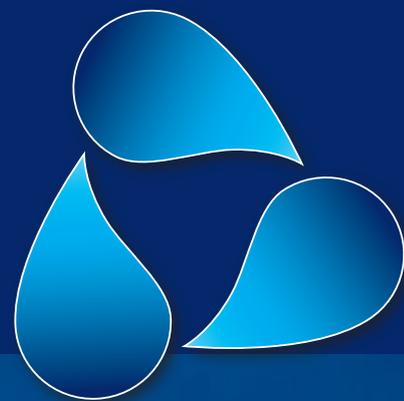


Norwegian Water

# Report



248 | 2018

## Organic Pollutants in Norwegian Wastewater Sludge

- Results from the Survey in 2017/18



Norsk Vann

# About Norwegian Water

Norwegian Water is a special interest organisation representing Norway's water industry. It acts on behalf of the members, which are municipalities, companies owned by municipalities, municipal operational assistance organisations and some private water works. Norwegian Water in total represents 365 municipalities, with 96 % of the population. There are also nearly 100 affiliated members like consultants, producers, suppliers and institutions for research and education. Norwegian Water serves both as a special interest organisation and a competence building organisation for the members. The organisation works within the vision of "clean water - our future".

## The Norwegian Water project system

Projects at a value of 10 million NOK (1.25 million EUR) are performed each year through the project system in Norwegian Water. The project system is financed by the members as a voluntary additional fee. The projects are proposed, approved and partly governed by the members, while specialists in the secretariat have the role as project managers. The best consultants in the marked are hired to perform the projects and write the reports and guidelines from the project system. Most of the projects are presented as a Norwegian Water report. The reports can be purchased from [www.norskvann.no](http://www.norskvann.no), and may be downloaded for free for the members taking part in the project system. The project system has so far produced nearly 250 reports and guidelines for the members.



Norwegian Water BA, Vangsvegen 143, 2321 Hamar, Norway  
Phone: +47 62 55 30 30 Email: [post@norskvann.no](mailto:post@norskvann.no)  
[www.norskvann.no](http://www.norskvann.no)



The project results from the Norwegian Water Report (Series A and B) can be used freely within the organization. When the results are used in writing material, source must be stated. Resale / dissemination of results cannot be done without the written agreement of Norwegian Water BA.

Norwegian Water reports are drawn up in interaction between authors, steering- and referencegroup for the project. The reports are not treated in Norwegian Water Governing bodies. Norwegian Water is not responsible for errors or incompleteness that may occur in the report and cannot be held economic or otherwise accountable for problems that may arise resulting from the use of this report.

# Norwegian Water Report

## Extract

A series of pollutants and pharmaceutical residues have been analysed at 18 treatment plants/biogas plants over a course of five months in winter 2017/2018. This is the same kind of survey that has been carried out approximately every five years since 1996/97. Analyses have been carried out on monthly combined samples for some compounds and on grab samples for other. The substances analysed in this study are PAH16, brominated flame retardants (BFH), phthalates (DEHP and DBP), nonylphenol/ nonylphenol ethoxylates and other alkylphenols, tensides (LAS), perfluorinated substances (PFAS), polychlorinated biphenyls (PCB), triclosan, siloxanes, musk compounds (galaxolide, tonalide and others), arsenic, silver, bisphenols, organophosphorus flame retardants, UV substances, chlorinated paraffins, organotin compounds (TBT, TFT, DBT, DOT), BTEX, trichlorethylene and various other chloro-organic compounds. Analyses have also been carried out on 71 different pharmaceutical residues.

Analysis results cannot be compared across treatment plants without also taking into consideration the different sludge treatment methods that are used. Digested sludge will generally contain more organic pollutants than raw sludge as the readily degradable organic material is broken down. It appears that medium-chain chlorinated paraffins (MCCPs) and short-chain chlorinated paraffins (SCCPs) are nevertheless broken down anaerobically.

## Norwegian Water BA (Norsk Vann BA)

Address: Vangsvegen 143, 2321 Hamar, Norway  
Tel: (+47) 62 55 30 30  
E-mail: post@norskvann.no  
Website: norskvann.no

## Title of the report:

Organic Pollutants in Norwegian Wastewater Sludge  
– Results from the Survey in 2017/18

## Author(s):

Line Diana Blytt and Pascale Stang.

Cover photos (from left):

Arne Haarr  
Norsk Vann  
Christen Ræstad

**Report number: 248/2018**

**ISBN 978-82-414-0429-0**

**(electronic edition)**

**ISSN 1890-8802 (electronic edition)**

---

## Keywords

Toxic organics, organic micropollutants  
Sewage sludge  
Sampling and analysis  
Norwegian wastewater treatment plants

---

# Foreword



An updated survey of organic pollutants in Norwegian sewage water has been undertaken over the course of five months in 2017/2018. This survey covers 18 treatment plants, between seven and nine of them were covered by the survey in 2012/2013 and/or in previous surveys. Several new substances have been analysed on this survey in comparison with previous surveys.

The project has been commissioned by Norwegian Water BA and carried out by COWI.

The project has been financed by the Norwegian Environment Agency, Norwegian Water BA and the following municipalities/plant owners: Bekkelaget Water BA, Bergen Municipality (Bergen Biogas Plant and Knappen Plant), Drammen Municipality, (Solumstrand Plant), FREVAR, (Øra Plant), IVAR (SNJ) in Stavanger, Gjøvik Municipality (Rambekk Plant), Hias in Hamar, Lindum Biogas in Drammen, NRA in Lillestrøm, MOVAR (Fuglevik Plant) at Moss, Sandefjord, Trondheim Municipality (Høvringen Plant

and Ladehammeren Plant), Tønsberg Plant IKS, VEAS in Asker, Ullensaker Municipality (Gardermoen Plant) and Ålesund Municipality (ÅRIM). In addition, Lindum

The project results provide us with important information about the content of pollutants in sewage sludge and will constitute an important contribution to future risk assessments and determination of limit values for sewage sludge used as a fertiliser and soil conditioner in Norway.

Biogas has also taken samples of raw sludge prior to anaerobic digestion in order to estimate decomposition effects throughout the biogas plant.

Norwegian Water BA would like to thank the

Norwegian Environment Agency and the plant owners for their voluntary participation which made it possible for this project to be carried out. The project results provide us with important information about the content of pollutants in sewage sludge and will constitute an important contribution to future risk assessments and determination of limit values for sewage sludge used as a fertiliser and soil conditioner in Norway.

Oslo 1. June 2019

Project Manager: Arne Haarr, Norwegian Water BA

# Abstract

A series of organic pollutants, arsenic, silver and pharmaceutical residues have been analysed on sludge from 18 treatment plants/biogas plants in monthly mixed samples in the autumn-winter 2017/2018. Siloxanes have only been analysed in grab samples due to the risk of contamination and loss from the sample.

The same type of survey has been carried out approximately every five years since 1996/97. The following substances have been analysed: PAH16, brominated flame retardants (BFR), phthalates (DEHP and DBP), nonylphenol/nonylphenol ethoxylates and other alkylphenols, surfactants (LAS), per- and polyfluoroalkyl substances (PFAS), polychlorinated biphenyl (PCB), triclosan, siloxanes, musk compounds (galaxolide, tonalide, etc.), arsenic, silver, bisphenols, organophosphorus flame retardants, UV substances, chlorinated paraffins, organotin compounds (TBT, TBT, DBT, DOT), BTEX, trichloroethylene and chloro-organic compounds. 71 different pharmaceutical residues have also been analysed.

There has been a noticeable decrease in LAS. The average concentration was previously 1,000 mg per litre while it is now currently 15 mg per litre. The cause of this is unclear but it might be due to the use of other surfactants. It has previously been observed that different methods of analysis can have significant effects on measured concentrations of LAS. The range of laboratory analyses in Europe changes continuously and it is not possible to determine which method shall be used in such surveys. As long as the laboratory is accredited for the analysis, we can trust that the values are correct, although it is important to be careful when changing laboratories.

The average value for the sum of brominated flame retardants (PBDEs) is 30 % lower than in 2012/13. This result is due to the fact that the two treatment plants that previously had the highest values are now showing lower values. An overview of the analysis results from the last 12 years does not show a general increase or reduction in values.

Since 2012/13, both the median and mean value for PAH has increased, although the values are lower than they were in 2006/07. The low concentrations in 2012/13 are partly due to high detection limits (10–250 µg/kg TS for individual PAHs). Since values below the detection limits are set to zero before summation, a high detection limit can result in a lower sum for PAH16. The detection limit for this survey was 5–10 µg/kg TS and fewer values were reported under the detection limit than in previous surveys.

All treatment plants except Solumstrand show a lower median value for phthalates (DEHP). In general, the concentration of both DEHP and DBP has been in steady decline since 1996/97.

The sum of NP+NPE was calculated this year as the sum of nonylphenol tech + nonylphenol monoethoxylate + nonylphenol diethoxylate. The average value was 4,127 µg/kg TS and the median was 3,850 µg/kg TS. This is approximately 20 % higher than in 2012/13, although in that study measurements were only taken for 4-n-nonylphenol. We can therefore estimate that NP+NPE have declined steadily since 1996–98.

The average value of the total amount of alkylphenols is approximately 70 % lower than in 2012/2013. Different components from previous survey were analysed, but in both this survey and in the 2012/13 survey, 4-t-octylphenol represents around 80 % of the alkylphenols. Dodecylphenol was detected in 38 out of 95 samples. The average value is assumed to be at the same level as the limit of detection (100 µg/kg TS).

PFAS was detected in all samples. It is difficult to make comparisons with previous surveys as different treatment plants were investigated and many of the results were reported to be under the detection limit. Two out of three treatment plants that were analysed in 2012/13 had an average value at the same level as the plants analysed in 2017/18. Treatment plants which receive wastewater from airports have higher values of PFAS than others.

PCB7 have not been analysed since 2001/02 and this survey has shown similar concentrations as back then. Since this survey has lower limits of detection than previous surveys and as several values are summed, this may indicate a slight decline in PCB.

Triclosan has a 33 % lower average value and 69 % lower median compared with 2012/13. There is a large difference between treatment plants. The median values for Gardermoen and SNJ are more than ten times higher than the median value for all samples.

Siloxanes were detected in all samples and the average value for the sum of siloxanes D4-D6 has doubled since 2012/13. D5, the dominant siloxane in previous surveys, has increased least, compared with D6 which was more than 30 times higher than in 2012/13. D5 is more than ten times higher. The concentration of hexamethyl-cyclo-trisiloxane (D6) was also ten-fold in the same period. This suggests that manufacturers have begun to

remove siloxanes listed as a priority pollutant, but that the overall consumption of siloxanes is increasing.

The musk substances galaxolide and tonalide were detected in all samples. The concentration of both substances has more or less doubled since 2012/13.

Silver was detected in 64 out of 70 samples. There was a 28% reduction of the average since 2012/13. The highest concentration has been measured at SNJ which also had the highest average.

Arsenic was detected in 36 of the 70 samples. Arsenic was not detected (detection level 1 µg/kg TS) at three of the 15 treatment plants (Bekkelaget, SNJ, VEA). Highest concentration was measured at Bergen Biogas Plant, where the concentration was 10 µg/kg TS or higher in all samples.

Bisphenol A was detected in all samples. Levels of this substance have doubled since 2012/13. The highest concentration was measured at Øra, which also had the highest average, and the lowest concentration was measured at the Knappen treatment plant. Other bisphenols were also detected, with bisphenol S and F being the substances with the highest concentrations (found in all samples).

Organotin compounds were detected in all samples. Roughly, the concentration of all organotin compounds has doubled since 2012/13. Only four plants were analysed for tin compounds.

Organophosphorus flame retardants, UV substances and chlorinated paraffins were detected in all samples. These substances are new in relation to previous surveys and their development in sludge can therefore not be assessed.

Chlorinated paraffins were detected in all samples. It seems that both short-chained and medium-chained chlorinated paraffins (SCCPs and MCCPs) are broken down anaerobically in biogas plants.

62 out of 71 medicines (pharmaceutical residues) that were analysed were detected in some samples, while 26 substances were detected in all the samples. There was a significant difference across the various pharmaceutical residues and the different treatment plants.

# Contents

<b>1. Introduction</b>	<b>9</b>	4.13. Bisphenols	47
1.1. Background	9	4.14. Organophosphorus flame retardants	49
1.2. Regulations and limits in Norway and other countries	9	4.15. UV substances	52
1.3. Short explanation on risk assessments for sludge disposal	11	4.16. Chlorinated Paraffins: SCCP and MCCP	54
1.4. The purpose of the survey	11	4.17. Pharmaceutical residues	56
<b>2. Parameters to the survey</b>	<b>12</b>	4.18. Organotin compounds	62
2.1. PAH	13	<b>References</b>	<b>65</b>
2.2. Brominated flame retardants (BFRs)	13	<b>Annex 1</b>	<b>68</b>
2.3. Phthalate (DEHP and DBP)	14	1.1. Raw data: PAH ( $\mu\text{g}/\text{kg}$ TS)	69
2.4. Nonylphenol, nonylphenol ethoxylates and other alkylphenols	15	1.2. Raw data: brominated flame retardants ( $\mu\text{g}/\text{kg}$ TS)	75
2.5. Surfactants (LAS)	15	1.3. Raw data: phthalates ( $\mu\text{g}/\text{kg}$ TS), Triclosan( $\mu\text{g}/\text{kg}$ TS), arsenic and silver (mg/kg TS)	80
2.6. Perfluorinated alkyl substances (PFAS)	16	1.4. Raw data: nonylphenol, nonylphenol ethoxylates and other alkylphenols ( $\mu\text{g}/\text{kg}$ TS)	83
2.7. Polychlorinated biphenyls (PCB)	16	1.5. Raw Data: LAS ( $\mu\text{g}/\text{kg}$ TS)	86
2.8. Triclosan	17	1.6. Raw data: perfluorinated alkyl substances ( $\mu\text{g}/\text{kg}$ TS)	89
2.9. Siloxanes	17	1.7. Raw data: PCB ( $\mu\text{g}/\text{kg}$ TS), chlorinated paraffins ( $\mu\text{g}/\text{kg}$ TS)	92
2.10. Musk compounds (galaxolide, tonalide, etc.)	18	1.8. Raw data: siloxanes ( $\mu\text{g}/\text{kg}$ TS)	95
2.11. Arsenic	18	1.9. Raw data: musk compounds ( $\mu\text{g}/\text{kg}$ TS)	97
2.12. Silver	19	1.10. Raw data: Bisphenols ( $\mu\text{g}/\text{kg}$ TS)	101
2.13. Bisphenols	19	1.11. Raw data: Organophosphorus flame retardants ( $\mu\text{g}/\text{kg}$ TS)	104
2.14. Organophosphorus flame retardants	20	1.12. Raw data: UV substances ( $\mu\text{g}/\text{kg}$ TS)	106
2.15. UV substances	20	1.13. Raw data: Pharmaceutical residues ( $\mu\text{g}/\text{kg}$ TS)	109
2.16. Chlorinated paraffins	21	1.14. Raw data: organotin compounds ( $\mu\text{g}/\text{kg}$ TS)	120
2.17. Pharmaceutical residues	21	1.15. Raw data: BTEX and trichloroethylene (pesticide) ( $\mu\text{g}/\text{kg}$ TS)	121
2.18. Organotin compounds (TBT, TFT, DBT, DOT)	23	1.16. Raw data: Chloro-organic compounds, residues from pesticides ( $\mu\text{g}/\text{kg}$ TS)	123
2.19. BTEX, trichlorethylene, and other chloro-organic compounds	23	<b>Annex 2</b>	<b>126</b>
<b>3. About the survey</b>	<b>24</b>	<b>Annex 3</b>	<b>127</b>
3.1. Treatment plants included in the survey	24	1. Background	127
3.2. Sampling plan	28	2. Plants included in the survey	128
3.3. Methods of analysis	28	3. Sampling points	129
<b>4. Results and discussion</b>	<b>29</b>	4. Contact information and shipping	129
4.1. PAH <sub>16</sub>	29	5. 5 Analysis Parameters and distribution of plants	131
4.2. Brominated flame retardants	30	6. Sampling	131
4.3. Phthalates	32	7. Storage and shipment	132
4.4. Nonylphenol, nonylphenol ethoxylates and other alkylphenols	34	8. Sampling plan	132
4.5. LAS	36	9. Summary	133
4.6. PFAS	37		
4.7. PCB <sub>7</sub>	39		
4.8. Triclosan	40		
4.9. Siloxanes	41		
4.10. Polycyclic musk compounds	43		
4.11. Arsenic	46		
4.12. Silver	47		



# 1. Introduction

---

## 1.1. Background

Wastewater sludge is used as a soil conditioner and as a fertiliser in both agriculture and in green areas. This usage means that it is necessary to limit the content of adverse substances in sludge. The use of sludge must not be allowed to cause damage to the environment or to public health or to cause any disadvantages. The strategy of environmental authorities and the water industry is therefore to remove environmental adverse substances at source.

The last nationwide survey of the content of organic pollutants in wastewater sludge from Norwegian treatment plants was carried out in 2012/13. Similar surveys have been carried out at intervals of approximately every five years since 1996. These surveys were completed in 1996/97 (Paulsrud et al., 1997), in 2001/02 (Nedland, 2002), in 2006/07 (Blytt, 2007) and in 2012/13 (Blytt et al., 2013). The present survey is a continuation and a follow-up of these four previous surveys.

A range of different monitoring and screening surveys have also been carried out for different organic pollutants in Norwegian sludge over the last few years: Koniczny et al. (2017), Koniczny et al. (2018), TemaNord (2012), Thomas et al. (2011), Thomas et al. (2014), Thomas et al. (2016). These studies have been initiated by Norwegian Water BA, the Norwegian Environment Agency, the Norwegian Food Safety Authority and the Nordic Council, and they have identified areas where further study applying to pollutants in sludge are necessary.

By conducting the same type of survey at regular intervals, comparable data is secured over time between different treatment plants and for each plant. Generally, the surveys reveal trends and patterns in developments over time to the content of various organic pollutants, used in households and in industry, that should not be spread in the environment. The survey gives us more knowledge in our work toward an environment free from pollutant.

---

## 1.2. Regulations and limits in Norway and other countries

The quality of wastewater sludge used as a fertiliser is regulated by Regulation no. 951 of 4 July 2003 on fertiliser products of organic origin (the fertiliser regulation). This is used as a basis in four different laws: The Food Act and the Land Act under the Ministry of Agriculture and Food, the Pollution Control Act under the Ministry of Climate and Environment and the Municipal Health Services Act under the Ministry of Health and Care Services. Requirements concerning the content of undesired substances in sludge are set out in the Food Act and managed by the Ministry of Agriculture and Food if the sludge is to be used as a fertiliser and raw material in the food chain. The Pollution Act will form the legal basis if limits for organic pollutants are established to protect the surrounding environment.

The fertiliser regulation is currently being revised and does not currently establish any limits for organic pollutants – only for heavy metals. The current regulation contains a provision which establishes a duty of care for responsible companies and organisations, stating that sludge shall not contain: "organic pollutants, pesticides, antibiotics/chemotherapeutics or other manmade organic substances in quantities that can damage public health or the environment when used." This wording is going to be changed and new requirements are going to be established. It is not yet clear from the draft regulation what these requirements are going to be. As before, there will be requirements for internal control, including the need to perform risk assessment and implement necessary measures to ensure compliance.

The draft regulation has introduced the term "sludge-based fertiliser product". This is designed for sludge products (pelleted/granulated and other forms) which have higher concentrations of nutrients and are therefore used in smaller quantities (max 100 kg per 1000 m<sup>2</sup> per year as fertiliser). The requirement for plowing or harrowing the sludge into the soil therefore does not apply. The draft also states that sterilised sludge can be used in areas where potatoes, vegetables, fruit and berries are cultivated provided that a quarantine period of ten months from the final spreading date is established before such plants are cultivated.

Tables 1.1 and 1.2 list the limits/normative values that apply in various European countries and in the proposal for the EU's revised regulation (third draft) for sludge (EU, 2003). The EU's sewage sludge directive 86/278/EEC aims to protect the environment, primarily when sludge is used on agricultural land. The regulation specifies limits for the maximum concentrations of heavy metals in sludge and in agricultural lands on which the sludge will be used. The directive has been under revision for many years and several European countries have also implemented stricter limits for heavy metals and introduced limits for selected organic pollutants. In the EU, several larger projects have been implemented to establish a better decision-making basis for new limits for both metals and organic pollutants (Langenkamp et al., 2001, Leschber, 2006 and Tavazzi et al., 2012). The "FATE-SEE" project has taken random "snapshot" samples of sludge and analysed them for different metals and organic pollutants (Tavazzi et al., 2012). The European Commission has also invited member states and relevant players to participate in the establishment of quality criteria for its forthcoming End of Waste regulation, so that waste-based products can be freely used as soil conditioners and fertiliser products. In the present proposal, there is not currently agreement as to whether sludge will be covered by these quality criteria.

The countries which have limit values for selected organic pollutants in Europe are Germany, Austria and Denmark. The limit values in Sweden and the limit for PCB in Denmark are normative (Danish Environmental Protection Agency, 2012, Budewig, 2012 and Wherter, 2012).

**Table 1.1** Limits/normative values for concentrations of organic pollutants in wastewater sludge in EU countries (Blytt et. al, 2018)

Country	AOX	DEHP	BaP	LAS	NPE	PAH	PCB	PCDD/F
	mg/kg TS							ng/kg TS
EU, (2003 draft)	500	100		5,000	50	6 <sup>1)</sup>	0.8	100
Denmark	-	50		1,300	10	3 <sup>1)</sup>	0.8	-
Sweden	-	-			50	3 <sup>3)</sup>	0.4 <sup>2)</sup>	-
France	-	-			-	4 <sup>4)</sup>	0.8	4 <sup>4)</sup>
Germany	500	-			-	-	0.2 <sup>5)</sup>	100
German proposals, 2007	400		1				0.1 <sup>5)</sup>	30
Czech Republic	500					3	0.6	
Austria	500				-	-	0.2 <sup>5)</sup>	100
Carinthia	500					6 <sup>1)</sup>	1	50

<sup>1)</sup> Sum of acenaphthene, phenanthrene, fluoranthene, pyrene, benzo[b/j/k]fluoranthene, benzo[a]pyrene, benzo[g/h/i], indeno[1,2,3-cd]pyrene

<sup>2)</sup> Sum of 7 PCB congeners 28, 52, 101, 118, 138, 153, 180

<sup>3)</sup> Sum of fluoranthene, benzo[b/j/k]fluoranthene, benzo[a]pyrene (BaP), benzo[ghi]perylene and indeno[1,2,3-cd]pyrene

<sup>4)</sup> See table below

<sup>5)</sup> Applies to each of the six PCB congeners 28, 52, 101, 138, 153, 180

**Table 1.2** French normative values for PAH concentrations and German requirements for other substances in wastewater sludge

Component	Concentration in sludge (mg/kg TS)	Country
Fluoranthene	4	France
Benzo(b)fluoranthene	2.5	France
Benzo(a)pyrene	1.5	France
2-Mercaptobenzothiazole+2-hydroxybenzothiazole	0.6	Germany
Tonalide	15	Germany
Galaxolide	10	Germany

---

### 1.3. Short explanation on risk assessments for sludge disposal

The dangers related to spreading sludge on soil are related to the risk of infection (hygienic risk) and the risk of increased concentrations of pollutants in soil and water, reaching toxic levels for organisms living there. In addition, there is a risk that pollutants spread in the natural environment and accumulate in the food chain. The food chain in soil is relatively short compared to the food chain in water. This means that more limit values are established for pollutants in water than for pollutants in soil because ecosystems in water are studied more than in soil.

Some guidelines for the classification of contaminated soils have been developed in the same way as for water. Norm values (uncontaminated soils) are based on ecotoxicological principles and connected to the predicted no effect concentration (PNEC) for the most sensitive organism tested. In cases where there are no PNEC values for soil organisms, the PNECs for water have been used. A study for the Norwegian Environment Agency in 2018 (Blytt et al., 2018) has looked at concentrations of different pollutants that can cause conflict with established norm values for contaminated soils when different waste products are used as fertiliser. This study found that concentration of some of the pollutants in sludge may raise the pollutant content in soil above the norm value when sludge is used as fertiliser. The questions whether legal limit values for fertilisers should be established, whether those limits should be calculated for sensitive aquatic organisms and what safety margins should be used to assess the limits, must be answered by the authorities. The effect of measures to reduce the emission of toxins into the environment must be viewed in a larger context so that the overall goal and the best socioeconomic outcome are achieved. Measures continuously assessed by treatment plants and environmental authorities are limit values for emissions from treatment operations, to ensure that treatment occurs locally and at source and to regulate the substitution and prohibition of substances. When environmental limit values are established, ecotoxicological principles should be used, as such an approach will be transparent and verifiable. Exactly what level of risk is considered as acceptable is a political matter.

Where relevant, results from the Norwegian Scientific Committee for Food and Environment's (VKM) risk assessment (Eriksen et.al, 2009) are used in this report. Evaluations in VKM's assessment, were made on the basis of sludge data from 2009, and a dosage of up to six tonnes of sludge TS per 1000 m<sup>2</sup>, a dose three times higher than in practice. VKM concluded that the risk involved in using sludge was very low. Since VKM's consideration placed human health in focus, the report is not an environmental assessment as such.

Different environmental risk assessments are constantly being undertaken for various organic substances in sludge in Europe, and new knowledge is established. Sweden has been undertaking a long-term trial (1981-) in which the effect of sludge on agricultural soils has been measured. In conclusion of the report from 2018 (Hörsing, 2018), it is stated that concentration of PFOS, PBDE (47, 99, 100 and 209), galaxolide, tonalide and DEHP will increase in soil treated with sludge. These substances can be found again in the upper layer of soil (0 - 0.3 m). There is an indication of increasing concentration of DIDP, nonylphenol and TCPP. For several of the selected organic pollutants, and even where soil is treated with sludge only, no detectable values were found. Accumulation of PFOS and BDE-209 in the soil after repeated fertilisation with sludge is consistent with what can be calculated in models. Alkylphenols, dibutyl phthalate and LAS cannot be measured in sludge-fertilised soil as predicted by the model calculations. Galaxolide is present in ordinary soil that has not been treated with sludge, but no conclusions can be drawn as to whether it accumulates in the soil or not. None of the analysed organic pollutants could be detected in the crops. PFOS and PBDE (47, 99 and 100) were detected in earthworms, which indicates an accumulation in the biota. A risk assessment in soil suggests no risk to the ecosystem or to human health even after long periods of sludge fertilisation.

---

### 1.4. The purpose of the survey

The purpose of this survey is to acquire better knowledge regarding the content of different pollutants in wastewater sludge and to extend the amount of data that can be used to assess the safety of sludge used as soil conditioner or fertiliser. The survey provides a timeline which indicates whether measures such as the phasing out, substitution or discharge control of substances work as intended and whether other pollutants require more focus in order to be stopped or phased out.

## 2. Parameters to the survey

This survey has been planned and implemented in the same way as previous surveys and is primarily based on the same factors for the selection of parameters analysed:

- Priority pollutants determined by authorities
- Probability of finding the substances in quantifiable amounts in Norwegian wastewater sludge
- Subject to regulation in other European countries and experience with parameters from such countries.
- Total analysis cost for the project

PCB<sub>7</sub> has been analysed again after an interruption in 2016/17 and 2012/13. Based on the Norwegian Environment Agency's priority list of chemicals dangerous for health and environment, several new substance groups have now been analysed for the first time. These are: organophosphorus flame retardants, UV substances and chlorinated paraffins, and additional bisphenols. The priority list is a list of substances covered by a national target aiming to reduce their use and emission and ultimately eliminate them prior to 2020.

For practical reasons, LAS and PFAS were analysed at the same plant and extra sludge samples have consequently been analysed for LAS than was originally planned. Only eight plants have time series data for LAS and have been analysed since the first survey in 1996/97. Since it is important to map out the extent to which PFAS exists in sludge, several treatment plants were selected for this and not just those connected to firefighting activities and airports, etc.

The following organic pollutants are included in the survey (substances marked with an asterisk (\*) are on the priority list):

### Basic Package (all 18 plants plus raw sludge from Lindum)

- PAH<sub>16</sub>\*
- Brominated flame retardants\*
- Phthalates\*
- Nonylphenol\*/ethoxylates, alkylphenols\*

### Additional Package 1 (13 plants)

- PCB<sub>7</sub>\* (back after an interruption since 2002/03)
- Triclosan\* + methyl-triclosan
- Siloxanes (analysed in grab samples)
- Polycyclic musk compounds (only musk xylene, musk ketone is on the priority list)
- Arsenic\* and silver
- Bisphenol A\* and other bisphenols
- Organophosphorus flame retardants\* (new)
- UV substances\* (new)
- Chlorinated paraffins\* (new)
- Pharmaceutical residues (new)

### Additional Package 2 (15 plants)

- LAS
- PFAS\*

### Organotin\* (4 plants)

- Dibutyltin oxide
- Dioctyltin oxide
- Tributyltin

---

## 2.1. PAH

PAH are formed through the incomplete combustion of organic materials and are important components in creosote, tar and asphalt. PAH are undesirable by-products from certain industrial processes and are also formed in connection with road wear. PAH is also found in adhesives and in produced water from the oil industry. Significant contributions to the total emissions in Norway also come from car exhausts, wood heating, oil heating, forest fires, bonfires and straw burning. The substance group consists of many different compounds which contains several benzene rings. Toxicity varies between different PAH compounds. Benzo[a]pyrene is thought to be one of the most harmful compounds to human health. Benzo[a]pyrene is classified as toxic, carcinogenic, mutagenic and harmful to reproduction.

PAH compounds degrade to varying degrees and can bioaccumulate. Several PAH compounds are highly toxic to aquatic organisms. Studies have also shown that several such compounds can be harmful to reproduction in fish. In the environment, PAH compounds are primarily found bound to particles. PAH can spread both in the atmosphere and through currents over long distances. The least volatile compounds are transported when bound to particles. Compounds in the air are deposited in the environment through precipitation. In the ocean, these compounds can be deposited in the ocean floor and in sediments.

Emissions of PAH have been reduced by approx. 63% between 1995 and 2013 in Norway. From 2015 onwards, the way in which emissions are reported has been changed. Registered quantities therefore appear to be much lower than in previous years, but there is no information to suggest that there have been significant reductions in real emissions of PAH. In 2015, the largest sources of emissions were aluminium industry, residential wood heating and road traffic. Creosote-treated wood is also a significant source of PAH leaching. PAH was banned from tyres in 2010 and a reduction in emissions from road traffic is therefore expected in the future as older tyres are replaced.

PAH is strictly regulated by REACH in wood preservatives, car tyres and a range of other consumer products, including toys and products for children (Environment.no, 2018).

---

## 2.2. Brominated flame retardants (BFRs)

Brominated flame retardant (BFR) is the term used for a group of organic substances that contain bromine and which have a retardant effect on the development of fires. The brominated flame retardants Penta-BDE, Octa-BDE, HBCD, Deca-BDE and TBBPA were added to the authorities' priority list in 1997.

Environmental authorities have thus far prioritised actions and measures to reduce the five most widely used brominated flame retardants. Of these five, three are polybrominated diphenyl ethers (PBDE), including penta-BDE (pentabromodiphenyl ether), octa-BDE (octabromodiphenyl ether) and deca-BDE (decabromodiphenyl ether), while the other two are HBCD (hexabromocyclododecane) and TBBPA (tetrabromobisphenol A). Other groups of flame retardants that the environmental authorities have placed in focus are polybrominated biphenyls (PBBs), including HexaBB, pentabromotoluene (PBT) and pentabromoethyl benzene (PBEB).

The use of brominated flame retardants in Norway has been reducing since 2005, although it has been relatively stable in recent years. We assume that imported solid products are the highest source of emissions. Although the amounts that are found in products in Norway are uncertain, it is reasonable to assume that emissions have increased in line with use. Many electrical and electronic products which contain brominated flame retardants are collected through collection schemes.

Brominated flame retardants can cause serious health issues such as cancer, reduced fertility, foetal damage and nerve damage. They can also cause environmental damage and are classified accordingly. They can also have endocrine-disrupting properties. Penta-BDE, octa-BDE, deca-BDE and HBCD are transported over large distances through ocean and air currents and can be retained in the environment for long periods of time, even building up in the food chain where they can have a toxic effect.

Treatment plants which receive water from laundries or textile industries have found an elevated concentration of brominated flame retardants in the sludge. Environmental monitoring and surveys have helped to identify the sources of pollution (Schlabach et al. 2011, Berge et al., 2008, Fjeld et al. 2005).

The following substances have been analysed in this survey:

**MonoBDE:**

- PBDE 3

**DiBDE:**

- PBDE 7
- PBDE 15

**TriBDE:**

- PBDE 17
- PBDE 28
- TriBDE

**TetraBDE:**

- PBDE 49+71
- PBDE 66
- PBDE 77
- PBDE 47
- TetraBDE

**PentaBDE:**

- PBDE 85
- PBDE 99
- PBDE 100
- PBDE 119
- PBDE 126
- PentaBDE

**HexaBDE:**

- PBDE 138
- PBDE 153
- PBDE 154
- PBDE 156
- HexaBDE

**HeptaBDE:**

- PBDE 175
- PBDE 183
- PBDE 184
- PBDE 190
- PBDE 191
- HeptaBDE

**OctaBDE:**

- PBDE 196
- PBDE 197
- PBDE 202
- OctaBDE

**NonaBDE:**

- PBDE 206
- PBDE 207
- NonaBDE

**DecaBDE:**

- PBDE 209

**DBDPE** (decabromodiphenyl ethane)

---

## 2.3. Phthalate (DEHP and DBP)

The phthalate substance group consists of many different substances used in large quantities in everyday products. Phthalates are primarily used as plasticisers in plastic (particularly in PVC) but are also used as plastic hardeners, binders for paint and in anti-fouling paints and adhesives. Phthalates in soft PVC and other plastic products are not chemically bound. This means that the substances can leach out from the product and into the surrounding environment when they are in use or after they have been discarded. In Norway, phthalates are primarily found in imported products.

Some phthalates are banned in toys and products for children, as well as in cosmetics. Several phthalates have been added to the candidate list and to the list of substances which require approval from REACH.

Phthalates are detected in many places in the environment, including fresh water, salt water, wastewater, in the air and in organisms. The substances bind to organic materials. Phthalates degrade relatively easily in the water but take a longer time to break down in sediment and soil. Phthalates bioaccumulate and can cause harm to reproductive systems. They are highly toxic to aquatic organisms and can cause undesired long-term effects in the aquatic environment.

Phthalates on the priority list include di-2-ethylhexyl phthalate (DEHP), benzyl butyl phthalate (BBP) and dibutyl phthalate (DBP) and diisobutyl phthalate (DIBP). Based on available information, use of DEHP has been calculated to be in the magnitude of 4,750 tonnes in 1995 and around 2,900 tonnes in 2015. Furthermore, total emissions of 135 tonnes DEHP have been estimated for 2015. This is a reduction of around 50 per cent since 1995. The numbers are very rough estimates (Sørensen, 2012 and Environment.no, 2018).

The following substances have been analysed in this survey:

- Di-2-ethylhexyl phthalate (DEHP)
- Dibutyl phthalate (DBP)

---

## 2.4. Nonylphenol, nonylphenol ethoxylates and other alkylphenols

Nonylphenol and octylphenol ethoxylates are surfactants and have therefore been widely used in products such as detergents and cosmetics. They degrade relatively easily into nonylphenols and octylphenols, which can then be found in the environment. Emissions of nonylphenols and octylphenols have been reduced by about 90 per cent since 1995. This decline is largely due to a greatly reduced usage of these substances in cleaners and detergent due to new regulations. In 2015, total emissions were around 1.3 tonnes. Uncertainty around these figures is quite high. Content of nonylphenols and octylphenols and their ethoxylates are found in several imported products, such as textiles, and are not included in the calculated emission figures.

The main part of registered emissions of nonylphenols and octylphenols in 2015 came from wastewater, sanitation and municipal sludge, with the emissions ending up in the water. It is uncertain what the primary sources of those substances in water and wastewater. Probably, imported products, such as textiles and plastic products, are a significant source. Several surveys confirm that such products contain nonylphenols and octylphenols especially nonylphenol ethoxylates.

Dodecylphenol is used in motor oils and the import of motor oils has increased over the last few years. Emissions of dodecylphenol are largely due to the improper disposal of motor oil which then ends up in municipal sewage. The import of motor oil has increased in recent years and emissions are expected to increase in line with this. Emissions of 4-tert-butylphenol, 4-tert-pentylphenol and 4-heptylphenol from plastic products, paints, lacquers and lubricants are not known.

Alkylphenols are a large group of substances that have long been suspected to be endocrine disrupters in the environment. They are persistent, accumulate in organisms and are highly toxic to life in water. Nonylphenols, octylphenols and their ethoxylates were added to the authorities' priority list in 1997. Dodecylphenol and 2/4/6-tri-tert-butylphenol were added to the list in 2007 while 4-tert-butylphenol and 4-heptylphenol were only added in 2018.

The following substances have been analysed in this survey:

- Nonylphenol monoethoxylates
- Nonylphenol diethoxylates
- Dodecylphenol
- Octylphenol
- Tri-tert-butylphenol
- Pentylphenol
- Heptylphenol
- Butylphenol

---

## 2.5. Surfactants (LAS)

Surfactants are surface active substances that have properties which remove dirt, particles and oil from surfaces and are therefore important additives in detergents and fabric softeners. Surfactants are spread in the environment through the release of wastewater and they bind to particles to a significant extent. It is assumed that surfactants which enter into the wastewater system are primarily found again in sediments and in sludge. Surfactants can be grouped into ionic surfactants, non-ionic surfactants, cationic surfactants and amphoteric surfactants.

Linear alkylbenzene sulfonates (LAS) are anionic surfactants which are toxic to aquatic organisms, have low levels of acute toxicity for mammals and while they enhance growth in other types of organisms (Environmental Chemistry, 1996). LAS can be absorbed by plants and leach out into groundwater if they end up in the soil (Kristiansen et al., 1996). LAS are persistent in anaerobic environments. They can be expected to degrade under aerobic conditions in soil, which reduces the risk of human exposure via plants and drinking water.

The presence of LAS has declined, but the use of liquid detergents that contain LAS has increased (NOU, 2010). LAS is not a priority substance and therefore does not figure on the authorities' priority list.

---

## 2.6. Perfluorinated alkyl substances (PFAS)

There are more than 3,000 different perfluorinated alkyl substances (PFAS) on the market. These substances are used as preservatives and firefighting foam. PFOS and PFOA are the best known in this group and are both strictly regulated. It is difficult to estimate the total development in PFAS emissions since there are so many different substances and sources of emission.

PFAS are surface active and highly stable compounds. PFAS, including PFOS-related compounds, have been used in industrial and consumer products since the 1950s. The substances have been used for their excellent surface properties. They can form thin films which prevent the spread of fire and the evaporation of volatile compounds, and which can improve the water and dirt repelling qualities of products. The most widespread application of PFOS has been special firefighting foam for extinguishing fires in oils and similar conditions. PFAS are and have been used in impregnation, in textiles and in Teflon coatings and ski waxes, etc.

PFOS have been added to the priority list of the Norwegian authorities in 2002. PFOA was then added in 2007 and other long-chain perfluorinated acids were added in 2014 (C9-PFCA - C14-PFCA) and in 2017 (PFHxS). PFOA is found as an impurity in small amounts in products where other perfluorinated substances have been used. Several PFAS are also converted into PFOA in the environment. In recent years, monitoring and research have led to increased recognition that all PFAS have undesirable properties and rising concerns due to the combined effect exerted by different PFAS when they occur together.

Perfluorinated compounds are highly stable. This means that they are rarely completely degraded. Instead, they accumulate in humans and in the environment and spread globally. The compounds have been detected in many parts of the world, including the Arctic regions. We may be exposed to them via the environment, through the consumption of polluted drinking water and food. PFOS and PFOA are found in the blood of women in Northern Norway and Siberia. Surveys have shown that the highest concentrations are found in fish-eating carnivores at the top of the food chain.

Past use of PFOS and other PFAS in firefighting foam have contaminated the ground at fire fighting training areas. The Norwegian Environment Agency requires that responsible users map out the ground areas in places that are contaminated by PFAS. Work has been initiated at several airports owned by Avinor and the Norwegian Armed Forces to assess risk and determine measures, in addition to clean-up initiatives.

22 perfluorinated compounds have been analysed in this survey:

- 2H,2H,3H,3H-Perfluoroundecanoic acid (H4PFUnA)
- 2H,2H-Perfluorodecanoic acid (H2PFDA)
- 6:2 Fluorotelomer sulfonate (FTS)
- 7H-Dodecafluoroheptanoic acid (HPFHpA)
- Perfluoro-3,7-dimethyloctanoic acid (PF-3,7-DMOA)
- Perfluorobutane sulfonate (PFBS)
- Perfluorobutanoic acid (PFBA)
- Perfluorodecane sulfonate (PFDS)
- Perfluorodecanoic acid (PFDA)
- Perfluorododecanoic acid (PFDoA)
- Perfluorohexane sulfonic acid (PFHxS)
- Perfluorohexanoic acid (PFHxA)
- Perfluoroheptane sulfonate (PFHpS)
- Perfluoroheptanoic acid (PFHpA)
- Perfluorononanoic acid (PFNA)
- Perfluorooctanesulfonamide (PFOS)
- Perfluorooctanoic acid (PFOA)
- Perfluorooctane sulfonate (PFOS)
- Perfluoropentanoic acid (PFPeA)
- Perfluorotetradecanoic acid (PFTA)
- Pentacosafuorotridecanoic acid (PFTrA)
- Perfluoroundecanoic acid (PFUnA)

---

## 2.7. Polychlorinated biphenyls (PCB)

PCB are a group of synthetic chlor-compounds which are carcinogenic, toxic to aquatic organisms, not readily biodegradable and which bioaccumulate and build up in the food chain.

PCB were used from as far back as the 1930s although they were mostly used in the 60s and 70s. PCB have been used in electrical equipment and in building materials such as mortar additives in insulating glass, adhesives, sealants and paints. PCB are now prohibited, although the substance can still leach out from old products and materials, particularly when they end up as waste at landfill. Leaching can also occur from polluted soils and sediments which have been contaminated by PCB.

---

## 2.8. Triclosan

Triclosan is used as an anti-bacterial agent in cosmetics, textiles and plastic products. The largest source of emissions is cosmetic products, such as dentifrices and hand soap. Triclosan was added to the priority list of the Norwegian authorities in 2008. It was then banned as an active substance in some biocidal products in Norway and the EU in 2014. The ban was extended in 2016.

Consumption of triclosan was estimated at 450 tonnes in 2006 in the EU/EEA, while in 2017 recordings made by REACH suggested that consumption was around 10-100 tonnes per year. (Environment.no, 2018). It is believed that triclosan primarily makes its way into the environment via municipal wastewater. Triclosan has been detected in sediment and municipal landfill sites in addition to other places. The substance can also be found in low concentrations in mussels and cod liver. Triclosan is persistent and bioaccumulates. Since the substance is persistent and because it also has a bactericidal effect, it can lead to the development of resistant bacteria strains (Jensen et al., 2012).

The following substances have been analysed in this survey:

- Triclosan (CAS no. 3380-34-5)
- Methyl triclosan (CAS no. 4640-01-1)

---

## 2.9. Siloxanes

Siloxanes are a group of chemicals that are used in large amounts, with products such as soaps, skincare products, deodorants and make-up suspected of being the greatest source of siloxane emissions in Norway. They are also used in industry, as additives in fuel, in car wax, cleaning agents, paints, insulation materials and cement. The consumption of siloxanes through imported cosmetics amounted to 475 tonnes in 2015. This was predominantly D5, which is also what we find the most in the lakes monitored. Siloxanes evaporate easily, and it is estimated that over 70 per cent of siloxane content in cosmetics evaporates during use, while about 10 per cent ends up in wastewater. In treatment plants, some of these siloxanes become bound to sludge.

We know most about the ring shaped siloxanes octamethyl cyclotetrasiloxane (D4) and decamethyl cyclopentasiloxane (D5). D4, D5 and D6 have environmental properties of concern. The substances are not readily biodegradable in water and sediment and accumulate very easily in organisms. D5 and D6 can also accumulate in the food chain. D5 and D4 were added to the authorities' priority list in 2006 and 2012 respectively, while D6 was only added in 2018. Under the EU's REACH chemical regulation, it has been decided to prohibit D4 and D5 in personal care products that wash off during normal use, such as shampoo, conditioner and soap. This ban will enter into force on 31 January 2020. The industry in Europe is in the process of phasing out D4 and switching to D5 and D6.

The following substances have been analysed in this survey:

- |                                      | <b>(CAS no.)</b> |
|--------------------------------------|------------------|
| • Decamethylcyclopentasiloxane (D5)  | 541-02-6         |
| • Decamethyltetrasiloxane            |                  |
| • Dodecamethylcyclohexasiloxane (D6) | 540-97-6         |
| • Dodecamethylpentasiloxane          |                  |
| • Hexamethylcyclotrisiloxane         |                  |
| • Octamethylcyclotetrasiloxane (D4)  | 556-67-2         |
| • Octamethyltrisiloxane              |                  |
| • Fenyltris(trimethylsiloxy)silane   | 2116-84-9        |

---

## 2.10. Musk compounds (galaxolide, tonalide, etc.)

Musk compounds are synthetic fragrances that are added to cleaning and laundry detergents, fabric softeners, cosmetics, perfumes, car wax and floor/furniture polishing products. Musk compounds are not very water soluble and many therefore bind to sediment and wastewater in treatment plants.

Synthetic musk compounds have been found in different compartments of the environment (Mogensen et al., 2004). Musk compounds enter the food chain and do not readily break down in the environment. They are suspected of being carcinogenic. Nitro musk compounds (musk xylene, musk ketone) appear to have more serious effects than polycyclic musk compounds such as galaxolide and tonalide (Environment.no, 2018). Musk xylene and musk ketone were not detected at levels over the limits of detection in the previous survey in 2012/13.

The following substances have been analysed in this survey:

- Galaxolide
- Tonalid
- Musk ketone
- Musk xylene
- Galaxolide-lactone
- Cashmeran
- Celestolide
- Moskene
- Musk ambrette
- Musk tibeten
- Phantolide
- Traseolide

---

## 2.11. Arsenic

Arsenic compounds can be toxic, even in small concentrations and may also cause cancer. Arsenic was added to the priority list of the Norwegian authorities in 2002. The use of arsenic in pressure-impregnated wood has been prohibited. This has resulted in a significant reduction in the consumption of arsenic. Arsenic nonetheless continues to leach out from CCA-wood (chromated copper arsenate) that will still be in use for many years. In the draft proposal for a new fertiliser regulation, one suggestion is to include arsenic on the list of limit values for heavy metals in fertiliser products.

Measurements in the largest rivers, from the beginning of the 1990s and until now, reveal low levels of arsenic without significant changes from year to year. Elevated concentrations of arsenic have been found in sediment in Kristiansand Fjord and Ballang Fjord without any associated biological effects having been identified. Elevated levels of arsenic have also been detected in the ground around impregnation plants. Surveys at several kindergartens show that the use of impregnated wood in playground equipment has led to high levels of arsenic in sand and soil.

Inorganic arsenic compounds are classified as toxic if inhaled or swallowed as they can cause cancer, they are highly toxic to aquatic organisms and can cause undesired long-term effects in aquatic environments. Organic arsenic compounds are less toxic.

Lead batteries and brass constitute the largest areas of application for arsenic but are not thought to entail arsenic emissions that are significantly high. Used lead batteries are collected and processed as hazardous waste and therefore do not result in significantly high emissions into the environment.

Around 30 years ago, arsenic emissions in Norway were high and amounted to around 35 tonnes per year. Between 1995 and 2015, arsenic emissions were reduced by around 34 per cent. CCA-impregnated wood (which is still in use today) was the largest source of arsenic emissions in 2015 and accounted for around 70 per cent of all emissions. This leaching will continue for a long time to come. A significant reduction in the size of emissions is not expected for the next 15–20 years. Emissions from other sources are relatively small.

Arsenic emissions in 2015 are estimated to be around 24 tonnes. In addition, around six tonnes of arsenic leach out from contaminated soils in different localities around Norway (Sørensen, 2012 and Environment.no, 2018).

---

## 2.12. Silver

Silver has antibacterial properties and is used increasingly in various products that are designed to prevent bacteria and smells, for example in fridges, washing machines, gloves, cloths and sportswear. Silver is also used in the healthcare sector for the treatment of injuries and illnesses – it is used to prevent burns from becoming infected, for example.

Fortunately, silver is not particularly toxic to humans and in countries such as the USA, nanosilver is sold for human consumption to treat diarrhoea and other digestive problems. The effects of silver ions in bacteria are well known. The ions can bind to the bacteria's cell walls and DNA and inhibit the transfer of electrons involved in metabolism. Silver has been less widely studied in particle form. Nano silver is released in laundry water as ions and to a certain extent as nanoparticles as well. Both parts find their way into wastewater and end up in wastewater sludge.

Nano silver is perhaps the nano-material that raises the most suspicions in an environmental context, both because its consumption has increased significantly and because it is potentially highly toxic due to the fact that it cannot be recycled. There are also questionable aspects to the extensive use of nano-silver as a bactericide since this could easily lead to the emergence of resistant bacteria. Antibiotic resistance is already a growing problem and it is highly questionable to undermine the fight against infections by rendering yet another anti-bacterial agent ineffective (Defra, 2009).

---

## 2.13. Bisphenols

### Bisphenol A

Bisphenol A was added to the priority list of the Norwegian authorities in autumn 2006. The substance's endocrine-disrupting effects in animals such as fish also affects the hormone system in humans and can be harmful to foetal development and the reproductive system. Bisphenol A breaks down relatively easily in water and does not bioaccumulate to a significant extent in organisms (Environment.no, 2018).

The use of bisphenol A in Europe has grown significantly over the last 20 years. Bisphenol A produced in Europe is primarily used in the production of polycarbonate plastic, which is used in plastic containers for food and drinks, electronic appliances and equipment for cars.

The substance is also used in products such as paints, varnishes, adhesives and floor coverings. Bisphenol A was previously used in certain types of heat-sensitive paper, such as cash receipts. As a raw material, the substance is used in the production of tetrabromo-bisphenol A, which is a brominated flame retardant.

The amount of bisphenol A recorded in the Norwegian product register was approximately 11 tonnes in 2015. There has been a considerable reduction since 2010 and this is largely due to a declining use of the substance in hardeners. At the same time, though, the use of bisphenol A in paints and varnishes has almost quadrupled. The numbers in the product register only account for bisphenol A in chemical products and not in solid products. The true level of bisphenol A in products that circulate in Norway is therefore significantly greater than 11 tonnes. Calculations regarding emissions of bisphenol A in Norway show that a relatively small amount spreads to the environment via leachate from landfills, sludge used in agriculture and stormwater. In 2015, emissions via these pathways was calculated to be around 1.2 tonnes.

### «New bisphenols»

Little information is available on consumption and emissions of other bisphenols such as bisphenol AF, bisphenol B, bisphenol BP, bisphenol F, bisphenol M and bisphenol S. These substances can be used as replacements for bisphenol A once it has been phased out. Bisphenol S is already used as a replacement for bisphenol A in heat-sensitive paper. Moreover, bisphenol F and bisphenol B have possibly replaced bisphenol A in products made from epoxy resin and polycarbonate, such as epoxy varnish and plastic cutlery. We have limited knowledge about the effects of these

substances on health and the environment. However, the different bisphenol types have structural similarities and ongoing surveys show that bisphenol F and bisphenol S may have similar effects as bisphenol A. (Environment.no 2018, ECHA 2018)

In previous surveys, only bisphenol A was analysed. The following bisphenols will be analysed in this survey:

<b>BISPHENOLS</b>	<b>CAS no.</b>	<b>BISPHENOLS</b>	<b>CAS no.</b>
• Bisphenol A	80-05-7	• Bisphenol Z	843-55-0
• Bisphenol S	80-09-1	• Bisphenol AP	1571-75-1
• Bisphenol F	1333-16-0	• Bisphenol E	"2081-08-5"
• 2,2-Bisphenol F	"2467-02-9"	• Bisphenol P	2167-51-3
• 4,4-Bisphenol F	620-92-8	• Bisphenol M	13595-25-0
• Bisphenol AF (hexafluorobisphenol A)	1478-61-1	• Bisphenol G	127-54-8
• Bisphenol BP	1844-01-5	• Bisphenol TMC	129188-99-4
• Bisphenol B	77-40-7		

## 2.14. Organophosphorus flame retardants

Organophosphorus flame retardants are widely used as flame retardants and softeners in plastic (plasticisers). They are also used as anti-foaming agents and as additives in lubricants, hydraulic oils, floor polishes and adhesives.

Tris(2-carboxyethyl)phosphine (TCEP) was added to the priority list in autumn 2012. This substance is strictly regulated in the EU. In 2015, TCEP was primarily used as a flame retardant in antifouling paints for ships and boats. The substance can also be used in textiles and plastic materials to prevent ignition and it is uncertain to what extent it is present in imported products.

The following organophosphorus flame retardants were analysed:

<b>3 chlorinated:</b>		<b>CAS no.</b>
• TCEP	Tris(2-carboxyethyl)phosphine	115-96-8
• TCPP	Tris (1-chloro-2-propyl)phosphate	13674-84-5
• TDCPP	Tris(1,3-dichloro-2-propyl)phosphate	13674-87-8
<b>6 non-chlorinated:</b>		
• TBEP	Tris(2-butoxyethyl) phosphate	78-51-3
• EHDPP	2-ethylhexyl diphenyl phosphate	1241-94-7
• TCP	Tricresyl phosphate	1330-78-5
• TBP/TnBP	Sum of tri-n- and isobutylphosphate	126-73-8, 126-71-6
• PPhDPhP	4-Isopropylphenyl diphenyl phosphate	55864-04-5
• TPPhP	Tris(2-isopropylphenyl) phosphate	26967-76-0, 64532-95-2

## 2.15. UV substances

Benzotriazole-based UV filters are used as stabilisers in paints and varnishes, rubber and transparent plastic to protect materials from sunlight. The substances UV-320, UV-327, UV-328 and UV-350 were added to the priority list of the Norwegian authorities in 2017.

We know most about UV-327 and UV-328, which both have very serious environmental properties. UV-320 and UV-350 also have properties of concern, even if these have not been studied and described to the same extent. We suspect that the four substances will behave in the same way when they end up in the environment. UV-320, UV-327, UV-328 and UV-350 are very persistent (vP) and easily accumulated in organisms (vB) and in the food chain and for this reason they count as pollutants. In addition, UV-320 and UV-328 have been showed to be toxic;

they cause liver damage in mammals in long-term or repeated exposure. UV-328 can also cause damage to the kidneys through long-term or repeated exposure.

The following substances have been analysed in this survey:

		<b>CAS no.</b>
• UV-320	2-Benzotriazol-2-yl-4,6-di-tert-butylphenol	3846-71-7
+UV-350	2-(2H-Benzotriazol-2-yl)-4-(tert-butyl)-6-(sec-butyl)phenol	36437-37-3
• UV-327	2,4-di-tert-butyl-6-(5-chlorobenzotriazol-2-yl)phenol	3864-99-1
• UV-328	2-(2H-Benzotriazol-2-yl)-4,6-di-tert-pentylphenol	25973-55-1

In addition to the benzotriazole-based UV filters, analyses were also undertaken for products used as UV filters in both cosmetic and technical products:

	<b>CAS no.</b>
• Octocrylene	6197-30-4
• Benzophenone-3	131-57-7
• Ethylhexyl methoxycinnamate	5466-77-3

---

## 2.16. Chlorinated paraffins

Chlorinated paraffins are primarily used as plasticisers and fire retardants. Medium-chain chlorinated paraffins (MCCP) can be found in rubber and PVC used for the cable production, floor coverings and various other consumer products. Only little is used in domestic production but can be found in imported products.

Short-chain chlorinated paraffins (SCCP) were banned in Norway in 2002. Emissions from old products still in use and leaching from contaminated areas can nonetheless continue to contaminate the environment. Some imported products may also contain short-chain chlorinated paraffins in small concentrations.

Calculations based on measurements in wastewater sludge show that over 300 kilograms of short-chain chlorinated paraffins were released in 2013. Medium-chain chlorinated paraffins were relatively more common. Between 1995 and 2015, emissions were reduced by 29 per cent, although they have increased again in the last few years. This is attributed to emissions from imported products.

---

## 2.17. Pharmaceutical residues

Pharmaceutical residues end up in the environment in several different ways. After normal use, the drug itself and/or its metabolites are secreted in urine and faeces and end up in wastewater. Medications which are discarded down the sink/toilet will also end up in wastewater. When pharmaceutical residues are disposed of in household waste, they can subsequently leak out into water at landfill sites. In addition, there are also emissions that come directly from production.

A range of different medications and their metabolites can be found in wastewater. In this survey, the following 48 substances have been analysed:

- 10,11-dihydro-10,11-dihydroxy-carbamazepine
- 10,11-dihydrocarbamazepine
- carbamazepine
- Alprazolam
- Amitriptyline
- Atenolol
- Atorvastatin
- Azithromycin
- Bezafibrate
- Biperiden
- Bisoprolol
- Caffeine
- Carbamazepine
- Carbamazepine 10,11-epoxide
- Cetirizine
- Cilazapril
- Citalopram
- Clarithromycin
- Clemastine
- Clindamycin
- Clindamycin\_sulfoxide
- Clomipramine
- Clonazepam
- Codeine
- Diclofenac
- Diltiazem
- Diphenhydramine
- Disopyramide
- Donepezil
- Fenofibrate
- Fexofenadine
- Glibenclamide
- Glimepiride
- Irbesartan
- Loperamide
- Maprotiline
- Meclozine
- Memantine
- Metoprolol
- Metoprolol acid
- Mianserin
- Mirtazapine
- N1\_Acetylsufamethaxazole
- N4\_Acetylsufamethaxazole
- N-Desmethylcitalopram
- O-Desmethylvenlafaxine
- Orphenadrine
- Oxazepam
- Oxcarbazepine
- Pizotifen
- Propranolol
- Ropinirole
- Sertraline
- Sotalol
- Sulfadiazine
- Sulfamerazine
- Sulfamethazine
- Sulfamethizole
- Sulfamethoxazole
- Sulfapyridine
- Tamoxifen
- Telmisartan
- Terbinafine
- Tramadol
- Trimethoprim
- Valsartan
- Venlafaxine
- Verapami

---

## 2.18. Organotin compounds (TBT, TFT, DBT, DOT)

In general, organic tin compounds are very persistent and accumulate very easily in organisms. The substances are highly toxic to aquatic organisms and some are classified as hazardous and highly toxic, with long-term effects on aquatic life. TBT and TPT are both endocrine-disrupting and toxic to warm-blooded animals. TBT can be broken down in nature into dibutyltin (DBT) and monobutyltin compounds (MBT). DBT and DOT are persistent and accumulate in organisms. These two compounds are also believed to be toxic for aquatic organisms.

From 1990, it has been forbidden to use organic tin compounds in antifouling agents for small boats and net impregnating agents. From 2003, this ban was extended to cover the use of antifouling agents that contain TBT or TFT on ships over 25 metres in length. From 2008, these kinds of antifouling agents were banned completely. According to the product register, approximately 105 kg DBT compounds and 5 kg DOT compounds were used in Norway in 2007. TBT and TFT have been added to the priority list of the Norwegian authorities. Emissions of TBT and TFT have not been recorded since 2003, although small amounts of TBT have been recorded in leachate from municipal landfills (Sørensen, 2012 and Environment.no, 2013). The following substances have been analysed in this survey:

- Dibutyltin oxide
- Dioctyltin oxide
- Tributyltin

---

## 2.19. BTEX, trichlorethylene, and other chloro-organic compounds

There were no original plans to analyse BTEX, trichlorethylene, HCH/HCB and DDT, but for technical reasons those substances were analysed and included in the report by the laboratory. BTEX and trichlorethylene were analysed in grab samples of sludge together with analyses for siloxane and are considered as snapshot values. The other chloro-organic compounds were analysed in monthly samples. The analysis results are included in this report as part of Appendix 1. They are presented as raw data and are not commented further in the report. Except for BTEX and trichlorethylene, the other chloro-organic compounds represent pesticides that are banned, such as lindane and DDT. Trichlorethylene is primarily used in the industrial degreasing of metals. This use represents around 96 per cent of all recorded usage. The substance is also used in laboratory chemicals. BTEX is an acronym for Benzene, Toluene, Ethylbenzene and Xylene which are volatile compounds used in oils and oil products.

## 3. About the survey

### 3.1. Treatment plants included in the survey

Eighteen treatment plants have been involved in this survey, with one of the plants (Lindum) providing samples both before and after digestion. Solumstrand, Knappen, NRA, Tønsberg and ÅRIM have also taken samples of raw sludge; i.e. samples before treatment such as digestion, composting and lime application. VEAS has taken samples of lime-treated sludge (lime application in connection with dewatering). When comparing the different treatment plants, it is important to consider the different treatment methods being used. Digested sludge will most likely contain higher concentrations of persistent organic pollutants compared with raw sludge. It is therefore not possible to directly compare sludge from the different treatment plants.

The plants that have been involved in the survey are:

Bekkelaget Plant, Bergen Biogas Plant, Fuglevik Plant (MOVAR), Gardermoen Plant, Hias IKS, Høvingen Plant, Knappen Plant, Ladehammern Plant, Lindum, Nedre Romerike Avløpsselskap IKS (NRA), Rambekk Plant, Sandefjord Plant, Nord Jæren Central Treatment Plant (SNJ, IVAR), Solumstrand Plant, Tønsberg Plant (formerly TAU), VEAS, Øra Plant (FREVAR) and septic sludge from two treatment districts in Ålesund Municipality (ÅRIM). A brief description of these plants is given in Table 3.1 and their locations are shown in the map below.



**Table 3.1. Information on the treatment plants involved in the survey in 2017/18.**

No	Treatment plant	Capacity (pe) - Associated (pe)	Amount of sludge 2017 (tonnes/year - tonnes TS/ year)	Wastewater treatment	Chemicals	Sludge treatment methods	Industrial connection / sludge from other plants
1	Bekkelaget Plant (Oslo)	270,000 - 320,000	21,819 - 6,181	Nitrogen removal, active sludge, simultaneous precipitation with iron sulfate. Sand filter. When high water volumes, a partial stream bypass the biological filter; this stream is precipitated directly before going to sand filters.	Iron sulfate for simultaneous precipitation. Sometimes, PAX and polymers for primary precipitation	Thermophilic digestion at 55°C Pumping in batches with retention time of two hours.	Almost no industry.
2	Bergen biogas Plant (new)	2 chemical/biological plants: 44,000 pe + 132,000 pe, 2 biological plants 54,000 pe + 152,000 pe, 1 chemical plant 63,000 pe 3 small biological/chemical plants (only 100-650 pe), - all pe figures relate to capacity	10,334 - 2,893 (rapportert: 5,714 - 600) <sup>3)</sup>	Chemical/biological plants: MBBR + Actiflo -i.e. some iron chloride dosing) Biological plant: active sludge Chemical plant (Knappen RA - see below).	PAX, iron chloride, Al salt	Desalting of sludge, hygenisation in connection with pasteurisation - 70 degrees in an hour, thermophilic digestion in centrifuges.	In addition to sludge from various treatment plants, this plant also receives grease from grease traps/treatment plants (only after 01/01/2018) and septic sludge (small amount in 2017) Some of the sludge plants which deliver to the biogas plant have a lot of industry (hospitals, food production, petrol stations) while others have mostly sanitary sewage from private households.
3	Fuglevik Plant (Moss)	80,000 - 80,000	2,636 - 683 <sup>4)</sup> (Normal: 3,067 - 779)	Primary precipitation	Iron chloride sulfate and PAX 18	Aerobic pretreatment and mesophilic anaerobic stabilisation	Airports, some food industry, various other industries
4	Hias IKS (Hamar)	150,000 - 117,000	6,140 - 2,174	Biological treatment and chemical post-precipitation	Ekoflock 90/96	Thermal hydrolysis mesophilic anaerobic stabilisation	A lot of the food industry
5	Høvringen Plant (Trondheim)	170,000 - 170,892	5,233 - 1,799	Mechanical treatment. Precipitation with polymers	Polymer: Superfloc c-491 HMW (Kemira)	Pasteurisation + stabilisation w/digestion (Biogas Plant)	No major industry, but facilities such as the Norwegian University of Science and Technology, St. Olav's Hospital and waste reception facilities such as Heggstadmoen. Town centre. They receive small amounts of sludge from Leirfallet and Byneset Plant. This goes directly into the Selsbakk tunnel.
6	Gardermoen Plant (Ullensaker)	57,400 - 78,388	5,152 - 1,185	Biological nitrogen treatment and chemical post-precipitation	Ekoflock 90	Thermophilic anaerobic stabilisation	Not much connection with industry, besides taking wastewater from Gardermoen Airport. Receives sludge from Kløfta Plant, which is a mechanical/chemical plant; precipitant is Pax 18, capacity is 12,000 pe (BOF <sub>3</sub> ) and 12,774 pe (BOF <sub>5</sub> ).

Continues next page

No	Treatment plant	Capacity (pe) - Associated (pe)	Amount of sludge 2017 (tonnes/year - tonnes TS/ year)	Wastewater treatment	Chemicals	Sludge treatment methods	Industrial connection / sludge from other plants																																
7	Knappen Plant (Bergen)	63,000 - 49,168	4,995 - 1,399	Chemical precipitation (requirement for 90% phosphorus removal) with sedimentation	PAX (+ some iron chloride), polymers for dewatering	Thickening through use of gravitational thickeners and then centrifuges	Not much industry, but there is a connection to a dairy.																																
8	Ladehammeren Plant (Trondheim)	120,000 - 106,575	5,000 - 1,750	Primary precipitation mechanical/chemical	PAX-18	Pasteurisation with mesophilic anaerobic stabilisation	Brewery, dairy, chocolate factory, paper factory (own emissions of process water), assisted living facility, other industry																																
9	Lindum (Drammen)	-	8,945 - 3,310	Biogas plant which receives sludge from various treatment plants	Muusøya and Svelvik use calcium precipitation while the others use precipitation with Fe, Al and a mix of these.	Thermal hydrolysis mesophilic anaerobic stabilisation. Samples have been taken from raw sludge and treated sludge	<table border="1"> <thead> <tr> <th>Treatment plant</th> <th>Sludge intake tonnes/year - tonnes TS/year</th> </tr> </thead> <tbody> <tr> <td>Lersbryggen</td> <td>796 - 180.5</td> </tr> <tr> <td>Bokerøya</td> <td>763 - 242.6</td> </tr> <tr> <td>Hokksund</td> <td>1,823.8 - 475.6</td> </tr> <tr> <td>Mjøndalen</td> <td>3,031.5 - 651.8</td> </tr> <tr> <td>Solumstrand</td> <td>9,582.2 - 2,611.1</td> </tr> <tr> <td>Muusøya</td> <td>2,630.7 - 910</td> </tr> <tr> <td>Viva IKS</td> <td>1,268.6 - 300.6</td> </tr> <tr> <td>Aurskog- Høland</td> <td>1,722.5 - 464.2</td> </tr> <tr> <td>Sandefjord</td> <td>37.2 - 10</td> </tr> <tr> <td>Nes</td> <td>45.6 - 10.7</td> </tr> <tr> <td>Sum</td> <td>21,702 - 5,857</td> </tr> <tr> <th>Industrial treatment plants</th> <th>Sludge intake tonnes/year - tonnes TS/year</th> </tr> <tr> <td>Pronova</td> <td>34.8 - 2</td> </tr> <tr> <td>Mills</td> <td>654.4 - 65.4</td> </tr> <tr> <td>Sum</td> <td>689.2 - 67.4</td> </tr> </tbody> </table>	Treatment plant	Sludge intake tonnes/year - tonnes TS/year	Lersbryggen	796 - 180.5	Bokerøya	763 - 242.6	Hokksund	1,823.8 - 475.6	Mjøndalen	3,031.5 - 651.8	Solumstrand	9,582.2 - 2,611.1	Muusøya	2,630.7 - 910	Viva IKS	1,268.6 - 300.6	Aurskog- Høland	1,722.5 - 464.2	Sandefjord	37.2 - 10	Nes	45.6 - 10.7	Sum	21,702 - 5,857	Industrial treatment plants	Sludge intake tonnes/year - tonnes TS/year	Pronova	34.8 - 2	Mills	654.4 - 65.4	Sum	689.2 - 67.4
Treatment plant	Sludge intake tonnes/year - tonnes TS/year																																						
Lersbryggen	796 - 180.5																																						
Bokerøya	763 - 242.6																																						
Hokksund	1,823.8 - 475.6																																						
Mjøndalen	3,031.5 - 651.8																																						
Solumstrand	9,582.2 - 2,611.1																																						
Muusøya	2,630.7 - 910																																						
Viva IKS	1,268.6 - 300.6																																						
Aurskog- Høland	1,722.5 - 464.2																																						
Sandefjord	37.2 - 10																																						
Nes	45.6 - 10.7																																						
Sum	21,702 - 5,857																																						
Industrial treatment plants	Sludge intake tonnes/year - tonnes TS/year																																						
Pronova	34.8 - 2																																						
Mills	654.4 - 65.4																																						
Sum	689.2 - 67.4																																						
10	Nedre Romerike Avløpselskap (NRA) <sup>1</sup> (Lillestrøm)	100,000 - 130,000	19,223 - 7,304	Biological nitrogen treatment and chemical precipitation	PAX 18	The Orsa method (burnt lime)	Some industry, Coca Cola - process water																																
11	Rambekk Plant (Gjøvik)	45,000 - 30,000	2,121 - 1,909	Secondary purification with pretreatment, pre-sedimentation, flocculation and post-sedimentation.	EcoFlock 90 (Aluminum chloride)	Mesophilic anaerobic stabilisation, thermal drying	Different types of industry: oil separators, food industry, laundries, textiles, surface treatment, waste recycling and leachate from landfills Rambekk processes sludge from its own treatment plant and from Søndre and Nordre Land, Østre and Vestre Toten, Lillehammer, Øyer and Gausdal. These municipalities have different industries: including metallurgy, surface treatment, food businesses, textiles, laundries, scrapyards, leachate from landfills, incineration plants, 15 plants.																																

No	Treatment plant	Capacity (pe) - Associated (pe)	Amount of sludge 2017 (tonnes/year - tonnes TS/ year)	Wastewater treatment	Chemicals	Sludge treatment methods	Industrial connection / sludge from other plants
12	Sandefjord Plant (Sandefjord)	41,100 - 79,137	4,524 - 1,077	Primary precipitation	Pax 1800	Pasteurisation with anaerobic stabilisation	Food industry
13	Nord Jæren Central Treatment Plant - SNJ (Stavanger)	400,000 - 300,000	1,400 - 1,300 (Normal: 4,000 -3,500) <sup>5)</sup>	Hydrotech drum filter, 100 um for approx. every 50% SS removal; Active sludge with biological P removal	None	Anaerobic digestion, dewatering and drying of sludge	Some industry; approx. 5% of total load
14	Solumstrand Plant (Drammen)	130,000 - 60,242	9,460 - 2,573	Mechanical (shaking, sand and grease traps), MBBR and Activated sludge	-	Gravitational thickeners, thickening machine, centrifuge. Sludge is delivered to Lindum for biogas production.	Aass Brewery, Mills and Lindum. Equivalent phosphorus pe of 5,739 (estimate)
15	Tønsberg Plant <sup>2)</sup> IKS (Tønsberg)	160,00 - 117,640	20,744 - 7,281	Mechanical - biological - chemical	Ferric chloride (Kemira Pix 318) up until 10/01/2018. Then aluminium (Kemtyl - Ekomix 1091)	The Orsa method (burnt lime)	4 large food companies and reject from Greve Biogas Plant. Insignificant amount of metal processing industry. 2 landfills (50,000 pe)
16	VEAS (Oslo/ Bærum/Asker)	750,000	38,040 - 16,966	Precipitation and biological nitrogen treatment	PAX XL61 and PIX318	Mesophilic anaerobic digestion, lime conditioning, drying in chamber filter presses	Not much industry, mostly households and offices, leachate from two landfills, wastewater from several large hospitals
17	Øra Plant (Fredrikstad)	120,000 - 80,000	9,600 - 2,700	Mechanical and chemical precipitation	Iron chloride	Pasteurisation with thermophilic anaerobic stabilisation and dewatering	Lots of food industry, other heavy process industry and leachate from landfills
18	Årim (Ålesund)	-	1,246 - 249	The septic sludge is dewatered and sent to the Åse treatment plant in Ålesund	-	Raw sludge/septic sludge. Dewatered sludge in two treatment districts	Septic sludge from two treatment districts: Ålesund and Gisle

<sup>1)</sup> Formerly known as RA-2 Plant.

<sup>2)</sup> Formerly known as TAU. This information is used to compare results from previous surveys.

<sup>3)</sup> Bergen Biogas only produces digestate from June until the end of the year. Annual production is two amounts of digestate from the last half year.

<sup>4)</sup> In 2017, sludge production at Fuglevik was somewhat lower than normal due to a review of the digesters (which entailed a few months of downtime). The normal is an average for the last five years.

<sup>5)</sup> In 2007, sludge production for SNJ was considerably less than normal due to reconstruction of the treatment plant and its sludge treatment. The normal is the same as in 2016.

---

## 3.2. Sampling plan

Sludge samples were taken over a course of five months from October 2017 through to February 2018. Five monthly samples were taken from 18 treatment plants/biogas plants in addition to raw sludge from Lindum Biogas and five grab samples from 13 of the plants. The entire survey consisted in total of:

- 95 monthly combined samples that have been analysed for base substances (18 treatment plants)
- 70 monthly combined samples that have been analysed for substances in additional package 1 (13 treatment plants)
- 70 grab samples that have been analysed for siloxanes (the same 13 treatment plants as above)
- 70 monthly combined samples that have been analysed for LAS and PFOS (15 treatment plants)
- 20 monthly combined samples that have been analysed for TBT (4 treatment plants)

Rilsan bags have been used to contain the samples. The samples were stored in a freezer box and sent via overnight mail to COWI which collected all of the samples, divided them down and sent them to the laboratory at the end of the sampling period.

A sampling plan and procedure was developed for this survey; see Annex 3.

---

## 3.3. Methods of analysis

The samples were analysed at the Laboratory of Environmental Chemistry and Biochemistry (LECHB) at the Faculty of Fisheries and Protection of Waters (FFPW), University of South Bohemia, České Budějovice (USB CB), and at the water laboratory Povodí Labe, státní podnik, in the Czech Republic. This latter laboratory provides complex and specialised advice on laboratory work, both nationally and to the EU. Povodí Labe also has the status and distinction of reference laboratory for the ring testing of substances in water in the EU. The laboratory's chief analyst is also an advisory member of the EU's PBT screening programme.

The laboratory complies with the quality system in accordance with ČSN EN ISO / IEC 17025 and is accredited by a certificate issued by the Czech Accreditation Institute (testing, sampling). It also holds a permit for the measurement and evaluation of natural radionuclide content (SÚJB).

## 4. Results and discussion

### 4.1. PAH<sub>16</sub>

PAH was detected in all 95 samples from all the 18 treatment plants. PAH varies from 174.8 to 6,767 µg/kg TS with a mean value of 1,692 µg/kg TS and a median value of 1,322 µg/kg TS; see Figure 4.1.

Since 2012/13, both the median and mean values have increased, although the values are lower than they were in 2006/07. The low concentrations in 2012/13 are partly due to high detection limits (10–250 µg/kg TS for individual PAHs). Since values below the detection limits are set to zero before summation, a high detection limit can result in a lower sum for PAH<sub>16</sub>. The detection limit for this survey was 5–10 µg/kg TS and fewer values were reported under the detection limit than in previous surveys.

Moreover, since 2001/02 there has been greater variation between treatment plants than there has been variation between sampling years. Some treatment plants have shown stable PAH concentrations (Bekkelaget, Knappen, Rambekk) while others have seen an increase (Høvringen, SNJ, Solumstrand, VEAS) or a reduction (Fuglevik, Ladehammeren, Sandefjord, Tønsberg, Øra); see Figure 4.2.

The PAH compounds with the highest concentrations in the 95 sludge samples from 2018/19 were phenanthrene and pyrene > fluoranthene > naphthalene and fluorene > acenaphthene > benzo(b)fluoranthene > benzo(a)anthracene and chrysene > indeno(1,2,3-cd)pyrene > benzo(a)pyrene > anthracene > dibenzo(a,h)anthracene > acenaphthylene > benzo(k)fluoranthene > benzo(g,h,i)pyrene. The first six compounds have a mean value of between 100 and 300 µg/kg TS in the 95 samples, while the average value for the rest of the compounds was between 12 and 80 µg/kg TS.

The Norwegian Scientific Committee for Food and Environment (VKM) has assessed the risk for PAH in wastewater sludge used on Norwegian soil (Eriksen et Al., 2009). The sludge concentration from that study was 1.8 mg/l for a sum of PAH<sub>16</sub> which is around the same level as the average in this study. The risk quotient (RQ) for soil organisms was far below 1 for all 16 PAHs. For aquatic organisms, the RQ was also <1 although closer to 1 for 2 of the PAHs (0.99 for pyrene and 0.88 for indeno(1,2,3-cd)pyrene). For humans that consume food produced on soil that has been fertilised by sludge, the calculated maximum intake of PAH<sub>4</sub> was 0.08 µg/kg BW/day which is far below the acceptable intake of 340 µg/kg BW/day for PAH<sub>4</sub>: benzo(a)pyrene, chrysene, benzo(a)anthracene and benzo(b)fluoranthene. These calculations apply for the highest dose of 60 tonnes of sludge per hectare over 10 years and for humans with the highest intake of the main source. VKM considered PAHs in sludge to be of a low risk to the environment and to public health.

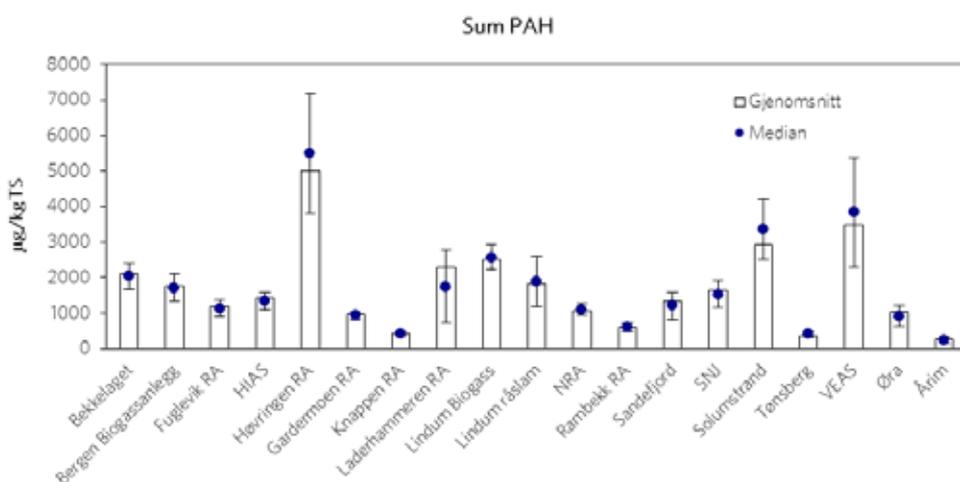
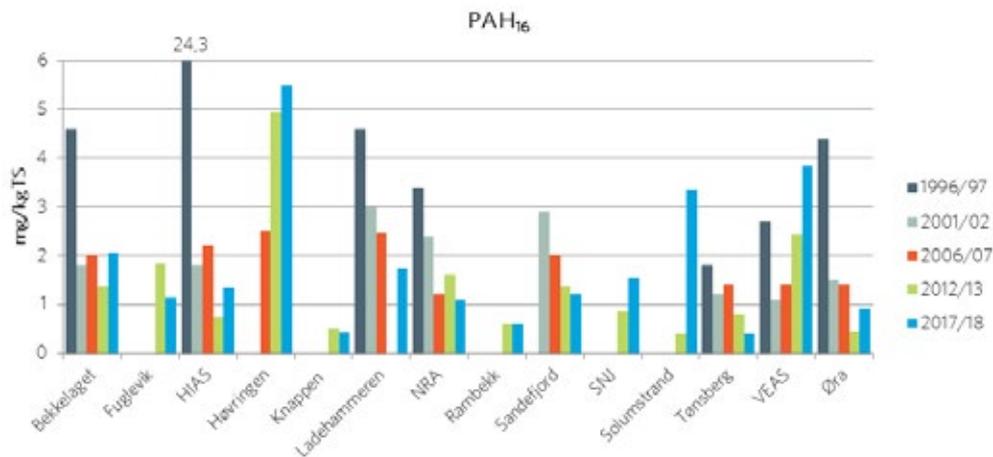


Figure 4.1. Results for PAH<sub>16</sub> in 2017/18 with mean, median and standard deviation.



**Figure 4.2.** Comparative data (PAH<sub>16</sub>, median values) 1996–2018. Sandefjord has been included in the survey since 2001/02, Høvingen since 2006/07, Fuglevik, Knappen, Rambekk, SNJ and Solumstrand since 2012/13. Ladehammeren was not involved in the survey for 2012/13.

**Table 4.1.** Concentration of PAHs ( $\mu\text{g}/\text{kg TS}$ ) in sludge from various surveys in Norway.

Min-Max	Median	Average	90 % percentile	Amount	Reference
0,7-30	4,10	6,1	14,2	35	Paulsrud et al 1997
0,86-4,3	1,8	2,1	3,40	40	Nedland 2002
0,62-3,7				12	Nedland og Paulsrud, 2006
0,44-5,0	1,9	2,0	3,0	44	Blytt, 2007
0,07-8,1	0,93	1,42	2,7	75	Blytt et al 2013
<b>0,17-6,8</b>	<b>1,3</b>	<b>1,7</b>	<b>3,4</b>	<b>95</b>	<b>This survey</b>

## 4.2. Brominated flame retardants

BFR were found in all samples. The average value of the sum of PBDE was 372  $\mu\text{g}/\text{kg TS}$  and the median value was 236  $\mu\text{g}/\text{kg TS}$ . The BFR with the highest concentration was PBDE 209 or decaBDE. This substance represents more than 90 % of the sum of PBDE with an average value of 352  $\mu\text{g}/\text{kg TS}$  and a median value of 230  $\mu\text{g}/\text{kg TS}$ .

DBDPE (which was not counted in the sum of PBDE) had the second biggest average value even though it was only detected in 31 out of 95 samples. The detection limit was high (20  $\mu\text{g}/\text{kg TS}$ ).

PBDE 47, PBDE 99, PBDE 206, PBDE 207 all had an average value of between 4 and 6  $\mu\text{g}/\text{kg TS}$ . PBDE 100 had an average value of 1,05  $\mu\text{g}/\text{kg TS}$ . 6 BFH was only detected in 1-5 of 95 samples (PBDE 28, PBDE 49+71, PBDE 66, PBDE 126, PBDE 153, PBDE 154) and 17 were not detected at levels over the detection limit (PBDE 3, PBDE 7, PBDE 15, PBDE 17, PBDE 77, PBDE 85, PBDE 119, PBDE 138, PBDE 156, PBDE 175, PBDE 183, PBDE 184, PBDE 190, PBDE 191, PBDE 196, PBDE 197, PBDE 202)

The average value of the sum of PBDE was 30 % lower than in 2012/13. This is because two of the treatment plants with the highest values have seen a reduction. An overview of the analysis results from the last 12 years does not show a general increase or reduction in values (Figure 4.4, table 4.2).

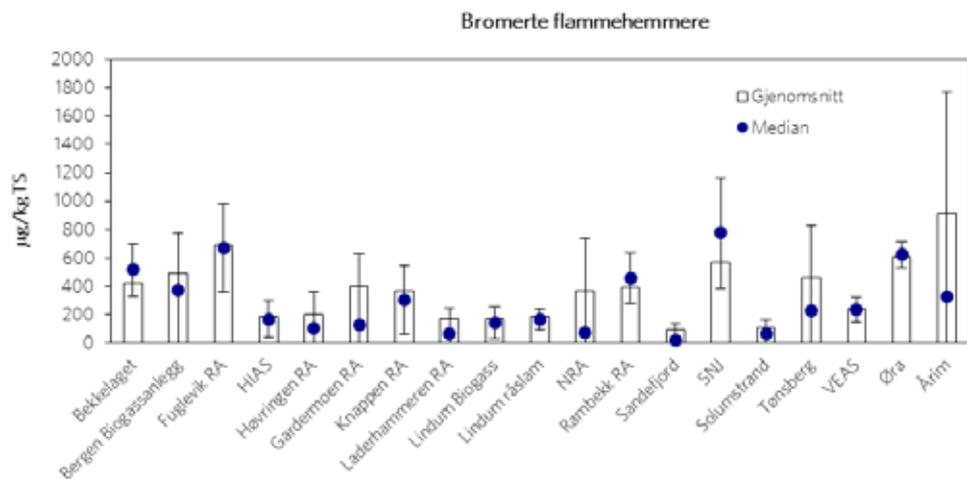


Figure 4.3. Results for brominated flame retardants in 2017/18 with mean, median and standard deviation.

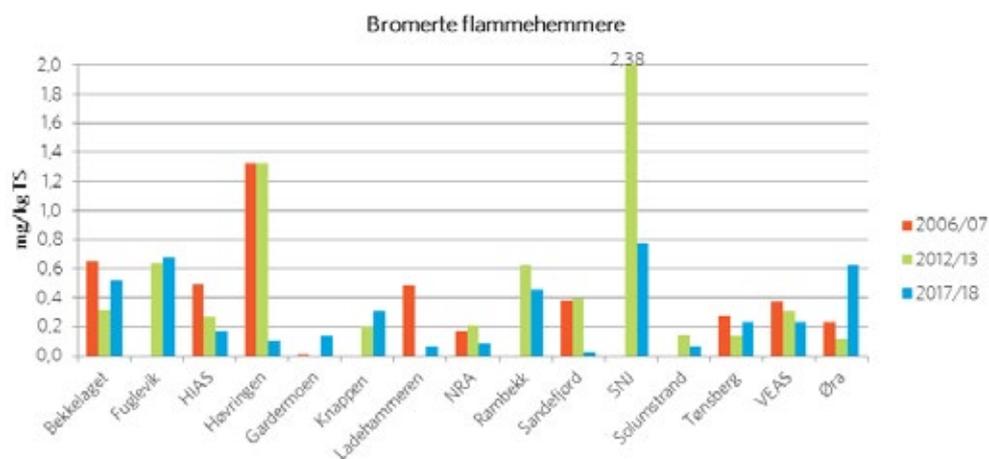


Figure 4.4. Comparative data (BFRs, median values). Fuglevik, Knappen, Rambekk, SNJ and Solumstrand were also involved in the survey for 2012/13. Ladehammaren and Gardermoen were not involved in the survey for 2012/13.

**Table 4.2.** Concentration of brominated flame retardants ( $\mu\text{g}/\text{kg TS}$ ) in sludge from various surveys in Norway.

Substance( $\mu\text{g}/\text{kg TS}$ )	Min	Max	Average	Median	90% perc.	Amount	Reference
11 PBDE <sup>1</sup>	<5	385	78	11		12	Nedland and Paulsrud, 2006
28 PBDE <sup>2</sup>	40	2,219	506	401	920	44	Blytt et al, 2007
5 BDE <sup>3</sup>	2	87	42	39			
BDE-207	2	185	30	16			
DekaBDE	89	1,960	391	285			
Sum 16 BPDE4	51	1,772		335	1,145	24	Thomas et al., 2011
DekaBDE	44	1,710		277			
Sum HBCD ( $\alpha+\beta+\gamma$ )	<LOD	134		7,70			
PBDE <sup>5</sup>	<29	5,125	537	261	1,178	75	Blytt et al, 2013
DekaBDE	49	2,800	453	190			
TBBPA/S derivatives	<LOD	<LOD				6	Konieczny et al, 2017
DekaBDE	230	1,100	462	270	910		
DekaBDE	47	498				37	Fjeld et al, 2007
<b>Sum PBDE</b>	<b>6</b>	<b>3,491</b>	<b>372</b>	<b>236</b>	<b>782</b>	<b>95</b>	<b>This survey</b>
<b>DekaBDE</b>	<b>&lt;2</b>	<b>3,400</b>	<b>352</b>	<b>230</b>	<b>740</b>		

<sup>1</sup> Sum 11 PBDE-: 28, 47, 99, 100, 138, 153, 154, 183, 190, sum of octabrominated diethyl ether and 209

<sup>2</sup> Sum 28 PBDE-: 17, 28, 37, 75, 49, 71, 47, 66, 77, 100, 119, 99, 85, 126, 154, 153,138, 183, 190, 203, 207, 209 and sum of other tri-, tetra-, penta-, hexa-, hepta-, octa- and nona-brominated diphenyl ethers

<sup>3</sup> Sum 5 PBDE-: 47, 99, 100, 153, 154

<sup>4</sup> Sum 17 PBDE 28, 47, 66, 49, 71, 77, 85, 99, 100, 119, 138, 153, 154, 183, 196, 206 and 209

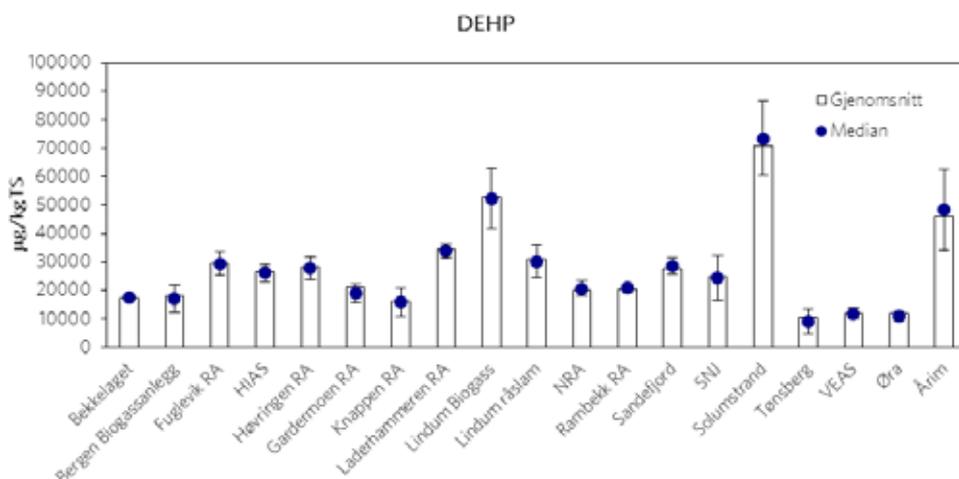
<sup>5</sup> Sum PBDE: tri-, tetra-, penta-, hexa-, hepta-, octa-, nona-, and deca-BDE

### 4.3. Phthalates

Dibutyl phthalate (DBP) was not detected in any of the 95 samples (LOD: 0.1 mg/kg TS). DEHP had an average value of 27.3 mg/kg TS (median 23.7 mg/kg TS).

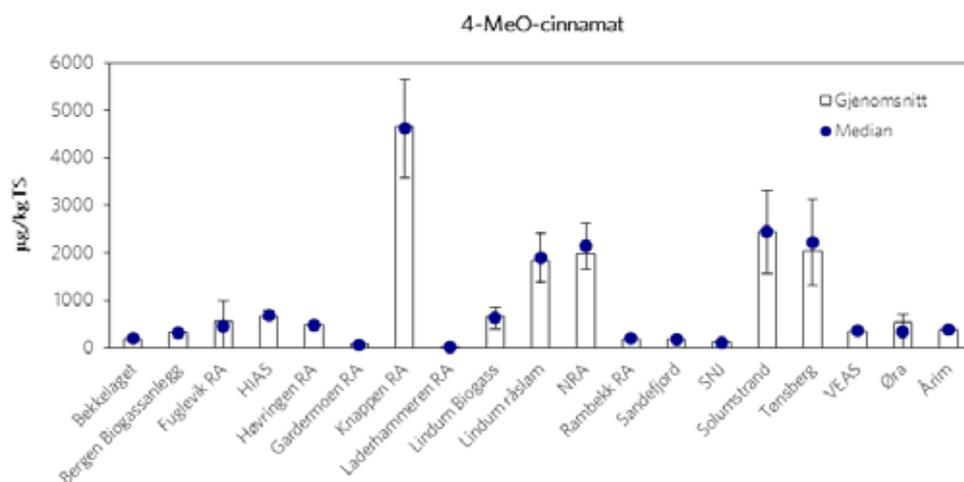
All the treatment plants, except Solumstrand show a lower median value for DEHP. In general, the concentration of both DEHP and DBP has been in steady decline since 1996/97.

VKM has assessed the risk for phthalates in wastewater sludge used on Norwegian soil (Eriksen et Al., 2009). The sludge concentration in VKMs analysis was 49.2 mg/l for DEHP and 0.34 mg/l for DBP which is higher than the average in this study. The risk quotient (RQ) for soil organisms was far below 1 (<0.10 for DEHP, 0.008 for DBP).



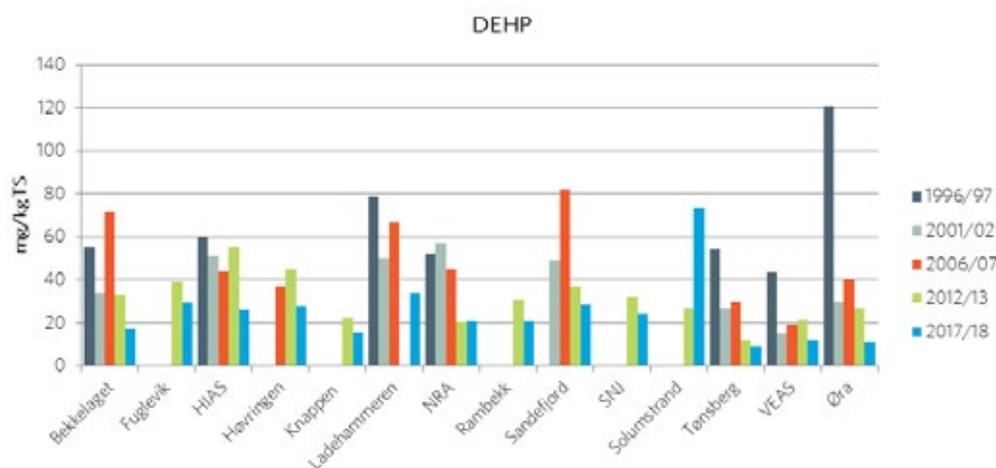
**Figure 4.5.** Results for DEHP in 2017/18 with mean, median and standard deviation.

For humans that consume food produced on soil that has been fertilised by sludge, the calculated maximum intake was 10.5 µg/kg bw/day for DEHP and 0.13 µg/kg bw/day for DBB. This is lower than the tolerable intake of 50 µg/kg bw/day for DEHP and 10 µg/kg bw/day for DBP. These calculations apply for the highest dose of 60 tonnes of sludge per hectare over 10 years and for humans with the highest intake of the main source. VKM considered phthalates in sludge to be of a low risk to the environment and to public health.



**Figure 4.6.** Results for 4-MeO-cinnamate (ethylhexyl methoxycinnamate) in 2017/18 with mean, average and standard deviation.

4-MeO-cinnamate was also analysed and this substance are used as an ingredient in sun cream and lip balm as UV-protector. The compound had an average value of 0.93 mg/kg TS (median 4.0 mg/kg TS) in sludge; see figure 4.6. We have not been able to find comparative data for 4-MeO-cinnamate. This substance is not a priority pollutant. However, this substance has shown negative effects on corals, and some popular places have banned the use of sunscreen with this substance.



**Figure 4.7.** Comparative data (DEHP, median values) 1996 – 2018. Sandefjord has been included in the survey since 2001/02, Høvringen since 2006/07, Fuglevik, Knappen, Rambekk, SNJ and Solumstrand since 2012/13. Ladehammaren was not involved in the survey for 2012/13.

## 4.4. Nonylphenol, nonylphenol ethoxylates and other alkylphenols

Interpreting the results for nonylphenols concentrations can be difficult as some laboratories report nonylphenols (nonylphenols/ nonylphenols tech) while others report 4-n-nonylphenol. The two parameters are often treated as equivalents, but they give widely different results. In this survey, the laboratory reported on both parameters and showed that concentrations of 4-n-nonylphenols are much lower than for nonylphenols tech and that the two concentrations do not correlate. 4-n-nonylphenol was detected above the detection limit (20 µg/kg TS) in only 20 out of 95 samples. Nonylphenol tech was detected in all samples with an average value of 1,079 µg/kg TS and a mean value of 940 µg/kg TS.

The sum of NP+NPE was calculated this year as the sum of nonylphenol tech + nonylphenol monoethoxylate + nonylphenol diethoxylate. The average value was 4,127 µg/kg TS and the median was 3,850 µg/kg TS. This is approximately 20% higher than in 2012/13, although in that study measurements were taken for 4-n-nonylphenol. We can therefore estimate that NP+NPE have declined steadily since 1996–98 (Figure 4.10, Table 4.3)

The average value for the sum of alkylphenols (butyl to octylphenols) was 54.6 µg/kg TS and the median was 52 µg/kg TS. This is approx. 70% lower than in 2012/13. Analyses were undertaken for a few different components but in both 2012/13 and in this survey, 4-t-octylphenols represent approximately 80% of alkylphenols.

Dodecylphenol was detected in 38 out of 95 samples. The average value is assumed to be at the same level as the limit of detection (100 µg/kg TS).

VKM has assessed the risk for nonylphenol (NP), nonylphenol ethoxylates (NPE), octylphenol (OP) and octylphenol ethoxylates in wastewater sludge used on Norwegian soil (Eriksen et al., 2009). The sludge concentration in VKMs analysis was 29.6 mg/kg TS for NP, 24.3 mg/kg TS for NPE and 0.47 mg/kg TS for octylphenol (OP), with these values being significantly lower than the averages in this study. The risk quotient (RQ) for soil organisms was 2.5 for NP and 22 for OP. These calculations apply for the highest dose of 60 tonnes of sludge per hectare over 10 years and right after spreading. For the current level of sludge, the RQ for NP will be less than 1 but for OP it will continue to have an elevated risk. RQ for aquatic organisms is far below 1 for all 4 substances analysed by VKM. For humans that consume food produced on soil that has been fertilised by sludge, the maximum intake is calculated by VKM as being 2.3 µg/kg bw/day for NP and 1.10 µg/kg bw/day for NPE for humans with the highest intake of the main source; 60 tonnes of sludge per hectare over 10 years, which is under the tolerable intake suggested by the Danish Environmental Protection Agency (5 µg/kg bw/day for NP and 13 µg/kg bw/day for NPE, (Nielsen et al, 2000)).

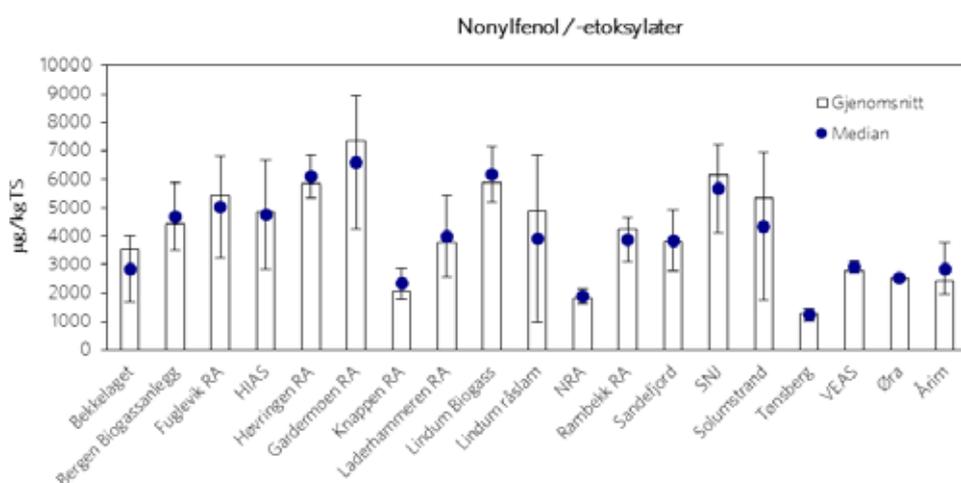


Figure 4.8. Results for nonylphenol and ethoxylates in 2017/18 with mean, median and standard deviation.

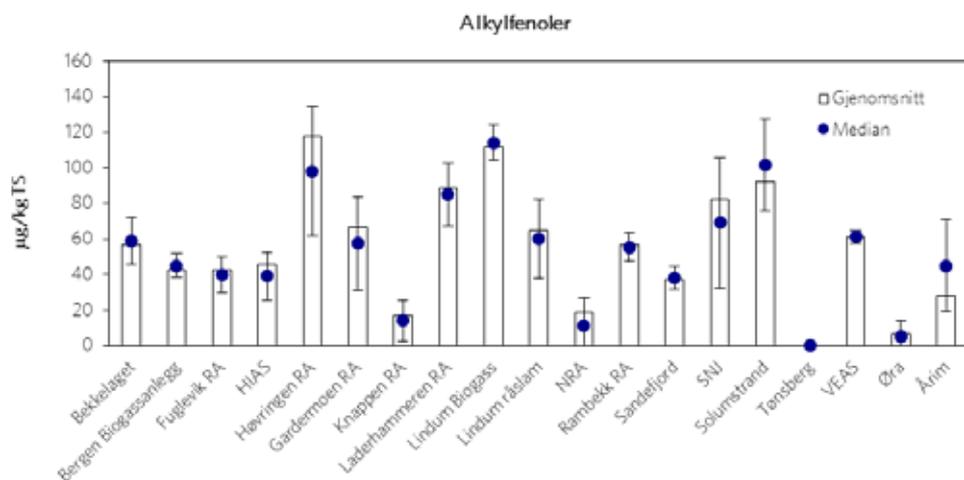


Figure 4.9. Results for sum alkylphenols in 2017/18 with mean, median and standard deviation.

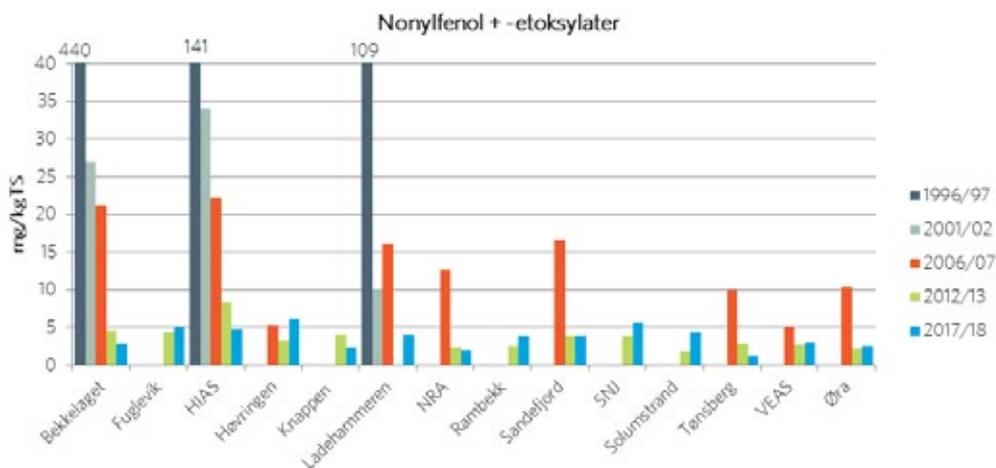


Figure 4.10. Comparative data (nonylphenol and ethoxylates, median values) 1996–2018. Parameters were only measured at Høvringen, NRA, Sandefjord, Tønsberg, VEAS and Øra from 2006/07, and they were only measured from Fuglevik, Knappen, Rambekk, SNI and Solumstrand since 2012/13. Ladehammeren was not involved in the survey for 2012/13.

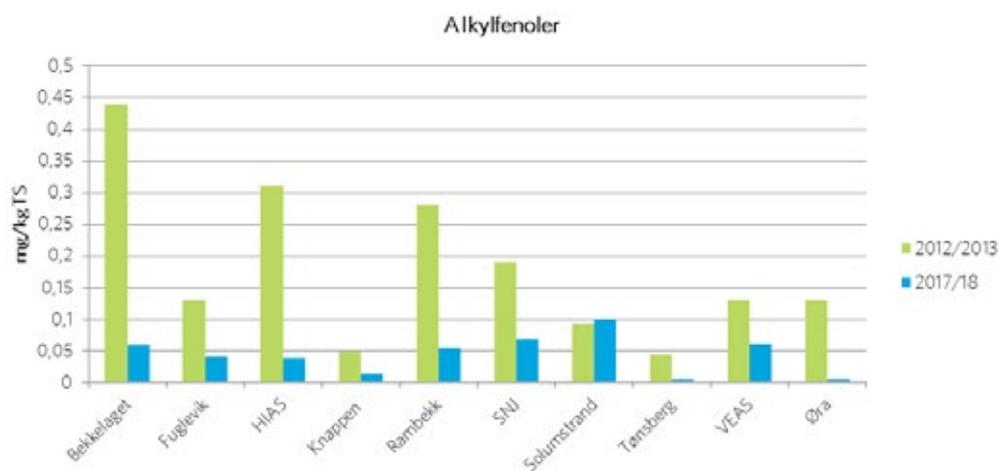


Figure 4.11. Comparative data (alkylphenols, median values) 2013–2018.

**Table 4.3.** Concentration of nonylphenol, nonylphenol ethoxylates and other alkylphenols (mg/kg TS) in sludge from various surveys in Norway.

Substance	Year	Amount	Min-Max	Median	Average	90% perc.	Reference
NP+NPE	2001/02	40	6.3 - 59	25			Nedland, 2002
NP+NPE	2006	12	53.5 - 128	85.2	85.9	113.9	Nedland and Paulsrud 2006
4-n-Nonylphenol			<0.02 - <0.2	-	-	-	
Iso-nonylphenol			12.3 - 44	31.6	29.6	41.4	
NP+NPE	2006/07	44	2 - 41	13.4	14.5	30	Blytt, 2007
Nonylphenoler			1.4 - 27	5	6.58	12	
NP+NPE	2012/13	75	0.2 - 10.5	3.2	3.5	5.7	Blytt et al, 2013
4-n-Nonylphenol			<0.001 - <10	-	-	-	
NP+NPE	<b>2017/18</b>	<b>95</b>	<b>0.9 - 11.4</b>	<b>3.8</b>	<b>4.1</b>	<b>6.6</b>	<b>This survey</b>
4-n-Nonylphenol			<b>&lt;0.02 - 0.061</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>0.04</b>	
Nonylphenoler tech.			<b>0.16 - 4.1</b>	<b>0.9</b>	<b>1.1</b>	<b>1.9</b>	
Sum alkylphenols <sup>1</sup>	2012/13	50	0.93 - 0.04	0.16	0.2	0.4	Blytt et al, 2013
Sum alkylphenols <sup>2</sup>	<b>2017/18</b>	<b>95</b>	<b>&lt;LOD - 0.172</b>	<b>0.052</b>	<b>0.055</b>	<b>0.105</b>	<b>This survey</b>
Dodecylphenol	2009	12	<0.02	-	-	-	Blytt, 2010
Dodecylphenol	2012/13	50	<0.4 - <2.4	-	-	-	Blytt et al, 2013
Dodecylphenol	<b>2017/18</b>	<b>95</b>	<b>&lt;0.1 - 0.79</b>	<b>&lt;0.1</b>	<b>0.111</b>	<b>0.180</b>	<b>This survey</b>

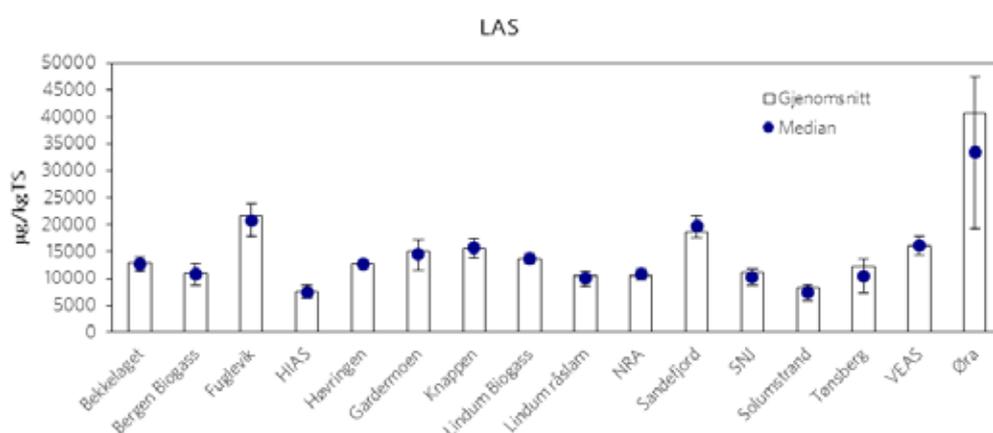
<sup>1</sup> Sum alkylphenols in 2012/13: 4-n-butylphenol, 3-t-butylphenol, 4-t-butylphenol, 4-n-pentylphenol, 4-n-hexylphenol, 4-n-heptylphenol, 4-n-octylphenol, 4-t-octylphenol

<sup>2</sup> Sum alkylphenols in this survey: 4-t-octylphenol, 4-n-octylphenol, heptylphenol, pentylphenol, butylphenol and 3-t-butylphenol. Data below the limit of detection are set to 0 in the summation.

## 4.5. LAS

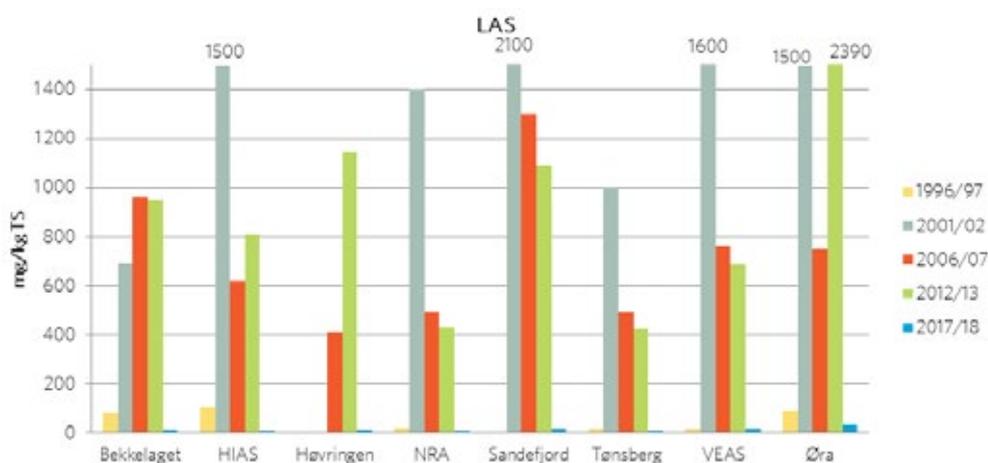
C14-alkyl-benzenesulfonate was not analysed this year, but since most samples were under the level of detection for this substance in 2012, we can estimate that the sum of C10-C13-ABS is approximately equivalent to the sum of C10-C14-ABS. The methods of analysis for LAS vary and since different laboratories have been used in these surveys, the development of LAS concentrations can be attributed to the methods of analysis. This survey shows a very low level of LAS content in sludge compared with previous surveys. There is no reason to assume that the analyses are wrong, but it is difficult to explain this extreme reduction. One possible explanation might be that LAS is not widely used in products anymore and has been replaced by other surfactants.

VKM has assessed the risk for LAS in wastewater sludge used on Norwegian soil (Eriksen et Al., 2009). The sludge concentration in this previous analysis was 1,441 mg/kg TS which is around 100 times higher than the average in this



**Figure 4.12.** Results for LAS in 2017/18 with mean, median and standard deviation.

study. The risk quotient was 1.0 for soil organisms and  $5 \cdot 10^{-5}$  for aquatic organisms. These calculations apply for the highest dose of 60 tonnes of sludge per hectare over 10 years and right after treatment. Overall, VKM assessed that the LAS content in sludge posed a low risk to the environment and to public health. The current levels in sludge do not pose a risk either to soil or aquatic organisms.

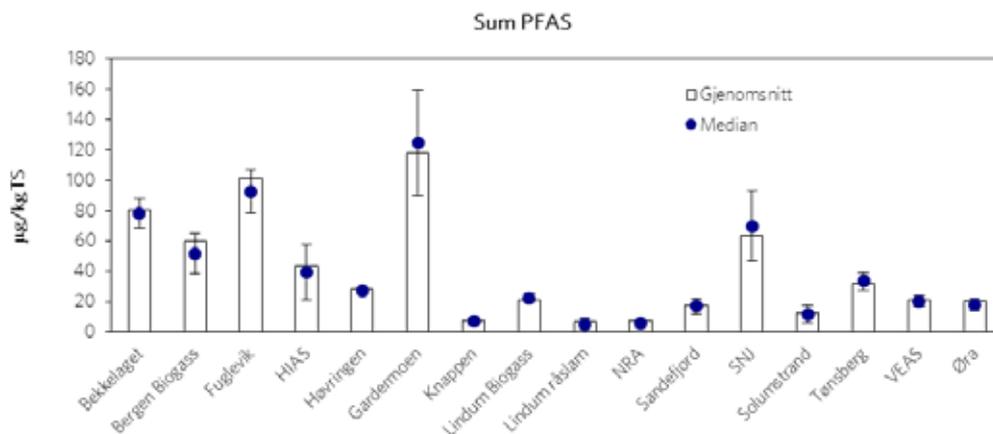


**Figure 4.13.** Comparative data (LAS, median values) 1996–2018. Sandefjord has only been included in this survey since 2001/02 and Høvringen since 2006/07.

## 4.6. PFAS

PFAS was detected in all samples. The average value is  $40 \mu\text{g}/\text{kg TS}$ , while the mean is  $25.2 \mu\text{g}/\text{kg TS}$ . To comparison with the previous survey (2012/13), we have only included the 22 components that were analysed on this occasion. The average value is  $35.7 \mu\text{g}/\text{kg TS}$  and the median is  $22.8 \mu\text{g}/\text{kg TS}$ . It is difficult to compare with previous surveys as different treatment plants were investigated and many of the results were reported as being under the limit of detection. All nine treatment plants studied in 2006/07 had lower average values for PFAS even when additional individual substances were analysed. Two out of three of the treatment plants in 2012/13 had average values in the same magnitude as what is shown now in 2017/18.

SNJ has a higher average value for sum PFAS in this survey than in 2012/13, though in 2012/13 most of the values were reported  $<10 \mu\text{g}/\text{kg TS}$ . If we take into consideration all the substances that were under the limit of detection, then the sum for 22 PFAS at SNJ was between  $3\text{--}197 \mu\text{g}/\text{kg TS}$  in 2012/13 and it is  $54\text{--}94 \mu\text{g}/\text{kg TS}$  in 2017/18.



**Figure 4.14.** Results for sum PFAS in 2017/18 with mean, median and standard deviation.

**Table 4.4.** Average value for PFAS in individual treatment plants from 2006/07 and 2012/13 ( $\mu\text{g}/\text{kg TS}$ ).

Treatment plant	Sum 13 PFAS 2006/07	Sum 22 PFAS 2012/13	Sum 22 PFAS (29 PFAS) This survey
Bekkelaget	45		59 (81)
Fuglevik		103	99 (101)
Gardermoen	1069		105 (118)
Hias	39		38 (44)
Høvringen	55		25 (28)
RA-2/NRA	38		6,6 (7,3)
Sandefjord	42		17 (17)
SNJ		13	54 (64)
Solumstrand		12	12 (13)
Tønsberg	40		30 (32)
VEAS	48		19 (21)
Øra (FREVAR)	37		20 (20)

**Table 4.5.** Concentration of perfluorinated substances ( $\mu\text{g}/\text{kg TS}$ ) in sludge from various surveys in Norway.

Substance	Year	Amount	Amount > LOD	Min-Max	Median	Average	90% percentile	Reference
Sum PFAS* - PFOA - PFOS	2006/07	10	10	12.2 – 1,069 <4 – 15.5 6.1 – 836	40.5 <9 23.2	142 - 102	158 - 129	Blytt, 2007
Sum PFAS* - PFOA - PFOS	2011	32	32	7.7 – 245 <LOD – 4.75 2.6 – 9.6	31.3 <LOD 4.7	44.7 0.72 5.1	76.8 2.26 8.7	Tomas et al 2011
Sum PFAS* - PFOA - PFOS - PFHxS	2012/13	15	7	<LOD – 193 <10 <10 – 180 <10	<LOD <10 <10	64 60	115 108	Blytt et al, 2013
Sum PFAS* - PFOA - PFOS - PFHxS	2016	7	7	117 – 2,703 <LOD 2.9 – 11 110 – 2,700	1,207 5.7 300	1,300 5.8 1,146	2,504 8.7 2,460	Konieczny et al, 2017
<b>Sum PFAS* - PFOA - PFOS - PFHxS</b>	<b>2017/18</b>	<b>80</b>	<b>80</b>	<b>2.63 – 168</b> <b>&lt;0.66 – 9.2</b> <b>1.1 – 130</b> <b>&lt;0.52 – 37</b>	<b>25.2</b> <b>&lt;LOD</b> <b>4.9</b> <b>4.55</b>	<b>40,0</b> <b>0.76</b> <b>13.97</b> <b>8.46</b>	<b>88.5</b> <b>1.13</b> <b>54.1</b> <b>23.2</b>	<b>This survey</b>

\*Sum PFAS 2006/07: FTS-6:2, PFBS, PFBA, PFDcS, PFDcA, PFUnA, PFHxS, PFHxA, PFHpA, PFNA, PFOSA, PFOA, PFOS

Sum PFAS 2011: FTS-6:2, FTS-8:2, PFOA, PFOS, 4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, N-Et FOSA, N-Me FOSA, N-Me FOSE, N-Et FOSE,

Sum PFAS 2012/13: FTS-6:2, HPFH-pA, PF-3,7-DMOA, PFBS, PFBA, PFDS, PFDA, PFDoA, PFHxS, PFHxA, PFHpS, PFHpA, PFNA, PFOSA, PFOA, PFOS, PFPeA,

Sum PFAS 2017: PFHxA, PFHpS, PFHpA, PFNA, PFOA, PFOS, PFPeA,

Sum PFAS this survey: FTS-6:2, FTS-8:2, HPFH-pA, PF-3,7-DMOA, PFBS, PFBA, PFDS, PFDA, PFUnA, PFDoA, PFHxS, PFHxA, PFHpS, PFHpA, PFNA, PFOSA, PFOA, PFOS, PFPeA, PFPeS, PFNS, H2PFDA, H4PFUnA, PFHpS, PFTrA, PFTA, 42FTS, FHpPA, N-Et FOSAA, N-Et FOSE,

## 4.7. PCB<sub>7</sub>

The average value of sum PCB is 16 µg/kg TS in the 95 sludge samples, which is in the same magnitude as the results for 2001/02 (14 µg/kg TS). Values below the limit of detection are expressed as 0 in the summation. The limit of detection is lower than it was in 2001/02 and fewer samples were reported as being under the limit of detection (4 out of 95 samples under the limit of detection in 2017/18 compared with 24 out of 40 samples in 2001/02).

PCB was not analysed in the survey in 2006/07 or 2012/13 due to the low values detected in 2001/02. Few sludge samples include PCB in this period. Two surveys in 2006 and 2016/17 show similar levels of PCB (table 4.6).

VKM has assessed the risk for PCB in wastewater sludge used on Norwegian soil (Eriksen et Al., 2009). The sludge concentration in this previous analysis was 12 µg/kg TS, which is lower than the averages in this study. For humans that consume food produced in soil that has been fertilised by sludge, the maximum intake was calculated by VKM as 0.03 µg/kg bw/day for humans with the highest intake of the main source, 60 tonnes of sludge per hectare over 10 years. This is higher than the tolerable intake (0.02 µg/kg bw/day). Overall, VKM assessed that the sludge posed a low risk to the environment and to public health.

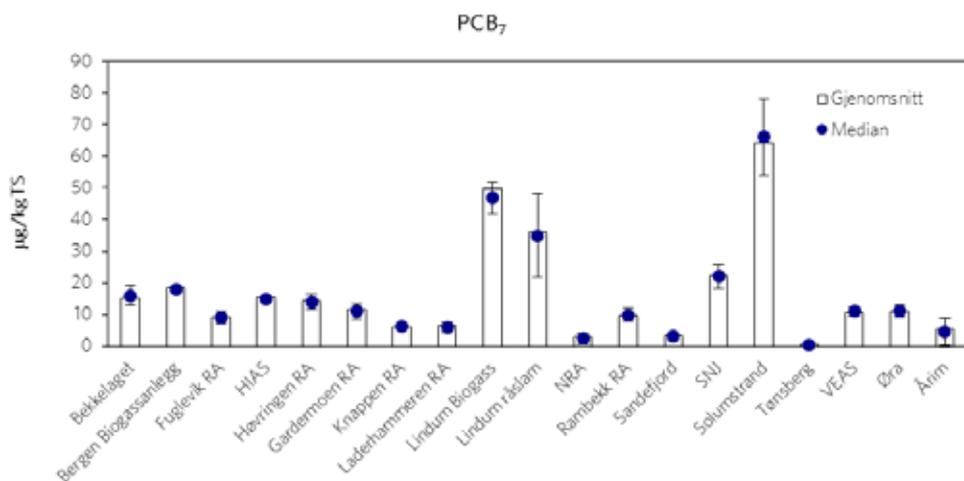


Figure 4.15. Results for PCB<sub>7</sub> in 2017/18 with mean, median and standard deviation.

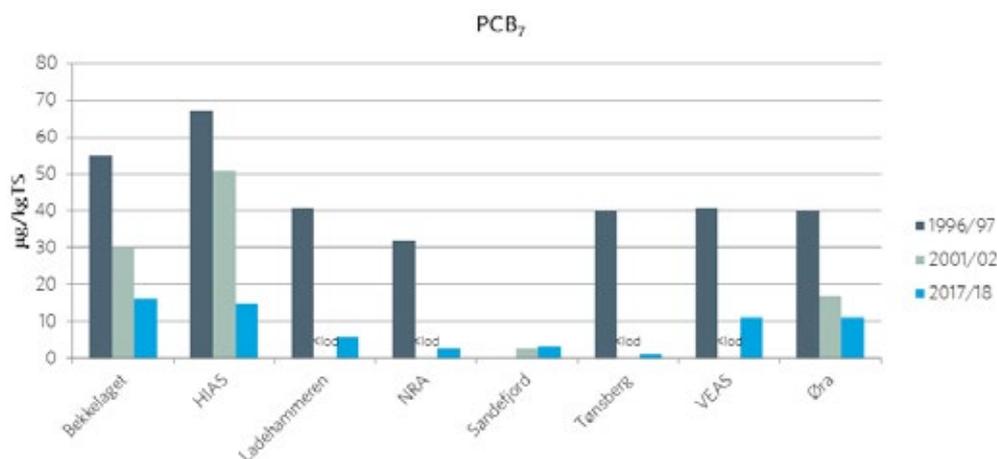


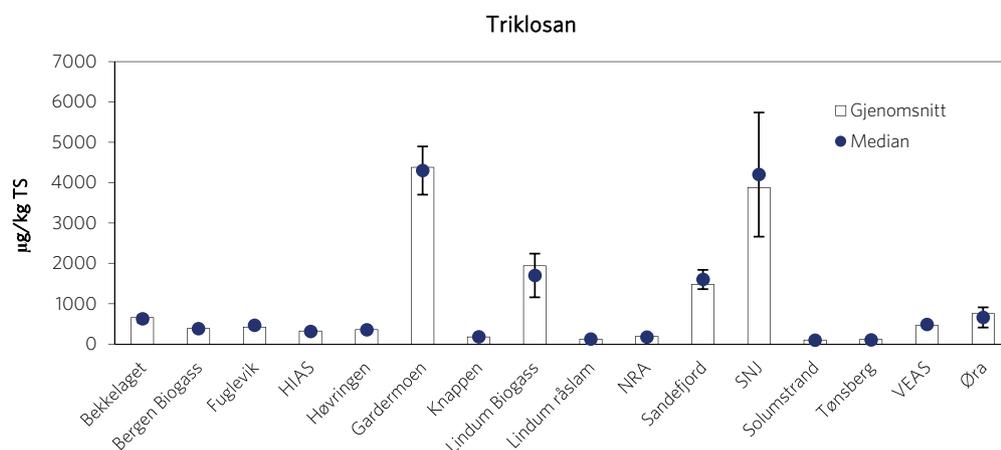
Figure 4.16. Comparative data (PCB<sub>7</sub> median values) 1996–2018. Sandefjord was included in the survey in 2001/02.

**Table 4.6.** Concentration of PCB<sub>7</sub> ( $\mu\text{g}/\text{kg TS}$ ) in sludge from various surveys in Norway.

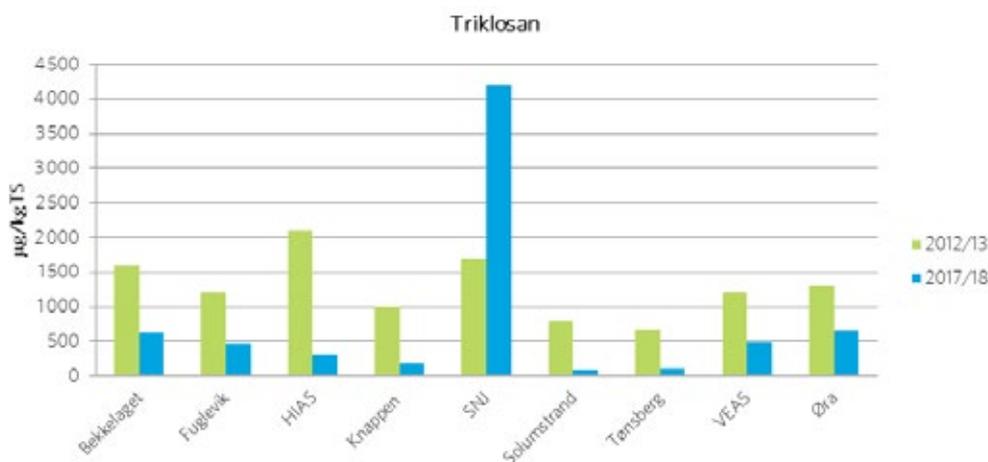
Min-Max	Median	Average	90% percentile	Amount	Reference
16.8-99.6	42.2	47.4	60	35	Paulsrud et al, 1997
<10-96	<10	14	37	40	Nedland, 2002
3.12-48	21.0	21.1	31.4	37	Fjeld et al, 2007
9.1-17.8	14.3	14.2	17	6	Konieczny et al, 2017
<1-77	<b>11</b>	<b>16.5</b>	<b>46</b>	<b>95</b>	<b>This survey</b>

## 4.8. Triclosan

Triclosan was detected in all samples with an average value of 984 and a mean value of 400  $\mu\text{g}/\text{kg TS}$ . Triclosan has a 33 % lower average value and 69 % lower median compared with 2012/13. There were big differences in the results between the treatment plants. The median values for Gardermoen and SNJ are more than ten times higher than the median value for all samples. Methyl triclosan was not detected above the detection limit (5  $\mu\text{g}/\text{kg TS}$ ).



**Figure 4.17.** Results for triclosan in 2017/18 with mean, median and standard deviation.



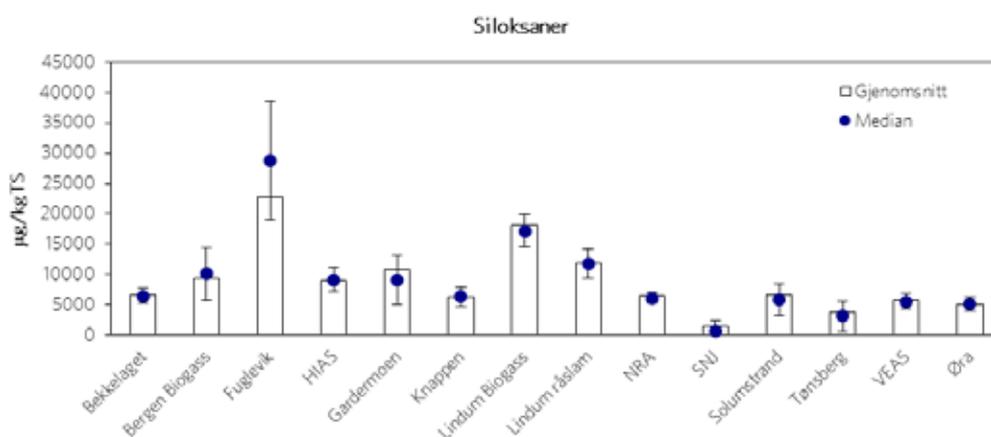
**Figure 4.18.** Comparative data (Triclosan, median) 2012-2018.

**Table 4.7.** Concentration of triclosan (mg/kg TS) in sludge from various surveys in Nordic countries.

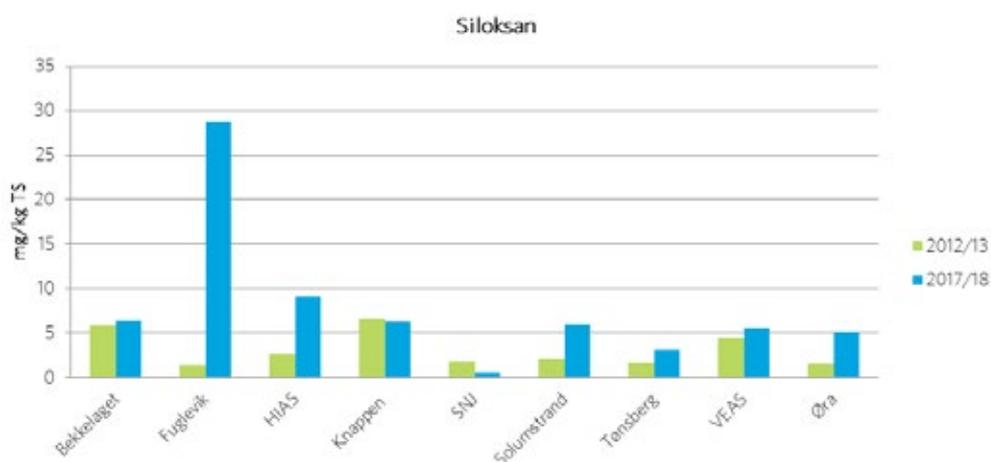
Country	Year	Amount	Variation	Median	Average	Reference
Sweden	2003		0.0028–6.4			Samsøe-Pettersen, 2003
Norway	2006	9	0.95–2.6	1.8	1.8	Blytt, 2007
Denmark	2008	10	0.07–11	3.2	4.4	Mogensen, 2008
Norway	2009	12	0.9–3.3	1.8	1.8	Blytt, 2010
Norway	2011/12	50	0.17–4.8	1.3	1.5	Blytt et al, 2013
<b>Norway</b>	<b>2017/18</b>	<b>80</b>	<b>0.082–5.4</b>	<b>0.4</b>	<b>0.984</b>	<b>This survey</b>

## 4.9. Siloxanes

Siloxanes were detected in all samples. Average value for the sum of siloxanes D4-D6: 8,844 µg/kg TS, median 6,815. This is more than twice the value from 2012/13. D5, the most important siloxane, has increased the least (by approximately 50%) while the concentration of D6 is more than 30 times higher than it was in 2012/13 and D5 is more than ten times higher. The concentration of hexamethyl-cyclotrisiloxane was also ten-fold in the same period. This suggests that manufacturers have begun to replace siloxanes that are on the priority list, but that the overall consumption of siloxanes is increasing.



**Figure 4.19.** Results for sum siloxanes (D4, D5 and D6) in 2017/18 with mean, median and standard deviation.



**Figure 4.20.** Comparative data (siloxanes D4, D5 and D6, median values) 2013–2018.

**Table 4.8.** Concentration of siloxanes (mg/kg TS) in sludge from various surveys in Norway.

Substance	Country	Year	Amount	Min-Max	Median	Average	Reference
D4	Nordic countries	2005	14			0.4	Kaj et al, 2005
	Sweden	2006	1			0.5	Kaj et al, 2007
	Europe	2012	12			0.5	Tavazzi et al, 2012
	Norway	2012/13	48	<0.01-0.34	0.05	0.07	Blytt et al, 2013
	<b>Norway</b>	<b>2017/18</b>	<b>70</b>	<b>0.14-3.8</b>	<b>0.915</b>	<b>0.892</b>	<b>This survey</b>
D5	Nordic countries	2005	14			22	Kaj et al, 2005
	Sweden	2006	1			19	Kaj et al, 2007
	Norway	2009/10	12			29.9	Blytt, 2010
	Europe	2012	12			10.8	Tavazzi et al, 2012
	Norway	2012/13	48	0.08-17	1.77	3.3	Blytt et al, 2013
<b>Norway</b>	<b>2017/18</b>	<b>70</b>	<b>0.034-24</b>	<b>3.2</b>	<b>5.093</b>	<b>This survey</b>	
D6	Nordic countries	2005	14			2.7	Kaj et al, 2005
	Sweden	2006	1			1.9	Kaj et al, 2007
	Europe	2012	12			2.8	Tavazzi et al, 2012
	Norway	2012/13	48	<0.01-0.32	0.03	0.09	Blytt et al, 2013
	<b>Norway</b>	<b>2017/18</b>	<b>70</b>	<b>0.088-8</b>	<b>2.5</b>	<b>2.859</b>	<b>This survey</b>
Decamethyl tetrasiloxane	Norway	2012/13	30	<0.01-0.05	0.02	0.03	Blytt et al, 2013
	<b>Norway</b>	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02-0.11</b>	<b>0.031</b>	<b>0.035</b>	<b>This survey</b>
Dodecamethyl pentasiloxane	<b>Norway</b>	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02-1.5</b>	<b>0.51</b>	<b>0.518</b>	<b>This survey</b>
Hexamethyl cyclotrisiloxane	Norway	2012/13	30	<0.01-0.51	0.13	0.21	Blytt et al, 2013
	<b>Norway</b>	<b>2017/18</b>	<b>70</b>	<b>&lt;0.1-6.2</b>	<b>1.8</b>	<b>2.26</b>	<b>This survey</b>
Octamethyltrisiloxane	Norway	2012/13	30	<0.01-0.07	0.02	0.02	Blytt et al, 2013
	<b>Norway</b>	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02-0.074</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>This survey</b>
Phenyltris(trimethylsiloxy) silane	<b>Norway</b>	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02-0.077</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>This survey</b>

## 4.10. Polycyclic musk compounds

Both galaxolide and tonalide were detected in all samples. The average value for galaxolide was 11,977  $\mu\text{g}/\text{kg}$  TS and the mean was 12,000  $\mu\text{g}/\text{kg}$  TS. The average value for tonalide was 2,747  $\mu\text{g}/\text{kg}$  TS and the mean was 2,650  $\mu\text{g}/\text{kg}$  TS. The concentrations of both substances have roughly doubled since the survey in 2012/13. More musk compounds have been analysed in this survey compared with previous surveys and the analysis values can be found in the appendix.

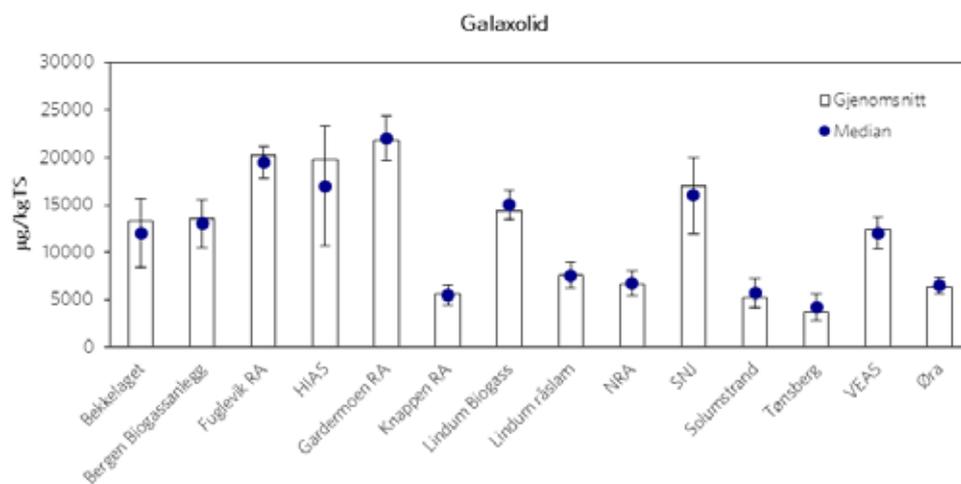


Figure 4.21. Results for galaxolide in 2017/18 with mean, median and standard deviation.

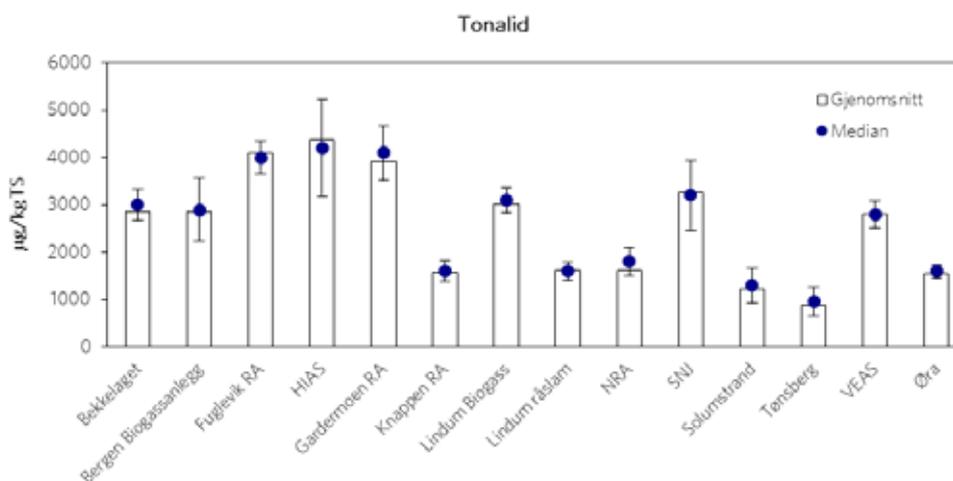


Figure 4.22. Results for tonalide in 2017/18 with mean, median and standard deviation.

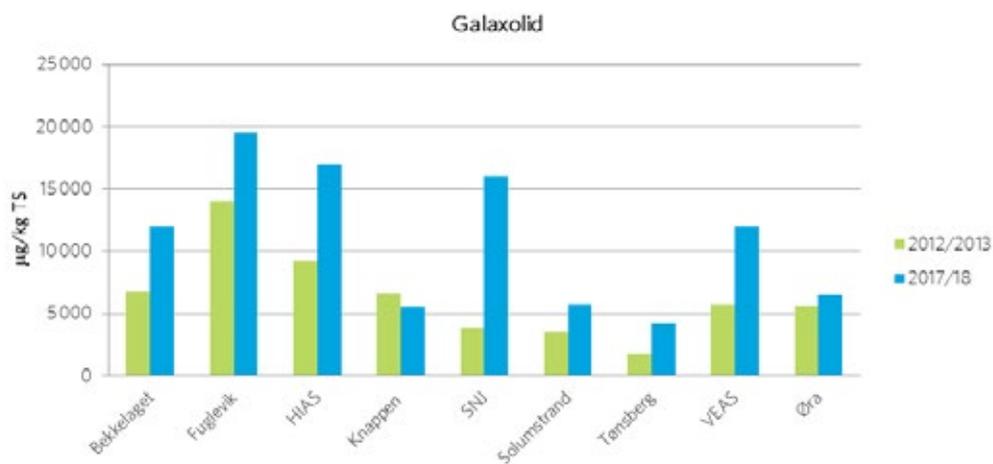


Figure 4.23. Comparative data (galaxolide, median values) 2013–2018.

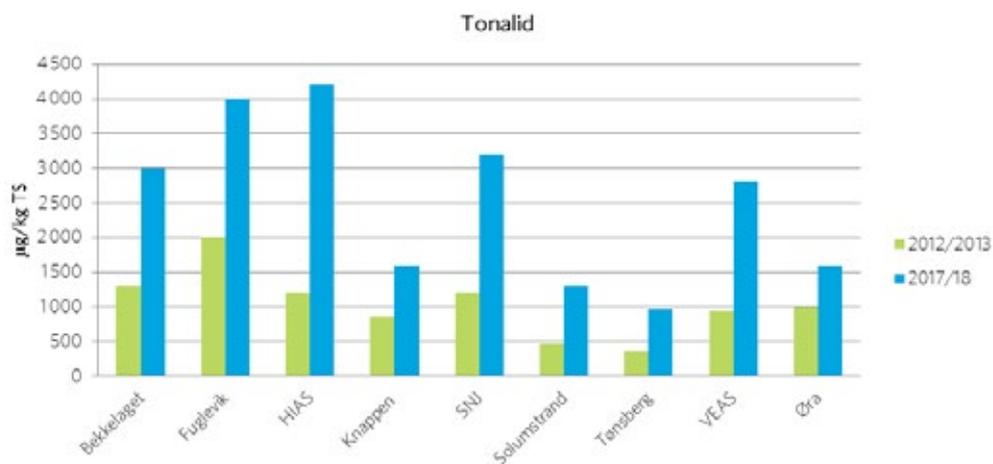


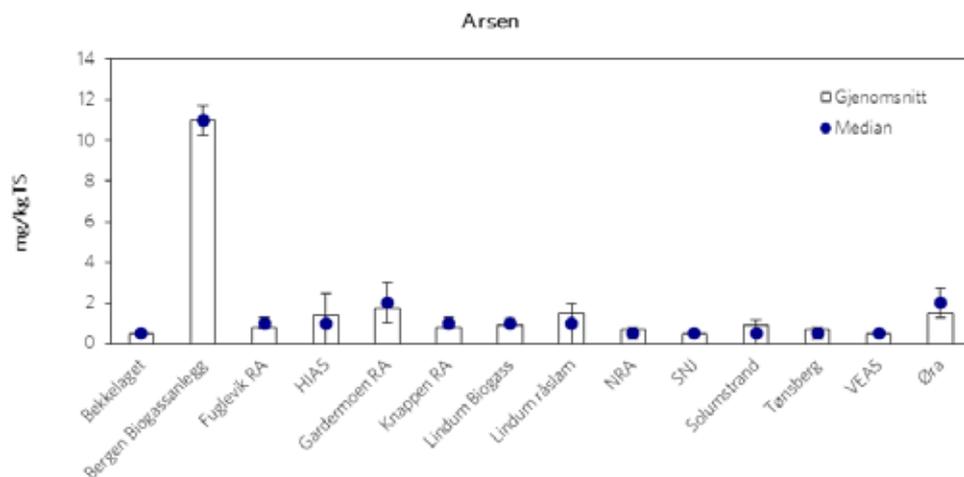
Figure 4.24. Comparative data (tonalide, median values) from 2013 to 2018.

**Table 4.9.** Concentration of musk compounds (mg/kg TS) in sludge from various surveys in Norway.

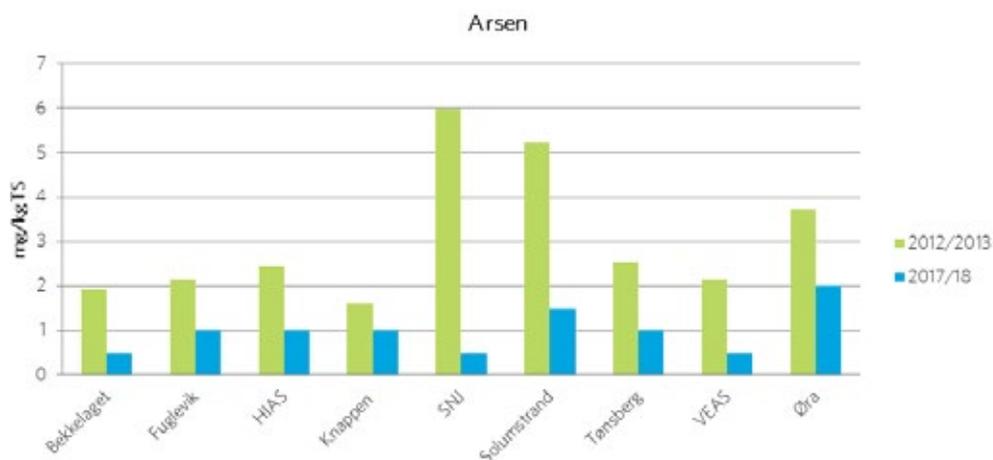
Substance	Year	Amount	Variation	Median	Average	90% perc.	Reference
Galaxolide	2007		07-2.1	1.5	1.4		Blytt, 2008
	2010	24	0.42-26.2	9.5	10.2	18.5	Thomas et al., 2011
	2012/13	49	0.6-23	5.5	6.6	13	Blytt et al, 2013
	2013	10	3.8-6.4	4.2	4.5	4.5	Thomas et al., 2014
	2016	6	8-21	15.0	15.0	20.5	Konieczny et al, 2017
	<b>2017/18</b>	<b>70</b>	<b>2-31</b>	<b>12</b>	<b>12</b>	<b>20.2</b>	<b>This survey</b>
Tonalide	2007		5.4-24	12	5.4		Blytt, 2008
	2010	24	0.06-1.3	0.8	0.7	1.1	Thomas et al., 2011
	2012/13	49	0.05-3.7	1.1	1.1	1.8	Blytt et al, 2013
	2016	6	8.3-22	14.5	14.7	18.5	Konieczny et al, 2017
	<b>2017/18</b>	<b>70</b>	<b>0.51-6.1</b>	<b>2.7</b>	<b>2.5</b>	<b>4.2</b>	<b>This survey</b>
Musk ketone	2006/07	10	<0.017-0.051	<0.029	0.030	0.040	Blytt, 2008
	2012/13	49	<0.001-0.018	<0.001	0.018		Blytt et al, 2013
	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02-0.04</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>25</b>	<b>This survey</b>
Musk xylene	2006/07	10	<0.018-0.039	<0.030	0.017	0.021	Blytt, 2007
	2012/13	49	<LOD				Blytt et al, 2013
	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02-0.04</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>This survey</b>
Galaxolide lactone	2012/13	49	0.64-59	0.007	0.009		Blytt et al, 2013
	<b>2017/18</b>	<b>70</b>	<b>0.14-2</b>	<b>0.048</b>	<b>0.059</b>	<b>0.130</b>	<b>This survey</b>
Cashmeran	2012/13	49	<0.001-0.068	0.018	0.025		Blytt et al, 2013
	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02-0.23</b>	<b>0.048</b>	<b>0.059</b>	<b>0.13</b>	<b>This survey</b>
Celestolide	2012/13	49	<0.005-0.11	0.026	0.029		Blytt et al, 2013
	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>This survey</b>
Moskene	2012/13	49	<LOD				Blytt et al, 2013
	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>This survey</b>
Musk ambrette	2011/12	49	<0.001-0.58	0.0375	0.105		Blytt et al, 2013
	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>This survey</b>
Musk tibeten	2012/13	49	<LOD				Blytt et al, 2013
	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>This survey</b>
Fantolide	2012/13	49	<0.001-0.011	0.0063	0.007		Blytt et al, 2013
	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>&lt;0.02</b>	<b>This survey</b>
Traseolide	2012/13	49	0.0021-0.12	0.026	0.028		Blytt et al, 2013
	<b>2017/18</b>	<b>70</b>	<b>&lt;0.02-0.067</b>	<b>0.024</b>	<b>0.023</b>	<b>0.037</b>	<b>This survey</b>

## 4.11. Arsenic

Arsenic was detected in 36 of the 70 samples analysed. The average value was 1.67 µg/kg TS and mean was 2.6 µg/kg TS. This represents a 50% reduction since 2012/13. Arsenic was not detected over the detection level (1 µg/kg TS) at three of the 14 treatment plants (Bekkelaget, SNJ, VEAS). The highest concentration was measured at Bergen Biogas Plant where the concentration was 10 µg/kg TS or higher for all samples. The source is probably not sludge from the Knappen Treatment Plant, but rather sludge from other plants that deliver raw sludge.



**Figure 4.25.** Results for arsenic in 2017/18 with mean, median and standard deviation. Arsenic was not detected at Bekkelaget, SNJ, VEAS; half of the detection limit was shown as average and median (0.5 µg/kg TS)



**Figure 4.26.** Comparative data (arsenic, median values) 2013–2018.

## 4.12. Silver

Silver was detected in 64 out of 70 samples with an average value of 1.82 µg/kg TS and a median of 1.75 µg/kg TS. This represents a reduction of 28% for the average since 2012/13. The highest concentration has been measured at SNJ which also had the highest average.

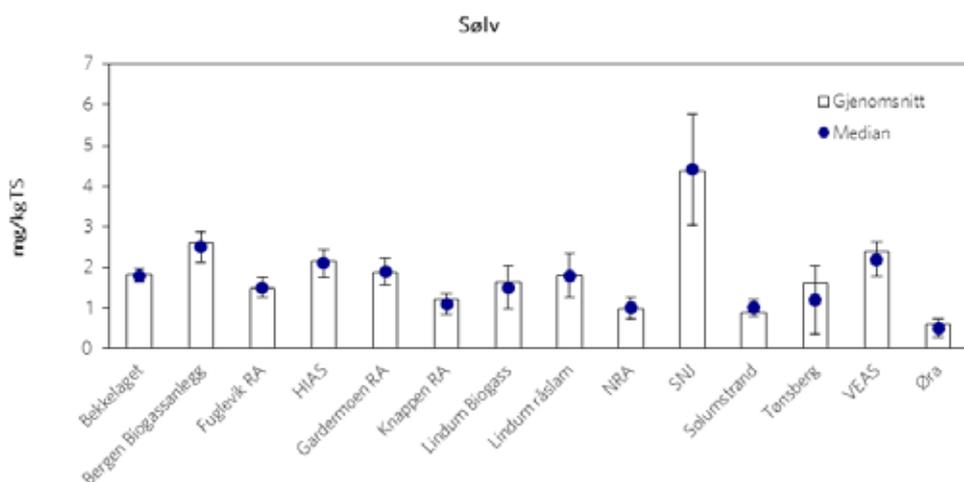


Figure 4.27. Results for silver in 2017/18 with mean, median and standard deviation.

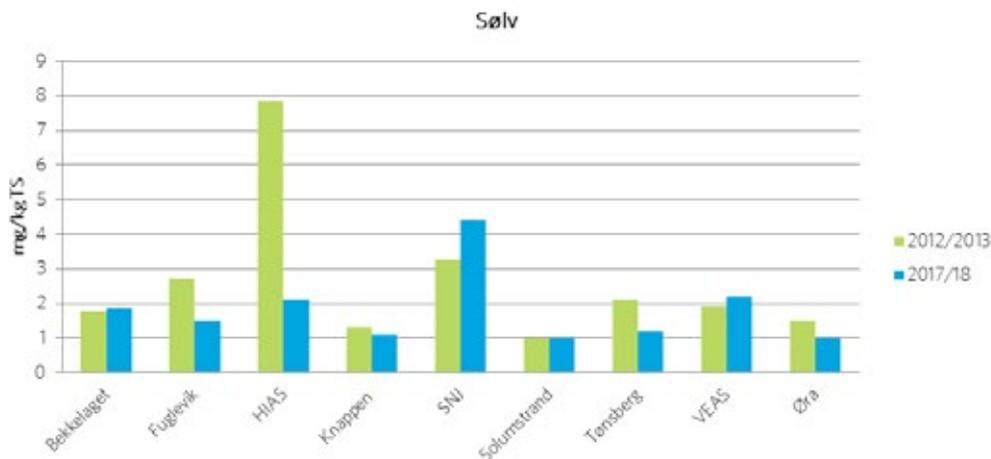


Figure 4.28. Comparative data (silver, median values) 2013–2018.

## 4.13. Bisphenols

Bisphenol A was detected in all the samples with an average value of 1,605 µg/kg TS and a median of 1,100 µg/kg TS. This represents an increase of 100% since 2012/13. The highest concentration has been measured at Øra, which also had the highest average value. The lowest concentration was measured at Knappen.

New bisphenols (other than bisphenol A) were detected in all samples. The average value for the sum of new bisphenols was 433 µg/kg TS and the median was 225 µg/kg TS. Bisphenols S and F had the highest concentrations and were found in all samples. Bisphenols AF, B, BP, M, P and Z were not detected at levels over the limit of detection.

We could only find two previous studies in which these other bisphenols were analysed in sludge. The results are summarised in table 4.10.

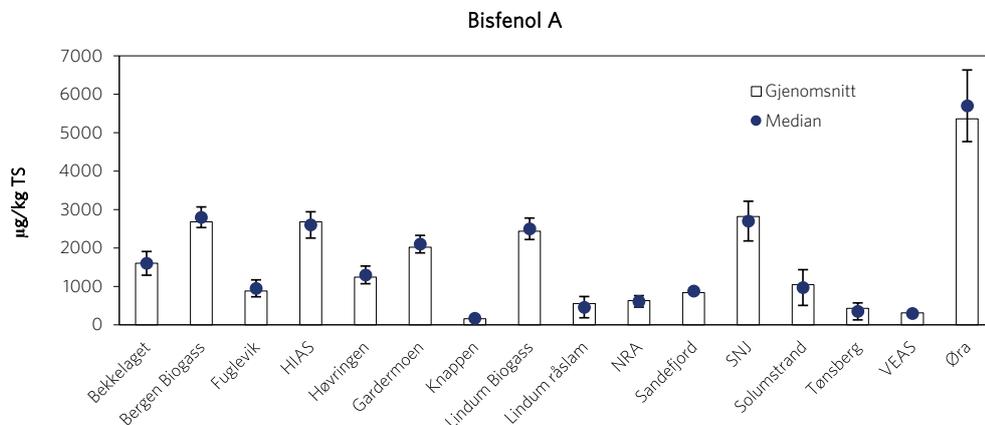


Figure 4.29. Results for bisphenol A in 2017/18 with mean, median and standard deviation.

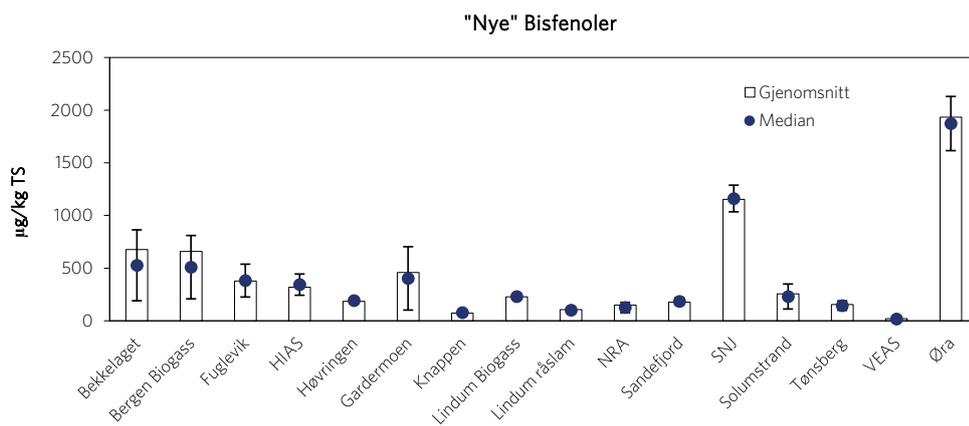


Figure 4.30. Results from 2017/18 for bisphenols other than bisphenol A with mean, median and standard deviation.

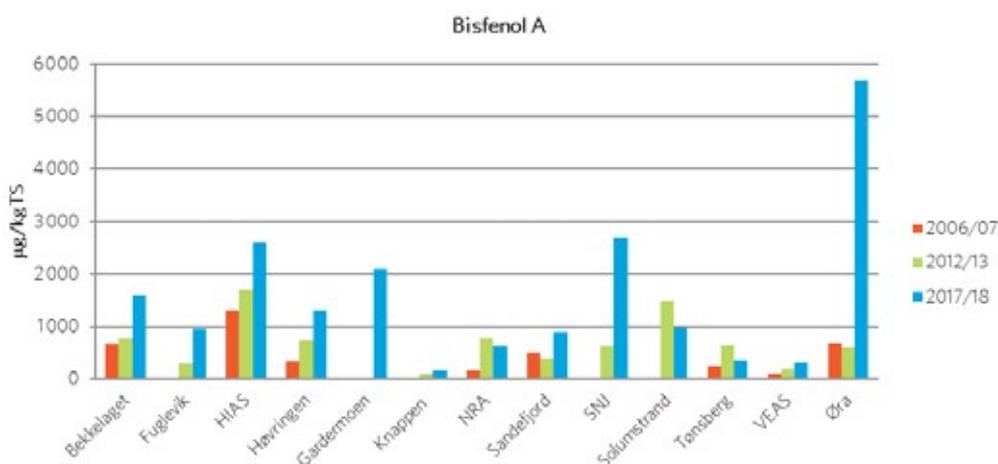


Figure 4.31. Comparative data (bisphenol A median values) 1996–2018. Fuglevik, Knappen, SNJ and Solumstrand were involved in the survey from 2012/13. Gardermoen was not included in 2012/13.

**Table 4.10.** Concentration of bisphenols ( $\mu\text{g}/\text{kg TS}$ ) in Norwegian sludge from various surveys. Bisphenol A has been analysed in several surveys, only results from surveys including other bisphenols are reported in the table.

Substance ( $\mu\text{g}/\text{kg TS}$ )	Min	Max	Average	Median	90 % percentile	Amount	Reference
Bisphenol A	290	3.400	1,538	1,105	3,200	6	Konieczny et al. 2018
	<3.5	4,534	2,941	4,143	4,473	10	Thomas et al. 2014
	<b>120</b>	<b>6,500</b>	<b>1,605</b>	<b>1,100</b>	<b>2,930</b>	<b>80</b>	<b>This survey</b>
Bisphenol AF (hexa-fluorobisphenol A)	<0.9 < <b>6.8</b>	3.6 < <b>22</b>	3	2.5	3.3	10 <b>80</b>	Thomas et al. 2014 <b>This survey</b>
Bisphenol AP	< <b>0.89</b>	<b>5.4</b>	<b>0.97</b>	< <b>1.85</b>	< <b>2.3</b>	<b>80</b>	<b>This survey</b>
Bisphenol B	< <b>0.74</b>	<b>13</b>	<b>2.12</b>	< <b>1.7</b>	<b>5.14</b>	<b>80</b>	<b>This survey</b>
Bisphenol BP	<0.85	<1.2				6	Konieczny et al. 2018
	<0.9	3.3	2.5	2.1	3	10	Thomas et al. 2014
	< <b>4.3</b>	< <b>11</b>				<b>80</b>	<b>This survey</b>
Bisphenol E	< <b>0.97</b>	<b>980</b>	<b>83.43</b>	< <b>1.9</b>	<b>251</b>	<b>80</b>	<b>This survey</b>
Bisphenol F	7.3	190	76.9	53	170	6	Konieczny et al. 2018
	<b>1.6</b>	<b>230</b>	<b>54.03</b>	<b>51.5</b>	<b>90.1</b>	<b>80</b>	<b>This survey</b>
2.2-Bisphenol F	<14	390	200	212	302	10	Thomas et al. 2014
	< <b>0.43</b>	<b>200</b>	<b>40.32</b>	<b>39</b>	<b>69</b>	<b>80</b>	<b>This survey</b>
4.4-Bisphenol F	<8	286	123	95.5	215	10	Thomas et al. 2014
	<b>1.6</b>	<b>35</b>	<b>13.62</b>	<b>13.5</b>	<b>26.1</b>	<b>80</b>	<b>This survey</b>
Bisphenol G	< <b>3.9</b>	<b>800</b>	<b>34.53</b>	< <b>7.4</b>	<b>45.3</b>	<b>80</b>	<b>This survey</b>
Bisphenol M	<2.7	<4.7				6	Konieczny et al. 2018
	< <b>2.9</b>	< <b>9.4</b>				<b>80</b>	<b>This survey</b>
Bisphenol P	<1.7	<3				6	Konieczny et al. 2018
	< <b>4.6</b>	< <b>12</b>				<b>80</b>	<b>This survey</b>
Bisphenol S	2.1	80.8	60	66.7	80.4	10	Thomas et al. 2014
	<b>7.1</b>	<b>2,100</b>	<b>262.6</b>	<b>95</b>	<b>1,100</b>	<b>80</b>	<b>This survey</b>
Bisphenol TMC	<0.23	<0.38				6	Konieczny et al. 2018
	< <b>0.45</b>	< <b>1.1</b>				<b>80</b>	<b>This survey</b>
Bisphenol Z	<1.3	<2.1				6	Konieczny et al. 2018
	< <b>0.26</b>	<b>0.63</b>	<LOD	<LOD	< <b>0.561</b>	<b>80</b>	<b>This survey</b>

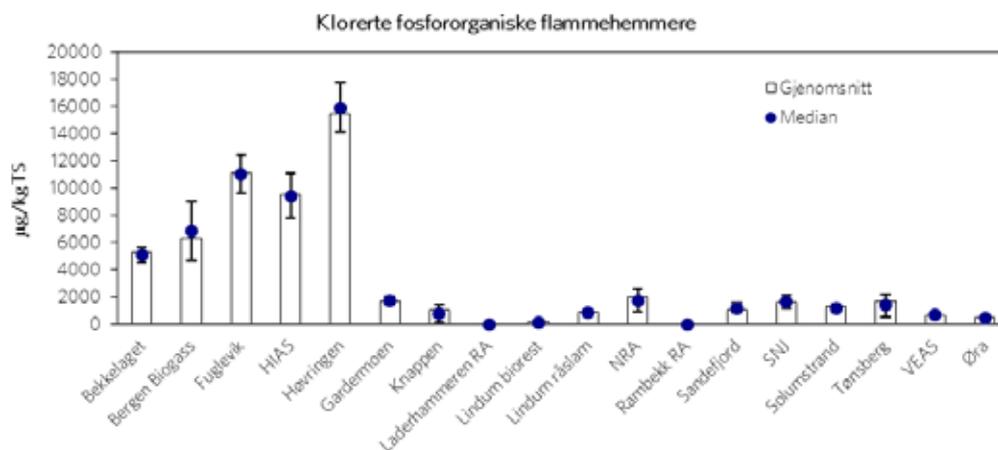
## 4.14. Organophosphorus flame retardants

Organophosphorus flame retardants were detected in all the samples. The average value for the sum of the chlorinated organic flame retardants was 3,774  $\mu\text{g}/\text{kg TS}$  and the median was 1,514  $\mu\text{g}/\text{kg TS}$ . TCPP was the chlorinated organophosphorus flame retardant with highest concentration, while TDCPP had the lowest concentration.

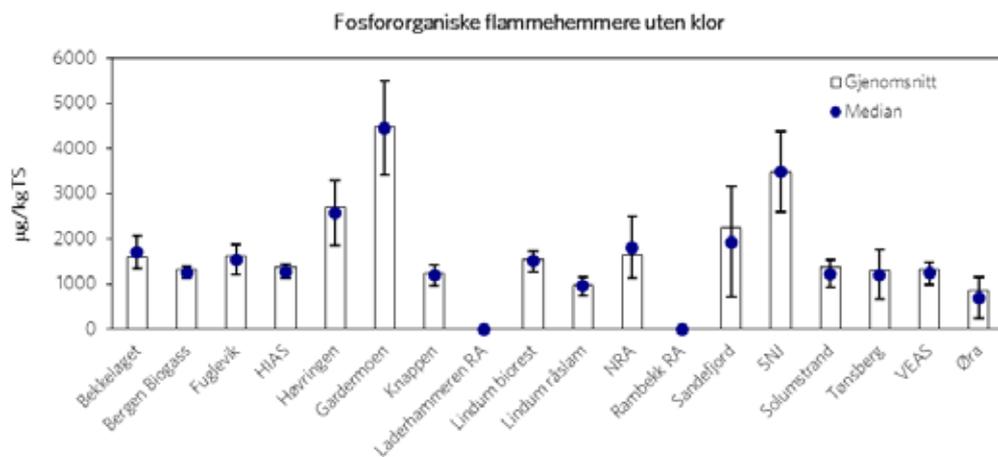
There were significant differences between treatment plants, particularly with regards to TCEP: in nine plants (Bekkelaget, Bergen Biogas Plant, Knappen RA, Lindum biorest, NRA, Sandefjord RA, SNJ, VEAS and Øra), TCEP was not detected at all, while in three plants the concentration was between 2,000 - 9,000  $\mu\text{g}/\text{kg TS}$  (Fuglevik RA, Hias IKS, Høvringen RA). At other plants (Gardermoen RA, Solumstrand RA, Tønsberg RA), the concentration was between <1 - 80  $\mu\text{g}/\text{kg TS}$ .

The average value for the sum of non-chlorinated flame retardants was 1,816  $\mu\text{g}/\text{kg TS}$  and the median was 1,498  $\mu\text{g}/\text{kg TS}$ . The highest concentrations were TBEP > EHDPP > TCP > PPhDPhP > TPPhP > TBP/TnBP.

Organophosphorus compounds have not been analysed in the previous surveys from Norwegian Water, but such analysis were carried out at eight treatment plants in 2010 (Thomas et al, 2011) and at two treatment plants in 2013 (Thomas et al, 2014). Since those surveys, the levels of non-chlorinated organophosphorus flame retardants and TDCPP have decreased, while the levels of TCEP and TCPP have increased (see table 4.11)



**Figure 4.32.** Results from 2017/18, for chlorinated organophosphorus flame retardants tris(2-chloroethyl) phosphate (TCEP) and tris(1-chloro-2-propyl) phosphate (TCPP) and tris(1,3-dichloro-2-propyl) phosphate (TDCPP) with mean, median and standard deviation.



**Figure 4.33.** Analysis results from 2017/18 for non-chlorinated organophosphorus flame retardants (tri(2-butoxyethyl) phosphate, 2-ethylhexyl diphenyl phosphate, tricresyl phosphate, tri-n-butyl phosphate, isobutyl phosphate, 4-Isopropyl phenyl diphenyl phosphate, tris(2-isopropyl phenyl) phosphate), with mean, median and standard deviation.

**Table 4.11.** Concentration of organophosphorus flame retardants ( $\mu\text{g}/\text{kg TS}$ ) in sludge from various surveys in Norway.

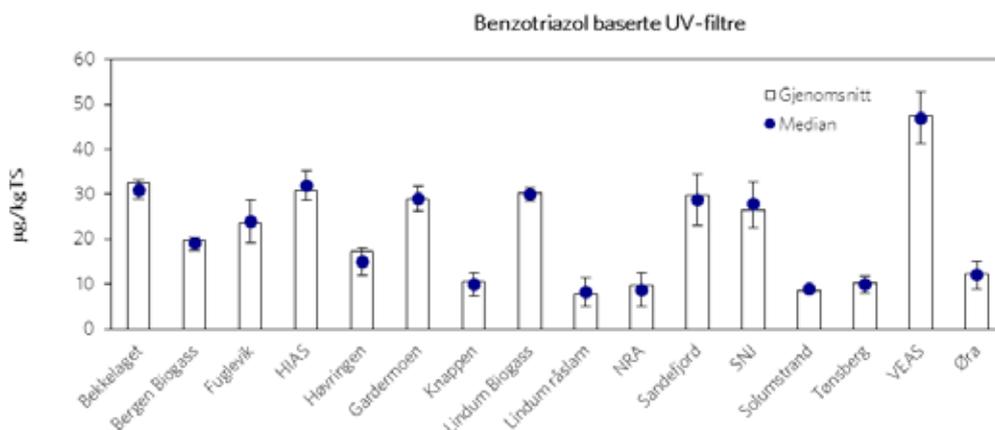
Subst.	( $\mu\text{g}/\text{kg TS}$ )	Min	Max	Average	Median	90 perc.	Amount	Reference
<b>CHLORINATED ORGANOPHOSPHORUS FLAME RETARDANTS</b>								
TCEP	Tris (2-chloroethyl) phosphate	30.4	276	132	128		32	Thomas et al., 2011
	Tris (2-chloroethyl) phosphate	<1.24	62	62	<40		10	Thomas et al., 2014
	<b>Tris(2-chloroethyl) phosphate</b>	<b>&lt;0.59</b>	<b>8,900</b>	<b>1,082</b>	<b>&lt;1.65</b>	<b>5,160</b>	<b>80</b>	<b>This survey</b>
TCPP	Tris(2-chloroisopropyl)-phosphate	560	7,200	3,199	2,580		32	Thomas et al., 2011
	<b>Tris(1-chloro-2-propyl)-phosphate</b>	<b>65</b>	<b>10,000</b>	<b>2,608</b>	<b>1,400</b>	<b>7,520</b>	<b>80</b>	<b>This survey</b>
TDCPP	Tris(2-chloropropyl) phosphate	<18	916	630	560		10	Thomas et al., 2014
	Tris(1,3-dichloro isopropyl) phosphate	8.8	1,040	269	246		32	Thomas et al., 2011
	<b>Tri-(1,3-dichloro-2-propyl) phosphate</b>	<b>&lt;2.2</b>	<b>230</b>	<b>84</b>	<b>68</b>	<b>160</b>	<b>80</b>	<b>This survey</b>
<b>NON-CHLORINATED ORGANOPHOSPHORUS FLAME RETARDANTS</b>								
TBEP	Tris-(butoxyethyl)phosphate	236	23,600	5,481	3,660		32	Thomas et al., 2011
	<b>Tris-(2-butoxyethyl) phosphate</b>	<b>63</b>	<b>4,300</b>	<b>742</b>	<b>465</b>	<b>1,520</b>	<b>80</b>	<b>This survey</b>
EHDPP	2-ethylhexyl diphenyl phosphate	21.2	12,800	2,408	2,300		32	Thomas et al., 2011
	<b>2-ethylhexyl diphenyl phosphate</b>	<b>98</b>	<b>1,200</b>	<b>456</b>	<b>420</b>	<b>782</b>	<b>80</b>	<b>This survey</b>
TCP	Tricresyl phosphate	10.8	12,000	1,142	460		32	Thomas et al., 2011
	Sum tris(cresyl) phosphate	<0.12	66	31.7	40		10	Thomas et al., 2014
	<b>Tricresyl phosphate</b>	<b>13</b>	<b>1,600</b>	<b>323</b>	<b>220</b>	<b>658</b>	<b>80</b>	<b>This survey</b>
TBP	Tributyl phosphate (n)	26.4	304	109	94		32	Thomas et al., 2011
	Tributyl phosphate (iso)	38.8	356	115	102		32	Thomas et al., 2011
	<b>Sum of tri-n- and isobutyl phosphate</b>	<b>11</b>	<b>760</b>	<b>70</b>	<b>39</b>	<b>97</b>	<b>80</b>	<b>This survey</b>
TPhP	Triphenyl phosphate	26.8	6,000	373	150		32	Thomas et al., 2011
	Triphenyl phosphate	13	33	24.8	25.5		10	Thomas et al., 2014
DBPhP	Dibutyl phenyl phosphate	0.8	20.8	5.68	3.9		32	Thomas et al., 2011
DPhBP	Diphenyl butyl phosphate	<LOD	<LOD				32	Thomas et al., 2011
PPhDPhP	<b>4-Isopropyl phenyl diphenyl phosphate</b>	<b>&lt;3.9</b>	<b>480</b>	<b>122</b>	<b>94</b>	<b>280</b>	<b>80</b>	<b>This survey</b>
TPPhP	<b>Tris(2-isopropyl phenyl) phosphate</b>	<b>17</b>	<b>450</b>	<b>103</b>	<b>85</b>	<b>201</b>	<b>80</b>	<b>This survey</b>

## 4.15. UV substances

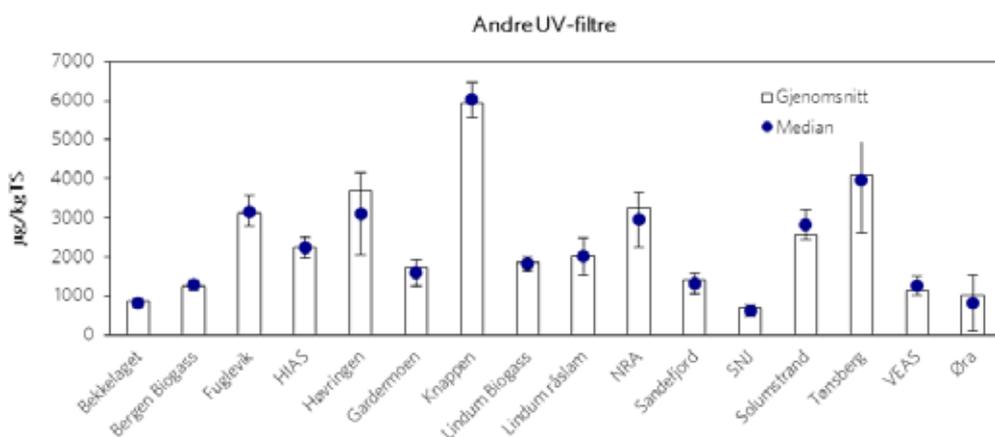
Benzotriazole-based UV substances were detected in all samples with a mean of total values of 21.6 µg/kg TS and a median of 21 µg/kg TS. UV-328, detected in all samples, represented the highest part of this sum (Average 21.4 µg/kg TS). UV-327 was not detected at all while UV-320 and 350 were only detected in 12 out of 80 samples.

Only few data from previous analyses of benzotriazoles in sludge have been found. Since the screening survey in 2013 (Thomas et al, 2014), UV-327 was reduced from about 80 to <10 µg/kg TS, while UV-328 has increased in Hias IKS (<25 µg/kg TS in 2013, 31 µg/kg TS in this survey) and in VEAS (<10 µg/kg TS in 2013, 48 µg/kg TS in this survey).

UV substances that are not based on benzotriazole were also detected in all samples with a total mean value of 2,302 µg/kg TS and a median of 2,019 µg/kg TS. Octocrylene and ethylhexyl methoxycinnamate had the highest concentrations (respective mean values of 1,172 µg/kg TS and 1,093 µg/kg TS) while benzophenone-3 was found in lower concentrations (37.5 µg/kg TS). All three substances have been found in lower concentrations than those found in the two treatment plants in Norway in 2013, but in much higher concentrations than those found in the Swedish survey from 2009.



**Figure 4.34.** Results for 2017/18 for the sum of benzotriazole-based UV filters (UV-320, UV-350, UV-327, UV-328) with mean, median and standard deviation.



**Figure 4.35.** Results for the UV filters octocrylene, benzophenone-3 and ethylhexyl methoxycinnamate with mean, median and standard deviation. From analyses carried out in 2017/18.

**Table 4.12.** Concentration of UV substances ( $\mu\text{g}/\text{kg TS}$ ) in sludge from this survey as well as a survey carried out in Norway in 2013 (Thomas 2014) and a survey from Sweden in 2009 (TemaNord 2012).

Subst. ( $\mu\text{g}/\text{kg TS}$ )	Min	Max	Average	Median	90 perc.	Number of samples	Reference
<b>BENZOTRIAZOLE</b>							
UV-320 +UV-350	< <b>0.3</b>	<b>3.1</b>	<b>0.71</b>	< <b>1.25</b>	<b>1.3</b>	<b>80</b>	<b>This survey</b>
UV-327	30 < <b>2.9</b>	160 < <b>9.8</b>	76.9	80		10 <b>80</b>	Thomas, 2014 <b>This survey</b>
UV-328	<8.9 <b>2.5</b>	<25 <b>55</b>	<b>21.4</b>	<b>21</b>	<b>33.1</b>	10 <b>80</b>	Thomas, 2014 <b>This survey</b>
UV-234	<6.6	<13.1				10	Thomas, 2014
UV-329	1,172	3,303	2,164	2,211		10	Thomas, 2014
UV-360	<125	<126				10	Thomas, 2014
UV-571	<125	<126				10	Thomas, 2014
<b>OTHER UV SUBSTANCES</b>							
Octocrylene	<LOD	64	64			8	TemaNord 2012
	3,448	41,610	20,910	19,742		10	Thomas, 2014
	<b>330</b>	<b>4,700</b>	<b>1,172</b>	<b>965</b>	<b>2,300</b>	<b>80</b>	<b>This survey</b>
Benzophenone-3	14	82	39.38			8	TemaNord 2012
	<10	2,113	1,428	824		10	Thomas, 2014
	< <b>1.4</b>	<b>450</b>	<b>37.5</b>	<b>8.2</b>	<b>96.5</b>	<b>80</b>	<b>This survey</b>
Ethylhexyl methoxycinnamate	31	410	160.4			8	TemaNord 2012
	551	4,689	2,072	1,647		10	Thomas, 2014
	<b>68</b>	<b>5,200</b>	<b>1,093</b>	<b>625</b>	<b>2,840</b>		<b>This survey</b>

## 4.16. Chlorinated Paraffins: SCCP and MCCP

Short-chain chlorinated paraffins (SCCP) were found in 68 out of 70 samples with an average value of 517  $\mu\text{g}/\text{kg}$  TS and a median of 285  $\mu\text{g}/\text{kg}$  TS. Medium-chain chlorinated paraffins (MCCP) were found in all samples with an average value of 4,031  $\mu\text{g}/\text{kg}$  TS and a median value of 2,200  $\mu\text{g}/\text{kg}$ . For both types of chlorinated paraffins, there was considerable differences between plants. This may be due to sludge treatment as Lindum had much lower concentrations of SCCPs and MCCPs in digestate compared with raw sludge that was treated. This indicates that substances may be broken down during the process. Raw sludge from Solumstrand, Knappen, NRA and Lindum was analysed as part of this survey and these plants also have the highest concentrations of chlorinated paraffins. Fuglevik has relatively high values in digested sludge, but in this case, we do not know the initial concentration in the raw sludge.

Little data exists from previous analyses of chlorinated paraffins in sludge. Since the screening survey in 2010 (Thomas et al, 2011), levels of SCCP have been halved and levels of MCCP have been six times higher. Nevertheless, the concentration in sludge is in the same magnitude as in 2005/06 (Fjeld 2008). These differences are as much due to the choice of treatment plants as they are to the timespan between surveys. Only one treatment plant (Hias) was involved in all three surveys. At Hias, it is possible to observe an increase in SCCPs while MCCPs follow the same variations as the national average.

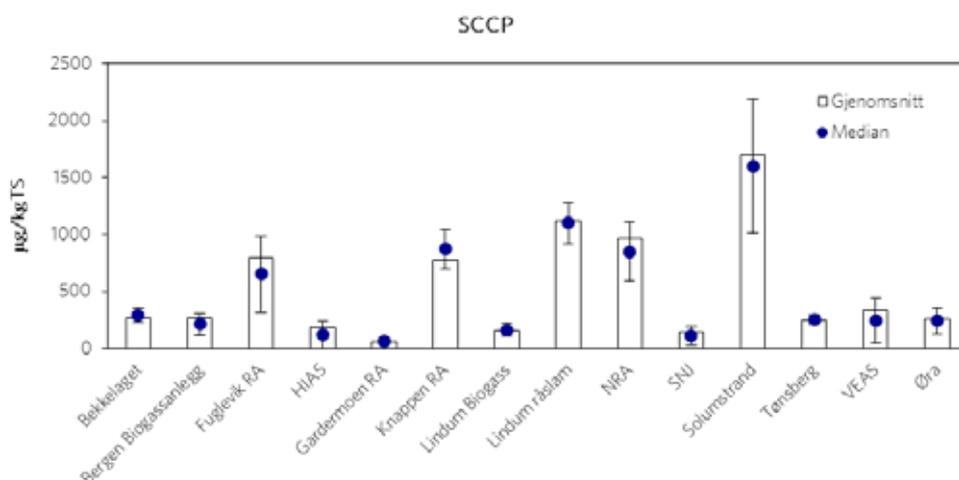


Figure 4.36. Results for short-chain chlorinated paraffins (SCCP) in 2017/18 with mean, median and standard deviation.

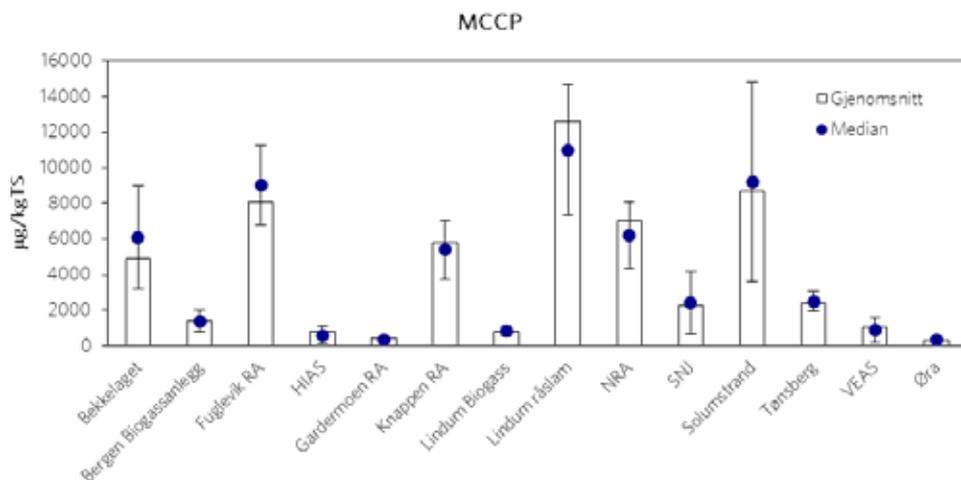


Figure 4.37. Results for medium-chain chlorinated paraffins (MCCP) in 2017/18 with mean, median and standard deviation.

Table 4.13. Concentration of chlorinated paraffins ( $\mu\text{g}/\text{kg TS}$ ) in sludge from various surveys in Norway. Data from Hias, which is the only treatment plant involved in all three surveys, are displayed in parentheses.

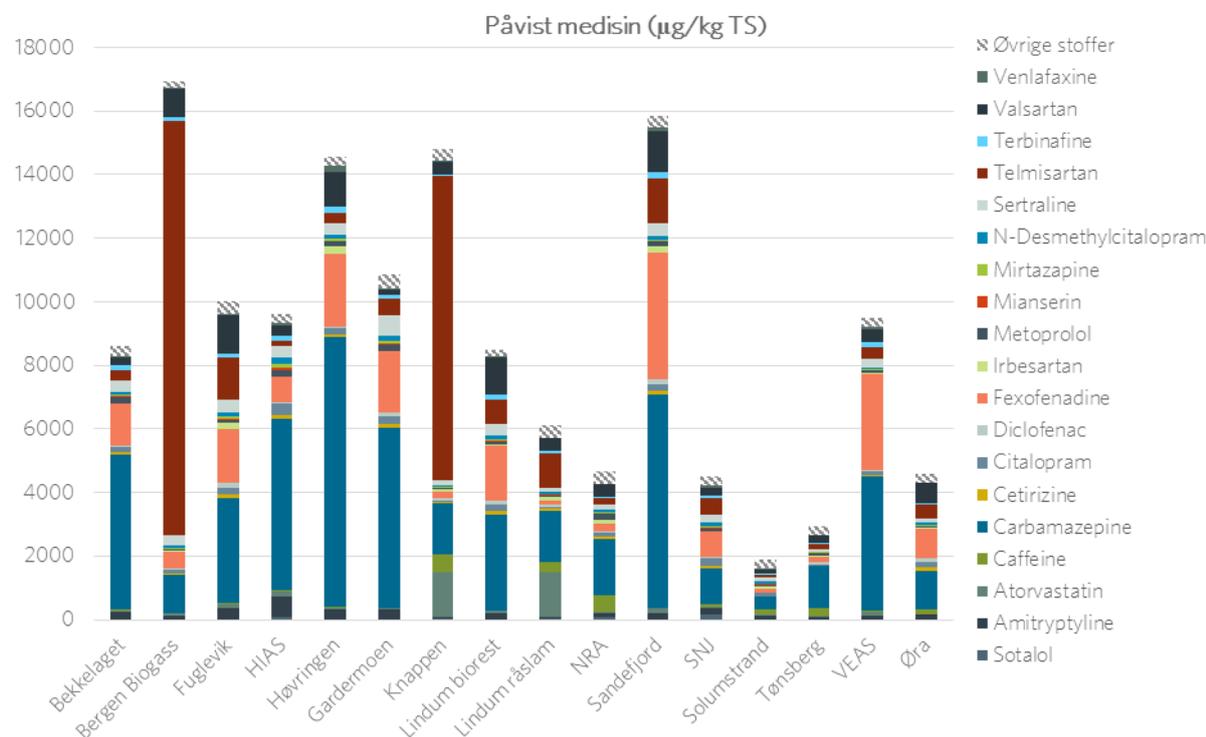
Subst. ( $\mu\text{g}/\text{kg TS}$ )	Min	Max	Average	Median	90 % perc.	Amount	Reference
SCCP	47	3,800	877 (Hias: 75)	715 (Hias: 70)	1,110	24	Fjeld 2008
	74	12,258	1,151 (Hias: 127)	416 (Hias: 98)		32	Thomas et al., 2011
	<50	2,500	517.5 (Hias: 182)	285 (Hias: 120)		70	This survey
MCCP	77	11,800	3,964 (Hias: 742)	2,850 (Hias: 472)	9,550	24	Fjeld 2008
	14	7,000	699 (Hias: 173)	385 (Hias: 76)		32	Thomas et al., 2011
	120	17,000	4,031 (Hias: 600)	2,200 (Hias: 794)		70	This survey

## 4.17. Pharmaceutical residues

Results show significant difference between the pharmaceutical residues and the different treatment plants:

- 9 substances were not detected above the limit of detection: Carbamazepine 10,11-epoxide, Alfuzosin, Cilazapril, Clemastine, Glimepiride, N4\_Acetylsulfamethoxazole, Pizotifen, Ropinirole, Sulfamethazine.
- 9 substances were only detected in 1–4 samples: 10,11-dihydrocarbamazepine; Alprazolam, Bezafibrate, Biperiden, Clonazepam, Disopyramide, Maprotiline, N1 Acetyl sulfamethoxazole, Orphenadrine.
- 2 substances were found in all samples in only one of the treatment plants: Sulfamerazine (VEAS), Sulfamethizole (Hias).
- 22 substances were found in more than 10 of the 80 samples: Bisoprolol, Clarithromycin, Clindamycin, Clindamycin sulfoxide, Clomipramine, Codeine, Diltiazem, Diphenhydramine, Donepezil, Fenofibrate, Glibenclamide, Memantine, Oxazepam, Oxcarbazepine, Sotalol, Sulfadiazine, Sulfamethoxazole, Tamoxifen, Trimethoprim, Verapamil.
- 26 substances were found in all samples: Atorvastatin, Azithromycin, Caffeine, Carbamazepine, Cetirizine, Citalopram, Diclofenac, Fexofenadine, Irbesartan, Loperamide, Meclozine, Metoprolol, Metoprolol acid, Mianserin, Mirtazapine, N Desmethylcitalopram, O Desmethylvenlafaxine, Propranolol, Sertraline, Sulfapyridine, Telmisartan, Terbinafine, Tramadol, Valsartan, Venlafaxine.

Pharmaceutical residues were not included in previous programmes of analysis for Norwegian Water. We have collected information about pharmaceutical residues analysed in sludge in Norway and other Nordic Countries in table 4.14



**Figure 4.38.** Results for pharmaceutical residues from 2017/18, median values. Only pharmaceuticals with a median value higher than 100 µg/kg TS in at least one treatment plant are shown in the figure.

**Table 4.14.** Concentration of pharmaceutical residues ( $\mu\text{g}/\text{kg TS}$ ) in sludge from different surveys in the Nordic countries.

Substance ( $\mu\text{g}/\text{kg TS}$ )	Min	Max	Average	Median	90 % perc.	Country (number of samples)	Reference
10,11-dihydro-10,11-dihydroxy carbamazepine	<0.54	140	10.04	6.85	16.1	Norway (80)	This survey
10,11-dihydrocarbamazepine	<3.4	19	3.54	<6.5	<8.91	Norway (80)	This survey
Alfuzosin	10 <6.6 <0.26 <0.96	34 <16 <0.41 <6.1	21.2			Sweden (5) Norway (7) Norway (6) Norway (80)	TemaNord 2012 Konieczny et al. 2017 Konieczny et al. 2018 This survey
Alprazolam	<0.73	5.6	0.82	<1.45	<2.1	Norway (80)	This survey
Amitriptyline	70 88 110 50	420 410 280 670		80 120 185 160		Norway (6) Norway (7) Norway (6) Norway (80)	Thomas et al. 2016 Konieczny et al. 2017 Konieczny et al. 2018 This survey
Atenolol	12 9.82 <LOD 58.6 <1.3	38 13.4 <LOD 1,652 14	20.2 11.62 624 5.51			Sweden (5), Faroe Isl (2), Greenland (2), Iceland (3) Norway (80)	TemaNord 2012 " " " This survey
Atorvastatin	<LOD 100 94 11	<LOD 170 1,400 2,800		130 130 465 56.5		Norway (6) Norway (7) Norway (6) Norway (80)	Thomas et al. 2016 Konieczny et al. 2017 Konieczny et al. 2018 This survey
Azithromycin	<LOD <LOD <29 3.6 2.5	5.6 -70 290 170 110	5.6 257.5 75.65 32.1	47 190 67.7 25.5		Sweden (5) Norway (6) Norway (7) Norway (6) Norway (80)	TemaNord 2012 Thomas et al. 2016 Konieczny et al. 2017 Konieczny et al. 2018 This survey
Bezafibrate	<0.045 <0.6	<0.91 1.35	0.65	<1.2	<1.91	Norway (6) Norway (80)	Konieczny et al. 2018 This survey
Biperiden	<1.2	3.9	1.29	<2.2	<3.52	Norway (80)	This survey
Bisoprolol	<3.1 <0.21 <0.56	<7.8 1.2 8	0.97 0.89	0.535 <1.25	1.14 1.7	Norway (7) Norway (6) Norway (80)	Konieczny et al. 2017 Konieczny et al. 2018 This survey
Caffeine	16 9 4.7	39 67 2,900	30.7 33.1 206	32 28.2 45.5	38.4 62 561	Norway (7) Norway (6) Norway (80)	Konieczny et al. 2017 Konieczny et al. 2018 This survey
Carbamazepine	66 290 240	99 650 20,000	86.0 470 3,695	90 470 2,950	99 635 7,340	Norway (7) Norway (6) Norway (80)	Konieczny et al. 2017 Konieczny et al. 2018 This survey
Carbamazepine 10,11-epoxide	<1.4	<7.4				Norway (80)	This survey
Cetirizine	10	180	76.74	70	130	Norway (80)	This survey

Continues next page

Continued from last page

Substance (µg/kg TS)	Min	Max	Average	Median	90 % perc.	Country (number of samples)	Reference
Cilazapril	1.1 <b>&lt;0.15</b>	2.6 <b>&lt;1.6</b>	1.54			Sweden (5) <b>Norway (80)</b>	TemaNord 2012 <b>This survey</b>
Citalopram	98 92 <b>47</b>	290 900 <b>370</b>	182.6 453.7 <b>158.5</b>	130 410 <b>145</b>	278 850 <b>260</b>	Norway (7) Norway (6) <b>Norway (80)</b>	Konieczny et al. 2017 Konieczny et al. 2018 <b>This survey</b>
Clarithromycin	<LOD -5 <13 2.2 <b>&lt;2.2</b>	13 -10 30 8.1 <b>74</b>	5.23  25.5 4.42 <b>12.1</b>	 7.7 17 4.15 <b>8.3</b>	  29.7 6.55 <b>28</b>	Sweden (5) Norway (6) Norway (7) Norway (6) <b>Norway (80)</b>	TemaNord 2012 Thomas et al. 2016 Konieczny et al. 2017 Konieczny et al. 2018 <b>This survey</b>
Clemastine	<10 <2.2 <b>&lt;0.89</b>	<14 <2.6 <b>&lt;4.4</b>				Norway (7) Norway (6) <b>Norway (80)</b>	Konieczny et al. 2017 Konieczny et al. 2018 <b>This survey</b>
Clindamycin	5.9 <5.3 <0.28 <b>&lt;0.72</b>	21 33 15 <b>28</b>	15.2 29.8 7.3 <b>7.8</b>	 24 5.14 <b>6.4</b>	32.7 13.4 <b>19.1</b>	Sweden (5) Norway (7) Norway (6) <b>Norway (80)</b>	TemaNord 2012 Konieczny et al. 2017 Konieczny et al. 2018 <b>This survey</b>
Clindamycin sulfoxide	<3 1.2 <b>&lt;0.67</b>	<6 1.6 <b>16</b>	 1.37 <b>3.78</b>	 1.3 <b>1.75</b>	 1.54 <b>11.1</b>	Norway (7) Norway (6) <b>Norway (80)</b>	Konieczny et al. 2017 Konieczny et al. 2018 <b>This survey</b>
Clomipramine	<7.1 2.6 <b>&lt;1.2</b>	13 12 <b>29</b>	12.3 5.98 <b>7.7</b>	11 5.75 <b>7.2</b>	13 9.15 <b>12.1</b>	Norway (7) Norway (6) <b>Norway (80)</b>	Konieczny et al. 2017 Konieczny et al. 2018 <b>This survey</b>
Clonazepam	<4 <0.07 <b>&lt;0.16</b>	<5 <0.13 <b>4.7</b>	  <b>0.50</b>	  <b>&lt;0.86</b>	  <b>&lt;1.5</b>	Norway (7) Norway (6) <b>Norway (80)</b>	Konieczny et al. 2017 Konieczny et al. 2018 <b>This survey</b>
Codeine	9.5 <b>&lt;0.8</b>	29 <b>56</b>	17.7 <b>13.3</b>	 <b>8.85</b>	 <b>34.2</b>	Sweden (5) <b>Norway (80)</b>	TemaNord 2012 <b>This survey</b>
Diclofenac	<LOD 160 <LOD  33.4 <LOD 54 26 <b>18</b>	<LOD 370 3,900  341.9 <LOD 81 49 <b>210</b>	350 260 370 148 23 190.8  67.4 36.5 <b>79.5</b>	       69 36.5 <b>64</b>	       74 46 <b>161</b>	Finland (14) Norway (6) Sweden (77) Faroe Isl (1), Greenland (1) Iceland (5) Norway (6) Norway (7) Norway (6) <b>Norway (80)</b>	TemaNord 2012 " " " " " Thomas et al. 2016 Konieczny et al. 2017 Konieczny et al. 2018 <b>This survey</b>
Diltiazem	<LOD <8 <0.19 <b>&lt;1.7</b>	0.8 <11 <0.48 <b>20</b>	0.8   <b>3.2</b>	   <b>&lt;3.1</b>	   <b>11.1</b>	Sweden (5) Norway (7) Norway (6) <b>Norway (80)</b>	TemaNord 2012 Konieczny et al. 2017 Konieczny et al. 2018 <b>This survey</b>

Continued from last page

Substance (µg/kg TS)	Min	Max	Average	Median	90 % perc.	Country (number of samples)	Reference
Diphenhydramine	<15	46	34.0	32	44	Norway (7)	Konieczny et al. 2017
	3	14	7.717	7.1	12.5	Norway (6)	Konieczny et al. 2018
	<b>&lt;1.9</b>	<b>40</b>	<b>8.6</b>	<b>6.95</b>	<b>16.1</b>	<b>Norway (80)</b>	<b>This survey</b>
Disopyramide	<5	<12				Norway (7)	Konieczny et al. 2017
	<0.2	0.43	0.36	0.27	0.41	Norway (6)	Konieczny et al. 2018
	<b>&lt;0.43</b>	<b>2.4</b>	<b>0.59</b>	<b>&lt;0.98</b>	<b>&lt;1.7</b>	<b>Norway (80)</b>	<b>This survey</b>
Donepezil	<b>&lt;1.9</b>	<b>8.3</b>	<b>2.5</b>	<b>&lt;4.2</b>	<b>3.6</b>	<b>Norway (80)</b>	<b>This survey</b>
Fenofibrate	<4	<6				Norway (7)	Konieczny et al. 2017
	<0.11	2.6	2.35	<2.1	2.55	Norway (6)	Konieczny et al. 2018
	<b>&lt;0.43</b>	<b>48</b>	<b>5.43</b>	<b>1.9</b>	<b>14</b>	<b>Norway (80)</b>	<b>This survey</b>
Fexofenadine	<LOD	-790		447		Norway (6)	Thomas et al. 2016
	780	1,500	1,096	1,000	1,440	Norway (7)	Konieczny et al. 2017
	1,200	3,900	2,250	1,700	3,800	Norway (6)	Konieczny et al. 2018
	<b>98</b>	<b>6,800</b>	<b>1,264</b>	<b>880</b>	<b>3,000</b>	<b>Norway (80)</b>	<b>This survey</b>
Glibenclamide	<3.6	4.6	4.6	<3.8	4.6	Norway (7)	Konieczny et al. 2017
	<0.14	0.27	0.235	<0.2	0.26	Norway (6)	Konieczny et al. 2018
	<b>&lt;0.46</b>	<b>34</b>	<b>2.23</b>	<b>&lt;0.9</b>	<b>3</b>	<b>Norway (80)</b>	<b>This survey</b>
Glimepiride	<4	<6				Norway (7)	Konieczny et al. 2017
	<0.03	<0.06				Norway (6)	Konieczny et al. 2018
	<b>&lt;0.49</b>	<b>&lt;1.8</b>				<b>Norway (80)</b>	<b>This survey</b>
Irbesartan	8.7	280	93.54			Sweden (5)	TemaNord 2012
	25	37	30.3	30	35.2	Norway (7)	Konieczny et al. 2017
	11	31	18.8	19	26	Norway (6)	Konieczny et al. 2018
	<b>8.5</b>	<b>280</b>	<b>83.9</b>	<b>51</b>	<b>210</b>	<b>Norway (80)</b>	<b>This survey</b>
Loperamide	17	39	26.7	22	38.4	Norway (7)	Konieczny et al. 2017
	6.6	27	13.9	12	21	Norway (6)	Konieczny et al. 2018
	<b>1.4</b>	<b>32</b>	<b>13.5</b>	<b>13.5</b>	<b>25</b>	<b>Norway (80)</b>	<b>This survey</b>
Maprotiline	<b>&lt;0.9</b>	<b>4.3</b>	<b>0.94</b>	<b>&lt;1.6</b>	<b>&lt;2.2</b>	<b>Norway (80)</b>	<b>This survey</b>
Meclozine	<b>4.1</b>	<b>88</b>	<b>26.84</b>	<b>23</b>	<b>45.3</b>	<b>Norway (80)</b>	<b>This survey</b>
Memantine	<4.2	13	12	<5.1	13	Norway (7)	Konieczny et al. 2017
	0.95	3.5	1.99	1.75	3.2	Norway (6)	Konieczny et al. 2018
	<b>&lt;0.46</b>	<b>1,700</b>	<b>30.02</b>	<b>1.1</b>	<b>3.91</b>	<b>Norway (80)</b>	<b>This survey</b>
Metoprolol	<LOD	21	21			Norway (7)	TemaNord 2012
	130	410	220			Sweden (5)	"
	108	324	216			Faroe Isl (2),	"
	14.7	41.4	28.1			Greenland (2)	"
	19.2	548.9	210.3			Iceland (3)	"
	61	310	167.4	81	304	Norway (7)	Konieczny et al. 2017
Metoprolol acid	<3	98	76.3	27.75	94.2	Norway (6)	Konieczny et al. 2018
	<b>24</b>	<b>1,000</b>	<b>115</b>	<b>89.5</b>	<b>200</b>	<b>Norway (80)</b>	<b>This survey</b>
	3.7	17	8.4	7	14	Norway (7)	Konieczny et al. 2017
Metoprolol acid	4.1	9.3	6.2	6.2	7.8	Norway (6)	Konieczny et al. 2018
	<b>1</b>	<b>580</b>	<b>25.0</b>	<b>11.5</b>	<b>39.1</b>	<b>Norway (80)</b>	<b>This survey</b>

Continues next page

Continued from last page

Substance (µg/kg TS)	Min	Max	Average	Median	90 % perc.	Country (number of samples)	Reference
Mianserin	<b>8.6</b>	<b>130</b>	<b>33.2</b>	<b>26</b>	<b>59.9</b>	<b>Norway (80)</b>	<b>This survey</b>
Mirtazapine	22	240	118.0	39	240	Norway (7)	Konieczny et al. 2017
	12	75	40.7	39.5	70	Norway (6)	Konieczny et al. 2018
	<b>10</b>	<b>130</b>	<b>43.4</b>	<b>40</b>	<b>79.1</b>	<b>Norway (80)</b>	<b>This survey</b>
N1_Acetylsulfamethoxazole	<b>&lt;0.48</b>	<b>6</b>	<b>0.73</b>	<b>&lt;1</b>	<b>&lt;1.62</b>	<b>Norway (80)</b>	<b>This survey</b>
N4_Acetylsulfamethoxazole	<b>&lt;0.18</b>	<b>&lt;3.1</b>				<b>Norway (80)</b>	<b>This survey</b>
N-Desmethylocitalopram	80	530	287.1	140	530	Norway (7)	Konieczny et al. 2017
	21	140	75.2	67.5	135	Norway (6)	Konieczny et al. 2018
	<b>28</b>	<b>210</b>	<b>90.3625</b>	<b>85.5</b>	<b>150</b>	<b>Norway (80)</b>	<b>This survey</b>
O-Desmethylvenlafaxine	14	47	29.3	27	46.5	Norway (7)	Konieczny et al. 2017
	3.3	12	7.6	7.3	11.5	Norway (6)	Konieczny et al. 2018
	<b>3.6</b>	<b>140</b>	<b>30.0</b>	<b>19.5</b>	<b>68.4</b>	<b>Norway (80)</b>	<b>This survey</b>
Orphenadrine	<8.6	<12				Norway (7)	Konieczny et al. 2017
	<0.49	0.62	0.47	0.51	0.60	Norway (6)	Konieczny et al. 2018
	<b>&lt;1.4</b>	<b>7.9</b>	<b>1.52</b>	<b>&lt;2.7</b>	<b>&lt;3.9</b>	<b>Norway (80)</b>	<b>This survey</b>
Oxazepam	<4.4	22	19.0	16	21.4	Norway (7)	Konieczny et al. 2017
	1.6	11	5.55	4.85	9.85	Norway (6)	Konieczny et al. 2018
	<b>&lt;0.15</b>	<b>63</b>	<b>14.4</b>	<b>12</b>	<b>30</b>	<b>Norway (80)</b>	<b>This survey</b>
Oxcarbazepine	<b>&lt;1.2</b>	<b>9.5</b>	<b>3.09</b>	<b>2.8</b>	<b>5.8</b>	<b>Norway (80)</b>	<b>This survey</b>
Pizotifen	<b>&lt;2.3</b>	<b>&lt;11</b>				<b>Norway (80)</b>	<b>This survey</b>
Propranolol	12.3	30	19.6			Norway (6)	TemaNord 2012
	15	110	46.7	21	90.8	Norway (7)	Konieczny et al. 2017
	<b>2</b>	<b>79</b>	<b>15.4</b>	<b>11</b>	<b>32</b>	<b>Norway (80)</b>	<b>This survey</b>
Ropinirole	<b>&lt;0.97</b>	<b>&lt;24</b>				<b>Norway (80)</b>	<b>This survey</b>
Sertraline	130	210	167	160	204	Norway (7)	Konieczny et al. 2017
	60	160	98	92	130	Norway (6)	Konieczny et al. 2018
	<b>28</b>	<b>700</b>	<b>283</b>	<b>290</b>	<b>431</b>	<b>Norway (80)</b>	<b>This survey</b>
Sotalol	<35	<84				Norway (7)	Konieczny et al. 2017
	<b>&lt;1.1</b>	<b>240</b>	<b>40.03</b>	<b>19</b>	<b>99.3</b>	<b>Norway (80)</b>	<b>This survey</b>
Sulfadiazine	<LOD	<LOD				Norway (6)	TemaNord 2012
	<LOD	<LOD				Denmark (10)	"
	<0.39	<1.5				Norway (6)	Konieczny et al. 2018
	<b>&lt;1.1</b>	<b>13</b>	<b>3.42</b>	<b>2.75</b>	<b>7.26</b>	<b>Norway (80)</b>	<b>This survey</b>
Sulfamerazine	<b>&lt;0.99</b>	<b>5.9</b>	<b>1.41</b>	<b>&lt;2.3</b>	<b>&lt;4.6</b>	<b>Norway (80)</b>	<b>This survey</b>
Sulfamethazine	<6.6	<16				Norway (7)	Konieczny et al. 2017
	<b>&lt;1.3</b>	<b>&lt;6.7</b>				<b>Norway (80)</b>	<b>This survey</b>
Sulfamethizole	<b>&lt;0.71</b>	<b>11</b>	<b>1.23</b>	<b>&lt;1.7</b>	<b>&lt;2.7</b>	<b>Norway (80)</b>	<b>This survey</b>

Continued from last page

Substance (µg/kg TS)	Min	Max	Average	Median	90 % perc.	Country (number of samples)	Reference
Sulfamethoxazole	<LOD	<LOD				Denmark (10)	TemaNord 2012
	<LOD	0.21	0.13			Norway (11)	"
	<LOD	0.29	0.13			Sweden (18)	"
	<LOD	<LOD		<LOD		Norway (6)	Thomas et al. 2016
	<5.2	27	27	<6.2	27	Norway (7)	Konieczny et al. 2017
	<b>&lt;1.1</b>	<b>14</b>	<b>2.2</b>	<b>&lt;2.4</b>	<b>4.6</b>	<b>Norway (80)</b>	<b>This survey</b>
Sulfapyridine	14	47	22.9	19	35	Norway (7)	Konieczny et al. 2017
	<0.73	0.97	0.81	0.75	0.91	Norway (6)	Konieczny et al. 2018
	<b>8.8</b>	<b>230</b>	<b>37.5</b>	<b>35</b>	<b>54</b>	<b>Norway (80)</b>	<b>This survey</b>
Tamoxifen	<LOD	2.10	1.50			Norway (4)	TemaNord 2012
	6.70	13	8.76			Sweden(5)	"
	<b>&lt;0.33</b>	<b>23</b>	<b>6.12044</b>	<b>5.85</b>	<b>13</b>	<b>Norway (80)</b>	<b>This survey</b>
Telmisartan	<LOD	1,400	540			Sweden (5)	TemaNord 2012
	<b>63</b>	<b>15,000</b>	<b>1,914</b>	<b>460</b>	<b>9,420</b>	<b>Norway (80)</b>	<b>This survey</b>
Terbinafine	150	740	425	415	705	Norway (6)	Konieczny et al. 2018
	<b>16</b>	<b>300</b>	<b>112</b>	<b>120</b>	<b>191</b>	<b>Norway (80)</b>	<b>This survey</b>
Tramadol	<LOD	68	62.5			Sweden (5)	TemaNord 2012
	6.3	26	13.7	7.4	25.4	Norway (7)	Konieczny et al. 2017
	4.4	11	7.65	7.3	11	Norway (6)	Konieczny et al. 2018
	<b>3.4</b>	<b>28</b>	<b>10.9</b>	<b>9.4</b>	<b>19</b>	<b>Norway (80)</b>	<b>This survey</b>
Trimethoprim	<3.9	<9.1				Norway (7)	Konieczny et al. 2017
	<0.51	0.84	0.74	0.66	0.83	Norway (6)	Konieczny et al. 2018
	<b>&lt;1.1</b>	<b>49</b>	<b>8.9</b>	<b>&lt;2.4</b>	<b>29.5</b>	<b>Norway (80)</b>	<b>This survey</b>
Valsartan	220	260	247.1	250	260	Norway (7)	Konieczny et al. 2017
	160	320	226.7	230	285	Norway (6)	Konieczny et al. 2018
	<b>82</b>	<b>1,700</b>	<b>577</b>	<b>400</b>	<b>1,210</b>	<b>Norway (80)</b>	<b>This survey</b>
Venlafaxine	740	920	814.3	810	872	Norway (7)	Konieczny et al. 2017
	48	92	63.5	61	78.5	Norway (6)	Konieczny et al. 2018
	<b>8.2</b>	<b>280</b>	<b>53.8</b>	<b>41</b>	<b>99</b>	<b>Norway (80)</b>	<b>This survey</b>
Verapamil	<LOD	18	18			Sweden (5)	TemaNord 2012
	<8.2	29	24.5	21	28.1	Norway (7)	Konieczny et al. 2017
	1.3	19	9.18	7.5	18.5	Norway (6)	Konieczny et al. 2018
	<b>&lt;1.7</b>	<b>100</b>	<b>18.0</b>	<b>11</b>	<b>46.3</b>	<b>Norway (80)</b>	<b>This survey</b>

## 4.18. Organotin compounds

Organotin compounds were analysed at only four treatment plants and were detected in all samples with a total average value of 75.4 µg/kg TS and a median value of 78.5 µg/kg TS. The majority of these were DBT (Average 57.4 µg/kg TS) which were detected in all samples. DOT was not detected, although the limit of detection was 20 µg/kg TS.

Broadly speaking, the concentration of all organotin compounds has doubled since 2012/13 (Table 4.15)

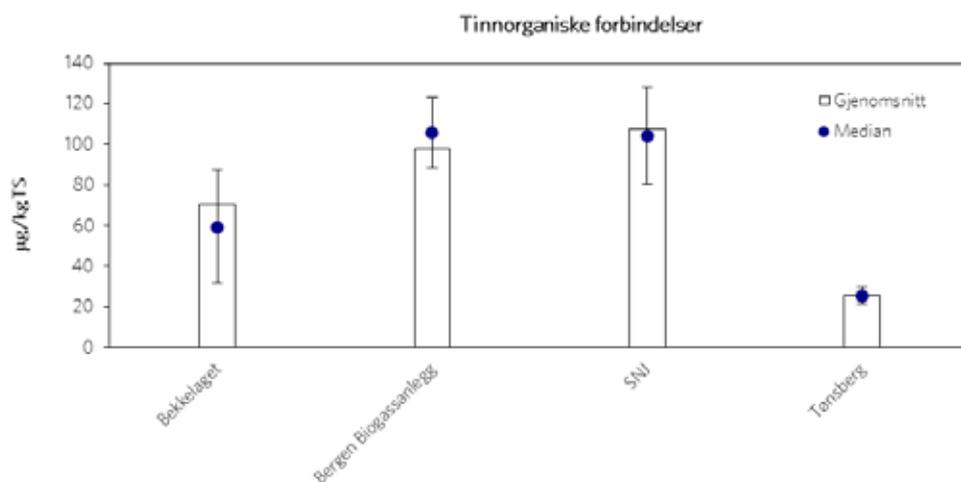


Figure 4.39. Results for tinorganic compounds in 2017/18 with mean, median and standard deviation.

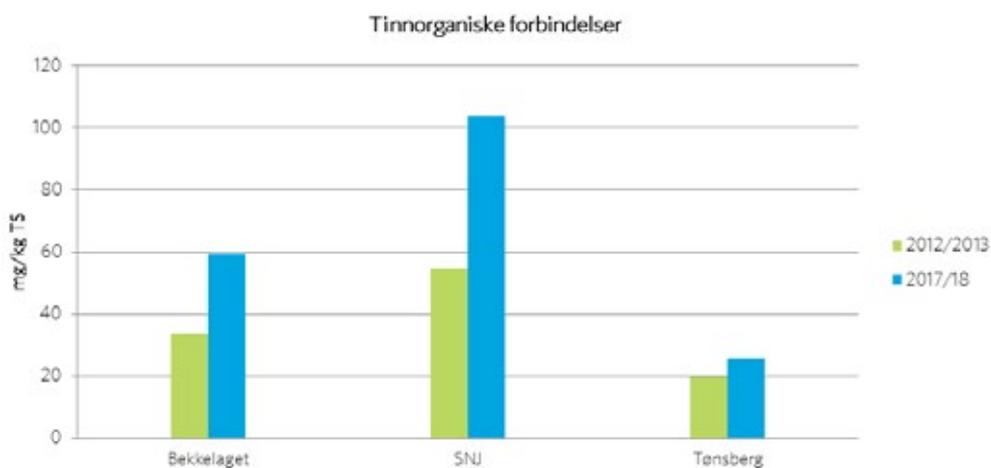


Figure 4.40. Comparative data (organotin compounds, median values) 2012/13 – 2017/18.

**Table 4.15.** Concentration of tinorganic compounds ( $\mu\text{g}/\text{kg TS}$ ) in sludge from various surveys.

Sub-stance	Country	Year	Amount	Variation	Median	Average	90% percentile	Reference
TBT	Norway	2006				45		Nedland and Paulsrud, 2006
	Sweden	2008/09				16		Pettersson and Wahlberg, 2010
	Norway	2012/13	50	<1-8.4	3.5	4.1		Blytt et al, 2013
	<b>Norway</b>	<b>2017/18</b>	<b>20</b>	<b>2.5-53</b>	<b>11.8</b>	<b>18.0</b>	<b>43.8</b>	<b>This survey</b>
DBT	Norway	2006				188		Nedland and Paulsrud, 2006
	Sweden	2008/09				108		Pettersson and Wahlberg, 2010
	Norway	2012/13	50	6.9-85	26	29		Blytt et al, 2013
	<b>Norway</b>	<b>2017/18</b>	<b>20</b>	<b>18-110</b>	<b>58.5</b>	<b>57.4</b>	<b>90.2</b>	<b>This survey</b>
DOT	Norway	2012/13	50	1-19	5.2	6.2		Blytt et al, 2013
	<b>Norway</b>	<b>2017/18</b>	<b>20</b>	<b>&lt;20</b>				<b>This survey</b>



# References

- Berge, J.A., Borgå, K. and Enge E.K.** (2008): *Analysis of sediments: Source tracking of brominated flame retardants in the Ålesund area*, NIVA-report no. 5674-2008, SFT report TA2441/2008
- Blytt, L.D.** (2007). *Organic pollutants in Norwegian wastewater sludge. Results from the survey in 2006/07*. NORVAR-report 157-2007
- Blytt, L.D., Bruskeland A.B. and Stang P.** (2013). *Organic Pollutants in Norwegian Wastewater Sludge – Results from the Survey in 2012/13*. NORVAR-report 198-2013
- Blytt, L.D. Henninge, L.B., Stang, P. and Neidel, T.L.** (2018), *Limit values for organic pollutants in fertilisers based on organic waste origin*, Report for the Norwegian Environment Agency.
- Blytt, L.D.** (2008): *Results from the additional sludge survey with focus on micropollutants*, Norwegian Food Safety Authority, Note 3 April 2008, Aquateam Project O-07071
- Blytt, L.D.** (2010): *Survey of pollutants in four Norwegian treatment plants PFOA: Bisphenol A, Triclosan, Siloxane (D5), Dodecylphenol and 2,4,6-tri tert-butylphenol*, Aquateam report 10-015, Klif report TA2636/2010
- Budewig, S.** (2012) *Legislation on sewage sludge in Germany. Workshop on FATE sludge and biowaste*, EU Commission
- \*\*\*Brevik, E.M.** (2001): *Status of organic pollutant content in sludge from the Drammen region of Norway*. BUVA-report 26/01 Buskerud Vann og Avløpssester AS Drammen
- Defra** (2009). *Advisory committee on hazardous substances - report on nanosilver*, Department for Environment, Food and Rural Affairs, UK
- ECHA** (2018). *Market Survey: Use of Bisphenol A and its alternatives in thermal paper in the EU from 2014 to 2017*. Ref: ECHA-18-R-11-EN. Mai 1018.
- Eriksen, S.E., Amundsen, C.E., Bernhoft, A., Eggen, T. Grave K., Hallgeir-Sørensen, B., Källqvist, T., Sogn, T. and Sverdrup, L.** (2009): *Risk assessment of contaminants in sewage sludge applied on Norwegian soils, Opinion of the Panel on Contaminants in the Norwegian Scientific Committee for Food Safety*, VKM Vitenskapskomiteen for mattrygghet
- Eriksson J.** (2001): *Content of 61 trace elements in wastewater sludge, manure, precipitation and in the soil and crops*, SNV report 5148, Swedish Environmental Protection Agency (Naturvårdsverket), Stockholm, Sweden
- EU** (2000): *Working document on sludge, 3rd draft*. Brussels, 27. April 2000
- EU** (2003): *Technical Guidance Document on Risk Assessment (TGD). Environmental risk assessment Part II*. European Commission.
- EU** (2011): *Technical Guidance for Deriving Environmental Quality Standards. Common Implementation Strategy for Water Framework Directive (200/60/EC) Guidance Document No.27*. European Commission.
- Fjeld E., Schlabach, M., Berge, J.A., Green, N., Eggen, T., Snilsberg, P., Vogelsang, C., Rognerud., Kjellberg, G., Enge, E.K., Dye., C. and Gundersen, H.** (2005): *Survey of select new organic pollutants in 2004. Brominated flame retardants, perfluoroalkyl substances, irgarol, diuron, BHT and dicofol*. SFT TA-2096/2005.
- Fjeld, E. Rognerud, S., Enge, E.K., Borgen, A.R., and Dye, C.** (2007). *The inflow of pollutants into Mjøsa Lake in Norway via municipal treatment plants and rivers, 2006*. State programme for pollution monitoring. SFT report TA-2270/2007.
- Fjeld, E.** (2008). *Pollutants in treatment plants in the Mjøs region, 2005–2007. Follow-up surveys into wastewater and sludge*. NIVA Report 1022/2008. SFT TA-2406/2008
- Hörsing, M.** (2018) *Screening wastewater sludge on farmland – what do we need to know about undesired organic substances?* Swedish Water & Wastewater Association R&D (SVU) Report no. 2018-4
- Jensen, J., Ingvertsen, S.T. and Magid, J.** (2012). *Risk evaluation of five groups of persistent organic contaminants in Sewage sludge*. Danish Environmental Protection Agency. Environmental project no. 1406 2012.
- Kaj, L., Schlabach, M., Andersson, J., Cousins, A.P., Schmidbauer, N. and Brorström-Lundén, E.** (2005): *Siloxanes in the Nordic environment*. Nordic Council of Ministers report, TemaNord 2005: 593
- Kaj, L. Ekheide, Y., Dusan, B., Hansson, K., Coisins, A.P., Remberger, M., Brorström-Lundén and Schlabach, M.** (2007): *Screening 2004 – follow-up project. Analysis of octachlorostyrene, liquid methyl siloxanes, certain phenols and endosulfan*. Swedish Environmental Research Institute, Report B1745
- Konieczny, R.M. Horvath, A., Lyngstad, E., Dalen, H. Blytt, L.D., Henninge, L.B., Ferenčík, M., Nilan, M.S., Bergqvist, P-A., Grabic, R., Haukelidsæter S. and Randall, S.** (2017): *Screening programme 2016: Suspected PBT compounds*. Environmental monitoring report M-806|2017

- Konieczny, R.M., Henninge, L.B., Dalen, H., Grabic, R., Ferenčík, M., Bergqvist, P-A., Lyngstad, E., Berger, J., Haukelidsæter S., and Randall, S.** (2018): *Screening programme 2017*. Suspected PBT compounds Environmental monitoring report M-1063|2018
- Langenkamp, H., Part, P., Erhardt, W. and Prües** (2001): *Organic contaminants in sewage sludge for agricultural use*. Joint Research Centre report.
- Leschber, R.** (2006): *Background values in European soils and sewage sludges. Results of a JRC coordinated study on background values. Part 1 Evaluation of the relevance of organic micro-pollutants in sewage sludge* EUR 22265EN
- Environmental Chemistry** (1996). *Environmentally hazardous substances. Analysis opportunities*. Course no. 96.304, 30.10.96, Norwegian Centre for the Environment, Oslo.
- Environment.no** (2018). <http://www.miljostatus.no>
- Environmental Protection Agency** (2012). *Survey of PCB, dioxins and heavy metals in sludge exported to Germany*. Environmental project no. 1433, 2012
- Mogensen, B.B., Pritzl, G., Rastogi, S., Glesne, O., Hedlund, B., Hirvi, J-P., Lundgren, A. and Sigurdsson, A.** (2004). *Musk Compounds in the Nordic environment*. TemaNord 2004:503
- Nedland K.T.** (2002). *Organic pollutants in Norwegian wastewater sludge. Results from a new survey in 2001/02*. Aquateam report 02-018. O-01031.
- Nedland K. T. and Paulsrud B.** (2006): *Screening survey of metals and organic contaminants in sludge from four Norwegian treatment plants*. Aquateam report 06-031. O-06072.
- Nielsen E., Østergaard G., Thorup I., Ladefoged O., Jernes J.E.** (2000) *Limit Values for Nonylphenol, Nonylphenol Ethoxylates, Tricresyl, Phosphates and Benzoic Acid*. The Institute of food Safety and Toxicology. Danish Veterinary and Food Administration. Toxicological Evaluation and Environmental Project No. 512 2000. Environmental Project.
- NOU – Norwegian Official Report** (2010): *A Norway without pollutants How we can stop the emission of pollutants that pose a threat to our health and environment*. 2010:9
- Pettersson, M. and Wahlberg C.** (2010): *Monitoring of priority substances in water and sludge from wastewater treatment plants in Stockholm*. Swedish Water & Wastewater Association R&D (SVU) Report no. 2010:62.
- Paulsrud, B., Nedland, K.T. and Wien, A.** (1997): *Organic pollutants in Norwegian wastewater sludge*. SFT report 97:25. The Norwegian Climate and Pollution Agency, Oslo.
- Pettersson, M. and Wahlberg C.** (2010): *Monitoring of priority substances in water and sludge from wastewater treatment plants in Stockholm*. Swedish Water & Wastewater Association R&D (SVU) Report no. 2010:62
- Samsøe-Petersen, L., Winther Nielsen, M., and Madsen, T.** (2003): *Environmental Project No 861, Fate and effects of triclosan*, Danish EPA (Miljøstyrelsen), Denmark
- Schlabach, M., Remberger, M., Brorström-Lundén E., Norström, K., Kaj L., Andersson, H., Herzke, D., Borgen A., and Harju, M.** (2011): *Brominated Flame Retardants (BFR) in the Nordic Environment*. Nordic Council of Ministers. TemaNord 2011:528
- Sørensen, P.** (2012). *Priority pollutants: National emissions – status in 2010*. Klif report TA 2981/2012
- Tavazzi, S., Locoro, G., Comero, S., Sobiecka, E., Loos, R., Gans, O., Ghiani, M., Umlauf, G., Suurkuusk, G., Paracchini, B., Cristache, C., Fissiaux, I., Riuz A.A., and Gawlik B.M.** (2012): *Occurrence and levels of selected compounds in European sewage sludge samples. Results of a Pan-European Screening Exercise*. Joint Research Centre report.
- Thomas K.V., Langford K.H., Muthanna T., Schlabach M., Enge E.K., Borgen A., Ghebremeskel M., Gundersen H., Leknes H., Uggerud H., Haglund P, Liao Z. and Liltved H.** (2011) *Occurrence of selected organic micropollutants and silver at wastewater treatment plants in Norway*. KLIF TA-2784/2011
- Thomas K.V., Schlabach M., Langford K., Fjeld E., Øxnevad S., Rundberget T., Bæk K., Rostkowski P. and Harju M.** (2014) *Screening programme 2013: New bisphenols, organic peroxides, fluorinated siloxanes, organic UV filters and selected PBT substances*. Norwegian Environment Agency M-176/2014
- Thomas K.V., Langford K., Reid M., Vogelsang C., Øxnevad S., Bæk K., Fjeld E., Brooks S., Pampanin D.M., Nikiforov V., Schlabach M.** (2016) *Screening Programme 2015: Pharmaceuticals and hormones*. Norwegian Environment Agency M-597/2016
- TemaNord** (2012) *PPCP monitoring in the Nordic Countries –Status Report*. TemaNord 2012:519 <http://www.miljodirektoratet.no/old/klif/publikasjoner/2954/ta2954.pdf>
- Wherter, I.** (2012): *Sewage Sludge Regulation in Denmark with Scandinavian outlook*, Workshop on FATE sludge and biowaste, EU commission



# Annex 1: Analysis results – raw data

## 1.1. Raw data: PAH (µg/kg TS)

Treatment plant	Mnth.	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene
Bekkelaget	Oct	170	65	94	160	320	86	410	400
	Nov	190	47	97	150	290	72	310	330
	Dec	200	46	97	130	300	62	250	290
	Jan	200	50	100	160	350	60	270	330
	Feb	130	39	78	110	280	49	230	280
Bergen Biogas Plant	Oct	55	28	42	50	110	26	200	240
	Nov	69	36	49	58	140	39	270	300
	Dec	99	49	110	130	220	40	320	370
	Jan	84	29	65	72	160	34	280	330
	Feb	110	38	68	94	190	41	330	400
Fuglevik Plant	Oct	180	20	57	71	150	31	150	130
	Nov	200	20	45	57	140	30	210	190
	Dec	320	17	42	55	150	27	150	150
	Jan	580	13	47	72	160	25	130	140
	Feb	310	12	49	59	130	22	110	120
Hias	Oct	83	16	76	110	230	29	240	230
	Nov	160	48	210	240	320	24	280	360
	Dec	130	39	230	190	250	19	190	300
	Jan	120	19	280	140	190	28	150	220
	Feb	180	17	240	180	150	27	160	200
Høvringen Plant	Oct	170	48	150	210	410	69	310	350
	Nov	280	150	350	590	1,100	69	440	740
	Dec	510	260	570	850	1,900	190	530	1,000
	Jan	330	190	520	890	1,600	200	360	690
	Feb	480	240	480	580	1,300	290	490	1,000
Gardermoen Plant	Oct	140	10	44	90	200	73	120	180
	Nov	170	12	49	110	210	73	120	170
	Dec	150	11	45	71	140	34	100	160
	Jan	94	12	41	65	120	27	110	160
	Feb	290	14	66	71	120	18	62	120
Knappen Plant	Oct	40	<5.0	11	14	45	5.9	52	56
	Nov	39	<5.0	14	12	53	6.8	64	85
	Dec	46	5.2	17	18	69	5.9	63	93
	Jan	38	8.8	29	29	92	7.5	60	86
	Feb	40	7.3	25	25	71	7	53	78

	Benzo(a) anthracene	Chrysene	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Benzo[a] pyrene	Dibenzo[a,h] anthracene	Benzo(ghi) perylene	Indeno [1,2,3- cd] pyrene	Sum PAH <sub>6</sub>
	150	140	160	82	160	100	26	130	2,653
	100	100	120	59	100	75	23	100	2,163
	79	76	84	42	69	51	13	77	1,866
	84	85	95	44	72	54	11	86	2,051
	78	75	92	40	67	49	13	79	1,689
	72	75	85	35	56	62	16	74	1,226
	110	100	110	60	110	90	21	120	1,682
	120	130	140	66	120	95	25	130	2,164
	95	99	110	52	90	81	17	115	1,713
	120	130	130	58	120	90	22	140	2,081
	41	33	38	16	29	22	<10	29	997
	60	57	51	25	43	31	15	42	1,216
	39	37	41	16	27	17	15	29	1,132
	33	36	140	83	25	17	<10	29	1,530
	26	28	41	14	19	19	<10	26	985
	32	35	24	11	<10	15	<10	21	1,152
	36	36	31	13	19	15	<10	25	1,817
	33	40	29	16	20	16	<10	29	1,531
	32	38	29	13	20	16	<10	27	1,322
	37	36	31	12	19	15	<10	27	1,331
	91	94	130	41	83	56	13	94	2,319
	150	170	190	65	110	94	24	160	4,682
	140	150	240	62	100	81	24	160	6,767
	93	160	180	49	63	45	16	100	5,486
	150	180	160	67	100	83	22	160	5,782
	33	33	36	18	32	18	<10	29	1,056
	33	35	35	16	29	21	<10	30	1,113
	31	32	37	17	31	25	<10	42	926
	36	36	40	19	33	22	<10	38	853
	19	22	28	13	18	14	<10	26	901
	14	18	19	9.4	11	11	<10	18	324.3
	20	24	28	11	17	16	<10	28	417.8
	17	22	22	9.7	13	12	<10	22	434.8
	16	21	20	8	11	11	<10	19	456.3
	13	18	18	7.6	10	<10	<10	19	391.9

Continues next page

Continued from last page

Treatment plant	Mnth.	Naphtha- lene	Acenapht- hylene	Acenapht- hene	Fluorene	Phenan- threne	Anthracene	Fluorant- hene	Pyrene	
Ladehammeren RA	Oct	200	26	120	130	250	49	230	250	
	Nov	140	22	110	110	230	40	230	280	
	Dec	190	26	130	140	250	40	230	300	
	Jan	230	28	140	160	330	52	350	390	
	Feb	270	30	150	200	600	120	780	590	
Lindum Biogas	Oct	140	45	98	87	300	41	350	400	
	Nov	120	52	120	140	300	72	370	390	
	Dec	135	53	135	150	370	98	440	460	
	Jan	190	68	140	97	350	35	530	560	
	Feb	150	74	160	200	420	130	480	510	
Lindum raw sludge	Oct	90	31	50	64	120	33	190	230	
	Nov	86	72	110	150	390	110	540	500	
	Dec	100	49	86	120	270	69	340	320	
	Jan	81	33	42	63	170	32	190	180	
	Feb	98	68	110	170	320	79	380	360	
NRA	Oct	91	18	50	49	99	21	130	120	
	Nov	85	20	79	110	250	56	220	190	
	Dec	410	52	110	120	130	15	72	100	
	Jan	67	18	41	54	190	32	210	220	
	Feb	140	16	68	71	140	24	120	130	
Rambekk Plant	Oct	54	11	25	34	110	22	130	160	
	Nov	46	9.2	18	26	84	13	88	120	
	Dec	56	11	29	36	96	14	77	110	
	Jan	52	8	24	35	93	14	70	92	
	Feb	54	6.7	23	34	93	15	66	97	
Sandefjord Plant	Oct	130	28	100	110	270	28	170	180	
	Nov	120	28	99	100	230	24	150	160	
	Dec	150	30	110	110	230	16	130	170	
	Jan	160	35	120	130	230	16	130	160	
	Feb	130	40	170	195	400	41	270	260	
SNJ	Oct	62	32	120	180	450	130	260	560	
	Nov	40	18	65	90	250	86	190	370	
	Dec	51	28	83	150	290	115	190	390	
	Jan	60	30	54	110	250	34	190	330	
	Feb	62	20	47	95	190	30	180	250	
Solumstrand Plant	Oct	68	47	42	54	170	36	300	330	
	Nov	95	66	97	120	320	65	420	430	
	Dec	110	93	150	190	450	120	660	640	
	Jan	140	92	190	210	580	130	680	650	
	Feb	120	89	160	190	480	120	630	640	

	Benzo(a) anthracene	Chrysene	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Benzo[a] pyrene	Dibenzo[a,h] anthracene	Benzo(ghi) perylene	Indeno [1,2,3- cd] pyrene	Sum PAH <sub>16</sub>
	67	65	74	31	60	46	12	70	1,680
	60	70	81	33	57	44	11	98	1,616
	57	68	88	29	48	41	12	94	1,743
	120	120	130	51	93	61	24	120	2,399
	240	190	370	82	170	97	40	120	4,049
	130	130	100	49	71	57	16	73	2,087
	130	120	98	48	85	54	20	70	2,189
	150	140	120	50	89	62	18	93	2,563
	180	160	120	62	110	60	22	89	2,773
	170	170	110	49	97	54	22	77	2,873
	74	69	56	28	51	32	18	40	1,176
	190	180	120	57	110	63	24	76	2,778
	120	98	91	34	70	45	20	58	1,890
	66	60	45	20	38	25	10	30	1,085
	130	110	86	40	72	42	17	52	2,134
	37	38	36	20	31	24	<10	28	792
	46	42	27	13	21	15	<10	22	1,196
	19	20	23	10	<10	11	<10	12	1,104
	87	91	66	34	49	34	<10	41	1,234
	50	53	46	24	37	22	<10	34	975
	49	54	47	20	35	28	<10	40	819
	32	35	36	15	27	23	<10	37	609.2
	26	34	30	13	20	18	<10	34	604
	22	27	23	10	15	11	<10	23	519
	21	25	22	9.2	15	16	<10	19	515.9
	53	52	46	22	30	30	<10	36	1,285
	33	37	37	14	15	19	<10	31	1,097
	33	36	40	13	17	22	<10	31	1,138
	33	41	52	20	17	20	<10	39	1,203
	85	84	100	42	61	55	16	69	2,018
	80	97	81	33	47	38	<10	82	2,252
	62	77	63	22	35	32	<10	74	1,474
	64	90	71	28	39	39	<10	73	1,701
	69	79	88	40	51	47	12	89	1,533
	58	67	74	30	38	38	<10	65	1,244
	130	120	110	43	74	60	18	77	1,679
	160	140	120	59	89	63	24	82	2,350
	240	210	180	68	135	81	26	100	3,453
	250	220	170	68	140	86	24	100	3,730
	215	190	150	58	130	71	24	91	3,358

Continues next page

Continued from last page

Treatment plant	Mnth.	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	
Tønsberg Plant	Oct	31	<5.0	10	13	30	<5.0	36	40	
	Nov	53	5	17	21	44	6.7	41	48	
	Dec	70	6.4	32	30	48	6.5	49	64	
	Jan	53	6.3	30	30	57	11	50	62	
	Feb	110	7.2	44	40	54	8.8	41	53	
VEAS	Oct	63	28	97	110	700	160	800	600	
	Nov	110	37	100	110	770	200	1,200	1,000	
	Dec	130	51	160	180	770	150	740	650	
	Jan	130	50	190	210	500	50	290	300	
	Feb	98	36	140	150	350	33	210	230	
Øra	Oct	200	47	180	210	340	27	110	140	
	Nov	110	26	130	120	150	21	90	110	
	Dec	110	24	58	100	120	18	85	100	
	Jan	120	32	59	93	135	19	93	100	
	Feb	180	69	110	150	180	25	130	160	
Årim	Oct	21	<5.0	<5.0	13	49	9.9	27	36	
	Nov	17	<5.0	5.8	17	71	7.6	80	92	
	Dec	22	7.5	7.4	14	68	12	29	45	
	Jan	22	6.5	<5.0	11	76	19	57	59	
	Feb	37	<5.0	5.2	8.5	34	6.2	43	40	
<b>Average</b>		135.2	37.8	101.5	127.7	283.7	51.1	243.6	282	
<b>Median</b>		110	28	79	110	210	32	190	230	
<b>90% percentile</b>		254	68.6	186	200	492	120	514	596	
<b>Minimum</b>		17	<5	<5	8.5	30	<5	27	36	
<b>Maximum</b>		580	260	570	890	1,900	290	1,200	1,000	
<b>n</b>		95	95	95	95	95	95	95	95	
<b>n &gt; LOD</b>		95	89	93	95	95	94	95	95	

	Benzo(a) anthracene	Chrysene	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Benzo[a] pyrene	Dibenzo[a,h] anthracene	Benzo(ghi) perylene	Indeno [1,2,3- cd] pyrene	Sum PAH <sub>16</sub>
	9.6	13	17	6.7	<10	<10	<10	14	220.3
	10	13	19	6.1	<10	<10	<10	15	298.8
	12	17	24	8.6	11	11	<10	20	409.5
	13	18	24	9.2	11	10	<10	19	403.5
	12	15	14	5.7	<10	<10	<10	11	415.7
	260	210	230	98	170	130	39	140	3,835
	410	340	350	160	270	180	39	240	5,516
	250	215	250	97	180	130	36	135	4,124
	87	86	140	40	72	55	16	71	2,287
	61	56	100	26	44	35	<10	52	1,621
	25	32	28	10	16	13	<10	48	1,426
	25	28	31	12	19	16	<10	33	921
	24	28	31	12	20	14	<10	29	773
	21	24	32	12	20	22	<10	30	812
	37	45	49	22	31	28	<10	46	1,262
	5.8	6.9	6.2	<5.0	<10	<10	<10	<10	174.8
	8.4	11	6.2	<5.0	<10	<10	<10	<10	316
	8.5	8.1	10	<5.0	<10	<10	<10	<10	231.5
	16	16	22	8.2	18	19	<10	19	368.7
	9.4	11	12	5.4	<10	<10	<10	<10	211.7
	77.6	76.9	79.9	32.7	54.3	40.3	12.0	60.12	1,692
	57	56	52	24	37	30	<10	42	1,322
	166	170	160	65.6	116	84.8	24	120	3,415
	5.8	6.9	6.2	<5	<10	<10	<10	<10	174.8
	410	340	370	160	270	180	40	240	6,767
	95	95	95	95	95	95	95	95	95
	95	95	95	92	86	87	43	91	95

## 1.2. Raw data: brominated flame retardants ( $\mu\text{g}/\text{kg TS}$ )

The table only shows brominated flame retardants that were detected in the sludge samples.

The following brominated flame retardants were measured but not detected at levels over the detection limit ( $\mu\text{g}/\text{kg TS}$ ): TriBDE (<1); Hepta BDE (<2); OctaBDE (<2); PBDE 3 (<0,5); PBDE 7 (<0,5); PBDE 15 (<0,5); PBDE 17 (<0,5); PBDE 77 (<0,5); PBDE 85 (<0,5); PBDE 119 (<0,5); PBDE 138 (<0,5); PBDE 156 (<0,5); PBDE 175 (<2); PBDE 183 (<2); PBDE 184 (<2); PBDE 190 (<2); PBDE 191 (<2); PBDE 196 (<2); PBDE 197 (<2); PBDE 202 (<2);

Treatment plant	Mnth.	PBDE 28	PBDE 47	PBDE 49+71	PBDE 66	PBDE 99	PBDE 100	PBDE 126	PBDE 153
Bekkelaget	Oct	<0.5	5.5	<1.0	<0.5	4.4	1.2	<0.5	<0.5
	Nov	<0.5	5.5	<1.0	<0.5	4.5	1.3	<0.5	<0.5
	Dec	<0.5	3.9	<1.0	<0.5	3.2	0.9	<0.5	<0.5
	Jan	<0.5	3.9	<1.0	<0.5	3.2	0.8	<0.5	<0.5
	Feb	<0.5	4.0	<1.0	<0.5	3.3	0.9	<0.5	<0.5
Bergen Biogas Plant	Oct	<0.5	4.5	<1.0	<0.5	3.6	0.9	<0.5	<0.5
	Nov	<0.5	4.3	<1.0	<0.5	2.6	0.8	<0.5	<0.5
	Dec	<0.5	3.9	<1.0	<0.5	3.4	0.8	<0.5	<0.5
	Jan	<0.5	4.5	<1.0	<0.5	3.2	0.9	<0.5	<0.5
	Feb	<0.5	5.3	<1.0	<0.5	5.2	1.4	<0.5	<0.5
Fuglevik Plant	Oct	<0.5	4.1	<1.0	<0.5	3.5	0.9	<0.5	<0.5
	Nov	<0.5	3.2	<1.0	<0.5	2.7	0.6	<0.5	<0.5
	Dec	<0.5	4.0	<1.0	<0.5	3.8	1.0	<0.5	<0.5
	Jan	<0.5	4.3	<1.0	<0.5	3.7	0.9	<0.5	<0.5
	Feb	<0.5	4.0	<1.0	<0.5	3.5	0.8	<0.5	<0.5
Hias	Oct	<0.5	5.4	<1.0	<0.5	5.0	1.2	<0.5	<0.5
	Nov	<0.5	4.7	<1.0	<0.5	4.4	1.0	<0.5	<0.5
	Dec	<0.5	4.6	<1.0	<0.5	3.8	1.0	<0.5	<0.5
	Jan	<0.5	4.5	<1.0	<0.5	4.3	1.0	<0.5	<0.5
	Feb	<0.5	5.4	<1.0	<0.5	4.0	1.0	<0.5	<0.5
Høvringen Plant	Oct	<0.5	3.5	<1.0	<0.5	2.6	0.8	<0.5	<0.5
	Nov	<0.5	2.8	<1.0	<0.5	1.8	<0.5	<0.5	<0.5
	Dec	<0.5	3.2	<1.0	<0.5	2.3	0.5	<0.5	<0.5
	Jan	<0.5	4.3	<1.0	<0.5	3.5	0.9	<0.5	<0.5
	Feb	<0.5	3.0	<1.0	<0.5	2.1	0.6	<0.5	<0.5
Gardermoen Plant	Oct	<0.5	8.3	<1.0	<0.5	7.5	1.9	<0.5	<0.5
	Nov	<0.5	8.6	<1.0	<0.5	6.3	1.6	<0.5	<0.5
	Dec	<0.5	8.1	<1.0	<0.5	6.6	1.6	<0.5	<0.5
	Jan	<0.5	6.1	<1.0	<0.5	5.2	1.4	<0.5	<0.5
	Feb	<0.5	6.6	<1.0	<0.5	5.7	1.2	<0.5	<0.5

	PBDE 154	PBDE 206	PBDE 207	PBDE 209	DBDPE	Tetra BDE	Penta BDE	Hexa BDE	Nona BDE	Sum* PBDE
	<0.5	<2.0	3.6	180.0	28	5.5	5.6	<1.0	3.6	194.7
	<0.5	3.5	5.3	240.0	31	5.5	5.8	<1.0	8.8	260.1
	<0.5	5.6	5.5	550	39	3.9	4.1	<1.0	11.0	569.0
	<0.5	6.9	4.1	560	<20	3.9	4.0	<1.0	11.0	578.9
	<0.5	5.1	4.0	500	23	4.0	4.2	<1.0	9.1	517.3
	<0.5	11.0	9.5	990	30	4.5	4.5	<1.0	21.0	1,020.0
	<0.5	18.0	12.0	760	27	4.3	3.4	<1.0	30.0	797.7
	<0.5	11.0	12.0	330.0	<20	3.9	4.2	<1.0	33.0	371.1
	<0.5	8.0	5.1	190	<20	4.5	4.1	<1.0	13.0	211.6
	<0.5	5.9	4.4	44.0	<20	5.3	6.6	<1.0	10.0	65.9
	<0.5	8.4	7.4	1,100	100	4.1	4.4	<1.0	16.0	1,124.5
	<0.5	4.9	3.1	660	130	3.2	3.3	<1.0	8.0	674.5
	<0.5	7.0	5.8	580	170	4.0	4.8	<1.0	13.0	601.8
	<0.5	<2.0	2.6	250.0	36	4.3	4.6	<1.0	2.6	261.5
	<0.5	12.0	6.2	760	70	4.0	4.3	<1.0	18.0	786.3
	<0.5	<2.0	<2.0	360	<20	5.4	6.2	<1.0	<2.0	371.6
	<0.5	<2.0	<2.0	200	<20	4.7	5.4	<1.0	<2.0	210.1
	<0.5	<2.0	<2.0	150	<20	4.6	4.8	<1.0	<2.0	159.4
	<0.5	<2.0	<2.0	160	<20	4.5	5.3	<1.0	<2.0	169.8
	<0.5	<2.0	<2.0	<2.0	<20	5.4	5.0	<1.0	<2.0	10.4
	<0.5	10.0	9.4	73.0	<20	3.5	3.4	<1.0	19.0	98.9
	<0.5	17.0	8.5	620	<20	2.8	1.8	<1.0	26.0	650.6
	<0.5	<2.0	<2.0	<2.0	<20	3.2	2.8	<1.0	<2.0	6.0
	<0.5	15.0	15.0	110.0	<20	4.3	4.4	<1.0	30.0	148.7
	<0.5	14.0	8.8	76.0	<20	3.0	2.7	<1.0	23.0	104.7
	<0.5	6.8	7.7	50.0	<20	8.3	9.4	<1.0	15.0	82.7
	<0.5	11.0	11.0	1,200	45	8.6	7.9	<1.0	22.0	1,238.5
	<0.5	5.1	3.1	51.0	<20	8.1	8.2	<1.0	8.2	75.5
	<0.5	12.0	8.7	100.0	<20	6.1	6.6	<1.0	21.0	133.7
	<0.5	3.4	2.4	460	43	6.6	6.9	<1.0	5.8	479.3

Continues next page

Continued from last page

Treatment plant	Mnth.	PBDE 28	PBDE 47	PBDE 49+71	PBDE 66	PBDE 99	PBDE 100	PBDE 126	PBDE 153
Knappen Plant	Oct	<0.5	2.4	<1.0	<0.5	2.1	<0.5	<0.5	<0.5
	Nov	<0.5	2.1	<1.0	<0.5	1.9	<0.5	<0.5	<0.5
	Dec	<0.5	2.2	<1.0	<0.5	1.8	<0.5	<0.5	<0.5
	Jan	<0.5	2.3	<1.0	<0.5	2.3	0.6	<0.5	<0.5
	Feb	<0.5	2.1	<1.0	<0.5	1.7	<0.5	<0.5	<0.5
Ladehammeren Plant	Oct	<0.5	3.7	<1.0	<0.5	2.6	0.7	<0.5	<0.5
	Nov	<0.5	2.8	<1.0	<0.5	2.4	<0.5	<0.5	<0.5
	Dec	<0.5	2.9	<1.0	<0.5	2.6	0.5	<0.5	<0.5
	Jan	<0.5	2.9	<1.0	<0.5	2.4	0.6	<0.5	<0.5
	Feb	<0.5	2.8	<1.0	<0.5	2.3	0.5	<0.5	<0.5
Lindum Biogas	Oct	<0.5	4.2	<1.0	<0.5	3.0	0.8	<0.5	<0.5
	Nov	<0.5	5.1	<1.0	<0.5	5.1	1.3	<0.5	<0.5
	Dec	<0.5	5.0	<1.0	<0.5	4.4	0.9	<0.5	<0.5
	Jan	<0.5	4.6	<1.0	<0.5	3.8	0.9	<0.5	<0.5
	Feb	<0.5	4.1	<1.0	<0.5	3.3	0.9	<0.5	<0.5
Lindum raw sludge	Oct	<0.5	3.5	<1.0	<0.5	2.4	0.7	<0.5	<0.5
	Nov	<0.5	1.8	<1.0	<0.5	2.4	<0.5	<0.5	<0.5
	Dec	<0.5	2.5	<1.0	<0.5	2.9	0.6	<0.5	<0.5
	Jan	<0.5	2.6	<1.0	<0.5	2.6	0.6	<0.5	<0.5
	Feb	<0.5	2.4	<1.0	<0.5	2.6	<0.5	<0.5	<0.5
NRA	Oct	<0.5	2.8	<1.0	<0.5	2.8	0.7	<0.5	<0.5
	Nov	<0.5	2.8	<1.0	<0.5	2.3	0.6	<0.5	<0.5
	Dec	<0.5	2.9	<1.0	<0.5	2.7	0.7	<0.5	<0.5
	Jan	<0.5	2.6	<1.0	<0.5	2.6	0.6	<0.5	<0.5
	Feb	<0.5	2.7	<1.0	<0.5	2.4	<0.5	<0.5	<0.5
Rambekk Plant	Oct	<0.5	43.0	1.4	0.6	34.0	7.4	0.9	<0.5
	Nov	0.5	38.0	1.4	0.6	29.0	6.5	0.8	0.9
	Dec	<0.5	39.0	1.2	<0.5	30.0	7.1	0.6	<0.5
	Jan	<0.5	37.0	1.4	<0.5	26.0	6.0	0.7	<0.5
	Feb	<0.5	35.0	<1.0	<0.5	24.0	5.6	0.6	<0.5
Sandefjord Plant	Oct	<0.5	6.5	<1.0	<0.5	6.1	1.5	<0.5	<0.5
	Nov	<0.5	5.5	<1.0	<0.5	4.6	1.1	<0.5	<0.5
	Dec	<0.5	4.0	<1.0	<0.5	3.1	0.8	<0.5	<0.5
	Jan	<0.5	4.7	<1.0	<0.5	4.5	0.9	<0.5	<0.5
	Feb	<0.5	3.6	<1.0	<0.5	2.8	0.8	<0.5	<0.5
SNJ	Oct	<0.5	11.0	<1.0	<0.5	6.3	1.9	<0.5	<0.5
	Nov	<0.5	7.3	<1.0	<0.5	2.3	0.7	<0.5	<0.5
	Dec	<0.5	5.9	<1.0	<0.5	4.2	1.3	<0.5	<0.5
	Jan	<0.5	5.3	<1.0	<0.5	3.9	1.3	<0.5	<0.5
	Feb	<0.5	5.1	<1.0	<0.5	4.5	0.9	<0.5	<0.5

	PBDE 154	PBDE 206	PBDE 207	PBDE 209	DBDPE	Tetra BDE	Penta BDE	Hexa BDE	Nona BDE	Sum* PBDE
	<0.5	2.5	<5.0	300	30	2.4	2.1	<1.0	2.5	307.0
	<0.5	<2.0	<2.0	150	<20	2.1	1.9	<1.0	<2.0	154.0
	<0.5	6.1	3.4	700	22	2.2	1.8	<1.0	9.5	713.5
	<0.5	3.9	<2.0	500	<20	2.3	2.9	<1.0	3.9	509.1
	<0.5	<2.0	<2.0	160	<20	2.1	1.7	<1.0	<2.0	163.8
	<0.5	<2.0	<2.0	<2.0	<20	3.7	3.3	<1.0	<2.0	7.0
	<0.5	<2.0	<2.0	370	33	2.8	2.4	<1.0	<2.0	375.2
	<0.5	4.7	2.6	350	<20	2.9	3.1	<1.0	7.3	363.3
	<0.5	<2.0	<2.0	47.0	<20	2.9	3.0	<1.0	<2.0	52.9
	<0.5	<2.0	<2.0	63.0	<20	2.8	2.8	<1.0	<2.0	68.6
	<0.5	<2.0	<2.0	91	<20	4.2	3.8	<1.0	<2.0	99.0
	<0.5	<2.0	<2.0	320	40	5.1	6.4	<1.0	<2.0	331.5
	<0.5	3.0	2.4	220	<20	5.0	5.3	<1.0	5.4	235.7
	<0.5	2.2	4.5	130	<20	4.6	4.7	<1.0	6.7	146.0
	<0.5	<2.0	<2.0	46.0	<20	4.1	4.2	<1.0	<2.0	54.3
	<0.5	<2.0	<2.0	250	<20	3.5	3.1	<1.0	<2.0	256.6
	<0.5	<2.0	<2.0	110	<20	1.8	2.4	<1.0	<2.0	114.2
	<0.5	<2.0	<2.0	160	<20	2.5	3.5	<1.0	<2.0	166.0
	<0.5	<2.0	<2.0	270	<20	2.6	3.2	<1.0	<2.0	275.8
	<0.5	<2.0	<2.0	130.0	<20	2.4	2.6	<1.0	<2.0	135.0
	<0.5	21.0	17.0	1,500	700	2.8	3.5	<1.0	38.0	1,544.3
	<0.5	2.1	<2.0	62.0	<20	2.8	2.9	<1.0	2.1	69.8
	<0.5	<2.0	<2.0	110.0	<20	2.9	3.4	<1.0	<2.0	116.3
	<0.5	<2.0	<2.0	30.0	<20	2.6	3.2	<1.0	<2.0	35.8
	<0.5	<2.0	<2.0	75	<20	2.7	2.4	<1.0	<2.0	80.1
	1.3	6.3	2.6	400	<20	45.0	42.0	1.3	8.9	497.2
	1.5	5.8	5.4	370	<20	40.0	36.0	2.4	11.0	459.4
	1.1	11.0	4.2	410	<20	40.0	38.0	1.1	15.0	504.1
	<0.5	7.5	4.4	340	<20	38.0	33.0	<1.0	12.0	423.0
	0.6	<2.0	<2.0	14.0	<20	35.0	30.0	<1.0	<2.0	79.0
	<0.5	<2.0	<2.0	<2.0	<20	6.5	7.6	<1.0	<2.0	14.1
	<0.5	12.0	10.0	120.0	<20	5.5	5.7	<1.0	22.0	153.2
	<0.5	<2.0	<2.0	<2.0	<20	4.0	3.9	<1.0	<2.0	7.9
	<0.5	<2.0	<2.0	15.0	<20	4.7	5.4	<1.0	<2.0	25.1
	<0.5	<2.0	<2.0	270	31	3.6	3.6	<1.0	<2.0	277.2
	<0.5	19.0	23.0	92.0	<20	11.0	8.2	<1.0	42.0	153.2
	<0.5	8.8	8.4	130	<20	7.3	3.0	<1.0	17.0	157.3
	<0.5	21.0	21.0	740	<20	5.9	5.5	<1.0	42.0	793.4
	<0.5	18.0	23.0	930	50	5.3	5.2	<1.0	41.0	981.5
	<0.5	13.0	13.0	740	34	5.1	5.4	<1.0	26.0	776.5

Continues next page

Continued from last page

Treatment plant	Mnth.	PBDE 28	PBDE 47	PBDE 49+71	PBDE 66	PBDE 99	PBDE 100	PBDE 126	PBDE 153
Solumstrand Plant	Oct	<0.5	1.9	<1.0	<0.5	2.0	0.5	<0.5	<0.5
	Nov	<0.5	2.7	<1.0	<0.5	2.7	0.7	<0.5	<0.5
	Dec	<0.5	2.2	<1.0	<0.5	2.2	0.5	<0.5	<0.5
	Jan	<0.5	2.6	<1.0	<0.5	2.3	0.5	<0.5	<0.5
	Feb	<0.5	2.6	<1.0	<0.5	2.2	<0.5	<0.5	<0.5
Tønsberg Plant	Oct	<0.5	1.3	<1.0	<0.5	1.4	<0.5	<0.5	<0.5
	Nov	<0.5	1.2	<1.0	<0.5	1.2	<0.5	<0.5	<0.5
	Dec	<0.5	1.7	<1.0	<0.5	1.7	<0.5	<0.5	<0.5
	Jan	<0.5	1.7	<1.0	<0.5	1.9	<0.5	<0.5	<0.5
	Feb	<0.5	4.4	<1.0	<0.5	7.2	2.1	<0.5	<0.5
VEAS	Oct	<0.5	3.2	<1.0	<0.5	2.8	0.7	<0.5	<0.5
	Nov	<0.5	3.1	<1.0	<0.5	2.4	0.6	<0.5	<0.5
	Dec	<0.5	3.2	<1.0	<0.5	2.6	0.7	<0.5	<0.5
	Jan	<0.5	3.1	<1.0	<0.5	2.6	0.5	<0.5	<0.5
	Feb	<0.5	3.4	<1.0	<0.5	2.9	0.8	<0.5	<0.5
Øra	Oct	<0.5	1.7	<1.0	<0.5	1.6	<0.5	<0.5	<0.5
	Nov	<0.5	2.0	<1.0	<0.5	2.7	0.8	<0.5	<0.5
	Dec	<0.5	1.8	<1.0	<0.5	1.7	0.5	<0.5	<0.5
	Jan	<0.5	1.6	<1.0	<0.5	2.0	<0.5	<0.5	<0.5
	Feb	<0.5	1.7	<1.0	<0.5	1.9	<0.5	<0.5	<0.5
Årim	Oct	<0.5	1.8	<1.0	<0.5	1.0	<0.5	<0.5	<0.5
	Nov	<0.5	2.8	<1.0	<0.5	0.7	<0.5	<0.5	<0.5
	Dec	<0.5	2.6	<1.0	<0.5	1.9	<0.5	<0.5	<0.5
	Jan	<0.5	2.9	<1.0	<0.5	1.7	<0.5	<0.5	<0.5
	Feb	<0.5	3.0	<1.0	<0.5	2.5	<0.5	<0.5	<0.5
<b>Average</b>		<0.5	5.59	<1	<0.5	4.50	1.05	<0.5	<0.5
<b>Median</b>		<0.5	3.5	<1	<0.5	2.8	0.8	<0.5	<0.5
<b>90% percentile</b>		<0.5	7.02	<1	<0.5	6.22	1.56	<0.5	<0.5
<b>Minimum</b>		<0.5	1.2	<1	<0.5	0.7	<0.5	<0.5	<0.5
<b>Maximum</b>		0.5	43	1.4	0.6	34	7.4	0.9	0.9
<b>n</b>		95	95	95	95	95	95	95	95
<b>n &gt; LOD</b>		1	95	4	2	95	73	5	1

\* Sum TriBDE, TetraBDE, PentaBDE, HexaBDE, HeptaBDE, OctaBDE, NonaBDE and decaBDE (or PBDE 209). Data under the limits are set as 0 for summation.

	PBDE 154	PBDE 206	PBDE 207	PBDE 209	DBDPE	Tetra BDE	Penta BDE	Hexa BDE	Nona BDE	Sum* PBDE
	<0.5	<2.0	<2.0	260	<20	1.9	2.5	<1.0	<2.0	264.4
	<0.5	<2.0	<2.0	110	<20	2.7	3.4	<1.0	<2.0	116.1
	<0.5	<2.0	<2.0	67	<20	2.2	2.7	<1.0	<2.0	71.9
	<0.5	<2.0	<2.0	40	<20	2.6	2.8	<1.0	<2.0	45.4
	<0.5	<2.0	<2.0	46	<20	2.6	2.2	<1.0	<2.0	50.8
	<0.5	<2.0	<2.0	230	98	1.3	1.4	<1.0	<2.0	232.7
	<0.5	<2.0	<2.0	300	41	1.2	1.2	<1.0	<2.0	302.4
	<0.5	<2.0	<2.0	120	<20	1.7	1.7	<1.0	<2.0	123.4
	<0.5	<2.0	<2.0	120	<20	1.7	1.9	<1.0	<2.0	123.6
	0.7	5.6	<2.0	1,500	29	4.4	9.3	<1.0	5.6	1,519.3
	<0.5	<2.0	<2.0	270	<20	3.2	3.5	<1.0	<2.0	276.7
	<0.5	<2.0	<2.0	230	<20	3.1	3.0	<1.0	<2.0	236.1
	<0.5	<2.0	<2.0	100	61	3.2	3.4	<1.0	<2.0	106.6
	<0.5	<2.0	<2.0	230	<20	3.1	3.1	<1.0	<2.0	236.2
	<0.5	<2.0	<2.0	340	<20	3.4	3.7	<1.0	<2.0	347.1
	<0.5	<2.0	<2.0	720	87	1.7	1.6	<1.0	<2.0	723.3
	<0.5	<2.0	<2.0	620	270	2.0	3.5	<1.0	<2.0	625.5
	<0.5	<2.0	<2.0	650	190	1.8	2.2	<1.0	<2.0	654.0
	<0.5	<2.0	<2.0	490	110	1.6	2.0	<1.0	<2.0	493.6
	<0.5	<2.0	<2.0	540	66	1.7	1.9	<1.0	<2.0	543.6
	<0.5	<2.0	<2.0	94	<20	1.8	1.0	<1.0	<2.0	96.8
	<0.5	55.0	33.0	3,400	<20	2.8	<1.0	<1.0	88.0	3,490.8
	<0.5	3.9	2.9	380	33	2.6	1.9	<1.0	6.8	391.3
	<0.5	<2.0	<2.0	250	<20	2.9	1.7	<1.0	<2.0	254.6
	<0.5	<2.0	<2.0	320	<20	3.0	2.5	<1.0	<2.0	325.5
	<0.5	5.12	4.23	352	35.13	5.65	5.53	<1	8.85	371.6
	<0.5	<2	<2	230	<20	3.5	3.5	<1	<2	236.2
	<0.5	12.6	10.6	740	68.4	7.02	7.78	<1	24.8	782.4
	<0.5	<2	<2	<2	<20	1.2	<1	<1	<2	6
	1.5	55	33	3,400	700	45	42	2.4	88	3,491
	95	95	95	95	95	95	95	95	95	95
	5	43	41	90	31	95	94	3	45	90

### 1.3. Raw data: phthalates ( $\mu\text{g}/\text{kg TS}$ ), Triclosan( $\mu\text{g}/\text{kg TS}$ ), arsenic and silver ( $\text{mg}/\text{kg TS}$ )

		DEHP	Dibutylphthalate	4-MeO-cinnamate	Triclosan	Methyltriclosan	Arsenic(As)	Silver (Ag)
Treatment plant	Mnth.	$\mu\text{g}/\text{kg TS}$	$\text{mg}/\text{kg TS}$	$\text{mg}/\text{kg TS}$				
Bekkelaget	Oct	15,500	<100	159	760	<5	<1.0	1.7
	Nov	16,400	<100	192	570	<5	<1.0	1.7
	Dec	18,700	<100	275	750	<5	<1.0	1.9
	Jan	17,500	<100	201	590	<5	<1.0	2.1
	Feb	17,300	<100	157	620	<5	<1.0	1.8
Bergen Biogas Plant	Oct	24,700	<100	280	470	<5	12.0	2.3
	Nov	21,400	<100	350	390	<5	11.0	2.7
	Dec	16,900	<100	322	360	<5	11.0	2.3
	Jan	13,000	<100	324	380	<5	11.0	2.5
	Feb	14,900	<100	352	340	<5	10.0	3.2
Fuglevik Plant	Oct	35,500	<100	439	420	<5	1.0	1.3
	Nov	23,700	<100	1,490	290	<5	<1.0	1.5
	Dec	29,400	<100	480	460	<5	<1.0	1.6
	Jan	29,200	<100	213	470	<5	1.0	1.8
	Feb	30,200	<100	97	480	<5	1.0	1.2
Hias	Oct	24,700	<100	608	370	<5	1.0	2.7
	Nov	22,300	<100	731	310	<5	4.0	2.2
	Dec	28,600	<100	788	380	<5	<1.0	1.9
	Jan	26,200	<100	545	300	<5	1.0	2.1
	Feb	30,000	<100	688	270	<5	<1.0	1.8
Høvringen Plant	Oct	27,800	<100	476	360	<5		
	Nov	25,700	<100	425	330	<5		
	Dec	23,700	<100	539	420	<5		
	Jan	32,400	<100	484	320	<5		
	Feb	32,900	<100	539	350	<5		
Gardermoen Plant	Oct	19,100	<100	96	5,400	<5	1.0	2.0
	Nov	19,100	<100	83	3,900	<5	<1.0	2.3
	Dec	18,700	<100	67	4,300	<5	2.0	1.9
	Jan	24,000	<100	50	4,000	<5	3.0	1.8
	Feb	25,400	<100	69	4,300	<5	2.0	1.4
Knappen Plant	Oct	15,800	<100	4,160	220	<5	1.0	1.1
	Nov	15,700	<100	4,620	150	<5	1.0	1.3
	Dec	22,500	<100	5,010	180	<5	1.0	1.6
	Jan	17,400	<100	6,130	180	<5	<1.0	1.0
	Feb	8,900	<100	3,330	150	<5	<1.0	1.0

Continued from last page

		DEHP	Dibutylphthalate	4-MeO-cinnamate	Triclosan	Methyltriclosan	Arsenic(As)	Silver (Ag)
Treatment plant	Mnth.	µg/kg TS	µg/kg TS	µg/kg TS	µg/kg TS	µg/kg TS	mg/kg TS	mg/kg TS
Ladehammeren RA	Oct	37,700	<100	<50		<5		
	Nov	32,400	<100	<50		<5		
	Dec	33,800	<100	<50		<5		
	Jan	32,100	<100	<50		<5		
	Feb	36,700	<100	<50		<5		
Lindum Biogas	Oct	67,400	<100	629	2,900	<5	<1.0	1.0
	Nov	39,500	<100	863	1,700	<5	1.0	1.4
	Dec	47,100	<100	929	1,800	<5	1.0	1.5
	Jan	52,100	<100	456	1,700	<5	1.0	1.9
	Feb	57,500	<100	409	1,600	<5	1.0	2.4
Lindum raw sludge	Oct	27,200	<100	1,440	160	<5	1.0	1.8
	Nov	37,200	<100	1,260	100	<5	3.0	1.2
	Dec	24,100	<100	1,890	130	<5	1.0	1.5
	Jan	36,000	<100	2,580	120	<5	<1.0	2.6
	Feb	30,200	<100	1,980	98	<5	2.0	1.9
NRA	Oct	21,200	<100	1,370	280	<5	<1.0	1.0
	Nov	15,300	<100	1,590	150	<5	<1.0	<1.0
	Dec	20,700	<100	2,170	200	<5	1.0	1.1
	Jan	20,700	<100	2,140	170	<5	1.0	1.0
	Feb	22,300	<100	2,580	140	<5	<1.0	1.2
Rambekk Plant	Oct	18,200	<100	205		<5		
	Nov	18,900	<100	165		<5		
	Dec	21,600	<100	201		<5		
	Jan	21,700	<100	215		<5		
	Feb	20,800	<100	162		<5		
Sandefjord Plant	Oct	28,700	<100	218	1,600	<5		
	Nov	22,400	<100	136	1,700	<5		
	Dec	29,300	<100	152	1,600	<5		
	Jan	28,500	<100	183	1,400	<5		
	Feb	28,100	<100	230	1,100	<5		
SNJ	Oct	36,500	<100	109	5,400	<5	<1.0	6.2
	Nov	24,300	<100	110	5,200	<5	<1.0	5.0
	Dec	27,200	<100	124	4,200	<5	<1.0	4.4
	Jan	16,700	<100	93	2,700	<5	<1.0	3.6
	Feb	19,500	<100	177	1,900	<5	<1.0	2.6

Continues next page

Continued from last page

		DEHP	Dibutylphthalate	4-MeO-cinnamate	Triclosan	Methyltriclosan	Arsenic(As)	Silver (Ag)
Treatment plant	Mnth.	µg/kg TS	µg/kg TS	µg/kg TS	µg/kg TS	µg/kg TS	mg/kg TS	mg/kg TS
Solumstrand Plant	Oct	50,200	<100	1,340	87	<5	2.0	<1.0
	Nov	80,400	<100	3,080	96	<5	1.0	1.0
	Dec	66,800	<100	1,830	92	<5	<1.0	1.0
	Jan	73,400	<100	3,460	110	<5	<1.0	1.0
	Feb	82,600	<100	2,440	130	<5	<1.0	1.0
Tønsberg Plant	Oct	5,810	<100	726	94	<5	<1.0	1.1
	Nov	8,900	<100	1,680	82	<5	1.0	1.0
	Dec	9,080	<100	2,220	150	<5	<1.0	3.0
	Jan	10,900	<100	2,480	130	<5	<1.0	1.8
	Feb	17,300	<100	3,120	100	<5	1.0	1.2
VEAS	Oct	10,400	<100	263	490	<5	<1.0	2.0
	Nov	9,260	<100	240	390	<5	<1.0	2.1
	Dec	13,600	<100	392	530	<5	<1.0	3.0
	Jan	11,900	<100	364	480	<5	<1.0	2.7
	Feb	13,500	<100	433	410	<5	<1.0	2.2
Øra	Oct	13,400	<100	646	1,200	<5	2.0	1.0
	Nov	10,800	<100	234	620	<5	<1.0	<1.0
	Dec	10,500	<100	281	660	<5	1.0	<1.0
	Jan	10,900	<100	326	620	<5	2.0	<1.0
	Feb	13,900	<100	1,150	670	<5	2.0	<1.0
Årim	Oct	25,200	<100	384		<5		
	Nov	55,100	<100	347		<5		
	Dec	39,900	<100	457		<5		
	Jan	61,400	<100	399		<5		
	Feb	48,300	<100	289		<5		
<b>Average</b>		27,287	<LOD	929	984	<5	1.67	1.82
<b>Median</b>		23,700	<100	399	400	<5	1	1.75
<b>90% percentile</b>		49,440	<100	2,540	3,000	<5	3	2.73
<b>Minimum</b>		5,810	<100	<50	82	<5	<1	<1
<b>Maximum</b>		82,600	<100	6,130	5,400	<5	12	6.2
<b>n</b>		95	95	95	80	95	70	70
<b>n &gt; LOD</b>		95	0	90	80	0	36	64

## 1.4. Raw data: nonylphenol, nonylphenol ethoxylates and other alkylphenols (µg/kg TS)

Treatment plant	Mnth	4-n-nonylphenol	Nonylphenols tech.	nonylphenol monoethoxylate	Nonylphenol diethoxylate	NP + NPEO	2,4,6-Tri-tert-butylphenol	4-tert.-octylphenol	4-n-octylphenol	Heptylphenol	Pentylphenol	Butylphenol	Sum alkylphenols	Dodecylphenol
Bekkelaget	Oct	45.0	750	3,600	650	5,000	<5.0	34.0	<20.0	<20	<20	<20	34	<100
	Nov	59.0	770	3,500	390	4,660	<5.0	41.0	<20.0	23	<20	<20	64	<100
	Dec	24.0	720	1,600	370	2,690	7.7	60.0	<20.0	<20	<20	<20	67.7	<100
	Jan	31.0	710	1,600	280	2,590	7.0	52.0	<20.0	<20	<20	<20	59	<100
	Feb	45.0	680	1,700	470	2,850	5.2	53.0	<20.0	<20	<20	<20	58.2	<100
Bergen Biogas Plant	Oct	<20.0	1,200	3,200	290	4,690	8.0	37.0	<20.0	<20	<20	<20	45	<100
	Nov	<20.0	840	1,800	320	2,960	11.0	30.0	<20.0	<20	<20	<20	41	<100
	Dec	28.0	860	3,500	980	5,340	9.1	23.0	<20.0	<20	<20	<20	32.1	<100
	Jan	<20.0	880	2,100	490	3,470	12.0	34.0	<20.0	<20	<20	<20	46	100
	Feb	23.0	900	4,000	800	5,700	14.0	36.0	<20.0	<20	<20	<20	50	<100
Fuglevik Plant	Oct	<20.0	800	3,700	580	5,080	24.0	28.0	<20.0	<20	<20	<20	52	100
	Nov	23.0	760	2,400	490	3,650	17.0	38.0	<20.0	<20	<20	<20	55	170
	Dec	<20.0	610	3,700	720	5,030	13.0	27.0	<20.0	<20	<20	<20	40	<100
	Jan	24.0	650	6,800	970	8,420	8.0	27.0	<20.0	<20	<20	<20	35	<100
	Feb	24.0	500	3,900	500	4,900	10.0	22.0	<20.0	<20	<20	<20	32	<100
Hias	Oct	<20.0	1,200	3,200	290	4,690	10.0	33.0	<20.0	<20	<20	<20	43	<100
	Nov	<20.0	810	3,300	640	4,750	9.1	29.0	<20.0	<20	<20	<20	38.1	160
	Dec	<20.0	820	5,800	580	7,200	11.0	28.0	<20.0	<20	<20	<20	39	180
	Jan	<20.0	810	3,900	940	5,650	8.7	30.0	<20.0	<20	<20	<20	38.7	120
	Feb	<20.0	830	330	750	1,910	12.0	36.0	<20.0	21	<20	<20	69	<100
Høvringen Plant	Oct	33.0	1,300	3,200	1,800	6,300	16.0	80.0	<20.0	<20	<20	<20	96	<100
	Nov	34.0	1,400	1,400	1,900	4,700	26.0	59.0	<20.0	<20	<20	<20	85	260
	Dec	30.0	1,300	2,600	1,600	5,500	35.0	63.0	<20.0	<20	<20	<20	98	230
	Jan	36.0	1,000	3,900	1,200	6,100	17.0	78.0	43.0	<20	<20	<20	138	<100
	Feb	32.0	1,300	3,900	1,400	6,600	33.0	59.0	80.0	<20	<20	<20	172	470
Gardermoen Plant	Oct	38.0	1,500	8,500	1,400	11,400	9.9	41.0	<20.0	62	<20	<20	112.9	<100
	Nov	36.0	1,500	5,300	340	7,140	7.9	44.0	<20.0	<20	<20	<20	51.9	130
	Dec	48.0	1,300	4,100	1,200	6,600	9.3	48.0	<20.0	<20	<20	<20	57.3	150
	Jan	44.0	1,100	3,500	910	5,510	5.1	47.0	<20.0	<20	<20	<20	52.1	<100
	Feb	26.0	1,100	4,400	500	6,000	7.8	50.0	<20.0	<20	<20	<20	57.8	<100
Knappen Plant	Oct	<20.0	340	1,500	570	2,410	7.9	<20.0	<20.0	<20	<20	<20	7.9	<100
	Nov	<20.0	340	660	620	1,620	14.0	<20.0	<20.0	<20	<20	<20	14	<100
	Dec	<20.0	280	1,100	1,200	2,580	13.0	24.0	<20.0	<20	<20	<20	37	<100
	Jan	<20.0	400	1,300	630	2,330	10.0	<20.0	<20.0	<20	<20	<20	10	<100
	Feb	<20.0	340	590	450	1,380	15.0	<20.0	<20.0	<20	<20	<20	15	<100

Continues next page

Continued from last page

Treatment plant	Mnth	4-n-nonylphenol	Nonylphenols tech.	nonylphenol monoethoxylate	Nonylphenol diethoxylate	NP + NPEO	2,4,6-Tri-tert-butylphenol	4-tert.-octylphenol	4-n-octylphenol	Heptylphenol	Pentylphenol	Butylphenol	Sum alkylphenols	Dodecylphenol
Ladehammeren RA	Oct	<20.0	1,200	1,800	1,000	4,000	33.0	81.0	<20.0	<20	<20	<20	114	<100
	Nov	<20.0	610	1,800	320	2,730	38.0	59.0	<20.0	<20	<20	<20	97	110
	Dec	26.0	640	1,100	260	2,000	21.0	58.0	<20.0	<20	<20	<20	79	<100
	Jan	34.0	770	2,600	1,200	4,570	11.0	57.0	<20.0	<20	<20	<20	68	<100
	Feb	43.0	990	3,600	1,000	5,590	10.0	75.0	<20.0	<20	<20	<20	85	<100
Lindum Biogas	Oct	26.0	1,900	3,700	350	5,950	16.0	100.0	<20.0	<20	<20	<20	116	<100
	Nov	27.0	1,700	4,100	390	6,190	30.0	73.0	<20.0	<20	<20	<20	103	170
	Dec	22.0	1,600	2,300	370	4,270	18.0	96.0	<20.0	<20	<20	<20	114	<100
	Jan	33.0	2,100	3,700	360	6,160	15.0	110.0	<20.0	<20	<20	<20	125	<100
	Feb	29.0	1,900	4,600	430	6,930	16.0	85.0	<20.0	<20	<20	<20	101	180
Lindum raw sludge	Oct	<20.0	1,200	2,100	630	3,930	20.0	37.0	<20.0	<20	<20	<20	57	<100
	Nov	21.0	2,200	6,100	1,500	9,800	18.0	82.0	<20.0	<20	<20	<20	100	160
	Dec	22.0	1,400	1,400	550	3,350	12.0	48.0	<20.0	<20	<20	<20	60	<100
	Jan	<20.0	550	1,300	420	2,270	10.0	29.0	<20.0	<20	<20	<20	39	160
	Feb	<20.0	1,300	3,000	740	5,040	7.3	59.0	<20.0	<20	<20	<20	66.3	170
NRA	Oct	<20.0	240	1,000	480	1,720	11.0	<20.0	<20.0	<20	<20	<20	11	<100
	Nov	<20.0	290	880	330	1,500	8.8	<20.0	<20.0	<20	<20	<20	8.8	<100
	Dec	<20.0	340	1,200	390	1,930	<5.0	23.0	<20.0	<20	<20	21	44	<100
	Jan	<20.0	420	950	510	1,880	<5.0	24.0	<20.0	<20	<20	<20	24	<100
	Feb	<20.0	160	1,200	840	2,200	6.7	<20.0	<20.0	<20	<20	<20	6.7	150
Rambekk Plant	Oct	<20.0	1,700	1,600	310	3,610	9.4	60.0	<20.0	<20	<20	<20	69.4	<100
	Nov	<20.0	1,400	1,800	480	3,680	7.3	48.0	<20.0	<20	<20	<20	55.3	<100
	Dec	<20.0	1,200	2,300	380	3,880	7.4	42.0	<20.0	<20	<20	<20	49.4	<100
	Jan	<20.0	1,400	2,700	580	4,680	6.5	45.0	<20.0	<20	<20	<20	51.5	<100
	Feb	<20.0	1,300	2,900	1,200	5,400	6.6	51.0	<20.0	<20	<20	<20	57.6	<100
Sandefjord Plant	Oct	48.0	1,100	3,200	590	4,890	11.0	31.0	<20.0	<20	<20	<20	42	130
	Nov	53.0	1,100	2,900	570	4,570	<5.0	33.0	<20.0	<20	<20	<20	33	120
	Dec	61.0	890	2,500	460	3,850	5.0	33.0	<20.0	<20	<20	<20	38	<100
	Jan	39.0	770	2,300	520	3,590	6.3	38.0	<20.0	<20	<20	<20	44.3	<100
	Feb	<20.0	610	1,200	320	2,130	<5.0	29.0	<20.0	<20	<20	<20	29	<100
SNJ	Oct	<20.0	4,100	3,900	600	8,600	8.3	110.0	<20.0	<20	<20	29	147.3	280
	Nov	<20.0	2,900	2,900	670	6,470	5.1	62.0	<20.0	<20	<20	<20	67.1	140
	Dec	<20.0	2,600	2,300	780	5,680	9.1	60.0	<20.0	<20	<20	<20	69.1	110
	Jan	<20.0	1,700	1,600	1,200	4,500	11.0	45.0	<20.0	<20	<20	<20	56	<100
	Feb	<20.0	2,300	2,300	860	5,460	6.7	45.0	<20.0	<20	<20	21	72.7	<100

Treatment plant	Mnth	4-n-nonylphenol	Nonylphenols tech.	nonylphenol monoethoxylate	Nonylphenol diethoxylate	NP + NPEO	2,4,6-Tri-tert-butylphenol	4-tert.-octylphenol	4-n-octylphenol	Heptylphenol	Pentylphenol	Butylphenol	Sum alkylphenols	Dodecylphenol
Solumstrand Plant	Oct	<20.0	1,700	880	300	2,880	<5.0	53.0	<20.0	<20	<20	<20	53	140
	Nov	<20.0	2,100	1,200	350	3,650	<5.0	80.0	<20.0	<20	<20	<20	80	160
	Dec	<20.0	2,300	1,600	440	4,340	9.6	97.0	<20.0	<20	<20	<20	106.6	130
	Jan	<20.0	1,000	6,000	2,300	9,300	9.8	110.0	<20.0	<20	<20	<20	119.8	560
	Feb	31.0	2,600	3,300	700	6,600	7.7	94.0	<20.0	<20	<20	<20	101.7	170
Tønsberg Plant	Oct	<20.0	350	510	320	1,180	<5.0	<20.0	<20.0	<20	<20	<20	<LOD	<100
	Nov	<20.0	440	510	320	1,270	<5.0	<20.0	<20.0	<20	<20	<20	<LOD	<100
	Dec	<20.0	570	830	270	1,670	<5.0	<20.0	<20.0	<20	<20	<20	<LOD	<100
	Jan	<20.0	560	240	300	1,100	<5.0	<20.0	<20.0	<20	<20	<20	<LOD	<100
	Feb	<20.0	390	380	470	1,240	<5.0	<20.0	<20.0	<20	<20	<20	<LOD	<100
VEAS	Oct	24.0	970	1,600	340	2,910	<5.0	55.0	<20.0	<20	<20	<20	55	<100
	Nov	26.0	970	1,200	310	2,480	6.7	58.0	<20.0	<20	<20	<20	64.7	<100
	Dec	<20.0	1,100	1,100	380	2,580	<5.0	61.0	<20.0	<20	<20	<20	61	<100
	Jan	30.0	1,100	1,400	420	2,920	<5.0	61.0	<20.0	<20	<20	<20	61	<100
	Feb	20.0	1,100	1,200	640	2,940	6.3	57.0	<20.0	<20	<20	<20	63.3	<100
Øra	Oct	<20.0	790	1,200	400	2,390	<5.0	22.0	<20.0	<20	<20	<20	22	170
	Nov	<20.0	570	1,400	480	2,450	<5.0	<20.0	<20.0	<20	<20	<20	<LOD	150
	Dec	<20.0	590	1,700	290	2,580	5.0	<20.0	<20.0	<20	<20	<20	5	180
	Jan	<20.0	630	1,500	400	2,530	6.2	<20.0	<20.0	<20	<20	<20	6.2	130
	Feb	<20.0	870	1,100	590	2,560	<5.0	<20.0	<20.0	<20	<20	<20	<LOD	170
Årim	Oct	<20.0	1,200	1,600	190	2,990	<5.0	<20.0	<20.0	<20	<20	<20	<LOD	130
	Nov	<20.0	940	1,300	620	2,860	<5.0	50.0	<20.0	<20	<20	<20	50	280
	Dec	<20.0	1,200	1,400	490	3,090	<5.0	46.0	<20.0	<20	<20	<20	46	790
	Jan	<20.0	940	1,000	360	2,300	<5.0	21.0	<20.0	<20	<20	24	45	230
	Feb	<20.0	380	350	170	900	<5.0	<20.0	<20.0	<20	<20	<20	<LOD	350
<b>Average</b>		<20	1,079	2,410	638.5	4,127	9.86	43.83	<20	<20	<20	<20	54.57	111
<b>Median</b>		<20	940	1,800	500	3,850	8	41	<20	<20	<20	<20	52	<100
<b>90% percentile</b>		38.6	1,900	4,060	1,200	6,600	18	80.6	<20	<20	<20	<20	105.2	180
<b>Minimum</b>		<20	160	240	170	900	<5	<20	<20	<20	<20	<20	<LOD	<100
<b>Maximum</b>		61	4,100	8,500	2,300	11,400	38	110	80	62	<20	29	172	790
<b>n</b>		95	95	95	95	95	95	95	95	95	95	95	95	95
<b>n &gt; LOD</b>		39	95	95	95	95	71	77	2	3	0	4	86	38

## 1.5. Raw Data: LAS ( $\mu\text{g}/\text{kg TS}$ )

Treatment plant	Mnth.	C10-ABS	C11-ABS	C12-ABS	C13-ABS	Sum LAS
Bekkelaget	Oct	630	2,800	4,600	4,500	12,530
	Nov	700	3,100	4,900	4,900	13,600
	Dec	630	2,800	4,600	4,700	12,730
	Jan	760	3,200	5,500	5,400	14,860
	Feb	560	2,500	4,100	4,100	11,260
Bergen Biogas Plant	Oct	380	1,800	3,200	3,200	8,580
	Nov	430	2,100	3,400	3,800	9,730
	Dec	470	2,300	3,800	4,200	10,770
	Jan	620	3,000	4,900	5,400	13,920
	Feb	550	2,600	4,200	4,600	11,950
Fuglevik Plant	Oct	1,700	7,300	9,700	7,100	25,800
	Nov	1,100	4,800	7,200	5,500	18,600
	Dec	1,600	6,800	9,200	6,200	23,800
	Jan	1,500	5,700	7,400	5,000	19,600
	Feb	1,300	5,500	7,800	6,200	20,800
Hias	Oct	420	1,800	2,900	2,400	7,520
	Nov	530	2,300	3,500	3,000	9,330
	Dec	480	2,000	3,200	2,600	8,280
	Jan	390	1,600	2,500	2,000	6,490
	Feb	390	1,600	2,500	1,800	6,290
Høvringen Plant	Oct	530	3,300	4,600	4,700	13,130
	Nov	440	3,000	4,100	4,900	12,440
	Dec	510	3,200	4,300	4,700	12,710
	Jan	570	3,400	4,700	4,500	13,170
	Feb	530	3,400	4,400	4,400	12,730
Gardermoen Plant	Oct	1,100	5,200	7,500	6,200	20,000
	Nov	850	3,800	5,400	4,900	14,950
	Dec	800	3,800	5,400	4,400	14,400
	Jan	780	3,800	5,100	3,600	13,280
	Feb	760	3,400	4,900	3,800	12,860
Knappen Plant	Oct	820	4,000	6,200	6,300	17,320
	Nov	720	3,600	5,500	5,800	15,620
	Dec	1,100	4,100	6,200	5,600	17,000
	Jan	850	3,500	4,700	3,900	12,950
	Feb	860	3,900	5,700	4,500	14,960
Lindum Biogas	Oct	850	3,500	4,600	3,200	12,150
	Nov	870	3,800	5,100	3,900	13,670
	Dec	900	3,900	5,200	4,300	14,300
	Jan	880	3,700	5,000	3,800	13,380
	Feb	970	4,000	5,500	4,200	14,670
Lindum raw sludge	Oct	600	2,500	3,500	3,400	10,000
	Nov	420	1,900	3,300	4,300	9,920
	Dec	560	2,200	3,300	2,900	8,960
	Jan	770	3,300	4,800	3,600	12,470
	Feb	710	2,800	4,400	3,900	11,810

Treatment plant	Mnth.	C10-ABS	C11-ABS	C12-ABS	C13-ABS	Sum LAS
NRA	Oct	430	1,900	3,300	4,400	10,030
	Nov	440	1,800	3,100	3,700	9,040
	Dec	530	2,100	3,600	5,200	11,430
	Jan	490	2,000	3,500	5,300	11,290
	Feb	480	2,100	3,400	4,800	10,780
Sandefjord Plant	Oct	950	4,000	5,900	5,200	16,050
	Nov	910	4,300	6,400	5,400	17,010
	Dec	1,100	5,000	7,700	6,800	20,600
	Jan	1,200	5,200	7,300	6,500	20,200
	Feb	1,300	5,200	7,500	5,700	19,700
SNJ	Oct	670	3,100	4,800	4,800	13,370
	Nov	420	2,000	3,600	4,200	10,220
	Dec	400	2,000	3,600	4,000	10,000
	Jan	500	2,600	4,500	4,800	12,400
	Feb	450	2,100	3,700	3,900	10,150
Solumstrand Plant	Oct	260	1,200	2,500	3,300	7,260
	Nov	340	1,500	2,600	2,800	7,240
	Dec	330	1,400	2,500	3,100	7,330
	Jan	410	1,900	3,400	4,100	9,810
	Feb	450	2,000	3,500	3,700	9,650
Tønsberg Plant	Oct	460	1,900	3,600	3,800	9,760
	Nov	560	2,300	3,800	3,800	10,460
	Dec	830	3,400	5,600	5,500	15,330
	Jan	1,100	3,900	5,900	4,900	15,800
	Feb	690	2,500	3,300	2,900	9,390
VEAS	Oct	980	4,400	6,400	6,000	17,780
	Nov	700	3,200	5,000	4,400	13,300
	Dec	970	4,300	6,300	5,900	17,470
	Jan	940	4,000	5,800	5,100	15,840
	Feb	940	4,100	5,800	5,300	16,140
Øra	Oct	2,200	8,200	12,000	11,000	33,400
	Nov	1,700	7,000	11,000	9,400	29,100
	Dec	2,100	8,100	11,000	9,500	30,700
	Jan	3,200	12,000	17,000	15,000	47,200
	Feb	5,400	17,000	22,000	18,000	62,400
<b>Average</b>		859	3,653.75	5,417.5	4,981.25	14,911.5
<b>Median</b>		700	3,250	4,750	4,500	13,040
<b>90% percentile</b>		1,320	5,520	7,710	6,320	20,620
<b>Minimum</b>		260	1,200	2,500	1,800	6,290
<b>Maximum</b>		5,400	17,000	22,000	18,000	62,400
<b>n</b>		80	80	80	80	80
<b>n &gt; LOD</b>		80	80	80	80	80

## 1.6. Raw data: perfluorinated alkyl substances ( $\mu\text{g}/\text{kg TS}$ )

Treatment plant	Mnth.	6:2 FTS	PFOSA	H4 PFUnA	PFDA	PFDoA	PFDS	PFHpS	PFHxS
Bekkelaget	Oct	9.9	1.2	4.0	3.5	1.2	1.7	6.2	28
	Nov	13	1.1	3.1	1.6	0.53	<1.2	6	20
	Dec	7.5	0.9	4.8	1.5	1.6	<1.2	13	26
	Jan	<0.78	<1	3.5	1.8	<0.56	<1.4	11	34
	Feb	10	<0.77	2.1	0.84	<0.35	<1.1	11	18
Bergen Biogas Plant	Oct	12	<0.74	0.74	<0.97	<0.34	<1	12	20
	Nov	1.8	<0.83	<0.46	<1.1	<0.68	<1.2	8.6	20
	Dec	1.8	<0.82	0.75	<1.2	<0.62	<1.2	7	22
	Jan	<0.77	<0.86	1.2	<1.2	<0.8	<1.2	5	22
	Feb	3.9	<0.82	0.94	<1.1	<0.63	<1.2	5.9	25
Fuglevik Plant	Oct	20	1.2	<0.6	<1.3	<1.1	<1.5	9.2	16
	Nov	6.5	<0.92	<0.51	<1.3	<0.53	<1.3	5.7	33
	Dec	34	<1.5	<0.84	<1.3	<1	<2.1	8.8	18
	Jan	9.5	<1	<0.55	<1.4	<0.64	<1.4	6.4	8.5
	Feb	8.8	<0.91	<0.5	<1.4	<0.83	<1.3	8.7	9.4
Hias	Oct	7.1	<0.98	<0.54	1.4	0.61	<1.4	6.2	37
	Nov	0.82	<1.3	<0.72	<1.4	1.8	<1.8	8.3	37
	Dec	<0.79	<1.1	<0.61	<1.1	<1.3	<1.5	6.2	28
	Jan	1.2	<0.98	<0.54	<0.99	<0.61	<1.4	4.2	23
	Feb	2.1	<0.85	<0.47	<1	<0.87	<1.2	3	11
Høvringen Plant	Oct	<0.54	<0.76	<0.42	<1.1	0.64	<1.1	11	8.2
	Nov	<0.77	<1.1	0.68	<1.3	<0.64	<1.5	13	8.8
	Dec	<0.65	<0.86	1.2	<1	<0.8	<1.2	14	8.3
	Jan	1.7	<0.84	0.51	<1.1	<0.54	<1.2	7.9	7.4
	Feb	<0.66	<0.86	1	<1.1	<0.51	<1.2	11	7
Gardermoen Plant	Oct	4.5	1.4	0.78	1.7	0.83	<1.5	2.6	4.7
	Nov	2.7	<0.95	0.82	<1.3	<0.8	<1.3	2.2	2.2
	Dec	4.3	<1	0.49	<1.3	<0.98	<1.5	4.9	4.6
	Jan	1.2	<0.97	0.69	<1.4	<0.77	<1.4	11	10
	Feb	5.1	<0.96	0.48	<1.4	<1.1	<1.4	5.5	12
Knappen Plant	Oct	0.61	<1.4	<0.74	<1.6	<1	<1.9	<0.82	<0.82
	Nov	<0.44	<1.4	<0.79	<1.8	<0.81	<2	<0.85	0.86
	Dec	<0.41	<1.6	<0.89	<1.6	<0.89	<2.3	<0.79	<0.8
	Jan	<0.3	<1.3	<0.69	<1.3	<0.93	<1.8	0.9	1
	Feb	<0.39	<1.4	<0.78	<1.4	<0.61	<2	<0.7	<0.71
Lindum Biogas	Oct	<0.64	<1.2	<0.51	<1.5	<1.1	<1.6	2.8	13
	Nov	<0.78	<1.3	<0.57	<1.8	<1.5	<1.8	3	14
	Dec	4.5	<1.1	<0.5	<1.7	<0.96	<1.6	1.5	12
	Jan	1.2	<0.95	<0.42	<1.4	<1.1	<1.3	1.2	9.7
	Feb	1.4	<1.1	<0.47	<1.5	<0.98	<1.5	1	9.5
Lindum raw sludge	Oct	<0.24	<1	<0.54	<0.91	<0.37	<1.4	<0.49	2.8
	Nov	<0.27	<1	<0.55	<0.94	<0.54	<1.4	1.7	6.9
	Dec	1.4	<1	<0.57	<1	<0.54	<1.4	0.62	<0.52
	Jan	0.33	<1.3	<0.71	<1.3	<0.54	<1.8	<0.66	<0.66
	Feb	2.6	<1.3	<0.7	<1.2	<0.56	<1.8	<0.73	<0.74

	PFOA	PFOS	PFUnA	PFTA	Sum 22 PFAS <sup>1)</sup>	82FTS	FHpPA	NEtFOSAA	NMeFOSAA	Sum 29 PFAS <sup>2)</sup>
	1.1	8.7	2.0	1.9	69.4	3	7	11	4.2	94.6
	<0.96	6.7	2.1	2	56.13	1.6	6	8.2	3.2	75.13
	<0.93	6.6	<0.95	2	63.9	1.8	6.6	8.7	4.1	85.1
	<1.1	6.4	<1.1	1.6	58.3	1.2	6.3	9.2	3.4	78.4
	<0.89	5.2	<0.86	0.89	48.03	0.56	4.4	13	3.4	69.39
	<0.84	28	1.5	0.96	75.2	0.67	1.4	3.1	0.8	81.17
	<0.88	16	<1.2	0.89	47.29	<0.47	1	3.4	<0.68	51.69
	<0.92	13	<1.2	1.3	45.85	<0.44	1.6	3.6	0.73	51.78
	<0.93	12	<1.2	1.8	42	0.47	1.3	3.8	1.5	49.07
	<0.82	17	1.3	1	55.04	1.3	1.4	4.6	1.5	63.84
	<1	59	<1.2	4.4	109.8	1.9	<0.42	5.6	<0.73	117.3
	<1.2	39	<1	1.6	85.8	1.4	<0.42	0.99	<0.62	88.19
	<1.2	55	<1.7	<2	115.8	1.6	<0.42	<1.5	<1	117.4
	<1.2	66	<1.1	<1.9	90.4	1.3	<0.46	<0.99	<0.67	91.7
	9.2	56	<1	<2.1	92.1	0.66	<0.46	<0.91	<0.62	92.76
	1.5	2.5	<1.1	<0.84	56.31	1.2	4	2.6	0.97	65.08
	1.5	1.9	<1.5	<1	51.32	0.81	4.7	2.2	<0.89	59.03
	<1.2	2.1	<1.2	<1.1	36.3	1.3	2.1	<1.1	<0.75	39.7
	<1	1.3	<1.1	<0.78	29.7	0.81	2.5	<0.97	<0.66	33.01
	1.4	1.1	<0.96	<0.72	18.6	0.34	1.8	<0.85	<0.58	20.74
	<0.87	4.8	<0.86	<1.1	24.64	0.37	<0.36	1.8	<0.52	26.81
	<1.2	4.4	<1.2	<1.1	26.88	<0.35	<0.44	3.4	<0.74	30.28
	<1	5	<0.96	<1.3	28.5	<0.29	<0.35	2.9	<0.58	31.4
	<1	4.1	<0.94	<1.4	21.61	<0.3	<0.36	2.9	0.76	25.27
	<1	4.2	<0.97	<1.3	23.2	<0.3	<0.37	3.3	0.75	27.25
	<1.6	130	<1.2	<1.3	146.5	5.1	9.3	5.4	1.8	168.1
	<1.2	100	<1.1	<0.72	107.9	8	5.7	2.1	0.96	124.6
	<1.3	100	<1.2	<0.72	114.3	5	5.2	1.8	1.7	128.0
	<1.1	56	<1.1	<0.58	78.89	3.2	3.6	<1	<0.64	85.69
	<1.1	54	<1.1	<0.64	77.08	2.8	4.3	<1	<1.1	84.18
	<1.1	10	<1.2	<0.94	10.61	<0.18	<0.55	<1.9	<1	10.61
	<1.2	6.8	<1.2	<0.86	7.66	<0.19	<0.62	<2.1	<1.1	7.66
	<1.1	6.8	<1.4	<1	6.8	<0.18	<0.57	<2.3	<1.3	6.8
	<0.83	4.7	<1.1	<1.1	6.6	<0.13	<0.46	<1.8	<0.98	6.6
	<1	4.7	<1.2	<1.2	4.7	<0.17	<0.48	<2	<1.1	4.7
	<1.1	6.9	<1.3	<0.61	22.7	0.3	<0.48	<1.2	<0.77	23
	<1.3	5.1	<1.5	<0.63	22.1	0.44	<0.57	<1.4	<0.85	22.54
	<1.3	5.1	<1.3	<0.69	23.1	<0.33	<0.55	<1.2	<0.74	23.1
	<1.1	5.3	<1.1	<0.83	17.4	<0.27	<0.45	<1.4	<0.62	17.4
	<1.2	6	<1.2	<0.73	17.9	0.52	<0.48	<1.1	<0.7	18.42
	<0.67	2.2	<0.86	<0.5	5	0.24	<0.32	<1.4	<0.77	5.24
	<0.78	3.6	<0.87	<0.48	12.2	0.23	<0.33	<1.4	<0.78	12.43
	<0.72	2.6	<0.89	<0.64	4.62	0.17	<0.36	<1.5	<0.8	4.79
	<0.97	1.9	<1.1	<0.83	2.23	0.4	<0.47	<1.9	<1	2.63
	<0.99	3.3	<1.1	<0.66	5.9	1.7	<0.43	<1.8	<0.99	7.6

Continues next page

Continued from last page

Treatment plant	Mnth.	6:2 FTS	PFOSA	H4 PFUnA	PFDA	PFDoA	PFDS	PFHpS	PFHxS
NRA	Oct	2.2	<0.62	0.65	<0.85	<0.49	<0.87	<0.55	<0.55
	Nov	<0.48	<0.57	0.79	<0.85	<0.36	<0.8	<0.52	1.3
	Dec	<0.49	<0.85	1.9	<1	<0.48	<1.2	<0.6	<0.6
	Jan	5.7	<0.79	1.8	<1.1	<0.52	<1.1	<0.61	1.8
	Feb	<0.52	<0.67	1.7	<0.9	<0.47	<0.94	<0.53	0.72
Sandefjord Plant	Oct	1.7	<1.4	5.5	<1.4	<0.62	<1.9	2	2.4
	Nov	3	<1.7	7	<1.6	<0.82	<2.4	1.7	4
	Dec	1.5	<1.5	6.7	<1.7	<0.64	<2.1	2.6	4.1
	Jan	3.2	<1.1	4.7	<1.6	<0.7	<1.6	1.3	4.6
	Feb	1.5	<0.96	4.4	<1.5	<1	<1.3	<0.78	2.3
SNJ	Oct	1.9	<1.3	5.4	<1.7	1.7	<1.8	36	<1.1
	Nov	2	<1.6	7.1	<1.9	<0.88	<2.2	33	<1.1
	Dec	<0.68	<1	3.2	<1.6	<0.84	<1.4	39	<1
	Jan	1	<1.4	4.6	<1.9	<1.1	<2	49	<1.4
	Feb	<0.91	<1.4	5.8	<1.9	<1.1	<2	9.7	<1.4
Solumstrand Plant	Oct	2	<0.74	4.4	<0.92	<0.49	<1	1.6	<0.69
	Nov	0.73	<0.64	3.7	<0.91	<0.59	<0.9	<0.59	<0.59
	Dec	1.8	<0.79	4.1	<1	<0.42	<1.1	2.3	0.68
	Jan	1	<0.94	5.2	<1	<0.62	<1.3	<0.67	<0.67
	Feb	2.7	<0.79	3.6	<0.97	<0.57	<1.1	12	<0.63
Tønsberg Plant	Oct	13	<0.97	5	<1.2	<0.92	<1.4	<0.76	3
	Nov	23	<1	5.3	<1.2	<0.71	<1.4	<0.77	1.6
	Dec	6.7	<1.3	5.8	<1.6	<1.2	<1.9	<0.91	3.4
	Jan	14	<1.4	6.2	<2	<0.83	<2	<1.1	1.5
	Feb	11	<0.89	4.8	<1.1	<0.54	<1.2	<0.68	0.88
VEAS	Oct	4.9	<1.3	7.1	<1.5	<1.3	<1.8	2.3	7.2
	Nov	1	<1.4	8.2	<1.5	<1.2	<1.9	1.6	4.5
	Dec	2.6	<1.5	8.5	<1.7	<1.1	<2.1	1.5	4.8
	Jan	<0.87	<1.3	6.9	<1.4	<0.97	<1.9	1.2	8.5
	Feb	1.7	<1.4	8.7	<1.6	<1.3	<2	1.8	1.8
Øra	Oct	15	<1.5	6.3	<2.4	<0.94	<2.1	3.2	<1
	Nov	1.5	<1.8	9	<2.4	<0.75	<2.6	2.6	5.6
	Dec	3.6	<1.2	5.8	<2.5	<0.87	<1.7	1.7	1.5
	Jan	2.5	<1.6	6.6	<3.5	<0.85	<2.2	3	3
	Feb	3.1	<1.6	5.3	<3.8	<0.94	<2.3	4.6	1.5
<b>Average</b>		4.04	<LOD	2.72	<LOD	0.46	<LOD	5.86	8.46
<b>Median</b>		1.8	<LOD	1.1	<LOD	<LOD	<LOD	2.6	4.55
<b>90% percentile</b>		11.1	<LOD	6.72	<LOD	0.65	<LOD	12	23.2
<b>Minimum</b>		<0.24	<0.57	<0.42	<0.85	<0.34	<0.8	<0.49	<0.52
<b>Maximum</b>		34	1.4	9	3.5	1.8	1.7	49	37
<b>n</b>		80	80	80	80	80	80	80	80
<b>n &gt; LOD</b>		59	5	53	7	8	1	60	62

<sup>1)</sup> 22 substances analysed in previous surveys; made up of the 12 substances to the left in the table in addition to the 10 substances that were not listed in this table as all values were under the limit of detection: 2H,2H-Perfluorodecanoic acid (H2PFDA); 7H-Dodecafluoroheptanoic acid (HPFHpa); Perfluoro-3,7-dimethyloctanoic acid (PF-3,7-DMOA); Perfluorobutanoic acid (PFBA); Perfluorobutane sulfonate (PFBS); Perfluoroheptanoic acid (PFHpA); Perfluorohexanoic acid (PFHxA); Perfluorononanoic acid (PFNA); Perfluoropentanoic acid (PFPeA); Perfluorotridecanoic acid (PFTrA);

<sup>2)</sup> All 29 substances measured in this survey: 16 substances shown in the table in addition to the 10 substances named above and three other substances which were under the limit of detection: 4:2 FTS; PFNS; PFPeS.

	PFOA	PFOS	PFUnA	PFTA	Sum 22 PFAS <sup>1)</sup>	82FTS	FHpPA	NEtFOSAA	NMeFOSAA	Sum 29 PFAS <sup>2)</sup>
	<0.67	3.9	<0.7	<0.44	6.75	0.49	<0.28	1.6	<0.42	8.84
	<0.66	2.4	<0.64	<0.41	4.49	<0.22	<0.28	0.94	<0.38	5.43
	<0.76	2.9	<0.95	<0.45	4.8	0.26	<0.35	<0.84	<0.57	5.06
	<0.79	2.5	<0.88	<0.46	11.8	0.22	<0.37	<0.78	<0.53	12.02
	<0.69	2.5	<0.75	<0.5	4.92	<0.23	<0.3	<0.66	<0.45	4.92
	<1.2	3.2	<1.5	<1.2	14.8	<0.28	<0.46	<1.5	<0.9	14.8
	<1.1	5.5	<1.9	1.5	22.7	<0.29	<0.51	2.3	<1.1	25
	<1.2	2	<1.7	<1.5	16.9	<0.35	<0.53	<1.6	<0.97	16.9
	<1.2	4.3	<1.3	<1.6	18.1	<0.32	<0.52	<1.2	<0.73	18.1
	<1.1	3.9	<1.1	<1.3	12.1	<0.33	<0.48	<1	<0.63	12.1
	2	22	<1.5	0.74	69.74	2.7	5	5.7	4.2	87.34
	1.8	13	<1.8	0.39	57.29	2.9	2.4	3.3	3.9	69.79
	<1.5	11	<1.1	<0.41	53.2	2.1	0.81	4.7	2	62.81
	<2.1	12	<1.6	<0.47	66.6	1.7	0.88	3.1	<0.91	72.28
	<2	6.6	<1.6	<0.41	22.1	0.96	<0.61	3.3	<0.93	26.36
	<0.9	3.3	<0.83	<0.37	11.3	0.35	<0.3	<0.74	<0.5	11.65
	<0.77	2.5	<0.72	<0.36	6.93	<0.21	<0.3	<0.64	<0.43	6.93
	<0.78	3	<0.89	<0.44	11.88	<0.21	<0.34	<0.79	<0.54	11.88
	<0.88	2.8	<1.1	<0.46	9	<0.27	<0.34	1.1	<0.64	10.1
	<0.83	3.1	<0.88	<0.48	21.4	0.58	<0.32	<0.78	<0.53	21.98
	1.5	9	<1.1	<0.43	31.5	2.1	<0.4	<0.97	<0.66	33.6
	<1.1	6	<1.1	<0.46	35.9	2.3	<0.41	<1	<0.68	38.2
	<1.2	8.8	<1.5	<0.64	24.7	2	<0.53	<1.3	<0.91	26.7
	1.4	9.9	<1.6	<0.75	33	3.5	<0.67	<1.4	<0.95	36.5
	<0.89	6.3	<1	<0.46	22.98	2.2	<0.37	<0.88	<0.6	25.18
	<1.4	2.1	<1.4	<1.2	23.6	<0.44	0.71	3.2	<0.87	27.51
	<1.4	2.4	<1.5	<0.96	17.7	<0.34	<0.64	2.7	<0.93	20.4
	<1.5	1.9	<1.7	<0.86	19.3	<0.45	<0.69	<2	<1	19.3
	<1.4	2	<1.5	<1	18.6	<0.39	0.6	2.1	<0.91	21.3
	<1.4	1.3	<1.6	<0.86	15.3	<0.41	<0.66	2.6	<0.96	17.9
	<1.6	2.4	<1.7	<1.8	26.9	<0.45	<0.77	<1.6	<1	26.9
	<1.3	3.3	<2	<1.5	22	<0.42	<0.77	<1.9	<1.2	22
	<1.3	2.9	<1.4	<1.9	15.5	<0.37	<0.79	1.8	<0.8	17.3
	<1.5	2.1	<1.8	<3.5	17.2	<0.47	<1.1	<1.7	<1	17.2
	<1.6	3.5	<1.8	<4.9	18	<0.46	<1.2	<1.7	<1.1	18
	0.76	13.97	<LOD	0.69	35.7	1.00	1.30	2.14	0.80	40.03
	<LOD	4.9	<LOD	<LOD	22.8	0.345	<LOD	<LOD	<LOD	25.2
	1.13	54.1	<LOD	1.6	79.56	2.71	4.73	4.77	1.82	88.5
	<0.66	1.1	<0.64	<0.36	2.23	<0.13	<0.28	<0.64	<0.38	2.63
	9.2	130	2.1	4.4	146.5	8	9.3	13	4.2	168.1
	80	80	80	80	80	80	80	80	80	80
	9	80	4	15	80	47	26	36	18	80

## 1.7. Raw data: PCB ( $\mu\text{g}/\text{kg TS}$ ), chlorinated paraffins ( $\mu\text{g}/\text{kg TS}$ )

Treatment plant	Mnth	PCB ( $\mu\text{g}/\text{kg TS}$ )								Chlorinated paraffins ( $\mu\text{g}/\text{kg TS}$ )	
		PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	sum PCB-7	SCCP	MCCP
Bekkelaget	Oct	1.7	1.9	2.2	1.6	3.1	5.3	2.0	18.0	220	2,000
	Nov	1.8	1.9	2.0	1.7	2.6	4.7	1.5	16.0	190	1,600
	Dec	2.0	1.6	1.7	1.4	2.2	2.4	1.1	12.0	330	6,100
	Jan	1.9	1.6	2.3	1.3	3.4	4.5	2.6	18.0	300	6,800
	Feb	2.0	1.6	1.5	1.2	2.1	2.6	1.3	12.0	290	8,000
Bergen Biogas Plant	Oct	3.5	2.7	2.3	1.5	3.1	3.4	1.6	18.0	210	670
	Nov	2.0	2.0	2.3	1.7	3.1	4.9	1.7	18.0	320	2,000
	Dec	2.4	2.3	2.5	1.8	3.3	5.2	2.4	20.0	190	1,400
	Jan	2.0	2.2	2.3	1.4	3.1	4.9	1.9	18.0	400	1,900
	Feb	2.4	2.4	2.4	1.5	2.7	4.9	1.7	18.0	200	910
Fuglevik Plant	Oct	1.3	1.4	1.5	1.1	1.6	3.9	1.1	12.0	570	7,400
	Nov	1.2	1	1	<1.0	1	4	<1.0	8	650	10,000
	Dec	1	1	1	1	2	2	1	9	1,200	9,000
	Jan	1.2	1.2	1.3	1.1	1.6	3	<1.0	9	440	4,500
	Feb	1	1	1	<1.0	2	2	<1.0	7	1,100	9,500
Hias	Oct	1.4	1.8	2.4	2.2	2.6	2.9	1.4	15.0	110	520
	Nov	1.5	2.1	2.6	2.5	2.9	3.1	1.3	16	180	450
	Dec	1.8	2	2.4	2.4	2.4	2.8	1.4	15	110	800
	Jan	1.7	2.2	2.4	2.5	2.7	2.9	1.3	16.0	390	600
	Feb	1.7	2.0	2.5	2.2	2.6	2.7	1.4	15.0	120	1,600
Høvringen Plant	Oct	2.5	1.4	1.1	1.0	1.6	3.8	1.3	13.0		
	Nov	2.8	1.2	1.2	<1.0	1.6	3.7	1.1	12		
	Dec	4.2	1.4	1.3	1.2	1.9	2.5	1.2	14		
	Jan	3.6	1.5	1.2	1.2	1.8	4.3	1.2	15		
	Feb	2	1	2	<1.0	3.4	5.9	3	18		
Gardermoen Plant	Oct	1.4	1.2	1.3	1	1.9	4.3	1.3	12	<50	300
	Nov	1.4	1.1	1.2	<1.0	1.7	3.9	1.2	11	61	490
	Dec	1.4	1.3	1.6	1.3	2.8	5.0	1.7	15.0	62	250
	Jan	1.1	1.2	1.3	<1.0	2.1	4.1	1.4	11.0	<50	580
	Feb	1.4	1	1	<1.0	1.6	2.1	1.2	8.3	100	360
Knappen Plant	Oct	<1.0	1.5	1.5	<1.0	1.4	1.8	<1.0	6.2	620	5,400
	Nov	1	1.4	1.2	<1.0	1.1	1.6	<1.0	6.3	950	8,600
	Dec	<1.0	1.6	1.4	<1.0	<1.0	1.4	<1.0	4.4	870	5,900
	Jan	1.1	1.8	1.3	<1.0	1.2	1.4	<1.0	6.8	560	4,700
	Feb	1.1	1.7	1.4	<1.0	1.2	1.4	<1.0	6.8	890	4,500
Ladehammeren RA	Oct	1.3	<1.0	1.1	<1.0	1.6	3.2	1	8.2		
	Nov	1.2	<1.0	<1.0	<1.0	1.4	1.8	1.1	5.5		
	Dec	<1.0	<1.0	<1.0	<1.0	1.6	2.1	1.2	4.9		
	Jan	1.2	<1.0	<1.0	<1.0	1.5	3.2	<1.0	5.9		
	Feb	1.4	<1.0	<1.0	<1.0	1.5	3.5	1.1	7.5		

Continued from last page

Treatment plant	Mnth	PCB (µg/kgTS)								Chlorinated paraffins (µg/kgTS)	
		PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	sum PCB-7	SCCP	MCCP
Lindum Biogas	Oct	8.2	5.9	5.8	4.9	6.3	8.6	6.7	46	190	840
	Nov	7.5	5.4	6.1	4.9	6.9	9.2	7.4	47	160	1,000
	Dec	8	5.4	5.6	4.4	6.8	8.6	6.8	46	92	1,100
	Jan	9.5	7.4	6.8	5.8	9.2	11	7.7	57	220	720
	Feb	9.4	6.3	6.9	5.1	7	10	7.9	53	86	390
Lindum raw sludge	Oct	4.8	3	3.8	2.6	4.3	5.7	4.7	29	1,100	17,000
	Nov	9.7	6.2	6.8	5	7.3	9.8	9.8	55	1,400	16,000
	Dec	6.5	3.9	3.9	3.4	4.6	6.4	5.9	35	1,100	11,000
	Jan	2.8	2.5	2.7	2.2	3.3	3.9	2.8	20	890	8,900
	Feb	7.1	4.9	5.2	3.8	5.3	7.8	7.3	41	1,100	10,000
NRA	Oct	<1.0	1.1	1.1	<1.0	1.3	1.5	<1.0	5	780	6,200
	Nov	<1.0	<1.0	<1.0	<1.0	1.1	1.3	<1.0	2.4	1,400	9,100
	Dec	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	<1.0	1.1	850	5,500
	Jan	<1.0	<1.0	<1.0	<1.0	1.4	1.8	1.4	4.6	800	5,400
	Feb	1.2	<1.0	<1.0	<1.0	<1.0	1.1	<1.0	2.3	980	9,000
Rambekk Plant	Oct	1	1	1	1	2	4	1	12		
	Nov	1	1	2	<1.0	2	4	1	11		
	Dec	<1.0	1.1	1.2	<1.0	1.7	3.7	1.1	8.8		
	Jan	<1.0	<1.0	1	<1.0	2	4	<1.0	6		
	Feb	1	<1.0	1.2	1.1	1.7	3.7	1.1	9.8		
Sandefjord Plant	Oct	1.4	1	<1.0	<1.0	1.4	1.9	<1.0	5.7		
	Nov	<1.0	<1.0	<1.0	<1.0	1	2	<1.0	3		
	Dec	1	<1.0	<1.0	<1.0	1.1	1.4	<1.0	3.5		
	Jan	<1.0	<1.0	<1.0	<1.0	1	2	<1.0	3		
	Feb	<1.0	<1.0	<1.0	<1.0	1.0	1.5	<1.0	2.5		
SNJ	Oct	3.1	2.7	4	2.8	5	6.9	2.8	27	110	310
	Nov	2	2	3	2	4	6	2	21	72	670
	Dec	3	2	3	2	4	6	2	22	81	4,200
	Jan	1.7	2	3	3	4.9	7.4	3	25	270	3,700
	Feb	1.5	1.3	2	1.9	3.1	5.4	1.6	17.0	160	2,400
Solumstrand Plant	Oct	8.2	5.6	5.9	4.7	7.0	9.3	9.0	50.0	1,500	2,700
	Nov	9.5	5.9	6	5.5	7.3	9.9	9.4	54	920	4,400
	Dec	14	8.3	9.5	8.3	11	14	12	77	1,600	9,200
	Jan	13	9	9.3	7.5	10	14	12	75	2,500	17,000
	Feb	12	7	7.9	6.3	9	13	11	66	2,000	10,000
Tønsberg Plant	Oct	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1	190	1,600
	Nov	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1	220	2,100
	Dec	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	<1.0	1.0	2,500	27,000
	Jan	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1	3,000	25,000
	Feb	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1	270	3,000

Continues next page

Continued from last page

Treatment plant	Mnth	PCB (µg/kgTS)							Chlorinated paraffins (µg/kgTS)		
		PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	sum PCB-7	SCCP	MCCP
VEAS	Oct	1.2	1.5	1.7	1.2	2.1	2.4	1.1	11	360	960
	Nov	1	2	2	1	2	2.5	1.3	12	660	2,300
	Dec	1.2	1.4	1.6	1.1	1.8	2.5	1.4	11	170	650
	Jan	1.5	1.4	1.4	<1.0	1.8	2.2	<1.0	8.3	240	500
	Feb	1.4	1.5	1.6	<1.0	2.3	3	1.6	11	230	890
Øra	Oct	1.2	1.2	1.5	1.3	2.1	2.5	1	11	240	350
	Nov	2	2	2	2	3	2.9	1.5	14	180	220
	Dec	<1.0	1	1	1	2	2.3	1	8.7	280	120
	Jan	<1.0	1	1	1	2	2.3	1.8	10	150	430
	Feb	1	1	2	1	2	2.3	1.1	11	440	310
Årim	Oct	1	<1.0	<1.0	<1.0	<1.0	1.5	<1.0	2.6		
	Nov	<1.0	<1.0	<1.0	<1.0	<1.0	1.3	<1.0	1.3		
	Dec	3	1	1	<1.0	2	3.1	1.3	12		
	Jan	2.8	<1.0	<1.0	<1.0	1.4	2.2	<1.0	6.4		
	Feb	<1.0	<1.0	<1.0	<1.0	1.3	2.2	1	4.5		
<b>Average</b>		2.54	1.96	2.14	1.64	2.73	3.97	2.22	16.47	517.5	4,031
<b>Median</b>		1.4	1.4	1.4	1.1	1.9	3.1	1.2	11	285	2,200
<b>90% percentile</b>		7.8	5.4	5.72	4.58	6.6	8.6	7.1	46	1,110	9,550
<b>Minimum</b>		<1	<1	<1	<1	<1	<1	<1	<1	<50	120
<b>Maximum</b>		14	9	9.5	8.3	11	14	12	77	2,500	17,000
<b>n</b>		95	95	95	95	95	95	95	95	70	70
<b>n &gt; LOD</b>		74	71	73	53	85	91	67	91	68	70

## 1.8. Raw data: siloxanes ( $\mu\text{g}/\text{kg TS}$ )

Treatment plant	Mnth	Octamethyl- cyclotetrasiloxane (D4)	Decamethyl- cyclopentasiloxane (D5)	Dodecamethyl- cyclohexasiloxane (D6)	Sum siloxanes (D4, D5, D6)	Decamethyl- tetrasiloxane	Dodecamethyl- pentasiloxane	Hexamethyl- cyclotrisiloxane	Octamethyl- trisiloxane	Phenyl-tris (trimethylsiloxy)silane
Bekkelaget	Oct	1,100	4,100	3,200	8,400	41	1,400	2,300	<20	<20
	Nov	750	3,000	2,700	6,450	33	310	1,600	<20	<20
	Dec	490	2,800	1,700	4,990	49	440	450	51	56
	Jan	970	3,200	3,000	7,170	35	380	1,800	<20	<20
	Feb	390	3,100	2,400	5,890	90	430	440	74	77
Bergen Biogas Plant	Oct	1,200	5,300	3,600	10,100	63	840	3,000	<20	<20
	Nov	140	3,000	1,100	4,240	40	50	250	<20	<20
	Dec	220	4,500	1,800	6,520	52	190	400	<20	<20
	Jan	1,100	9,800	4,600	15,500	89	810	3,300	<20	<20
	Feb	1,100	6,100	2,900	10,100	58	400	3,100	<20	<20
Fuglevik Plant	Oct	280	11,000	2,100	13,380	94	600	6,000	36	<20
	Nov	1,400	6,000	3,800	11,200	53	590	5,700	20	<20
	Dec	1,100	20,000	7,700	28,800	82	870	5,500	<20	20
	Jan	1,200	21,000	6,800	29,000	110	1,100	5,000	<20	<20
	Feb	1,100	24,000	6,700	31,800	99	910	4,800	<20	<20
Hias	Oct	390	3,600	2,400	6,390	36	530	1,100	<20	<20
	Nov	1,000	6,000	4,200	11,200	50	570	4,000	<20	<20
	Dec	590	4,100	3,200	7,890	38	400	2,000	<20	<20
	Jan	650	5,500	4,300	10,450	52	560	2,900	<20	<20
	Feb	750	5,500	2,900	9,150	54	520	2,300	<20	<20
Gardermoen Plant	Oct	800	4,500	3,200	8,500	51	550	3,200	<20	21
	Nov	1,200	8,100	8,000	17,300	62	950	2,300	<20	23
	Dec	730	4,100	4,200	9,030	37	450	2,100	<20	<20
	Jan	990	5,700	5,100	11,790	50	540	3,100	<20	<20
	Feb	640	3,000	3,700	7,340	25	340	1,300	<20	<20
Knappen Plant	Oct	390	3,600	1,600	5,590	32	140	1,800	48	<20
	Nov	1,100	1,600	1,400	4,100	23	52	1,600	33	<20
	Dec	950	2,400	3,000	6,350	35	140	3,800	26	<20
	Jan	1,300	2,400	3,300	7,000	31	320	4,600	<20	<20
	Feb	1,700	2,800	3,900	8,400	31	530	5,700	29	<20
Lindum Biogas	Oct	490	11,000	3,600	15,090	24	650	1,800	<20	<20
	Nov	1,100	14,000	4,300	19,400	23	500	4,400	<20	<20
	Dec	690	12,000	4,500	17,190	22	360	3,300	<20	<20
	Jan	950	12,000	4,100	17,050	<20	370	4,000	<20	<20
	Feb	1,200	15,000	5,800	22,000	38	750	5,400	<20	<20
Lindum raw sludge	Oct	390	6,600	1,000	7,990	35	170	1,100	27	<20
	Nov	1,600	7,900	3,700	13,200	33	660	4,500	26	<20
	Dec	900	7,100	3,800	11,800	27	640	4,800	<20	<20
	Jan	2,000	7,400	5,000	14,400	50	760	6,200	44	<20
	Feb	1,900	7,400	2,500	11,800	37	360	3,900	47	<20

Continues next page

Continued from last page

Treatment plant	Mnth	Octamethyl- cyclohexa- siloxane (D4)	Decamethyl- cyclopentasi- loxane (D5)	Dodecamethyl- cyclohexa- siloxane (D6)	Sum siloxanes (D4, D5, D6)	Decamethyl- tetrasiloxane	Dodecamethyl- pentasiloxane	Hexamethyl- cyclotrisiloxane	Octamethyl- trisiloxane	Phenyl-tris (trimethylsi- loxy)silane
NRA	Oct	1,600	3,800	2,500	7,900	51	930	2,000	33	<20
	Nov	1,500	1,900	2,400	5,800	23	340	1,300	30	<20
	Dec	1,500	2,200	2,400	6,100	29	430	1,300	21	<20
	Jan	1,300	2,100	2,300	5,700	22	230	1,600	<20	<20
	Feb	1,500	2,200	2,800	6,500	23	540	2,000	<20	<20
SNJ	Oct	150	72	88	310	<20	<20	100	<20	<20
	Nov	3,800	410	490	4,700	<20	73	300	<20	<20
	Dec	730	82	220	1,032	<20	<20	<100	<20	<20
	Jan	340	34	160	534	<20	<20	<100	<20	<20
	Feb	340	51	160	551	<20	<20	<100	<20	<20
Solumstrand Plant	Oct	450	3,100	1,500	5,050	<20	160	720	<20	<20
	Nov	1,000	2,300	1,500	4,800	<20	25	590	<20	<20
	Dec	930	3,200	2,500	6,630	<20	160	1,100	<20	<20
	Jan	1,300	2,600	2,000	5,900	<20	980	1,100	<20	<20
	Feb	1,100	7,900	2,200	11,200	<20	650	2,100	<20	<20
Tønsberg Plant	Oct	170	800	230	1,200	<20	<20	370	<20	<20
	Nov	1,300	1,200	1,500	4,000	<20	1,500	240	<20	<20
	Dec	930	840	1,300	3,070	<20	1,000	800	<20	<20
	Jan	570	810	1,100	2,480	<20	480	470	<20	<20
	Feb	1,300	2,700	3,800	7,800	21	780	4,000	<20	<20
VEAS	Oct	520	2,700	2,300	5,520	22	500	810	<20	<20
	Nov	260	4,800	2,500	7,560	37	930	780	<20	<20
	Dec	410	3,000	1,800	5,210	25	630	670	<20	<20
	Jan	290	2,500	1,400	4,190	20	480	480	<20	<20
	Feb	530	3,300	2,600	6,430	24	600	1,000	<20	<20
Øra	Oct	570	2,300	2,200	5,070	25	600	1,000	<20	<20
	Nov	320	2,100	2,300	4,720	<20	660	1,400	<20	<20
	Dec	190	1,700	1,400	3,290	20	430	1,600	<20	<20
	Jan	180	3,200	3,200	6,580	31	1,100	2,100	<20	<20
	Feb	440	2,400	2,500	5,340	<20	850	3,200	<20	<20
<b>Average</b>		892	5,093	2,859	8,844	35	518	2,259	<20	<20
<b>Median</b>		915	3,200	2,500	6,815	31	510	1,800	<20	<20
<b>90% percentile</b>		1,500	11,100	4,640	17,064	62	932	4,820	33	<20
<b>Minimum</b>		140	34	88	310	<20	<20	<100	<20	<20
<b>Maximum</b>		3,800	24,000	8,000	31,800	110	1,500	6,200	74	77
<b>n</b>		70	70	70	70	70	70	70	70	70
<b>n &gt; LOD</b>		70	70	70	70	53	65	67	15	5

## 1.9. Raw data: musk compounds ( $\mu\text{g}/\text{kg TS}$ )

Treatment plant	Mnth	Musk ketone	Musk xylene	Galaxolide	Tonalide - AHTN	Galaxolide-lactone	Cashmeran	Celestolide	Moskene	Musk ambrette	Musk tibeten	Phantolide	Traseolide
Bekkelaget	Oct	<20	<20	17,000	3,100	480.0	23.0	<20	<20	<20	<20	<20	28.0
	Nov	<20	<20	17,000	2,800	450.0	<20	<20	<20	<20	<20	<20	21.0
	Dec	<20	<20	12,000	3,100	430.0	70.0	<20	<20	<20	<20	<20	31.0
	Jan	<20	<20	12,000	3,000	430.0	80.0	<20	<20	<20	<20	<20	30.0
	Feb	<20	<20	8,600	2,300	1,000.0	55.0	<20	<20	<20	<20	<20	25.0
Bergen Biogas Plant	Oct	<20	<20	13,000	3,300	350.0	65.0	<20	<20	<20	<20	<20	37.0
	Nov	<20	<20	13,000	2,900	230.0	<20	<20	<20	<20	<20	<20	44.0
	Dec	<20	<20	12,000	2,100	340	<20	<20	<20	<20	<20	<20	23.0
	Jan	<20	<20	12,000	2,300	270	<20	<20	<20	<20	<20	<20	30
	Feb	<20	<20	18,000	3,700	420	45.0	<20	<20	<20	<20	<20	38.0
Fuglevik Plant	Oct	<20	<20	22,000	4,000	680	180	<20	<20	<20	<20	<20	34.0
	Nov	<20	<20	19,000	3,800	520	140	<20	<20	<20	<20	<20	27
	Dec	<20	<20	18,500	4,600	480	120	<20	<20	<20	<20	<20	25
	Jan	<20	<20	22,000	3,800	900	<20	<20	<20	<20	<20	<20	27
	Feb	<20	<20	19,500	4,300	630	140	<20	<20	<20	<20	<20	28
Hias	Oct	<20	<20	18,000	4,400	380	110	<20	<20	<20	<20	<20	37.0
	Nov	<20	<20	17,000	3,500	290	120	<20	<20	<20	<20	<20	30
	Dec	<20	<20	17,000	3,700	290	130	<20	<20	<20	<20	<20	32
	Jan	<20	<20	16,000	4,200	350	140	<20	<20	<20	<20	<20	27.0
	Feb	<20	<20	31,000	6,100	540	210	<20	<20	<20	<20	<20	44.0
Gardermoen Plant	Oct	<20	<20	20,000	3,200	1,200	59	<20	<20	<20	<20	<20	32
	Nov	<20	<20	25,000	4,500	820	130	<20	<20	<20	<20	<20	43
	Dec	<20	<20	23,000	4,100	1,100	120	<20	<20	<20	<20	<20	41.0
	Jan	<20	<20	19,000	3,400	1,400	72.0	<20	<20	<20	<20	<20	37.0
	Feb	<20	<20	22,000	4,300	770	110	<20	<20	<20	<20	<20	42
Knappen Plant	Oct	<20	<20	5,300	1,500	860	64	<20	<20	<20	<20	<20	<20
	Nov	<20	<20	4,200	1,300	810	49	<20	<20	<20	<20	<20	<20
	Dec	27.0	<20	5,500	1,600	1,300	43.0	<20	<20	<20	<20	<20	<20
	Jan	25	<20	5,800	1,600	1,400	47	<20	<20	<20	<20	<20	<20
	Feb	25	<20	7,300	1,900	680	60	<20	<20	<20	<20	<20	<20
Lindum Biogas	Oct	<20	<20	12,000	2,800	460	110	<20	<20	<20	<20	<20	26
	Nov	<20	<20	14,000	2,700	410	47	<20	<20	<20	<20	<20	21
	Dec	<20	<20	15,000	3,100	510	110	<20	<20	<20	<20	<20	25
	Jan	<20	<20	16,000	3,300	400	230	<20	<20	<20	<20	<20	31
	Feb	<20	<20	15,000	3,200	460	77	<20	<20	<20	<20	<20	30
Lindum raw sludge	Oct	<20	<20	9,700	1,900	320	64	<20	<20	<20	<20	<20	<20
	Nov	<20	<20	6,700	1,500	320	36	<20	<20	<20	<20	<20	<20
	Dec	33	<20	7,900	1,600	330	31	<20	<20	<20	<20	<20	<20
	Jan	23	<20	6,300	1,400	630	56	<20	<20	<20	<20	<20	<20
	Feb	<20	<20	7,600	1,700	720	25	<20	<20	<20	<20	<20	<20

Continues next page

Continued from last page

Treatment plant	Mnth	Musk ketone	Musk xylene	Galaxolide	Tonalide - AHTN	Galaxolide-lactone	Cashmeran	Celestolide	Moskene	Musk ambrette	Musk tibeten	Phantolide	Traseolide
NRA	Oct	23	<20	5,000	1,200	420	30	<20	<20	<20	<20	<20	<20
	Nov	22	<20	6,100	1,400	460	28	<20	<20	<20	<20	<20	<20
	Dec	30	<20	7,100	1,800	450	47.0	<20	<20	<20	<20	<20	22
	Jan	30	<20	6,700	1,800	440	53.0	<20	<20	<20	<20	<20	24.0
	Feb	39.0	<20	8,600	1,900	1,200	54.0	<20	<20	<20	<20	<20	20
SNJ	Oct	<20	<20	23,000	4,500	700	32	<20	<20	<20	<20	<20	67
	Nov	<20	<20	18,000	3,200	500	50	<20	<20	<20	<20	<20	30
	Dec	<20	<20	16,000	2,800	390	<20	<20	<20	<20	<20	<20	37
	Jan	<20	<20	16,000	3,200	270	66	<20	<20	<20	<20	<20	34
	Feb	<20	<20	12,000	2,600	260	<20	<20	<20	<20	<20	<20	31.0
Solumstrand Plant	Oct	<20	<20	2,800	660	540	<20	<20	<20	<20	<20	<20	<20
	Nov	21	<20	4,300	1,100	690	<20	<20	<20	<20	<20	<20	<20
	Dec	<20	<20	5,700	1,300	440	30	<20	<20	<20	<20	<20	<20
	Jan	29	<20	6,600	1,500	2,000	43	<20	<20	<20	<20	<20	<20
	Feb	<20	<20	6,300	1,600	530	29	<20	<20	<20	<20	<20	<20
Tønsberg Plant	Oct	<20	<20	2,000	510	440	<20	<20	<20	<20	<20	<20	<20
	Nov	<20	<20	2,400	650	430	<20	<20	<20	<20	<20	<20	<20
	Dec	<20	<20	42,000	9,900	4,700	<20	<20	<20	<20	<20	<20	<20
	Jan	<20	<20	42,000	9,700	4,700	<20	<20	<20	<20	<20	<20	<20
	Feb	<20	<20	5,600	1,300	360	<20	<20	<20	<20	<20	<20	<20
VEAS	Oct	<20	<20	10,000	2,400	160	63	<20	<20	<20	<20	<20	21
	Nov	<20	<20	12,000	2,700	140	78	<20	<20	<20	<20	<20	22
	Dec	<20	<20	12,000	2,800	150	<20	<20	<20	<20	<20	<20	<20
	Jan	<20	<20	14,000	2,900	170	85	<20	<20	<20	<20	<20	27
	Feb	<20	<20	14,000	3,200	190	90	<20	<20	<20	<20	<20	27
Øra	Oct	<20	<20	6,200	1,400	340	<20	<20	<20	<20	<20	<20	<20
	Nov	<20	<20	7,400	1,700	290	<20	<20	<20	<20	<20	<20	<20
	Dec	<20	<20	6,500	1,600	270	<20	<20	<20	<20	<20	<20	<20
	Jan	<20	<20	6,700	1,600	280	<20	<20	<20	<20	<20	<20	<20
	Feb	<20	<20	5,100	1,400	630	<20	<20	<20	<20	<20	<20	<20
<b>Average</b>		<20	<20	11,977	2,547	549	59.2	<20	<20	<20	<20	<20	22.7
<b>Median</b>		<20	<20	12,000	2,650	450	48	<20	<20	<20	<20	<20	23.5
<b>90% percentile</b>		25	<20	20,200	4,210	1,010	130	<20	<20	<20	<20	<20	37.1
<b>Minimum</b>		<20	<20	2,000	510	140	<20	<20	<20	<20	<20	<20	<20
<b>Maximum</b>		39	<20	31,000	6,100	2,000	230	<20	<20	<20	<20	<20	67
<b>n</b>		70	70	70	70	70	70	70	70	70	70	70	70
<b>n &gt; LOD</b>		12	0	70	70	70	50	0	0	0	0	0	42



## 1.10.Raw data: Bisphenols ( $\mu\text{g}/\text{kg TS}$ )

Treatment plant	Mnth	Bisphenol A	2.2 bisphenol F	4.4 bisphenol F	Bisphenol F	Bisphenol AF	Bisphenol AP	Bisphenol B	
Bekkelaget	Oct	1,300	37	13	50	<14	<1.8	<1.5	
	Nov	1,400	40	12	52	<14	<1.7	<1.4	
	Dec	2,100	61	19	80	<19	<2.3	<1.9	
	Jan	1,600	44	16	60	<17	<2.1	<1.8	
	Feb	1,600	46	14	60	<17	<2.1	<1.7	
Bergen Biogas Plant	Oct	2,500	33	6.7	39.7	<8.9	<1.5	<1.2	
	Nov	2,300	41	5.7	46.7	<9.9	<1.6	<1.3	
	Dec	2,800	40	6.3	46.3	<11	<1.9	<1.5	
	Jan	2,900	53	9.2	62.2	<11	<1.8	<1.5	
	Feb	2,900	50	8.8	58.8	<11	<1.7	<1.4	
Fuglevik Plant	Oct	1,000	61	20	81	<18	<2.2	<1.9	
	Nov	530	26	35	61	<17	<2.1	<1.8	
	Dec	820	41	28	69	<22	<2.7	<2.3	
	Jan	1,100	44	21	65	<22	<2.7	<2.2	
	Feb	950	32	19	51	<20	<2.5	<2.1	
Hias	Oct	2,800	56	24	80	<16	<2	<1.7	
	Nov	2,300	69	22	91	<15	<1.9	<1.5	
	Dec	3,200	170	35	210	<17	<2.1	<1.8	
	Jan	2,600	150	27	180	<14	<1.8	3.7	
	Feb	2,500	200	32	230	<16	<2	<1.7	
Høvringen Plant	Oct	1,000	33	15	48	<13	5.4	<1.3	
	Nov	1,000	45	27	72	<16	<2	2.8	
	Dec	1,500	55	33	88	<18	<2.2	3	
	Jan	1,400	41	19	60	<12	<1.5	3.5	
	Feb	1,300	54	30	84	<15	<1.9	<1.6	
Gardermoen Plant	Oct	2,300	85	26	110	<22	<2.5	<2	
	Nov	1,700	57	18	75	<16	<1.8	<1.5	
	Dec	2,100	69	21	90	<18	<2	<1.6	
	Jan	1,900	53	19	72	<15	<1.7	3.5	
	Feb	2,100	61	20	81	<16	<1.8	4.6	
Knappen Plant	Oct	190	<0.6	2.6	2.6	<15	<2	<1.7	
	Nov	130	<0.55	1.6	1.6	<14	<1.8	<1.5	
	Dec	170	6.5	2.6	9.1	<13	<1.7	<1.4	
	Jan	170	12	5.1	17	<12	<1.6	<1.3	
	Feb	120	3.2	2.6	5.8	<9.9	<1.3	<1.1	
Lindum Biogas	Oct	2,500	55	12	67	<18	<2	1.7	
	Nov	2,200	49	12	61	<14	<1.5	2.8	
	Dec	2,700	61	15	76	<18	<2.1	3.2	
	Jan	2,100	41	10	51	<14	<1.6	<1.3	
	Feb	2,700	62	13	75	<18	<2	<1.7	

	Bisphenol BP	Bisphenol E	Bisphenol G	Bisphenol M	Bisphenol P	Bisphenol TMC	Bisphenol Z	Bisphenol S	Sum new bisphenols
	<7	420	<6.1	<6.1	<7.5	<0.74	<0.43	27	497
	<6.7	210	<5.9	<5.9	<7.2	<0.71	<0.41	34	296
	<9.1	950	<8	<8	<9.8	<0.96	<0.56	42	1,072
	<8.4	890	<7.4	<7.4	<9.1	<0.89	<0.52	39	989
	<8.1	430	<7.2	<7.1	<8.7	<0.86	<0.5	37	527
	<5.7	980	<6.8	<5	<6.2	<0.61	<0.35	48	1,067.7
	<6.3	780	<5.6	<5.6	<6.8	<0.67	<0.39	64	890.7
	<7.3	370	<6.5	<6.4	<7.9	<0.77	<0.45	93	509.3
	<7.1	260	<6.3	<6.2	<7.6	<0.75	<0.43	100	422.2
	<6.7	250	<6	<5.9	<7.3	<0.71	<0.41	100	408.8
	<8.8	11	390	<7.7	<9.5	<0.93	<0.54	140	622
	<8.4	97	<7.4	<7.3	<9	<0.88	<0.51	85	243
	<11	120	43	<9.4	<12	<1.1	<0.66	150	382
	<11	31	140	<9.3	<11	<1.1	<0.65	170	406
	<9.8	40	<8.7	<8.6	<11	<1	<0.6	150	241
	<7.9	3.1	<7	<7	<8.5	<0.84	<0.49	140	223.1
	<7.3	3	<6.5	<6.4	<7.9	<0.77	<0.45	120	214
	<8.3	<1.9	<7.3	<7.3	<8.9	<0.88	<0.51	160	370
	<6.9	<1.6	<6.1	<6	<7.4	<0.73	<0.42	160	343.7
	<7.9	<1.9	<7	<6.9	<8.5	<0.83	<0.48	220	450
	<6.3	<1.5	<5.6	<5.6	<6.8	<0.67	<0.39	110	163.4
	<7.7	<1.8	<6.8	<6.8	<8.3	<0.82	<0.47	82	156.8
	<8.6	<2	8.9	<7.6	<9.3	<0.92	<0.53	110	209.9
	<6	<1.4	27	<5.2	<6.4	<0.63	<0.36	110	200.5
	<7.5	<1.8	11	<6.6	<8.1	<0.8	<0.46	98	193
	<9.6	<2.3	220	<8.5	<10	<1	<0.59	73	403
	<7.1	<1.7	120	<6.2	<7.6	<0.75	<0.43	45	240
	<7.8	<1.8	29	<6.8	<8.3	<0.82	<0.48	52	171
	<6.5	<1.5	450	<5.7	<7	<0.69	<0.4	29	554.5
	<7.2	<1.7	800	<6.3	<7.7	<0.76	<0.44	41	926.6
	<9.8	<1.8	25	<6.5	<11	<1	<0.6	52	79.6
	<8.9	<1.7	44	<5.9	<9.6	<0.95	<0.55	34	79.6
	<8.4	<1.6	7.6	<5.5	<9	<0.89	<0.51	57	73.7
	<7.9	<1.5	<7	<5.2	<8.5	<0.84	<0.48	76	93
	<6.4	<1.2	<5.6	<4.2	<6.8	<0.67	<0.39	40	45.8
	<7.9	30	<9.1	<6.9	<8.5	<0.83	<0.48	120	218.7
	<6	65	<6.9	<5.3	<6.5	<0.63	0.63	130	259.43
	<8.1	<1.9	<9.3	<7.1	<8.7	<0.85	<0.49	170	249.2
	<6.1	2	<7.1	<5.4	<6.6	<0.65	<0.38	130	183
	<7.9	<1.9	15	<6.9	<8.5	<0.84	<0.49	140	230

Continues next page

Continued from last page

Treatment plant	Mnth	Bisphenol A	2.2 bisphenol F	4.4 bisphenol F	Bisphenol F	Bisphenol AF	Bisphenol AP	Bisphenol B	
Lindum raw sludge	Oct	330	6.9	2.6	9.5	<8.1	<1.1	<0.88	
	Nov	950	4.2	4	8.2	<8.4	<1.1	<0.91	
	Dec	460	5.2	2.8	8	<6.8	<0.89	<0.74	
	Jan	310	5.2	1.9	7.1	<9.1	<1.2	<0.99	
	Feb	730	5.6	3.1	8.7	<9.6	<1.2	<1	
NRA	Oct	600	17	11	28	<16	<2	<1.7	
	Nov	410	13	7.7	20.7	<8.8	<1.1	<0.91	
	Dec	710	24	15	39	<13	<1.6	<1.3	
	Jan	810	24	19	43	<13	<1.6	<1.4	
	Feb	610	27	14	41	<12	<1.5	<1.2	
Sandefjord Plant	Oct	760	57	15	72	<19	<2.1	5.9	
	Nov	760	75	19	94	<16	<1.8	11	
	Dec	880	110	17	130	<18	<2	13	
	Jan	900	77	16	93	<20	<2.2	6.1	
	Feb	890	49	12	61	<18	<2	4.1	
SNJ	Oct	3,200	34	18	52	<19	<2.1	<1.8	
	Nov	3,500	38	21	59	<21	<2.4	2.4	
	Dec	2,700	36	18	54	<20	<2.3	<1.9	
	Jan	2,400	22	16	38	<20	<2.2	13	
	Feb	2,300	24	14	38	<20	<2.2	5.1	
Solumstrand Plant	Oct	580	10	3.2	13.2	<11	<1.4	3.5	
	Nov	780	<0.43	3.1	3.1	<11	<1.4	<1.2	
	Dec	970	6.9	3.9	10.8	<11	<1.4	<1.1	
	Jan	1,100	7.9	3.8	11.7	<12	<1.5	<1.2	
	Feb	1,800	8.9	6.8	16	<16	<2	<1.7	
Tønsberg Plant	Oct	180	55	12	67	<14	<1.7	<1.4	
	Nov	310	49	12	61	<11	<1.3	<1.1	
	Dec	580	61	15	76	<18	<2.2	<1.9	
	Jan	350	41	10	51	<16	<1.9	<1.6	
	Feb	730	62	13	75	<10	<1.3	<1.1	
VEAS	Oct	300	6.9	2.6	9.5	<10	<1.4	13	
	Nov	260	4.2	4	8.2	<11	<1.4	<1.4	
	Dec	360	5.2	2.8	8	<12	<1.7	<1.7	
	Jan	340	5.2	1.9	7.1	<10	<1.4	<1.4	
	Feb	300	5.6	3.1	8.7	<8.6	<1.2	<1.2	
Øra	Oct	5,700	17	11	28	<20	<2.2	4.9	
	Nov	6,500	13	7.7	20.7	<18	<2	5.5	
	Dec	5,800	24	15	39	<18	<2	5.7	
	Jan	4,500	24	19	43	<17	<1.8	2.7	
	Feb	4,300	27	14	41	<22	<2.4	3.1	
<b>Average</b>		1,605	40.3	13.6	54.0	<LOD	0.97	2.12	
<b>Median</b>		1,100	39	13.5	51.5	<15	<1.85	<1.7	
<b>90% percentile</b>		2,930	69	26.1	90.1	<20	<2.3	5.14	
<b>Minimum</b>		120	<0.43	1.6	1.6	<6.8	<0.89	<0.74	
<b>Maximum</b>		6,500	200	35	230	<22	5.4	13	
<b>n</b>		80	80	80	80	80	80	80	
<b>n &gt; LOD</b>		80	77	80	80	0	1	24	

	Bisphenol BP	Bisphenol E	Bisphenol G	Bisphenol M	Bisphenol P	Bisphenol TMC	Bisphenol Z	Bisphenol S	Sum new bisphenols
	<5.2	<0.97	<4.6	<3.5	<5.6	<0.55	<0.32	65	74.5
	<5.4	<1	<4.8	<3.6	<5.8	<0.57	<0.33	140	148.2
	<4.4	7.7	<3.9	<2.9	<4.7	<0.46	<0.27	87	102.7
	<5.8	32	<5.2	<3.9	<6.3	<0.62	<0.36	60	99.1
	<6.1	<1.1	<5.4	<4.1	<6.6	<0.65	<0.38	96	104.7
	<7.9	<1.8	120	<6.9	<8.5	<0.83	<0.48	87	235
	<4.3	<1	57	<3.8	<4.6	<0.45	<0.26	46	123.7
	<6.2	<1.4	7.1	<5.4	<6.6	<0.65	<0.38	71	117.1
	<6.4	<1.5	<5.7	<5.6	<6.9	<0.68	<0.39	100	143
	<5.8	<1.4	12	<5.1	<6.3	<0.62	<0.36	73	126
	<8.3	<1.9	<9.6	<7.3	<8.9	<0.88	<0.51	77	154.9
	<7	<1.6	<8.1	<6.2	<7.5	<0.74	<0.43	81	186
	<8	<1.9	<9.2	<7	<8.6	<0.85	<0.49	83	226
	<8.7	<2	<10	<7.7	<9.4	<0.92	<0.53	85	184.1
	<7.7	<1.8	<8.9	<6.7	<8.2	<0.81	<0.47	69	134.1
	<8.3	<1.9	<9.6	<7.3	<8.9	<0.88	<0.51	1,200	1,252
	<9.3	<2.2	<11	<8.2	<10	<0.99	<0.57	1,100	1,161.4
	<8.8	<2.1	<10	<7.8	<9.5	<0.94	<0.54	1,200	1,254
	<8.6	<2	<10	<7.6	<9.3	<0.91	<0.53	1,100	1,151
	<8.5	<2	<9.9	<7.5	<9.2	<0.9	<0.52	900	943.1
	<5.6	<1.3	<4.9	<4.9	<6	<0.59	<0.34	130	146.7
	<5.4	<1.3	<4.8	<4.8	<5.8	<0.57	<0.33	150	153.1
	<5.4	<1.3	<4.7	<4.7	<5.8	<0.57	<0.33	220	230.8
	<5.8	<1.4	<5.1	<5.1	<6.3	<0.62	<0.36	310	321.7
	<7.9	<1.9	<7	<6.9	<8.5	<0.83	<0.48	410	426
	<6.6	<1.6	<5.9	<5.8	<7.1	<0.7	<0.41	49	116
	<5.3	<1.2	<4.7	<4.6	<5.7	<0.56	<0.32	53	114
	<8.8	<2.1	<7.8	<7.7	<9.5	<0.93	<0.54	110	186
	<7.6	<1.8	<6.8	<6.7	<8.2	<0.81	<0.47	94	145
	<5.1	<1.2	<4.5	<4.5	<5.5	<0.54	<0.31	140	215
	<5.4	<1.6	<5.9	<4.6	<7.2	<0.71	<0.41	11	33.5
	<5.5	<1.6	<6	<4.7	<7.3	<0.72	<0.42	7.1	15.3
	<6.3	<1.8	<6.9	<5.4	<8.4	<0.83	<0.48	8.9	16.9
	<5.4	<1.6	<5.9	<4.6	<7.1	<0.7	<0.41	11	18.1
	<4.5	<1.3	<4.9	<3.8	<5.9	<0.58	<0.34	7.6	16.3
	<8.7	240	<10	<7.6	<9.3	<0.92	<0.53	1,600	1,872.9
	<7.9	170	<9.2	<7	<8.5	<0.84	<0.49	2,000	2,196.2
	<8	17	24	<7	<8.6	<0.84	<0.49	1,700	1,785.7
	<7.2	170	<8.4	<6.4	<7.8	<0.77	<0.44	1,400	1,615.7
	<9.5	52	<11	<8.4	<10	<1	<0.58	2,100	2,196.1
	<LOD	83.43	34.53	<LOD	<LOD	<LOD	<LOD	262.6	170.4
	<7.4	<1.9	<7.4	<6.35	<8.15	<0.805	<0.47	95	81.15
	<8.92	251	45.3	<7.71	<9.62	<0.951	<0.561	1,100	471.2
	<4.3	<0.97	<3.9	<2.9	<4.6	<0.45	<0.26	7.1	3.1
	<11	980	800	<9.4	<12	<1.1	0.63	2,100	1,030
	80	80	80	80	80	80	80	80	80
	0	27	20	0	0	0	1	80	80

Continues next page

## 1.11. Raw data: Organophosphorus flame retardants ( $\mu\text{g}/\text{kg}$ TS)

Treatment plant	Mnth	TCEP	TCPP	TDCPP	Sum FOF w. chlorine	TBEP	EHDPP	TCP	TBP/TnBP	iPPDPP	TIPPP	Sum OPFR w/o. chlorine
Bekkelaget	Oct	<0.95	4,600	75	4,675	670	440	290	24	52	85	1,561
	Nov	<0.85	5,000	68	5,068	880	490	330	31	59	83	1,873
	Dec	<0.84	6,100	90	6,190	760	450	340	30	51	70	1,701
	Jan	<1.6	5,200	87	5,287	800	480	340	41	64	91	1,816
	Feb	<0.82	5,000	75	5,075	360	310	170	25	33	68	966
Bergen Biogas Plant	Oct	<0.94	8,100	47	8,147	590	510	110	65	64	110	1,449
	Nov	<1.4	3,600	39	3,639	490	420	140	48	62	78	1,238
	Dec	<1.3	6,800	56	6,856	460	440	150	51	69	84	1,254
	Jan	<0.95	8,400	61	8,461	500	410	90	56	71	83	1,210
	Feb	<0.76	4,400	55	4,455	650	500	98	67	79	93	1,487
Fuglevik Plant	Oct	2,600	8,900	190	11,690	320	640	870	48	100	140	2,118
	Nov	2,800	7,500	130	10,430	240	440	450	12	58	38	1,238
	Dec	3,200	7,700	150	11,050	410	630	590	23	75	56	1,784
	Jan	3,800	5,500	150	9,450	270	510	550	34	53	38	1,455
	Feb	4,700	8,300	140	13,140	330	510	540	37	71	49	1,537
Hias	Oct	7,500	4,600	61	12,161	500	410	430	26	110	110	1,586
	Nov	6,100	3,300	49	9,449	280	420	350	21	100	100	1,271
	Dec	6,100	3,700	63	9,863	390	510	370	25	100	110	1,505
	Jan	5,100	3,000	47	8,147	320	380	360	26	93	100	1,279
	Feb	5,100	3,000	52	8,152	330	330	350	21	91	98	1,220
Høvringen Plant	Oct	5,700	10,000	230	15,930	250	680	820	37	280	120	2,187
	Nov	8,300	6,300	180	14,780	430	1,100	1,600	34	480	200	3,844
	Dec	8,900	8,100	230	17,230	350	770	1,200	48	350	140	2,858
	Jan	8,400	4,100	190	12,690	370	700	590	48	220	95	2,023
	Feb	8,000	8,500	230	16,730	320	690	1,100	44	310	110	2,574
Gardermoen Plant	Oct	12	1,900	230	2,142	4,300	690	210	290	78	130	5,698
	Nov	6.2	1,200	150	1,356.2	2,300	390	120	97	53	73	3,033
	Dec	<1.5	1,600	160	1,760	4,100	560	110	270	43	88	5,171
	Jan	<1.5	1,200	150	1,350	3,300	370	110	540	40	82	4,442
	Feb	<2.2	1,600	160	1,760	2,900	230	81	760	25	52	4,048
Knappen Plant	Oct	<1.3	1,700	120	1,820	740	360	130	37	200	64	1,531
	Nov	<1.2	700	59	759	550	290	100	22	170	61	1,193
	Dec	<1.1	360	110	470	670	300	200	31	170	42	1,413
	Jan	<1.1	1,600	110	1,710	490	260	100	26	120	27	1,023
	Feb	<0.99	610	75	685	540	230	83	29	130	25	1,037
Lindum Biogas	Oct	<1.5	390	84	474	710	190	76	25	100	220	1,321
	Nov	<1.7	72	25	97	820	190	71	30	92	150	1,353
	Dec	<2.4	67	10	77	990	240	90	35	110	180	1,645
	Jan	<1.6	65	44	109	910	240	65	38	97	150	1,500
	Feb	<1.7	100	5.9	105.9	1,100	300	81	61	140	180	1,862
Lindum raw sludge	Oct	20	820	78	918	230	200	130	31	130	83	804
	Nov	<0.59	790	66	856	91	160	78	32	180	200	741
	Dec	<0.95	840	46	886	210	270	150	37	190	93	950
	Jan	<1.4	960	110	1,070	340	280	190	50	140	89	1,089
	Feb	<1.3	650	86	736	400	270	140	81	210	150	1,251

Continued from last page

Treatment plant	Mnth	TCEP	TCPP	TDCPP	Sum FOF w. chlorine	TBEP	EHDPP	TCP	TBP/TnBP	iPPDPP	TIPPP	Sum OPFR w/o. chlorine
NRA	Oct	<2.1	3,200	91	3,291	180	1,200	840	66	110	85	2,481
	Nov	<0.68	2,400	55	2,455	97	420	280	42	54	26	919
	Dec	<1.5	1,700	72	1,772	180	1,000	450	71	74	34	1,809
	Jan	<0.67	1,300	67	1,367	250	1,000	490	150	140	56	2,086
	Feb	<1	1,300	70	1,370	85	540	230	39	43	25	962
Sandefjord Plant	Oct	<2.1	1,300	140	1,440	710	470	180	39	100	100	1,599
	Nov	<1.1	1,100	110	1,210	3,200	530	250	47	130	130	4,287
	Dec	<0.95	1,100	110	1,210	1,100	660	210	35	160	140	2,305
	Jan	<1.9	640	160	800	870	540	210	46	140	120	1,926
	Feb	<1	420	130	550	610	230	150	21	70	77	1,158
SNJ	Oct	<2.1	1,600	54	1,654	1,500	980	520	93	200	330	3,623
	Nov	<0.89	2,200	42	2,242	1,000	440	300	48	190	230	2,208
	Dec	<2.5	1,800	64	1,864	2,100	890	820	98	330	450	4,688
	Jan	<2.3	1,200	54	1,254	1,300	930	640	70	250	290	3,480
	Feb	23	910	66	999	1,700	570	470	92	270	210	3,312
Solumstrand Plant	Oct	78	1,600	30	1,708	63	340	500	22	320	250	1,495
	Nov	49	980	46	1,075	85	300	340	17	220	140	1,102
	Dec	38	1,100	39	1,177	85	290	370	19	280	170	1,214
	Jan	30	1,500	58	1,588	83	310	350	12	320	150	1,225
	Feb	<1.7	990	69	1,059	130	570	480	47	400	230	1,857
Tønsberg Plant	Oct	<1.9	730	44	774	150	590	200	17	57	27	1,041
	Nov	<1	1,100	61	1,161	85	330	180	11	30	17	653
	Dec	<2	2,800	84	2,884	440	940	560	31	95	34	2,100
	Jan	<1	2,100	100	2,200	340	640	380	16	73	22	1,471
	Feb	<0.85	1,300	84	1,384	360	490	260	13	63	20	1,206
VEAS	Oct	<1.5	370	4.4	374.4	1,000	460	44	61	10	78	1,653
	Nov	<1.7	710	4.4	714.4	910	160	13	48	<4.1	33	1,164
	Dec	<0.73	820	3.8	823.8	730	230	19	42	3.5	37	1,061.5
	Jan	<0.69	760	<2.2	760	1,000	340	37	88	5.3	60	1,530.3
	Feb	<1.7	490	5.3	495.3	870	250	18	55	<3.9	41	1,234
Øra	Oct	<2.5	670	46	716	470	160	830	47	25	44	1,576
	Nov	<0.95	510	32	542	200	98	160	17	12	29	516
	Dec	<0.94	330	31	361	140	100	130	70	13	30	483
	Jan	<1.1	240	32	272	160	120	170	200	17	32	699
	Feb	<1.8	420	67	487	230	140	230	360	21	32	1,013
<b>Average</b>		1,082	2,608	84	3,774	742	456	323	70	122	103	1,816
<b>Median</b>		<1.65	1,400	67.5	1,514	465	420	220	39	94	85	1,498
<b>90% percentile</b>		5,160	7,520	160	11,114	1,520	782	658	97.1	280	201	3,494
<b>Minimum</b>		<0.59	65	<2.2	77	63	98	13	11	<3.9	17	483
<b>Maximum</b>		8,900	10,000	230	17,230	4,300	1,200	1,600	760	480	450	5,698
<b>n</b>		80	80	80	80	80	80	80	80	80	80	80
<b>n &gt; LOD</b>		23	80	79	80	80	80	80	80	78	80	80

## 1.12. Raw data: UV substances ( $\mu\text{g}/\text{kg TS}$ )

Treatment plant	Mnth	UV-320+350	UV-327	UV-328	Sum Benzo-triazole	Octocrylen	Benzo-phenone-3	Etylhexyl methoxycinnamate	Sum of other UV substances
Bekkelaget	Oct	<3.2	<5.4	33	33	590	1.2	230	821.2
	Nov	<2.2	<6	31	31	720	4.8	290	1,014.8
	Dec	<2	<5.9	31	31	740	1.8	260	1,001.8
	Jan	<2.2	<7.1	36	36	480	1.1	270	751.1
	Feb	<1.4	<5.8	31	31	540	12	200	752
Bergen Biogas Plant	Oct	<1.4	<5.4	22	22	1,100	<1.4	230	1,330
	Nov	<1.3	<5.2	20	20	830	1.5	300	1,131.5
	Dec	<3.2	<6.1	19	19	780	1.3	260	1,041.3
	Jan	<2.6	<5.8	19	19	1,100	2	290	1,392
	Feb	<1.5	<5.9	18	18	1,000	1.8	280	1,281.8
Fuglevik Plant	Oct	<2.2	<7.6	29	29	3,100	2.3	300	3,402.3
	Nov	<1.6	<7.3	16	16	1,800	1.5	1,700	3,501.5
	Dec	<1.8	<8.3	25	25	2,300	1.6	730	3,031.6
	Jan	<1.6	<7.7	24	24	2,300	2.2	220	2,522.2
	Feb	<1.6	<7.9	24	24	3,000	3.2	160	3,163.2
Hias	Oct	<2.4	<5.9	33	33	1,300	12	930	2,242
	Nov	<1.4	<5	26	26	1,600	24	1,000	2,624
	Dec	<1.6	<6.2	34	34	1,300	14	1,000	2,314
	Jan	<2	<5.8	32	32	1,300	18	740	2,058
	Feb	<1.8	<5.4	29	29	1,100	20	830	1,950
Høvringen Plant	Oct	<0.9	<4.5	15	15	3,900	3.5	520	4,423.5
	Nov	<1.2	<5.6	21	21	2,300	4.2	610	2,914.2
	Dec	<1.3	<5.9	20	20	2,300	4.9	540	2,844.9
	Jan	<1	<4.5	15	15	2,800	6	290	3,096
	Feb	<1.2	<5.5	15	15	4,700	8.4	470	5,178.4
Gardermoen Plant	Oct	<2.0	<7.3	28	28	1,900	2.5	200	2,102.5
	Nov	<1.2	<5.6	25	25	1,900	2.7	130	2,032.7
	Dec	<1.6	<6.3	33	33	1,400	9.9	180	1,589.9
	Jan	<1.6	<5.9	29	29	1,400	4	110	1,514
	Feb	<1.3	<6.2	29	29	1,200	3.1	130	1,333.1
Knappen Plant	Oct	<1.8	<8.2	14	14	1,600	150	4,500	6,250
	Nov	<1.5	<7.2	10	10	1,300	130	4,400	5,830
	Dec	<1.2	<6.1	12	12	1,400	220	4,400	6,020
	Jan	<1.3	<6.1	8.4	8.4	2,300	450	3,600	6,350
	Feb	<1.2	<5.4	8.1	8.1	1,500	230	3,500	5,230
Lindum Biogas	Oct	1.2	<8.5	31	32.2	1,200	8.7	510	1,718.7
	Nov	1.6	<7	28	29.6	1,000	4.7	1,000	2,004.7
	Dec	1.2	<7.5	27	28.2	1,000	<2.4	1,100	2,100
	Jan	0.96	<7.6	29	29.96	920	3.6	890	1,813.6
	Feb	1.4	<8.5	30	31.4	970	2.8	710	1,682.8

Continued from last page

Treatment plant	Mnth	UV-320+350	UV-327	UV-328	Sum Benzo-triazole	Octocrylen	Benzo-phenone-3	Etylhexyl methoxycinnamate	Sum of other UV substances
Lindum raw sludge	Oct	<0.45	<4.3	10	10	880	91	710	1,681
	Nov	<0.49	<4.7	8.2	8.2	730	95	680	1,505
	Dec	<0.3	<2.9	7.7	7.7	770	130	1,100	2,000
	Jan	<0.5	<4.8	2.5	2.5	750	130	1,800	2,680
	Feb	<0.49	<4.7	11	11	540	110	1,600	2,250
NRA	Oct	<0.58	<5.6	16	16	1,200	44	2,800	4,044
	Nov	<0.34	<3.3	6.9	6.9	960	53	1,500	2,513
	Dec	<0.45	<4.3	8.7	8.7	620	48	2,100	2,768
	Jan	<0.44	<4.2	10	10	510	46	2,400	2,956
	Feb	<0.38	<3.6	7.2	7.2	660	59	3,200	3,919
Sandefjord Plant	Oct	1.1	<7.5	38	39.1	1,500	2.4	210	1,712.4
	Nov	0.71	<5.7	28	28.71	1,100	1.5	210	1,311.5
	Dec	<0.68	<6.6	27	27	1,400	62	210	1,672
	Jan	1.3	<7.2	29	30.3	1,100	1.5	220	1,321.5
	Feb	<0.69	<6.6	24	24	890	2.2	200	1,092.2
SNJ	Oct	1.7	<6	26	27.7	680	36	92	808
	Nov	2.1	<6.1	27	29.1	510	49	68	627
	Dec	3.1	<7.3	30	33.1	700	72	98	870
	Jan	0.68	<6.5	21	21.68	400	27	110	537
	Feb	<0.7	<6.8	21	21	360	19	190	569
Solumstrand Plant	Oct	<0.45	<4.3	8.2	8.2	920	34	1,300	2,254
	Nov	<0.52	<5	9	9	890	42	1,900	2,832
	Dec	<0.48	<4.6	7.4	7.4	920	46	1,100	2,066
	Jan	<0.53	<5.1	9.2	9.2	770	50	2,000	2,820
	Feb	<0.6	<5.7	9.2	9.2	1,100	56	1,700	2,856
Tønsberg Plant	Oct	<0.63	<6	13	13	830	37	1,700	2,567
	Nov	<0.49	<4.7	8	8	680	48	2,800	3,528
	Dec	<0.64	<6.1	10	10	720	56	3,300	4,076
	Jan	<0.74	<7.2	11	11	990	74	5,200	6,264
	Feb	<0.48	<4.6	10	10	1,100	74	2,800	3,974
VEAS	Oct	<0.63	<6.7	40	40	720	2	640	1,362
	Nov	<0.82	<8.7	45	45	400	1.8	430	831.8
	Dec	<0.92	<9.8	55	55	580	2.8	680	1,262.8
	Jan	<0.84	<9	47	47	450	3	850	1,303
	Feb	<0.87	<9.2	51	51	420	2.3	510	932.3
Øra	Oct	<0.94	<9.1	16	16	470	3	520	993
	Nov	<0.72	<6.9	14	14	330	1.2	170	501.2
	Dec	<0.71	<6.8	12	12	350	<1.4	170	520
	Jan	<0.66	<6.3	12	12	380	<1.4	430	810
	Feb	<0.86	<8.2	7.4	7.4	530	8	1,700	2,238

Continues next page

Continued from last page

Treatment plant	Mnth	UV-320+350	UV-327	UV-328	Sum Benzo-triazole	Octocrylen	Benzo-phenone-3	Etylhexylmethoxycinnamate	Sum of other UV substances
<b>Average</b>		0.71	<LOD	21.4	21.6	1,172	37.5	1,093	2,302.3
<b>Median</b>		<1.25	<LOD	21	21	965	8.2	625	2,018.7
<b>90% percentile</b>		1.3	<LOD	33.1	33.19	2,300	96.5	2,840	4,110.75
<b>Minimum</b>		<0.3	<2.9	2.5	2.5	330	<1.4	68	501.2
<b>Maximum</b>		3.1	<9.8	55	55	4,700	450	5,200	6,350
<b>n</b>		80	80	80	80	80	80	80	80
<b>n &gt; LOD</b>		12	0	80	80	80	76	80	80

## 1.13. Raw data: Pharmaceutical residues ( $\mu\text{g}/\text{kg}$ TS)

Pharmaceutical residues not detected in the sludge samples ( $\mu\text{g}/\text{kg}$  TS):

	Alfuzosin	Carbamazepine 10,11-epoxide	Cilazapril	Clemastine	Glimepiride	N4_Acetylsulfamethoxazole	Pizotifen	Ropinirole	Sulfamethazine
Minimum limit	<0.96	<1.4	<0.15	<0.89	<0.49	<0.18	<2.3	<0.97	<1.3
Maximum limit	<6.1	<7.4	<1.6	<4.4	<1.8	<3.1	<11	<24	<6.7
Number of samples	80	80	80	80	80	80	80	80	80

Pharmaceutical residues detected in < 8 of 80 samples ( $\mu\text{g}/\text{kg}$  TS):

	10,11-dihydrocarbamazepine	Alprazolam	Bezafibrate	Biperiden	Clonazepam	Disopyramide	Maprotiline	N1_Acetylsulfamethoxazole	Orphenadrine	Sulfamerazine	Sulfamethizole
Detected in treatment plant (month)	Hias (Nov)	Hias (Feb)	Hias (Oct, Feb)	Knappen (nov)	Fuglevik (oct.) Hias (feb.) Gardermoen (jan.) NRA (dec)	SNJ (dec)	Gardermoen (dec., jan., feb.)	Hias (dec)	Sandefjord (dec)	VEAS (all samples)	Hias (all samples)
Average > LOD	19	5.6	1.32	3.35	2.03	2.4	3.8	6	7.9	3.36	7.32
Minimum LOD	<3.4	<0.73	<0.6	<1.2	<0.16	<0.43	<0.9	<0.48	<1.4	<0.99	<0.71
Maximum > LOD	19	5.6	1.3	2.8	0.85	2.4	3.5	6	7.9	2.2	3.5
Maximum	19	5.6	1.35	3.9	4.7	2.4	4.3	6	7.9	5.9	11
n	80	80	80	80	80	80	80	80	80	80	80
n > LOD	1	1	2	2	4	1	3	1	1	5	5

Pharmaceutical residues detected in >10 of 80 samples ( $\mu\text{g}/\text{kg}$  TS):

Treatment plant	Mnth	Bisoprolol	Clarithromycin	Clindamycin	Clindamycin sulfoxide	Clomipramine	Codeine	Diltiazem	Diphenhydramine	Donepezil	
Bekkelaget	Oct	<1.2	29	1	<0.84	6.4	3	<2.4	13	<2.6	
	Nov	<0.92	22	0.95	<0.75	6.7	1.3	<2.6	11	<3.2	
	Dec	1	28	1	<0.74	7.2	1.9	<2.2	11	<2.9	
	Jan	<2.7	43	<1.4	<1.4	12	2.6	<3	12	<3.5	
	Feb	<0.93	25	<0.72	<0.72	8.9	2.7	<2	12	<2.9	
Bergen Biogas Plant	Oct	<1	8.5	1.2	<0.83	9.2	5.1	<2.6	12	<2.7	
	Nov	<1.7	9.5	<1.2	<1.2	7.7	10	<2.8	8	<2.9	
	Dec	<1.6	13	2.8	<1.2	22	2.8	<2.8	6.5	<2.6	
	Jan	<0.78	14	3.1	<0.83	15	3.8	<2.6	8.1	<4	
	Feb	<0.63	8.2	1.7	<0.67	9.4	3.3	<2.7	8.5	<3.9	
Fuglevik Plant	Oct	2.1	12	19	1.9	11	19	<2.6	7.5	<4.5	
	Nov	1	5.3	11	2	7.6	37	<2.6	5.3	<4.4	
	Dec	<1.1	14	27	2.8	10	44	<4	6.8	<4.7	
	Jan	2.1	5	20	0.94	7.2	33	<2.3	8	<4.2	
	Feb	1.8	3.2	19	1.4	9.1	56	<2.7	10	<4.9	
Hias	Oct	1.9	11	<1.3	<1.3	12	29	<2.8	5.7	<4.1	
	Nov	1.3	3.6	<0.81	<0.81	8.2	14	<2.2	4.1	<3.2	
	Dec	<2.4	<4.3	<1.4	<1.4	11	12	<2.8	4.6	<5.6	
	Jan	<1.9	5	<1.6	<1.6	10	17	<3.1	5.4	<4.2	
	Feb	1.7	<4.2	<1.4	<1.4	8.5	12	<3	5.6	<4.4	
Høvringen Plant	Oct	<1.1	<2.5	1.5	2	11	46	<2.2	6	<3.5	
	Nov	<1.2	<4.2	3.9	1.8	9.1	37	<4.5	5.6	<4.1	
	Dec	<1.5	<3.6	6.5	<1.2	9.4	56	<2.9	7.4	<4.1	
	Jan	<1.2	<2.8	9.2	<0.96	9.2	13	<2.4	8.5	<3	
	Feb	<1.3	<3.1	5.1	<1	8.5	43	<2.7	6.6	<3.7	
Gardermoen Plant	Oct	2.6	52	<1.5	<1.5	9.2	<1.5	<3.4	40	<5.5	
	Nov	1.3	19	<0.76	<0.76	5.3	2	<2.3	23	<4.9	
	Dec	2	28	<1.3	<1.3	6.4	1.1	<3.1	30	<6.8	
	Jan	0.84	34	<1.3	<1.3	8.2	1.9	<3	31	<4.7	
	Feb	<0.9	74	<2	<2	8.1	1.5	<3.4	27	<4.2	
Knappen Plant	Oct	<1.7	22	20	12	11	11	19	3.5	8.1	
	Nov	<0.91	8.7	11	15	6.7	8.9	11	<2.6	7.2	
	Dec	<1.5	9.9	14	11	5.8	24	15	<2.1	6.7	
	Jan	<1.6	21	13	6.3	8.8	14	15	<2.1	8.3	
	Feb	<1.5	8.3	8.7	8	8	23	12	<1.9	6.9	
Lindum Biogas	Oct	<1.1	4.2	<1.3	<1.3	8.9	6.5	<4.2	7.6	<5.7	
	Nov	<1.7	4.8	<1.5	<1.5	6.4	9.3	<3.6	5.7	<5	
	Dec	<1.2	9.1	<2.1	<2.1	7.1	12	<4.1	6.6	<5.9	
	Jan	<1.8	4	<1.4	<1.4	8	9.7	<3.4	7.4	<5.4	
	Feb	<1.6	<3.9	<1.5	<1.5	9.2	15	<3.6	8.4	<5.5	
Lindum raw sludge	Oct	<1.7	21	10	7.9	2.7	28	2.9	3.1	<2.5	
	Nov	<0.79	8.5	17	11	2.7	36	1.7	6.9	<2.7	
	Dec	<1.6	9.6	6.3	16	2.9	17	<2	2.8	<2.3	
	Jan	<1.3	10	3.3	16	4.5	32	<3.2	3.2	<4.2	
	Feb	<1.2	9.4	7.4	14	3.1	16	<2.7	4.5	<3.3	

	Feno-fibrate	Gliben-clamide	Meman-tine	Oxazepam	Oxcarba-zepine	Sotalol	Sulfadia-zine	Sulfamet-hoxazole	Tamoxifen	Trimet-hoprim	Verapamil
	1.9	<0.73	1.4	4.4	3	17	<3.4	<1.7	5.8	<2.4	3.6
	4.9	<0.82	<0.77	3.9	2.4	<2.8	4.2	<1.3	7.2	<1.5	2.9
	3.7	<0.69	1.2	6.2	3.2	9.1	3.1	<1.2	7.9	<1.7	2.4
	1.8	<0.93	<2.2	4.8	2.9	4.1	5.7	<2.8	6.2	<2.4	2.9
	1.3	<0.63	1.1	5	3.5	22	2.7	<1.3	3.3	<2.1	3.4
	2.3	<0.78	2.3	3.5	1.6	15	<1.6	<1.5	7.9	<3.2	<1.9
	1.9	<0.83	1.9	2.4	<1.2	12	1.9	<2.4	5.9	<1.4	<2.1
	1.9	<0.82	2	5	1.4	17	2.9	<2.4	4.9	<1.8	<2
	1.5	<0.77	2.9	5	2.3	34	6.6	<1.4	6	<1.8	<1.9
	1.8	<0.79	2.1	4.7	2.1	11	2.4	<1.1	6.5	<1.3	<2
	1.3	<0.81	2.4	24	4.2	37	5.3	<1.2	7.1	<1.6	7.4
	12	<0.8	1.1	12	2.8	15	4.2	<1.3	4.8	<1.5	13
	6	<1.2	<1	21	3.4	22	4.5	<1.6	5.3	<2.3	9.2
	<0.87	<0.73	2.1	16	3.7	25	3.2	<1.7	3.4	<2.8	5
	<0.86	<0.83	2	19	5	19	4.1	<1.6	3.4	<1.9	10
	1.7	<0.87	4	11	3.7	120	3.6	<1.8	6.8	3.1	2.5
	1.7	<0.69	3.1	<0.79	7.4	62	5.1	<1.2	4.6	<2	2.5
	1.7	<0.88	5	<0.85	5.9	62	8.5	<3.2	6.7	<2.4	<2.3
	2.6	<0.95	3.9	<1	5.8	130	8.6	<2.5	6	<4.6	2.7
	<1.3	<0.94	5	5.2	2.2	97	13	<2.4	5.1	<4.9	<2.4
	7.6	<0.67	<0.96	25	2.1	28	2.7	<1.7	11	<2.4	6.7
	4.4	<1.4	<0.88	12	<2.3	9.8	2.2	<2.2	13	<2.3	5
	1.6	<0.91	<1.3	20	2.8	20	2.6	<2.1	9.7	<1.4	3.9
	2.9	<0.76	<1.1	18	2.9	11	4.8	<2	9.9	<2.6	2.8
	1.8	<0.83	<1.1	17	2.5	51	3.5	<2	8.6	<1.9	3.4
	<1.2	<0.87	5.1	4.8	5.7	25	4.5	<2.8	13	<3.4	<2.6
	<1.1	<0.59	2.3	5.9	4.2	12	2.1	<1.4	9.5	<1.5	<1.7
	<1.3	<0.79	3.8	5.2	3.3	7.7	4	<2.5	19	<2.1	<2.3
	<1.2	<0.79	2.5	12	4.2	19	3.6	<1.7	23	<2.3	<2.3
	<1.9	<0.89	1.6	8.8	2.7	24	4	<1.5	22	<2.2	<2.6
	17	13	2.1	27	1.6	71	<1.6	<2.7	0.97	34	29
	6.7	17	<1	11	<1.6	33	<1.4	2.7	<0.38	29	18
	9.7	16	1.7	18	1.3	31	2.5	<2.4	0.8	23	16
	14	20	2.4	36	1.8	37	2.7	<2.3	1.1	25	20
	9.6	14	1.6	23	1.2	16	<1.5	2.4	0.82	27	20
	4.7	<1.1	1.8	1.7	<2.1	6.5	7.8	<2.1	6.4	<1.7	5.5
	4.8	<0.93	3.1	1.8	2.9	25	8.7	<2.2	13	<1.8	<2.8
	8.1	<1	1.9	3.5	2.4	32	8.8	<1.5	12	<1.9	<3.1
	11	<0.88	3.8	<0.94	4.2	16	6.4	<2.4	12	<1.7	<2.6
	19	<0.94	3.1	<1.2	5.1	10	4.3	<3.3	14	<1.6	<2.8
	24	<0.71	1.8	43	3.4	19	3.6	<2.1	<0.33	8.3	30
	9.7	<0.73	1.6	32	3.6	19	5.7	1.6	<0.42	8.1	100
	27	<0.95	1.2	52	2.6	25	4.2	4	0.63	5.6	49
	48	<1.5	2.6	63	7.2	65	7.2	<4.9	0.93	10	46
	26	<1.3	<1.2	30	4.6	30	4.3	4	0.72	9.5	58

Continued from last page

Treatment plant	Mnth	Bisoprolol	Clarithromycin	Clindamycin	Clindamycin sulfoxide	Clomipramine	Codeine	Diltiazem	Diphenhydramine	Donepezil	
NRA	Oct	<0.76	44	12	9.1	4.9	13	16	7.1	3.8	
	Nov	1.3	23	6.5	1.7	2.9	7.6	10	4.1	2.4	
	Dec	<0.64	46	5.2	9.3	4.2	15	14	5.1	3.1	
	Jan	1.7	15	9.3	2.8	5.1	34	20	5	3	
	Feb	1.7	18	6.7	1.7	1.7	21	12	3.2	3.2	
Sandefjord Plant	Oct	<1.6	<4.8	16	2.4	17	3.8	<3.6	8.9	<6.2	
	Nov	1.2	<2.5	6.8	1.8	25	5.3	<4.8	7.3	<3.4	
	Dec	1	<2.2	4.6	1.3	16	5.9	<3.5	7	<4.2	
	Jan	<1.6	<4.4	12	3.3	11	4.7	<3.5	9.7	<3.8	
	Feb	0.86	2.5	13	2.5	3.3	7.1	<2.3	7.5	<3.5	
SNJ	Oct	<1.1	5.4	8.1	6.1	13	6.3	<5.4	21	<6.2	
	Nov	<1	3.3	5.4	3.8	7	1.7	<3.2	16	<6.2	
	Dec	<1.7	<5.8	8.5	9.7	12	4.1	<5.9	17	<5.5	
	Jan	<1	6.9	11	13	20	5.8	<7.1	20	<6.5	
	Feb	<0.9	4.8	6.3	15	29	7.4	<6.2	15	<11	
Solumstrand Plant	Oct	<0.56	9	9.4	4.2	2.6	4.8	<2.1	3.8	<1.9	
	Nov	<1.3	10	11	1.3	1.9	6.1	<1.7	3.4	2.1	
	Dec	<0.76	5.1	8.5	3.5	1.9	12	2.2	5.2	<2.8	
	Jan	<0.83	8.3	11	3	<1.4	17	2.8	4.7	<2.6	
	Feb	<1.1	14	10	13	3.3	29	<3.4	8.9	3.7	
Tønsberg Plant	Oct	<0.65	17	6.4	2.7	<2	3.7	<2.5	2.6	<2	
	Nov	<1.1	3.5	6.4	<0.89	<1.2	3.4	2	2.2	<2.1	
	Dec	<0.96	23	12	5.8	<3	10	3.8	9.6	<3	
	Jan	<0.94	9	11	2.4	<2.6	7.4	<3.2	3.2	<3.2	
	Feb	<0.76	7.8	13	3.8	<2	8.8	<2.5	2.3	<2	
VEAS	Oct	<0.57	6.6	24	6.6	6.8	7.2	<2.9	13	2.5	
	Nov	<0.69	5.5	25	8.2	5.6	9	<2.7	11	2.8	
	Dec	<0.64	1.9	26	2.3	3.6	2.7	<2.2	10	2.6	
	Jan	<0.66	2.6	28	3.8	5.9	6.5	<3.1	14	3.6	
	Feb	<0.62	7	27	8.1	6	3.7	<2.6	11	<2.7	
Øra	Oct	<0.88	13	<2.2	<2.2	7.2	<0.8	<4.2	3.8	<6.2	
	Nov	<0.8	5.8	<0.83	<0.83	3.2	1.9	<2.5	3.4	<3.7	
	Dec	<0.92	2.9	<0.82	<0.82	3.1	<1.3	<2.4	3	<4.7	
	Jan	<1	<2.5	<0.92	<0.92	3.2	1.7	<2.6	4.3	<4.1	
	Feb	<2.5	<4.3	4.3	<1.6	2.8	9.2	<3.3	4.1	<4	
<b>Average</b>		0.89	12.1	7.8	3.8	7.7	13.3	3.2	8.6	2.5	
<b>Median</b>		<1.25	8.3	6.4	1.75	7.2	8.85	<3.1	6.95	<4.2	
<b>90 percentile</b>		1.7	28	19.1	11.1	12.1	34.2	11.1	16.1	3.61	
<b>Minimum</b>		<0.56	<2.2	<0.72	<0.67	<1.2	<0.8	<1.7	<1.9	<1.9	
<b>Maximum</b>		8	74	28	16	29	56	20	40	8.3	
<b>n</b>		80	80	80	80	80	80	80	80	80	
<b>n &gt; LOD</b>		18	65	58	46	74	77	16	76	16	

	Feno- fibrate	Gliben- clamide	Meman- tine	Oxazepam	Oxcarba- zepine	Sotalol	Sulfadia- zine	Sulfamet- hoxazole	Tamoxifen	Trimet- hoprim	Verapamil
	17	<1.2	<0.64	24	2.8	240	9.5	9.2	3.7	45	46
	8.9	<0.51	<0.76	14	1.6	150	<1.3	6	1.7	28	28
	2.9	34	<0.53	16	2.1	73	<1.5	9.4	2	49	39
	7.6	<1.2	1.1	22	9.5	81	<2.3	12	4.6	44	68
	3.9	<0.65	<1.1	17	2.9	85	<2.2	14	1.2	37	13
	<1.3	<0.94	<1.4	18	2.7	15	4.2	<3.2	11	<1.8	18
	<1.6	1.7	<1	17	6.1	23	4.4	<1.2	18	<1.8	18
	<1.2	2	<0.89	18	2.1	18	3.2	<1.1	11	<1.6	19
	<1.2	1.3	<1.9	22	3.5	19	4.7	<3.4	13	<1.8	19
	<0.83	<0.59	<0.89	19	3	12	4.1	<1.3	7.1	<1.5	19
	0.98	<1.4	<1.3	<0.57	<2.6	140	<2.8	4.2	7.2	<2.2	11
	0.33	<0.83	<1.2	<0.15	3.5	180	<3	3.6	2.1	2.8	11
	0.95	<1.5	<2	<0.41	5	210	<3.1	<3.5	6.5	2.7	21
	0.64	<1.8	<1.4	<0.45	9.3	190	<3.6	4	5.6	3.2	23
	1.8	1.7	<1.3	<0.55	3.5	93	<2	<3.3	9.8	2.4	25
	1.9	12	<0.46	6	1.2	10	<1.1	2.7	5.9	12	43
	1.9	15	<1.1	7.6	1.8	25	<1.4	2.8	1	17	40
	4.4	<0.51	0.94	10	3.5	20	<1.4	2.8	0.96	17	61
	2.6	<0.56	0.98	9	2.8	9	<1.6	4.6	0.86	19	52
	4.2	<1	<1.1	14	3.8	96	<5.6	1.9	<1.7	28	100
	1.6	<0.78	<0.51	6.6	<1.3	16	<1.6	4.2	<1.5	27	24
	<0.43	<0.46	<0.9	9	1.7	5.4	<1.3	5.6	<0.86	26	11
	14	<1.1	<0.83	11	3.2	25	<2.1	8.1	1.8	41	53
	1.8	<0.99	<0.79	8.3	6.1	12	<1.9	5.1	1.9	37	31
	5	<0.76	<0.67	18	6.1	13	<1.3	4.1	<2	38	32
	6.5	<1.2	<0.76	16	<1.9	12	<2.3	<1.7	9	<1.2	27
	3.1	<1.1	<0.89	16	<1.7	8.5	<2.1	<2.2	7.9	<1.2	20
	4.8	<0.9	1.4	17	1.7	10	<2.3	<1.6	10	<1.1	12
	10	<1.2	1.6	22	<2	16	<2.8	2.4	11	<2.1	19
	7.5	<1	<0.81	19	<1.6	9.1	13	<1.7	6.9	<1.1	20
	1.3	<1.1	<0.92	35	<2.1	7.6	<2.7	<1.5	<3.7	<2.1	9.5
	<0.91	<0.64	9.7	26	2.1	<1.1	2.4	<1.4	<3.3	<1.8	<1.9
	<0.84	<0.63	100	38	2.2	<1.8	<3.3	<1.3	<3.1	<1.9	<1.9
	1.8	<0.66	480	31	2.1	<2.5	<4.5	<1.5	<3.1	<2.2	<2
	0.55	<0.84	1,700	20	2.6	<3.5	<6.4	<3.5	<1.7	<3.2	5.7
	5.4	2.2	30	14.4	3.1	40	3.4	2.2	6.1	8.9	18.0
	1.9	<0.9	1.1	12	2.8	19	2.75	<2.4	5.85	<2.4	11
	14	3	3.91	30.1	5.81	99.3	7.26	4.65	13	29.5	46.3
	<0.43	<0.46	<0.46	<0.15	<1.2	<1.1	<1.1	<1.1	<0.33	<1.1	<1.7
	48	34	1,700	63	9.5	240	13	14	23	49	100
	80	80	80	80	80	80	80	80	80	80	80
	64	12	44	70	69	75	48	24	68	30	61

Pharmaceutical residues detected in all samples ( $\mu\text{g}/\text{kg}$  TS) (A-L):

Treatment plant	Mnth.	Atorvastatin	Azithromycin	Caffeine	Carbamazepine	Cetirizine	Citalopram	Diclofenac	Fexofenadine	Irbesartan	Loperamide
Bekkelaget	Oct	34	42	11	4,500	68	140	66	1,200	28	14
	Nov	43	24	6.2	4,900	64	140	73	1,200	25	17
	Dec	39	22	8.2	5,000	66	140	64	1,300	28	14
	Jan	52	25	11	4,800	85	170	96	2,600	33	19
	Feb	22	28	11	5,300	71	150	48	1,500	29	7.1
Bergen Biogas Plant	Oct	61	20	14	940	48	130	63	470	17	17
	Nov	55	28	9	1,000	36	99	46	650	27	16
	Dec	58	49	20	1,200	38	95	52	690	47	15
	Jan	59	80	19	1,900	43	110	60	510	43	16
	Feb	56	48	12	1,600	44	110	68	360	45	15
Fuglevik Plant	Oct	140	43	54	2,600	120	210	200	1,400	170	12
	Nov	110	27	26	2,800	67	140	110	900	140	10
	Dec	160	42	55	3,300	110	180	190	2,100	200	14
	Jan	110	51	19	3,900	100	190	150	1,700	180	11
	Feb	140	34	16	4,800	120	190	180	2,500	230	13
Hias	Oct	170	7.4	48	7,700	150	370	67	1,100	22	30
	Nov	120	8.2	43	5,400	87	240	50	400	23	16
	Dec	170	7.5	31	6,200	120	310	70	780	24	26
	Jan	160	7.5	34	5,200	130	340	67	900	23	29
	Feb	140	5.7	28	5,200	110	370	63	550	21	26
Høvringen Plant	Oct	35	18	20	5,800	73	200	44	1,700	170	20
	Nov	43	27	12	8,500	68	170	38	1,900	210	24
	Dec	54	11	11	9,100	86	230	42	3,000	250	24
	Jan	51	9.1	9.5	8,600	83	220	45	2,300	230	24
	Feb	50	7.5	65	8,200	78	210	39	2,300	230	21
Gardermoen Plant	Oct	18	78	4.7	7,300	180	340	210	3,800	19	30
	Nov	11	78	5.9	5,200	85	240	95	1,400	12	18
	Dec	19	87	8.5	5,900	93	260	130	1,800	14	25
	Jan	20	51	6.3	5,700	100	280	120	1,900	15	31
	Feb	19	110	7	5,600	85	270	99	2,200	15	32
Knappen Plant	Oct	1,800	71	570	1,300	46	82	63	260	180	13
	Nov	850	51	400	4,400	28	51	32	140	70	7.1
	Dec	1,400	59	570	1,600	33	52	59	150	81	9.4
	Jan	1,300	68	560	1,800	40	66	69	200	74	10
	Feb	1,400	62	460	1,200	33	54	60	320	81	8.4
Lindum Biogas	Oct	30	2.5	35	1,900	180	200	97	1,700	49	12
	Nov	59	2.9	22	2,400	110	180	130	1,100	51	12
	Dec	60	3.5	37	3,000	110	210	150	2,200	56	14
	Jan	61	6.1	19	3,400	110	210	140	1,300	41	15
	Feb	83	9.4	15	3,400	150	220	190	1,700	78	16
Lindum raw sludge	Oct	2,600	17	410	1,900	62	76	89	390	130	5.8
	Nov	740	15	49	510	59	120	33	98	220	6.5
	Dec	1,400	11	990	1,200	40	59	64	160	99	6.1
	Jan	2,800	31	330	2,900	59	62	75	130	110	8
	Feb	1,300	26	180	1,600	39	61	64	130	94	6.5

Treatment plant	Mnth.	Ator- vastatin	Azithro- mycin	Caffeine	Carbama- zepine	Cetiri- zine	Citalo- pram	Diclo- fenac	Fexo- fenadine	Irbesar- tan	Lopera- mide
NRA	Oct	20	65	540	13,000	64	160	56	580	120	9.4
	Nov	15	37	370	3,500	34	83	25	250	79	6.5
	Dec	25	49	530	1,400	53	140	55	480	110	9.5
	Jan	45	49	620	1,800	67	120	81	180	170	12
	Feb	15	41	440	920	20	93	26	160	110	4
Sandefjord Plant	Oct	110	20	15	6,400	130	240	120	4,800	190	22
	Nov	150	11	13	5,800	130	200	160	1,700	200	27
	Dec	160	9	12	6,700	110	160	180	3,100	210	16
	Jan	170	20	15	8,100	140	200	170	6,800	280	18
	Feb	56	25	16	6,800	87	160	67	4,000	250	4.3
SNJ	Oct	34	18	100	630	80	240	39	750	19	20
	Nov	16	12	110	430	45	170	20	240	10	11
	Dec	42	15	850	1,300	75	210	43	820	20	20
	Jan	45	32	140	1,100	78	260	37	850	36	16
	Feb	76	28	85	2,500	68	240	52	860	39	24
Solumstrand Plant	Oct	23	27	110	240	19	74	24	150	51	4.7
	Nov	29	27	190	350	24	73	26	120	58	3.9
	Dec	37	25	190	370	32	90	30	120	84	4.5
	Jan	22	43	390	550	29	89	20	130	84	2.6
	Feb	58	16	510	790	75	190	45	680	140	6.1
Tønsberg Plant	Oct	25	17	110	860	22	51	23	340	32	1.9
	Nov	21	15	180	840	10	49	18	150	25	1.4
	Dec	100	16	550	1,400	52	89	73	500	100	6
	Jan	57	30	270	20,000	28	47	48	170	61	3
	Feb	31	16	570	1,300	25	47	43	180	55	4.9
VEAS	Oct	140	69	40	4,100	76	110	60	3,000	30	19
	Nov	130	68	39	4,200	57	110	48	3,700	29	14
	Dec	91	63	35	3,300	38	68	42	1,100	17	8.8
	Jan	180	74	55	4,900	66	110	69	1,200	26	15
	Feb	160	77	39	5,100	69	120	68	4,000	25	15
Øra	Oct	37	12	920	1,200	170	170	160	1,900	44	5.9
	Nov	15	7.9	66	1,200	130	140	56	620	19	2.5
	Dec	18	8.4	60	1,400	150	130	87	930	23	1.7
	Jan	28	9	150	1,300	80	140	130	480	8.5	2.2
	Feb	45	8.5	2,900	1,200	99	160	200	960	21	2
<b>Average</b>		254.1	32.1	206.3	3,695	77	158.5	79.5	1,263.6	83.9	13.5
<b>Median</b>		56.5	25.5	45.5	2,950	70	145	64	880	51	13.5
<b>90% percentile</b>		895	69.2	561	7,340	130	260	161	3,000	210	25.1
<b>Minimum</b>		11	2.5	4.7	240	10	47	18	98	8.5	1.4
<b>Maximum</b>		2,800	110	2,900	20,000	180	370	210	6,800	280	32
<b>n</b>		80	80	80	80	80	80	80	80	80	80
<b>n &gt; LOD</b>		80	80	80	80	80	80	80	80	80	80

Pharmaceutical residues detected in all of the samples ( $\mu\text{g}/\text{kg TS}$ ) (M-Z):

Treatment plant	Mnth	Meclozine	Metoprolol	Metoprolol acid	Mianserin	Mirtazapine	N-Desmet-hylcitalopram	O-Desmet-hylenlafaxine	
Bekkelaget	Oct	37	170	7.7	34	50	89	58	
	Nov	37	180	12	36	59	88	84	
	Dec	27	180	12	35	62	97	67	
	Jan	38	180	27	38	79	110	83	
	Feb	21	160	9.1	30	42	97	46	
Bergen Biogas Plant	Oct	39	31	3.2	27	34	73	13	
	Nov	39	30	6.5	20	41	61	18	
	Dec	31	36	7.9	19	40	60	12	
	Jan	29	42	3.2	25	42	73	13	
	Feb	34	37	3.8	24	37	74	10	
Fuglevik Plant	Oct	34	110	38	53	39	130	36	
	Nov	17	88	22	31	51	77	22	
	Dec	23	85	25	43	55	110	44	
	Jan	20	100	43	43	54	130	20	
	Feb	26	140	40	42	70	130	38	
Hias	Oct	39	210	16	110	110	200	21	
	Nov	28	160	10	81	93	140	15	
	Dec	28	220	37	110	120	170	16	
	Jan	29	180	15	120	120	180	16	
	Feb	25	150	14	130	130	210	10	
Høvringen Plant	Oct	30	100	6.6	23	52	120	30	
	Nov	35	170	5.7	19	49	100	46	
	Dec	35	170	15	24	67	150	40	
	Jan	36	140	8.4	23	58	150	27	
	Feb	30	150	8.5	22	53	140	26	
Gardermoen Plant	Oct	45	250	13	56	54	200	81	
	Nov	21	200	3.7	40	67	140	90	
	Dec	34	220	11	49	51	150	53	
	Jan	40	200	3.5	59	90	160	100	
	Feb	31	180	3.4	59	80	150	140	
Knappen Plant	Oct	22	57	42	16	17	61	8.8	
	Nov	9.8	54	11	8.9	12	38	9.8	
	Dec	19	75	27	10	17	52	7.9	
	Jan	15	35	32	12	22	52	8	
	Feb	16	48	31	8.6	12	40	6.4	
Lindum Biogas	Oct	22	92	5.6	34	43	97	19	
	Nov	35	91	7	28	62	89	13	
	Dec	48	110	5.5	31	54	100	28	
	Jan	40	100	7.3	29	73	110	15	
	Feb	35	100	6.7	30	42	110	14	
Lindum raw sludge	Oct	17	100	120	22	25	53	23	
	Nov	5.2	28	23	23	21	90	7.7	
	Dec	12	1,000	580	11	11	47	8.8	
	Jan	18	61	67	9.7	19	58	8.3	
	Feb	13	44	35	13	18	56	14	

	Propranolol	Sertraline	Sulfapyridine	Telmisartan	Terbinafine	Tramadol	Valsartan	Venlafaxine
	19	330	37	350	120	11	190	53
	11	370	43	290	150	11	240	65
	16	330	33	320	130	11	250	45
	32	420	62	460	160	13	310	60
	16	310	28	370	58	10	250	51
	13	340	8.8	12,000	130	4.3	620	23
	15	290	17	12,000	120	3.8	660	31
	14	310	19	13,000	120	4.3	900	33
	9.7	330	45	15,000	120	4.9	960	35
	6.5	340	20	15,000	130	4.3	950	25
	18	420	51	870	130	19	1,200	72
	13	280	31	770	130	13	1,100	56
	9.8	500	47	1,400	190	19	1,500	51
	24	400	36	1,400	140	16	1,200	58
	17	510	41	1,300	190	18	1,700	80
	54	380	47	140	180	20	320	73
	32	270	37	84	120	16	220	50
	65	360	51	130	190	17	340	54
	50	440	56	170	190	20	320	54
	48	380	38	170	180	21	300	36
	21	350	19	200	210	15	440	170
	10	340	13	300	300	16	890	280
	21	390	19	370	240	19	1,100	250
	21	390	24	320	210	17	1,300	190
	19	340	23	350	210	15	1,100	180
	47	700	41	970	190	28	190	28
	25	410	24	530	110	19	99	22
	39	510	32	460	150	25	160	26
	22	660	35	520	150	24	160	13
	21	640	35	520	130	22	150	15
	16	190	14	11,000	74	6	420	33
	5.3	140	9.9	9,400	34	3.4	400	29
	11	150	20	8,600	49	5.1	360	46
	12	230	21	9,600	54	3.9	370	12
	9.2	140	14	10,000	40	3.6	400	16
	10	310	21	1,200	82	8	1,200	47
	11	320	25	610	140	7.5	1,100	32
	8	390	19	730	160	11	1,300	52
	16	380	28	700	170	9.7	1,200	38
	13	430	17	890	170	8.9	1,400	44
	11	190	46	1,200	48	9	550	27
	14	100	72	800	35	5.4	200	14
	79	140	49	1,100	52	6.2	400	12
	5.4	150	39	1,700	55	8.4	470	9.7
	7.1	110	61	1,000	45	4.9	330	14

Continues next page

Continued from last page

Treatment plant	Mnth	Meclozine	Metoprolol	Metoprolol acid	Mianserin	Mirtazapine	N-Desmet-hylcitalopram	O-Desmet-hylenlafaxine	
NRA	Oct	23	250	31	24	45	100	44	
	Nov	10	140	43	13	18	51	5.3	
	Dec	14	210	32	17	40	73	34	
	Jan	12	190	33	19	34	77	12	
	Feb	4.8	86	63	14	24	74	7.5	
Sandefjord Plant	Oct	67	120	14	30	54	110	66	
	Nov	88	130	8.4	30	36	110	35	
	Dec	77	140	7.2	31	36	93	48	
	Jan	60	120	13	43	90	120	50	
	Feb	21	130	6.9	29	31	100	28	
SNJ	Oct	65	29	1.5	68	39	96	41	
	Nov	35	24	1	44	31	57	10	
	Dec	65	72	2.5	54	51	83	41	
	Jan	42	47	1.7	70	41	120	39	
	Feb	58	63	1.6	69	41	110	31	
Solumstrand Plant	Oct	9.7	25	15	13	22	37	15	
	Nov	9.6	25	39	12	20	45	3.6	
	Dec	11	35	24	17	41	67	8.5	
	Jan	4.6	43	26	15	30	55	12	
	Feb	9.9	74	36	31	55	110	100	
Tønsberg Plant	Oct	8	51	22	14	17	28	24	
	Nov	4.1	53	29	10	13	33	5	
	Dec	12	58	27	30	29	51	30	
	Jan	5.8	70	16	11	25	33	8.9	
	Feb	6.3	72	27	11	22	34	11	
VEAS	Oct	37	70	3.3	26	17	42	10	
	Nov	23	74	4.6	22	17	35	12	
	Dec	16	79	4.1	21	16	31	5	
	Jan	22	94	4.8	26	20	43	4.8	
	Feb	22	81	4	26	19	40	12	
Øra	Oct	16	58	4	20	36	75	100	
	Nov	7	55	3.8	16	30	68	26	
	Dec	4.8	51	4.4	18	17	66	27	
	Jan	6.3	55	4.6	23	11	79	18	
	Feb	5.1	53	11	25	10	71	8.8	
<b>Average</b>		26.8	114.9	25.0	33.2	43.4	90.4	30	
<b>Median</b>		23	89.5	11.5	26	40	85.5	19.5	
<b>90 percentile</b>		45.3	200	39.1	59.9	79.1	150	68.4	
<b>Minimum</b>		4.1	24	1	8.6	10	28	3.6	
<b>Maximum</b>		88	1,000	580	130	130	210	140	
<b>n</b>		80	80	80	80	80	80	80	
<b>n &gt; LOD</b>		80	80	80	80	80	80	80	

	Propranolol	Sertraline	Sulfapyridine	Telmisartan	Terbinafine	Tramadol	Valsartan	Venlafaxine
	8.2	170	40	190	56	11	340	57
	16	110	38	120	43	7.4	380	31
	7.9	290	49	200	64	9.4	530	55
	9.2	200	110	210	76	9.6	860	23
	20	100	68	82	32	8.2	210	21
	11	470	39	1,200	160	8.9	950	110
	3.6	420	43	1,600	220	13	1,300	90
	4.2	420	34	990	200	12	1,500	110
	15	390	52	1,400	190	14	1,600	100
	7.3	220	49	1,500	50	12	750	91
	8.8	260	35	360	110	9	190	54
	12	110	21	330	26	5.5	82	32
	12	270	36	500	85	13	270	84
	7.5	380	53	670	99	7.4	240	69
	9.1	420	41	670	150	12	260	82
	2	80	19	70	42	3.5	130	15
	8.3	89	37	81	25	4.1	150	13
	7.4	140	62	100	29	5	190	14
	8.6	110	27	120	16	6.3	140	19
	9.1	190	230	160	36	13	190	53
	2	58	13	130	22	5.7	170	11
	4.5	28	16	63	23	4.7	89	8.2
	3.1	110	39	190	62	8.7	420	19
	5	88	35	140	40	9.2	360	11
	3.9	78	35	110	39	8	260	11
	4.1	300	39	390	260	8.4	380	77
	6.3	280	31	370	190	8.1	360	81
	8.7	170	28	230	120	9.3	260	76
	9.6	270	54	360	160	11	420	99
	5.8	280	32	420	170	9.9	400	85
	3.4	230	18	540	66	9.5	1,100	26
	5.5	160	17	520	22	8	580	9.4
	6.5	140	29	440	19	7.8	660	15
	7.6	110	28	190	21	8	540	22
	12	100	34	170	20	10	720	26
	15.4	283.1	37.5	1,913.9	111.6	10.9	577.5	53.8
	11	290	35	460	120	9.45	400	41
	32	431	54.2	9,420	191	19	1,210	99.1
	2	28	8.8	63	16	3.4	82	8.2
	79	700	230	15,000	300	28	1,700	280
	80	80	80	80	80	80	80	80
	80	80	80	80	80	80	80	80

## 1.14. Raw data: organotin compounds ( $\mu\text{g}/\text{kg TS}$ )

Treatment plant	Mnth	Tributyltin	Dibutyltin	Diocetyltn	Sum organotins
Bekkelaget	Oct	7.6	110	<20	117.6
	Nov	6.9	66	<20	72.9
	Dec	6.3	53	<20	59.3
	Jan	5.4	43	<20	48.4
	Feb	4.9	49	<20	53.9
Bergen Biogas Plant	Oct	19	59	<20	78
	Nov	23	58	<20	81
	Dec	51	55	<20	106
	Jan	43	65	<20	108
	Feb	53	64	<20	117
SNJ	Oct	35	110	<20	145
	Nov	16	88	<20	104
	Dec	27	82	<20	109
	Jan	26	75	<20	101
	Feb	18	61	<20	79
Tønsberg Plant	Oct	3.6	18	<20	21.6
	Nov	2.5	19	<20	21.5
	Dec	3.4	25	<20	28.4
	Jan	5.4	26	<20	31.4
	Feb	3.5	22	<20	25.5
<b>Average</b>		18.0	57.4	<20	75.4
<b>Median</b>		11.8	58.5	<20	78.5
<b>90% percentile</b>		43.8	90.2	<20	117.1
<b>Minimum</b>		2.5	18	<20	21.5
<b>Maximum</b>		53	110	<20	145
<b>n</b>		20	20	20	20
<b>n &gt; LOD</b>		20	20	0	20

## 1.15. Raw data: BTEX and trichloroethylene (pesticide) (µg/kg TS)

Treatment plant	Mnth	Trichloroethylene	Benzene	Toluene	Xylene	1,4-Xylene	1,2-Xylene	Ethylbenzene	Sum BTEX
Bekkelaget	Oct	<20	<20	110	<20	<20	<20	<20	110
	Nov	<20	<20	200	<20	<20	<20	37	237
	Dec	<20	<20	130	<20	<20	<20	<20	130
	Jan	<20	<20	100	<20	<20	<20	<20	100
	Feb	<20	<20	88	<20	<20	<20	<20	88
Bergen Biogas Plant	Oct	<20	<20	135	<20	<20	<20	<20	135
	Nov	<20	<20	220	<20	<20	<20	<20	220
	Dec	<20	<20	160	<20	<20	<20	<20	160
	Jan	<20	<20	180	<20	<20	<20	<20	180
	Feb	<20	<20	190	<20	<20	<20	<20	190
Fuglevik Plant	Oct	<20	<20	56	<20	<20	<20	<20	56
	Nov	<20	<20	77	<20	<20	<20	<20	77
	Dec	<20	<20	70	<20	<20	<20	<20	70
	Jan	<20	<20	58	<20	<20	<20	<20	58
	Feb	<20	<20	50	<20	<20	<20	<20	50
Hias	Oct	<20	<20	74	<20	<20	<20	<20	74
	Nov	<20	<20	66	<20	<20	<20	<20	66
	Dec	<20	<20	40	<20	<20	<20	<20	40
	Jan	<20	<20	76	<20	<20	<20	<20	76
	Feb	<20	<20	41	<20	<20	<20	<20	41
Gardermoen Plant	Oct	<20	<20	73	<20	<20	<20	<20	73
	Nov	<20	<20	220	<20	<20	<20	<20	220
	Dec	<20	<20	150	<20	<20	<20	<20	150
	Jan	<20	<20	130	<20	<20	<20	<20	130
	Feb	<20	<20	98	<20	<20	<20	<20	98
Knappen Plant	Oct	<20	<20	730	<20	<20	<20	<20	730
	Nov	<20	<20	410	<20	<20	<20	<20	410
	Dec	<20	<20	2,200	72	35	37	35	2,307
	Jan	<20	<20	480	57	30	27	<20	537
	Feb	<20	<20	710	<20	<20	<20	<20	710
Lindum Biogas	Oct	<20	<20	87	48	48	<20	<20	135
	Nov	<20	<20	110	93	93	<20	<20	203
	Dec	<20	<20	73	150	130	23	<20	226
	Jan	<20	<20	100	89	89	<20	<20	189
	Feb	<20	<20	150	69	69	<20	<20	219

Continues next page

Continued from last page

Treatment plant	Mnth	Trichlor-ethylene	Benzene	Toluene	Xylene	1,4-Xylene	1,2-Xylene	Ethyl-benzene	Sum BTEX
Lindum raw sludge	Oct	<20	<20	830	120	94	30	36	990
	Nov	<20	<20	850	160	120	40	48	1,058
	Dec	<20	<20	480	76	76	<20	33	589
	Jan	<20	<20	530	230	160	69	84	843
	Feb	<20	<20	1,200	100	100	<20	55	1,355
NRA	Oct	<20	<20	590	270	240	26	69	925
	Nov	<20	<20	130	140	140	<20	<20	270
	Dec	<20	<20	480	300	260	42	62	844
	Jan	<20	<20	690	410	380	33	91	1,194
	Feb	<20	<20	540	170	170	<20	35	745
SNJ	Oct	<20	<20	<20	<20	<20	<20	<20	<LOD
	Nov	<20	<20	29	215	215	<20	<20	244
	Dec	<20	<20	<20	<20	<20	<20	<20	<LOD
	Jan	<20	<20	<20	<20	<20	<20	<20	<LOD
	Feb	<20	<20	<20	<20	<20	<20	<20	<LOD
Solumstrand Plant	Oct	<20	<20	280	<20	<20	<20	<20	280
	Nov	<20	<20	87	<20	<20	<20	<20	87
	Dec	<20	<20	170	<20	<20	<20	<20	170
	Jan	<20	<20	200	<20	<20	<20	<20	200
	Feb	<20	<20	92	<20	<20	<20	<20	92
Tønsberg Plant	Oct	<20	<20	93	<20	<20	<20	<20	93
	Nov	<20	<20	220	<20	<20	<20	<20	220
	Dec	<20	<20	270	<20	<20	<20	<20	270
	Jan	<20	<20	190	<20	<20	<20	<20	190
	Feb	<20	<20	130	<20	<20	<20	<20	130
VEAS	Oct	<20	<20	73	<20	<20	<20	<20	73
	Nov	<20	<20	620	<20	<20	<20	<20	620
	Dec	<20	<20	<20	<20	<20	<20	<20	<LOD
	Jan	<20	<20	40	<20	<20	<20	<20	40
	Feb	<20	<20	59	<20	<20	<20	<20	59
Øra	Oct	<20	<20	81	50	50	<20	<20	131
	Nov	<20	<20	120	65	65	<20	<20	185
	Dec	<20	<20	110	53	53	<20	<20	163
	Jan	<20	<20	170	180	130	47	33	380
	Feb	<20	<20	240	200	160	40	45	485
<b>Average</b>		<20	<20	250	54.1	48.2	<20	<20	309
<b>Median</b>		<20	<20	130	<20	<20	<20	<20	167
<b>90% percentile</b>		<20	<20	627	171	142	30.3	37.8	842
<b>Minimum</b>		<20	<20	<20	<20	<20	<20	<20	<LOD
<b>Maximum</b>		<20	<20	2,200	410	380	69	91	2,307
<b>n</b>		70	70	70	70	70	70	70	70
<b>n &gt; LOD</b>		0	0	65	23	23	11	13	65

## 1.16. Raw data: Chloro-organic compounds, residues from pesticides ( $\mu\text{g}/\text{kg}$ TS)

Treatment plant	Mnth.	alfa-HCH	HCB	beta-HCH	gamma-HCH	delta-HCH	o,p-DDE	p,p-DDE	o,p-DDD	p,p-DDD	o,p-DDT	p,p-DDT	chloropyrifos
Bekkelaget	Oct	<1.0	1.4	<1.0	<1.0	<1.0	<3.0	3.6	<3.0	<3.0	<3.0	<3.0	2.1
	Nov	<1.0	1.2	<1.0	<1.0	<1.0	<3	3.6	<3.0	<3.0	<3	<3.0	1.1
	Dec	<1.0	1.3	<1.0	<1.0	<1.0	<3	3.2	<3	<3.0	<3	<3.0	<1.0
	Jan	<1.0	1.1	<1.0	<1.0	<1.0	<3	3.2	<3	<3.0	<3	<3.0	<1.0
	Feb	<1.0	<1.0	<1.0	<1.0	<1.0	<3	3.1	<3	<3.0	<3	<3.0	<1.0
Bergen Biogas Plant	Oct	<1.0	1.5	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	1.1	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	1.3	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	1.2	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	1.2	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
Fuglevik Plant	Oct	<1.0	1.1	<1.0	<1.0	<1.0	<3.0	<3.0	19.0	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	1	<1.0	<1.0	<1.0	<3.0	<3.0	27	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	22	<3.0	<3.0	<3.0	1
	Jan	<1.0	1	<1.0	<1.0	<1.0	<3.0	<3.0	22	<3.0	<3.0	<3.0	3.4
	Feb	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	18	<3.0	<3.0	<3.0	<1.0
Hias	Oct	<1.0	2.6	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	2.1	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	1.8	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	2.2	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	2.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
Høvringen Plant	Oct	<1.0	1.2	<1.0	<1.0	<1.0	<3.0	<3.0	13.0	<3.0	<3.0	<3.0	1.3
	Nov	<1.0	1.1	<1.0	<1.0	<1.0	<3.0	<3.0	87	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	1.4	<1.0	<1.0	<1.0	<3.0	<3.0	42	<3.0	<3.0	<3.0	2.3
	Jan	<1.0	1.4	<1.0	<1.0	<1.0	<3.0	<3.0	20	<3.0	<3.0	<3.0	6.2
	Feb	<1.0	2	<1.0	<1.0	<1.0	<3.0	<3.0	48	<3.0	<3.0	<3.0	4
Gardermoen Plant	Oct	<1.0	1	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	1.1	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
Knappen Plant	Oct	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	1.2	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	1.5
	Dec	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	1.0
	Jan	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	1
	Feb	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	1

Continues next page

Continued from last page

Treatment plant	Mnth.	alfa-HCH	HCB	beta-HCH	gamma-HCH	delta-HCH	o,p-DDE	p,p-DDE	o,p-DDD	p,p-DDD	o,p-DDT	p,p-DDT	chloropyrifos
Ladehammeren Plant	Oct	<1.0	1.2	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	1.5	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	1.6	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	1.8	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	1.1
Lindum Biogas	Oct	<1.0	1.6	<1.0	<1.0	<1.0	<3.0	3.4	<3.0	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	1.1	<1.0	<1.0	<1.0	<3.0	3.3	<3	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	2.2	<1.0	<1.0	<1.0	<3.0	3.1	<3.0	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	3.2	<1.0	<1.0	<1.0	<3.0	5.3	<3	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	1.7	<1.0	<1.0	<1.0	<3.0	4	<3	<3.0	<3.0	<3.0	<1.0
Lindum raw sludge	Oct	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	1.4	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
NRA	Oct	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	2
	Nov	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	1.2
	Dec	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	1.5
	Jan	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	1.3
	Feb	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	1.5
Rambekk Plant	Oct	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	4	<3.0	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	4	<3.0	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	3.2	<3.0	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	3.4	<3.0	<3.0	<3.0	3	<1.0
Sandefjord Plant	Oct	<1.0	1	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	1.1
	Nov	<1.0	1	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	1.1	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	1	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	1.3	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
SNJ	Oct	<1.0	4.3	<1.0	<1.0	<1.0	<3.0	5.1	28	<3.0	<3.0	<3.0	5.8
	Nov	<1.0	4	<1.0	<1.0	<1.0	<3.0	5	25	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	1	<1.0	<1.0	<1.0	<3.0	4	28	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	2.2	<1.0	<1.0	<1.0	<3.0	3	26	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	2.1	<1.0	<1.0	<1.0	<3.0	3	10	<3.0	<3.0	<3.0	2.3
Solumstrand Plant	Oct	<1.0	1.7	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	1.1	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	2.6	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	1.7
	Jan	<1.0	2.7	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	1.6
	Feb	<1.0	2.4	<1.0	<1.0	<1.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	1.3

Treatment plant	Mnth.	alfa-HCH	HCB	beta-HCH	gamma-HCH	delta-HCH	o,p-DDE	p,p-DDE	o,p-DDD	p,p-DDD	o,p-DDT	p,p-DDT	chloropyrifos
Tønsberg Plant	Oct												
	Nov	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
VEAS	Oct	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	1.4	<1.0	<1.0	<1.0	<3.0	3.7	9.4	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	1.7	<1.0	<1.0	<1.0	<3.0	7	8	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	7	7	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	1.4	<1.0	<1.0	<1.0	<3.0	4	10	<3.0	<3.0	<3.0	<1.0
Øra	Oct	<1.0	1.1	<1.0	<1.0	<1.0	<3.0	3.6	11	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	1.7	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	2	<1.0	<1.0	<1.0	<3.0	3	<3	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	2	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
Årim	Oct	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	3	<3	<3.0	<3.0	<3.0	<1.0
	Nov	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Dec	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Jan	<1.0	1	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
	Feb	<1.0	<1.0	<1.0	<1.0	<1.0	<3.0	<3.0	<3	<3.0	<3.0	<3.0	<1.0
<b>Average</b>		<1	1.19	<1	<1	<1	<1	<3	6.24	<3	<3	<3	<1
<b>Median</b>		<1	1.1	<1	<1	<1	<3	<3	<3	<3	<3	<3	<1
<b>90% percentile</b>		<1	2.16	<1	<1	<1	<3	3.76	21.2	<3	<3	<3	1.56
<b>Minimum</b>		<1	<1	<1	<1	<1	<3	<3	<3	<3	<3	<3	<1
<b>Maximum</b>		<1	4.3	<1	<1	<1	<3	7.2	87	<3	<3	3	6.2
<b>n</b>		95	95	95	95	95	95	95	95	95	95	95	95
<b>n &gt; LOD</b>		0	58	0	0	0	0	27	20	0	0	1	24

## Annex 2: Methods of analysis

Siloxane analysis of solid samples was carried out by extraction of wet sample (1-3 grams) after spiking with internal standard (fluorobenzene) with 6 mL methanol in ultrasonic bath at 40°C for one hour. An aliquot of 1 mL of extract was transferred into 10 mL headspace vial with 6 mL of water and this was then followed by Solid Phase Micro Extraction (SPME) with fibre Stableflex 85 µm Car/PDMS (Supelco) for 25 min at 35°C using Gerstel MPS2 autosampler and GC-MS detection on Agilent 6890N with 5973 MSD. Target compounds were separated using GC column (HP-VOC 30 m x 0.20 mm ID and 1.12 µm film thickness) and detected in full scan mode. LOD and LOQ of individual analytes were calculated as 3 x S/N ratio and 9 x S/N, respectively and uncertainty of 30% was determined from repetitive analyses of spiked material. The method is accredited.

Phthalate analysis including 4-MeO-cinnamate (ethylhexylmethoxycinnamate) was carried out by extraction of wet sample (1-3 grams) dried by anhydrous sodium sulfate with 5 mL of mixture hexane: acetone, 1:2 (v:v) after spiking with internal standard (D4-DEHP) in 40 mL screw vials. Mixture was extracted in ultrasonic bath at 40°C for one hour. An aliquot of extract (2 mL approximately) was mixed with 3 mL of water and 1 µl of hexane layer was used for GC/MS analysis performed on Rtx-5 30 m x 0.25 mm ID, 0.25 µm film thickness in selected ion mode. Uncertainty was 30%, determined using the reference material. The method is accredited.

Nonpolar semivolatiles (PAH's, PCB's, PBDE's) were extracted from approximately 1 g of freeze dried samples by two step sonication in hexane:acetone (1:1, v:v) mixture. Isotope labelled (<sup>13</sup>C PCB 153, <sup>13</sup>C PBDEs) and native (PCB 15) internal standards were added to the sample prior to the extraction step. The extracts were cleaned up using gel permeation chromatography (GPC) and this was then followed by a Florisil column cleanup procedure. The sample volume was then finally reduced to approximately 500 µl. 20 µL of extract was injected (Large Volume Injector, LVI) into GC Column Select PAH 30 m x 0.25 mm ID and 0.15 µm film. Target compounds were detected using Agilent GC-MS/MS 7890 with 7000C triple quadrupole mass spectrometer operated in SRM mode. PBDE's 206-209 were analysed by gas chromatography with negative chemical ionisation detection (GC-NCI-MS) on Agilent 7890 with 5975 MSD (methane as reagent gas) using GC Column Restek Rtx-1 15 m x 0.25 mm ID with 0.1 µm film thickness and (<sup>13</sup>C labelled internal standard). LOQs were calculated from lowest calibration point of a curve, where RSD of response factor was lower than 30%. Chlorinated paraffins were determined according to the standard method ČSN EN ISO 18635 by GC-NCI-MS. Musk compounds were analysed by GC-MS/MS after extraction with hexane:acetone (1:1, v:v) mixture in ultrasonic bath, GPC and Florisil cleanup. Methods are accredited.

Alkylphenols were analysed by GC-MS after extraction with hexane:acetone (1:1, v:v) mixture in ultrasonic bath, GPC and Florisil cleanup. Extract was evaporated to dryness and derivatised by N-Methyl-N-(trimethylsilyl)-trifluoroacetamide (MSTA) and diluted with acetone. D4-n-nonylphenol was used as an internal standard. The method was adapted from ISO/TS 13907:2012. LOD and LOQ of individual analytes were calculated as 3 x S/N ratio and 9 x S/N, respectively and uncertainty of 30% was determined from repetitive analyses of spiked material. The method is not accredited.

Polar analytes were extracted using two step extraction of freeze dried homogenated samples (0.5 g) with mixture water:acetonitrile:isopropanol (2 x 4 ml) after addition of internal standards (IS). A mixture of <sup>13</sup>C labelled per-fluorinated acids and sulphonates (10), <sup>13</sup>C and 2D labelled pharmaceuticals (10), pesticides (4) and triclosane was used for quantification of polar compounds in these analyses. Aliquot of the sample was filtered through regenerated cellulose syringe filter (0.2 µm pore size) to autosampler vial. 10 µl of the extract was injected into the analytical systems.

Pharmaceuticals and parts of PFRs compounds were detected using electrospray QqQ tandem mass spectrometry (Quantiva, ThermoScientific) while high resolution product scan (QExactive hydride quadrupole/orbital trap mass spectrometer, ThermoScientific) was applied for detection of perfluorinated compounds together with linear alkyl benzene sulphonates (PFCs and LAS) and APCI/APPI analytes (bisphenols and part of PFRs). A separation of target analyses were performed on the following analytical column: HypersilGold aQ column (50 mm x 2.1 mm ID and 5 µm particles) for pharmaceuticals, Hypersil Gold PFP (50 mm x 2.1 mm ID and 5 µm particles) for PFCs and HypersilGold Phenyl (50 mm x 2.1 mm ID and 3 µm particles) for APCI/APPI compounds. Gradient of acetonitrile in water (both acidified with 0.1% formic acid) was used for the separation of ESI compounds while gradient of methanol in water without additives was used for APCI/APPI detection.

Internal standard method combined with matrix matching standards was used for quantification. LOQs were calculated from one half of the response of the lowest point in calibration curve, where RSD of response factor was lower than 30%.

---

## 1. Background

Norwegian Water is once more launching its baseline survey with support from the Norwegian Environment Agency to analyse pollutants in wastewater sludge. Samples shall be taken in the period October 2017 to February 2018. A total of five monthly mixed samples and five grab samples will be taken from each plant.

This sampling plan and its procedure shall be used to ensure that the sludge samples are representative for the treatment plant and to make sure that the samples are not destroyed or contaminated during the sampling process or during transport to the laboratory. The sludge will be analysed for organic pollutants, and it is therefore important that the sampling procedure is followed carefully given that the purpose of the survey is to identify the levels of organic pollutants in wastewater sludge in Norway.

Sampling is divided into two different analysis packages: "Basic" and "Additional". There are a few small differences within these packages with regards to the number of plants that will analyse various substances. The reason for dividing the analysis is because the basic package corresponds to pollutants that have been analysed in surveys since the mid-90s. The additional package represents new substances in sludge for which more information is needed.

For this study, we shall use a university laboratory in the Czech Republic, Expors. This laboratory is specialized in organic pollutants including pharmaceutical residues in environmental samples. Due to this, all samples will be sent to COWI in Oslo before being transported to the laboratory.

## 2. Plants included in the survey

18 plants are involved in the survey, each with different treatment processes and methods of sludge treatment; see table 1 and table 2 for contact information. Eight of these plants have been involved in previous surveys and seven are new plants.

Table 1. Treatment plants included in the survey. Plants which have never been included before are marked as "new".

	Treatment plant	Wastewater treatment	Sludge treatment
1	Bekkelaget Plant (Oslo)	Pre-precipitation/simultaneous precipitation with biological nitrogen treatment	Thermophilic anaerobic stabilisation
2	Bergen Biogas Plant (new)	Sludge from two biological plants and two with primary precipitation (chemical)	Pasteurisation with thermophilic anaerobic stabilisation
3	Fuglevik Plant (Moss)	Primary precipitation	Aerobic pre-treatment and mesophilic anaerobic stabilisation
4	Hias (Hamar)	Biological treatment and chemical post-precipitation	Thermal hydrolysis mesophilic anaerobic stabilisation
5	Høvringen Plant (Trondheim)	Mechanical treatment	Pasteurisation with mesophilic anaerobic stabilisation
6	Gardermoen Plant (Ullensaker)	Biological nitrogen treatment and chemical post-precipitation	Thermophilic anaerobic stabilisation
7	Ladehammeren Plant (Trondheim)	Mechanical treatment	Pasteurisation with mesophilic anaerobic stabilisation
8	Lindum (Drammen)	Biogas plant which receives sludge from various treatment plants	Thermal hydrolysis mesophilic anaerobic stabilisation. Samples of raw sludge shall be taken as well
9	Knappen Plant (Bergen)	Primary precipitation	Raw sludge
10	Lower Romerike Avløpsselskap (NRA) (Lillestrøm)	Biological nitrogen treatment and chemical precipitation	Orsa (lime treatment)
11	Rambekk Plant (Gjøvik)	Primary precipitation	Mesophilic anaerobic stabilisation, thermal drying
12	Sandefjord Plant (Sandefjord)	Primary precipitation	Pasteurisation with anaerobic stabilisation
13	Nord Jæren Central Treatment Plant - SNJ (Stavanger)	Primary precipitation	Mesophilic anaerobic stabilisation, thermal drying
14	Solumstrand Plant NEW! (Drammen)	Biological treatment and chemical post-precipitation	Raw sludge
15	Tønsberg Plant (Tønsberg)	Biological treatment and chemical post-precipitation	Orsa (lime treatment)
16	VEAS (Oslo/Bærum/Asker)	Precipitation and biological nitrogen treatment	Mesophilic anaerobically stabilised lime-conditioned vacuum drying
17	Øra Plant (Fredrikstad)	Primary precipitation	Pasteurisation with thermophilic anaerobic stabilisation
18	Årim (Ålesund)	Septic sludge from two treatment districts: Ålesund and Gisle	Raw sludge

### 3. Sampling points

The same sampling points must be used across the entire survey. For plants that have been involved in previous surveys, the sampling points used should be the same as in previous years. The sampling point shall be after final sludge treatment and dewatering in order to be representative to the sludge quality that is used as soil conditioner/fertiliser.

**Solumstrand Plant, Knappen Plant, NRA and Tønsberg Plant** take sludge samples after dewatering at the plant and before further sludge treatment is undertaken. These samples are raw sludge samples. The sludge samples should be taken prior to liming at all plants except for **VEAS** which shall take samples of lime-conditioned sludge just as it has done in previous surveys.

**ÅRIM** takes septic samples from two different treatment districts for septic tank sludge; one of these districts before the new year and the other after.

**Lindum** also takes samples of raw sludge, before digestion.

All other plants take samples after the following steps of sludge treatment:

- After dewatering and digestion. For plants which use sludge drying, samples are taken after drying.
- After dewatering if the sludge is limed or transported for sludge treatment outside of the treatment plant (except for VEAS).

### 4. Contact information and shipping

COWI will send out sampling packages which will include:

- 15 labels, one for the combined sample and one for the grab sample, and a label for the collection bag that both samples shall be placed in.
- Rilsan bags + strips
- Shipment packaging for return shipments to COWI

The treatment plants will send each sample round themselves. One monthly combined sample and one grab sample sent in the post using the Business Express (Bedriftspakke) service. Shipping labels are included in the pack that COWI will send. Remember to fill the box with newspaper and/or loose Styrofoam to insulate the samples as well as possible.

Table 2 Contact information for the project; postal addresses for sampling and delivery.

	Treatment plant	Delivery address	Postal address/ invoicing address	Contact person Project/sampling	E-mail: Project/sampling	Tel. no. Project/ sampling
1	Bekkelaget Plant (Oslo)	Ormsundveien 5 0198 OSLO, Norway	Bekkelaget Vann AS - BEVAS Ormsundveien 5, 0198 OSLO, Norway	Ola Toftdal/Jessika	jg@bvas.no	+47 98289914/ +47 23386328
2	Bergen Biogas Plant (Bergen) New this year	Spelhaugen 22 5147 FYLLINGSDALEN	Bergen kommune, Vann- og avløpsetaten, Postboks 7700, 5020 BERGEN, Norway	Kristine Akervold	kristine.akervold@bergen.kommune.no	+47 91797781
3	Fuglevik Plant (Moss)	Båthavnveien 50 1570 DILLING	MOVAR IKS Kjellerødveien 30, 1580 RYGGE, Norway	Jonny Sundby/ Kaj-Werner Grimen og Hans Wold	Jonny.sundby@movar.no kaj-werner.grimen@movar.no hrwold@movar.no	+47 97067875/ +47 69276171/ +47 91816014
4	Hias (Hamar)	Sandvikavegen 136 2312 OTTESTAD	Hias IKS Postboks 4065, 2306 HAMAR, Norway	Thorbjørn Nettelund	thorbjorn.nettelund@hias.no	+47 95216678

Continues next page

Continued from last page

	Treatment plant	Delivery address	Postal address/ invoicing address	Contact person Project/sampling	E-mail: Project/sampling	Tel. no. Project/ sampling
5	Høvringen Plant (Trondheim)	Bynesetveien 66 7018 TRONDHEIM	Trondheim kommune, bydrift, VA-enheten, Tempevn. 22, 7018 TRONDHEIM, Norway  Trondheim kommune fakturamottak TK org.kode 610 000 Postboks 2399 Torgarden 7004 TRONDHEIM, Norway	Marianne B. Dybsland	marianne.dybsland@trondheim.kommune.no	+47 95803620
6	Gardermoen Plant (Ullensaker)	Renseveien 84 2065 GARDERMOEN Næringspark, Norway	Gardermoen renseanlegg Postboks 470, 2051 JESSHEIM, Norway	Jostein Skjefstad/ Morten Kjevevud	jostein.skjefstad@ullensaker.kommune.no/ morten.kjevevud@ullensaker.kommune.no/ cornelia.togea@ullensaker.kommune.no	+47 97151037/ +47 40038036/
7	Ladehamneren Plant (Trondheim)	Ormen Langes vei 29, 7041 TRONDHEIM, Norway	Trondheim kommune, bydrift, VA-enheten, Tempevn. 22, 7018 TRONDHEIM, Norway  Trondheim kommune fakturamottak TK org.kode 610 000 Postboks 2399 Torgarden 7004 TRONDHEIM, Norway	Kristin Greiff Johnsen/ Inge Dragsnes	kristin-greiff.johnsen@trondheim.kommune.no/ inge.dragsnes@trondheim.kommune.no	+47 72542683/ +47 90946126
8	Lindum (Drammen)	Lerpeveien 155, 3036 DRAMMEN, Norway	Lindum AS Lerpeveien 155, 3036 DRAMMEN, Norway	Jan Petter Hammer	Jan-petter.hammer@lindum.no	+47 90530311
9	Knappen Plant (Bergen)	Spelhaugen 22 5147 FYLLINGSDALEN, Norway	Bergen kommune, Vann- og avløpsetaten, Postboks 7700, 5020 BERGEN, Norway	Kristine Akervold/ Fereidun Akhoundzadeh	kristine.akervold@bergen.kommune.no/ fereidun.akhoundzadeh@bergen.kommune.no	
10	NRA (Lillestrøm)	Strandveien 22 2010 STRØMMEN, Norway	Nedre Romerike Avløpsselskap IKS Postboks 26, 2011 STRØMMEN, Norway	Erik Rismyhr/ Bernt Helland	bernt.helland@nrva.no	+47 48159036
11	Rambekk Plant (Gjøvik)	Rambekk r.a. Renseveien 7 2816 GJØVIK, Norway	Post: Postboks 630 2810 GJØVIK Faktura: Serviceboks, 2810 GJØVIK, Norway	Inger Katharina Gregersen	igg@gjovik.kommune.no	+47 61189557
12	Sandefjord Plant (Sandefjord)	Enga 3231 SANDEFJORD, Norway	Sandefjord renseanlegg Enga, 3231 SANDEFJORD, Norway	Eva Kristin Mathisen	eva.kristin.mathisen@sandefjord.kommune.no	+47 90880141
13	Nord Jæren Central Treatment Plant – SNJ (Stavanger)	4070 RANDABERG, Norway	IVAR IKS, Postboks 8134, 4069 STAVANGER, Norway	Oddvar Tornes/ Oddgeir Volle	oddgeir.volle@ivar.no	+47 93488858
14	Solumstrand Plant (Drammen)	Svelvikveien 171 3037 DRAMMEN, Norway	Drammen kommune, Engene 1 3008 DRAMMEN, Norway	Liv Marlene Wilhelmine Jensen	alexander.g.vedeler@drmk.no/ majens@drmk.no	+47 91885685/ +47 93493077/
15	Tønsberg Plant (Tønsberg)	Carl XV's gate 8A 3150 TOLVSRØD/ VALLØ, Norway	Tønsberg renseanlegg Postboks 47, 3166 TOLVSRØD, Norway	Jørgen Fidjeland	jorgen.fidjeland@rense.no	+47 91638409/ +47 33357750
16	VEAS (Oslo/Bærum/Asker)	Bjerkåsholmen 125 3470 SLEMMESTAD, Norway	VEAS – Vestfjorden Avløpsselskap Bjerkåsholmen 125 3470 SLEMMESTAD, Norway	Anne-Kari Marsteng/ Birgit Johnsen	akm@veas.nu/ bijo@veas.nu	+47 91324614
17	Øra Plant (Fredrikstad)	Habornveien 61 1630 Gamle Fredrikstad, Norway	FREVAR KF, Postboks 1430 1602 FREDRIKSTAD, Norway	René Karstensen	reka@fredrikstad.kommune.no	+47 90932542/ +47 69357300
18	ÅRIM (Ålesund) new this year	Langelandsvegen 1 – 6010 ÅLESUND, Norway	ÅRIM – Ålesundregionen Inter- kommunale Miljøsekskap IKS Langelandsvegen 1 6010 ÅLESUND, Norway	Lars M Fugledal	lmf@arim.no	+47 70374100/

## 5.5 Analysis Parameters and distribution of plants

Parameters investigated in this survey are listed below. The list is not entirely complete as the prices may be subject to change. All plants must therefore take grab samples so that analyses can be done for siloxanes if there is money in the budget to do so.

### Basic Package (18 plants) Additional Package (approx. 10 plants)

- LAS
- PAH<sub>16</sub>
- Brominated flame retardants
- Phthalates
- Nonylphenol/ ethoxylates
- PCB<sub>7</sub> (analysed again after a hiatus in 2006/07 and 2012/13)

### Additional Package

- Triclosan
- Methylparaben
- Siloxanes
- Perfluorinated compound (PFAS) (only at a few plants)
- Polycyclic musk compounds
- Organophosphorus flame retardants
- Arsenic and silver
- Alkylphenols
- Organotins
- Pharmaceutical residues

## 6. Sampling

### 6.1. Monthly combined samples for analysis of organic pollutants

All samples (except siloxane) are taken as monthly combined samples. Subsamples are taken over the course of the month and collected in a Rilsan bag which is stored in the freezer. The total sample collected over the month should weigh circa one kilogram, or somewhere between one and two litre sample.

Fill the Rilsan bag with the subsamples evenly distributed over the month and taken after dewatering (drying) to about one litre, or approximately ¼ of a full bag.

Twist the top of the bag well and close it tightly with a strip; see image. Fix the label onto the bag and put the entire bag into a new bag together with the grab sample which is also closed up with a strip.

Subsamples should be taken every day as far as possible (approx. 20 working days per month). Subsamples should be frozen in the same Rilsan bag and together constitute the monthly mixed sample. It is important that each of the subsamples represents an equally large proportion of the final sample.



The samples must be frozen, and the final sample shall be sent to COWI when it is a "finished" monthly combined sample, together with the grab sample for siloxane.

### 6.2. Grab sample for the analysis of siloxane

There is a separate sampling procedure for siloxane due to the risk of evaporation and contamination of the sample. The sludge shall be taken as a grab sample of approximately one litre. The sample material is transferred away from the sampling site directly in a Rilsan bag and immediately close and freeze.

Employees taking samples for the analysis of siloxanes must not use any personal care products on the days of collecting the sample. Personal care products include deodorants, perfumes, lotions, creams and hair products such as conditioner, hair gel, wax and similar.

The sample must be stored in a Rilsan bag and all equipment used (spoons, spatulas, etc) must be made of steel. Nitrile gloves must be used.

The bag must be closed properly with a strip and the sample must be frozen immediately after sampling (as quickly as is physically possible) to prevent evaporation of siloxanes.

## 7. Storage and shipment

All samples are kept frozen in freezers at a temperature of  $-20^{\circ}\text{C}$ . After each sampling round (month), the combined sample is sent to COWI, Karvesvingen 2, 0579 Oslo, FAO: Line Diana Bytt. Use newspaper/insulation material to provide the samples from thawing.

## 8. Sampling plan

Monthly combined samples and grab samples of sludge are taken over the course of five months, beginning in October and in accordance with the following plan:

	2017						2018			
	Sampling round 1		Sampling round 2		Sampling round 3		Sampling round 4		Sampling round 5	
Plant	Monthly mixed sample	Grab sample								
Bekkelaget Plant	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Bergen Biogas	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Fuglevik Plant	1/9 - 30/9	Week 39	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Hias	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Høvringen Plant	1/10 - 31/10	Week 44	1/11 - 30/11	Week 44	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Knappen Plant	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Lindum Biogas	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Raw sludge and digestate	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Ladehammeren	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
NRA	1/10 - 31/10	Week 44	1/11 - 30/11	Week 44	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Rambekk Plant	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Sandefjord Plant	1/10 - 31/10	Week 44	1/11 - 30/11	Week 44	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
SNJ (IVAR)	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Solumstrand Plant	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Tønsberg Plant	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
VEAS	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Øra Plant	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8
Årim - 2 district	1/10 - 31/10	Week 44	1/11 - 30/11	Week 48	1/12 - 31/12	Week 51	1/1 - 31/1	Week 3	1/2 - 28/2	Week 8

---

## 9. Summary

The plants receive sampling packages, labels, return packages and return shipment labels from COWI. All samples are labelled and returned to COWI which will then forward them on to the analysis laboratory.

- COWI sends 15 Rilsan bags; 10 for samples and five collection bags, labels, return box and return shipment label and this procedure in a separate consignment to each of the treatment plants/contact points.
- The plants acquire: Nitrile gloves
- The plants acquire: Clean sampling spoon made from stainless steel
- On the plant: Freezer with a capacity to reach temperatures of -20°C
- The sample material in the bag must be approximately one litre; i.e. ¼ of the bag's full volume.
- The samples are sent once a month – two samples for each month. The total number of samples from each plant shall be five monthly combined samples and five grab samples.
- Grab samples are taken on one day in the sampling period in a Rilsan bag for the analysis of siloxane: total of samples (one per month). **Remember** no personal care products on this day; i.e. deodorant, hair conditioner/styling product, hand creams, etc.
- The two Rilsan bags per month are closed with strips and put into a new bag for double protection. The bag with the two other sealed bags is then close with a strip in the same way.
- The plant must securely tape up the packaging box after filling it with newspaper/insulation
- Two samples (monthly combined sample and grab sample) are sent frozen each month via the Business Express delivery service to COWI, packed with wrap-around paper/insulation to reduce thawing. The return label is attached to the packaging provided by COWI for Business Express overnight delivery. **Do not** send samples at the end of the week as there is a greater chance it will begin to thaw and smell.

Any questions can be directed to:

**Line Diana Blytt**

Mobile: (+47) 91 81 31 79

Switchboard: 02694

Delivery address:

COWI v/ Line Diana Blytt

Karvesvingen 2, 0579 Oslo, Norway

E-mail: [LDBL@cowi.com](mailto:LDBL@cowi.com)



Norsk Vann BA, Vangsvegen 143, 2321 Hamar  
Tlf: 62 55 30 30 E-post: [post@norsk vann.no](mailto:post@norsk vann.no)  
[www.norsk vann.no](http://www.norsk vann.no)