COHIBA

CONTROL OF HAZARDOUS SUBSTANCES IN THE BALTIC SEA REGION

Recommendation Report

COST EFFECTIVE MANAGEMENT OPTIONS TO REDUCE DISCHARGES, EMISSIONS AND LOSSES OF HAZARDOUS SUBSTANCES

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1 Introduction

The Baltic Sea ecosystem is particularly at risk from hazardous substances, due to its natural characteristics, such as slow water exchange, and due to a long history of urbanisation and industrialisation at the shores and in the catchment area. The ecosystem status of nearly all open-sea and coastal areas of the Baltic Sea is considered to be "disturbed by hazardous substances" (HELCOM 2010).

Therefore, HELCOM identified 11 hazardous substances of special concern (Table 1) and laid down environmental targets in the Baltic Sea Action Plan (BSAP) for a Baltic Sea with life undisturbed by hazardous substances and all fish safe to eat.

Table 1: Hazardous substances and substance groups of special concern to the Baltic Sea identified by HELCOM

1. Dioxins (PCDD), furans (PCDF) and dioxin-like polychlorinated biphenyls (PCBs)
2. Tributyltin compounds (TBT), triphenyltin compounds (TPhT)
3. Pentabromodiphenyl ether (pentaBDE), octabromodiphenyl ether (octaBDE), decabromodiphenyl ether (decaBDE)
4. Perfluorooctane sulfonate (PFOS), Perfluorooctanoic acid (PFOA)
5. Hexabromocyclododecane (HBCDD)
6. Nonylphenols (NP), nonyphenol ethoxylates (NPE)
7. Octylphenols (OP), octylphenol ethoxylates (OPE)
8. Short-chain chlorinated paraffins (SCCP), medium-chain chlorinated paraffins (MCCP)
9. Endosulfan
10. Mercury
11. Cadmium

To achieve the targets of the BSAP, measures for emission reduction are needed. This report summarises the main results and conclusions of the 11 Guidance Documents on hazardous substances of special concern to the Baltic Sea which have been compiled within COHIBA and gives recommendations for reduction strategies.

It starts with a brief description of the used evaluation methodology (Chapter 2) and existing regulations (Chapter 3), followed by important emission sources (Chapter 4). The main part of this report deals with the measures to reduce emissions (Chapters 5) and reduction strategies (Chapter 6) and concludes with an outlook (Chapter 7).

2 Evaluation methodology

In order to identify appropriate measures for reducing emissions of hazardous substances to the Baltic Sea a pragmatic approach was applied. Sources and measures promising a large reduction potential were pre-selected. For the identification of large reduction potential two criteria are taken into account: firstly the load at the source and secondly the effectiveness of the applied measure. In a second step these pre-selected measures were analysed in detail and compared. If appropriate data on effectiveness and costs were available a quantitative assessment of the cost-effectiveness of measures was performed by using the following evaluation criteria:

- Effectiveness: The effectiveness of a measure at a given source relates to the reduction it achieves in the emissions of a given hazardous substance. In combination with the load of the respective source, the effectiveness is expressed as load reduction in kilogramme.
- Costs: The evaluation of costs is subdivided in direct costs and running costs.
- Cost-effectiveness analysis: For calculations of cost-effectiveness of the different measures, expressed by the ratio of cost to the reduced load of hazardous substances, different scenarios (low load reduction effectiveness – high costs and high load reduction effectiveness – low costs) were applied.

The quantitative assessment is subject to high uncertainties, as costs and loads may vary between locations. The cost-effectiveness scenarios are meant to indicate the ranges and to compare measures to each other. The quantitative assessment is complemented by a qualitative evaluation to include sustainability aspects, mainly based on experts' estimates rather than on empirical data. For this additional assessment the following qualitative aspects were taken into account:

- Secondary environmental effects: Besides the direct effects on emissions of the targeted hazardous substance further positive and negative secondary environ- mental effects were assessed, e.g. effects on emission reduction of other haz- ardous substances or nutrients.
- Technical feasibility: The technical feasibility was assessed through the ease of technical implementation of the respective measure under different boundary conditions, e.g. time needed for the technical implementation of the measure.
- Secondary socio-economic effects: Besides the primary costs of a measure, there are also secondary socio-economic effects, such as indirect costs, effects on employment and product prices.
- Geographical and time scale of effects: Effects on a local, regional, national or international level as well as immediate and long-term effects of the measures were evaluated.
- Political enforceability: The alignment of measures with other political targets was assessed considering both possible conflicting interests and the acceptance by existing interest groups.

3 Regulatory framework

International, European and/or national regulations exist for most of the 11 hazardous substances. As eight substances are priority substances or priority hazardous substances under the Water Framework Directive (2000/60/EC), source screening has to be conducted and measures have to be elaborated to ensure that the emissions, discharges and losses will be ceased or phased out by the year 2021 (see Table 2). PFOS and PCDD, PCDDF, PCB are listed in annex III of the daughter directive (2008/105/EC) to the Water Framework Directive as a substance subject to review for possible identification as a priority sub-stance (or priority hazardous substance). This review process is currently ongoing.

On an international level some of them are regulated e.g. as POPs under the Stockholm Convention and LRTAP Protocol or they are at least candidates (see Table 2).

On a European level additional regulations focusing on the substance, like the Regulation on the registration, evaluation and authorization of chemicals (REACH 1907/2006/EC), regulations focusing on the emissions and the different sources, like Integrated Pollution Prevention and Control (IPPC) Directive (1996/61/EC), and several regulations regarding marketing and different uses of the substances are in place Furthermore different HELCOM recommendations on hazardous substances, their production, use and after-use management exist. The detailed status of these regulations is available in Annex 2 of the HELCOM Background paper on hazardous substances (HELCOM 2007).

For some substances additional national measures either in the form of regulations or voluntary agreements were established, which have led to stricter national regulations or even bans on the use of the substances.

Some of the hazardous substances are banned or heavily restricted like TBT/TPhT, endosulfan, PCDD, PCDF, PCBs, penta- and octaBDEs, others are only partially banned and restricted (with exceptions) in the Baltic Sea Region and PFOA and MCCP are not regulated in the Baltic Sea Region(see Table 2).

Regulatory gaps can be determined for PFOA, MCCP, HBCDD, decaBDE, NP/NPE, OPE, where some substances are only partially regulated and/or remaining relatively large industrial sources were identified, while others like PFOA, MCCP, decaBDE are almost not regulated at a EU or international level.

The legal system of chemicals management has developed differently in Russia than it has in the EU. It puts more emphasis on substances which pose acute toxic risks – not so much stressing persistence and bioaccumulation - as a result nationally and regionally set restrictions do not cover exactly the same substances that are included in different EU legal acts. The Russian Federation has ratified the Stockholm Convention on 17.08.2011. For the Baltic Sea region, pollutants well known in the Russian Federation (mercury, cadmium, dioxins, PCBs, endosulfan), are well regulated and enforced (they are being regularly monitored in wastewater treatment plants' (WWTP) outgoing effluents). At the same time, other substance groups are being regulated only for specific cases (e.g. coastal waters) or simply

Table 2: The regulatory status of 11 BSAP substances in the EU Baltic Sea region (Status January 2012).

BSAP substance	Stockholm POP convention	WFD priority substance	Use almost totally banned in EU-BSR	Use partially banned / restricted in EU-BSR	Not regulated in EU-BSR
Dioxins & furans	X		X		
PCBs	X		X		
TBT		X (PHS)	X		
TPhT			X		
pentaBDE	X	X (PHS)	X		
octaBDE		X (PS)	X		
decaBDE		X (PS)		X	
HBCDD	X *			X *	
PFOS	X		X		
PFOA					X
NP & NPE		X (PHS)		X	
OP & OPE		X (PS)		X	
SCCP	X *	X ((PHS)		X	
MCCP					X
Endosulfan	X	X (PHS))	X		
Cd		X (PHS)		X	
Hg		X (PHS)		X	

* Candidate for Stockholm POP convention
PS = WFD priority substance, PHS = WFD priority hazardous substance

being restricted for emissions, at the same time allowing the production, import and use of them. This leads to a situation of these substance groups not being included in monitoring programmes and not being asked to be controlled by companies in their effluents because formally there should be zero emissions.

4 Important emission sources

Hazardous substances can reach the Baltic Sea via a multitude of pathways. A general overview of sources and pathways of hazardous substances is given in Figure 1.

“Classical” emission sources are industries, where most of the 11 hazardous substances are produced or used (production or industrial use, see left side of graph). Usually, industries have “technical barriers” in place to tackle their waste streams e.g. wastewater treatment plants or flue gas scrubbers. But sometimes these technical barriers are not effective against hazardous substances. Also emission can bypass abatement processes e.g. via dust or even mismanagement.

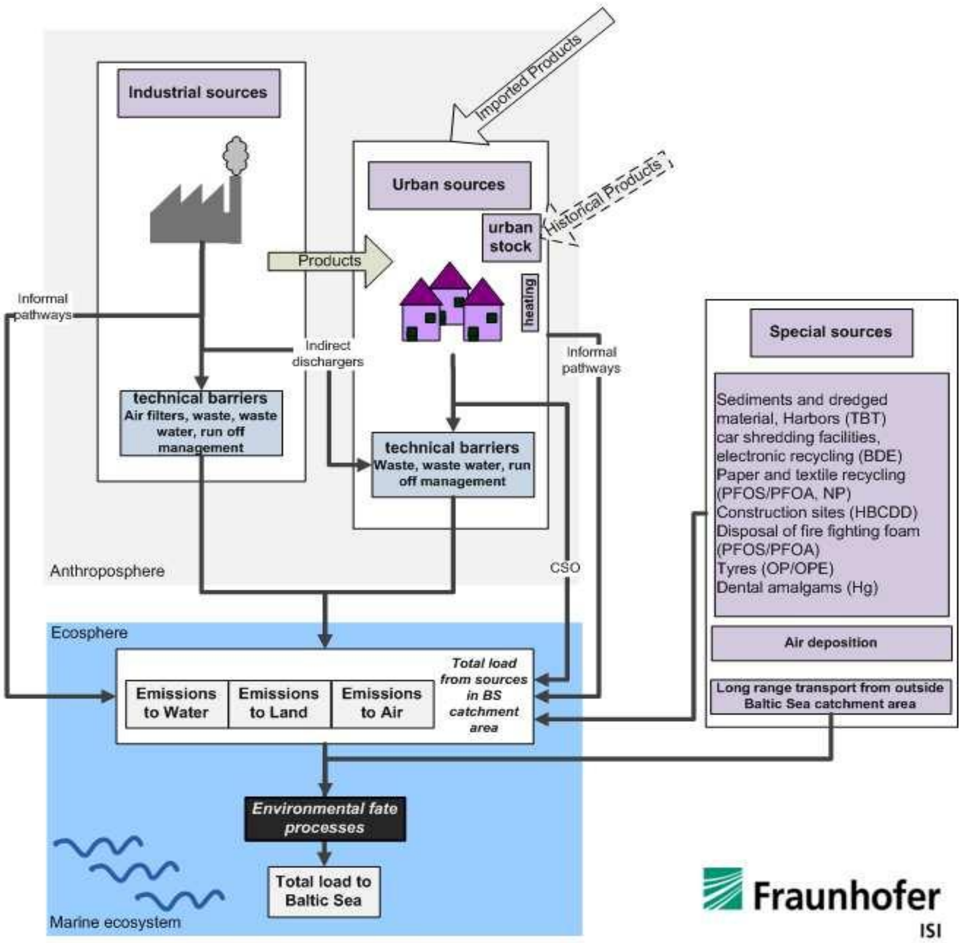

Figure 1: Emissions sources to the Baltic Sea

Another pathway for hazardous substances out of the industrial domain is via products for private use. Although every product usually contains only small amounts of hazardous substances, a large stock can pile up in urban areas. Consequently, urban areas or the urban stock of hazardous substances are also emission sources. The urban stock also includes imported products and "historical" products with a long technical lifespan. The emission from urban stock is mostly channelled through urban infrastructure systems, but standard treat- ment is not very effective for many of the 11 hazardous substances. Emission from urban areas can also bypass urban infrastructure systems via informal pathways, e.g. via activities like (illegal) burning of household or electricity waste, illegal disposal of waste, illegal dis- charge of wastewater or losses from sewer systems.

For most of the 11 hazardous substances, changes of emission patterns could be observed in the last decades. Due to regulations and consequent emission reduction measures at large industrial point sources, emissions from industrial sources and therefore loads of hazardous substances to the environment were reduced. Non-industrial emission sources are therefore becoming more important. These sources have a more diffuse character i.e. emissions from use of products in urban areas or contaminated sediments.

For some substances, air deposition and long range transport are also important pathways, affecting the whole Baltic Sea catchment area.

Industrial emissions are related to intentional use of hazardous substances in production processes or as a component in products or to unintentional emissions in technological processes. In the metal industry some of the hazardous substances concerned are still in use (e.g. use of PFOS in chromium plating, of SCCP/MCCP and NP/NPE in cutting oils). After going through an industrial wastewater treatment plant the hazardous substances might be discharged directly into the surface waters or, when the industry plant is an indirect dis- charger, the hazardous substances are routed to a MWWTP.

In other industries the hazardous substances are used as component of products, from which emissions arise: examples are the textile industry (e.g. NPE/OPE for printing) or the poly- mer industry (PFOS/PFOA; NP/NPE, PBDE, HBCDD, TBT/TPhT, Cd). In power plants and other combustion processes like iron or cement production (PCDD/PCDF, Cd, Hg) or the chemical industry, hazardous substances are unwanted by-products.

Hazardous substances are also used in small and medium sized enterprises (SMEs). SMEs are not regulated by IPPC, if they emit below the thresholds given in regulations like the IPPC directive, or if the activity is not mentioned in the directive, like car shredder facili- ties, dentistry or shipyards.

Urban sources include emissions from service life of products and from urban stock, like e.g. PFOS/PFOA or TBT/TPhT from impregnated carpets, leather/apparel, tex- tiles/upholstery, paper and packaging etc. Other urban emissions coming from industrial and household cleaning products and consumer articles like cookware, textiles, wire and cable coating, electronics, cosmetics, paints, lamps etc. Emissions of NP/NPE, PBDE, TBT/TPhT, Cd, PFOS, Hg arise from these products. Even if the use of a certain chemical is restricted in the EU, emissions are possible from **imported products** e.g. NP/NPE from hygiene or cosmetic products or endosulfan from imported foods.

Emissions from urban stock are usually directed through urban infrastructures, e.g. MWWTP. Therefore, wastewater and sewage sludge from MWWTP, as well as urban run-off, contains many hazardous substances in low concentrations (µg to ng/l or µg to mg/kg in sludge) e.g. PBDE, endosulfan, PFOS/PFOA, NP/NPE, and SCCP/MCCP. Waste incineration and landfills are another important source of urban infrastructure for e.g. PCDF/PCDD and Hg.

Atmospheric deposition is also an important pathway for some of the hazardous substances. Next to the deposition from regional air emissions like household burning **long range transport** is notable for some of the hazardous substances.

The **agricultural sector** has been a large polluter with certain hazardous substances in the past e.g.NP/NPE / OPE (used in pesticides), endosulfan. It is still an issue regarding Cd content in fertilisers.

In some cases the hazardous substances are degradation products from other substances, like e.g. PFOS/PFOA from precursors like fluorotelomer alcohols (FTOHs).

Some of the 11 hazardous substances are accumulated in sediments or soils, which then can be seen as a secondary source of **historical contamination** for e.g. PCDD/PCDF, TBT/TPhT, Cd and Hg.

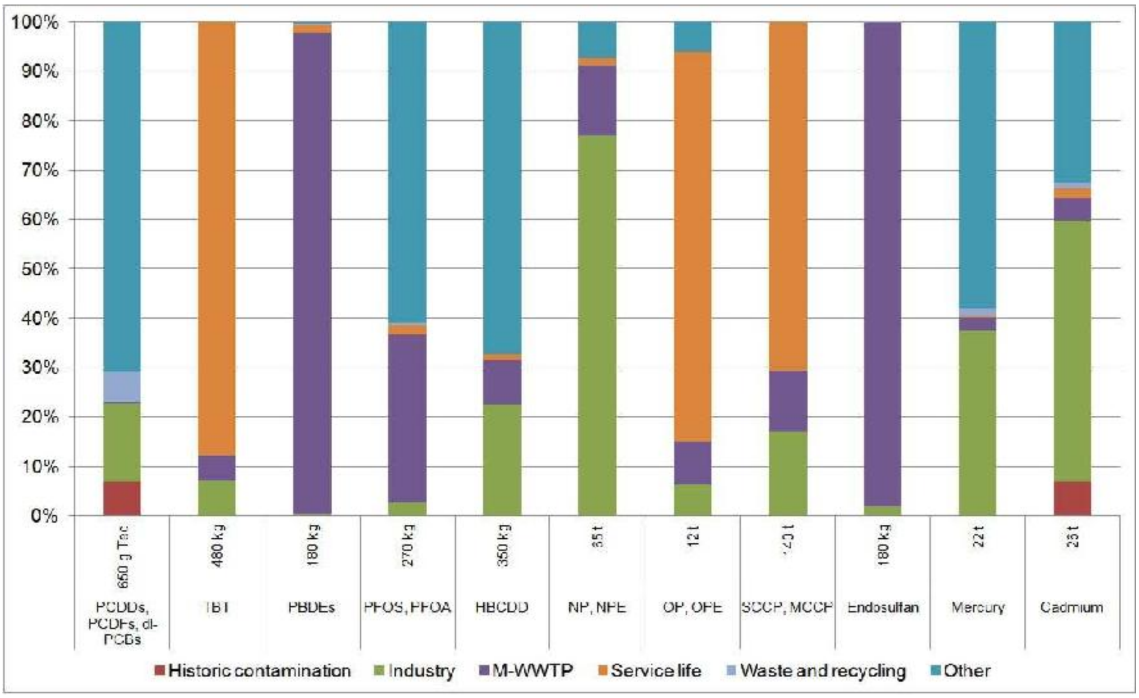

Figure 2: Share of emission sources for emissions to the environment in the BSR (based on data from the “low emission scenario” of WP4, December 2011)

Figure 2, shows the result of the Substance Flow Analysis (SFA) within COHIBA work package 4, (Andersson et al. 2012). Each hazardous substance shows a distinct source pattern. Industry is a big source for NP/NPE, Cd, Hg, and HBCDD.

MWWTP is the most relevant source for PBDEs and endosulfan, but also important for PFOS/PFOA, SCCP/MCCP, HBCDD and the alkyl phenols. Emissions from service life of products are an issue for TBT emissions from treated timber, for OP from abrasion of tyres and for MCCP from waste remaining in the environment. Historic contaminations are a source of dioxins and cadmium.

The category "Others" includes for example construction areas (HBCDD and partially NP from paints), fire foams (PFOS/PFOA) and heat and power production (PCDD/PCDF).

Due to incomplete data bases, uncertainties of SFAs are high, especially for historic contaminations. More information about categories, calculations and uncertainties is available in the WP 4 final report (Andersson et al. 2012).

5 Measures to reduce emissions

5.1 General Considerations

Life cycle of substances, emission reduction and the subsequent reduction of concentration in environmental media of hazardous substances follow a typical pattern which is generically described in Figure 3.

In the beginning the use of a substance is unrestricted and without much thought (yellow line) resulting in massive inputs into the environment. When environmental or health problems caused by this substance become obvious, voluntary or legal measures to reduce inputs into the environment are put in place. As a result of these initial reduction measures the amount used in industry and society drops quickly, as early substitutions are exploited and/or basic emission reduction technologies come into operation. These measures are generally very cost effective (black line).

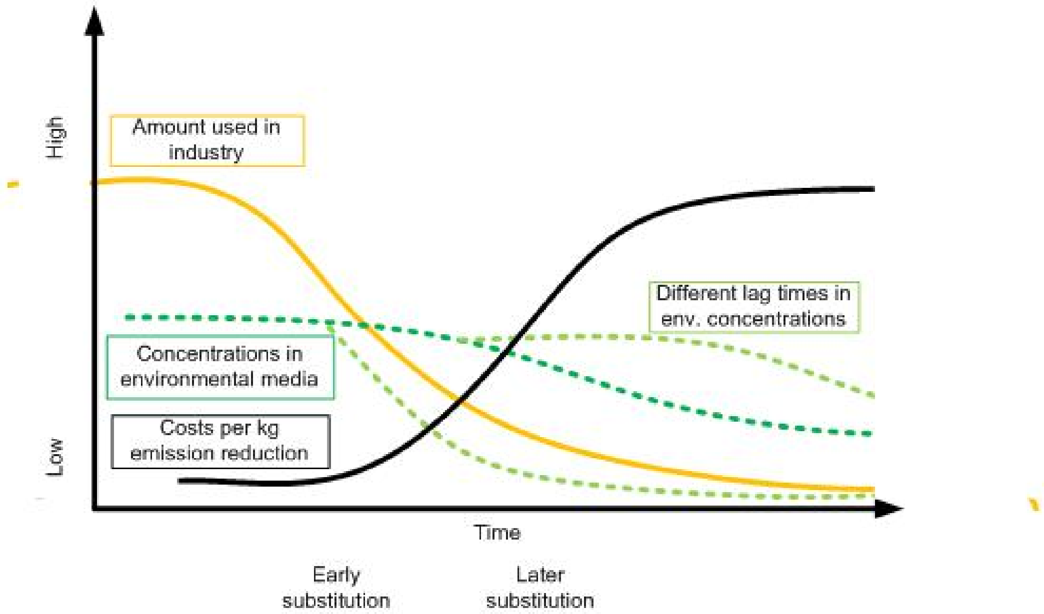

Figure 3: Changes of specific costs, used amounts and environmental concentration during substitution processes

The remaining uses of the substance are often more specialized, thus substitution and costs per kg emission reduction are (significantly) higher. This is an example of the Pareto principle, that states that the highest effect can be gained in the beginning with low effort, while at later stages much more effort is required to have even just little effects.

The observed concentrations in municipal wastewater or environmental media (green lines) normally do not directly drop in proportion to the reduction of production and use, due to products which were manufactured before the introduction of threshold values or imported products, or due to contaminated sediments and other sources. E.g. urban stock can be an emission source for many years to come, depending on the life span and use pattern of these products. Therefore, the total load of a particular hazardous substance in municipal wastewater may be higher than the total load from industrial sources. At this stage additional end-of- pipe measures (EoP) at MWWTPs become increasingly more favourable, especially as they reduce the inputs of many substances simultaneously.

5.2 Substance specific measures

The following conclusions regarding substance-specific measures are drawn from the COHIBA Guidance Documents, which are available from the project website: www.cohiba-project.eu).

1. **Dioxins (PCDD), furans (PCDF) and dioxin-like polychlorinated biphenyls (PCBs):** Concerning the reduction of PCDD/F air emissions in the residential sector the replacement and retrofitting of household furnaces seems to be the most important measure. This measure should be combined with generally improving building energy performance like thermal insulation. For industrial air abatement, technical measures with improved combustion and clean up techniques are the most cost-effective. This includes the improvement of BAT and revision of the BREF document concerning small particle (PM 2.5) emission reduction for different industry branches (power plants/energy sector, metallurgical sector, waste incineration) on a SME level.

   Contaminated soil and sediments are local problems and should be treated on a case by case basis. Suitable technical measures are dredging and on-site combustion of contaminated soil or on-site capping. Those should be applied to highly contaminated soil.

2. **Tributyltin compounds (TBT), triphenyltin compounds (TPhT):** Measures regarding sediment management especially in harbours like environmental dredging, ex-situ solidification and stabilisation and no dumping in the Baltic Sea are effective but often very costly. Therefore more information on the location of contaminated hot spots of TBT would be required to determine the places which should be treated first.

   National legislation regarding the technical possibilities of implementation and linkage between the different EU regulations and directives defining the use of organotins and dredged material are still needed.

3. **Pentabromodiphenyl ether (pentaBDE), octabromodiphenyl ether (octaBDE), decabromodiphenyl ether (decaBDE)**: Substitution of PBDEs (mainly decaBDEs, because penta- and octaBDE are already well regulated) at the source - in polymers, textiles and construction material - starting from replacing PBDEs with different flame retardants up to re-design of the product in a way that eliminates the need for flame retardants as such seems to be the most cost-effective measure and is easy to implement.

4. **Perfluorooctane sulfonate (PFOS), Perfluorooctanoic acid (PFOA):** For PFOS, substitution in metal plating is very cost effective. As polyfluorinated substitutes cause concern, additional end-of-pipe measures or the development of a better substitute should be considered. BREF needs updating and there is a gap in the regulations for SMEs.

   There are only few data on industrial uses for PFOA, due to a lack of regulation. Therefore, calculation of cost effectiveness of substitution in manufacture of semiconductors and of photographic material is subject to high uncertainties.

5. **Hexabromocyclododecane (HBCDD):** The use of mineral wool as a substitute for HBCDD-containing insulation boards in the building sector is a cost-effective measure but it cannot be applied in all applications where polystyrene boards are used. Re-design of the construction, controlled demolition of buildings and recycling as measures regarding waste management are the main recommendations.

6. **Nonylphenols (NP), nonyphenol ethoxylates (NPE):** A EU-wide (absolute) ban of NPEs is primarily recommended for the following usages (manufacture, marketing & use): in industrial, professional and domestic cleaning products and textiles and secondarily, the EU-wide absolute ban of NP and NPEs for the use in the leather and the metal sector. Thus, those usages which were only conditionally banned in 2005 (directive 2003/53/EC) should be banned completely.

   The alcohol ethoxylates are environmentally less harmful, cost-effective and already used as substitutes for NP and NPE in the above mentioned applications. The substitution of NP and NPE with alcohol ethoxylates is possible for a small additional cost for example in cleaning products. These measures would significantly facilitate authority control and elimination of emissions from the above mentioned significant NP and NPE emission sources.

   Additionally, the ban of NP and NPE in textile goods imported from outside of the EU is recommended.

7. **Octylphenols (OP), octylphenol ethoxylates (OPE):** Substitution has been implemented for instance in textile printing but in some cases it is difficult, e.g. in tyre production. End-of-life tyres should not be crushed but disposed of by controlled incineration as a waste management option to prevent OP emissions.

   Voluntary agreements of the industry to a more restricted use are recommended to accelerate the substitution process.

8. **Short-chain chlorinated paraffins (SCCP), medium-chain chlorinated paraffins (MCCP):** Since substitution of SCCP has proven to be possible in most areas of application, the knowledge regarding substitution should be transferred to regions outside EU where SCCP are still produced and used in large amounts (reduction of emissions via long range transport).

The use of MCCP as a substitute for SCCP should be avoided. Possible restrictions and a substitution of MCCP (e.g. in emulsion and oil-based metal cutting fluids) need to be evaluated further, since the industry and the use of products containing MCCP seem to be the dominant sources of MCCP emissions to the environment. As only few regulations have been issued for MCCP up to now, this type of measure should have a significant impact on the reduction of MCCP emissions to the environment.

In addition restrictions on the use of SCCP could be extended to include the remaining areas of application like rubber, paints and varnishes.

9. **Endosulfan:** A global ban to list endosulfan according to the decision of the Stockholm Convention would be the most effective measure since endosulfan is still in use in India and parts of Africa. Substitution is available and very effective. Besides that for the Baltic Sea Area improvement of control and a ban of contaminated foods is recommended as a precautionary measure

10. **Mercury:** The improvement of BAT and revision of BREF for combustion power plants and for the chlorine-alkali industry are recommended. The substitution of mercury in dentistry is highly recommended and the dental amalgams should be considered further in the HELCOM recommendations, because the problem is not solved yet.

    The EU mercury strategy should be implemented further to reduce the use in products like batteries, electrical and electronic equipment and thermometers.

11. **Cadmium:** The biggest reduction potential can be expected from measures concerning air emission abatement in the residential and industrial sectors. On the one hand upgrading and retrofitting of burners in individual households is potentially a cost-effective measure, on the other hand the improvement of BAT and a revision of the BREF document (ferrous, non-ferrous, metal and energy sector) for industrial air abatement is recommended. Small and medium companies should be included (lower or skip threshold values) in the BREF process.

    The treatment of contaminated land is important for selected regions were the soil and sediment pollution is high. Another option seems to be the reduction of Cd-content in fertilisers.

    Restriction of Cd-Ni batteries is another effective measure.

Substitution or changes at technical processes are generally preferable but due to product life span, highly specific applications, long range transport etc. often not sufficient to achieve the targets laid out in the BSAP. Therefore EoP measures are also important as they reduce a lot of substances simultaneously, first of all:

- Advanced wastewater treatment (recommended for NP/NPE, OP/OPE, PFOS/PFOA, HBCDD, TBT/TPhT, Endosulfan, Cd).

- Sludge treatment (recommended for NP/NPE, OP/OPE, SCCP/MCCP, HBCDD, PBDEs, TBT/TPhT, Endosulfan).
- Waste management (recommended for OP/OPE, MCCP/SCCP, PCDD/PCDF, HBCDD, TBT/TPhT, Cd).

5.3 Measures with cross substance effects

Measures such as advanced wastewater treatment, sewage sludge treatment, waste management and treatment of urban run-off reduce the emissions of a multitude of substances including the emissions of hazardous substances simultaneously. In this chapter advanced wastewater treatment, sewage sludge treatment and treatment of urban run-off are discussed in more detail.

According to WFD the emissions, discharges and losses of priority hazardous substance should be ceased or phased out by the year 2020. This supports HELCOM’s objective (e.g. 11 HELCOM BSAP substances) to prevent pollution of the Baltic Sea with the ultimate aim of concentrations in the environment being near background values for naturally occurring substances and close to zero for man-made synthetic substances (HELCOM 2010). Therefore, the end-of-pipe measures like conventional and advanced wastewater treatment, sludge treatment, urban run-off management are effective options especially in cases where EQS values of a WFD priority hazardous substance are exceeded.

The kind and load of hazardous substances varies between individual facilities and also in time. This was also observed in the COHIBA screening campaign. Therefore, load calculations are subject to high uncertainties. As a reference point for the calculation of cost effectiveness, we use average concentrations of the COHIBA WP3 screening campaign.

Advanced wastewater treatment

Apart from wastewater from households, MWWTPs often also receive wastewater from SMEs (indirect dischargers), urban run-off or landfill leachate.

A state of the art 3-stage MWWTP is designed to reduce organic load and nutrients, but is not equipped to eliminate persistent substances with a low biodegradability, such as the 11 hazardous substances and other micro-pollutants. Therefore, an advanced treatment step to eliminate persistent substances is discussed in many European countries; the legal implementation in Switzerland is under preparation. Ozone treatment or activated carbon processes are available, as are proven technologies, which can be integrated in existing plants (BAFU 2009).

By the ozonisation hydroxyl radicals are formed, which part-oxidize and break down the contaminates. These smaller molecules can often be degraded biologically. Another particular advantage of the ozonisation consists in the construction being very compact. Disadvantages consist in the fact that the micro-pollutants are degraded but often not removed and new and possibly toxic compounds may be produced during the oxidation process.

Therefore, the ozonisation is used preferably in combination with an adsorption process, e.g. a sand filter with a biofilm.

Another possibility for an advanced wastewater treatment is the use of activated carbon, which can be dosed as granulated coal somewhere in the water stream inside the MWWTP or used as a fixed bed reactor at the outlet of the plant.

Costs of advanced wastewater treatment depend above all on the size of the MWWTP and the amount of reagents (ozone or activated carbon) that is necessary for the treatment. To calculate overall costs in the BSR, we use a wide cost range of 5 to 20 euros per year and person, see for example Rölle and Kuch (2011). Taking into account that in the BSR 195 MWWTPs are bigger than 100,000 person equivalents and serve approx. 41.3 million people (PLC-4), the annual total cost for all 195 plants for this measure can be estimated between 200 and 825 million euros.

Table 3: Effectiveness of advanced wastewater treatment

	TBT/ TPhT	**BDE Penta Octa Deca**	**PFOS / PFOA**	**HBCDD**	**NP/ NPE**	**OP/ OPE**	**SCCP/ MCCP**	**Endo-sul-fan**	**Hg**	**Cd**
Concentration after standard MWWTP (mean values from WP 3)	0.53 0.50 ng/l	0.29 0.18 0.84 ng/l	3.75 6.48 ng/l	1.53 ng/l	0.33 0.06 µg/l	0.08 0.04 µg/l	0.99 2.37 µg/l	0.04 µg/l	0.06 µg/l	0.28 µg/l
Concentrations in sludge (mean values from WP 3)	10.5 1.5 µg/kg	29.9 2.2 350 µg/kg	0.64 7.2 µg/kg	26.6 µg/kg	5.7 2.4 mg/kg	0.2 0.02 mg/kg	8.25 0.63 mg/kg	0.4 mg/kg	0.71 mg/kg	0.59 mg/kg
Estimated elimination efficiency [%] *	90	80	75	80	93	75	95	87	80	80

* WP 5 Guidance Documents (GD 2012), Fahlenkamp et al. (2008)

The effectiveness of ozonation or activated carbon treatment for municipal wastewater is difficult to predict, as it depends on the system setup and concentration of hazardous substances and of potentially competing organic substances. For the calculation, we use values from screening data from COHIBA WP3 reported in Table 3.

Based on median concentrations calculated from the screening data from COHIBA, the cost effectiveness for advanced water treatment in the Baltic Sea catchment area can be calculated for each of the 11 hazardous substances individually. Cost effectiveness lies between approx. 30,000 euros/kg[1] for MCCP and approx. 1,900 million euros/kg[2] for octaBDE, depending on the eliminated load.

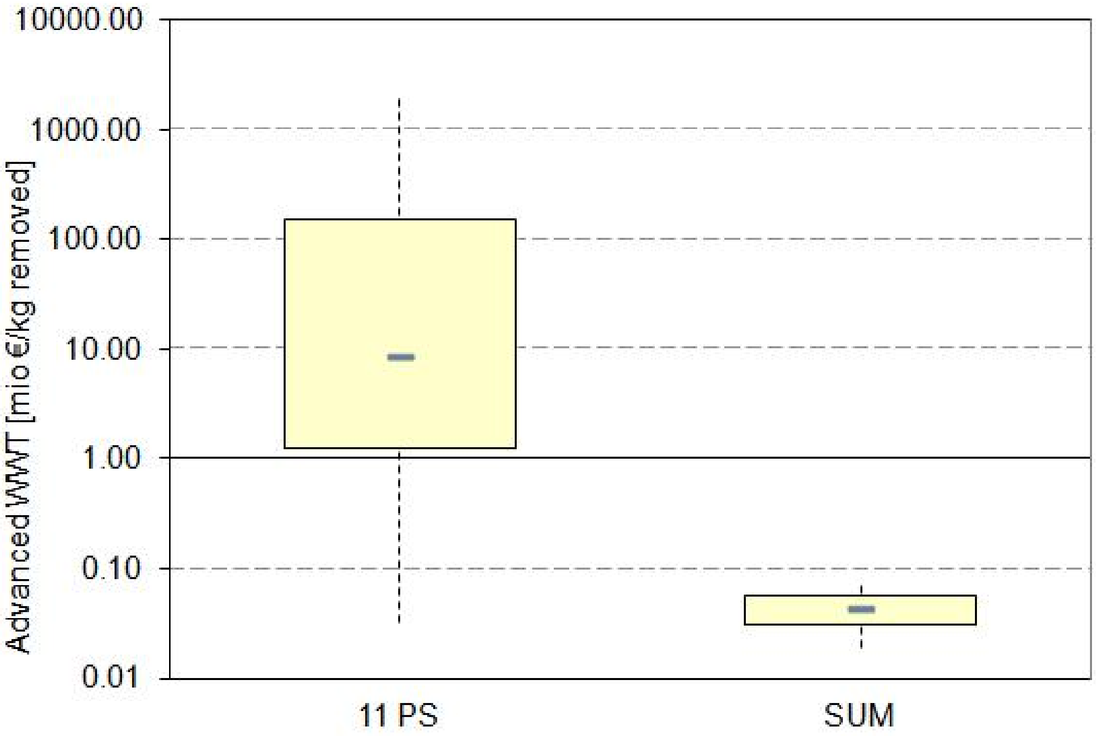

Figure 4: Cost-effectiveness of advanced wastewater treatment

To indicate the cross substance effect, we add up the effect on 11 hazardous substances on a mass base as cost per kg emission reduced (sum of all substances), without weighing for a total amount of emission. Cost effectiveness lies between 17,000 and 69,000 euros per kg emission reduced (sum of all substances). The results are shown in Figure 4.

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1 Example calculation for MCCP: BSR average concentration from table 2: 2.37 µg/l, Load in person equivalent (p.e., calculated with 200 l per person and day): 173 mg/(p.e·a): An 95 % elimination equals to 164 mg/(p.e. a) eliminated MCCP. Assuming annual cost of 5 euros per person for the process, the specific cost are 5 euros/164 mg = 30,000 euros/kg.

2 The eliminated amount of octaBDE calculated from table 2 is 0.0107 mg/(p.e. a). Taking into account the higher value in the cost range of 20 euros per person, the specific costs are approx. 1,900 euros/kg.

Sludge treatment

While most hazardous substances cannot be reduced efficiently by biological treatment in conventional wastewater treatment plants, they often tend to adsorb onto sludge generated in the wastewater treatment process due to their low solubility and high sorption potential (e.g. Endosulfan, HBCDD, OP, NP, SCCP/MCCP and heavy metals), leading to an accumulation of hazardous substances in this compartment. The sludge from the wastewater treatment process is often applied to land to allow a re-use of contained nutrients or disposed of in landfills or by incineration.

Hazardous substances contained in sewage sludge which is used in open applications can reach surface or groundwater e.g. via leaching or erosion, but can also be retained in the soil. Measures targeting sewage sludge have a lower direct influence on concentrations in water than measures targeting effluent of MWWTPs, which represents a direct pathway to the aquatic environment. Anyhow, to prevent emissions to the environment from hazardous substances contained in sludge (e.g. via application to land or from leachate of landfills), proper sludge management and handling is crucial. Land application of contaminated sludge cannot be recommended and should be avoided.

Anaerobic and aerobic stabilisation

For very few of the hazardous substances (e.g. NP) a reduction could be observed after biological stabilisation with sufficient retention times and sludge application to the soil (Donner et al. 2010).

Controlled land filling

Controlled land filling of sewage sludge means that the site needs to be fitted with a leachate barrier system and leachate collection and treatment system. Leachate treatment can be conducted by applying processes of advanced wastewater treatment.

Incineration

From the perspective of reducing potential emissions of hazardous substances from sludge, incineration is one of the most effective options, as it practically eliminates all traces of most organic pollutants in the sludge, thus preventing further emissions.

Incineration of sewage sludge can be conducted as co-incineration in power-plants or in the cement industry, or in sludge incineration plants, so called “mono-incineration”, to allow a better recovery of phosphorous that is contained as a valuable substance in significant amounts. The technical process is similar to the incineration of waste with temperatures above 850°C and flue gas treatment (ECB European Chemicals Bureau 2008). Regular monitoring of emission gases from incineration process must be done to ensure that all air quality requirements are met.

The most common technologies used for sludge incineration are hearth incineration and fluidised bed incineration. Each system has its advantages – hearth incinerators are the most widely used at the moment – movement of sludge through hearths exposes a larger area for incineration than other technologies, making it very efficient. Fluidised bed incinerators, however, allow high utilisation of energy, thus leading to cost savings. In general, the specific technology should be chosen depending on site-specific and local conditions.

Incineration can be a very costly option, especially if no local/regional incinerators are available. Costs can vary considerably depending on specific local and regional conditions. Generally speaking, the highest costs are investments to build an incineration facility. Operating costs can vary depending on amounts of sludge incinerated, water content of sludge, whether there are other types of waste incinerated as well, etc. In the long term investments might pay back and become more feasible, especially if the incinerator can generate heat or electricity which can be sold to consumers and if sludge otherwise has to be transported over long distances or exported for utilisation.

Costs for co-incineration can be assumed to be in the area of 250-300 euros per tonne dry matter (Schaum et al. 2010; Sede and Andersen 2002), and for mono-incineration in the area of 350-400 euros per tonne dry matter (Schaum et al. 2010). The costs of incineration are highly variable due to design aspects and regarding energy recovery, as sales of both electricity and heat can generate substantial revenue that can cover some of the incineration costs.

Based on median concentrations calculated from screening data from COHIBA, the cost effectiveness of sludge incineration can be estimated. High concentrations of hazardous substances in sludge lead to specifically low costs per removed mass. As explained above not all the eliminated hazardous substances can be seen as reduced emissions into the Baltic Sea.

The cost-effectiveness for 11 hazardous substances and for the sum is presented in Figure 5. Estimated average costs for the removal of hazardous substances from sludge by sludge incineration in the Baltic Sea Area range from less than 0.05 million euros (for SCCP[3]) to several hundreds of million euros per kilogramme removed substance (PFOS), depending on the estimated median concentrations of these substances in the sludge. Due to high measured concentrations of singular substances within the COHIBA measuring campaign, the costs for removal of all described hazardous substances by sludge incineration can be estimated to be in the range of 0.013-0.02 million euros per kilogramme removed substance.

In the Baltic Sea area, approximately 6 % of sewage sludges are incinerated at the moment, the remaining amount is used in applications open to the environment. Assuming that 30-50 % of these would also be incinerated, the costs would be in the range of 100 to 220 Mio

3 Example calculation for SCCP: BSR average concentration from table 2: 8.25 mg/(kg sludge); costs per t incinerated sludge: 250-400 €/t equals to 0.03-0.05 million €/kg removed SCCP.

euros[4]. The total eliminated amount of 11 hazardous substances would be in the range of 3.4 to 5.7 t/a.

It is recommended that highly concentrated sludge should not be applied to land. In wastewater treatment plants with high loads of contaminated sludge, this sludge should be incinerated.

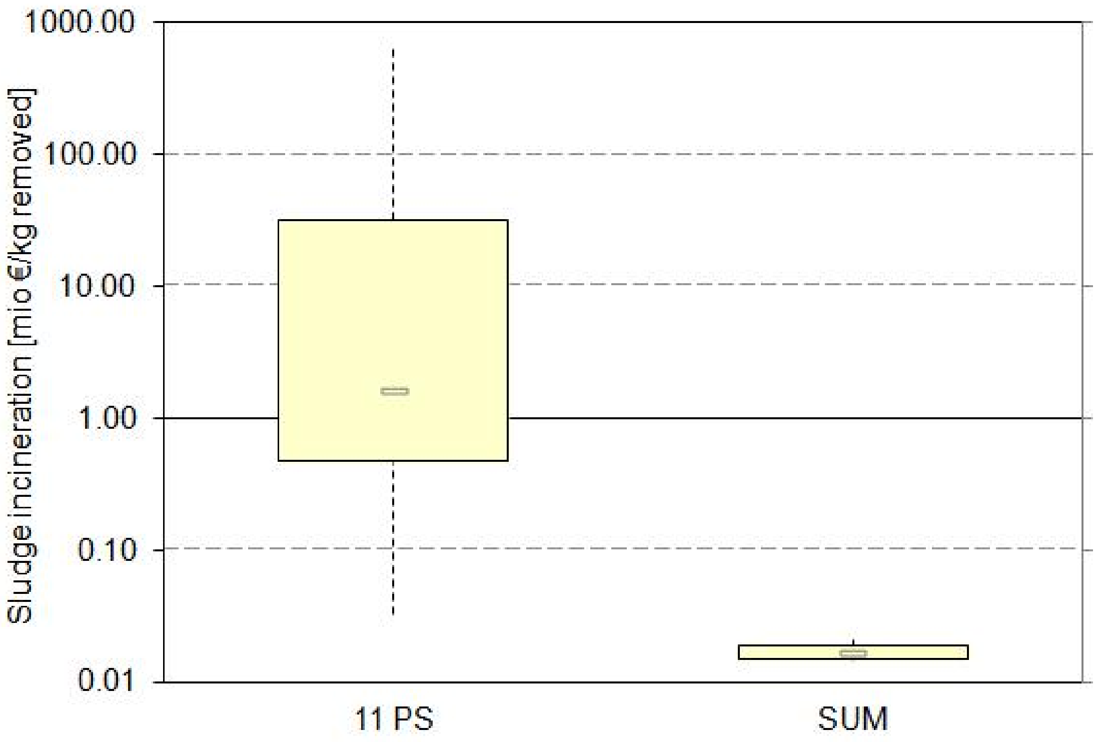

Figure 5: Cost- effectiveness of sludge incineration

Managing urban wastewater

In a Danish case study of the COHIBA project (Nielsen et al. 2011) the Copenhagen area was studied in detail. The local different emission sources were analysed, including effluent and bypasses of the two MWWTPs, combined sewage overflows and urban run-off. These

4 Without including costs for mineral fertilizer that is needed to replace the sludge.

sources were monitored and modelled. Different kind of abatement technologies were installed and tested.

It was found, that urban run-off and combined sewer overflows (CSO) are important sources for some of the hazardous substances in Copenhagen. For example, the discharge from the two MWWTP's represents 33% of the annual NP+NPE load to the Øresund, while the urban run-off and the River (with CSO and run-off during precipitation) correspond to 28 and 24% of the total load. In case of PFC the biggest load comes from CSO which makes up 44% of the total load while the MWWTP's and the urban run-off make up 33% and 20% respectively. The highest concentrations of PFC appear in the CSO and in wastewater from a shredder plant and an incineration plant (Nielsen et al. 2011).

The pilot plant technologies studied in Copenhagen showed that emission reduction for selected hazardous substances by several orders of magnitude is possible. But it's important to emphasise that the different tested technologies were effective on different hazardous substances. None of the three tested pilot plant technologies were effective on all the prioritised hazardous substances in Copenhagen. Further tests including technology modification to target the BSAP hazardous substances are needed.

Since urban run-off is a highly relevant source for some substances, it is recommended that an overview of the urban run-off emissions is elaborated on regional level and sufficient control and treatment is implemented.

5.4 Regional perspective

Measures for reduction of emissions proposed by the project have been based on cost efficiency and highest reduction potential. However, for different regions surrounding the Baltic Sea their efficiency may greatly vary due to specific regional conditions.

For technical measures, which in most cases focus on substitution of hazardous substances and wastewater treatment options, the applicability of measures does not differ too much from country to country, as currently applied technologies are similar in the entire region. Of course, different social and economical boundaries persist in these countries, especially when comparing Eastern and Western coasts of the sea but such differences are usually reflected in the household/municipal rather than in the industrial sector, which, in many cases, is working on an international scale. Regulatory boundaries exist due to different legal frameworks for EU and non-EU countries (namely in this case Russian Federation), this problem is described in more detail further down.

In some cases, E-BSR countries can be in an advantageous position as particular specific hazardous substances have not been used for purposes thought to be innovative 10 – 15 years ago and readily applied in Western countries, later to be included in different legal lists of restricted substances.

However, from the perspective of enforcement of legal measures there is quite a substantial gap between Western and Eastern regions of the Baltic Sea, with E-BSR still lacking complete practical implementation of IPPC and BAT principles in EU Member States and with a very differing permission and control system in the Russian Federation.

A similar situation can be noted regarding the informal pathways of substance emissions: in E-BSR burning of waste, littering, leakage from sewers or wrongly connected sewer pipes are still likely to play a significant role in the total emission load by diffuse emissions from households/urban sources. The behaviour of citizens (consumption and disposal behaviour) and the state of urban infrastructures (especially for wastewater, combined sewer overflow and surface run-off) is also to be taken into account.

Connected to this situation another important local boundary condition (identified in internal discussions of COHIBA WP5) is the relative importance of industrial sources vs. community/urban/household sources. Experiences from W-BSR show a time trend: as industrial sources become better regulated and the total load of hazardous substances decreases, the relative importance of community/urban/household sources increases. For the E-BSR region it is still too early to determine definite trends in this perspective as the data collected so far is insufficient for making a quantitative assessment.

Economic measures and voluntary agreements seem to have an effect on regions where general public awareness on hazardous substances is on a high level and has lasting traditions. As a result this seems to be very complicated in the E-BSR region as general awareness on this topic both within the industry and the general public is rather low and lacking good local examples.

As far as legal measures are concerned the situation is slightly different due to geopolitical reasons – not all countries around the Baltic Sea are EU Member States – two regions of the Russian Federation (St. Petersburg/Leningrad region and Kaliningrad) are adjacent to the sea as well. The legal system of chemicals management in Russia has developed differently than it has in the EU. It puts more emphasis on substances which pose acute toxic risks – not so much stressing persistence and bioaccumulation. As a result nationally and regionally set restrictions do not cover exactly the same substances that are included in different EU legal acts. This also applies to the 11 HELCOM BSAP substances, especially taking into account that only a small part of Russia is located within the catchment area of the Baltic Sea which makes the implementation of recommendations more complicated and more regional. This could be a potentially significant gap for emissions of substances which are currently not regulated in Russia, especially taking into account that industries which are likely to emit these hazardous substances are definitely present and operate both in St. Petersburg and Kaliningrad (e.g. metal plating, production of cleaning agents and detergents, finishing of textiles, leather tanning, etc.).

6 Reduction strategies

6.1 Strategies to close gaps in regulation

Action on international, EU and HELCOM level is needed to close gaps in the regulation (see chapter 3).

Additional international regulations need to be considered for those substances which still reach the Baltic Sea Region via imported products or via long range transport - like a global ban of manufacturing and use of endosulfan or control of imported goods containing e.g. PBDEs, TBT, NP/NPE. The inclusion of PFOA and HBCDD and further active risk reduction work within POP Convention is highly recommended.

On an EU level, it is recommended to nominate PFOA as a REACH candidate and to put it on the list of substances of very high concern (SVHC) which means further substance restriction. This has already successfully been done for OP (December 2011) and HBCDD. Additional research is necessary to substitute and ban these substances completely. For PFOA and MCCP even less information is available especially on industrial sources and the corresponding emission factors, because no reporting duties exist.

An EU-wide absolute ban of NP and NPE is primarily recommended for usages like cleaning, textiles, and secondarily for leather and metal working. Those usages, which were only conditionally banned in 2005 (directive 2003/53/EC) are recommended to be totally banned. It is recommended to extend the restricted uses in the regulations on other remaining uses for SCCP. The usage of MCCP in emulsion and oil based metal cutting fluids should be restricted, since this application is one of the main contributors to total emissions from industry.

Despite of existing bans or regulations on an EU level, some of the hazardous substances continue to be found in water samples throughout the Baltic Sea Region (BSR). Therefore there is a need to search and identify further sources. Then reduction measures on the sources are recommended like the improvement of BAT and the revision of BREF under the IPPC-Directive e.g. for energy production, the metallurgical sector and waste incineration regarding PCDD, PCDF and PCBs, for metal surface treatment regarding PFOS, for combustion power plants regarding Hg, for industrial air abatement and waste treatment regarding Cd.

Although a great number of different EU regulations on the use of the substances exist, national legislation considering technical possibilities of implementation and linkage between these regulations is still needed especially in the East Baltic Sea countries (e.g. TBT) In addition emphasis should be put on the control and enforcement of the existing regulations. There is a need for further harmonisation of a criteria system, which facilitates the selection of substances as hazardous substances simultaneously in e.g. HELCOM, WFD, REACH etc.

In some cases like TBT in sediments substances of concern are strongly regulated, and emissions are expected to decline, but the lag time can be very long.

Finally it is recommended to support and promote the ongoing strategies for PCDD/PCDF, PCB and mercury of the European Commission and the global mercury initiative.

It seems necessary to create incentive systems to increase data quality and dissemination to the public, e.g. by including the St. Petersburg region in the PRTR.

As in HELCOM also non-EU countries are contracting parties, HELCOM recommendations regarding emission reduction play an important role in implementing common goals. In accordance with the HELCOM recommendation we would recommend:

- The revision of HELCOM Recommendation 25/2 “Reduction of Emissions and Discharges from Industry by effective use of BAT”, to develop e.g. ELVs for heavy metals (air and water emissions), PM10 and dioxins.
- The further progress of the implementation of HELCOM requirements con- cerning proper handling of waste/landfilling (Recommendation 31E/4), because illegal landfills are still an issue in the Baltic Sea Area especially in the East Baltic Sea Countries and Russia (see country-specific survey).
- The revision of HELCOM Recommendation 28E/8 “Reduction of dioxins and other hazardous substances from small-scale combustion” as stated in the BSAP, to develop specific efficiency requirements and emission limit values for small scale combustion appliances (deadline was 2008 already). This is es- pecially important with a focus on Poland and other East Baltic Sea Countries regarding PCDD, PCDF, PCBs.
- The HELCOM Dentistry Recommendation 6/4 should be kept and revised be- cause the COHIBA project findings indicate that the use of amalgam contain- ing Hg in dentistry is still an issue in the Baltic Sea Area.
- The further step-by-step reduction of the Cd-threshold in fertilisers is recommended, therefore a revision of the Recommendation 31E/3 on Cadmium in Fertilisers should go further and come up with a region-wide value compromise.

6.2 Strategies for industries and SMEs

For most of the 11 hazardous substances, regulations with respect to production and use restrictions as well as on the use of modern abatement technologies have been adopted and have already been implemented or are currently under implementation (namely IPPC).

However, a detailed analysis in the E-BSR shows that the practical implementation of IPPC and BAT principles still has deficits in these countries. Therefore emphasis should be put on the improved implementation of IPPC/BAT.

As outlined in the previous paragraphs, there are gaps in regulation, regarding PFOA, MCCP, HBCDD and decaBDEs. As these substances are not or almost not regulated, there are no reporting duties. Therefore, information on production and use is scarce, especially on amounts used in industry, emission factors and corresponding load to the environment. It is recommended to make the information available for these purposes by REACH.

For other substances like NP/NPE, PFOS, SCCP, Cd, Hg gaps in existing regulations have been identified and should be closed. These refer for example to obsolete exemptions from bans, IPPC size thresholds and necessary BREF updates. For regulated substances there is more information available than for the non-regulated substances mentioned above. But often this information is not up-to-date and highly aggregated (e.g. national or EU-27 level).

The relevance of SMEs, which do not fall under the IPPC-regime, also increases when the emissions from big industrial sources are strongly reduced. Regarding SMEs' emission of hazardous substances, there are large gaps in data base and regulation. SMEs often discharge to public sewer systems respectively to MWWTP, which are not designed to eliminate hazardous substances. It is usually more cost-effective to implement additional EoP measures in the SME compared to a MWWTP. Therefore an appropriate wastewater (pre) treatment (according to BAT or even beyond) needs to be implemented in all Baltic Sea countries. Examples are targeting mercury emissions from dental clinics or cadmium emissions from galvanic industries.

In addition to closing these regulation gaps (see also Chapter 6.1), additional action by local, regional and national authorities is needed to improve the efficiency of implementation of existing regulations or even go beyond. Environmental permission is a valuable instrument to control and monitor emissions from industrial sources. Monitoring is also a necessary prerequisite to eliminate the emission of hazardous substances from industrial sources via informal pathways. This can be accidental mismanagement, such as uncontrolled dust emission or uncollected leachate from industrial waste sites, or even criminal mismanagement.

On the individual facility level, emission reduction can be achieved by substitution or by EoP measures. In face of the hazardous characteristics, substitution is the preferable measure. It eliminates both on-site and off-site emissions via products contributing to urban stock to prevent discharges of hazardous substances to the municipal wastewater treatment system. As discussed in chapter 5.1, substitution of hazardous substances typically follows the Pareto principle, with "early" substitutions being considerably more cost effective than "later" substitutions in more specialised applications. It is recommended to support the use of less harmful substituting substances and existing techniques by promoting also voluntary agreements with industries (see chapter 6.4) for substitution of the use where it is still allowed and while awaiting further regulatory processes.

During the time lag due to development time for substitutes, additional EoP measures can also reduce emission of substances in the mean time. Therefore, substitution and EoP measures should be seen as complimentary measures.

Following the polluter pays principle, industry sources should be targeted as a priority. Industries with high emissions should, as a part of the permit procedure, be requested to introduce advanced wastewater treatment. This can be fostered by voluntary agreements and economic incentives.

With information from monitoring, accurate and up-to-date inventories of industrial sources, emission factors and corresponding loads to the Baltic Sea can be built on smaller geographical scales. The picture needs to be completed with an inventory of urban sources (e.g. landfills, MWWTP, see also following chapter 6.3). With a detailed and up-to-date inventory of hazardous substances in the region, it is possible to find the most cost-effective measures and to build a strategy for the region that suits its specific source pattern (as was demonstrated in COHIBA case studies of Copenhagen and Stockholm, see chapter 5.3). The COHIBA guidance documents and other sources of information can help to build the necessary knowledge base for local, regional and national authorities. Exchange of data and experiences from different regions is very important.

6.3 Strategies for urban areas

Targeting urban sources may further contribute to a reduction of emission, when emissions from large industrial point sources are already controlled by regulation and effective reduction measures have been implemented (EoP measures and substitutions).

When targeting urban sources, a regional perspective is important, taking into account local boundary conditions of the settlement and its hinterlands. This includes the technical state of urban infrastructure systems (sewers, MWWTPs, landfills), pattern of indirect dischargers to municipal sewer system (SMEs), pollutant load from urban surfaces (industrial parks, roofs, streets etc.), as well as consumption and disposal patterns of products containing hazardous substances.

Firstly, the technical status of urban infrastructure systems has to be assessed, including the degree of implementation of UWWTD[5]. It is recommended to focus on the implementation of the UWWTD in the BSR and to begin assessing the situation with respect to the emissions of hazardous substances from informal pathways at the same time.

The most important part of urban infrastructure systems are MWWTP. They receive municipal wastewater from private households, as well as from small scale businesses and from indirect dischargers. In addition, MWWTPs may receive urban run-off (in case of combined sewer systems) and landfill leachate. Therefore, the MWWTPs influent can contain a multitude of hazardous substances like the 11 hazardous substances in focus of

5 There are different deadlines in place for the countries of the E-BSR to comply with the UWWTD: for Lithuania and Estonia the final deadline is over. In Latvia and Poland the final deadline of the transitional period is 31 December 2015 (DG ENV 2011).

BSAP, pharmaceutical substances or endocrine disruptors. The existing process of wastewater treatment is not sufficient for the treatment of these persistent chemicals. Hazardous substances are only partially degraded, and the remains are partitioned to gas phase, effluent and sludge.

To eliminate hazardous substances from effluents of large MWWTPs, advanced technologies such as ozonisation or activated carbon treatment are available. The choice should be assessed for individual MWWTPs, because it depends strongly on the kind and load of pollutants in the flow streams. If one particular hazardous substance shows elevated levels due to an indirect discharger, EoP measures at the source should be implemented, which it usually more cost effective. This also follows the polluter pays principle. Advanced wastewater treatment has a large cross substance effect, as it targets several of the 11 hazardous substances simultaneously, as well as other substances of potential concern (see chapter 5.3). Besides the cross substance effects due to the economy of scale bigger scaled WWTPs show more favourable cost-effectiveness. More than half of the total wastewater discharges to the Baltic Sea come from municipal WWTPs which represent more than 100,000 person equivalents. Therefore it is recommended to start the assessment and a possible implementation of advanced wastewater treatment on these plant sizes.

Local authorities and water administrations should introduce programmes to restrict the emissions of hazardous substances to the municipal wastewater systems. Since urban runoff is a highly relevant source for some substances, it is recommended that an overview of the urban run off emissions is elaborated and sufficient control and treatment implemented on regional level.

For highly contaminated sewage sludge it is recommended for it not to be applied to land. The most effective measure to reduce the content of hazardous substances is to incinerate the sludge. A side effect would be to generate substantial revenue from energy recovery.

For landfill leachates appropriate wastewater pre-treatment needs to be implemented. Further clean-up work should be carried out to rehabilitate old landfills. The costs of measures for urban infrastructures have to be paid by the community. Problem awareness is an important prerequisite for acceptance of these measures. They should be implemented as part of an integrated strategy, which also includes measures at industrial sources and raising awareness.

6.4 Strategies for raising awareness

Public awareness of hazardous substances is often rather low, due to the complexity of the issue. At the same time, awareness campaigns focusing on relevant stakeholders (users, SMEs, trade associations, etc.), e.g. on buying imported products, proper use of products or possible product substitutions, can limit emissions in urban areas and must be always be part of a Cleaner City Campaign.

Successful methods of increasing public awareness can include the promotion of new legislation, eco labels like the “blue angel” or the “white swan”, supervision of implementation of existing legislation and providing information to specific groups of consumers and retailers. These methods can be enforced by media attention, economic subsidies and in the generation of development areas (Wickman 2011).

A positive example for successful awareness campaigns is the information in and to shops selling artist material regarding cadmium contained in artist paints, how to avoid cadmium containing paints and how to handle products if necessary (Wickman 2011). According to Wickman amounts of cadmium sold in artist paints decrease as well as the resulting cadmium concentrations in sewage sludge. Another example is a Swedish campaign for the reduction of mercury from dental clinics (reduction of mercury due to economic subsidies for decentralised mercury removal devices) (Wickman 2011). Similar campaigns can be implemented in other states or cities in the BSR and to the fields of PFOS and PFOA (teflon pans, impregnated jackets, mist suppressant in metal plating) or PCDD/F (promotion of good practices in maintenance of burners and boilers, discouraging illegal conduct e.g. in collecting and processing of metal scraps, agricultural field burning). Other awareness campaigns have been arranged to promote environmentally friendly small-scale combustion to avoid dioxin emissions and boat-hull washing sites have been established in small harbours /marinas to ensure proper handling and disposal of contaminated wash-water.

Awareness campaigns are often considered to be merely addressing the public as consumers. However, there are several examples where dialogue and information directed towards other stakeholders are effective.

Costs of single and simple actions (leaflets, brochures, posters, internet information) undertaken by local municipalities, regional NGOs and other institutions can be relatively low. Costs for similar country-wide campaigns are assumed to be medium.

Local continuous activities focusing on special target groups, such as young people or women, are especially promising. Sectoral (agriculture, recycling) campaigns are also important. Experiences show that the potential effectiveness of awareness campaigns is rather low in the short term. However, voluntary economic instruments (voluntary agreements, eco labels etc.) don’t seem to be working in Russia, mainly because of the general public awareness level and lack of demand for cleaner or safer products. Nevertheless, as changing the attitudes of people takes long time, effects can normally be expected in the long term.

7 Outlook

There is no “one size fits it all” strategy. Of course, as a basis it is necessary for the assessment of measures that the “core measures” like the urban wastewater directive or the IPPC directive are implemented. On top of these measures and depending on local boundary conditions, an adapted set of additional measure combinations must be found. This is an iterative process starting with measures promising a big reduction at reasonable costs. The progress made and the selection of measures should be reviewed regularly. Such a boundary condition is for example the source pattern (which industries are present, how large are the emissions, how important are urban sources compared to other sources in the area etc).

Following the polluter pays principle, industry sources should be targeted first. As it was outlined in chapter 6, action on an EU and/or HELCOM level is needed to close gaps in regulations. On the one hand this refers to not yet regulated substances and on the other hand to gaps in existing regulations (IPPC thresholds, BREF update etc.). Simultaneously, action on a local/regional level is needed in order to advance the degree of implementation of existing regulations or even go beyond.

Issuing environmental permits is a valuable instrument to control and monitor emissions from industrial sides. The emission monitoring data can be supplemented by estimations from urban sources in order to compile an inventory of emissions of the hazardous substances into the aquatic environment of the region[6]. With a detailed and up-to-date inventory of hazardous substances in the region it is possible to find the most cost-effective measures from the substance-specific guidance documents for the particular substance of concern and to build an adapted strategy for the region.

As MWWTP normally is a large source for hazardous substances, advanced wastewater treatment could be an appropriate measure to reduce emission. Such measures could become cost-effective for most of the evaluated substances taken the cross substance effect into account. But it has to be considered who pays for the measure. It does not necessarily follow the polluter pays principle, but normally costs have to be paid by citizens, regardless of their consumption pattern. The original polluter (i.e. producer of substance) is not involved in paying the costs. Therefore in addition of the implementation of technical measures raising awareness is important to achieve acceptance for such kind measure.

Reducing emission is a moving target, as more new substances will be in focus especially with the present REACH implementation. The introduction of advanced wastewater treatment will also reduce the emissions of many “new” hazardous substances like for example pharmaceuticals.

6 See also the “Technical Guidance on the Preparation of an Inventory of Emissions, Discharges and Losses of Priority and Priority Hazardous Substances” of the Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Additionally, an evaluation of measures and reduction strategies should take into account synergies and trade-offs with other environmental goals set by BSAP, such as a trophic state of the sea (emission of nutrients) and global environmental goals, such as reduction of greenhouse gas emissions, as well as economic and social implications.

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9 Glossary of terms

BAT:	Best available technology
BREF:	Best Available Techniques Reference Documents, available at http://eippcb.jrc.es/reference/
BSAP:	Baltic Sea Action Plan
BSR:	Baltic Sea Region
Cd:	Cadmium
COHIBA:	Baltic Sea Region Project “Control of hazardous substances in the Baltic Sea region”
Cross substance effects:	Reduction of a multitude of substances (in one treatment step)
decaBDE:	Decabromodiphenyl ether
E-BSR:	Eastern Baltic Sea Region
ELV:	Emission limit value
EoP measures:	End-of-Pipe measures are e.g. conventional and advanced wastewater treatment, Sludge treatment, urban run-off management
HBCDD:	Hexabromocyclododecane
HELCOM:	Helsinki Commission: Short name for the Baltic Marine Environment Protection Commission
Hg:	Mercury
Indirect discharger:	Industrial emitters of waste water, who discharge not directly into a surface water but into the municipal sewer system
Informal pathways:	Non classical emission pathways of hazardous substances, e.g. via activities like (illegal) burning of house-hold or electricity waste, illegal disposal of waste, illegal discharge of waste water or losses from sewer system
IPPC:	Directive for Integrated Pollution Prevention and Control.
MCCP:	Medium-chain chlorinated paraffins

NGO:	Non Governmental Organization
NP:	Nonylphenol
NPE:	Nonylphenol ethoxylates
octaBDE:	Octabromodiphenyl ether
OP:	Octylphenol
OPE:	Octylphenol ethoxylates
PCBs:	Dioxin-like polychlorinated biphenyls
PCDD:	Dioxins
PCDF:	Furans
pentaBDE:	Pentabromodiphenyl ether
PFOA:	Perfluorooctanoic acid
PFOS:	Perfluorooctane sulfonate
SCCP:	Short-chain chlorinated paraffins
SME:	Small and Medium Enterprise
TBT:	Tributyltin compounds
Technical barriers:	General term for different kinds of abatement technologies like waste water treatment, flue gas treatment, physico-chemical treatment etc.
TPhT:	Triphenyltin compounds
UWWTD:	Urban Waste Water Treatment Directive

10 Appendix A

Annex 1: Overview of the measures in the Guidance Document (the figures correspond to the no. of the measure in the GD)

Substances	1. Dioxins	2. Organotin		3. Brominated diphenyl ethers			4. Perfluoroalkylated		5.	6. Nonylphenols		7. Octylphenols		8. Chlorinated		9.	10.	11.
in GD described measures	(PCDD), furans (PCDF) & dioxin-like polychlorinated biphenyls	2a. Tributyltin compounds (TBT)	2b. Triphenyltin compounds (TPhT)	3a. Pentabromodiphenyl ether (pentaBDE)	3b. Octabromodiphenyl ether (octaBDE)	3c. Decabromodiphenyl ether (decaBDE)	4a. Perfluorooctane sulfonate (PFOS)	4b. Perfluorooctanoic acid (PFOA)	Hexabromocyclododecane (HBCDD)	6a. Nonylphenols (NP)	6b. Nonylphenol ethoxylates (NPE)	7a. Octylphenols (OP)	7b. Octylphenol ethoxylates (OPE)	8a. Short-chain chlorinated paraffins (SCCP, C_{10-13})	8b. Medium-chain chlorinated paraffins (MCCP, C_{14-17})	Endosulfan	Mercury (Hg)	Cadmium (Cd)
Substitution of substance x in product / process				2			1, 2, 3		1	1, 2		1		2			1	
Changing of product material									2									
Advanced waste water treatment – AC treatment							5, 6			4		4		3		3		
Advanced waste water treatment – membrane filtration										5				4				6
Advanced waste water treatment – ozonisation/oxidative techniques										6				5				
Urban run-off management (collecting & treatment)				3						8								
Sludge treatment – anaerobic digestion									4, 5	7								
Sludge treatment – aerobic degradation										7								
Sludge treatment – controlled incineration		4		1								5		6		2		
Improvement of BAT and revision of BREF document	5						4										2	1, 2
Waste management – controlled incineration									6			2		7			3	
Waste management – controlled land filling	4	5							7					7				
Waste management – recycling																		4
Public awareness raising	3						7, 8											7
Financial support programs for residential sector emission reduction	2																	
Replacement and Retro-Fit of household heating furnaces	1																	3
Ban of substance x in product / process														1		1		
Restriction of substance x in product / use										3								
Sediment management – environmental dredging		1																
Sediment management – no dumping of substance x sediments in the Baltic Sea		2																
Sediment management – ex situ solidification and stabilization		3																
Treatment of contaminated soil	6																	8
Substance specific measures																		
Emission reducing demolition techniques									8									
Reduction of Cd in fertilizers																		5
Wastewater treatment in shipyards		6																
Voluntary agreement stop using of OP												3						
Improvement of control and ban of contaminated foodstuff																4		

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