

Comparison to information reported under the E-PRTR and CLRTAP

The RETs for lead releases from lead sheets are not comparable with each other since the method outlined in publication Tukker et. al. (2001) may also contain other application than just lead roofing and flashings. However, the results show that the use of lead sheets may generate considerable releases of lead to the environment through corrosion. During this project, the extent to which the lead sheets are in use today in the Nordic countries and whether this application is gradually phasing out or to be banned was not studied. Activity data used in the calculations are old and based on future scenarios but the releases can be expected to be relevant since the lifetime of lead sheets in the building sector is 50 years (Tukker, 2001). As presented in Table 6A.7, none of the Nordic countries reported releases to soil to E-PRTR in 2007.

Table 6A.12. Lead releases reported to E-PRTR and CLRTAP.

Country	Lead 2007 releases reported to E-PRTR (t)			Lead 2007 releases reported to CLRTAP (t)
	Air	Water	Soil	Air
FIN	2.67	1.08	-	21.874
S	4.32	2.16	-	10.94
N	3.62	3.67	-	6.714
DK	-	0.213	-	6.17

A6.3 Nordic releases of nonylphenols (NP) and nonylphenol ethoxylates (NPE)

NP/NPE releases to air and soil from the use of products

Nonylphenol and nonylphenol ethoxylate (NP/NPE) releases to air and soil from the use of pesticides were calculated based on information collected from SPIN and an emissions factor from the publication by Hansson et. al.(2008). The results are presented in Figure 6A.9. With the selected search parameters no activity data for Finland and Norway was found from the SPIN database.

In the publication by Hanson et al (2008), there are also RETs available for NP and NPE releases from the use of pharmaceuticals and car care products. However, activity data for these emissions sources were not found during this project. It can be assumed, that these release quantities are already largely collected by the PRTRs, as the releases are likely to be captured by the wastewater collection and treatment systems in the Nordic countries.

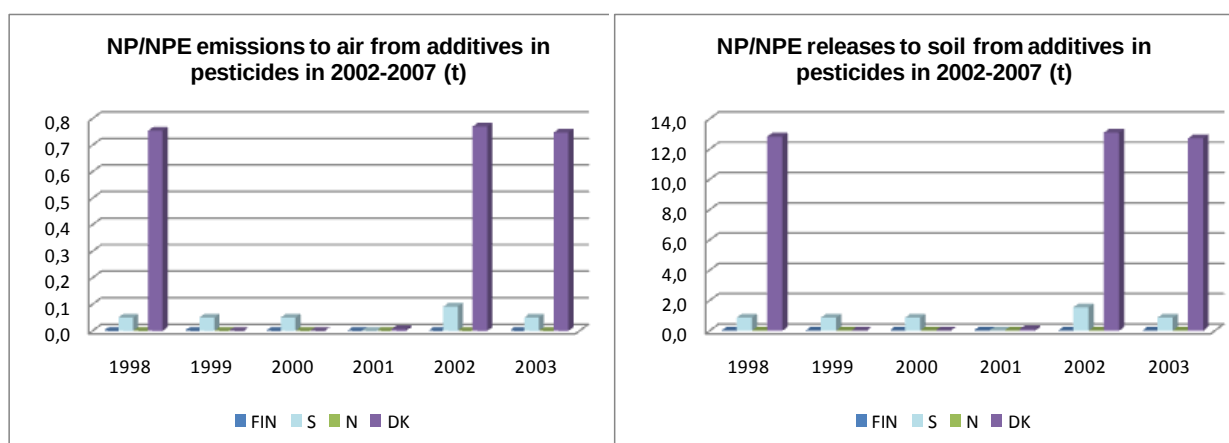


Figure 6A.9. NP and NPE releases⁶² to air and soil from the use of pesticides.

Table 6A.13. Summary of RETs for NP and NPE releases⁶³ to air and soil.

Product group	Activity data description	Emission factor	Emission factor reference
Additives in pesticides			
	SPIN database	5% of NP/NPE content in pesticides (air) 85% of NP/NPE content in pesticides (soil)	Hansson et. Al (2008)
Pharmaceuticals			
	Activity data not available	5% of NP/NPE content in pharmaceuticals (air) 85% of NP/NPE content in pharmaceuticals (soil)	Hansson et. Al (2008)
Car care products			
	Activity data not available	13,6% of NP/NPE content in car care products (soil)	SFT (2004)

⁶² NP/NPE stands for the combined emission quantities of NP and NPE releases.

NP and NPE releases to water from the use of products

NPE releases to wastewater treatment plants in 2008 following the use of textiles were calculated with two different RETs, and are presented in Table 6A.14. In method 1 population data in the Nordic countries was used as activity data (available from Eurostat) and the emission factor 1,6 g/person was taken from the publication Månsson et al 2008. Activity data for method 2 was calculated based on information of textiles imported to Finland (Uljas, 2010) and by proportioning this information to population in the other Nordic countries (Eurostat, 2010a). The emission factor 0,25 kg/t was used (Hansson et. Al. 2008).

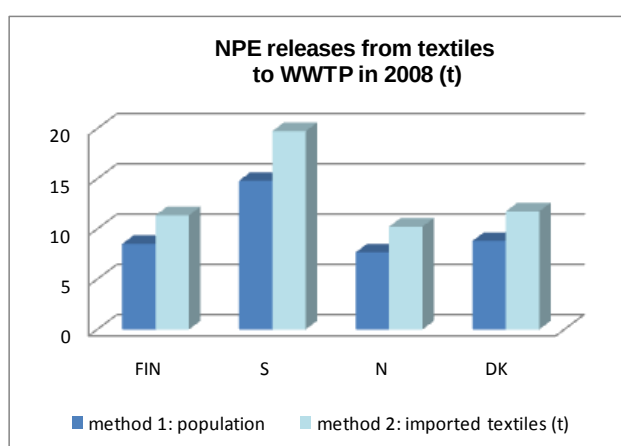


Figure 6A.10. NPE releases from textiles to WWTPs in 2008

NPE releases to water from the use of wall and floor coverings, additives in pesticides, adhesives, paints and varnishes as well as from the use of concrete and cleaning agents were also calculated. The emission factors are taken from publication Hansson et. al. 2008. The calculation methods are summarized in Table 6A.14.

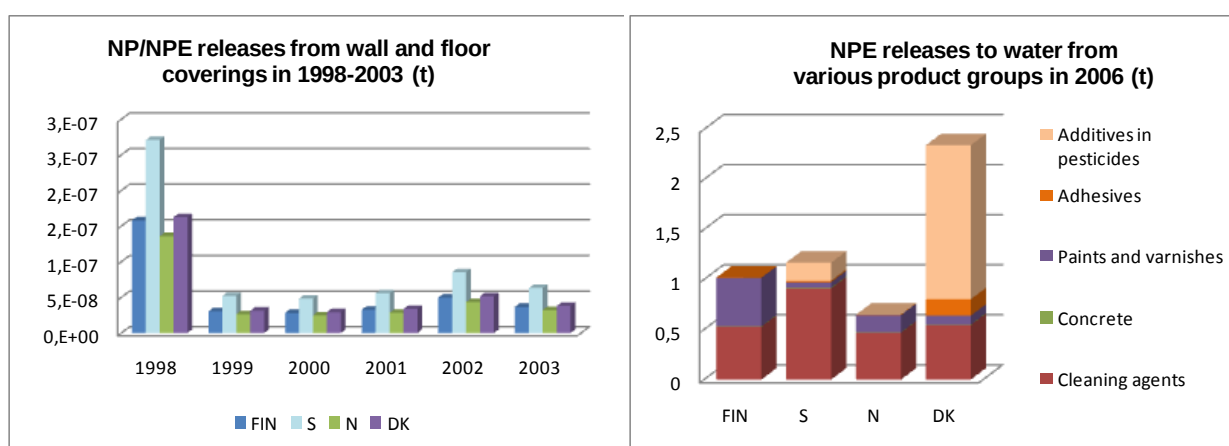


Figure 6A.11. NP and NPE release quantities to water from various product groups.

Although RETs were found for NP/NPE releases from the use of pharmaceuticals and car care products, no activity data for these sources were found during this project.

Table 6A.14. Summary of RETs for combined NP and NPE releases to water.

Product group	Activity data description	Emission factor	Emission factor reference
Additives in pesticides			
	SPIN database	10% of NP/NPE content in pesticides	Hansson et. al, 2008
Adhesives			
	SPIN database	1% of NP/NPE content in adhesives	Hansson et. al, 2008
Paints and varnishes			
	SPIN database	0,5% of NP/NPE content in paints and varnish	Hansson et. al, 2008
Concrete			
	calculated based on information on surface on concrete construction received from Sweden and proportioning figures to population (Eurostat, 2010a)	0,2 mg/m ² of concrete construction	Hansson et. al, 2008
Cleaning agents			
	population (Eurostat, 2010a)	0,1 g/person	Hansson et. al, 2008
Wall and floor coverings			
	calculated based on information on PVC wall and floor coverings received from Sweden and proportioning figures to population (Eurostat, 2010a)	Average EF 3,71E-12 kg/m ² calculated from emission factors 4,64E-12 (soft plastics) and 2,78E-12 (hard plastics)	SYKE based on Hansson et. al, 2008
Pharmaceuticals			
	Activity data not available	10% of NP/NPE content in pharmaceuticals	Hansson et. al, 2008
Car care products			
	Activity data not available	28% of NP/NPE in car care products	SFT (2004)
Textiles			
method 1	population (Eurostat, 2010a)	1,6 g/person	Månsson et al 2008
method 2	calculated based on information of textiles imported to Finland (Uljas, 2010) and by proportioning figures to population of other Nordic countries (Eurostat, 2010a)	0,25 kg/t textiles	Hansson et. al, 2008

Comparison to information reported under the E-PRTR

Based on information on in the literature, most of the releases from products occur to water. Only for a few products their use may cause releases to air or soil.

NP and NPE releases to air, water and soil from the use of the different products could not be calculated for a same year due to lack of activity data required by the methods. Therefore in Table 6A.15 releases to water from the use of floor covering are presented for year 2003, and releases from the use of pesticide, adhesives, paints and varnish, concrete, cleaning agents and textiles for the year 2006. Releases to soil and air are estimated from the use of pesticides for the year 2006.

When comparing the calculated releases from product groups presented above to the NP and NPE releases to water reported to the E-PRTR register in 2007, it can be concluded that emissions from part of the products may contribute greatly to the total emissions. However, it should be kept in mind that the RETs presented in this Annex contain large uncertainties. For

example, part of these releases to water can be assumed to be captured by the wastewater collection and treatment systems in the Nordic countries.

Table 6A.15. Comparison to NP and NPE releases reported to E-PRTR.

Country	NP/NPE 2007 releases reported to E-PRTR (t)			NP/NPE releases presented in this annex (t)			
	Air	Water	Soil	Air (2006)	Water (2003)*	Water (2006)**	Soil (2006)
FIN	-	0.0938	-	-	3.67E-08	9.5	-
S	-	0.13	-	0.09	6.31E-08	16.0	1.54
N	-	0.0508	-	-	3.22E-08	8.1	-
DK	-	0.0012	-	0.77	3.79E-08	11.1	13.1

* Water releases in 2003 from the use of floor coverings

** Water releases in 2006 from the use of pesticide, adhesives, paints and varnish, concrete, cleaning agents and textile (method 1)

A6.4 Nordic releases of brominated flame retardants (BFR)

Releases of brominated flame retardants to air and water from the use of insulating materials, enclosures and monitors, and construction work were estimated for the year 2006. Releases from the use of textiles were not estimated since activity data were not found for this activity (Vaara (2003), SFT (2004 and 2009), SPIN, (2010)).

Activity data for Norway is taken from the publication by SFT (2009). For Finland the activity data is calculated based on information in the publication by Vaara (2003) and by proportioning this to the figures on the amount of BFR in products based on information from Norway. Activity data for Sweden and Denmark is calculated by proportioning the information from Norway and Finland to the population in these countries (Eurostat, 2010). The emission factor used to air emissions was 0.05% and to releases to water 0.7%, which is a worst case emission factor (SFT 2004, 2009).

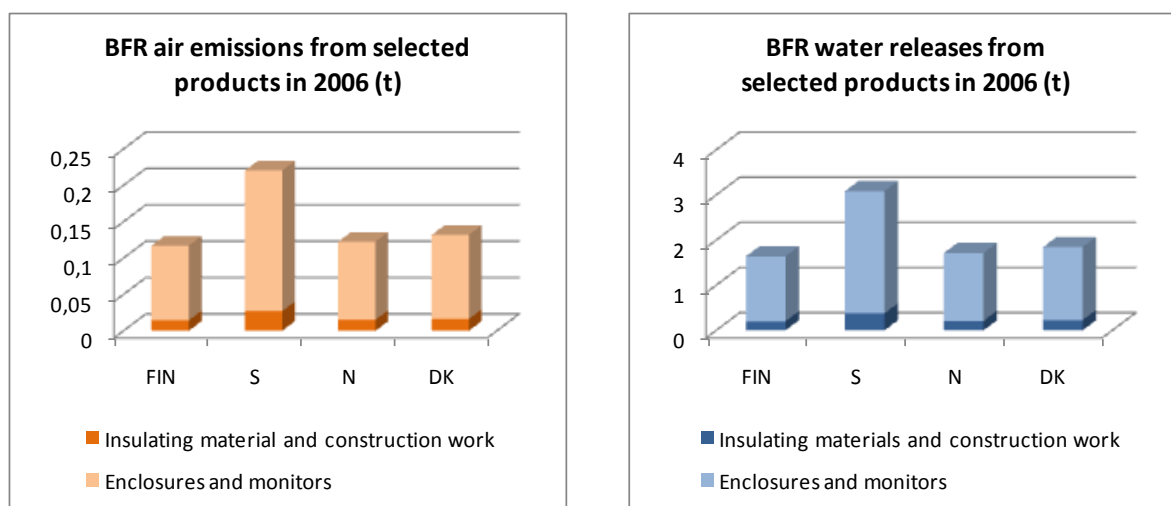


Figure 6A.12. Air and water emissions of brominated flame retardants from insulating material and construction work and enclosures and monitors.

None of the Nordic countries reported polybrominated diphenyl ether (PBDE) releases to E-PRTR in 2007 (E-PRTR, 2010).

A6.5 Nordic releases of persistent organic compounds (POPs)

A6.5.1 Releases of Cationic surfactants (DTDMAC, DSDMAC, DHTDMAC)⁶³ from the Use of Products

Water and soil emissions of selected cationic surfactants (DTDMAC, DSDMAC, DHTDMAC) from car care (washing agents, wax etc.) and other products were calculated based on information in SPIN and emission factors of 20% and 40%, respectively. The emission factors were derived from information in the publication by SFT (2004).

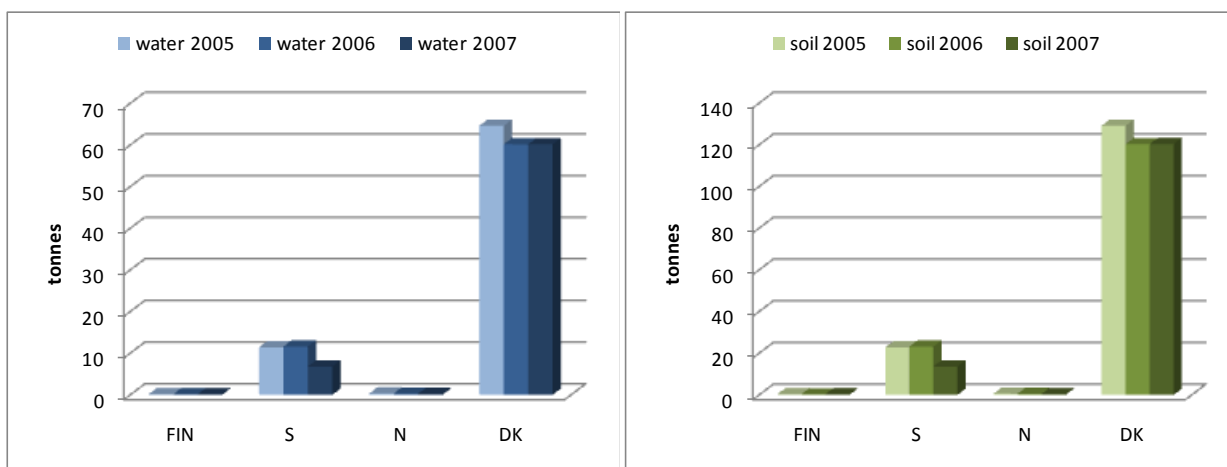


Figure 6A.13. Water and soil emissions of selected cationic surfactants (DTDMAC, DSDMAC, DHTDMAC) from car care (washing agents, wax etc.) and other products. note: part of the data in SPIN was confidential for Finland and Sweden.

A6.5.2 Releases of DEHP (Bis(2-ethylhexyl)phthalate) from the Use of Products

There are release estimation techniques available in the literature for DEHP from the use vinyl products, roofing materials and cables that contain DEHP. However, during this project activity data only for vinylproducts for 2006 was found. An emission factor of 9,5 mg/m² to air was used and activity data was calculated based on information on the surface area of vinyl products used based on information from Sweden. The release estimates are presented in Figure 6A.14.

⁶³ DTDMAC = ditallow dimethyl ammonium chloride, DSDMAC = distearyl dimethyl ammonium chloride, DHTDMAC = bis(hydrogenated tallow alkyl) dimethyl ammonium chloride

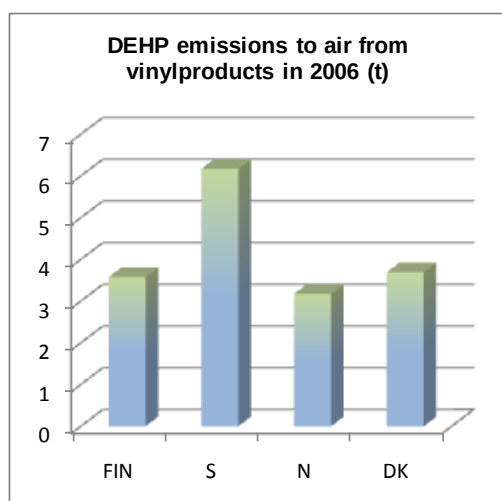


Figure 6A.14. DEHP emissions to air from vinylproducts in 2006 (t).

Comparison to information reported under the E-PRTR

As presented in Table 6A.16 only Sweden has reported DEHP emissions to air to the E-PRTR in 2007. DEHP emissions from the use of vinylproducts may also generate air emissions.

Table 6A.16. Comparison of DEHP releases reported to E-PRTR.

Country	DEHP 2007 releases reported to E-PRTR (t)			DEHP 2006 releases presented in this annex (t)		
	Air	Water	Soil	Air	Water	Soil
FIN	-	0.113	-	3.6	-	-
S	0.725	0.399	-	6.2	-	-
N	-	0.481	-	3.2	-	-
DK	-	0.008	-	3.7	-	-

A6.5.3 Releases of Hexachlorobenzene (HCB) from the Use of Products

HCB emissions to air from pesticide use were estimated using the emission factor of 40% of the HCB content in pesticides (EMEP, 2005). Activity data was taken from the Finnish HCB inventory to the UNECE CLRTAP⁶⁴. During the manufacture of chlorine containing pesticides HCB may be formed as a by-product and some of the HCB may be left in the product as an impurity (Jones, 2005). These pesticides include, for example, lindane, dacthal (DCPA), pentachlorophenol, atrazine, simazine, picloram, pentachloronitrobenzene (PCNB, quintozone), chlorothalonil, endosulfan and clopyralid (Jones, 2005; Environment Canada, 2006). The HCB impurity concentrations in certain pesticides are taken from the literature (Environment Canada, 2006) and sales of the effective substance in pesticides is from the Finnish statistics (Kemira-Kemi; Evira).

⁶⁴ <http://www.ymparisto.fi/default.asp?node=13256&lan=en>

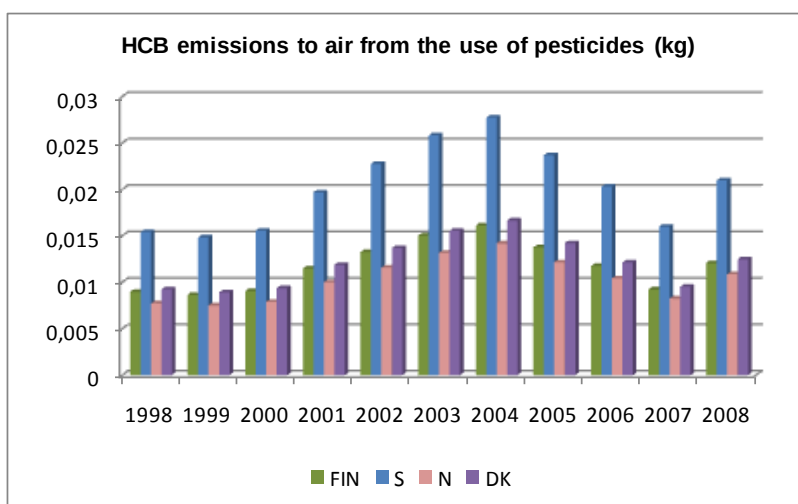


Figure 6A.15. HCB emissions to air from the use of pesticides.

Conclusions of calculated HCB releases and comparison with E-PRTR and CLRTAP

Only Finland has reported HCB emissions to air to the E-PRTR in 2007. In the Finnish CLRTAP⁴ inventory, the calculated HCB emissions from the use of products (Figure 6A.15) are only marginal when compared to the total releases (30.7 kg), which are influenced by releases from industrial processes (which are, however, currently declining). Finland has reported HCB emissions of 44.446 kg in 2007 to CLRTAP, Sweden 0.0178 kg and Denmark 3.97 kg. Norway has not estimated HCB emissions.

A6.5.4 Releases of Short chain chlorinated paraffins (SCCP) from the Use of Products

SCCP releases to air and water from paint application were estimated using an emission factor of 16.5% (SFT, 2004) and activity data collected from SPIN. The calculated emissions are presented in Figure 6A.16.

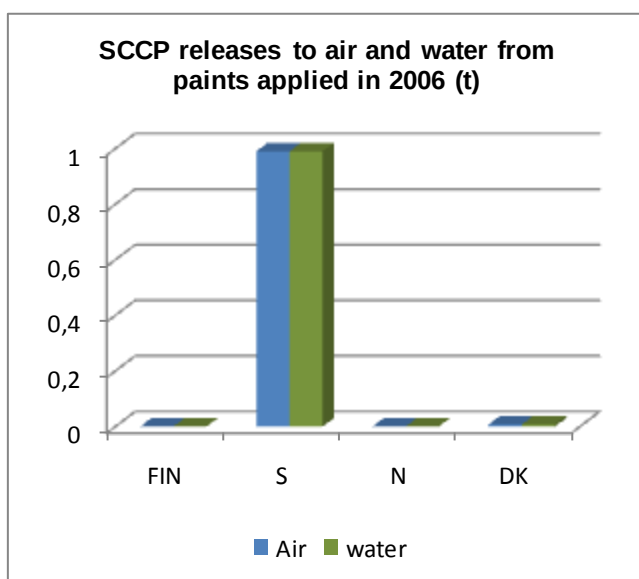


Figure 6A.16. SCCP releases to air and water from paint application in 2006.

A6.5.5 Releases of Musk compounds from the Use of Products

RETs for releases to soil and water are available for musk compounds from the use of detergents and cosmetics. During this project activity data was found only for the year 2000. Releases were calculated using the emission factor 36% to soil and 20% to water. The emission factors were derived from information on consumption and emissions of muskxylene and musk ketone presented in the publication by SFT (2004). Activity data was calculated by proportioning the figures presented in the EU Risk assessment report (EU Com, 2005a, 2006b) to the population in each of the Nordic countries. The calculated releases are presented in Figure 6A.17.

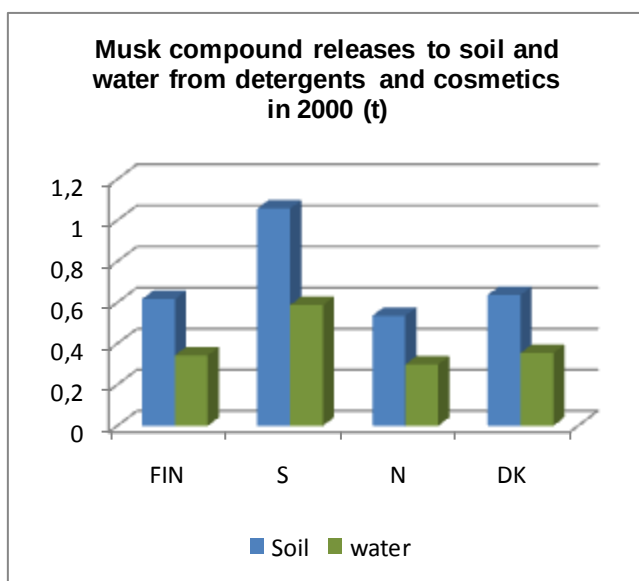


Figure 6A.17. Musk compound releases from the use of detergents and cosmetics.

A6.6 Summary

Based on the calculations carried out in this exercise it can be concluded that considerable releases of heavy metals and nonylphenols may be generated from the use of certain products and that most of these releases are lead directly to the soil, or in some cases are not captured by the wastewater collection and treatment systems and therefore released directly to surface water.

From all those product groups for which estimates were prepared, releases from mercury containing products can be estimated to be the most significant source.

Also, the use of CCA treated wood may generate copper, chromium and arsenic releases to soil. Copper releases to soil are also generated from the use of fungicide and antifouling paint, which is also assumed to generate emissions to water. Copper emissions from pipes and taps and roofing may generate emissions to soil and the latter also emissions to storm water in some extent.

Nonylphenol and nonylphenol ethoxylate releases from the use of pesticides, adhesives, paints and varnish, concrete, cleaning agents and textile may generate considerable releases to water and soil. The release rates of certain persistent organic pollutants, such as HCB, DEHP, SCCP, are difficult to assess and it is hard to conclude if these are considerable or not, due to lack of information.

Due to the lack of both activity data and information on chemical contents in the products rough assumptions have been made in the calculations and therefore the results should be treated bearing in mind that they include high uncertainties. As the choice of the method greatly affects the results, release estimation techniques should therefore be carefully applied and adjusted taking into account national circumstances.

When comparing the calculated releases from product groups presented in this Annex to releases reported to the E-PRTR register in 2007, it can be concluded that releases from part of the products may have a significant contribution to total releases, if included in the reported releases.

Releases from the use of products may also give valuable additional information on the migration of chemicals into the environment, especially if reliable RETs can be developed for estimation of these releases.

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