SWEDISH ENVIRONMENTAL PROTECTION AGENCY

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REPORT

Screening of TPPO, TMDD and TCEP, three polar pollutants

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REPORT

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Summary

The occurrence of three polar organic chemicals in the Swedish aquatic environment and in waste water treatment plants have been investigated by means of a screening investigation. The studied chemicals are:

- triphenylphosphineoxide (TPPO),
- 2,4,7,9-tetramethyl-5-decyne-4,7-diol (TMDD),
- tris(2-choroethyl)phosphate (TCEP).

Octylphenol, nonylphenol and their corresponding ethoxylates were used as reference substances. This investigation is part of the national environmental monitoring programme, run by the Swedish EPA, but also includes the participation of twelve county administrative boards. The investigation includes a number of subprogrammes that addresses certain key questions:

- Whether these chemicals are present in lakes and watersheds
- To what degree these chemicals are present in domestic incoming and outgoing waste waters
- If releases from municipal waste water treatment plants influence the occurrence in their recipients
- If diffuse emissions occur in urban areas
- If the chemicals are released from certain point sources: industries and landfills

In total 118 samples were analysed. The sampling medias were, listed in decreasing number of samples: sewage sludge, outgoing waste water, surface water, sediment, incoming waste water, stormwater, landfill leachate and industrial waste waters. This report aims at giving a general description of the results and provides a discussion in relation to the questions shown above.

TMDD and TCEP were commonly occurring in both incoming and outgoing municipal waste waters, whereas TPPO was detected less frequently. TMDD was the most abundant of these chemicals in the waste waters, and was also detected in a few of the sewage sludge samples; neither TCEP nor TPPO were detected in sludge. The rare occurrence in sludge is expected when considering the high water solubility and low K_{ow} values of these chemicals. TCEP appears to pass the waste water treatment plant essentially unaffected whereas TMDD probably is degraded to a certain extent. These empirical observations are in agreement with model calculations performed.

Outgoing waste waters contained considerably higher concentrations of TMDD and TCEP than of nonylphenol. The concentrations of TCEP in waste waters were lower than in a former Swedish study, in agreement with the decreased use of this chemical.

In order to assess whether outgoing municipal waste waters influence their recipients with regard to these chemicals, surface waters and sediments from eight recipients were ana-

lysed. TMDD and TCEP were detected in surface waters from two of these recipients. Concentrations found in surface waters appear to be lower than what has previously been published from German rivers. This may be explained by a higher degree of waste water dilution in Swedish recipients, a consequence of the considerably lower population density in Sweden.

High concentrations of TMDD were also detected in landfill leachates; in one case also in the corresponding recipient. TMDD was also present at high levels in an industrial waste water. Both TMDD and TCEP were detected in one out of five urban stormwaters, and in one out of four urban surface waters. This suggests that urban stormwaters may be a source of TMDD and TCEP to urban recipients, but that waste water treatment plants probably are a more generally important source.

The concentrations found of TMDD and TCEP in surface waters are well below the corresponding PNEC values, suggesting that they pose no immediate threat to the aquatic ecosystem. Nevertheless, these and similar chemicals are cause for concern because they are persistent, highly soluble in water and only to a small degree reduced in conventional waste water treatment plants. Additionally, TCEP is classified as carcinogenic.

TMDD is suggested as the chemical of most concern in this study. This is motivated by the relatively high concentrations measured, the general occurrence and the fairly persistent properties. The abundance of TMDD in waste water treatment plants and the environment is in good agreement with the exposure index presented by the Swedish Chemicals Agency.

Sammanfattning

Förekomsten av tre polära organiska föroreningar i miljön har undersökts genom en screeningundersökning. De studerade föroreningarna är:

- trifenylfosfinoxid (TPPO),
- 2,4,7,9-tetrametyl-5-dekyn-4,7-diol (TMDD),
- tris(2-kloretyl)fosfat (TCEP).

Som referenssubstanser undersöktes oktyl- och nonylfenol samt motsvarande etoxilater. Uppdraget ingår i Naturvårdsverkets miljöövervakning men innefattar också deltagande av 12 länsstyrelser. Studien innefattar ett antal delprogram som alla är upprättade efter några huvudsakliga frågeställningar:

- Om dessa ämnen förekommer i sjöar och vattendrag
- I vilken mån ämnena sprids till och från kommunala reningsverk
- Om utsläpp från kommunala reningsverk påverkar halterna i recipienterna
- Om diffus spridning sker i urban miljö
- Om ämnena sprids till miljön från punktkällor: industrier och deponier

Totalt omfattade undersökningen 118 prov, fördelat på följande matriser i avtagande omfattning: slam, utgående avloppsvatten, ytvatten, sediment, inkommande avloppsvatten, dagvatten, lakvatten och slutligen industriella avloppsvatten. Denna rapport syftar till att ge en allmän beskrivning av resultaten samt att presentera övergripande tolkningar.

TMDD och TCEP förekom allmänt i både inkommande och utgående avloppsvatten från kommunala reningsverk, medan TPPO påträffades mer sparsamt. I slam påträffades TMDD sällan medan varken TPPO eller TCEP kunde detekteras alls. Det är rimligt med tanke på ämnenas höga vattenlöslighet och relativt låga K_{OW}-värden. TCEP föreföll i stort sett passera reningsverken opåverkat, medan viss nedbrytning av TMDD troligen sker. Resultaten överensstämmer väl med modellberäkningar som genomförts inom uppdraget. TMDD var det ämne som påträffades i högst halter i avloppsvatten; i utgående avloppsvatten var halterna av både TMDD och TCEP avsevärt högre än av referenssubstansen nonylfenol. Halter av TCEP i avloppsvatten är lägre än vad som uppmätts i Sverige för ca 8 år sedan, i överensstämmelse med minskad användning av denna kemikalie.

För att studera om utgående avloppsvatten påverkar förekomsten av dessa ämnen i recipienterna provtogs även ytvatten och sediment från recipienterna till åtta reningsverk. TMDD och TCEP påträffades i ytvattnet från två recipienter. I övrigt kunde de undersökta föroreningarna inte detekteras i recipienterna. Halterna var lägre än vad som detekterats i motsvarande undersökningar från Tyskland. Troligen beror detta på att avloppsvattnets utspädning generellt är högre i Sverige än i Tyskland, till följd av den avsevärt lägre befolkningstätheten i Sverige.

Höga halter av framförallt TMDD påträffades i lakvatten från deponier, och i ett fall kunde även höga halter av TMDD uppmätas i motsvarande recipient. TMDD uppträdde också i mycket höga halter i ett industriellt avloppsvatten. Till följd av utspädning i avloppssystem och recipient gav detta inte något tydligt påslag i vare sig det kommunala reningsverket eller dess recipient. Både TMDD och TCEP detekterades också i ett av fem urbana dagvattenprov, och i ett av fyra urbana ytvatten, men inte i några urbana sediment. Detta tyder på att TMDD och TCEP kan spridas diffust via dagvatten, även om spridning via reningsverk troligen är betydligt mer omfattande.

De uppmätta ytvattenhalterna av TMDD och TCEP förefaller inte vara direkt toxiska. Det kan ändå finnas anledning till att uppmärksamma dessa och liknande ämnen eftersom de är stabila och svårnedbrytbara, har hög vattenlöslighet och endast i liten till måttlig omfattning reduceras i konventionella reningsverk. Den sistnämnda aspekten indikerar även att biotillgängligheten i recipienten kan vara hög. TCEP är dessutom klassat som cancerogent.

Störst behov av fortsatt uppmärksamhet råder enligt vår bedömning för TMDD och därefter TCEP. Motiveringen är att TMDD uppträder i höga halter, uppträder allmänt och är tämligen stabil. Den omfattande förekomsten i reningverk och miljö stämmer väl överens med det exponeringsindex som Kemikalieinspektionen presenterat, och som bygger på förutsedd risk för spridning. Användning av TCEP förefaller minskat över längre tid, vilket indikerar att substitution eller andra åtgärder redan initierats.

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1. Introduction

1.1. General

In environmental science and monitoring, the last ca 10 years have brought about a focus on relatively polar pollutants. Kolpin et al. (2002) demonstrated widespread pollution of rivers located downstream urban areas in the US. Pollutants with various intended use and of various origin were found in those rivers, including e.g. pharmaceuticals, stimulants, detergents, biocides, pesticides, plasticizers, flame retardants and fragrances. Similar findings have been drawn from numerous studies since then.

The Swedish Screening program, run by the Environmental Protection Agency, has also included a large number of samples from urban areas and waste water treatment plants (wwtp´s). A review on these Swedish screening studies that encompasses urban areas and wwtp´s can be found in WSP (2010). It appears that wwtp´s can be major "sources[1]" of many current use polar pollutants. There is also a potential for direct diffuse emissions through e.g. urban and industrial stormwater.

As an assignment from the Swedish Environmental Protection Agency, WSP Environmental has during 2011-2012 performed a national screening investigation of three groups of relatively polar or volatile chemicals in the Swedish environment:

1. Fragrances: OTNE, acetyl cedren and diphenylether
2. Complexing agents: EDTA, NTA, DTPA, 1,3-PDTA and ADA
3. Three polar pollutants: TPPO, TMDD and TCEP.

A number of regional screening studies of the same chemicals have also been performed by the county administrative boards, and are reported jointly with the national screening study in this and two other reports.

The goals of these studies are to investigate if:

- these chemicals are found in the Swedish environment
- diffuse releases appears to occur
- they are present in background lakes
- wwtp effluents may influence the chemical status of aquatic recipients
- industrial use may lead to a direct emission.

[1] WWTP´s many not be considered as primary sources, because the chemicals emitted from wwtp´s are generally used upstream of the wwtp.

1.2. Brief introduction to TPPO, TMDD and TCEP

Triphenyl phosphine oxide, tetramethyldecynediol and trichloroethylphosphate are current–use chemicals that have been reported to occur in the aquatic environment in e.g. Germany and the US. They all display relatively high water solubility. Triphenyl phosphine oxide (TPPO) is a chemical intermediate that occasionally have been analysed together with organic phosphate esters that are used as plasticizers and flame retardants, e.g. trichloroethylphosphate (TCEP). Both TPPO and TCEP have been reported in the range ca 10-100 ng/l in various German rivers, and at lower levels also in the North Sea (Bollmann et al., 2012).

Tetramethyldecynediol (TMDD) has been reported from e.g. the river Rhine at fairly high levels (Guedez et al., 2010). WWTPs were suggested as major emission sources of TMDD, and the need for data demonstrating the degree to which TMDD is reduced in wwtp´s was highlighted. In the US, TMDD is listed as a high production volume chemical.

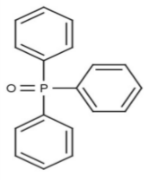
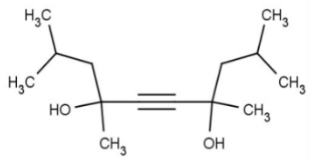
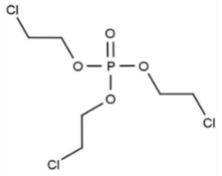
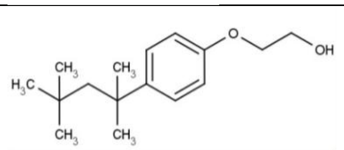
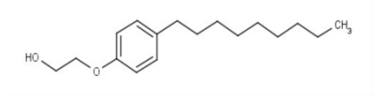
To the best of our knowledge, trichloroethylphosphate (TCEP) is the only one of these three chemicals that previously has been found in the Swedish environment, both indoor and outdoor (e.g. Haglund and Marklund, 2004). The environmental occurrence of TCEP is generally investigated jointly with several other organic phosphate-based chemicals that are used as flame retardants and plasticisers.

2. Properties of the studied substances

2.1. Physical and chemical properties

The substances in this group are fairly disparate. Triphenyl phosphine oxide (TPPO) and tris(2-chloroethyl) phosphate (TCEP) are both organic phosphorus compounds, the first with three phenyl groups attached to the phosphorus atom. The latter consists of a phosphate molecule to which three chloroethyl groups are attached. 2,4,7,9-tetramethyl-5-decyne-4,7-diol (TMDD) is a non-halogenated branched aliphate with two OH-groups that contribute to the high solubility in water. Physical and chemical properties are summarised in Table 2. None of the substances are highly lipophilic nor regarded as highly bioaccumulative, as supported by log K_{OW} values << 4,5 and BCF << 2000 (ECHA, 2008).

Table 1. Structure and abbreviations of the studied compounds. OPEO and NPEO are reference substances in this study.

Abbrev.	CAS	Structure	Full name
TPPO	791-28-6		Triphenylphosphine oxide
TMDD	126-86-3		2,4,7,9-Tetramethyl-5-decyne-4,7-diol
TCEP	115-96-8		Tris(2-chloroethyl) phosphate
OPEO	2315-67-5		Octylphenol ethoxylate
NPEO	104-35-8		Nonylphenol ethoxylate

2.2. Degradation, bioaccumulation and toxicity

According to EU RAR (2009) TCEP fulfills the criteria for P/vP and T, but not for B. TCEP is classified as non-biodegradable. TCEP is probably carcinogenic and is classified according to CLP (appendix VI) as:

- Carc. 2,
- Repr. 1B,
- Acute Tox. 4
- Aquatic Chronic 2.

TMDD is suggested to be inherently biodegradable (USEPA, 2001) and is not classified according to CLP (appendix VI). According to a compilation of COWI (2011), TMDD is toxic to several groups of aquatic organisms and should be classified as R52.

TPPO is probably not ready biodegradable (COWI, 2011; EPIWIN) and is not classified according to CLP (appendix VI). Neither is TPPO considered as bioaccumulative.

Table 2. Physical and chemical properties of the studied compounds. Unless otherwise stated, data is from the compilation of COWI (2011). Data in italics are model estimates.

Property	TPPO	TMDD	TCEP	Nonylphenol
CAS	791-28-6	126-86-3	115-96-8	84852-15-3
M, g mol^{-1}	278,3	226,4	285,5	220,3
log K_{ow}	2,8	2,8	1,8	4,5
H, Pa m^3 mol^{-1}	*$4{,}2 \cdot 10^{-5}$*	*$2{,}5 \cdot 10^{-2}$*	$4{,}2 \cdot 10^{-5}$	11
K_{OC}, l/kg	920	*43-125*	*67-390*	
S_w, mg/l	369$	1700	7800	6

$: ECHA database.

Table 3. Bioaccumulation and toxicity of the studied compounds. Unless otherwise stated, data is from the compilation of COWI (2011). Possible classification as PBT is denoted with P, B or T. Data in italics are model estimates.

Property	TPPO	TMDD	TCEP
Biodegradable	*?*	Inherently	No
BCF	*34-59*		1-5
NOEC, mg/l, lowest reported value	22 (fish)	1 (algae)	0,65 (algae)
PNEC, µg/l, suggested value	18	15	65
P (persistence)	*Yes*	Probably	Yes
B (bioaccumulation)	No	No	No
T (toxicity)	?	?	Yes

3. Use and release of TPPO, TMDD and TCEP

This chapter gives a brief presentation of how the studies chemicals are used, their function and possible emission pathways.

It is difficult to find detailed information on the Swedish use of TPPO because data on the used amounts are not public. It appears that TPPO is used for various chemical reactions and products, e.g. in formulating certain flame retardants. TPPO is also used as a crystallizing agent in chemical reactions. TPPO is also formed as a by-product in certain industrial organic syntheses, a.o. involving triphenylphosphine. Consequently TPPO has been found in effluents from petrochemical and pharmaceutical industries in Germany (Botalova, 2010). Other studies have also frequently found TPPO in effluents from the pharmaceutical industry (Emery et al., 2005).

TMDD is used as a non-ionic surfactant used as an industrial defoaming agent or as an wetting agent in e.g. waterbased paint and glue (kemstat, www.kemi.se). TMDD also occurs in other chemical forms where the alcohol groups are methoxylated, similar to nonylphenol and nonylphenolethoxylates.

The amount of TMDD used as a chemical in Sweden, according to Swedish Products Registry, increased between 1992 to 2009 from ca 40 to 150 tonnes. Additional amounts are probably imported in various finished goods. Almost all TMDD registered for use in Sweden was intended for production of water based paint.

A German dissertation provided data on TMDD in waste water and surface waters, as well as in certain goods (Guedez Orozco, 2011). At least in Germany, it appears that TMDD is relased in large amounts from WWTPs to surface waters (Guedez et al., 2010).

The use of TCEP in Sweden has decreased from ca 600 tonnes in 1995, to ca 5-30 tonnes during the period 2005-2010. It is reported to be used in the Swedish plastics industry. TCEP may be used both as plasticiser and a flame retardant.

To give a rough estimate of the potential for diffuse release of individual chemicals, the National Chemicals Inspectorate has developed an "exposure index". This index gives a value from 1 to 7, on relative terms, for the potential for release to e.g. WWTPs and for human exposure. The index considers both the amount used and the way the chemical is handled and used. As an example, equal amounts used results in a higher index if the chemical is used is in a solvent formulation than if it would be if it was used as raw product for polymerisation.

The exposure indexes for TPPO, TMDD and TCEP are shown in Table 4, based on data for 2008. Of these three chemicals TMDD has high exposure indexes, in particular for release to wwtp´s. Both TCEP and TPPO have low potential for diffuse release. In chapter 8, these predictions will be compared to the actual levels measured in this study. A former review of screening data from urban areas and wwtp´s showed a fairly good agreement between the exposure indexes and measured levels, although the scatter was wide (WSP, 2010).

Table 4. Exposure index (KemI, 20XX). The relative scale goes from 1 to 7.

	Exposure index					*Trend*	
Substance	Surface water	Air	Soil	WWTP	Human	*Human (-2 - +2)*	*Environment (-2 - +2)*
TPPO, 791-28-6	1	1	1	2	1		1
TMDD, 126-86-3	6	3	6	7	7	1	0
TCEP, 115-96-8	1	1	1	1	1		-1

4. Previous environmental studies

Both TPPO, TMDD and TCEP have been analysed in environmental samples previously. Of these three chemicals, TCEP is probably the ony most widely studied. A selection of data is presented in Table 5. Data on TPPO and TMDD are mainly from Germany, whereas TCEP have been investigated in several European countries, including Sweden, as well as in USA.

Measured levels in various (mainly German) anthropogenically influenced rivers are in the range tens to hundreds of ng/l. For TPPO and TCEP, Italian background lakes showed lower levels than the more polluted rivers.

All these three substances were also found in incoming and effluent waste waters, with concentrations generally falling in this order: TMDD >TCEP > TPPO.

Table 5. Environmental levels determined in previous studies. Sewage sludge in mg/kg dw; all other samples in ng/l.

Sub-stance	Sewage sludge	Incoming waste water	Effluent waste water	Surface water	Study site	Reference
TPPO				46-195		Hendriks et al, 1994
				<1-4	Italian background lakes	Bacaloni et al, 2008
				15-185	Various North Sea tributaries	Bollmann et al. 2012
		24-48	20-52			Rodil et al 2009
TMDD				190-2500		Guedez et al., 2010
		130-5800	<r.l. - 3500			Guedez Orotzco, 2011
TCEP	6,6-110	90-1000	350-890		Swedish wwtp´s	Marklund et al., 2005
			100-300		European wwtp´s	Reemstsma et al., 2006
			190-1800			Lilja et al., 2010
				5-70	Various North Sea tributaries	Bollmann et al. 2012
				<40 - 540	Rivers downstream urban areas	Kolpin et al., 2002
				<1-27	Italian lakes	Bacaloni et al, 2008

5. Sampling strategy and study areas

WSP developed a general strategy for the investigations, and this strategy was communicated and discussed with all participating county administrative boards. In each county, the regional sampling programme was setup and implemented by the county administrative boards. The strategy of the national programme is outlined below

- A possible global influence, resulting from long-range atmospheric transport by sampling in two national background lakes (Limmingssjön in the Örebro county and Remmarsjön in Västernorrland county).
- A possible urban influence, resulting from diffuse emissions, was investigated by sampling in two urban regions (Stockholm, Eskilstuna). This includes both local background, city centre, and downstream.
- The role of wastewater was investigated at two municipal sewage treatment plants and at the recipients of these STPs.
- To illustrate point source emissions, samples were taken in waste water from a chemical industry, in leachates from three landfill leachates and in surface water downstream two landfills.

The study consists of a national programme, financed by the Swedish EPA, and regional programmes for 12 counties. The national and regional programmes are summarised in Table 6 and Table 7. In total 118 samples were analysed. All sample details are listed in Appendix 1.

The regional programmes were dominated by samples from wwtp´s, whereas the national programme had a larger focus on the aquatic environment.

It is common in screening investigations to include some reference substance, which ideally should be a more well-known pollutant but with similar physical-chemical properties as the main substances investigated. In this study octylphenol and nonylphenol and their ethoxylates were chosen.

Table 6. National programme. The total number of samples is 30.

Category	Storm water	Surface water	Sed-iment	WWTP			Landfill leachate	Ind waste water
				Incoming	Effluent	Sludge		
Back-ground		2	2					
Urban	2	2	2					
WWTP					4	4		
WWTP recipients		2	2					
Industry		2		1	1	1		2
Landfill							1	
Total	*2*	*8*	*6*	*1*	*5*	*5*	*1*	*2*

Table 7. Regional programmes. The total number of samples is 88.

Category	Stormwater	Surface water	Sediment	WWTP			Landfill leachate
				Incoming	Effluent	Sludge	
Urban	3	2	1				
WWTP				9	28	30	
WWTP recipients		7	2				
Diffuse		1	1				
Industry		2					2
Total	*3*	*12*	*4*	*9*	*28*	*30*	*2*

6. Methods

6.1. Sampling

WSP developed general recommendations for sampling which were also communicated with the county administration boards. This protocol for sampling was sent to all personal involved in sampling, to assure similar treatment. Samples were stored dark and cold until transport to the laboratory within 1-2 days. Water samples were treated with acid before stored to stop any biological activity in the samples.

The national screening of water and sediments in urban and industrial sites were performed mainly by WSP, but local contractors or personnel from the county administration boards were also involved. Samples of surface water and sediment from background lakes were sampled by the county administration board in those counties. Water samples were generally taken as grab samples and surface sediments by gravity corers. Waste water and sewage sludge were sampled by staff at the waste water treatment plants, and was pursued in the same manner as the regulatory periodical sampling executed at each plant.

6.2. Chemical analysis

Chemical analyses were performed by ALS Scandinavia in cooperation with GBA Germany. The analyses were performed according to the methods outlined below.

TMMD / TPPO / TCEP

Water

- Sample amount: 50- 1000 mL (depends on matrix)
- Daily blank samples
- Internal standard: deuterated Tributylphosphate
- Liquid/liquid-extraction with MTBE (1 x)
- Liquid/liquid-extraction with Hexane (1 x)
- Concentration down to 0.2 mL (nonane as keeper)
- Derivatization with MSTFA (for TMDD)

Soil, sediment and sludge

- Sample amount: 0,5- 2g (depends on matrix)
- Daily blank samples
- Internal standard: deuterated Tributylphosphate
- Liquid/liquid-extraction with Acetone/hexane (1 x)
- Liquid/liquid-extraction with MTBE (3 x)
- Concentration down to 0.5 mL (nonane as keeper)
- Derivatization with MSTFA (for TMDD)

Measurement

Analysis with GC/MS/MS, equipped with 30 m DB5ms column.

Daily 4-6 point-calibration.

Components out of linear working area: dilution.

OP / NP / OPEO / NPEO

Water

According to accredited GBA-method MA-M 3-64

- Sample amount: 900 mL or less
- Daily blank samples
- Internal standards:
    - 4-n-nonylphenol-2,3,5,6-d4
    - 4-n-nonylphenolmonoethoxylate
    - 4-n-nonylphenoldiethoxylate
- Liquid/liquid-extraction with MTBE and hexane
- Concentration down to 0.5 – 1.0 mL
- Clean-up if necessary
- Derivatization with MSTFA

Soil, sediment and sludge

According to accredited GBA-method MA-M 3-65. Sample amount: 0,2 - 1g (depends on matrix). Daily blank samples.

- Internal standards:
    - 4-n-nonylphenol-2,3,5,6-d4
    - 4-n-nonylphenolmonoethoxylate
    - 4-n-nonylphenoldiethoxylate
- Liquid/liquid-extraction with acetone/hexane
- Concentration down to 1.0 mL
- Clean-up with Chromabond SiOH
- Derivatization with MSTFA

Measurement

Analysis with GC/MS/MS, equipped with 30 m DB5ms column.

Reporting limits

Analytical reporting limits are summarised in Table 8. These limits varied slightly between different samples due to different degrees of interferring substances. In general the lower values in the intervals given were most representative, whereas the higher values were valid for only one or a few samples. There are also certain samples with quantified levels that were lower than these limits.

Table 8. Reporting limits in different media.

Substance		TPPO	TMDD	TCEP	OP	NP
Surface water	*ng/l*	5-20	5-40	5-20	10	100
Sediment	*µg/kg dw*	20-130	20-180	20-260	1-10	10-100
wwtp incoming	*ng/l*	10-20	20	10	10-100	100-250
wwtp effluent	*ng/l*	5-20	30	100	10	100
wwtp sludge	*µg/kg dw*	30-500	20-700	30-500	30-700	
Storm water	*ng/l*	5-10	5-150	5-10	10	100
Landfill leachate	*ng/l*					

7. Results

A general overview of the levels and detection frequencies of the studied compounds are presented for each media in this section. Sample details are given in Appendix 1 and all data are presented in Appendix 2. A discussion on spatial trends, emission sources, environmental partitioning and possible risks to the health and environment is given in chapter 8.

TMDD was the most commonly found substance and TPPO the least frequently found. Effluents is the media where the substances were most frequently detected. Second to that comes incoming waste waters. Findings in the aquatic environment, i.e. surface water and sediments, were rare or absent for TPPO, TMDD and TCEP. Neither were these substances commonly found in urban stormwater. The fact that TPPO and TCEP never were found in the solids (sediment and sludge) may be due to the high water solubility and the low Kow of these substances.

The fact that TMDD and TCEP were more frequent than nonylphenol in certain media may partly be explained by the higher reporting limit for the latter substance, and is thus not necessarily reflecting their actual presence in various media.

Table 9. The occurrence of five compounds in different media, where n is the number of samples analysed. When n < 10, the reporting frequency is given as a ratio rather than a percentage.

	TPPO	TMDD	TCEP	4-tert-OP	4-NP
Incoming ww, n=10	20%	90%	90%	60%	80%
Effluent, n=33	30%	97%	94%	33%	42%
Surface water, n= 20	0%	20%	20%	5%	5%
Stormwater n=5	0 / 5	1 / 5	1 / 5	1 / 5	1 / 5
Leachate, n=3	2 / 3	3 / 3	2 / 3	3 / 3	2 / 3
Industrial effluent, n=2	2 / 2	2 / 2	2 / 2	1 / 2	1 / 2
Sediment, n=10	0%	0%	0%	40%	50%
Sludge, n=35	0%	9%	0%	43%	80%

Table 10. Summary of the results in this study. All concentrations in ng/l except sediments and sludge (µg/kg dw).

	TPPO	TMDD	TCEP	OP	OP-EO1	OP-EO-2	OP-EO3	NP	NP-EO1	NP-EO2	NP-EO3
WW INCOMING	n= 10										
min	< 10	< 20	< 10	<10 - <100	<10 - <100	<10 - <200	<10 - <100	<100 - < 250	<200 - < 500	<100- <1000	<150- < 3500
max	39	32000	250	36	180			1600	1900	100	
median		445	105	21	33			530	610		
average		3700	127	20				687	795		
std dev		9954	77					565	695		
EFFLUENT	n=33										
min	< 5 - < 20	< 30	<50 - <100	< 10	< 10	< 10	< 10	< 100	< 100	< 100	< 100
max	35	37000	860	860	140	470	860	320	270	140	
median		770	210								
average		2230	240								
std dev		6520	167								
SURFACE WATER	n=20										
min	< 5 - < 20	<5 - < 40	< 10	< 10	< 10	< 10	< 10	< 100	< 100	< 100	< 100
max		450	29	30				190			
median											
average											
std dev											
STORMWATER	n=5										
min	< 5 - < 10	< 5 - <25	< 5 - < 10	< 10	< 10	< 10	< 10	< 100	< 100	< 100	< 100
max		150	31	30				180			

Table 10. Continued.

	TPPO	TMDD	TCEP	OP	OP-EO1	OP-EO-2	OP-EO3	NP	NP-EO1	NP-EO2	NP-EO3
LANDFILL LEACHATE	n=3										
min	23	970	100	14	< 10 - < 100	< 10 - < 100	< 10 - < 100	< 100 - < 1000	< 100 - < 1000	< 100 - < 1000	< 100 - < 1000
max	160	87 000	170	5400				750			
INDUSTRIAL EFFLUENT	n=2										
min											
max	4500	1400 000	1600	2800	540			1400			
SEDIMENT	n=10										
min	<20	<21	<22	<1	< 2	<2	< 5	< 20	< 20	< 20	< 80
median								9			
max				77				330	62		
SLUDGE	n=35										
min	<7	<20	<7	<30	<30	<10	<25	<700	<700	<130	<250
max		1400		730	420	130	480	12 000	8000		
median								2800	2200		
average								3600	1800		

7.1. Surface water

Surface waters were sampled from 20 locations, including two national background lakes, nine wwtp recipients, four urban sites, four industrial point source recipients and one diffusely influenced river.

TPPO was not found in any of the surface water samples, i.e. concentrations were less than 5-20 ng/l. Higher concentrations were previously found in various tributaries to the North Sea (Bollmann et al, 2012).

TMDD and TCEP were found in four samples out of 20, two of which were in common. TCEP was detected at 16 ng/l in Limmingssjön which is a national background lake. This finding was somewhat unexpected since levels were < 10 ng/l in many more anthropogenically influenced waters. Two wwtp recipients contained detectable concentrations of both TMDD (140-180 ng/l) and TCEP (18-29 ng/l). In one of these, samples were also taken upstream of the wwtp. Neither TMDD nor TCEP were detected in the upstream sample.

TCEP and TMDD were also detected in one out of four urban surface water samples, though it was not the same sites. TMDD was found at fairly high levels (450 ng/l) in a small river downstream of a landfill, where the leachate also contained very high levels of TMDD (see chapter 7.5).

7.2. Sediment

Sediments were sampled from ten sites, including background lakes, urban and wwtp recipients and one diffusely influenced river. Neither TPPO, TMMD nor TCEP were detected in any of these samples. The reference substance nonylphenol was detected in some of the urban and wwtp recipients.

7.3. Waste water and sewage sludge

Waste water treatment plants were the main study objects in this study, comprising 10 incoming waste waters, 33 effluents and 35 sludge samples. TMDD and TCEP were detected in most samples of incoming waste water and effluents, whereas TPPO was less frequently detected. All data for TMDD and TCEP are shown statistically in Figure 1. The scatter is wide for TMDD and ranges over more than three orders of magnitude. This large variation is mainly caused by a single wwtp with very high concentrations of TMDD in both incoming waters and effluents.

For ten wwtp´s, pairwise data exist for incoming waters and effluents. According to a pairwise statistical test (Wilcoxon signed rank test), there is no difference between incoming waters and effluents for TMDD. For TCEP, however, such a difference is demonstrated with slightly higher levels in the effluents, and is discussed in chapter 8.

TPPO was only detected in 20 % of the incoming waste waters and in 30 % of the effluents. Highest measured levels were 39 and 35 ng/l, respectively. Thus TPPO is less abundant than TMDD and TCEP both in terms of detection frequency and concentrations.

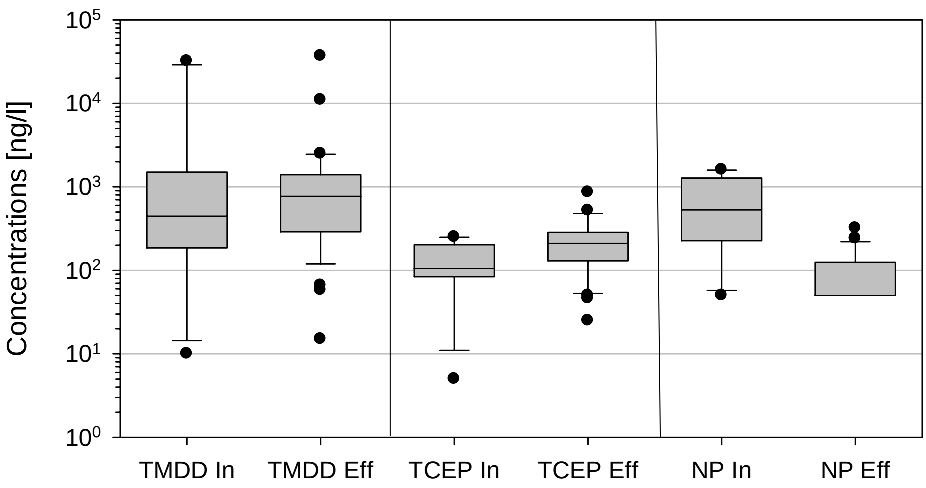


Figure 1. Comparison of concentrations of TMDD, TCEP and nonylphenol in incoming waste waters and effluents. Data consists of 10 samples of incoming waste water and 33 effluents.

7.4. Storm water and industrial waste water

Five samples of urban stormwater were analysed. One of these samples contained TMDD (150 ng/l) and TCEP (31 ng/l). TPPO was not detected in any of these samples, whereas octylphenol and nonylphenol were detected in one sample.

Samples of treated process water were also taken from an industry that uses large amounts of TMDD. This process water was followed downstream by sampling in the junction to the municipal waste water, the incoming and effluent of the municipal wwtp and in the recipient to the wwtp. Results are shown in Figure 2. As expected from the chemical use at the facility, very high levels of TMDD were found in the treated industrial waste water. Also TPPO and octylphenol are elevated. The concentrations of these chemicals decline progressively to the wwtp effluent, and none of the compounds were detected in the recipient where large dilution occurs.

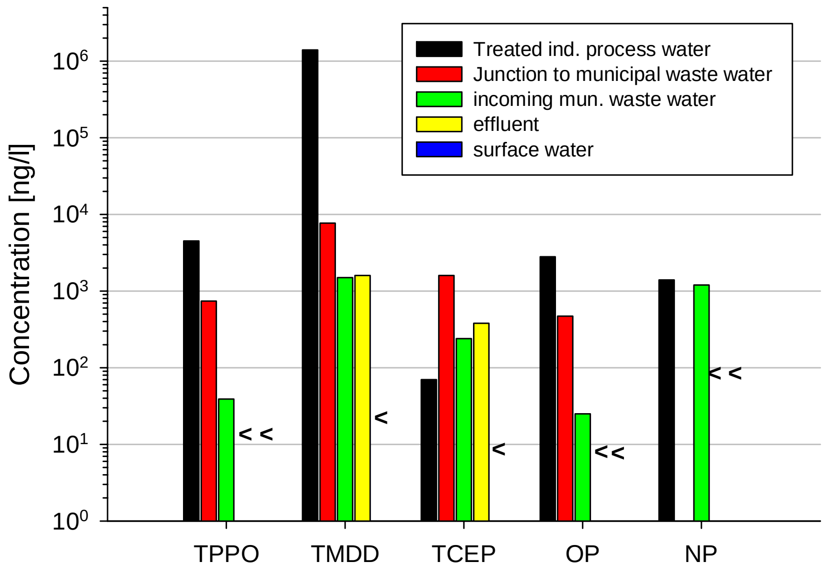


Figure 2. Concentrations in samples from an industry, through the municipal wwtp and to the wwtp recipient. Samples with non-detectable concentrations are denoted with "<".

7.5. Landfill leachate

Leachate samples were also taken from three landfills. The studied substances were found in two or three of the samples. In two of the samples, TMDD was found in 5 and 87 µg/l, which is high compared to most of the studied waste waters, and also much higher than OP and NP in the same samples. The max concentration of TMDD found is actually higher than almost any other organic pollutant as determined in a study of 400 organic pollutants in leachates from 12 Swedish landfills (Öman och Junestedt, 2008).

Concentrations of TCEP was similar to that in the waste waters analysed.

Table 11. Concentrations in landfill leachates (ng/l).

Plats	TPPO	TMDD	TCEP	4-t-octylphenol	4-nonylphenol
Fågelmyra	<200	5100	<200	240	750
Lilla Nyby	23	970	170	14	110
Landfill 1	160	87000	100	5400	<1000

8. Discussion

8.1. Background areas

TCEP was found in one surface water sample from the background lake Limmingsjön. Otherwise there were no indications that these chemicals are present in background lakes. The lake Limmingsjön, where TCEP was found, is not a *remote* background lake. The lake is actually located close to an urban area (Örebro). Possible diffuse sources may include nearby road traffic or individual sewage. The occurrence of TCEP in air and deposition in a remote site in Northern Finland also demonstrates the potential of TCEP for large-scale atmospheric transport, from source regions to remote areas (Haglund och Marklund, 2004).

8.2. Urban areas

Many current use chemicals are released by diffuse processes. This may result in elevated levels in the urban aquatic environment, which has been recognized in many studies of the Swedish national screening programme (see a review in WSP, 2010). In this report, we try to distinguish between this direct result of diffuse emissions and the impact that is caused by releases from wwtp´s.

Several samples of stormwater (n=5), sediment (n=3) and surface water (n=4) were sampled in urban areas in order to investigate whether there was a general diffuse influence on their environmental occurrence.

Out of four stormwater samples (one is yet under analysis), TMDD and TCEP were detected in one from Eskilstuna. Neither TPPO (r.l.=5-10 ng/l) nor OP (r.l.= 10 ng/l) or NP (r.l.=100 ng/l) were detected in any of these stormwater samples. The representative sampling of stormwater is difficult since concentrations tend to vary strongly over time, including the "first flush" effect. Other recent Swedish studies did generally find e.g. nonylphenol at levels above the current reporting limit (e.g. Björklund, 2011). Possibly, the absence of NP in the current samples indicates sampling during low-level periods, but large difference between different laboratories have also been demonstrated (see Wahlberg and Wistrand, 2006).

Regarding the screening pollutants of this study, the results shows that TMDD and TCEP may appear in stormwater occasionally but not ubiquitiously. TCEP have previously been found in snow close to roads (Haglund and Marklund, 2005).

8.3. Waste water treatment plants

8.3.1. Variation between differents wwtp´s

The degree to which concentrations vary in waste waters is indicative of the chemicals sources to waste water. High variability or the existence of anomalously high values are indicative of points sources; whereas low variability is indicative of a diffuse input.

Table 12 shows CV and skewness as two measures of variability. CV is calculated as standard deviation divided by arithmetic average. A CV-value larger than ca 50% indicates non-normal distribution. A Skewness close to zero would indicate normal distribution. Clearly both TMDD, TCEP and NP display significant variability between the samples. TMDD data is far more variable than TCEP or NP. The omission of two outliers (11 000 and 37 000 ng/l) considerably reduces variability of TMDD.

Concentration variability was not apparently related to wwtp parameters such a size, domestic vs mixed load, stormwater etc. Certain wwtp´s were sampled twice, with a few months inbetween. Concentrations of TMDD and TCEP within each of these wwtp´s varied at the two occasions. The differences were generally within a factor two but occasionally up to a factor 10. Because most wwtp´s were only sampled once, there is no specific information on their temporal variability. Moderate differences between the wwtp´s should therefore not be interpreted as true differences in the load of the TMDD or TCEP.

In conclusion, the variability in load of TMDD and TCEP to many of the wwtp´s studied here may be lower than indicated by the concentrations in the spot samples. The general occurrence of TMDD and TCEP in municipal waste waters is thus likely to have a diffuse origin. This dataset also revealed strong point source influence on the TMDD load in two wwtp´s. In the national screening, a major industrial user of TMDD was selected (se chapter 7.4) but the wwtp to which this industry was connected did not show any elevated levels of TMDD.

Table 12. Statistical description on variability of waste waters. TMDD effluents are also described without two outliers.

Chemical	***n***	***CV***	***Skewness***
TMDD incoming	10	270%	3,1
TMDD effluent	33	290%	5,1
TMDD eff, exkl 2 outliers	31	77%	1,1
TCEP incoming	10	61%	0,44
TCEP effluent	33	70%	1,8
4-nonylphenol incoming	10	82%	0,66
4-nonylphenol effluent	33	72%	1,6

8.3.2. Comparison with previous studies

Examples of data from previous investigations are shown in Table 13. TCEP is the one chemical for which previous data from Sweden exists. TCEP was investigated in Swedish waste waters collected during 2002 and 2003 (Marklund et al. 2005). If we assume that both this study and the one of Marklund et al represent random samples of Swedish waste waters, concentrations can be compared using a Mann-Whitney Rank Sum Test. This comparison indicates that concentrations in both incoming waste waters and effluents have decreased by a factor 2-4 over these ca 9 years. This is in line with the decreased use of TCEP over this time period (chapter 3).

TCEP in effluents is neverthless in the same range as found in several European countries ca 7 years ago (Reemstma et al., 2006). This similarity in concentrations across several countries further supports the hypothesis that diffuse emissions are important for the load to municipal wwtp´s.

Neither TMDD nor TPPO seems to have been studied in Swedish wwtp´s before. Reference data for TPPO in waste water consists of only four samples. Concentrations of TPPO in those samples were higher than in most of our samples. For TMDD more reference data is available and is the same range as the present data, which is actually relatively high concentrations for an organic pollutant in waste water.

Table 13. Levels of TPPO, TMDD and TCEP in sewage sludge (SS), incoming waste water (IN WW) and effluents (EFF) compared to previous studies. Concentrations are given as average and min-max. Average values are not shown where the detection frequency was low.

Substance	Present study		Previous studies		Reference
	Average	min-max	Average	min-max	
TPPO					
IN WW (ng/l)	< 10	< 10 – 39		24 - 48	Rodil et al., 2009
EFF (ng/l)	< ca 10	35		20-52	Rodil et al., 2009
SS (µg/kg)	< 7				
TMDD					
IN WW (ng/l)	3700	< 20 – 32000		130-5800	Guedez Orotzco, 2011
EFF (ng/l)	2230	< 30 – 37000		< r.l. - 3500	Guedez Orotzco, 2011
SS (µg/kg)		< 20- 1400			
TCEP					
IN WW (ng/l)	127	< 10-250	470	90-1000	Marklund et al., 2005
EFF (ng/l)	240	<50-860	500	350-890	Marklund et al. ,2005
EFF (ng/l)			ca 200-300	100-300	Reemtsma et al., 2006
SS (µg/kg)	< 7		41	6-110	Marklund et al. ,2005
			7	<2-20	Olofsson et al, 2012

8.3.3. Mass balance in wwtp´s

The distribution of the studied chemicals in wwtp´s was simulated using the SimpleTreat model (Struijs, 1996). Because these chemicals were not or only rarely detected in sludge, model results cannot be validated by such data. However, the percentage of chemical in incoming waste water that leaves the wwtp by the effluent can also be predicted.

A retention of ca 1-2 % was predicted for TCEP; the major part of TCEP is thus predicted to reach the recipients. A pairwise t-test for TCEP in incoming and effluents actually shows a statistically significant increase in TCEP levels. Similar results have been found before (Marklund et al., 2005; Olofsson et al., 2010) and may either be due to insufficiently representative sampling or to the actual formation of the substance in the wwtp. For instance, some chemicals are producted by degradation of larger polymers in the sewage process. Because such formation cannot be predicted with the SimpleTreat model, the model output is considered in good agreement with experimental results.

TMDD is classified as inherently biodegradable in active sludge (US EPA, 2001), from which we predict a degradation of ca 25% or more, whereas sorption on sludge is negligble. This is in good agreement with experimental results from a German wwtp, elimination rates varied between 33% and 68 %, mainly due to aerobic biodegradation. A pairwise test (Wilcoxon) of TMDD in incoming and effluents did not show any significant differnece between incoming and effluents, probably due to too few samples in relation to the variability of the data.

A retention of ca 1-2 % was predicted also for TPPO. It is not possible to compare this with the data because TPPO was not detected in effluents and the few positive results of incoming waters were very close to the reporting limit. However, the results presented by Rodil et al (2009) point in the same direction as our model results.

8.3.4. Influence on recipients

As shown in the preceding section, large fractions of TPPO, TMDD and TCEP appear to pass wwtp´s unretained. Waste water treatment plants will thus be potentially important sources of these pollutants to recipients. This was previously highlighted for TMDD, where its abundance in the river Rhine was attributed to emissions from wwtp´s (Guedez et al., 2010).

In this study surface water from eight wwtp recipients were analysed for TPPO, TMDD, TCEP and the reference substances OP and NP. Neither TPPO, OP, NP nor their ethoxylates were found in these samples. TMDD and TCEP were detected in the recipients to two wwtp´s. One of these also encompassed an upstream reference sample, where these chemicals were not detected. The levels of TCEP detected were very close to the reporting limits, why it is possible that TCEP also may have been present in the recipients to other wwtp´s. The occurrence of TMDD at 180 ng/l in the recipient to Kristinehamn wwtp cannot unequivocally be attributed to this relatively small wwtp. TMDD was not detected in the effluent and there is also an industrial plant for adhesives nearby. Both TMDD and TCEP were also found in surface water from a wetland that was used in the post treatment of effluents from Eskilstuna wwtp.

Both TMDD and TCEP are relatively stable toward degradation in surface waters, and since they are so commonly detected in effluents they probably do occur in more of the wwtp recipients than in which they were detected. The potential for a wwtp pollutant to be detected in the recipient surface water is dependent on the degree of dilution in the recipient and on the ratio between effluent concentration and reporting limit.

In the German river Rhine average levels of TMDD was in the range 300-600 ng/l (Guedez et al., 2010), which is much higher than the findings in this study. Nevertheless concentrations in effluents were similar to those found in the present study. Possibly, the degree of dilution of waste waters in much lower in river Rhine than in recipients studied here. In fact the population density is high in river Rhine compared to most areas in Sweden. The effluent will therefore be less diluted in Rhine compared to many Swedish rivers.

8.4. Point sources

Both TPPO, TMDD and TCEP were found in the landfill leachates. Particularly high concentrations were found of TMDD (and octylphenol) in one the samples. TMDD was also detected at high levels (450 ng/l) in a small river downstream this landfill, clearly demonstrating the impact of this landfill on the recipient. Surface water was also sampled downstream a fourth landfill. The reference substances OP and NP were detected, but neither TPPO, TMDD nor TCEP.

An industry that uses large amounts of TMDD was also studied, from the industrial waste water through the municipal wwtp and to the final recipient. Although very high levels of TMDD was detected in the outgoing waste water from the industry (1,4 mg/l !), the concentrations in the municipal wwtp were close to the average levels for wwtps. No influence on the recipient could be detected, partly due to very high dilution.

8.5. Environmental significance of the observations

The three chemicals studied are examples of the polar pollutants that has gained increasing attention over the last 5-10 years. Although none of them are considered highly bioaccumulative, they have toxic properties and are probably persistent.

According to the results of the current study and certain literature, the most obvious and generally occurring environmental exposure pathway is from wwtp´s to recipients. In the recipients these substances are diluted and only slowly reduced by degradation or sorption to settling particles. Even the highest levels measured in surface waters are more than order of magnitude lower than the corresponding PNEC value.

The highest effluent concentration of TMDD is 37 µg/l, however, which exceeds the PNEC value. This indicates that TMDD in certain cases may contribute to a toxicity of undiluted effluents.

Due to the low BCF or logKow values, there is probably no risk of secondary poisoning in the recipients.

According to these MEC/PNEC[2] considerations there appears to be no obvious environmental risk with these chemicals in the aquatic environment. Other facts still suggest a cause for concern:

- These chemicals are highly soluble and persistent
- They are detected in all or most effluents studied
- They show some aquatic toxicity and TCEP is classified as toxic to reproduction and carcinogenic.

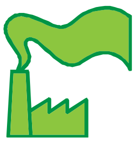
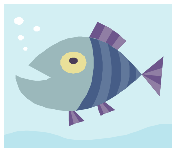
[2] MEC: measured environmental concentration; PNEC: predicted no effect concentration.

Two exposure pathways during end-of-life are sludge application on arable land and leachates from landfills. TPPO, TMDD and TCEP were not or only to a low extent detected in sludge, which was also in agreement with model predictions. Therefore, these polar pollutants are probably not relevant for the assessment of risks from using sludge on arable land. Regarding landfill leachates, only three samples were included in this study but those indicate that in particular TMDD can reach high levels and contaminate nearby watersheds.

The results can be compared to the exposure indexes (Table 4). Most data are from wwtp´s. For wwtp´s TMDD hade the highest index value whereas TPPO and TCEP had the lowest values. The results from this study supports a high index for TMDD and a very low for TPPO. For TCEP the results indicate a slightly higher exposure than was predicted by the index.

9. Conclusions

- Neither TMDD nor TPPO was found in background lakes. One positive result of TCEP was found in one background lake, but overall there is no strong evidence of large scale transport.
- TMDD and TCEP were ubiquitous pollutants in municipal waste water, occurring at levels higher than nonylphenol.
- Little or no reduction in waste water treatment plants was demonstrated for TMDD and TCEP, in agreement with model predictions.
- WWTP´s are probably the major emission source of TMDD and TCEP.
- Landfills are also potential sources of TMDD, TPPO and TCEP.

				Not covered in this study 	Not covered in this study 
	Long range transport	**Diffuse emissions**	**Point sources**	**Bioaccumula-tion**	**Human exposure**
TPPO	No	No	Yes		
TMDD	No	Yes	Yes		
TCEP	Possibly	Yes	Yes		

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Appendix 1. Sample details

This appendix shows sample details for all samples. Note that positions are given in different geographical systems. The corresponding analytical results are shown in appendix 2.

Appendix 1.1. Industrial waste water, stormwater, landfill leachates and surface waters. Note that positions are given in different geographical systems.

Sample no	Programme	County	Municipality	Media	Site name	Position X	Position Y	Category	Sampling date
WSP_828_WSP_472	National	Skåne	Malmö	Industrial waste water	Chemical industry			Industry	2011-10-25
WSP_828_WSP_473	National	Skåne	Malmö	Industrial waste water	Chemical industry			Industry	2011-10-25
WSP_828_I_65	Regional	Gotland	Gotland	Stormwater	Visby harbour	6392789	696043	Urban	2011-09-27
WSP_828_D_156	Regional	Södermanland	Katrineholm	Stormwater	Katrineholm, huvudledning	6539624	569996	Urban	2011-09-28
WSP_828_D_161	Regional	Södermanland	Flen	Stormwater	Flen, huvudledning	6547196	590130	Urban	2011-09-28
WSP_828_WSP_431	National	Södermanland	Eskilstuna	Stormwater	Eskilstuna	6583283	585485	Urban	2011-09-21
WSP_828_WSP_432	National			Stormwater	Stockholm			Urban	sept. 2011
WSP_828_W_01	Regional	Dalarna	Borlänge	Landfill leachate	Fågelmyra	6712080	1483320	Landfill	2011-10-13
WSP_828_D_154	Regional	Södermanland	Eskilstuna	Landfill leachate	Lilla Nyby	6579430	587524	Landfill	2011-09-06
WSP_828_WSP_450	National			Landfill leachate	Landfill X			Landfill	2012-02-24
WSP_828_F_52	Regional	Jönköping	Eksjö	Surface water	Torsjöån	6387132	499682	Punktkälla	2011-11-21
WSP_828_I_61	Regional	Gotland	Gotland	Surface water	Åminne	6391826	724271	Diffuse	2011-09-26
WSP_828_D_155	Regional	Södermanland	Katrineholm	Surface water	Djulösjön	6537300	570920	WWTP REC.	2011-09-28
WSP_828_D_160	Regional	Södermanland	Flen	Surface water	Gårdsjön	6546818	590520	WWTP REC.	2011-09-28
WSP_828_S_331	Regional	Värmland	Årjäng	Surface water	Kyrkbruds RV	6584925	335558	WWTP REC.	2011-12-13
WSP_828_S_335	Regional	Värmland	Storfors	Surface water	Storforsälven	6601914	1412306	WWTP REC.	january 2012
WSP_828_S_339	Regional	Värmland	Kristinehamn	Surface water	Kristinehamn ARV	6577984	1400628	WWTP REC.	2011-12-14
WSP_828_S_343	Regional	Värmland	Sunne	Surface water	Kolsnäs	6634409	129770	WWTP REC.	2012-01-04

WSP_828_E_375	Regional	Östergötland	Linköping	Surface water	Stångån downstream Nykvarn wwtp			WWTP REC	2011-10-25
WSP_828_E_376	Regional	Östergötland	Linköping	Surface water	Stångån upstream Nykvarn wwtp			Urban	2011-10-25
WSP_828_WSP_391	National	Västernorrland	Örnsköldsvik	Surface water	Remmarsjön			Background	2011-07-12
WSP_828_WSP_394	National	Örebro	Hällefors	Surface water	Limmingssjön			Background	2011-08-17
WSP_828_WSP_413	National	Södermanland	Eskilstuna	Surface water	Eskilstunaån, downstream wwtp	6584822	583205	WWTP REC.	2011-09-21
WSP_828_WSP_414	National	Södermanland	Eskilstuna	Surface water	Eskilstunaån, Torshälla	6587467	583397	WWTP REC.	2011-09-21
WSP_828_WSP_426	National	Södermanland	Eskilstuna	Surface water	Eskilstunaån upstream wwtp	6583857	583152	URBAN	2011-09-21
WSP_828_WSP_428	National	Stockholm	Stockholm	Surface water	Årstaviken			URBAN	sept. 2011
WSP_828_WSP_451	National			Surface water	Landfill X			Landfill rec.	2012-02-24
WSP_828_WSP_470	National	Skåne	Malmö	Surface water	Öresund downstream Sjölunda wwtp	N 55° 38.962	E 013° 00.209	WWTP REC	2011-11-09
WSP_828_F_492	Regional	Jönköping	Hultsfred	Surface water	Storgölen	6364673	549172	Landfill Rec.	2011-11-22
WSP_828_F_494	Regional	Jönköping	Vetlanda	Surface water	Linneån	6358547	494178	Urban	2011-12-06

Appendix 1.2.Surface sediments. Note that positions are given in different geographical systems.

Sample no	Programme	County	Municipality	Media	Site name	Position X	Position Y	Category	Sampling date	Sediment depth, cm
WSP_828_F_54	Regional	Jönköping	Eksjö	Sediment	Kvarnarpssjön	6389489	498572	wwtp rec	2011-11-22	
WSP_828_I_63	Regional	Gotland	Gotland	Sediment	Åminne	6391826	724271	Diffuse	2011-09-26	0-2
WSP_828_D_152	Regional	Södermanland	Eskilstuna	Sediment	Ekeby våtmark	6583995	583069	wwtp rec	2011-09-06	
WSP_828_WSP_392	National	Västernorrland	Örnsköldsvik	Sediment	Remmarsjön			Background	2011-07-12	0-2
WSP_828_WSP_395	National	Örebro	Hällefors	Sediment	Limmingssjön			Background	2011-08-17	0-2
WSP_828_WSP_417	National	Södermanland	Eskilstuna	Sediment	Eskilstunaån	6584822	583205	wwtp rec	2011-09-21	0-4
WSP_828_WSP_418	National	Södermanland	Eskilstuna	Sediment	Eskilstunaån, Torshälla	6587467	583397	wwtp rec	2011-09-21	0-4
WSP_828_WSP_433	National	Södermanland	Eskilstuna	Sediment	Eskilstunaån	6583857	583152	Urban	2011-09-21	0-4
WSP_828_WSP_434	National	Stockholm	Stockholm	Sediment	Årstaviken			Urban	sept. 2011	
WSP_828_F_493	Regional	Jönköping	Eksjö	Sediment	Lilla Bellen	6380842	520254	Urban	2011-11-22	

Appendix 1.3. Incoming waste waters. Note that positions are given in different geographical systems.

Sample no	Programme	County	Municipality	wwtp name	Position x	Position y	Sampling date	Size wwtp (pe)	Load	Storm-water load	Active sludge	Chem. prec.
WSP_828_T_121	Regional	Örebro	Ljusnarsberg	Bångbro	6635238	503167	110629	33 000	ind		yes	yes
WSP_828_T_124	Regional	Örebro	Nora	Nora	6597357	501883	110629	8 500	dom		yes	yes
WSP_828_T_127	Regional	Örebro	Ljusnarsberg	Bångbro	6635238	503167	111027	33 000	ind		yes	yes
WSP_828_T_130	Regional	Örebro	Nora	Nora	6597357	501883	111027	8 500	dom		yes	yes
WSP_828_M_271	Regional	Skåne	Helsingborg	Öresundsverket	6218100	1305000	111213	200 000	dom	Yes	Yes	No
WSP_828_S_332	Regional	Värmland	Årjäng	Kyrkbrud	6584925	335558	111213	5000	dom	No	yes	yes
WSP_828_S_336	Regional	Värmland	Storfors	Storfors	6601824	1412526	jan-12	4500	dom	Yes	No	yes
WSP_828_S_340	Regional	Värmland	Kristinehamn	Kristinehamn	6578081	1401161	111214	12 080	dom	Yes	yes	yes
WSP_828_S_346	Regional	Värmland	Sunne	Sunne	6636693	131770	120104	7500	dom	No	no	yes
WSP_828_WSP_474	National	Skåne	Malmö	Sjölunda			111116	293 700	Mix		Yes	Yes

Appendix 1.4. Outgoing waste waters. Note that positions are given in different geographical systems.

Sample no	Pro-gramme	County	Municipality	wwtp name	Position x	Position y	Sampling date	Size wwtp (pe)	Load	Storm-water load	Active sludge	Chem. prec.
WSP_828_W_04	Regional	Dalarna	Borlänge	Borlänge	6705951	1482832	111006	34 000	mix	Yes	Yes	Yes
WSP_828_W_07	Regional	Dalarna	Falun	Främby	6718593	1491668	111011	45 000	mix	Yes	Yes	Yes
WSP_828_F_31	Regional	Jönköping	Jönköping	Simsholmen	6403325	450565	111010	61700	dom		yes	yes
WSP_828_F_55	Regional	Jönköping	Vetlanda	Vetlanda	6363971	506543	111123	19300	mix		Yes	Yes
WSP_828_T_122	Regional	Örebro	Ljusnarsberg	Bångbro	6635238	503167	110629	33 000	ind		yes	yes
WSP_828_T_125	Regional	Örebro	Nora	Nora	6597357	501883	110629	8 500	dom		yes	yes
WSP_828_T_128	Regional	Örebro	Ljusnarsberg	Bångbro	6635238	503167	111027	33 000	ind		yes	yes
WSP_828_T_131	Regional	Örebro	Nora	Nora	6597357	501883	111027	8 500	dom		yes	yes
WSP_828_D_151	Regional	Södermanland	Eskilstuna	Ekeby våtmark	6583995	583069	110906	94 000	dom/mix	Yes	YES	Yes

WSP_828_D_157	Regional	Södermanland	Katrineholm	Rosenholm	6547196	590130	111011	53 000	mix	Yes	No	Yes
WSP_828_D_162	Regional	Södermanland	Flen	Flen	6546653	591968	111011	19 900	mix	Yes	YES	Yes
WSP_828_Y_181	Regional	Västernorrland	Sundsvall	Fillanverket	6924335	623173	111019	21 600	mix		Yes	Yes
WSP_828_Y_183	Regional	Västernorrland	Örnsköldsvik	Knorthem	7022222	687655	111004	12 500	dom		Yes	Yes
WSP_828_Y_184	Regional	Västernorrland	Sollefteå	Hågesta	7006684	615763	110901	13 150	mix		No	Yes
WSP_828_BD_211	Regional	Norrbotten	Luleå	Uddebo	7289342	832634	120209	60 000	dom		no	yes
WSP_828_BD_213	Regional	Norrbotten	Piteå	Sandholmen	7255642	801308	111028	30 500	dom		no	yes
WSP_828_M_272	Regional	Skåne	Helsingborg	Öresundsver-ket	6218100	1305000	111213	200 000	dom (119450)	yes	Yes	No
WSP_828_S_333	Regional	Värmland	Årjäng	Kyrkbrud	6584925	335558	111213	5000	dom (1800)	no	yes	yes
WSP_828_S_337	Regional	Värmland	Storfors	Storfors	6601814	1412507	jan-12	4500	dom (3500 pe)	yes	No	yes
WSP_828_S_341	Regional	Värmland	Kristinehamn	Kristinehamn	6578075	1400681	111214	12 080	dom	yes	yes	yes
WSP_828_S_345	Regional	Värmland	Sunne	Sunne	6636693	131770	120104	7500	dom (5500pe)	no	no	yes
WSP_828_E_361	Regional	Östergötland	Åtvidaberg	Håckla			110926	7700	dom	yes	no	yes
WSP_828_E_363	Regional	Östergötland	Mjölby	Gudhem			111019	6 000	dom	yes	yes	yes
WSP_828_E_365	Regional	Östergötland	Mjölby	Mjölkulla			111019	55 000	dom	yes	yes	yes
WSP_828_E_367	Regional	Östergötland	Motala	Karshult	6492095	505457	10-16 oct 2011	40 000	dom	yes	yes	yes
WSP_828_E_369	Regional	Östergötland	Vadstena	Vadstena	6477879	492555	10-16 oct 2011	9 500	dom	Yes	no	yes
WSP_828_E_371	Regional	Östergötland	Norrköping	Slottshagen			111012	200 000	dom	Yes	yes	yes
WSP_828_E_373	Regional	Östergötland	Linköping	Nykvarn			111025	235 000	dom	Yes	yes	yes
WSP_828_WSP_400	National	Södermanland	Eskilstuna	Ekeby			110628	94 000	dom (82700)	yes	yes	Yes
WSP_828_WSP_403	National	Stockholm	Stockholm	Henriksdal			110726	700 000	dom			Yes
WSP_828_WSP_406	National	Södermanland	Eskilstuna	Ekeby			sept. -11	94 000	dom (82700)	yes	yes	Yes
WSP_828_WSP_409	National	Stockholm	Stockholm	Henriksdal			110919	700 000	dom			Yes
WSP_828_WSP_471	National	Skåne	Malmö	Sjölunda			111116	294 000	Mix		Yes	Yes

Appendix 1.5.Sewage sludge from municipal wwtp´s. Note that positions are given in different geographical systems.

Sample no	Pro-gramme	County	Municipality	WWTP name	Position x	Position y	Sampling date	Size WWTP (pe)	Load	Stormwater load	Active sludge	Chem. prec.
WSP_828_I_62	Regional	Gotland	Gotland	Visby	6391626	695288	110927	60 000	mix		yes	yes
WSP_828_G_91	Regional	Kronoberg	Alvesta	Alvesta	6305166	472520	111212	12 000	dom	no		yes
WSP_828_G_95	Regional	Kronoberg	Lessebo	Lessebo	6289111	515723	111201	9000	mix	no		yes
WSP_828_G_99	Regional	Kronoberg	Ljungby	Ljungby	6297950	434491	111122	33 000	mix	no	yes	yes
WSP_828_G_103	Regional	Kronoberg	Markaryd	Ribersdal	6259659	412501	120305	10 000	dom	no	yes	yes
WSP_828_G_107	Regional	Kronoberg	Tingsryd	Tingsryd	6262777	499328	111201	42 000	dom	no	yes	yes
WSP_828_G_110	Regional	Kronoberg	Uppvidinge	Åseda	6335875	522559	111206	6000	mix	no	yes	yes
WSP_828_G_113	Regional	Kronoberg	Växjö	Sundet	6301548	485327	111201	80 000	mix	no	yes	yes
WSP_828_G_117	Regional	Kronoberg	Älmhult	Älmhult	6265197	445771	111123	22 700	dom	no	yes	yes
WSP_828_T_123	Regional	Örebro	Ljusnarsberg	Bångbro	6635238	503167	110708	33 000	ind		yes	yes
WSP_828_T_126	Regional	Örebro	Nora	Nora	6597357	501883	110708	8 500	dom		yes	yes
WSP_828_T_129	Regional	Örebro	Ljusnarsberg	Bångbro	6635238	503167	111027	33 000	ind		yes	yes
WSP_828_T_132	Regional	Örebro	Nora	Nora	6597357	501883	111027	8 500	dom		yes	yes
WSP_828_D_158	Regional	Södermanland	Katrineholm	Rosenholm	6547196	590130	111011	53 000	mix	yes	no	yes
WSP_828_D_163	Regional	Södermanland	Flen	Flen	6546653	591968	111011	19 900	mix	yes	yes	yes
WSP_828_D_165	Regional	Södermanland	Vingåker	Vingåker	6546252	551335	111011	9600	mix	yes	no	yes
WSP_828_BD_212	Regional	Norrbotten	Luleå	Uddebo	7289342	832634	120209	Ca 60 000	dom		no	yes
WSP_828_BD_214	Regional	Norrbotten	Piteå	Sandholmen	7255642	801308	111028	Ca 30 500	dom		no	yes
WSP_828_M_273	Regional	Skåne	Helsingborg	Öresund	6218100	1305000	111213	200 000	dom	yes	yes	no
WSP_828_S_334	Regional	Värmland	Årjäng	Kyrkbrud	6584925	335558	111213	5000	dom	no	yes	yes
WSP_828_S_338	Regional	Värmland	Storfors	Storfors			jan-12	4500	dom	yes	no	yes
WSP_828_S_342	Regional	Värmland	Kristinehamn	Kristinehamn			111214	12 080	dom	yes	yes	yes

WSP_828_S_344	Regional	Värmland	Sunne	Sunne	6636693	131770	120104	7500	dom	no	no	yes
WSP_828_E_362	Regional	Östergötland	Åtvidaberg	Håckla				7700	dom	yes	no	yes
WSP_828_E_364	Regional	Östergötland	Mjölby	Gudhem			111019	6 000	dom	yes	yes	yes
WSP_828_E_366	Regional	Östergötland	Mjölby	Mjölkulla			111019	55 000	dom	yes	yes	yes
WSP_828_E_368	Regional	Östergötland	Motala	Karshult	6492095	505457	111016	40 000	dom	yes	yes	yes
WSP_828_E_370	Regional	Östergötland	Vadstena	Vadstena	6477879	492555	111016	9 500	dom	yes	no	yes
WSP_828_E_372	Regional	Östergötland	Norrköping	Slottshagen				200 000	dom	yes	yes	yes
WSP_828_E_374	Regional	Östergötland	Linköping	Nykvarn			111025	235 000	dom	yes	yes	yes
WSP_828_WSP_401	National	Södermanland	Eskilstuna	Ekeby			110628	94 000	dom	yes	yes	yes
WSP_828_WSP_404	National	Stockholm	Stockholm	Henriksdal			110726	ca 700 000	dom			
WSP_828_WSP_407	National	Södermanland	Eskilstuna	Ekeby			sep. -11	94 000	dom	yes	yes	yes
WSP_828_WSP_410	National	Stockholm	Stockholm	Henriksdal			110919	ca 700 000	dom			
WSP_828_WSP_475	National	Skåne	Malmö	Sjölunda			111213	293 700	Mix		yes	yes

Appendix 2. Analytical results

This appendix shows concentrations of the investigated substances for all samples.

Appendix 2.1. Concentrations (ng/l) in industrial waste water, stormwater, landfill leachates and surface waters. NP-EO1: nonylphenolmonoethoxylate etc.

Provnummer	Media	Category	TPPO	TMDD	TCEP	4-OP	4-OP-EO1	4-OP-EO2	4-OP-EO3	4-NP	4-NP-EO1	4-NP-EO2	4-NP-EO3
WSP_828_WSP_472	AV Ind	Point source	4500	1400 000	70	2800	<600	<100	<100	1400	<8000	<500	<500
WSP_828_WSP_473	AV Ind	Point source	740	7700	1600	470	540	<100	<100	<1000	<1000	<1000	<1000
WSP_828_I_65	DV	Urban	<5	<5	<5	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_D_156	DV	Urban	<10	<20	<10	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_D_161	DV	Urban	<5	<10	<5	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_WSP_431	DV	Urban	<10	150	31	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_WSP_432	DV	Urban	<10	<25	<10	30	<10	<10	<10	180	<100	<100	<100
WSP_828_F_52	YV	Point source	<20	<40	<10	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_I_61	YV		<5	<5	<5	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_D_155	YV	wwtp rec.	<10	<20	<10	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_D_160	YV	wwtp rec.	<10	<20	<10	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_S_331	YV	wwtp rec.	<20	<30	<10	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_S_335	YV	wwtp rec.	<20	<30	<20	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_S_339	YV	wwtp rec.	<20	180	29	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_S_343	YV	wwtp rec.	<20	<30	<20	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_E_375	YV	wwtp rec.	<5	140	18	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_E_376	YV	urban	<5	<10	<5	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_WSP_391	YV	Background	<10	<10	<10	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_WSP_394	YV	Background	<5	<5	16	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_WSP_413	YV	wwtp rec.	<10	<25	<10	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_WSP_414	YV	wwtp rec.	<10	<25	<10	<10	<10	<10	<10	<100	<100	<100	<100

WSP_828_WSP_426	YV	Urban	<10	55	<10	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_WSP_428	YV	Urban	<5	<10	5,3	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_WSP_451	YV	Point source	<20	450	<20	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_WSP_470	YV	Point source	<20	<30	<10	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_F_492	YV	Point source	<20	<40	<10	30	<10	<10	<10	190	<100	<100	<100
WSP_828_F_494	YV	Urban	<20	<40	<10	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_W_01	LV	Point source	<200	5100	<200	240	<10	<10	<10	750	<1200	<250	<1100
WSP_828_D_154	LV	Point source	23	970	170	14	<10	<10	<10	110	<100	<100	<100
WSP_828_WSP_450	LV	Point source	160	87 000	100	5400	<100	<100	<100	<1000	<1000	<1000	<1000

Appendix 2.2. Concentrations (µg/kg dw) in sediments. NP-EO1: nonylphenolmonoethoxylate etc.

Provnummer	Category	DW, %	TPPO	TMDD	TCEP	4-OP	4-OP-EO1	4-OP-EO2	4-OP-EO3	4-NP	4-NP-EO1	4-NP-EO2	4-NP-EO3
WSP_828_F_54	Urban	7,8	<130	<65	<260	12	<5	<2	<60	330	<90	<60	<300
WSP_828_I_63		45,2	<90	<90	<90	<2	<2	<2	<2	<20	<20	<20	<50
WSP_828_D_152	wwtp	55,8	<20	<20	<20	<4	<10	<10	<10	38	<100	<100	<100
WSP_828_WSP_392	Background	8,2	<25	<20	<25	3,7	<2	<2	<5	<20	<20	<20	<160
WSP_828_WSP_395	Background	6,6	<20	<20	<31	77	<2	<2	<20	<20	<20	<20	<120
WSP_828_WSP_417	wwtp rec.	34,5	<30	<30	<30	<6	<2	<2	<5	70	<20	<20	<80
WSP_828_WSP_418	wwtp rec.	29,7	<30	<30	<30	<6	<2	<2	<7	<60	<29	<20	<90
WSP_828_WSP_433	Urban	34,8	<30	<30	<30	<6	<2	<2	<5	92	<25	<20	<80
WSP_828_WSP_434	Urban	10,1	<50	<100	<50	<1	<3	<4	<50	38	62	<60	<90
WSP_828_F_493	Urban	5,6	<90	<180	<90	2,9	<2	<2	<30	<20	<20	<20	<120

Appendix 2.3. Concentrations (ng/l) in incoming waste waters. NP-EO1: nonylphenolmonoethoxylate etc.

Sample no	Category	TPPO	TMDD	TCEP	4-OP	4-OP-EO1	4-OP-EO2	4-OP-EO3	4-NP	4-NP-EO1	4-NP-EO2	4-NP-EO3
WSP_828_T_121	wwtp	<20	<20	190	22	42	<10	<70	780	850	<150	<800
WSP_828_T_124	wwtp	<10	1500	120	<100	<100	<100	<100	1600	1700	<1000	<3500
WSP_828_T_127	wwtp	<20	390	90	<10	<10	<10	<10	290	<550	<600	<500
WSP_828_T_130	wwtp	<20	350	100	13	23	<10	<10	550	670	<150	<250
WSP_828_M_271	wwtp	32	560	250	22	130	<70	<60	1500	1900	<150	<1800
WSP_828_S_332	wwtp	<20	230	65	<10	<10	<10	<10	<250	<200	<100	<250
WSP_828_S_336	wwtp	<20	500	95	20	<10	<200	<50	510	<350	<200	<1500
WSP_828_S_340	wwtp	<20	54	<10	<10	<10	<10	<10	<100	130	100	<150
WSP_828_S_346	wwtp	<20	32000	110	36	100	<30	<10	260	550	<150	<800
WSP_828_WSP_474	wwtp	39	1500	240	25	180	<60	<25	1200	1600	<150	<2000

Appendix 2.4. Concentrations (ng/l) in outgoing waste waters (effluents). NP-EO1: nonylphenolmonoethoxylate etc.

Sample no	Category	TPPO	TMDD	TCEP	4-OP	4-OP-EO1	4-OP-EO2	4-OP-EO3	4-NP	4-NP-EO1	4-NP-EO2	4-NP-EO3
WSP_828_W_04	wwtp	30	1500	520	<10	<10	<10	<10	130	190	<100	<150
WSP_828_W_07	wwtp	<10	570	<50	60	15	10	<10	<100	130	<100	<100
WSP_828_F_31	wwtp	9,1	1400	220	12	13	<10	<10	<100	<100	<100	<100
WSP_828_F_55	wwtp	<20	11000	200	<10	<10	<10	<10	120	<100	<100	<100
WSP_828_T_122	wwtp	<20	670	180	<10	19	20	28	<100	170	<100	<100
WSP_828_T_125	wwtp	<20	58	130	<15	<10	<10	<35	140	<100	<100	<100
WSP_828_T_128	wwtp	<20	360	130	860	<10	<10	11	<100	<100	<250	<100
WSP_828_T_131	wwtp	<20	850	220	<10	<10	<10	<10	<100	<100	<100	<150
WSP_828_D_151	wwtp	<5	210	150	<10	<10	<10	<10	<100	<100	<100	<100

WSP_828_D_157	wwtp	<10	640	95	<10	12	12	<10	<100	270	<250	<100
WSP_828_D_162	wwtp	35	720	<100	<10	<10	<10	<10	100	110	<400	<200
WSP_828_Y_181	wwtp	25	950	220	11	25	30	<10	170	170	<100	<100
WSP_828_Y_183	wwtp	<10	550	860	100	43	12	<10	240	220	<100	<150
WSP_828_Y_184	wwtp	7,2	280	290	19	39	38	24	120	200	120	<100
WSP_828_BD_211	wwtp	<20	770	330	<10	96	320	89	<100	<100	<100	<400
WSP_828_BD_213	wwtp	<20	790	480	16	<10	<10	<10	240	<100	<100	<100
WSP_828_M_272	wwtp	<20	860	270	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_S_333	wwtp	<20	250	110	<10	<10	12	<10	100	<100	140	<100
WSP_828_S_337	wwtp	<20	200	46	<10	<10	<20	<10	<100	<200	<100	<400
WSP_828_S_341	wwtp	<20	<30	57	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_S_345	wwtp	<20	37000	280	19	37	26	14	<100	140	<100	<100
WSP_828_E_361	wwtp	<5	66	100	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_E_363	wwtp	<10	1400	180	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_E_365	wwtp	28	1500	210	<10	<10	<10	<10	160	<100	<100	<100
WSP_828_E_367	wwtp	12	960	280	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_E_369	wwtp	11	1300	170	20	<10	<10	<10	<100	<100	<100	<100
WSP_828_E_371	wwtp	<10	2500	190	<10	<10	<10	<10	320	<100	<100	<100
WSP_828_E_373	wwtp	<5	2400	240	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_WSP_400	wwtp	<10	250	480	<10	23	<10	<10	100	<150	<100	<100
WSP_828_WSP_403	wwtp	<10	710	360	52	130	470	860	190	<100	<100	<150
WSP_828_WSP_406	wwtp	11	870	280	<10	<10	<10	<10	<100	<100	<100	<100
WSP_828_WSP_409	wwtp	11	300	190	28	140	230	310	110	<100	<100	<100
WSP_828_WSP_471	wwtp	<20	1600	380	<10	<10	<10	<10	<100	<100	<100	<100

Appendix 2.5. Concentrations (µg/kg dw) in sewage sludge. NP-EO1: nonylphenolmonoethoxylate etc.

Sample no	Category	dw %	TPPO	TMDD	TCEP	4-OP	4-OP-EO1	4-OP-EO2	4-OP-EO3	4-NP	4-NP-EO1	4-NP-EO2	4-NP-EO3
WSP_828_I_62	wwtp	19,7	<51	<51	<51	190	420	<40	<200	3800	6100	<400	<5500
WSP_828_G_91	wwtp	33	<60	120	<60	<30	<30	<30	<30	1700	1000	<300	<600
WSP_828_G_95	wwtp	14,3	<140	<70	<140	<70	<70	<70	<70	2000	<1400	<700	<4200
WSP_828_G_99	wwtp	16,1	<32	<64	<32	1400	930	120	<70	7500	2000	<700	<700
WSP_828_G_103	wwtp	14,6	<70	<35	<140	<70	89	<70	<450	1200	2400	<700	<7000
WSP_828_G_107	wwtp	16,4	<120	<60	<120	<70	67	<70	<110	1800	1900	<1100	<2800
WSP_828_G_110	wwtp	16,4	<120	1400	<120	<70	<70	<70	<70	<700	<700	<700	<700
WSP_828_G_113	wwtp	5,9	<340	<170	<340	<200	<200	<1400	<200	2000	3100	<2000	<4000
WSP_828_G_117	wwtp	1,5	<340	<700	<340	<700	<700	<700	<700	<7000	<7000	<7000	<7000
WSP_828_T_123	wwtp	6,2	<160	<160	<160	<150	<150	<800	<150	3200	5200	<1500	<9200
WSP_828_T_126	wwtp	10,4	<50	<100	<50	<100	<100	<100	<900	1200	<3500	<1000	<3000
WSP_828_T_129	wwtp	6,1	<85	<170	<85	<200	<200	<200	<200	<2000	<3000	<2000	<3000
WSP_828_T_132	wwtp	3,6	<140	<280	<140	<100	<100	<100	<100	2400	5300	<1000	<6000
WSP_828_D_158	wwtp	6,6	<60	<60	<60	<150	<150	<150	480	<1500	3000	<1500	<5500
WSP_828_D_163	wwtp	12,1	<83	<83	<83	<90	<90	<90	<90	<900	830	<900	<3000
WSP_828_D_165	wwtp	2	<500	<500	<500	<500	<500	<500	<500	<5000	8000	<5000	<10000
WSP_828_BD_212	wwtp	21,7	<47	<24	<93	290	160	<50	<300	8800	4100	<500	<1000
WSP_828_BD_214	wwtp	3,3	<150	<300	<150	<100	<100	<100	<100	5800	5800	<1000	<5000
WSP_828_M_273	wwtp	22,2	<90	<45	<90	120	77	<50	<50	4000	1700	<500	<600
WSP_828_S_334	wwtp	21	<95	<48	<95	57	<10	130	<10	2100	2200	<130	<360
WSP_828_S_338	wwtp	18,4	<55	<27	<110	<50	60	<50	<180	980	2800	<500	<1300

WSP_828_S_342	wwtp	16,4	<120	<61	<120	61	<70	<70	<70	3700	610	<700	<1000
WSP_828_S_344	wwtp	25,8	<80	250	<80	150	190	<40	<40	4300	3200	<400	<1400
WSP_828_E_362	wwtp	34,8	<72	<72	<72	69	32	<10	<40	5200	1800	<100	<1100
WSP_828_E_364	wwtp	16,4	<15	<30	<15	<30	<30	<30	<30	1900	2300	<300	<1700
WSP_828_E_366	wwtp	14,3	<35	<70	<35	<80	140	<80	<80	2000	2700	<800	<2000
WSP_828_E_368	wwtp	28	<15	<30	<15	390	86	<40	<40	11000	2000	<400	<800
WSP_828_E_370	wwtp	16,8	<30	<60	<30	260	95	<50	<50	3400	950	<500	<500
WSP_828_E_372	wwtp	27,2	<20	<40	<20	280	70	<40	<40	9200	3000	<400	<1200
WSP_828_E_374	wwtp	28,2	<18	<36	<18	390	78	<30	<30	9600	2200	<300	<3000
WSP_828_WSP_401	wwtp	6,7	<370	<370	<150	<150	<400	<900	<150	5100	<4600	<1500	<21000
WSP_828_WSP_404	wwtp	28,9	<7	<20	<7	730	73	<10	<35	10000	2900	<100	<400
WSP_828_WSP_407	wwtp	20,3	<25	<50	<25	320	59	<50	<50	11000	3000	<500	<1300
WSP_828_WSP_410	wwtp	25,8	<40	<40	<40	700	89	<25	<25	12000	2100	<250	<250
WSP_828_WSP_475	wwtp		<25	<25	<25	300	<50	<50	<50	10000	1700	<500	<500