

Results from the Swedish  
National Screening Programme  
2004

Subreport 4: Siloxanes

Lennart Kaj, Jeanette Andersson, Anna Palm Cousins,  
Mikael Remberger, Eva Brorström-Lundén, IVL  
Ingemar Cato, SGU  
B1643  
October 2005

<p><b>Organization</b></p> <p>IVL Swedish Environmental Research Institute Ltd.</p>	<p><b>Report Summary</b></p>
<p><b>Address</b></p> <p>P.O. Box 21060 SE-100 31 Stockholm</p>	<p><b>Project title</b></p>
<p><b>Telephone</b></p> <p>+46 (0)8-598 563 00</p>	<p><b>Project sponsor</b></p>
<p><b>Author</b></p> <p>Lennart Kaj, Jeanette Andersson, Anna Palm Cousins, Mikael Remberger, Ylva Ekheden. Brita Dusan, Eva Brorström-Lundén, IVL, Ingemar Cato, SGU</p>	
<p><b>Title and subtitle of the report</b></p> <p>Results from the Swedish National Screening Programme 2004. Subreport 4: Siloxanes</p>	
<p><b>Summary</b></p> <p>As an assignment from the Swedish Environmental Protection Agency, IVL has performed a screening study of siloxanes. The substances included were three cyclic polydimethylsiloxanes (D4, D5, and D6) and four linear analogues (MM, MDM, MD2M and MD3M). The overall objectives of the screening were to determine concentrations in a variety of media in the Swedish environment, to highlight important transport pathways, and to assess the possibility of current emissions in Sweden. A total of 138 samples of air, water, sludge, sediment and fish were analysed. D4 that is classified as a phase out substance was found in 37 out of 54 municipal sludge samples in concentrations from 130 to 2 300 ng/g DW and in various air samples in concentrations up to 300 ng/m<sup>3</sup>. D4 was not found in any of the water, sediment or fish samples. MM, which is on the OSPAR candidate list for dangerous substances, was found in leachate water from landfills and in low concentrations in air in the Stenungsund chemical industrial area. D5 was the dominating siloxane in most samples. It was found in all sludge samples from municipal treatment plants. The average concentration was 11 000 ng/g DW. Siloxanes were not found in aquatic biota (fish muscle). One or more of D4, D5 and D6 were found in 11 out of 49 samples of human breast milk. The maximum concentration of D4 was 10 µg/L, of D5 4.5 µg/L and of D6 4.8 µg/L.</p>	
<p><b>Keyword</b></p> <p>Screening siloxanes D4 D5 D6 MM MDM MD2M MD3M</p>	
<p><b>Bibliographic data</b></p> <p>IVL Report B1643</p>	
<p><b>The report can be ordered via</b></p> <p>Homepage: <a href="http://www.ivl.se">www.ivl.se</a>, e-mail: <a href="mailto:publicationservice@ivl.se">publicationservice@ivl.se</a>, fax+46 (0)8-598 563 90, or via IVL, P.O. Box 21060, SE-100 31 Stockholm Sweden</p>	

## Sammanfattning

IVL Svenska Miljöinstitutet har på uppdrag av Naturvårdsverket utfört en screeningstudie av siloxaner. Studien omfattade tre cykliska polydimetysiloxaner (D4, D5, D6) och fyra linjära (MM, MDM, MD2M, MD3M). Det huvudsakliga syftet med studien var att bestämma koncentrationen i ett antal matriser i den svenska miljön, att undersöka viktiga transportvägar samt att utröna om pågående emissioner kan tänkas förekomma i Sverige. Vidare var syftet att undersöka betydelsen av atmosfärisk transport samt upptag i biota.

En nationell provtagningsstrategi utarbetades. Provtagningsprogrammet baserades på identifierade möjliga utsläppskällor samt på ämnens egenskaper. Programmet inkluderade mätningar både i bakgrundsområden och nära potentiella punktkällor. Även mätningar av diffusa spridningsvägar i form av avloppssystem inkluderades. Mätningarna omfattade 39 prov fördelade på luft, vatten, slam, sediment och fisk. För att belysa humant upptag analyserades också 39 prov av bröstmjölk.

Utöver det nationella programmet bidrog tretton länsstyrelser med ytterligare 99 prov av samma provtyper från regionala program.

D4 som klassas som ett utfasningsämne återfanns i 37 av 54 slamprov från kommunala avloppsreningsverk i koncentrationer mellan 130 och 2 300 ng/g TS. D4 kunde inte detekteras i prov på vatten, sediment eller fiskmuskel.

MM som finns upptagen på OSPARs kandidatlista över farliga substanser förekom i lakvatten från deponier och i låga halter i luft från Stenungsundsområdet.

D5 var den dominerande siloxanen i de flesta proven. D5 fanns i alla slamprov från kommunala reningsverk. Medelkoncentrationen var 11 000 ng/g DW.

Siloxaner detekterades inte i något av de biologiska proven från den akvatiska miljön (fiskmuskel).

I elva av 49 analyserade prov av human bröstmjölk påvisades en eller flera av D4, D5 och D6. Den maximala koncentrationen av D4 var 10 µg/l, av D5 4.5 µ/l och av D6 4.8 µg/l. Kvantifieringsgränsen var 2 µg/l.

## Summary

As an assignment from the Swedish Environmental Protection Agency, IVL has performed a screening study of siloxanes. The substances included were three cyclic polydimethylsiloxanes (D4, D5, and D6) and four linear analogues (MM, MDM, MD2M and MD3M). The overall objectives of the screening were to determine concentrations in a variety of media in the Swedish environment, to highlight important transport pathways, and to assess the possibility of current emissions in Sweden.

A national sampling strategy was developed. The sampling programme was based on identified possible emission sources and use of the chemicals as well as on the behaviour of the substances in the environment. The programme included measurements in background areas and close to potential point sources. Measurements of diffuse pathways from the society including sewage systems were also included. This programme totalled 39 samples of air, water, sludge, sediment and fish. To elucidate human exposure of siloxanes 39 samples of human breast milk were included in the national program. Thirteen county administrative boards throughout Sweden contributed 99 additional samples of the same sample types.

D4 that is classified as a phase out substance was found in 37 out of 54 municipal sludge samples in concentrations from 130 to 2 300 ng/g DW and in various air samples in concentrations up to 300 ng/m<sup>3</sup>. D4 was not found in any of the water, sediment or fish samples.

MM, which is on the OSPAR candidate list for dangerous substances, was found in leachate water from landfills and in low concentrations in air collected in the Stenungsund chemical industrial area.

D5 was the dominating siloxane in most of the samples. It was found in all sludge samples from municipal treatment plants. The average concentration was 11 000 ng/g DW.

Siloxanes were not found in biota from aquatic environment (fish muscle).

One or more of D4, D5 and D6 were found in 11 out of 49 samples of human breast milk. The maximum concentration of D4 was 10 µg/l, of D5 4.5 µg/l and of D6 4.8 µg/l. The quantification limit was 2 µg/l.

## Table of contents

Sammanfattning.....	1
Summary .....	2
1 Introduction .....	5
2 Chemical properties, fate, toxicity and regulation.....	7
3 Production and use .....	11
4 Previous measurements in the environment.....	12
5 Sampling strategy and study sites.....	13
5.1 National.....	13
5.2 Regional.....	13
6 Methods .....	14
6.1 Sampling.....	14
6.1.1 Air .....	14
6.1.2 Water .....	14
6.1.3 Sediment.....	14
6.1.4 Sludge .....	15
6.1.5 Fish .....	15
6.1.6 Breast milk.....	15
6.2 Analysis.....	15
6.2.1 Analysis of sludge, sediment, breast milk and water.....	15
6.2.2 Analysis of air samples.....	16
6.2.3 Analysis of fish samples.....	16
7 Results and discussion .....	18
7.1 National programme .....	18
7.1.1 Sludge .....	18
7.1.2 Air .....	18
7.1.3 Fish .....	19
7.1.4 Water .....	19
7.1.5 Sediment.....	20
7.1.6 Breast milk.....	20
7.2 Regional programme .....	20
7.2.1 Sludge .....	20
7.2.2 Water .....	24
7.2.3 Sediment.....	24
7.2.4 Biota.....	24
8 Conclusions.....	25
9 Acknowledgements .....	25

10	References .....	26
Appendix	Information on samples and lists of results	

## 1 Introduction

As an assignment from the Swedish Environmental Protection Agency, IVL has performed a "Screening Study". This screening, which was carried out during 2004/2005, includes the following substances: adipates, octachlorostyrene, limonene, siloxanes, mirex, endosulfan and isocyanates. The different substances or groups of substances are emitted to and spread in the environment via a variety of sources, e.g. point sources and use in products. Some of the chemicals are commonly used internationally and/or in Sweden.

The seven chemicals or chemical groups studied have been identified as potentially toxic, bioaccumulative and/or persistent. Some are also included on different international/national priority lists. Table 1 shows an overview of the chemicals included and the major reasons for their concern.

Table 1. Overview of chemicals included in the screening 2004 and the reason for their concern (Loh et al., 2003; Andersson, 2004; OSPAR, 2005; UNEP, 2005) The chemicals considered in the current report are written in bold/italic letters.

	Chemical type	Banned/ Restricted	HPV <sup>a</sup>	Indications of toxicity	Evidence for B/P <sup>b</sup>	International Priority List
Adipates	Additive	No	x	x		
Octachlorostyrene	Unintentional by-product	PRIO- substance <sup>c</sup>		x	x	Candidate for the Stockholm convention
Limonene	Cleaning agent (also naturally occurring)			x		
<b>Siloxanes</b>	<b>Lubricant, industrial raw material, chemical additive</b>	<b>PRIO- substance<sup>c</sup></b>	<b>x</b>	<b>x</b>	<b>x</b>	<b>OSPAR (HMDS)</b>
Mirex	Pesticide	Banned		x	x	Stockholm convention
Endosulfan	Pesticide	Banned		x	x	WFD, OSPAR, Candidate for the Stockholm convention
Isocyanates	Industrial raw material	Regulated	x	x		OSPAR <sup>d</sup>

<sup>a)</sup> High Production Volume

<sup>b)</sup> Bioaccumulation/Persistence

<sup>c)</sup> The chemical is included on Swedish Chemicals Inspectorate's PRIO-list, and is identified as a "phase-out-chemical"

<sup>d)</sup> Concerns 3,3'-(ureylenedimethylene)-bis-(3,5,5-trimethylcyclohexyl) diisocyanate

The overall objectives of the screening were to determine concentrations in a variety of media in the Swedish environment, to highlight important transport pathways, and to assess the possibility of current emissions in Sweden. A further aim was to investigate the likelihood of atmospheric transport and uptake in biota. The outcome of the study is aimed to serve as a basis for decision-making regarding monitoring activities of these chemicals.

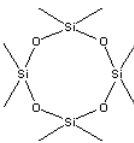
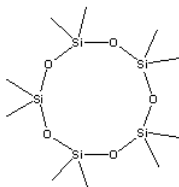
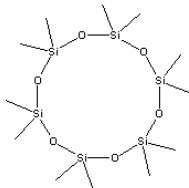
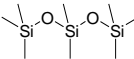
Due to the variety in emission sources and use as well as differences in chemical properties, the screening has been carried out in seven sub-projects. This report concerns the results of **siloxanes**. Results for the other chemicals are presented in subreports 1-3 and 5-6.



## 2 Chemical properties, fate, toxicity and regulation

Siloxanes form a large group of chemicals with molecular weights from a few hundreds to several hundred thousands. This study is limited to three cyclic and four linear polydimethylsiloxanes of low molecular weight. These compounds are listed in Table 2. They are referred to by their full names or the abbreviations given in this table. The abbreviated names are according to the General Electric's siloxane notation (Hurd, 1946).

Table 2. Siloxanes included in the screening programme.

Abbreviation	Name	CAS #	Structure
D4	Octamethylcyclotetrasiloxane	556-67-2	
D5	Decamethylcyclopentasiloxane	541-02-6	
D6	Dodecamethylcyclohexasiloxane	540-97-6	
MM (or HMDS)	Hexamethyldisiloxane	107-46-0	$\begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\   \quad   \\ \text{CH}_3 - \text{Si} - \text{O} - \text{Si} - \text{CH}_3 \\   \quad   \\ \text{CH}_3 \quad \text{CH}_3 \end{array}$
MDM	Octamethyltrisiloxane	107-51-7	
MD2M	Decamethyltetrasiloxane	141-62-8	$\begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \quad \text{CH}_3 \quad \text{CH}_3 \\   \quad   \quad   \quad   \\ \text{CH}_3 - \text{Si} - \text{O} - \text{Si} - \text{O} - \text{Si} - \text{O} - \text{Si} - \text{CH}_3 \\   \quad   \quad   \quad   \\ \text{CH}_3 \quad \text{CH}_3 \quad \text{CH}_3 \quad \text{CH}_3 \end{array}$
MD3M	Dodecamethylpentasiloxane	141-63-9	$\begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \quad \text{CH}_3 \\   \quad   \quad   \\ \text{CH}_3 - \text{Si} - \text{O} - (\text{Si} - \text{O})_3 - \text{Si} - \text{CH}_3 \\   \quad   \quad   \\ \text{CH}_3 \quad \text{CH}_3 \quad \text{CH}_3 \end{array}$

The siloxanes selected in this study occur as clear viscous liquids at room temperature and have varying physical-chemical properties according to Table 3.

Table 3. Chemical and physical data.

Substance	MW	W <sub>sol</sub> (mg/l)	V <sub>p</sub> (mm Hg)	H (Atm m <sup>3</sup> /mol)	Log K <sub>ow</sub>	BCF	K <sub>oc</sub> (L/kg)
D4 <sup>a</sup>	296.6	0.9 (25°)	1 (25°)	0.42	-	12400	2.85×10 <sup>4</sup>
D5 <sup>b</sup>	370.8	0.24 <sup>b</sup> ; 0.017 <sup>c</sup> (25°)	0.2 (25°) <sup>b,c</sup>	0.4 <sup>b</sup> ; 0.3 <sup>c</sup>	5.7 <sup>b</sup> ; 5.2 <sup>c</sup>	5000 <sup>b</sup>	1.6×10 <sup>4b</sup>
D6	444.9						
MM <sup>a</sup>	162.4	2 (25°)	42 (25°)	4.5	4.2	5000	4.6×10 <sup>3</sup>
MDM	236.5						
MD2M	310.7						
MD3M <sup>c</sup>	384.8	3.1×10 <sup>-4</sup>	0.10	0.79	6		

<sup>a</sup> HSDB, 2004; <sup>b</sup> ECB, 2005; <sup>c</sup> SRC, 2005

In the atmosphere siloxanes may exist both in the vapour and particle phases. However the most volatile siloxanes are mainly in the vapour phase. In particle phase, the siloxanes are mainly removed from the air through deposition whereas in the vapour phase they may also react with hydroxyl radicals. Half-lives for reaction with hydroxyl radicals in air are given in Table 4.

Table 4. Half-lives for reaction with hydroxyl radicals in air.

Substance	Half life	Reference
D4	16 days	HSDB, 2004
D5	10 days	HSDB, 2004
MM	12 days	HSDB, 2004

MM, D4 and D5, have high vapour pressures and high Henry's law constants and may vaporise both from soil and from water. Siloxanes have high K<sub>OC</sub> (Table 3) and are considered not to be transported with water in soil. In water, they may sorb to particles and are likely to be enriched in sediment (HSDB, 2004). Siloxanes are resistant to chemical reactions such as oxidation, reduction, and direct photodegradation (HSDB, 2004). However, varying information exists on the possibility of siloxanes to undergo hydrolysis e.g in a study of hydrolysis kinetics of D4 the degradation rate was considered environmentally significant. Intermediate and final hydrolysis products were not established in the study (Durham, 2004).

A modelling exercise was performed using the Equilibrium Criterion (EQC) model (Mackay et al., 1996) in order to highlight the likely fate and partitioning behaviour of siloxanes. D5 and MD3M were selected as model substances for fate assessment. Physical-chemical properties were taken from Table 2. The degradation half-lives used were as follows; air: 170 h, water 550 h, soil 1700 h and sediment 5500 hours. The data was based on degradation data obtained from HSDB (2004), as well as estimated data using the EPIWIN software (Meylan, 1999) and classified according to Mackay (2001). Emission rates were set to 1000 kg/h, only for illustrative purposes. The outcome of the modelling exercise is shown in Table 5. The numbers given in the table should be regarded as indicative, as they are dependent on model structure as well as chemical property data.

The overall residence time in the system of both substances is predicted to be fairly low, and generally lower for D5 (<14 days when emitted to all media) than for MD3M (≈30 days). It should be emphasised, however, that advective processes contribute significantly to this low residence

time, and it does not necessarily imply that the chemical is ultimately removed from the environment. On the contrary, the atmospheric half-lives of 1-2 weeks (Table 4) and their general resistance to chemical reactions as mentioned above, imply that siloxanes are persistent enough to undergo long-range atmospheric transport.

The model results emphasize the high volatility of these siloxanes, showing significant partitioning to air regardless of emission media. When emitted to water, however, a large amount is also expected to deposit to sediments, as a result of a relatively high LogK<sub>OW</sub>-value. The primary receiving media are likely to be air and water, based on the high volatility and the areas of use of siloxanes.

Table 5. Results from EQC modelling of D5 and MD3M, using emission rates of 1000 kg/h

Emission medium	% in air		% in water		% in soil		% in sediment		Persistence (h)	
	D5	MD3M	D5	MD3M	D5	MD3M	D5	MD3M	D5	MD3M
Air	99.9	100	<0.001	<0.001	0.1	<0.1	<0.01	<0.001	71	71
Water	4	1	26	8	<0.01	<0.001	70	91	778	2271
Soil	50	81	<0.01	<0.001	50	19	<0.01	<0.01	138	87
<b>All three</b>	<b>17</b>	<b>6.5</b>	<b>21</b>	<b>8</b>	<b>7</b>	<b>0.5</b>	<b>55</b>	<b>85</b>	<b>329</b>	<b>810</b>

Laboratory experiments have shown high BCF for D4 and somewhat lower for D5 and MM (Table 3). High vaporisation rate from water as a result of high volatility, combined with high tendency to bind to particles and thereby high sedimentation rates acts to reduce the actual concentrations available for uptake in biota (HSDB, 2004).

Ecotoxicity data are given in Table 6 below.

Table 6. **Ecotox data for D4 (US EPA, 2005)** IMBL: Immobilisation, GRO: growth, MOR: mortality, REP: Reproduction, ITX: intoxication, NOC, MULT: Multiple effects recorded as one result

Common name, Scientific name	Endpoint	Effect	Duration	Conc (ug/L)
Opposum Shrimp (Americamysis bahia)	NOEC	IMBL	14 d	9.1
Midge (Chironomus tentans)	NOEC	GRO	14 d	>15
Midge (Chironomus tentans)	NOEC	MOR	14 d	>15
Sheepshead minnow (Cyprinodon variegatus)	NOEC	MOR	14 d	6.3
Water flea (Daphnia magna)	NOEC	IMBL	48 h	>15
Water flea (Daphnia magna)	NOEC	REP	21 d	1.7 - 15
Rainbow trout, donaldson trout (Oncorhynchus mykiss)	LC50	MOR	14 d	10, 8.5 - 13
Rainbow trout, donaldson trout (Oncorhynchus mykiss)	LOEC	MOR	14 d	6.9
Rainbow trout, donaldson trout (Oncorhynchus mykiss)	NOEC	MOR	14 d	<=4.4
Rainbow trout, donaldson trout (Oncorhynchus mykiss)	NOEC	NOC, MULT	93 d	4.4
Water flea (Daphnia magna)		ITX, IMBL	21 d	1.7 - 15

The lowest value for No Observed Effect Concentrations (NOEC) was obtained for water fleas (Daphnia magna), a zooplankton that is an important grazer in many limnic ecosystems. Lassen et al., (2005) have derived so-called Chronic Values (ChV) for fish for a number of siloxanes by using

the U.S. EPA PBT Profiler software (U.S. EPA, 2005). ChV is the same as the chronic no effect concentration and shows at what concentration no long-term effects are expected. The results are listed in Table 7.

Table 7. Chronic values for fish derived by Lassen et al., (2005)

<b>Chemical abbreviation</b>	<b>Fish ChV (mg/L)</b>
D4	0.058
D5	0.021
MM	0.062
MDM	0.028

Some evidence exists on the potential carcinogenicity of D5 (U.S. EPA, 2003).

D4 is classified as R62 “possible risk of impaired fertility” and as R53 “may cause long-term adverse effects in the aquatic environment” (KemI, 2004). D4 is also classified as a PBT/vPvB substance and hence as a phase-out substance in the priority data base of the Swedish Chemicals Inspectorate and as such not supposed to be used in any new chemical applications within Sweden. MM is included on the OSPAR candidate list for dangerous substances.

### 3 Production and use

Siloxanes are widely used over the world and D4, D5 and MM are chemicals of high production volume within the European Union. Table 8 shows the main fields of application for siloxanes within the Nordic countries.

Table 8. Fields of application of siloxanes in the Nordic countries (SPIN, 2005).

Field of application	
D4	Fuel additives, Cleaning/washing agents, Impregnation materials, Adhesives, Binding agents, Surface treatment, Construction materials, Paints, laquers and varnishes, Fillers, Reprographic agents, Process regulators, Anti-set-off, Anti adhesive agents
D5	Fuel additives, Surface treatment, Cleaning/washing agents, Fillers, Impregnation material, Adhesives, Binding agents, Paints, laquers and varnishes, Reprographic agents, Softeners, Surface active agents, Process regulators
D6	Surface treatment, Paint, laquers and varnishes
MDM, MD2M	Paint, laquers and varnishes

In Sweden, there is limited use of MD2M, MDM and MM, and more extensive use of D4, D5 and D6 (Figure 1). The use of MD3M is however confidential (too few users). In the cosmetics industry, the name cyclometicone is used for the cyclic dimethylsiloxanes. Examples of product categories are body lotion, hair styling products, creams, lipstick and deodorants.

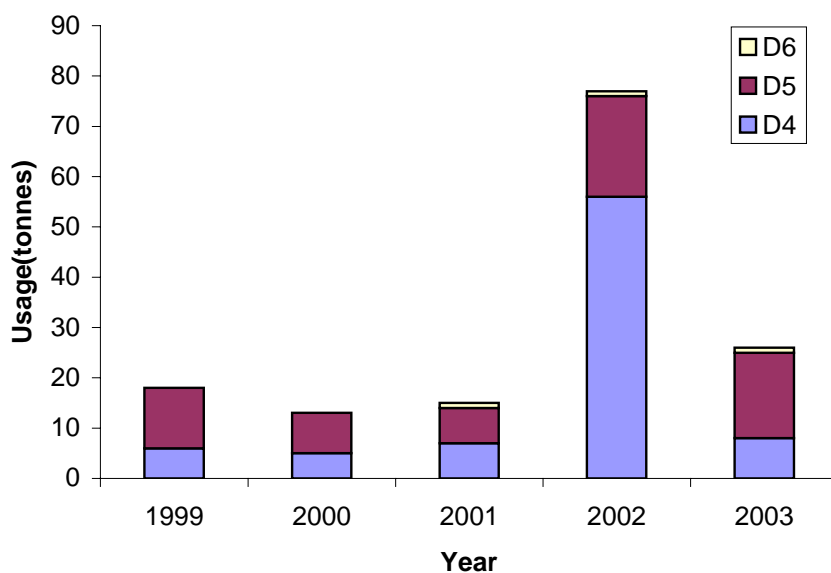


Figure 1. Swedish use of D4, D5, and D6 (SPIN, 2005)

## 4 Previous measurements in the environment

Data on the occurrence of siloxanes in the environment are scarce. Table 9 shows examples on previously detected concentrations of MM and D4 in the environment.

Table 9. Concentration levels of siloxanes in various matrices.

Country	Location	Matrix	MM	D4	Reference
Sweden	Landfill	Percolate water ( $\mu\text{g/l}$ )	2-106	1-2	Paxéus, 2000
Germany	Landfill 1	Biogas ( $\text{mg/m}^3$ )	1.04-1.31	7.97-8.84	Schweigkopfler & Niessner 1999
Germany	Landfill 2	Biogas ( $\text{mg/m}^3$ )	0.38-0.77	4.24-5.03	Schweigkopfler & Niessner 1999
Germany	STP 1	Biogas ( $\text{mg/m}^3$ )	0.05	6.40-6.98	Schweigkopfler & Niessner 1999
Germany	STP 2	Biogas ( $\text{mg/m}^3$ )	0.01	2.87-3.02	Schweigkopfler & Niessner 1999

In order to extend reference data, Table 10 shows results from previous measurements of polydimethylsiloxanes found in the literature, even though the specific compounds were not specified.

Table 10. Concentration levels of polydimethylsiloxane in different matrices (HSDB, 2004)

Matrix	Country	Concentration
Surface water near sewage treatment plant	Australia, Japan and USA, 1997	0.8-5 $\mu\text{g/l}$ .
Surface water near industrial area	Japan, 1997	2.8 –54.2 $\mu\text{g/l}$
Water from a sewage water treatment plant	USA and Japan, 1997	Barely detected
Sludge	Australia, Canada, Germany, Japan and USA, 1997	20-50100 $\text{mg/kg dw}$
Sediment	Australia, Germany, Japan and USA, 1997	314 $\text{mg/kg dw}$
Fish		0.6-0.7 $\text{mg/kg}$

As part of an interdisciplinary field study (DBH: Dampness in buildings and health) indoor air measurements in 400 Swedish homes has recently been carried out. The results for siloxanes from a study of VOCs in air in children's bedrooms are summarised in Table 11 (Schmidbauer, 2005).

Table 11. Concentration of siloxanes in indoor air in Sweden.

Siloxane	Number of homes with siloxane detected	Mean ( $\mu\text{g/m}^3$ )	Min ( $\mu\text{g/m}^3$ )	Max ( $\mu\text{g/m}^3$ )
D5	250	9.7	0.5	79.4
D6	142	7.9	0.6	164
D4	73	9.0	0.6	51.2
D7	8	6.4	1.2	35.5
MD2M	5	20	5.3	73.2
MDM	2	7.4	2.5	12.3
MM	1	1.5	-	-
D3	1	7.3	-	-

## 5 Sampling strategy and study sites

### 5.1 National

A national sampling strategy was developed in order to determine the environmental concentrations of siloxanes and related substances in different environmental matrices in Sweden. An additional aim of the sampling programme was to identify major emission sources as well as important transport pathways. The sampling programme was therefore based on identified possible emission sources and use of the chemicals as well as on the behaviour of the substances in the environment. The programme included both measurements in background areas and close to potential point sources. Measurements of diffuse pathways from the society including sewage systems were also included. The programme is summarised in Table 12.

Table 12. National sampling strategy for siloxanes

Site	Air	Water	Sediment	Fish	Sludge	Total
<b>Background</b>						
Råö	3					3
Various			3	3		6
<b>Point sources</b>						
Stenungsund (industrial area)	3	3	3	3		12
Chemical production plant, Sundsvall	3	3	3	3		12
<b>Diffuse sources</b>						
STP Henriksdal					1	1
STP Borås					1	1
STP Göteborg					1	1
Stockholm	3					3
<b>Total</b>						<b>39</b>

Additionally 39 samples of human breast milk were analyzed.

### 5.2 Regional

Swedish county administrative boards have had the possibility during the sampling period to add regional samples to the national sampling programme. Different counties have chosen different strategies for their regional sampling scheme. One way of selecting has been to increase the number of samples for substances connected to their environmental programmes i.e. substances that have been regulated or included in the national priority database. Another strategy has been to choose substances where environmental levels are expected to differ from national levels because of intense use within the county i.e. local industrial areas or because of geographic proximity to European industrial areas.

Thirteen regional county administrative boards participated in the regional screening programme with in total 99 additional samples consisting of 10 fish samples, 20 water samples, 17 sediment samples and 52 sludge samples.

## 6 Methods

### 6.1 Sampling

As a guideline for adequate and consistent sampling, a manual for the sampling personnel in the national as well as the regional screening programmes was developed. Detailed instructions for sampling, storing and transport were given. Sampling protocols for all sample types were included in the manual. The overall aim of the sampling protocols was to:

1. Guide the personnel, responsible for sampling on how to avoid contamination of the samples
2. Ensure documentation of the sampling procedure, quality of the sample and environmental and physical circumstances during the sampling.

All samples from the regional county administrative boards were sent to IVL Swedish Environmental Research Institute for analysis.

#### 6.1.1 Air

Air samples were collected by pumping air through two adsorbent tubes in series containing Tenax™. The airflow varied between 50 and 100 ml/min. The sampling duration was 2 hours. An additional unexposed adsorbent tube was used as a field blank.

#### 6.1.2 Water

Water samples were collected with pre-heated (400°C) bottles fitted with aluminium foil lined screw cap and stored in a refrigerator until analysed. A bottle with milli-Q water, which was exposed to the surrounding environment during the sampling time, was used as a field blank.

#### 6.1.3 Sediment

Sediment samples from lakes or sites close to the coast were collected by means of a Kajak sampler. The sediment core was sliced and transferred into pre-heated (400°C) glass jars fitted with aluminium foil lined screw caps and stored in a refrigerator until analysed. A glass jar filled with diatomaceous earth, which was exposed to the surrounding environment during the sampling time, was used as a field blank.

The four marine sampling sites (Ö Gotlandsdjupet, Ö Öland, Norrköpingsdjupet, Ö Landsortsdjupet) were chosen from areas with continuous deposition of fine-grained sediment. These sites were identified with hydroacoustic methods (shallow seismic, sub-bottom profiler and chirp side-scan sonar). Prior to sampling, the bottom at the sampling site was inspected with a submarine video camera. Furthermore, a sediment-core from the site was X-rayed with a sediment-scanner (Cato et al. 2000) in order to detect unwanted physical disturbances as strong bioturbation, anchoring, trawling, etc. Sites, which fulfilled the sedimentological demands set up, were then sampled with a Gemini corer and the cores were sliced in vertical position with a core-cutter onboard. Surface sediments (0-1 cm) from four cores taken at each site were mixed in order to neutralise sediment inhomogenities. The samples collected were stored dark and frozen in pre-cleaned and burned glass bottles.



### 6.1.4 Sludge

The staff at the different treatment plants collected the sludge samples from the anaerobic chambers. The sludge was transferred into pre heated (400°C) glass jars fitted with aluminium foil lined screw caps and stored at 4°C or -18°C until analysed. A glass jar filled with diatomaceous earth, which was exposed to the surrounding environment during the sampling time, was used as a field blank.

### 6.1.5 Fish

Fish were collected by means of fishing net, hoop net or fishing-rod, individually wrapped in aluminium foil and stored in a freezer (-20°C). Later the fish were dissected and muscle samples taken for analysis. Muscle samples from herring from background areas were directly supplied from The Environmental Specimen Bank and the Museum of Natural History (A. Bignert and Colleagues).

### 6.1.6 Breast milk

Human breast milk samples were provided by The University Hospital of Lund (Department of Occupational and Environmental Medicine). The sampling strategy and methodology have been described elsewhere (Appelgren 2005, in prep.).

The samples were primarily collected for analysis of phthalates. They were acidified with phosphoric acid (1 M; 125 µl/ml) immediately after collection. The samples were stored in a freezer (-80°C) and were transported to the IVL laboratory in Stockholm on dry ice. The obtained samples were marked with numbers and carried no personal information or medical history.

## 6.2 Analysis

### 6.2.1 Analysis of sludge, sediment, breast milk and water

The samples were diluted with water and purged with a gas stream passing through an adsorbent from which the analytes were thermally desorbed and analysed by GC-MS.

Approximately 2 g of wet sludge were diluted to 20 ml with MilliQ water and homogenised with a high frequency mixer (Polytron). Approximately 1 ml of the slurry was weighed in to the purge & trap apparatus and diluted to 10 ml. 0.5 ml buffer solution (2M K<sub>2</sub>HPO<sub>4</sub>, 0.4M HCl, 80g Na<sub>2</sub>EDTA 2H<sub>2</sub>O per litre) was added. Sediment was diluted in a similar way, but homogenised by shaking only. Breast milk, 2 ml, was diluted to 5 ml with Milli Q water.

The purge & trap apparatus for sludge, sediment, breast milk and waste water samples consisted of a 25 ml graduated glass test tube with an adapter with one inlet for a Pasteur pipette extending to the bottom of the tube and one side arm to which an empty adsorbent tube was connected using flexible tubing (Viton). This tube acted as a short cooler and water trap. An adsorbent tube containing 0.25 g Tenax TA was connected to the empty tube, the Pasteur pipette was connected to the purge gas (nitrogen, 50 ml/min) and the tube was immersed in a thermostatic water bath. An electric fan facilitated air cooling of the upper part of the apparatus. Samples were purged at 70°C

for 20 min (analysis of MM) and for 2h (all other siloxanes). For low contaminated water samples a gas washing bottle with glas frit gas inlet was used as purge vessel. Water volume was 60 - 80 ml, the other conditions was the same as above.

The adsorbent tube was transferred to a thermal desorber (Unity, Markes) connected to a GC-MS instrument (6890N, 5973N, Agilent). Prepurge time was 2 min, tube desorption time 5 min at 225°C, the trap was held at 3°C and heated at 32°C/s to 250°C. The desorbing flow was 30 ml/min and the split flow 10 ml/min. The flow path temperature was 150 °C and it connected directly to the GC-column, which was a CP-Sil 8CB 30m × 0.25 mm id, film thickness 0.5µm (Varian). The column temperature was 40°C for 3 min, programmed to 200°C at 12°C/min and to 260°C at 30°C/min. The carrier gas was helium held at constant pressure 10 psi measured at 40°C. The mass detector was used in single ion recording mode.

500 mg each of D3, D4, D5, MM, MDM, MD2M, MD3M (Aldrich) and D6 (Gelest) were mixed in a test tube. The chemicals were of 97% declared purity or better. 200 mg of the mixture were dissolved in methanol and diluted to 25 ml. This made a stock solution of 1 mg/ml for each component. This solution was further diluted with methanol. Different amounts of this solution were added to 10 ml MilliQ water and 0.5 ml buffer solution in the purge & trap apparatus and analysed as samples. In this way a seven-point linear calibration curve was constructed and used for quantification of the samples. The blank level and calibration was regularly checked by running water blanks and one or more of the calibration solutions together with the samples.

Table 13. Retention times, quantification and supporting ions used for analysis of siloxanes

	RT, min	Quant. Ion	Supp. ion 1	Supp. Ion 2	Supp ion 3
MM	4.28	147	148		
D3	7.07	207	208		
MDM	8.15	221	73		
D4	10.04	281	282		
MD2M	11.17	207	295	73	
D5	12.41	355	267	73	
RD3M	13.60	281	369	147	73
D6	14.71	341	429	325	

### 6.2.2 Analysis of air samples

The adsorbent tubes were analyzed using the thermal desorber and GC-MS system described above (6.2.1). Calibration was carried out using adsorbent tubes to which a small volume of siloxane standard solution in methanol had been injected while a stream of nitrogen was flowing through the tube.

### 6.2.3 Analysis of fish samples

Different methods for determination of D4 and D5 in biota are described in literature (Flassbeck et al., 2001, Flassbeck et al. 2003, Kala et al. 1998, and Varaprath et al. 2000). However, none of the described methods were using high resolution mass spectrometry for quantification. Due to the ubiquity of the cyclic siloxanes great care was given to reduce the risk for contamination of the samples with siloxanes through direct contact with the lab staff, the equipment used for sample

storage, preparation, and extraction. To avoid evaporation loss of the volatile siloxanes and to reduce the contamination risk, a very short and comprehensive sample preparation and quantification method was developed and validated.

Typically the sample material was thawed and homogenised with a household mixer. A 0.30 g aliquot of the sample was mixed thoroughly with 1 mL n-hexane on a whirl mixer for 5 min. The mixture was separated by centrifugation at 10000 rpm and the clear solution was carefully removed with a Pasteur pipette and transferred without any further treatment into a GC-MS vial. There was no significant difference in the results from sample extracts which were dried with sodium sulfate according to the procedure published by Dow Corning (Varaprath et al., 2000) and the results from undried extracts.

For method testing and calibration a solution was prepared containing D3, D4, D5, D6, MM, MDM, MD2M, and MD3M at concentrations of about 3 ng/ $\mu$ L and about 30 ng/ $\mu$ L in n-hexane.

The sample extracts were analysed on a GC-HRMS system (GC: 6890 Agilent, MS: Micromass Ultra Autospec) using the following parameters: Gas chromatograph: Splitless injection (injector temp: 200°C), Helium as carrier gas (1 mL/min; constant flow), 25m $\times$ 0.2mm $\times$ 0.11 $\mu$ m Agilent Ultra2 capillary; Temperature program: 35°C, 3min, 7°/min, 130°C, 0 min, 30°/min, 325° C, 5 min. Interface temperature: 250 ° C. Mass spectrometer: Ion source temperature: 200° C; Electron impact mode with accelerating voltage 8000 V, Resolution: 10000 at 5 %; Single ion monitoring mode acquiring the following masses (m/z): 147.0661 (MM), 207.0329 (D3), 221.0849 (MDM), 281.0517 (D4), 295.1037 (MD2M), 355.0705 (D5), 369.1225.

Before and after a series of 10 samples including a complete method blank the calibration solution was injected in 2 parallels. Quantification was performed as external standard quantification. Analysis of biota was done by NILU, Norwegian Institute for Air Research, Kjeller, Norge.

## 7 Results and discussion

All individual results are given in Appendix 1, Tables A3, A4 and A5.

### 7.1 National programme

#### 7.1.1 Sludge

Sludge from the three large municipal sewage treatment plants (STPs) in Stockholm, (Henriksdal), Gothenburg (Ryaverken) and Borås (Gässlösa) showed a similar pattern of siloxanes. D5 dominated with concentrations in the range 10 000 to 22 000 ng/g DW. D6 and D4 followed with concentrations close to 3000 and 300 ng/g DW, respectively. The concentrations of the linear analogues were considerably lower: MM and MDM <2 ng/g DW, MD2M 8-16 ng/g DW and MD3M 24-46 ng/g DW.

The concentrations as well as the distribution among the measured siloxanes are illustrated below (Figure 5) where also the concentrations found in sludge samples from the regional programs are given.

#### 7.1.2 Air

The results from analysis of siloxanes in air are presented in Figure 2.

The background samples from Råö, which were all taken in November 2004, showed great variations in the concentrations; it was 6 times higher during the last occasion. The concentrations during this period were higher compared to the samples collected both at point sources and in the urban area. Back trajectories using the HYSPLIT model (NOAA, 2005), which indicate the origin of the air masses, could not explain the observed concentration differences at Råö. Contamination of the sample can not be ruled out. The samples collected close the first point source, Stenungsund show somewhat elevated concentrations compared to two of the background samples as well as to the second point source Stockvik. Concentrations in the urban area (Stockholm) were in the same order of magnitude as the concentrations at the background site and in Stockvik.

The siloxane that occurred in the highest concentration in most of the samples was D4, the most volatile of the measured cyclic siloxanes. The most volatile linear siloxane, MM, was detected in all three samples from Stenungsund and in the last sample from the background site, but not in the other samples.

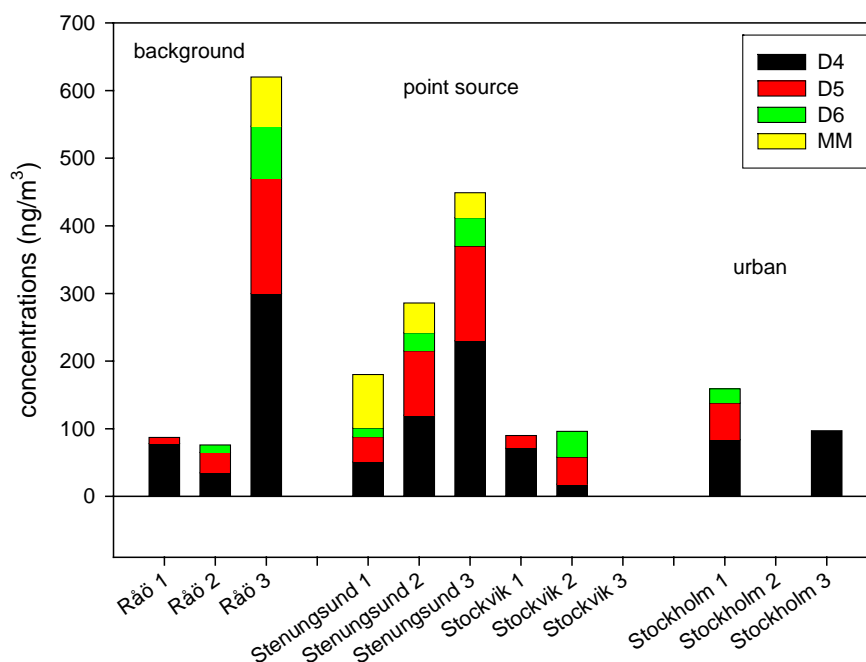


Figure 2. Measured concentrations of siloxanes in air, within the national programme.

### 7.1.3 Fish

No siloxanes were detected in the muscle samples from different species of fish. The obtained limits of detection (LOD) are shown in Table 14.

Table 14. LOD of siloxanes in fish muscle

Siloxane	LOD, ng/g ww
D4	5
D5	5
D6	5
MM	0.4
MDM	0.3
MD2M	0.4
MD3M	0.5

### 7.1.4 Water

Only two of the six water samples from the national sampling programme, which were all collected at the point sources, showed detectable concentrations of siloxanes, and in each case only one single substance was detected. D6 was found in a concentration of 0.04 µg/L in the surface water sample from the industrialised area in Stenungsund and MM was detected (0.0006 µg/L) in outgoing sewage water from the Stockvik industrial site.

### 7.1.5 Sediment

No cyclic siloxanes were detected in any of the sediment samples analysed within the national programme. Linear siloxanes were detected in two samples, from the bay of Sundsvall outside Stockvik industrial area. MD2M was detected in one of the deeper sediments (2-7 cm) in a concentration of 0.9 ng/g dw and MD3M was detected in both deeper sediment samples from this area in concentrations of 1.7 and 0.7 ng/g dw respectively.

### 7.1.6 Breast milk

One or more of the cyclic siloxanes, D4, D5 and D6, was found in 11 out of 49 human breast milk samples. The results are illustrated in Figure 3. The maximum concentration of D4 was 10 µg/l, of D5 4.5 µg/l and of D6 4.8 µg/l. Trace amounts of linear siloxanes were found in 6 of the samples, however all concentrations were below 0.04 µg/l.

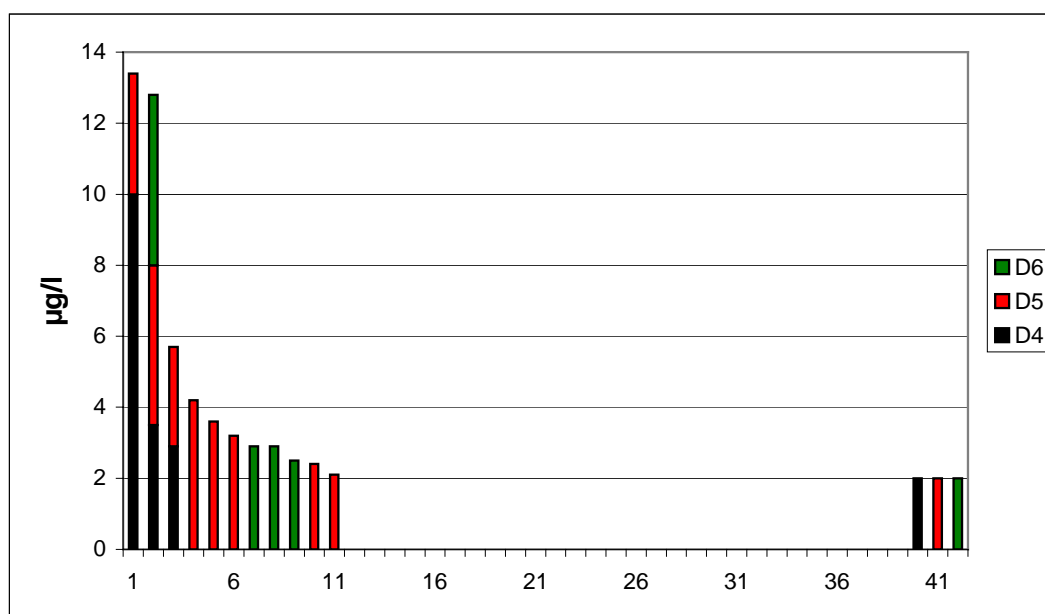


Figure 3. Concentrations of D4, D5 and D6 (µg/l) in breast milk. The samples are sorted in decreasing order of concentration. Results for sample 12-39 are below the quantification limit. The bars to the right illustrate the quantification limits.

## 7.2 Regional programme

### 7.2.1 Sludge

An overview of concentrations of siloxanes in the sludge samples from the regional screening is illustrated in "box plots" in Figure 4. The results from the three STPs in the national programme are also included in the plots. The concentrations in sludge from the different STPs are graphically illustrated in Figure 5.

There was a great variation in the concentrations in the sludges from the different STPs. D5 and D6 were detected in all 52 sludge samples except in one industrial sludge from Olofström. The sample from Fagersta STP, Borlänge, showed the highest concentrations, D5, 54 000 ng/g DW and D6, 8 400 ng/g DW which were substantially higher than in the sludges from the large STPs in Stockholm, Göteborg and Borås.. The lowest concentrations (D5 54 ng/g DW and D6 37 ng/g DW) were found in a sample from Härjedalen, Björnrike STP, that also had the highest dry weight (69% DW) of all the samples. It is possible that siloxanes had been lost in the drying procedure. The sample with next lowest concentrations (Flen STP, D5 570 ng/g DW, D6 170 ng/g DW) was not exceptionally dry (28% DW)

D4 was detected in 34 of the samples. The concentration range was 130 - 2300 ng/g DW. Concentrations of D4 higher than 1000 ng/g DW was found in the samples from Kristianstad, Gnesta, and Lidköping.

The concentrations of the linear analogues were, as in the national programme, substantially lower: MM was found in only three samples with a maximum of 8 ng/g DW, MDM in 12 samples with a maximum of 22 ng/g DW. MD2M was in the range <0.5 to 37 and MD3M <0.5 to 160 ng/g DW.

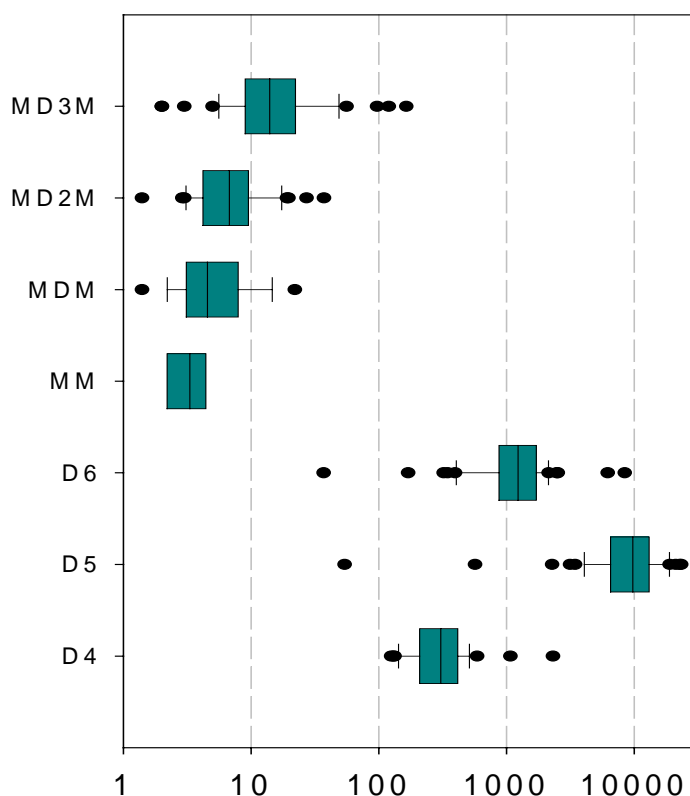


Figure 4. Concentrations of siloxanes (ng/g DW, logarithmic scale) in sludge from all municipal STPs. The lower and upper boundaries of the box represent the 25- and 75-percentiles, the line within the box is the median concentration. The whiskers represent the 10- and 90-percentiles, and the dots are individual results outside this range.

A summary of the siloxane concentrations found in the 54 sludge samples from municipal STPs (national and regional programme) is given in Table 15.

The concentration of D5 found in sludge could be compared to the concentrations of some other widespread organic contaminants without implying any similarities in their effects. In a recent study concerning sludge from 20 Swedish STPs, di-(ethylhexyl)-phthalate (DEHP) averaged to 49 000 and 4-nonylphenol to 9 000 ng/g DW (Bignert and Remberger, 2005). In another study including 23 Swedish STPs the average concentration of 4-nonylphenol was 15 000 ng/g DW (Remberger et al., 2004). Thus, the concentration level of D5 found in the present study is similar to that for 4-nonylphenol and somewhat lower than that for DEHP. Siloxanes may therefore be added to the list of organic pollutants that make it problematic to use municipal sewage sludge in a sustainable way, i.e. as a source of nutrients in agriculture.

Table 15. Summary of siloxane concentrations found in sludge from the 54 municipal STPs in the national and regional programmes.

Siloxane	Detected in number of samples	Median conc. ng/g DW	Average conc. ng/g DW	Maximum conc. ng/g DW
D4	37	310	390	2300
D5	54	9500	11000	54000
D6	54	1300	1500	8400
MM	3	5	5	8
MDM	12	5	7	37
MD2M	46	7	9	37
MD3M	44	15	24	160



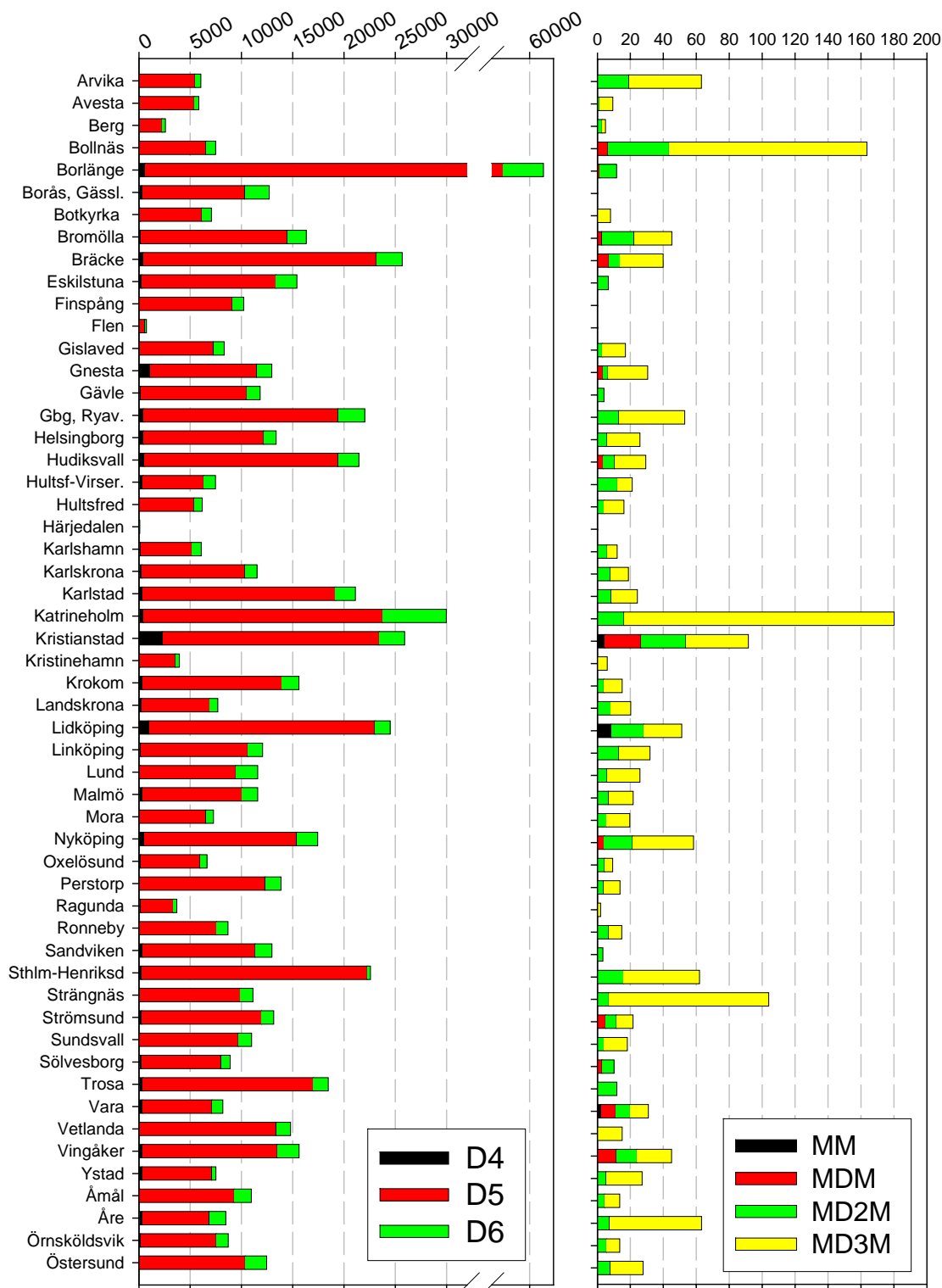


Figure 5. Concentrations of siloxanes in sludge from municipal STPs, ng/g DW. Please note the different concentration scales in the left and right parts of the figure.

## 7.2.2 Water

Four samples of influent water to municipal STPs were included in the regional program. D5 was found in three of the samples in concentrations from 1.1 µg/L (Gislaved) to 0.1 µg/L. The limit of detection was 0.04 µg/L. D6 was like D5 highest in Gislaved (0.27 µg/L) and 0.06-0.08 µg/L in the other influents. In the 12 effluent water samples from municipal STPs D5 was found in one (Gislaved, 0.051 µg/L) and D6 in five. The concentration of D6 was highest in Gislaved (0.23 µg/L) and 0.05-0.08 µg/L in the remaining three effluents. The concentrations of D5 and D6 in the industrial effluent sample from a pulp and paper production plant were 0.059 and 0.15 µg/L respectively. D4 was not found in any of the water samples.

In percolate waters from landfills detectable concentrations of MM (0.058 and 0.0015 µg/L) were found, while no cyclic siloxanes were detected. MM was also found in one effluent from a municipal STP (Arvika STP 0,0098 µg/L. MM was the only linear siloxane detected. in the water samples.

## 7.2.3 Sediment

The siloxanes D5, D6, MD2M and MD3M were found in sediments from Himmerfjärden, Botkyrka in the concentrations 190, 51, 1.2 and 0.44 ng/g DW respectively.

In lake Vänern, D5, D6 and MD3M occurred in sediment from Åsjorden (36, 200, 0.45 ng/g DW respectively) and MD2M (0,3 ng/g DW) in sediment from Kattfjorden.

## 7.2.4 Biota

No siloxanes were detected in biotic samples, which were all muscle samples from different species of fish. The obtained limits of detection (LOD) are shown in Table 14 above.

## 8 Conclusions

D4, which is classified as a phase out substance was found in 37 out of 54 municipal sludge samples in concentrations from 130 to 2 300 ng/g DW and in various air samples in concentrations up to 300 ng/m<sup>3</sup>. D4 was not found in any of the water, sediment or fish samples.

D5 was the dominating siloxane in most samples. It was found in all sludge samples from municipal treatment plants. The average concentration was 11 000 ng/g DW.

MM, which is on the OSPAR candidate list for dangerous substances, was found in leachate water from landfills and in low concentrations in air in the Stenungsund chemical industrial area.

Siloxanes were not found in biota (fish muscle).

## 9 Acknowledgements

Thanks to all staff at the county administrative boards and different municipalities that have contributed to the sampling. Especially thanks to Anders Bignert, NRM, and staff at potential point source industry for contributing samples to the national programme. The study was financed by Environmental Monitoring at Swedish Environmental Protection Agency.

## 10 References

- Andersson, J. 2004. Teoretisk förstudie till screening av miljögifter i Skåne 2004. M Sc. Thesis. Department of Ecology, University of Lund. *In Swedish*
- Appelgren, M., Bensryd, I., Berglund, M., Calafat, A., Falk Filipsson, A., Hanberg, A., Håkansson, H., Högberg, J., Jansson, B., Remberger, M., Skerfving, S. (2005) Phthalates and their metabolites in human breast milk, blood and urine as measures for monitoring exposure in human risk groups. Institute of Environmental Medicine, Karolinska Institutet, Box 210, SE-171 77 Stockholm, Sweden
- Bignert, A., Remberger, M. (2005). Utvärdering av analyser av ämnen prioriterade inom vattendirektivet och direktiv 76/464/EEG i miljöprover. Preliminär sakrapport Naturhistoriska Riksmuseet.
- Cato, I., Rindby, A., Rudolfsson, J., 2000: Unik sedimentscanner utvecklad. Geologiskt forum 25, 13-15. *In Swedish*
- Flassbeck, D., Pfeleiderer, B., Grumping, R., Hirner, A.V., 2001 Determination of low molecular weight silicones in plasma and blood of women after exposure to silicone breast implants by GC/MS, Analytical Chemistry 73, pp. 606-611.
- Flassbeck, D., Pfeleiderer, B., Klemens, P., Heumann, K.G., Eltze, E., Hirner, A.V., 2003. Determination of siloxanes, silicon, and platinum in tissues of women with silicone gel-filled implants, Analytical and Bioanalytical Chemistry 375, pp. 356-362.
- Hurd, C. B. 1946. Siloxanes. 1. The specific volume and viscosity in relation to temperature and constitution. J Am Chem Soc 68:364.
- Durham, J. .2004. Non –Regulated Study: Method development and preliminary assessment of the hydrolysis kinetics of Octamethylcyclotetrasiloxane (D4) according to the principles of OECD. Dow Corning Corporation. Health & Environmental Sciences. Final Report HES Study no: 9931-102
- HSDB 2004. Hazardous Substance Data Base. U.S. National Library of Medicine <http://www.toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB> .2004-02-10 till 2004-04-20
- Kala, S.V., Lykissa, E.D., Neely M. W., Lieberman, M.W. 1998. American journal of pathology, 152(3) 645-649.
- KemI.2004.Klassificeringslistan.<http://www.kemi.se/Kemi/Kategorier/Databaser/Klassificeringslistan/amne.cfm?id=602-077-00-1>. 2004-02-12 till 2004-04-20
- Loh, C., Johansson, V., Ivarsson, P. 2003. Utredning av ämnen inför screening 2004. EnviroPlanning Rapport 1003-01/10/01/rap001. In Swedish

Mackay, D., Di Guardo, A., Paterson, S.; Cowan, C.E. 1996. Evaluating the environmental fate of a variety of types of chemicals using the EQC model. Environ. Toxicol. Chem. Vol. 15 pp 1627-1637

Mackay, D. 2001. Multimedia Environmental Models: The Fugacity Approach, CRC Boca Raton, FL, USA

Meylan, W. 1999. EPIWIN x3.04 [computer program: US EPA Version for Windows], Syracuse Research Corporation, Syracuse, NY, US.  
<http://www.epa.gov/oppt/exposure/docs/episuitd1.htm> (June 13, 2005)

Paxéus, N. 2000. Organic Compounds in Municipal Landfill Leachates. Water Science and Technology 42: 323-333.

Remberger, M., Kaj, L., Palm, A., Sternbeck, J., Kvernes, E., Brorström-Lundén, E., (2004) Screening tertiary butylphenols, methylphenols, and long-chain alkylphenols in the Swedish environment IVL Rapport B1594

NOAA (2005) The NOAA ARL HYSPLIT model.  
<http://www.arl.noaa.gov/ready/hysplit4.html>

OSPAR. 2005. OSPAR List of Chemicals for Priority Action - Replaced OSPAR Annex 2 from June 2002, [www.ospar.org](http://www.ospar.org), March, 2005.

Schmidbauer, Norbert , 2005, NILU (Norwegian Institute for Air Research). Personal communication.

Schweigkopfler, M. and Niessner, R.1999. Determination of Siloxanes and VOC In Landfill Gas and Sewage Gas by Canister Sampling and GC-MS/AES Analysis. Environ. Science and Technology. 1999 33:3680-3685.

SPIN, 2005. Substances for Preparation in Nordic Countries. Chemical Substance Database. Available at: <http://www.spin2000.net/spin.html> Aug, 2005

SRC, 2005. Syracuse Research Corporation's Interactive PhysProp Database Demo. Available at <http://www.syrres.com/esc/physdemo.htm>, 30 June, 2005

UNEP. 2005. Stockholm Convention on Persistent Organic Pollutants (POPs)  
<http://www.pops.int/>

US EPA. 2003. Siloxane D5 in Drycleaning Applications.Fact Sheet  
Can be found at: <http://www.epa.gov/dfe/pubs/garment/d5fs.pdf>

Varaprath, S., Seaton, M., McNett, D., Cao, L., Plotzke, K.P., 2000. Quantitative determination of octamethylcyclotetrasiloxane (D-4) in extracts of biological matrices by gas chromatography-mass spectrometry, International Journal of Environmental Analytical Chemistry 77, pp. 203-219.

Appendix 1. Sample description and results

Table A 1 Sample list for national screening of siloxanes. DW = dry weight (sediment, sludge). LW = lipid weight (biota)

Category	Sample ID	City	Site	Matrix Notes	Sampling date	X RT90	Y RT90	DW/LW(%)
Back-ground			Råö	Air	2004-11-16			-
			Råö	Air	2004-11-23			-
			Råö	Air	2004-11-30			-
	MR-3750		Ö Gotlandsdjupet	Sed	0-2 cm, 121 m depth, SGU 04-0058	6216805	1697299	9.5
	MR-3751		Ö Öland	Sed	0-2 cm, 77m depth SGU 04-0368	6277308	1607374	8.3
	MR-3752		Norrköpingsdjupet	Sed	0-2 cm , 179m depth SGU 071-001	6435399	1625504	6.6
	MR-3639		V.Fladen	biota	herring	57° 04' 47"	15 °55' 18"	1.7
	MR-3640		Ångskärsklubb	biota	baltic herring	65°43'	23°*03'	2.3
	MR-3641		Landsort	biota	baltic herring	57° 12' 27"	11°39' 53"	4.5
Potential point sources		Stenungsund		Air	2004-11-08			-
		Stenungsund		Air	2004-11-09			-
		Stenungsund		Air	2004-12-08			-
	MR-3872		Stenungsund	Sed	A1	6446247	1264535	27.2
	MR-3874		Stenungsund	Sed	D7	6446760	1264051	31.1
	MR-3876		Stenungsund	Sed	E1	6446077	1253472	27.2
	MR-3878		Stenungsund	water	A1	6446247	1264535	-
	MR-3880		Stenungsund	water	D7	6446760	1264051	-
	MR-3882		Stenungsund	water	E1	6446077	1253472	-
	MR-4053		Stenungsund	biota	Eelpout, females			-
	MR-4054		Stenungsund	biota	Eelpout, males			-
	MR-4055		Stenungsund	biota	Eelpout, juveniles			-
	MR-4050		Sundsvall bay	biota	baltic herring			-
MR-4051		Sundsvall bay	biota	herring			-	
MR-4052		Sundsvall bay	biota	salmon			-	

Table A 1. Cont.

Category	Sample ID	City	Site	Matrix	Notes	Sampling date	X RT90	Y RT90	DW/LW(%)
Potential point sources			Stockvik	Air		2004-11-04		-	
			Stockvik	Air		2005-01-26		-	
			Stockvik	Air				-	
	MR-3600	Sundsvall	Bay outside Stockvik 1	Sed	0-2 cm	6918274	1581483	41.3	
	MR-3601	Sundsvall	Bay outside Stockvik 1	Sed	2-7 cm	6918274	1581483	43.6	
	MR-3603	Sundsvall	Bay outside Stockvik 2	Sed	0-2 cm	6915504	1581340	44.0	
	MR-3604	Sundsvall	Bay outside Stockvik 2	Sed	2-7 cm	6915504	1581340	30.4	
	MR-3612	Sundsvall	Akzo-Nobel Stockv. Expancel TP	water	effluent	2004-10-22		-	
	MR-3613	Sundsvall	Akzo-Nobel Stockvik	water	water from well on factory area	2004-10-22		-	
	MR-3610	Sundsvall	Bay outside Stockvik	water	recipient	2004-10-21	1581178		
Diffuse sources		Stockholm	Hudiksvallsgratan 2	Air		2004-11-18		-	
		Stockholm	Hudiksvallsgratan 2	Air		2004-12-02		-	
		Stockholm	Hudiksvallsgratan 2	Air		2004-12-03		-	
	MR-3760	Stockholm	Henriksdal STP	sludge	700.000 pe, mech, chem, bio cleaning. No major industrial impact	2004-11-16		28.6	
	MR-3790	Borås	Gässlösa STP	sludge	p.e 98250, mec, chem and bio cleaning, textile-, graphic- industries, slaughterhouse, laundry, finishing activities, landfill leachate, incineration	2004-11-24		22.4	
	MR-3867	Gothenburg	Ryaverket STP	sludge	p.e 620 683, mech, chem, bio cleaning, incineration, industrial and municipal	2004-12-15		28.8	

Table A 2 Sample list for regional screening of siloxanes. DW = dry weight (sediment, sludge). LW = lipid weight (biota)

County	Sample ID	City	Site	Site information	Matrix	Notes	pe (STP)	Treatment (STP)	Sampling date	DW/LW (%)	
Blekinge	MR-3462	Karlshamn	Mörrom landfill		water	leachate			2004-09-23	-	
	MR-3468	Karlshamn	Mörrom STP		sludge		3900	active sludge, chem, mech	2004-09-28	26.1	
	MR-3537	Karlskrona	Koholmen STP		sludge		40000	bio,chem post susp.mech.	2004-10-07	14.7	
	MR-3529	Olofström	Volvo personvagnar		sludge				2004-10-06	28.3	
	MR-3533	Ronneby	Angelskog landfill		water	leachate			2004-10-06	-	
	MR-3538	Ronneby	Angelskog landfill		water	background				-	
	MR-3531	Ronneby	Ronneby STP		sludge		15000	bio, chem,mech.	2004-10-06	15.4	
	MR-3487	Sölvesborg	Sölvesborg STP		sludge		10300	active sludge with N-elimination	2004-09-29	18.8	
	MR-3498	Avesta	Bäringen		sediment	lake			2004-10-04	21.4	
	MR-3501	Avesta	Bäringen		fish				2004-09-29	-	
Dalarna	MR-3478	Avesta	Krylbo		sludge	digested	17000	suspension, active sludge	2004-09-29	24	
	MR-3540	Borlänge	Fagersta		sludge	digested	44000	suspension, active sludge	2004-10-12	29	
	MR-3535	Mora	Venjan STP		sludge	digested	500	mech, chem	2004-10-06	0.7	
	MR-3496	Mora	Venjansjön		sediment	lake			2004-10-03	5.19	
	MR-3500	Mora	Venjansjön		fish				2004-10-01	-	
	MR-3584	Bollnäs	Bollnäs STP		sludge				2004-10-20	14.6	
	MR-3549	Gävle	Duvbacken STP		sludge				2004-10-12	19.9	
	MR-3846	Hudiksvall	Resselvans STP		sludge				2004-12-07	26.6	
	MR-3555	Sandviken	Sandviken STP		sludge				2004-10-13	22.0	
	MR-3687	Berg	Myrviken STP	Mun.	sludge	Primary		mech, dehydration, compost	2004-11-01	19.2	
Gävleborg	MR-3619	Bräcke	Bräcke STP	Mun., ind.	sludge	Primary	1800	mech, bio	2004-10-19	10.5	
	MR-3470	Härjedalen	Björnsrike STP	Mun. ( sample taken during tourist season not according to sampling instructions)	sludge	Primary	2325	mech, chem	2004-06-21	76.7	
	MR-3574	Krokoms	Hissmofors STP	Mun., ind.	sludge	Primary	3600	mech, chem, bio	2004-10-19	13.4	
	MR-3586	Ragunda	Överammer STP	Mun.	sludge	Primary		Dehydration	2004-10-19	28.8	
	MR-3625	Strömsund	Strömsund STP	Mun., ind.	sludge	Primary	7000	mech,chem,bio	2004-10-27	17.6	
	MR-3469	Åre	Åre STP	Mun. (sample taken during tourist season not according to sampling instructions)	sludge	Primary	16000	mech, chem, bio	2004-04-13	18	
	MR-3472	Östersund	Gövikens STP	Mun., ind. (Dairy)	sludge	digested	55900	mech, chem, bio	2004-09-29	27.3	



Table A 2. Cont

County	Sample ID	City	Site	Site information	Matrix	Notes	Specie (STP)	Treatment (STP)	Sampling date	DW/LW (%)
Jönköping	MR- 3733	Gislaved	Gislaveds STP		sludge					16.5
	MR- 3735	Gislaved	Gislaveds STP		water	effluent				-
	MR-3731	Gislaved	Gislaveds STP		water	influent				-
	MR- 3803	Vetlanda	Gröpplebacken		sediment				2004-11-24	22.8
	MR- 3802	Vetlanda	Landsbro STP		sludge				2004-11-24	3.87
	MR- 3807	Vetlanda	Landsbro STP		water	influent			2004-11-24	-
	MR-3808	Vetlanda	Landsbro STP		water	effluent			2004-11-24	-
	MR-3800	Hultsfred	Hulingen		sediment				2004-11-24	34.4
Kalmar	MR-3799	Hultsfred	Hultsfred STP		sludge				2004-11-24	18.8
	MR-3809	Hultsfred	Hultsfred STP		water	Effluent			2004-11-24	-
	MR-3810	Hultsfred	Hultsfred STP		water	Influent			2004-11-24	-
	MR-3798	Hultsfred	Virserum		sediment	Recipient			2004-11-24	58.5
	MR- 3805	Hultsfred	Virserum STP		water	Effluent			2004-11-24	-
	MR-3797	Hultsfred	Virserum STP		sludge				2004-11-24	14.5
	MR-3804	Hultsfred	Virserum STP		water	Influent			2004-11-24	-
	MR-3627	Oskarshamn	Mouth of Emån		sediment	Recipient			2004-10-27	22.7
	MR-3466	Bromölla	Bromölla STP		sludge				2004-09-28	25.7
	MR-3679	Bromölla	Ivösjön		sediment				2004-10-19	6.68
Skåne	MR-3682	Bromölla	Ivösjön		fish	Perch			2004-10-19	1.1
	MR-3459	Helsingborg	Helsingborg STP		sludge				2004-09-22	25
	MR-3706	Helsingborg	Coast	55 59 110-12 44 265	sediment				2004-11-03	43.4
	MR-3708	Helsingborg	Coast	55 58 915-12 44 313	fish	Flounder			2004-10-15	1.1
	MR-3677	Kristianstad	Hammarsjön		sediment				2004-10-19	14.2
	MR-3681	Kristianstad	Hammarsjön		fish	Flounder			2004-10-19	1
	MR-3514	Kristianstad	Kristianstad STP	Possible siloxane contamination from STP	sludge				2004-10-05	18.2
	MR-3489	Landskrona	Lundåkraverket	d.o	sludge				2004-09-29	22
	MR-3464	Lund	Källby STP		sludge	Thermophilic incineration			2004-09-27	26.1
	MR-3456	Malmö	Sjölunda STP		sludge				2004-09-22	23.8
	MR-3623	Perstorp	Perstorp STP		sludge				2004-10-26	18.7

Table A 2. Cont

County	Sample ID	City	Site	Site information	Matrix	Notes	pe (STP)	Treatment (STP)	Sampling date	DW/LW (%)
Skåne	MR-3670	Perstorp	Storarydsdammen		sediment				2004-10-22	9.66
	MR-3672	Perstorp	Storarydsdammen		fish	Perch			2004-10-22	1.1
	MR-3453	Ystad	Ystad STP		slam				2004-09-22	15.8
	MR-3480	Botkyrka	Himmerfjärdsverket		water	Effluent				-
	MR-3482	Botkyrka	Himmerfjärdsverket		sludge	Mixed sample (3 days)			2004-09-28 till 2004-10-09-30	23.3
Stockholm	MR-3449	Botkyrka	Himmerfjärden	X: 654978 Y: 161021	sediment				2004-09-01	24.4
	MR-3450	Botkyrka	Himmerfjärden		fish	Perch			2004-09-01	-
	MR-3448	Södertälje	St Envättern	X: 655613 Y: 158793	sediment				2004-09-01	3.75
	MR-3451	Södertälje	St Envättern		fish	Perch			2004-07-22	-
	MR-3551	Flen	Flen STP	GB	sludge	Primary	10200	mech, chem,biol	2004-10-11	27.8
Södermanland	MR-3576	Gnesta	Gnesta STP	Chem., technical ind.	sludge	Digested	5200	mech, chem	2004-10-19	18
	MR-3568	Eskestuna	Eskestuna STP	Stormwater (possibly containing siloxanes), car repair shops	sludge	Digested	54763	mech,chem,bio, Wetland	2004-10-18	20.5
	MR-3578	Katrineholm	Katrineholm STP	printing ind., concrete ind., chicken slaughterhouse	sludge	Primary	32000	mech, chem,bio	2004-10-20	17.2
	MR-3570	Nyköping	Nyköping STP		sludge	Mesophilic incineration	44500	mech, chem, bio		24.4
	MR-3637	Oxelösund	Oxelösund STP	SSAB, harbour, mechanical ind. (no process water)	sludge	Digested	12000	mech, wetland	2004-10-27	23
Värmland	MR-3572	Strängnäs	Strängnäs STP	Mun.	sludge	Primary	25000	mech, chem,bio		15.8
	MR-3553	Trosa	Vagnhärad STP	Mun., chemical, technical ind.	sludge	Digested	4100	mech, chem, wetland	2004-10-13	27.3
	MR-3557	Vingåker	Vingåker STP		sludge	Digested	7000	mech, chem,bio, wetland	2004-10-13	19.5
	MR-3709	Arvika	Vik STP	Mun., varying ind.	sludge	Digested	19500	mech, chem, bio	2004-11-02	14.5
	MR-3711	Arvika	Vik STP	d.o	water	Effluent	19500	mech, chem, bio	2004-11-02	-
Värmland	MR-3502	Grums	Vänern, Äsfjorden	Pulp and paper ind., viscous manufacturing	sediment				2004-09-30	18.9
	MR-3506	Grums	Vänern, Äsfjorden	d.o	fish	Perch			2004-09-30	-
	MR-3507	Hammarö	Vänern, Kattfjorden	pulp and paper ind., chlorine/alkali and pesticide ind.	fish	Perch			2004-09-30	-
	MR-3504	Hammarö	Vänern, Kattfjorden	d.o	sediment				2004-09-30	13.1
	MR-3580	Karlstad	Skåre STP	Mun., varying ind.	water	Effluent	4005	mech, chem, bio	2004-10-19	-
	MR-3582	Karlstad	Skåre STP	d.o	sludge	Primary	4005	mech, chem, bio	2004-10-19	14.5
	MR-3629	Kristinehamn	Fiskartorpet STP	Mun.	sludge	Digested	16109	mech, chem, bio	2004-10-26/28	29.9
	MR-3631	Kristinehamn	Fiskartorpet STP	d.o	water	Effluent	16109	mech, chem, bio		

Table A 2. Cont

County	Sample ID	City	Site	Site information	Matrix	Notes	pe (STP)	Treatment (STP)	Sampling date	DW/LW (%)
Väster-norrland	MR-3754	Sundsvall	Tivoliverket		sludge					19
	MR-3615	Timrå	SCA Östrand		sediment					24.0
	MR-3756	Timrå	SCA Östrand		water					-
	MR-3726	Örnsköldsvik	Bodum STP		sludge				2004-11-10	31
	MR-3508	Lidköping	Lidköping STP	Mun.	water	Effluent	28000		?	-
Västra Götaland	MR-3510	Lidköping	Lidköping STP	d.o	sludge	Primary	28000		?	19.5
	MR-3512	Vara	Vara STP	Mun., laundry	sludge	Digested	6360	mech,chem,biol	2004-10-04	19
	MR-3474	Åmål	Åmål STP	municipal., car treatment plants, work shops	water	Effluent	10000	mech, chem	2004-09-29	-
	MR-3476	Åmål	Åmål STP	d.o	sludge		10000	mech, chem	2004-09-29	20.2
	MR-3633	Finspång	Finspångs STP		sludge				2004-10-26	5.4
Öster-götaland	MR-3635	Finspång	Finspångs STP		water				2004-10-27	-
	MR-3683	Finspång	Skuten		sediment				2004-10-29	7.65
	MR-3728	Linköping	Linköping STP		water				2004-11-09	-
	MR-3729	Linköping	Linköping STP		sludge				2004-11-09	27.6
	MR-3685	Linköping	Roxen		sediment				2004-10-21	12.7

Table A 3. Results from the national programme. Sum D = D4+D5+D6. Sum M= MM+MDM+ MD2M+MD3M. Values below the detection limit are not included in the sum.

Category	Sample ID	Site	Matrix	Unit	D4	D5	D6	MM	MDM	MD2M	MD3M	Sum D	Sum M
		Råö	Air	ng/m <sup>3</sup>	78	9	<12	<20	<5	<5	<5	87	-
		Råö	Air	ng/m <sup>3</sup>	35	30	11	<26	<5	<5	<5	76	-
		Råö	Air	ng/m <sup>3</sup>	300	170	77	73	<6	<6	<6	547	73
	MR-3750	Ö Gotlandsdjupet	Sediment	ng/g dw	<22	<6	<3	<1	<1	<1	<1	-	-
<b>Background</b>	MR-3751	Ö Öland	Sediment	ng/g dw	<44	<11	<6	<1	<1	<1	<1	-	-
	MR-3752	Norrköpingsdjupet	Sediment	ng/g dw	<14	<4	<2	<1	<1	<1	<1	-	-
	MR-3639	V. Fladen	Biota	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-
	MR-3640	Ångsskärsklubb	Biota	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-
	MR-3641	Landsort	Biota	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-
<b>Potential point sources</b>		Stenungsund	Air	ng/m <sup>3</sup>	51	37	13	79	<5	<5	<5	101	79
		Stenungsund	Air	ng/m <sup>3</sup>	120	95	27	44	<5	<5	<5	242	44
		Stenungsund	Air	ng/m <sup>3</sup>	230	140	42	37	<6	<6	<6	412	37
	MR-3872	Stenungsund	Sediment	ng/g dw	<9	<7	<6	<0.1	<0.1	<0.1	<0.1	-	-
	MR-3874	Stenungsund	Sediment	ng/g dw	<14	<7	<6	<0.2	<0.2	<0.2	<0.2	-	-
	MR-3876	Stenungsund	Sediment	ng/g dw	<18	<9	<7	<0.2	<0.2	<0.2	<0.2	-	-
	MR-3878	Stenungsund	Water	µg/L	<0.06	<0.03	0.038	<0.0005	<0.0005	<0.0005	<0.0005	0.038	-
	MR-3880	Stenungsund	Water	µg/L	<0.06	<0.03	<0.03	<0.0005	<0.0005	<0.0005	<0.0005	-	-
	MR-3882	Stenungsund	Water	µg/L	<0.06	<0.03	<0.03	<0.0005	<0.0005	<0.0005	<0.0005	-	-
	MR-4053	Stenungsund	Biota	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-
	MR-4054	Stenungsund	Biota	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-
	MR-4055	Stenungsund	Biota	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-
	MR-4050	Sundsvallsbukten	Biota	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-
	MR-4051	Sundsvallsbukten	Biota	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-
	MR-4052	Sundsvallsbukten	Biota	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-

Table A 3. Cont

Category	Sample ID	Site	Matrix	Unit	D4	D5	D6	MM	MDM	MD2M	MD3M	Sum D	Sum M
Potential point sources		Stockvik	Air	ng/m <sup>3</sup>	71	19	<12	<19	<3	<3	<3	90	-
		Stockvik	Air	ng/m <sup>3</sup>	18	40	38	<19	<3	<3	<3	96	-
	MR-3600	Bay outside Stockvik 1	Sediment	ng/g dw	<11	<6	<5	<0.2	<0.2	<0.2	<0.2	-	-
	MR-3601	Bay outside Stockvik 1	Sediment	ng/g dw	<22	<11	<10	<0.3	<0.3	0.9	1.7	-	2.6
	MR-3603	Bay outside Stockvik 2	Sediment	ng/g dw	<11	<6	<5	<0.2	<0.2	<0.2	<0.3	-	-
	MR-3604	Bay outside Stockvik 2	Sediment	ng/g dw	<12	<6	<6	<0.2	<0.2	<0.2	0.7	-	-
	MR-3612	Akzo-Nobel Stockv. STP	Water	µg/L	<0.06	<0.03	<0.06	0.00063	<0.0005	<0.0005	<0.0005	-	0.0006
	MR-3613	Akzo-Nobel Stockvik	Water	µg/L	<0.06	<0.03	<0.06	<0.0005	<0.0005	<0.0005	<0.0005	-	-
	MR-3610	Bay outside Stockvik	Water	µg/L	<0.06	<0.03	<0.06	<0.0005	<0.0005	<0.0005	<0.0005	-	-
	Diffuse sources		Hudiksvallsgatan 2	Air	ng/m <sup>3</sup>	84	54	21	<19	<3	<3	<3	160
		Hudiksvallsgatan 2	Air	ng/m <sup>3</sup>	<23	<13	<12	<26	<3	<3	<3	-	-
		Hudiksvallsgatan 2	Air	ng/m <sup>3</sup>	97	<13	<12	<26	<3	<3	<3	97	-
MR-3760		Henriksdal STP	Sludge	ng/g DW	280	22000	3100	<2	<2	16	46	25000	62
MR-3790		Gässlösa STP	Sludge	ng/g DW	310	10000	2400	<2	<2	8	24	13000	32
MR-3867		Ryaverket STP	Sludge	ng/g DW	430	19000	2600	<2	<2	13	40	22000	53

**Table A 4 Results from regional screening of siloxanes.** Sum D = D4+D5+D6. Sum M= MM+MDM+ MD2M+MD3M. Values below the detection limit are not included in the sum.

County	Sample ID	Site	Matrix	Unit	D4	D5	D6	MM	MDM	MD2M	MD3M	Sum D	Sum M
Blekinge	MR-3468	Karishamn STP	Sludge	ng/g DW	150	5000	900	<0.5	<0.5	6.0	6	6100	12
	MR-3462	Mörrum landfill	Water	µg/L	<0.07	<0.04	<0.04	0.0015	<0.0005	<0.0005	<0.0005	-	0.0015
	MR-3537	Kariskrona STP	Sludge	ng/g DW	300	10000	1200	<0.5	<0.5	7.8	11	12000	19
	MR-3529	Volvo cars STP	Sludge	ng/g DW	<120	<28	<16	<0.5	<0.5	<0.5	3	-	3
	MR-3533	Angelskogs landfill	Water	µg/L	<0.07	<0.04	<0.04	0.058	0.00085	<0.0005	<0.0005	-	0.059
Dalarna	MR-3538	Angelskogs landfill, water Angleån	Water	µg/L	<0.07	<0.04	0.076	<0.0005	<0.0005	<0.0005	<0.0005	0.08	-
	MR-3531	Ronneby STP	Sludge	ng/g DW	<250	7600	1100	<0.5	<0.5	6.8	8	8700	15
	MR-3487	Sölvesborg STP	Sludge	ng/g DW	230	7800	930	<1	2.8	7.3	<4	8900	10
	MR-3498	Lake Bäsingen	Sediment	ng/g dw	<19	<9.3	<7.2	<0.2	<0.2	<0.2	<0.2	-	-
	MR-3501	Lake Bäsingen	Fish	ng/g WW	<5	<5	<5					-	-
Gävleborg	MR-3478	Krylbo STP	Sludge	ng/g DW	130	5300	430	<1	<1	1.4	8	5800	10
	MR-3540	Fagersta STP	Sludge	ng/g DW	590	54000	8400	<0.5	1.4	10	<3	63000	12
	MR-3535	Venjan STP	Sludge	ng/g DW	<470	6500	740	<0.5	<0.5	5.7	14	7300	20
	MR-3496	Lake Venjan	Sediment	ng/g dw	<47	<23	<18	<0.48	<0.48	<0.48	<0.48	-	-
	MR-3500	Lake Venjan	Fish	ng/g WW	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-
Jämtland	MR-3584	Bollnäs STP	Sludge	ng/g DW	<280	6500	950	<0.5	6.4	37	120	7500	163
	MR-3549	Duvbacken STP	Sludge	ng/g DW	200	10000	1300	<0.5	<0.5	4.0	<4	12000	4
	MR-3846	Resselvans STP	Sludge	ng/g DW	490	19000	2000	<0.5	3.51	6.9	19	21000	29
	MR-3555	Sandviken STP	Sludge	ng/g DW	350	11000	1600	<2	<0.5	3.3	<4	13000	3
	MR-3687	Myrviken STP	Sludge	ng/g DW	<150	2300	320	<0.5	<0.5	2.9	2	2600	5
Gävleborg	MR-3619	Bräcke STP	Sludge	ng/g DW	430	23000	2500	<0.5	6.9	7.0	26	26000	40
	MR-3470	Björnsrike STP	Sludge	ng/g DW	<78	54	37	<0.5	<0.5	<0.5	<0.5	91	<2
	MR-3574	Hissmofors STP	Sludge	ng/g DW	370	14000	1700	<0.5	<0.5	4.0	11	16000	15
	MR-3586	Ragunda STP	Sludge	ng/g DW	210	3100	350	<0.5	<0.5	<0.5	2	3700	2
	MR-3625	Strömsund STP	Sludge	ng/g DW	260	12000	1200	<0.5	5.0	6.6	10	13000	21
Gävleborg	MR-3469	Åre STP	Sludge	ng/g DW	310	6500	1600	<0.5	<0.5	7.2	56	8500	63
	MR-3472	Östersund STP	Sludge	ng/g DW	<140	10000	2100	<0.5	<0.5	7.7	20	12000	27

Table A 4. Cont

County	Sample ID	Site	Matrix	Unit	D4	D5	D6	MM	MDM	MD2M	MD3M	Sum D	Sum M	
Jönköping	MR-3733	Gislavads STP	Sludge	ng/g DW	<270	7200	1100	<0.5	<0.5	3.0	14	8300	17	
	MR-3735	Gislavads STP	Water	µg/L	<0.07	1.1	0.27	<0.0005	<0.0005	<0.0005	<0.0005	1.37	-	
	MR-3731	Gislavads STP	Water	µg/L	<0.07	0.051	0.23	<0.0005	<0.0005	<0.0005	<0.0005	0.28	-	
	MR-3803	Gröpplebacken	Sediment	ng/g DW	<16	17.2	<6.1	<0.16	<0.16	<0.16	<0.16	17.2	-	
	MR-3802	Landsbro STP	Sludge	ng/g DW	<680	13000	1400	<0.5	<0.5	<0.6	15	15000	15	
	MR-3807	Landsbro STP	Water	µg/L	<0.06	<0.03	0.055	<0.0005	<0.0005	<0.0005	<0.0005	0.055	-	
	MR-3808	Landsbro STP	Water	µg/L	<0.06	<0.03	0.046	<0.0005	<0.0005	<0.0005	<0.0005	0.046	-	
	MR-3800	Hulingen	Sediment	ng/g DW	<44	<22	<17	<0.5	<0.5	<0.5	<0.5	-	-	
Kalmar	MR-3799	Hultsfred STP	Sludge	ng/g DW	<210	5400	790	<0.5	<0.5	4.1	12	6200	16	
	MR-3809	Hultsfred STP	Water	µg/L	<0.07	<0.04	<0.04	<0.0005	<0.0005	<0.0005	<0.0005	-	-	
	MR-3810	Hultsfred STP	Water	µg/L	<0.08	0.21	0.069	<0.0005	<0.0005	<0.0005	<0.0005	0.28	-	
	MR-3798	Virserum	Sediment	ng/g dw	<6.9	<3.4	<2.6	<0.1	<0.1	<0.1	<0.1	-	-	
	MR-3805	Virserum STP	Water	µg/L	<0.06	<0.04	<0.04	<0.0005	<0.0005	<0.0005	<0.0005	-	-	
	MR-3797	Virserum STP	Sludge	ng/g dw	380	5900	1200	<0.5	<0.5	12	9	7500	21	
	MR-3804	Virserum STP	Water	µg/L	<0.08	0.099	0.076	<0.0005	<0.0005	<0.0005	<0.0005	0.18	-	
	MR-3627	Mouth of Emån	Sediment	ng/g dw	<12	<6	<5	<0.1	<0.1	<0.1	<0.1	<0.1	-	-
	MR-3466	Bromölla STP	Sludge	ng/g dw	190	14000	1900	<1	2.6	20	23	16000	45	
	MR-3679	Ivösjön	Sediment	ng/g dw	<60	<29	<23	<0.6	<0.6	<0.6	<0.6	-	-	
Skåne	MR-3682	Ivösjön	Fish	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-	
	MR-3459/60	Öresunds STP	Sludge	ng/g dw	450	12000	1200	<1	<1	5.8	20	13000	26	
	MR-3706	Helsingborg	Sediment	ng/g dw	<16	<8	<6	<0.2	<0.2	<0.2	<0.2	-	-	
	MR-3708	Helsingborg	Fish	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-	
	MR-3677	Hammarsjön	Sediment	ng/g dw	<20	<10	<8	<0.2	<0.2	<0.2	<0.2	-	-	
	MR-3681	Hammarsjön	Fish	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-	
	MR-3514	Kristianstad STP	Sludge	ng/g dw	2300	21000	2500	5	22	27	38	26000	92	
	MR-3489	Lundåkrav. STP	Sludge	ng/g dw	270	6700	770	<1	<1	8.2	12	7700	20	
	MR-3464	Källby STP	Sludge	ng/g dw	130	9300	2100	<1	<1	5.8	20	12000	26	
	MR-3456/57	Sjölunda STP	Sludge	ng/g dw	300	9800	1500	<1	<1	6.7	15	12000	21	
MR-3623	Perstorp STP	Sludge	ng/g dw	<220	12000	1600	<0.5	<0.02	3.7	10	14000	14		
MR-3670	Storarydsdammen	Sediment	ng/g dw	<28	<14	<10	<0.3	<0.3	<0.3	<0.3	-	-		
MR-3672	Storarydsdammen	Fish	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-		
MR-3453/54	Ystad STP	Sludge	ng/g dw	330	6800	420	<2	<3	5.2	22	7500	27		

Table A 4. Cont

County	Sample ID	Site	Matrix	Unit	D4	D5	D6	MM	MDM	MD2M	MD3M	Sum D	Sum M
Stockholm	MR-3480	Himmerfjärdsverket	Water	µg/L	<0.06	<0.04	<0.04	<0.0005	<0.0005	<0.0005	<0.0005	-	-
	MR-3482/84/86	Himmerfjärdsverket	Sludge	ng/g dw	140	6000	940	<1	<1	<1	8	7100	8
	MR-3449	Himmerfjärden	Sediment	ng/g dw	<23	190	51	<0.2	<0.2	1.2	0.4	240	1.6
	MR-3450	Himmerfjärden	Fish	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-
	MR-3448	St Envättern	Sediment	ng/g dw	<115	<57	<44	<1.2	<1.2	<1.2	<1.2	-	-
	MR-3451	St Envättern	Fish	ng/g ww	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-
	MR-3551	Flen STP	Sludge	ng/g dw	<130	570	170	<2	<0.5	<1	<3	740	0
MR-3576	Gnesta STP	Sludge	ng/g dw	1100	10000	1500	<0.5	3.4	3.1	24	13000	30	
MR-3568	Eskilstuna STP	Sludge	ng/g dw	280	13000	2000	<0.5	<0.5	6.6	<4	15000	7	
MR-3578	Katrineholm STP	Sludge	ng/g dw	460	23000	6200	<0.5	<0.5	16	160	30000	181	
MR-3570	Nyköping STP	Sludge	ng/g dw	490	15000	2100	<0.5	4	17	37	17000	58	
MR-3637	Oxelösund STP	Sludge	ng/g dw	180	5800	680	<0.5	<0.5	4.3	5	6600	9	
MR-3572	Strängnäs STP	Sludge	ng/g dw	<260	9900	1200	<2	0.00	7.0	97	11000	104	
MR-3553	Vagnhärad STP	Sludge	ng/g dw	370	17000	1500	<2	<0.5	12	<3	18000	12	
MR-3557	Vingåker STP	Sludge	ng/g dw	410	13000	2100	<0.5	12	13	21	16000	45	
MR-3709	Vik STP	Sludge	ng/g DW	<300	5500	570	<0.5	<0.5	19	44	6000	63	
MR-3711	Vik STP	Water	µg/L	<0.06	<0.04	<0.04	0.0098	<0.0005	<0.0005	<0.0005	<0.0005	0.0098	-
MR-3502	Vänern, Äsfjorden	Sediment	ng/g DW	<28	37	196	<0.3	<0.3	<0.3	<0.3	0.5	230	0.5
MR-3506	Vänern, Äsfjorden	Fish	ng/g WW	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-	-
MR-3507	Vänern, Kattfjorden	Fish	ng/g WW	<5	<5	<5	<0.4	<0.3	<0.4	<0.5	-	-	-
MR-3504	Vänern, Kattfjorden	Sediment	ng/g DW	<23	<11	<8.8	<0.2	<0.2	<0.2	1.3	-	-	1.3
MR-3580	Skåre STP	Water	µg/L	<0.06	<0.04	<0.04	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	-	-
MR-3582	Skåre STP	Sludge	ng/g DW	340	19000	2000	<0.5	<0.5	8.3	16	21000	25	
MR-3629	Fiskartorpet STP	Sludge	ng/g DW	130	3400	400	<2	<3	<4	6	4000	6	
MR-3631	Fiskartorpet STP	Water	µg/L	<0.06	<0.04	<0.04	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	-	-
MR-3754	Tivoliverket	Sludge	ng/g DW	<270	9700	1300	<0.5	<0.5	4.1	14	11000	18	
MR-3615	SCA Östrand	Sediment	ng/g DW	<16	<7.8	<6.0	<0.2	<0.2	<0.2	<0.2	<0.2	-	-
MR-3756	SCA Östrand	Water	µg/L	<0.07	0.059	0.15	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.21	-
MR-3726	Bodum STP	Sludge	ng/g DW	180	7400	1100	<0.5	<0.5	5.5	8	8700	13	



Table A 4. Cont

County	Sample ID	Site	Matrix	Unit	D4	D5	D6	MM	MDM	MD2M	MD3M	Sum D	Sum M
Västra Götaland	MR-3508	Lidköping STP	Water	µg/L	<0.06	<0.04	<0.04	<0.0005	<0.0005	<0.0005	<0.0005	-	-
	MR-3510	Lidköping STP	Sludge	ng/g DW	1000	22000	1500	8.2	<1	20	23	25000	52
	MR-3512	Vara STP	Sludge	ng/g DW	350	6800	1100	2.2	9.0	8.8	11	8200	31
	MR-3474	Åmål STP	Water	µg/L	<0.06	<0.04	<0.04	<0.0005	<0.0005	<0.0005	<0.0005	-	-
	MR-3476	Åmål STP	Sludge	ng/g DW	<190	9300	1700	<0.5	<0.5	4.5	9	11000	13
Östergötland	MR-3633	Finspångs STP	Sludge	ng/g DW	<840	9100	1100	<0.5	<0.5	<0.5	<0.5	10000	-
	MR-3635	Finspångs STP	Water	µg/L	<0.07	<0.04	<0.04	<0.0005	<0.0005	<0.0005	<0.0005	-	-
	MR-3683	Skuten	Sediment	ng/g DW	<28	26	<11	<0.3	<0.3	<0.3	<0.3	26	-
	MR-3728	Linköping STP	Water	µg/L	<0.06	<0.03	<0.04	<0.0005	<0.0005	<0.0005	<0.0005	-	-
	MR-3729	Linköping STP	Sludge	ng/g DW	220	10000	1400	<0.5	<0.5	13	19	12000	32
	MR-3685	Roxen	Sediment	ng/g DW	<45	<22	<17	<0.5	<0.5	<0.5	<0.5	-	-

**Table A5 Concentration of siloxanes in breast milk**

Sample nr	Unit	D4	D5	D6	MM	MDM	MD2M	MD3M
MR3007	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3008	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3009	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3010	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3011	µg/L	<2	3.6	<2	<0.004	0.007	0.013	<0.04
MR3012	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3013	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3015	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3016	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3017	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3018	µg/L	<2	<2	2.9	<0.004	0.003	<0.005	<0.04
MR3019	µg/L	<2	<2	2.9	<0.004	0.003	<0.005	<0.04
MR3020	µg/L	<2	<2	<2	<0.004	0.005	<0.005	<0.04
MR3021	µg/L	<2	2.1	<2	<0.004	<0.002	<0.005	<0.04
MR3023	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3024	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3025	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3026	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3027	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3028	µg/L	<2	<2	2.5	0.005	<0.002	<0.005	<0.04
MR3029	µg/L	<2	3.2	<2	<0.004	<0.002	<0.005	<0.04
MR3030	µg/L	<2	<2	<2	<0.004	0.008	0.008	<0.04
MR3031	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3032	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3181	µg/L	3.5	4.5	4.8	<0.004	<0.002	<0.005	<0.04
MR3280	µg/L	<2	4.2	<2	<0.004	<0.002	<0.005	<0.04
MR3281	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3282	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3283	µg/L	<2	<2	<2	0.006	<0.002	<0.005	<0.04
MR3284	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3285	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3286	µg/L	10	3.4	<2	<0.004	<0.002	<0.005	<0.04
MR3287	µg/L	<2	<2	<2	<0.004	0.003	<0.005	<0.04
MR3288	µg/L	<2	2.4	<2	<0.004	<0.002	<0.005	<0.04
MR3289	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3290	µg/L	2.9	2.8	<2	<0.004	<0.002	<0.005	<0.04
MR3291	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3292	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04
MR3293	µg/L	<2	<2	<2	<0.004	<0.002	<0.005	<0.04