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New bisphenols, organic peroxides, fluorinated siloxanes, organic UV filters and selected PBT substances

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Screening programme 2013: New bisphenols, organic peroxides, fluorinated siloxanes, organic UV filters and selected PBT substances
Screening program 2013: Nye bisfenoler, organiske peroksider, fluorerte siloksaner, UV-filtre og utvalgte PBT stoffer

Summary - sammendrag

The occurrence and environmental risk of a number of new bisphenols, organic peroxides, fluorinated siloxanes, organic UV filters and selected PBT substances are reported for wastewater effluents and leachates, as well as sediments and biota from Oslofjord and Lake Mjøsa.

Forekomsten og miljørisiko av en rekke nye bisfenoler, organiske peroksider, fluorerte siloksaner, organiske UV-filtre og utvalgte PBT stoffer er rapportert for utslipp fra avløpsvann renseanlegger og sigevann, samt sedimenter og biota fra Oslofjorden og Mjøsa.

4 emneord

Nye miljøgifter, screening, forekomst, næringskjeden

4 subject words

Emerging contaminants, screening, occurrence, food chain

Front page photo

Oslofjord (Shutterstock Inc.)

Foreword

The Norwegian Environment Agency annually performs a screening for selected contaminants of emerging concern with the purpose of achieving the goal of a contaminant-free environment. As such it is very important to detect and regulate new contaminants before they are dispersed into the environment and become an environmental problem. The overall objective of the screening program is to establish the occurrence and environmental impact of new POPs in Norwegian and Arctic environment and use the data to assess the implementation of local, national and international actions. The data will also be used to help determine whether a substance requires continuous monitoring. A new contaminant typically has one or more of the following characteristics; is non-regulated, environmental properties (PBT) that are cause for concern, a use that provides the potential for adverse effects in the environment, not included in routine monitoring, lacking or incomplete environmental risk assessment, and a potential candidate for future regulation. In 2013 organic UV-chemicals, selected PBT substances, new bisphenols, organic peroxides and fluorinated-siloxanes were selected. NILU and NIVA were together commissioned to perform the study that aimed to show the occurrence of these chemicals in the Norwegian marine and freshwater environments, with particular focus on their potential to bioaccumulate.

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Summary

Upon assignment from the Norwegian Environment Agency (Miljødirektoratet), the Norwegian Institute for Water Research (NIVA) and Norwegian Institute for Air Research (NILU) have together performed a screening of selected organic UV filters, organic peroxides, new bisphenols and three selected PBT compounds. In addition the analyses also included a number of other compounds such as phosphour organic flame retardants and the insect repellent DEET (*N*,*N*-Diethyl-*m*-toluamide). The objective of the project was to establish the occurrence of these chemicals in Norwegian marine and freshwater environments, with particular focus on their potential to bioaccumulate.

The most important findings can be summarised as follows:

- Several UV filters, as well as the insect repellant DEET, are entering the environment through WWTW effluent and sludge. Dicumyl peroxide was the only of the selected organic peroxide to be detected in WWTW effluent at low ng/L concentrations. WWTW effluent and sludge are also a source of the selected PBT substances and new bisphenols.

- Landfill leachate is a source of several organic UV filters. The organic peroxide di(tert-butylperoxyisopropyl)benzene was associated with leachate particulates. All of the selected PBT substances occurred in leachate along with several bisphenols.

- Several organic UV filters, the insect repellant DEET, some of the selected PBT substances and two bisphenols were shown to accumulate in marine and freshwater sediments receiving treated wastewater.

- Several organic UV filters, DEET, most of the selected PBT substances and bisphenols were shown to occur in Oslofjord biota.

- Several organic UV filters, most of the selected PBT substances and bisphenols were shown to occur in Lake Mjøsa biota.

- Available data suggests that under certain conditions the organic UV filters BP3 and OC may pose a risk to surface waters and that further evaluation of the risk posed by BP3 in sludge is considered. The absence of ecotoxicity data make it difficult to assessment the potential risks associated with a number of the compounds released into the environment. There are potential risks associated with the accumulation of these chemicals in sediments and biota, however these have not been evaluated.

Organic UV filters
The organic UV-filters benzophenone-3 (BP3), ethylhexylmethoxycinnamate (EHMC), octocrylene (OC), and 2-(2H-benzotriazol-2-yl)-4,6-bis(2-phenyl-2-propanyl)phenol (UV-234) were detected in treated wastewater and leachate. Concentrations of OC where an order of magnitude higher in the samples from Tomasjord than VEAS or HIAS WWTWs. BP3, EHMC, OC, 2-(5-chloro-2H-benzotriazol-2-yl)-4,6-bis(2-methyl-2-propanyl)phenol (UV-327) and 2-(2H-benzotriazol-2-yl)-4-(2,4,4-trimethyl-2-pentanyl)phenol (UV-329) were the organic UV filters detected in sludge. Organic UV chemicals also occur in sediments collected from the respective recipients, with EHMC, OC, UV-327, 2-(2H-benzotriazol-2-yl)-4,6-bis(2-methyl-2-butanyl)phenol (UV-328) present in the sediments collected from Oslofjord, with only EHMC present in Mjøsa sediments. A number of the UV filters (BP3, ODPABA, EHMC, UV-238 and OC) were also detected in Oslofjord cod livers, although there was no evidence of biomagnification through the organisms collected.

The insect repellant DEET was present at µg/L concentrations in WWTW effluent and leachate. A simple risk assessment suggests that DEET alone does not pose a threat to surface waters but may contribute to the total environmental risk posed by the complex mixture of chemicals found in WWTW effleunt.

Organic peroxides
Dicumyl peroxide was the only organic peroxide detected in wastewater effluent and at low ng/L concentrations. Di(tert-butylperoxyisopropyl)benzene was the only organic peroxide detected in leachate, bound to the particulates in the samples collected from Lindum . Based upon published ecotoxicity data these levels are not sufficiently high to pose an environmental risk to surface waters.

New bisphenols
New bisphenols were determined to be present in effluent at a range of between LOD – 6.2 µg/L. The two bisphenol F (BPF) isomers and bisphenol A (BPA) were the dominating bisphenols occurring in the effluent samples collected. The sulphur containing Bisphenol S (BPS) was detected in HIAS effluent and at much lower concentrations in VEAS effluent and not in the effluent from Tomasjord WWTW in Tromsø. Bisphenol BP (BP-BP) was only found in two effluent samples from HIAS WWTW and at high µg/L concentrations. Only low concentrations of BPA, BPF, bisphenol AF (BPAF), and BPS were detected in sludge from the VEAS WWTW, however, in sludge from HIAS all of the selected bisphenols were detected. BPA was found at very high concentrations. New bisphenols were detected in leachates BPF (both isomers) and BPA were the dominating BPs in leachates. Low levels of BPF and BPA were occasionally detected in sediments collected from Oslofjord, while all new BPs were detected in sediments from Lake Mjøsa with the two BPF isomers dominating. New BPAs were frequently detected in the fish collected from Lake Mjøsa. In perch, whitefish, and brown trout the BPF isomers dominated, whereas in burbot liver, BPA was the bisphenol found at the highest concentrations. New BPs were also frequently detected in Northern shrimp and cod liver from Oslofjord, however only occasionally detected in shore crabs.

Selected PBT compounds
The phosphorous flame retardants (PFR)s tris(2-chlorpropyl) phosphate (TCPP) and tris(2-chloroethyl) phosphate (TCEP) were detected in WWTW effluent at concentrations below the PNECs for receiving waters and therefore pose little direct risk. The levels of TCPP detected do however pose a risk to WWTW microorganisms. TCPP and triscresyl phosphate (TCP) were detected in sludge with the risks to soils receiving sludge containing these compounds evaluated to be low, although a thorough assessment is recommended. TCEP and TCPP, were shown to accumulate in sediments, whilst all the PFRs were shown to occur in marine and freshwater biota.

The two diisopropyl naphthalenes 2,6-DIPN and 2,7-DIPN were detected in all sludge samples at ng/g dw levels as well as in the leachate samples. The concentrations of 2,6-DIPN and 2,7-DIPN were typically below LoQ for shrimps and crabs, while around 30 % of the cod livers contained ng/g ww levels. The frequency of detection in freshwater biota was very low.

The fragrance Galaxolide (HHCB) was detected in all effluent, leachate and sludge samples at concentrations below PNECs for receiving environments. HHCB was not detected in sediments and quantifiable concentrations were only detected in a few cod liver freshwater fish samples.

Fluorinated siloxanes
The levels of fluorinated siloxanes present in the samples collected were below the limits of detection. Further work is required to improve the sensitivity of the methods available for their analysis.

Sammendrag

På vegne av Miljødirektoratet har Norsk institutt for vannforskning (NIVA) og NILU - Norsk institutt for luftforskning i fellesskap gjennomført en screeningstudie av utvalgte organiske UV-kjemikalier, organiske peroksider, nye bisfenoler og utvalgte PBT-stoffer. I tillegg til disse ble flere fosforflammehemmere og insektrepellent DEET (*N,N*-Diethyl-*m*-toluamide) inkludert i analysene. En av hovedmålsetningene var å få fastslått om disse stoffer slippes ut til Norsk miljø og om nivåer i miljøet tilsier at disse stoffene allerede er problematiske, eller om dagens bruk kan føre til et miljøproblem i fremtiden. Med unntak av nye bisfenoler legges det også særlig vekt på å få belyst bioakkumuleringspotensialet av disse stoffer.

De viktigste funnene kan oppsummeres som følger:

- Flere organiske UV-kjemikalier og insektrepellent DEET, utvalgte PBT-stoffer og nye bisfenoler blir sluppet ut til miljøet via utløp fra renseanlegg og kloakkslam. Av organiske peroksider er det bare dicumylperoksid som kunne påvises i utløpsvann med lave ng/L konsentrasjoner.

- Sigevann fra avfallsdeponier er en kilde for noen UV-kjemikalier, for alle utvalgte PBT-stoffer og bisfenolene. Av de organiske peroksider var det kun di(tert-butylperoxyisopropyl)benzene som ble påvist i partikkelfasen av sigevannet.

- Flere organiske UV kjemikalier, insektrepellent DEET, flere av de utvalgte PBT-stoffene og to bisfenoler kunne påvises i marint og ferskvannssediment i nærheten av de undersøkte renseanlegg.

- Flere organiske UV kjemikalier, insektrepellent DEET, flere av de utvalgte PBT-stoffene og flere bisfenoler kunne påvises biotaprøver fra Oslofjord.

- Flere organiske UV kjemikalier, flere av de utvalgte PBT-stoffene og alle undersøkte bisfenoler kunne påvises biotaprøver fra Mjøsa.

- Det finnes veldig begrenset med data som beskriver økotoksikologi av de påviste stoffer og en evaluering av miljørisikoen forbundet med forekomst av UV-kjemikalier og nye bisfenoler er dermed veldig vanskelig. Akkumulering av disse stoffer i sediment og biota er også forbundet med en miljørisiko, heller ikke det kunne vurderes på en kvantitativ måte.

- De foreliggende data tyder på at de organiske UV kjemikalier BP3 og OC under vise betingelser kan medføre et miljørisiko i overflatevann. Man bør også se nærmere på miljørisiko av BP3 gjennom kloakkslam. Siden det er store mangler når det gjelder økotoksikologiske data for mange av stoffene påvist i denne undersøkelsen, er det vanskelig å bedømme hvilket risiko tilstedeværelse av disse stoffer i miljøet utgjør. Det er ikke foretatt en evaluering av miljørisiko som skyldes akkumulering av disse stoffer i sediment og biota.

Organiske UV-kjemikalier
UV-kjemikalier Benzophenone-3 (BP3), Ethylhexylmethoxycinnamate (EHMC), Octocrylene (OC), og 2-(2H-Benzotriazol-2-yl)-4,6-bis(2-phenyl-2-propanyl)phenol (UV-234) ble funnet i utløp fra renseanlegg og sigevann fra avfallsdeponier. I prøvene fra Tomasjord var konsentrasjon av OC mer enn en størrelsesorden høyere enn i prøvene fra VEAS og HIAS. BP3, EHMC, OC, 2-(5-Chloro-2H-benzotriazol-2-yl)-4,6-bis(2-methyl-2-propanyl)phenol (UV-327) og 2-(2H-Benzotriazol-2-yl)-4-(2,4,4-trimethyl-2-pentanyl)phenol (UV-329) ble påvist i slamprøvene fra renseanlegg. En vurdering av miljørisiko som skyldes utslipp av disse stoffer er vanskelig siden det mangler tilstrekkelig data om økotoksisitet. Organiske UV-kjemikalier ble også påvist i sedimenter som ble tatt i nærheten av disse utslippskilder (resipient). EHMC, OC, UV-327 og 2-(2H-Benzotriazol-2-yl)-4,6-bis(2-methyl-2-butanyl)phenol (UV-328) ble funnet i sedimentprøver fra Oslofjord, mens i Mjøsa ble kun EHMC funnet. BP3, ODPABA, EHMC, UV-238 og OC ble detektert i torskelever fra Oslofjorden, men datasettet er ikke tilstrekkelig for å bevise en biomagnifisering.

Insektrepellent DEET finnes i µg/L konsentrasjoner i utløpsvann og sigevann. En enkel risikovurdering tyder ikke på at DEET alene utgjør en spesiell miljørisiko for overflatevannet, men kan trolig bidra til å øke den totale miljørisikoen av de komplekse stoffblandinger som slippes ut av renseanleggene.

Organiske peroksider
Dicumyl peroksid var det eneste organiske peroksid som ble funnet i utløp fra renseanlegg, med konsentrasjoner i det lave ng/L området. Di(tert-butylperoxyisopropyl)benzene var det eneste organiske peroksid som ble funnet i sigevann, nærmere bestemt i partikkelfasen av prøvene fra Lindum. Basert på publiserte økotoksikologiske data antas det at disse stoffer ikke medfører en miljørisiko for overflatevannet.

Nye bisfenoler
Alle undersøkte bisfenoler ble funnet i utløpsvann fra renseanlegg. Bisfenol F (BPF) og bisfenol A (BPA) er de dominerende bisfenoler i utløpsvann. Det svovelholdige stoffet bisfenol S (BPS) ble funnet med høye konsentrasjoner i utløpsvann fra HIAS, ved mye lavere konsentrasjoner i prøver fra VEAS, mens det ikke kunne påvises i prøver fra Tomasjord. Bisfenol BP (BPBP) ble kun påvist i 2 prøver fra HIAS, men med høye µg/L-konsentrasjoner. I slam fra VEAS ble det påvist kun lave konsentrasjoner av BPA, BPF, BPAF og BPS. I slamprøver fra HIAS derimot ble det detektert alle bisfenoler ved delvis svært høye konsentrasjoner (BPA). Med unntak av BPAF ble alle undersøkte bisfenoler funnet i sigevann fra avfallsdeponier der BPF og BPA dominerer. I noen sedimentprøver fra Oslofjord ble det funnet lave konsentrasjoner av BPF og BPA, mens alle undersøkte bisfenoler ble funnet i sedimentprøver fra Mjøsa med BPF som dominerende forbindelse. Nye bisfenoler ble funnet hyppig i både reker og torskelever fra Oslofjord, men bare unntaksvis i strandkrabbe. Alle undersøkte bisfenoler ble funnet i biotaprøver fra Mjøsa. Mens det er BPF som dominerer i abbor, sik og ørret, så er det BPA som dominerer i lakelever.

Utvalgte PBT-stoffer
Fosforflammehemmere (PFR) Tris(2-chlorpropyl) phosphate (TCPP) og Tris(2-chloroethyl) phosphate (TCEP) ble påvist i utløpsvann fra renseanlegg i konsentrasjoner lavere enn PNEC for overflatevann og medfører derfor en lav direkte miljørisiko. De målte TCPP-konsentrasjoner kan derimot være problematisk for mikroorganismene i renseanleggene. TCPP og TCP ble funnet i slam i konsentrasjoner som trolig ikke medfører noen miljørisiko om slammet spres på jord. Dette bør imidlertid undersøkes nærmere. Både TCEP og TCPP akkumulerer i sediment og alle undersøkte fosforflammehemmere ble funnet i både marint og ferskvannsbiota.

De to diisopropylnaftalene 2,6- og 2,7-DIPN ble funnet i alle slamprøver og i sigevannsprøver. I cirka 30 % av alle torskeleverprøver fra Oslofjord var det mulig å påvise 2,6- og 2,7-DIPN i lave ng/g vv konsentrasjoner. I de fleste andre biotaprøver fra Oslofjord og Mjøsa var det ikke mulig å detektere DIPN over deteksjonsgrensen.

Parfymstoffet Galaxolide (HHCB) ble funnet i alle prøver av utløpsvann, sigevann og slam ved konsentrasjoner som er lavere enn PNEC for overflatevann og jord. HHCB ble ikke påvist i sediment og kun i noen få prøver av torskelever og ferskvannsfisk.

Fluorerte siloksaner
Nivået av fluorerte siloksaner i de innsamlete prøver ligger under deteksjonsgrensen som var mulig å oppnå i denne studien. For å forbedre metodens følsomhet er en ytterligere metodeutvikling nødvendig.

Contents

1. Background and Introduction

1.1 General

The Norwegian Environment Agency in 2013 selected five groups of compounds for inclusion in its annual screening programme. These were organic UV filters, organic peroxides, new bisphenols and a three selected PBT compounds. In addition the analyses also included a number of other compounds such as selected phosphour organic flame retardants and the insect repellent DEET (*N,N*-diethyl-*m*-toluamide).

The objective of the project was to establish the occurrence of these chemicals in the Norwegian marine and freshwater environments, with particular focus on their potential to bioaccumulate.

1.2 Organic UV filters

Concern over our contribution to the loads of environmental contaminants originating from our use of personal care products is continuing to grow. Due to their continuous release via wastewater effluent, personal care products have been termed pseudo-persistent (Barceló, 2007) irrespective of their PBT characteristics. The occurrence of pharmaceuticals for example is well studied and there is growing interest in the occurrence of fragrances and UV (ultraviolet) protective compounds also used in personal care products. The increase in public awareness over the dangers of over exposure to sunlight has lead in an increase in products available to protect us. This study aims to address the paucity of data on the occurrence of UV protective compounds and assess the environmental risk of these compounds and establish if they are also pseudo-persistent and released continuously into the Norwegian aquatic environment.

The first reported environmental occurrence of an organic UV filter was over 30 years ago when benzophenone was determined in the Baltic Sea (Ehrhardt et al., 1982), although personal care products were not identified as the source. UV filters and UV stabilizers all absorb UV light and in general can be loosely divided into 2 categories; UV filters used in personal care products to protect hair and cutaneous membranes from sun damage, and UV stabilizers used in technical products such as plastics and paints to protect polymers and pigments against photodegradation, and to prevent discolouring. Many of the compounds are used for both purposes and frequently used in combination to extend the UV range protection provided. It is widely reported that UV filters and stabilizers used in personal care products enter the aquatic environment indirectly via sewage effluent discharges and directly from water sports activities causing them to wash directly from skin surfaces into receiving waters. UV filter occurrence can be season and weather dependent, higher concentrations were detected in wastewater influents in summer than in winter (Tsui et al., 2014) and receiving waters have demonstrated the same patterns of distribution with higher concentrations in hot weather than in cold (Langford and Thomas, 2008). This study investigates the occurrence of 13 organic UV filters covering both these groups (Table 1). To date there have been numerous studies focusing on the occurrence of UV filters such as BP3, OC and EHMC in receiving waters, particularly those impacted by recreational activities (Santos et al., 2012; Fent et al., 2010; Díaz-Cruz et al., 2008; Langford and Thomas, 2008; Buser et al., 2006), but there are limited data available on the environmental occurrence of benzotriazole and benzothiazole UV stabilizers outside of Japan and Sweden, where UV-234, 327, 328 and 329 appear to dominate. The hydrophobic properties of some UV filters also indicate that they show the potential to bioaccumulate in biota.

Mercaptobenzothiazoles
Have been known to cause allergic contact dermatitis (Barnes et al., 2003; Bergendorff et al., 2006), most commonly known is reaction to latex gloves used in medicine and laboratory work.

MBT (Benzothiazole-2-thiol)
MBT is used extensively in rubber production as an accelerator to improve strength and elasticity and also as a fungicide and machine coolant. MBT is also formed as the main breakdown product of the biocide 2-(thiocyanomethylthiol)benzothiazole used in wood and leather preservation (Reyes et al., 2002) and its biocidal

properties and uses mean its use is controlled by the biocides directive. Its main pathways into the environment are either discharge from manufacturing processes or leachate from landfills disposing of rubber (Haroune, 2004), in particular, car tires. Road runoff is another potential source resulting from fine particles produced during tire abrasion. It is also used in paper production as a corrosion inhibitor.

MBT is amenable to photodegradation (Maloukia et al., 2004; Brownlee et al., 1992) and has a half-life in water of 0.05 days in summer, and 0.21 days in winter. It may partially dissociate or also sorb to sediment (Haroune et al., 2004). In the atmosphere, MBT is susceptible to reaction with hydroxyl radicals and has a half-life of 8.4 hours. MBT is not expected to persist or accumulate (Brownlee et al., 1992). MBT is relatively resistant to biodegradation although enzymatic biodegradation by *Rhodococcus rhodochrous* isolated from biological wastewater treatment systems, has been observed (Haroune, 2004) and removal during biological wastewater treatment has also been reported elsewhere (Kloepfer et al., 2005; Reemtsma et al., 1995; Wever and Verachtert, 1997). However other reports suggest that MBT may reduce the efficiency of wastewater treatment processes and that removal from wastewater streams is limited. In terms of environmental effects, MBT is known to interfere with membrane linked proteins has been reported to induce tumours and is toxic to aquatic life.

MBTS (Di(benzothiazol-2-yl)disulphide)
MBTS is used in rubber production as an accelerator to improve strength and elasticity. MBTS partitions to sediment and photodegration is possible and in the atmosphere, in the same way as MBT, MBTS reacts with hydroxyl radicals and has a half-life of just 1.3 hours.

Benzotriazoles
Orthohydroxy benzotriazole UV stabilizers are heterocyclic compounds with a hydroxyphenyl group attached to the benzotriazole structure. This class of UV stabilizers has a broad range of physico-chemical properties enabling them to absorb or scatter UV light as well as reflect it, making them very useful for UV protection. The ozone layer is efficient at removing UV radiation below 280 nm so benzotriazoles have been developed to absorb the full spectrum of light from 280 nm to 400 nm (Crawford, 1999).

UV-234 (2-(2H-Benzotriazol-2-yl)-4,6-bis(2-phenyl-2-propanyl)phenol)
UV-327 (2-(5-Chloro-2H-benzotriazol-2-yl)-4,6-bis(2-methyl-2-propanyl)phenol)
UV-328 (2-(2H-Benzotriazol-2-yl)-4,6-bis(2-methyl-2-butanyl)phenol)
UV-329 (2-(2H-Benzotriazol-2-yl)-4-(2,4,4-trimethyl-2-pentanyl)phenol)
UV-360 (2,2'-Methylenebis[6-(2H-benzotriazol-2-yl)-4-(2,4,4-trimethyl-2-pentanyl)phenol])
UV-571 (2-(2H-Benzotriazol-2-yl)-6-dodecyl-4-methylphenol (branched and linear))

Bioaccumulation has been observed in the marine environment in Japan for this group of UV stabilizers (Nakata et al., 2009). UV-320 (2-(3,5-di-t-butyl-2-hydroxyphenylbenzotriazole) for example is considered to be a PBT compound and has been banned form manufacture or use in Japan. Filter feeding and sediment dwelling organisms contained some of the high concentrations indicating sorption to particulates is a likely sink for some benzotraizole UV stabilizers.

Some of the derivatives of benzotriazole UV stabilizers have demonstrated toxicity to plants, and mutagenic properties in bacterial systems (Farre et al., 2008) which may have detrimental effects in wastewater treatment.

Others
BP-3 (Benzophenone-3)
Benzophenones have a high stability in UV light and absorb UV light in the UVA and UVB range. Benzophenones interact with the estrogen and androgen receptor and induce vitellogenin in male fathead minnow (*Pimephales promelas*), although *in vitro* BP-3 was up to 100,000 times less potent than estradiol. BP-3 demonstrated some limited agonistic activity at the androgen receptor but significant anti-estrogenic activity in vitro. Androgen receptor antagonist activity using yeast cells possessing the androgen receptor was equally as potent as flutamide. It is possible that the estrogenic activity may have resulted from demethylation of BP-3 to the 4-hydroxy metabolite, which is a more potent estrogen receptor agonist than the BP-3 (Kunz and Fent, 2006).

ODPABA (2-ethylhexyl-4-dimethylaminobenzoate)
ODPABA absorbs UV light only in the UVB range. ODPABA has a half-life of 39 hours in seawater and the presence of organic matter may inhibit photolysis (Sakkas et al., 2003).

EHMC (Ethylhexylmethoxycinnamate)
EHMC is the most commonly used UV filter in sun lotions and is used in over 90% of those available in Europe. It has demonstrated multiple hormone activities in fish with gene expression profiling showing antiestrogenic activity compared to estrogenic/antiandrogenic activity using VTG induction (Christin et al., 2011; Fent et al., 2008). EHMC is lipophilic and accumulates in biota showing a tendency to bioaccumulate through different trophic levels (Fent et al., 2010).

OC (Octocrylene)
OC absorbs light in the UVB range and short wavelength UVA light also, and is frequently used to protect other UV filters from photodegradation in the UVB range.

DCHA (Dicyclohexylamine)
DCHA is used in plasticizers and insecticides as well as a fuel oil additive and is also a potential degradation product of the benzothiazole UV filters as well as having its own UV stabilizing properties. It undergoes rapid photolysis in water although its high Log K_{ow} means it is likely to bind to particulates and sediment reducing its exposure to sunlight as the particulates settle. DCHA has a high vapor pressure and volatilization from wet soil and water surfaces has been observed. Rapid degradation ($t_{½}$ = 2.9 hours) by free radicals in the atmosphere then occurs. DCHA is also biodegradable and is likely to be removed during wastewater treatment processes.

Insect repellent
DEET (N,N-Diethyl-m-toluamide)
DEET is the most widely used insect repellent worldwide and was originally registered in the US for indoor use only which means that there is limited environmental toxicology data available because it was not required for product registration. The most likely major source of DEET in the environment is through wastewater discharge, either directly washing off skin after topical applications. Any DEET absorbed through the skin is completely metabolized. DEET has been detected in receiving waters worldwide (Aronson et al., 2011). Recreational activities such as bathing and swimming have also been identified as point sources (Langford and Thomas, 2008).

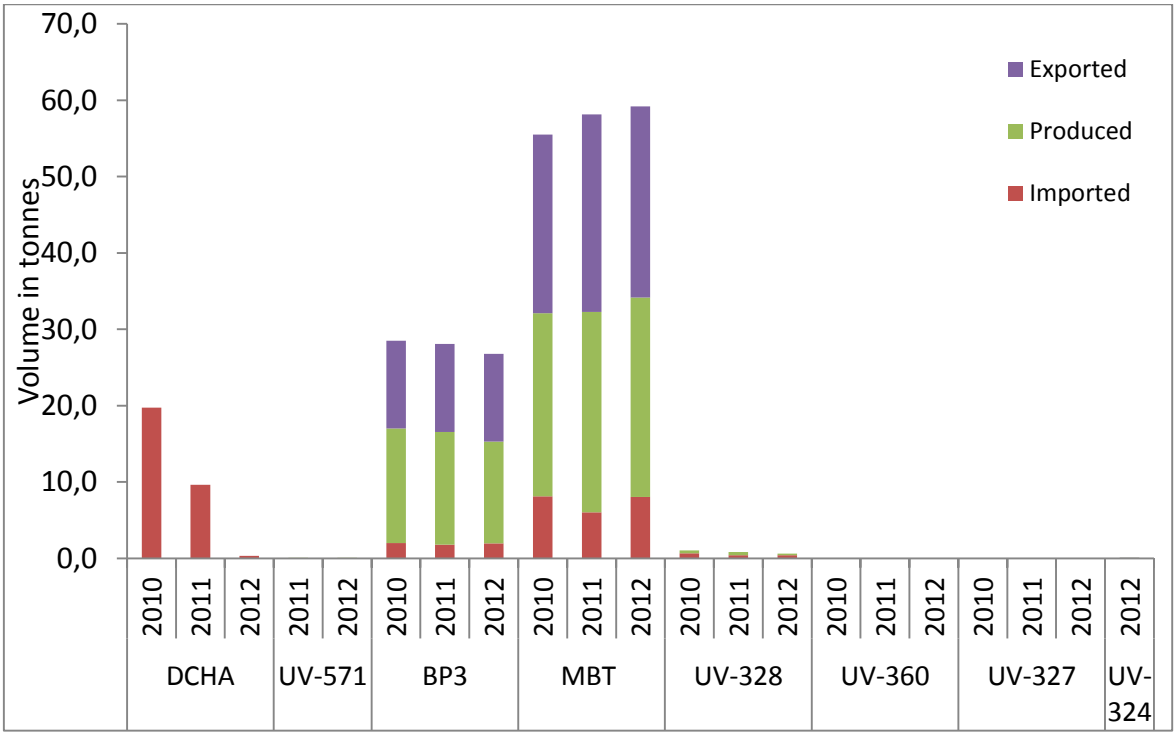
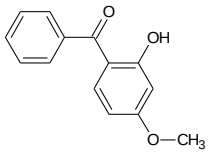
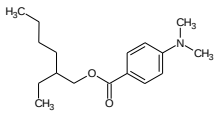
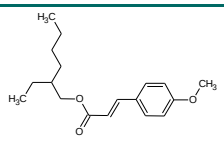
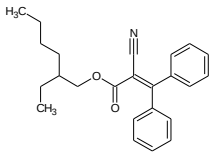
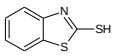
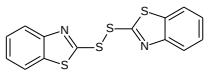
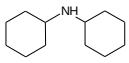
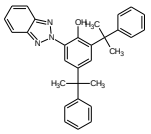
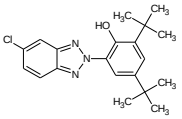
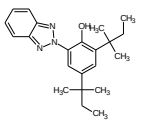
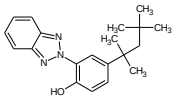
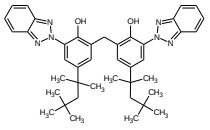
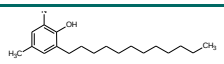
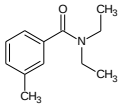


Figure 1. Available data for the production, export and import of selected UV compounds in Norway (no data for other UV compounds is available in the public domain).

Table 1: Organic UV filters selected for screening

Name, Acronym, CAS and Log K_{OW}

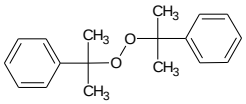
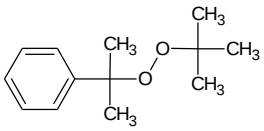
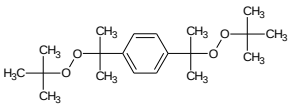
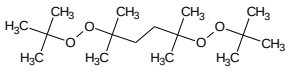
Type	Compound	Acronym	Structure	CAS	Function	Log K_{OW}
Benzophenone	Benzophenone-3	BP3		131-57-7	Filter/ stabilizer	3.8
Aminobenzoic acid derivative	2-ethylhexyl-4-dimethylaminobenzoate	ODPABA		21245-02-3	Filter	5.4
Cinnamate	Ethylhexylmethoxycinnamate	EHMC		5466-77-3	Filter/ stabilizer	5.8
	Octocrylene	OC		6197-30-4	Filter/ stabilizer	7.3
Mercaptobenzo-thiazole	Benzothiazole-2-thiol	MBT		149-30-4	Stabilizer	1.5
	Di(benzothiazol-2-yl) disulphide	MBTS		120-78-5	Stabilizer	7
Alylcyclic amine	Dicyclohexylamine	DCHA		101-83-7	Stabilizer	0.6
Benzotriazole	2-(2H-Benzotriazol-2-yl)-4,6-bis(2-phenyl-2-propanyl)phenol	UV-234		70321-86-7	Stabilizer	7.7
	2-(5-Chloro-2H-benzotriazol-2-yl)-4,6-bis(2-methyl-2-propanyl)phenol	UV-327		3864-99-1	Stabilizer	7
	2-(2H-Benzotriazol-2-yl)-4,6-bis(2-methyl-2-butanyl)phenol	UV-328		25973-55-1	Stabilizer	7.2
	2-(2H-Benzotriazol-2-yl)-4-(2,4,4-trimethyl-2-pentanyl)phenol	UV-329		3147-75-9	Stabilizer	6.2
	2,2'-Methylenebis[6-(2H-benzotriazol-2-yl)-4-(2,4,4-trimethyl-2-pentanyl)phenol]	UV-360		103597-45-1	Stabilizer	14.3
	2-(2H-Benzotriazol-2-yl)-6-dodecyl-4-methylphenol (branched and linear)	UV-571		125304-04-3	Stabilizer	10.3
Insect repellent	*N,N*-Diethyl-*m*-toluamide	DEET		134-62-3	Insect repellent	2.4

1.3 Organic peroxides

Organic peroxides are a broad group of chemicals with many different uses. Some are used in polymer chemistry and act as accelerators, cross-linking agents, curing and vulcanization agents in rubber, hardeners, and polymerization agents. More specifically, methyl ethyl ketone peroxide and benzoyl peroxide are used as initiators for radical poliymerisation in polyester and silicon resins, benzoyl peroxide and hydrogen peroxide are used as bleaching and 'maturing' agents for treating flour to speed up the release of gluten from the grain. Benzoyl peroxide is also an effective topical medication for treating acne vulgaris when used in combination with antibiotics (Eadym et al., 2006).

Organic peroxides contain the peroxide functional group (ROOR'). It is the O-O bond that is responsible for the useful properties of peroxides as it easily breaks and undergoes decomposition to form free radicals of the form RO•, and it is this characteristic that makes them useful in polymer and resin processing. Dicumyl peroxide is the main crosslinking peroxide used in polyethylene production (Dorn, 2010), it is cost effective although has the drawback of acetophenone as a decomposition product which is not desirable in product formation. Di(tert-butylperoxyisopropyl)benzene is a suitable replacement, being less volatile but is more costly and has a slower reaction rate. The peroxide curing reaction can leave a toxic acid residue on the rubber that deposits as a powder on the surface of the material (Park, 2008).

Table 2: Organic peroxides selected for screening
Name, Acronym, CAS and Log K_{OW}

Type	Compound	Acronym	Structure	CAS	Function	Log K_{OW}
Organic peroxides	Dicumyl peroxide	Di-Cup		80-43-3	Catalyst	5.7
	Tert-butyl cumyl peroxide	TB-Cup		3457-61-2	Catalyst	3.3
	Di(tert-butylperoxyisopropyl)benzene			25155-25-3	Catalyst	6.8
	2,5-dimethyl-2,5-di(tert-butylperoxy) hexane			78-63-7	Catayst	5.9

Releases of dicumyl peroxide into the environment are likely to be during production, processing and industrial use and will be mainly via wastewater discharges. As the substances have a low water solubility and high Log K_{ow}, sediment is the likely sink due to a high sorption potential. However, the quantity of the substance used in polymer/elastomer production is low, and it is almost totally consumed during the process. Therefore the release to environment is also likely to be very low and the use is considered as safe for the environment (which has been confirmed by a quantitative risk assessment performed in the framework of REACH regulation). Upon contact with water and organic matter, substance undergoes rapid degradation resulting in the formation of respective alcohols and acids.

The free radical forming characteristic that is of benefit for the production of rubber and silicone is of detriment to biological systems. The free radical reactions in biological systems can have cytotoxic and mitogenic effects on a system. Dicumyl peroxide, for example, is a known skin tumor promoter (Kensler et al., 1995, Gimenez-Conti et al., 1998).

This study investigates the occurrence of 4 organic peroxide compounds (Table 2) in the Norwegian environment. Data on the import and production of organic peroxides are limited but between 4 and 17 tonnes of dicumyl peroxide (Di-Cup) was imported annually between 2010 and 2012.

1.4 New bisphenols

Bisphenol A (BPA) is a high-production volume chemical and used as a monomer in the production of polycarbonate polymers. It is recognized as an endocrine disruptor. Since there is a growing concern that exposure to BPA can cause a wide range of adverse health effects, Health Canada, Denmark, and the European Union have banned BPA use in baby bottles. In July 2013, BPA use in the coating of infant formula packaging has been prohibited by the US FDA. However, a related group of chemicals with structural similarity to BPA are also used in the manufacturing of similar polymers. These substances, with two phenolic rings joined through a bridging carbon or sulfur, are called “BPA-related compounds” or bisphenols (BPs; Table 3). They are synthesized by the condensation of a ketone (such as acetone, hence the suffix A in the name) with two equivalents of phenol. Recently, the restrictions for the use of BPA have forced the polymer industry to replace it with bisphenol S (BPS) in thermal paper and other products. Bisphenol F (BPF) and bisphenol B (BPB) can probably replace BPA in the production of epoxy resin and polycarbonate. They have been detected in canned foods and soft drinks. In addition to these analogs, bisphenol AF (BPAF) has broad application in the manufacture of phenolic resins or fluoroelastomers. Annual production is assumed to be in the range of 5 to 300 t in the USA (Yang et al., 2014).

Unfortunately these BP's may have the same health effects as BPA. In vitro and QSAR studies have shown that BPS, BPB, and BPF possess estrogenic activity similar to that of BPA (Rosenmai et al., 2014). A recent study by (Feng et al., 2012) demonstrated that BPAF can cause testosterone reduction by directly affecting testis function in adult male rats. Furthermore, some BP's are much less biodegradable than BPA.

The environmental occurrence of BPA has motivated substantial research into other BPs. In the past, the occurrence of TBBPA has been investigated in water, soil, sediment, and sewage. BPF is reported to occur in surface water, sewage, and sediment. More recently, several studies have been conducted on the occurrence of BPAF, BPS, and BPB in dust, water, and sediment. However, little is known about the environmental occurrence of bisphenol BP (BP-BP) and no scientific reference on environmental occurrence is available in relevant databases (SciFinder and Web of Science).

1.5 Selected PBT and other compounds

The group of selected PBT and other compounds are very diverse and consist of both phosphorous flame retardants (PFR), isopropyl naphthalenes and the cosmetic compound/fragrance Galaxolide/HHCB (Table 4). Organophosphate esters are used as flame retardants in different consumer and industrial products, like plastics, electronic equipment, furniture, textiles, and building materials. Furthermore, some of these chemicals, especially the non-chlorinated alkyl phosphates, are used as plasticizers and antifoaming agents in varnishes, hydraulic fluids, and polishes.

Isopropyl substituted naphthalenes are partially used as substitutes for PCBs and one major technical application is as solvent/modifier in polymer production and carbonless copy paper. Diisopropyl naphthalenes (DIPN) were produced and used as a mixture of isomers. Technical DIPN consists mainly of seven of the 10 possible isomers (1,3-, 1,4-, 1,5-, 1,6-, 1,7-, 2,6-, and 2,7-), and may contain minor amounts of the sterically hindered ortho-(1,2- and 2,3-) compounds and at most traces of the most hindered peri-(1,8-) isomer. 2,6- and 2,7-DIPN are commercially available as single isomers only (Franke and Grunenberg, 2007). They are suspected to be persistent and bioaccumulative. DIPN are frequently observed low-level contaminants of surface waters and aquatic sediments, however, the occurrence and fate of diisopropyl naphthalenes (DIPN) in the general environment has not been systematically investigated (Franke and Grunenberg, 2007, Suzuki et al., 2012).

The cosmetic compound/fragrance Galaxolide/HHCB is frequently used in washing, cleansing, and cosmetic products. Fragrances are constantly discharged in wastewater and can lead to elevated concentrations in surface waters, even if the respective substances are degradable (pseudo- persistency) (Klaschka et al., 2013).

Table 3: New bisphenols selected for screening

Name, Acronym, CAS and Log K_{ow}

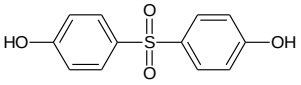
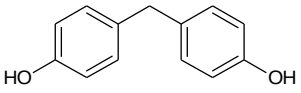
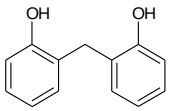
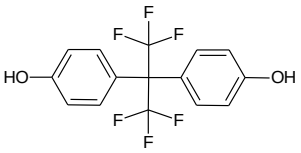
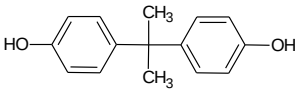
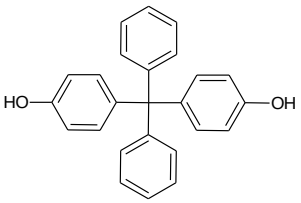
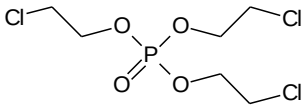
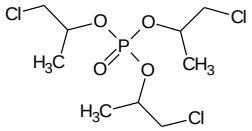
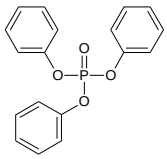
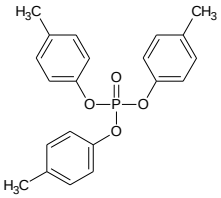
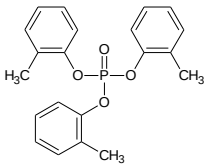
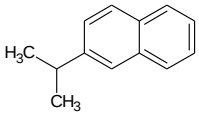
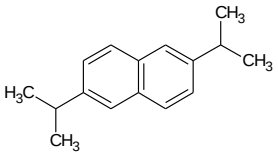
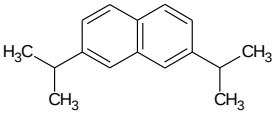
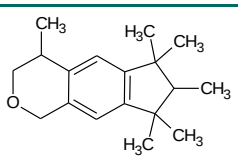
Type	Compound	Acronym	Structure	CAS	Function	Log K_{ow}
New bisphenols	4,4'-sulfonylbisphenol or Bisphenol S	BPS		80-09-1	Monomer in plastic production	1.7
	Methylenebisphenol or Bisphenol F	BPF		1333-16-0		2.9
	4,4'-methylenebisphenol or 4,4'-Bisphenol F	4,4'-BPF		620-92-8		2.9
	2,2'-methylenebisphenol or 2,2'-Bisphenol F	2,2'-BPF		2467-02-9		2.9
	4,4'-[2,2,2-trifluoro-1-(trifluoromethyl)ethylidene] bisphenol or Bisphenol AF	BPAF		1478-61-1		4.5
	4,4'-(1-methylethylidene)bisphenol or Bisphenol A	BPA		80-05-7		3.6
	4,4'-(diphenylmethylene)bisphenol or Bisphenol BP	BP-BP		1844-01-5		4.9

Table 4: PBT and other compounds selected for screening

Name, Acronym, CAS and Log K_{OW}

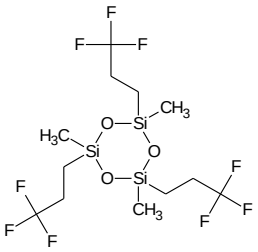
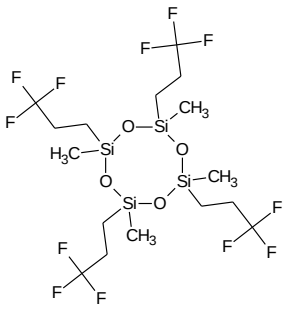
Type	Compound	Acronym	Structure	CAS	Function	Log K_{OW}
Phosphorous flame retardant	Tris(2-chloroethyl) phosphate	TCEP		115-96-8	FR	1.6
	Tris(2-chloropropyl) phosphate	TCPP		13674-84-5	FR	2.9
	Triphenyl phosphate	TPP		115-86-6	FR	4.7
	Tris(p-cresyl) phosphate	pppTCP		78-32-0	FR	6.3
	Tris(o-cresyl) phosphate	oooTCP		78-30-8	FR	6.3
	Tricresyl phosphate	SumTCP		1330-78-5	FR	6.3
	2-isopropyl naphthalene	2-IPN		2027-17-0	Solvent/ modifier	4.6
	2,6-Diisopropyl naphthalene	2,6-DIPN		24157-81-1	Solvent/ modifier	6.1
	2,7-Diisopropyl naphthalene	2,7-DIPN		40458-98-8	Solvent/ modifier	6.1
	Diisopropyl naphthalene	SumDIPN		38640-62-9	Solvent/ modifier	6.1
Fragrances	1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethylcyclopenta-γ-2-benzopyran or Galaxolide®	HHCB		1222-05-5	Fragrance	6.3

1.6 Fluorinated siloxanes

A comprehensive screening assessment recently performed by Howard and Muir (2010) has provided an insight into commercial chemicals that may be persistent (P) and bioaccumulative (B). Using several chemical registry lists within Canada and the United States, the US Environmental Protection Agency EPISuite software prioritized over 610 chemicals produced in significant amounts that were meet P and B criteria (Howard and Muir, 2010). Of these chemicals, 2,4,6-trimethyl-2,4,6-tris(3,3,3-trifluoropropyl)-cyclotrisiloxane (TFP-D3) was prioritized as one of the top 10 chemicals that should be further investigated due to its atmospheric persistence, large production volumes (0.45 - 4.5 kilotons) and high log K_{ow} (8.66 or 9.8). 2,4,6,8-tetramethyl-2,4,6,8-tetrakis(3,3,3-trifluoropropyl)-cyclotetrasiloxane (TFP-D4) was also listed as chemicals to be prioritized (Table 5).

Siloxanes use is widespread throughout industry, although their dominant usage has been in the personal care product and cosmetic industry. Much focus has been placed on octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5) and dodecamethylcyclohexasiloxane (D6) due to the high concentrations in cosmetic products (Horii and Kannan, 2008) and findings of elevated concentrations within various environmental media (Kierkegaard and McLachlan, 2010; Sparham et al., 2011; Sparham et al., 2008) and have displayed potential bioaccumulative behavior (Borgå et al., 2012; Kierkegaard et al., 2011; Warner et al., 2010). However, fluorinated siloxanes have also been listed as ingredients in cosmetic products and may also be a source of other fluorinated compounds present within cosmetic products (Yukiko et al., 2013).

Table 5: Fluorinated siloxanes selected for screening
Name, Acronym, CAS and Log K_{OW}

Type	Compound	Acronym	Structure	CAS	Function	Log K_{OW}
Fluorinated siloxanes	2,4,6-trimethyl-2,4,6-tris(3,3,3-trifluoropropyl)-cyclotrisiloxane	TFP D3		2374-14-3	Industrial, cosmetics	9.8
	2,4,6,8-tetramethyl-2,4,6,8-tetrakis(3,3,3-trifluoropropyl)-cyclotetrasiloxane	TFP D4		429-67-4	Industrial, cosmetics	12.4

2. Materials and Methods

2.1 Sample Collection

2.1.1 Wastewater treatment works

All of the wastewater treatment works (WWTW) samples were collected by staff at the respective plants. They were kindly asked not to use plastic gloves during samples and to avoid the use of personal care products. Twenty four hour composite effluent samples were collected by means of the automatic sampling equipment already found at the WWTWs for routine monitoring. The effluent samples were collected in clean glass bottles and shipped to NIVA. Sludge samples were collected using a procedure for the sampling of sludge was based on the Mattilsynet guideline for the sampling of sludge, compost and other waste-based fertilizer products. Five core samples of mixed sludge were collected from each facility. Each mixed sample was transferred to 4 glass sample jars using pre-washed stainless steel equipment provided by NIVA.

• Vestfjorden avløpsselskap (VEAS) at Slemmestad is Norway´s largest WWTW receiving municipal wastewater from a population of around 550,000. The plant annually receives between 100-110 million m^3 of wastewater that is treated mechanically, chemically and biologically (post-denitrification). The sludge is treated by anaerobic digestion and drying. The treated effluent is discharged at a depth of approx. 50 m depth in the Oslofjord .

• HIAS owned and receives wastewater from approx. 52,000 people from the municipalities of Hamar, Løten, Ringsaker, and Stange. The plant is located at Ottestad on Lake Mjøsa with the discharge point at a depth of 15 m around 250 m from the shore. Wastewater is treated mechanically, biologically (not N removal) and chemically. The sludge is treated by thermal hydrolysis (Cambiprocess at 160°C) prior to anaerobic digestion at 38°C.

• Tomasjord WWTP in the municipality of Tromsø is a primary WWTP with a capacity of 38,400 person equivalents. The wastewater is primarily domestic sewage and the mechanical treated wastewater is discharged into Tromsøysundet.

2.1.2 Landfill sites

Leachate sampling was performed using an ISCO 6712 automatic sampler for collecting a 24 hr composite sample from ISI landfill and Lindum Resource and Recycling AS. Flow data were obtained from the plants own water flow measurements.

• ISI landfill (Bærum Kommune) was established in 1974 and ceased being used in 2002. ISI covers an area of approximately 1.4 km^2 with a fill depth of between 12 and 21m. Groundwater levels in the landfill can be 7.2 m above the base of the landfill. The draining water, composed of leachate and incoming groundwater, flows through a discharge tank downstream of the landfill. Leachate from ISI is sent to VEAS WWTW for treatment.

• Lindum Resource and Recycling is located in Drammen and receives solid waste from the Drammen Region. Leachate from the landfill is heavily influenced by incoming groundwater, especially in the wake of heavy rainfall events. The total annual leachate volume in the period 2000-2006 was at 366,000 to 910,000 m^3. All the leachate goes through an aerated lagoon with subsequent sedimentation before it is pumped to Solumstranda WWTW.

2.1.3 Inner Oslofjord

Sediment

Sediment samples were collected at five stations along a transect from close to the discharge diffuser from the VEAS WWTW and southward in the deep water channel of Oslofjord (Figure 2; Table 6). On the west side of the

fjord, the tidal current runs in a southerly direction and is split by a vortex near the middle of the fjord south of Søndre Langåra. There are also currents through Ristsundet on the east side of Håøya, and one current on the west side of Håøya (Gråøyrenna). On rising tide most of the current flows on the east side of Håøya. Sediment stations were placed in the deep channel on both sides of Håøya. The sediment stations were on approximately same depths (Figure 3). Sediment was collected with a stainless steel Van Veen grab (Picture 1 and 2). Four replicate samples of the top 2 cm of the sediment were collected from each station. Each sample was a mixed composite from three grabs.

Figure 2. Map of the sediment stations in the Oslofjord.

Table 6: Position and depth of the sediment stations in the Oslofjord.

Station Nr.	Depth (m)	Position	Distance from VEAS diffuser (m)
1	100	N59 47.411 E10 31.153	400
2	98.6	N59 47.292 E10 31.149	300
3	100.5	N59 46.696 E10 31.407	2600
4	114	N59 42.431 E10 32.351	10000
5	140	N59 42.460 E10 34.462	9000

Pictures 1 and 2. Sediment was collected from five stations with a Van Veen grab (photos: Merete Schøyen, NIVA).

Atlantic cod

Atlantic cod (*Gadus morhua*) were caught by trawling from the research vessel F/F Trygve Braarud on the 5th of August 2013 (picture 3 and 4). The cod were caught in the area between Askerlandet and Steilene in the Inner Oslofjord and ranged in size from 0.755 to 8.5 kg (Table 7). Individual samples of liver were removed for chemical analysis and stored in heat-treated (500 °C) glass containers sealed with heat-treated aluminium foil underneath the lids. Samples were stored frozen (-20 °C) until analysis.

Pictures 3 and 4. Trawling of cod in the Inner Oslofjord (photos: Merete Schøyen, NIVA).

Table 7: Size, sex and liver weight of cod caught in the Inner Oslofjord

Fish No.	Length (cm)	Weight (kg)	Sex (M/F)	liver weight (g)
1	82	8.5	F	161
2	73	4.6	F	176
3	79	6.5	F	152
4	80	4.8	F	85
5	72	4.7	M	88
6	61	2.3	M	27
7	65	3.1	M	82
8	54	2.2	F	154
9	48	1.1	M	22
10	53	0.97	F	16
11	43	0.90	M	25
12	48	1.1	F	15
13	52	1.3	F	23
14	45	0.78	F	13
15	44	0.76	M	9.1

Northern shrimp

Northern shrimp (*Pandalus borealis*) were caught by trawling from the research vessel F/F Trygve Braarud on the 5th of August 2013 (picture 5 and 6). The shrimps were peeled and split into 15 bulk samples. Each sample was comprised of between 50 and 60 individual shrimps.

Pictures 5 and 6. Northern shrimp were caught by trawling in the Inner Oslofjord (photos: Sigurd Øxnevad, NIVA).

Common shore crab
Common shore crabs (*Carcinus meanas*) were caught at Sjøstrand, north of VEAS sewage treatment plant (Figure 3) on the 15th of August. A total of 180 common shore crabs were caught by snorkeling, and then stored at -20 °C. The crabs ranged from between 4 and 46 grams in size (picture 7 and 8). Fifteen bulk samples of soft tissue were made, with each sample comprised of a mixture of tissue from between 10 and 13 crabs.

Figure 3. Map with the station where common shore crabs were collected.

Pictures 7 and 8. Common shore crabs caught at Sjøstrand, north of VEAS sewage treatment plant (photos: Sigurd Øxnevad, NIVA).

2.1.4 Lake Mjøsa

Sediment
Five pooled samples of sediment were taken along a gradient from the discharge point to HIAS and south (Figure 4; Table 8). Each pooled sample consisted of three individual subsamples taken from the upper 0-2 cm sediment layer at a water depth of 25–35 m. We used a gravity corer with a core tube and a retractable sediment stopper in stainless steel. The samples were transferred to heat-treated (500 °C) glass containers sealed with heat-treated aluminium foil underneath the lids. The core tube and other sectioning equipment used were thoroughly cleaned with acetone and cyclohexane (HPLC grade) before use, and direct hand contact with the sampling matrix was avoided. They samples were stored frozen (-20 °C) until analysis.

Fish

From Lake Mjøsa we collected benthic fish of the following species during June–August 2013: burbot (*Lota lota*), perch (*Perca fluviatilis*) and whitefish (*Coregonus lavaretrus*). They were caught with gillnets, deployed in the area around the outlet of discharge pipe of the HIAS sewage treatment plant, at a depth of about 20 – 35 m (Table 8; Figure 4).

The fish were taken out of the nets as they were hauled, instantly killed with a short blow to the head, put in portable cool boxes (with ice packs) lined with clean aluminium foil and transported to a freezer (-20 °C). Before freezing the fish were wrapped in clean aluminium foil and put in polyethylene bags. At no time were the fish allowed in contact with plastics or other potentially contaminated surfaces. The time between catch and transfer to the freezer took no longer than 4 hours.

Before preparing soft tissue samples of the benthic fish, they were thawed, scraped clean of mucus with a solvent washed knife and placed on a cutting board covered with solvent rinsed aluminium foil. For each fish a solvent cleaned set of stainless steel dissection tools was used. We dissected the sagittal otoliths, and determined sex and maturity after opening of the abdomen. The stomach and intestines were then emptied and a soft tissue sample was prepared by dissecting out internal abdominal organs and lateral skeleton muscles. We registered the liver weight and total weight of each sample. The samples were stored in heat treated (500 °C) glass containers sealed with heat treated aluminium foil underneath the lids. The samples were then frozen (-20 °C) and sent to homogenization before analysis. 15 individual samples were prepared of each species.

To reduce the risk of contamination during catch and sample preparation, all personnel involved avoided use of personal care products at least 24 hours in advance. Also, dissection and preparing of samples took place outside in a non-urban area. Dissection equipment and aluminium foil that could be in direct contact with the samples were cleaned with acetone and cyclohexane (HPLC grade) before use, and direct hand contact with the sampling matrix was avoided.

Supplementary samples of large piscivorous pelagic brown trout (*Salmo trutta*) were included in the present project at a later stage. The brown trout were caught by gill-nets during August 2013 in the northern part of Lake Mjøsa (Table 8). They were stored frozen (-20 °C), wrapped in clean aluminium foil and polyethylene bags, until preparation of dorsal muscle samples using the same protocols as for the benthic fish.

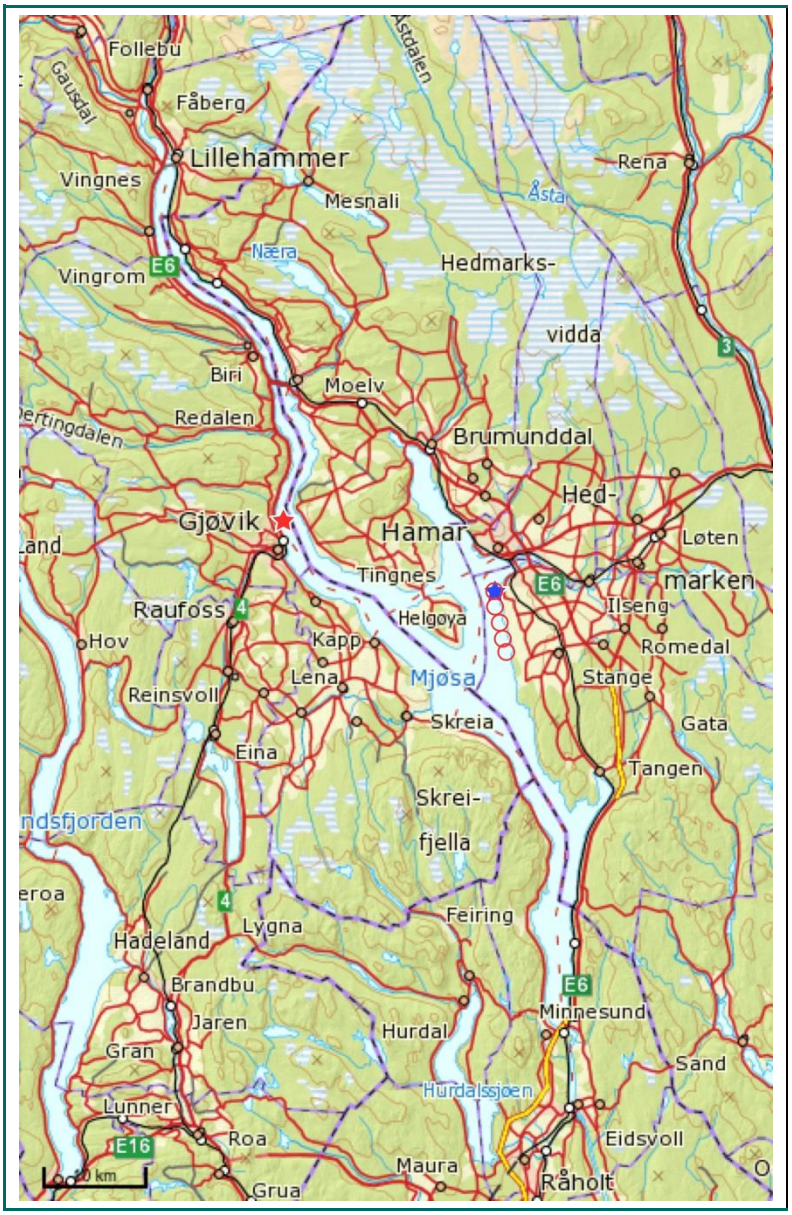


Figure 4. Map showing Lake Mjøsa, the catch sites (blue star: whitefish, perch and burbot; red star: brown trout) and sediment sampling sites (red circles). The location coordinates are given in Table 8

Table 8: Coordinates for the Lake Mjøsa sediment and fish sampling stations

Station	Date	Depth (m)	UTM 33E	UTM 33 N	°E	°N
Sediments						
St-1	26.06.13	35	286400	6743600	11.059	60.766
St-2	26.06.13	25	285941	6742150	11.075	60.759
St-3	26.06.13	25	285932	6740684	11.072	60.744
St-4	26.06.13	25	286479	6739302	11.084	60.732
St-5	26.06.13	25	287021	6737370	11.096	60.715
Fish						
St-1	26.06-17.08.13	20–35	286400	6743600	11.059	60.766
St. Gjøvik	20.08.13	10-20	265100	6750000	10.680	60.816

2.2 Chemical analysis

2.2.1 Organic UV filters

Materials
All standards (DEET, BP-3, ODPABA, EHMC, OC, MBT, MBTS, DCHA, UV-234, UV-327, UV-328, UV-329, UV-360, UV-571) and internal standards (BP-d10, naphthalene-d8, chrysene-d12, atrazine-d5 and caffeine-13C) were purchased from Sigma-Aldrich (Germany). Bulk primary secondary amine (PSA) sorbent (Supelco, SuperClean) was supplied by Sigma Aldrich (St. Louis MO, USA) and Hydromatrix was supplied by Varian.

Sample Preparation and Extraction
Solid samples (biota, sediment and sludge)
Samples were weighed according to Table 9. Note that cod liver was initially weighed and extracted as a wet-weight, but a sub-sample of the extracted lipid was processed for analysis. All solid samples were extracted by Accelerated Solvent Extraction (Dionex ASE 200 system, Sunnyvale CA, USA). Sediment and sludge samples were freeze dried prior to extraction and biota samples were extracted wet. Approximately 1 g of PSA was added to the ASE cells (22 ml) to aid the clean-up of fatty acids and other matrix interferents. Samples were mixed with Hydromatrix sorbent to improve the solvent flow through the ASE cell and the mixture composed the second layer in the ASE cell. The ASE extraction solvent was hexane/dichloromethane (50/50, v/v) at a temperature of 100 ºC. The static time was 5 mins, and the purge time 2 mins with 3 static cycles. Internal standard (100 ng) was spiked into each ASE cell before extraction. The only exception was samples of cod liver where the internal standard (100 ng) was spiked to the lipid sub-sample (prior to GPC cleanup, below).

Table 9: Clarification of solid sample weights and measures

		Sample weight detail		
Matrix	Nominal sample weight (g)	Wet weight	Dry weight	Lipid weight
Sludge	3		X	
Sediment	2		X	
Cod (liver)	0.2			X
Shrimp (whole)	5	X		
Perch (filet)	5	X		
Burbot (filet)	5	X		
Whitefish (filet)	5	X		
Crab	2	X		

The ASE extracts were reduced to approximately 1 ml under a stream of before further clean-up via Gel Permeation Chromatography (GPC). GPC was carried out on an Alliance 2695 system (Waters, Milford MA, USA) with two sequential Envirogel (Waters, Milford MA, USA) GPC clean-up columns (19 x 300 mm and 19 x 150 mm) and dichloromethane (DCM) as a mobile phase. The 12.1 – 20.0 minute fraction was collected and further processed for analysis. (Fractions 0 – 12.1 minutes and 20.0 – 30.0 minutes were discarded).
The GPC cleaned fraction was subsequently reduced to 2 ml under a stream of nitrogen (35 ºC). PSA sorbent (approximately 100 mg) was added to each extract to further remove matrix interferants. Samples were centrifuged (21 000 g, 10 minutes) and the supernatant transferred to vials for analysis via LC-HRMS and GC-HRMS. Note that samples for LC-HRMS were solvent-exchanged to acetonitrile (from DCM) before injection on the LC system.

Water samples
Wastewater samples (approximately 1 L) were spiked with internal standard (100 ng) and extracted via solid phase extraction (SPE) on Oasis HLB (200 mg, 6 ml) cartridges (Waters Corp, Milford MA, USA).
SPE cartridges were pre-washed with dichloromethane (10 ml) and methanol (10 ml) before equilibration with water (10 ml) prior to sample-loading. SPE cartridges were eluted with 20 ml ethylacetate/DCM (50/50) and the eluent reduced to 2 ml under a stream of nitrogen (35 ºC) and transferred to vials for analysis via LC-HRMS

and GC-HRMS. Note that samples for LC-HRMS were solvent-exchanged to acetonitrile (from ethylacetete/DCM) before injection on the LC system.

Sample Analysis

GC-HRMS

Samples (1 µl) were injected into an Agilent gas chromatograph fitted with a 30 m × 0.25 mm, 0.25 µm film thickness DB-5MS column (Agilent Technologies) with helium carrier gas (Table 10). Splitless injection at 250 °C was used. The initial temperature of 60 °C was held for 2 min, followed by an increase of 15 °C/min to 120 °C, followed by 5 °C/min to 280 °C and held for 5 minutes. The high-resolution time-of-flight mass spectrometer (GCT Premier, Waters Corp, Milford MA, USA) was operated in full scan positive electron impact mode with a scan range of 100−450 m/z. Accurate mass spectra to 4 decimal places was used for peak identification with an error threshold of 5 mDa. See Table 10 for details.

LC-HRMS

Analysis was carried out on an Acquity UPLC system with a Xevo G2-S QTOF mass spectrometer as detector (both UPLC and MS from Waters Corp, Milford MA, USA). Chromatography was performed on a Waters Acquity BEH C8 column (2.1 x 50 mm) running a 7 min gradient from 50 % methanol in 10 mM ammonium acetate to 100 % methanol. Mass spectrometry was performed in positive electrospray mode (0.7 kV capilliary and 20 V cone). Data acquisition was in MS^E mode with the low energy (LE) function having a 5 V collision, and the high energy (HE) function having a collision ramp from 15 – 45 V. The LE function provides accurate mass detection of the parent ions (MH^+), while the HE function provides time-aligned accurate mass fragment information. See Table 10 for details.

Table 10: Analytical parameters for theGC and LC analysis of UV filters

Analyte	GC		LC	
	Retention time (min)	m/z	Retention time (min)	m/z
DEET	15.5	190.129+119.05	0.52	192.13
BP3	25.2	227.088+228.099+ 151.055		
ODPABA	29.0	165.082+148.086+ 227.22	2.16	278.208
EHMC	29.9	178.066+61.069+ 290.215	-	161.055+179.065+291.192
OC	35.0	360.17+361.192+ 250.072+249.68	2.52	250.08+232.07+362.21
MBT	-		-	167.989
MBTS	-		1.4	332.961
DCHA	-		0.33	182.186
UV-234	-		3.38	448.237
UV-327	35.2	323.199	3.47	358.165
UV-328	35.1	351.266	3.61	352.235
UV-329	35.1	342.149+357.194	2.73	324.204
UV-360	-		5.03	659.410
UV-571	-		-	394.280

2.2.2 Organic peroxides

Reagents and standard solutions
Peroxides, dicumyl peroxide (CAS 80-43-3), bis(tert-butylperoxyisopropyl)benzene (CAS 25155-25-3) and dimethyl-di(tert-butylperoxy)hexane (CAS 78-63-7) were purchased from Sigma-Aldrich and tert-butyl-cumyl peroxide (CAS 3457-61-2) was obtained from AkzoNobel. Other reagents and solvents (methanol, acetonitrile, formic acid and ammonium formate) were of HPLC grade or analytical-reagent grade and obtained from Rathburn Chemicals (Walkerburn, UK). Water was deionized (MilliQ). Oasis HLB SPE columns were from Waters (Milford, MA, USA)

Sample preparation
Homogenized solid samples (approx. 2 g) of fish, shrimp, crab, sediment and sludge (centrifuged) were double extracted with 3 ml ACN by vortex mixing for 3 min, and centrifuged at 2500 g for 5 min between extractions. The two extracts were combined in a volumetric tube, and the volume was adjusted to 10 mL with ACN. Water samples were extracted on HLB SPE columns, preconditioned with MeOH and water, and the peroxides eluted with MeOH (6 ml). Extracts were filtered prior to analysis using Costar Spin-X 0.2 µm nylon filter (Corning, NY, USA).

UPLC-MSMS
Liquid chromatography was performed on a BEH C18 column (3µm, 50 × 2.1 mm) (Waters, Milford, MA, USA), using a Waters Acquity UPLC module. Separation was achieved using a linear gradient elution at 0.4 mL/min starting with methanol–water (40:60, water both containing 2.6 mM ammonium acetate) rising to 100% methanol over 5 min. Isocratic elution with 100% methanol was maintained for 5 min before the eluent was switched back to 40% methanol. The UPLC system was coupled to a Quattro Premiere triple quadrupole mass spectrometer operating with an ESI interface (Waters Micromass, Manchester, UK). Typical ESI parameters were a spray voltage of 3.5 kV, desolvation temperature at 400°C, source temperature at 120 °C and cone gas and desolvation gas at 50 and 800 L/h of N2, respectively. The mass spectrometer was operated in MS/MS mode with argon as collision cell gas at 1.3 × 10-3 Torr. Ionization and MS/MS collision energy settings (typically 25 eV) were optimized while continuously infusing (syringe pump) 20 ng/mL of individual peroxide standards at a flow rate of 10 µL/min. Screening of the peroxides was performed with multiple reaction monitoring (MRM) in positive ionization mode using the $(M+NH_4)^+$ adducts of dicumyl peroxide 288.2>119, tert-butyl cumyl peroxide 288.2>91, 226.2>135, 226,2>119, di(tert-butylperoxyisopropyl)benzene 356.2>249.1 and 2,5-dimethyl-2,5-di(tert-butylperoxy)hexane 308.3>73. The organic peroxides were quantified using an external calibration curve of standard specimens solved in acetonitrile–water (90:10).

Validation
Control fish fillet (2 g) were fortified with 100 and 1000 ng (n=3) of each of the peroxides to give concentrations of 50 and 500 ng of each peroxide/g sample. 1 L of water was fortified with 100 ng (n=3) of each of peroxides to give a concentration of 100 ng/L sample (Table 11).

Table 11: Recoveries of organic peroxides
[a]fish fillet (ng/g), [b]water (ng/g), n=3

Level	Dicumyl peroxide		Di(tert-butylperoxyisopropyl)benzene		2,5-dimethyl-2,5-di(tert-butylperoxy)hexane	
	Recovery (%)	RSD (%)	Recovery (%)	RSD (%)	Recovery (%)	RSD (%)
50[a]	98	5.4	98	4.7	95	4.2
100[b]	92	6.3	90	6.8	89	6.9
500[a]	101	5.1	95	3.8	102	4.7

Determination of LOD
LOD were calculated using signal/noise ratio of 3. In biota and sediments LODs were 5, 1 and 10 ng/g for dicumyl peroxide, Di(tert-butylperoxyisopropyl)benzene and 2,5-dimethyl-2,5-di(tert-butylperoxy)hexane respectively. In water LODs were LODs were 5, 1 and 10 ng/L for dicumyl peroxide, Di(tert-butylperoxyisopropyl)benzene and 2,5-dimethyl-2,5-di(tert-butylperoxy)hexane respectively.

Within the time frame of the project there was no standard commercially available for tert-butyl cumyl peroxide that could be delivered. The M/S mass transitions were determined theoretically and samples were monitored for the occurrence but no peaks were observed. Delivery of a standard after project completion enabled the mass transitions to be verified although ionization was very poor resulting in non-determinable limits of detection.

2.2.3 New bisphenols

Materials and General Remarks
Standards (BPA, o,o'-BPF, p,p'-BPF, BPS, BPAF, and BP-BP) and internal standards (^{13}C BPA) were purchased from Sigma. Solvents, adsorbents and SPE were purchased from VWR and Matriks, Oslo, Norway.

Special precautions of sample preparation and cleanup of samples is important to decrease background levels of bisphenols. All glassware was heated to 450 ºC before use and washed with acetone. Metallic spoons were sonicated in acetone, while solid phase cartridges were thoroughly washed with the strongest eluent.

Sample Preparation and Extraction
Biological samples
1 g of sample was homogenized in dry Na_2SO_4 and added internal standard and extracted with DCM by ultra-sonication. The extract was concentrated, solvent exchanged to n-hexane, and liquid-liquid partition extraction was performed using n-hexane and acetonitrile. The n-hexane phase was discarded while the acetonitrile fraction was further cleaned using florisil chromatography and the analytes with DCM/MeOH 1/1. In the last step, the volume of the extract was reduced almost to dryness, diluted with methanol and subjected to LC-HR-TOF analysis.

Sediment and particle samples
Wet Sediment/sludge samples were mixed with a mixture containing Thermo Dionex ASE Prep MAP and Thermo Scientific Dionex DE- diatomaceous earth) and packed into the ASE cells containing diatomaceous earth and 3 g of activated Florisil and extracted using acetone:hexane (50:50) with a following method: Pressure: 1500 Psi temperature: 100 ºC, Flush: 80%, 1 min preheat, 5 min heat, Static: 8 min, Purge: 90 sec. In the next step, the extract was concentrated up to 2 ml, diluted with MilliQ water (pH 3) and further cleaned with Biotage Isolute MM SPE cartridge that was conditioned with 5ml ethyl acetate, acetonitrile and MilliQ. After loading the sample cartridges were washed with 15 ml of MilliQ water, dried down for 30 min and eluted with 5 ml of acetonitrile, ethyl acetate and 10 ml acetone:DCM (5:1). In the last step, the volume of the extract was reduced almost to dryness, diluted with methanol and subjected to LC-HR-TOF analysis.

Water samples
Water samples were extracted using Agilent BondELut PPL SPE cartridges preconditioned with 5 ml of methanol/acetonitrile (1:1) and 5 ml of MilliQ water. After loading the sample, the cartridge was washed with 5 ml of MilliQ, dried for 30 min and eluted with 10 ml of methanol/acetonitrile (1:1) and 5 ml acetone. The extracts were combined, volume reduced to near dryness, diluted with 0.5 ml of methanol and subjected to LC-HR-TOF analyses.

Analysis
LC-HR-TOF analyses were performed with an Agilent 1290 Infinity UHPLC coupled with Agilent 6530 QTOFMS with Agilent JetStream ESI source operated in negative mode. Samples were separated using a reverse phase Waters Cortecs UPLC C18 column (90 Å, 1.6 µm, 2.1 mm x 150 mm) with Waters Cortecs UPLC C18 VanGuard pre-column (90 Å, 1.6 µm, 2.1 mm x 5 mm). The mobile phase was water (A) and methanol (B). Separation was achieved using a flow rate of 0.35 ml/min with the following gradient: 80:20 to 40:60 in 2 min, 30:70 at 5 min, 25:75 in 7 min and 10:90 in 10 min which was hold for 4.5 min. ^{13}C-bisphenol A was used as an internal standard.

2.2.4 PBT compounds

Materials and General Remarks

Standards (TCEP, TCPP, TPP, oooTCP, 2-IPN, 2,6-DIPN, 2,7-DIPN, and HHCB) and internal standards (d_{15} TEP, d_{27} TBP and d_{15} TPP) were purchased from Sigma. Solvents, adsorbents and SPE were purchased from VWR, Oslo, Norway.

Special precautions for sample preparation and the cleanup of samples are important to decrease background levels of PFRs. All glassware was heated to 450 ºC before use and washed with acetone. Metallic spoons were sonicated in acetone, while solid phase cartridges were thoroughly washed with the strongest eluent.

Sample Preparation and Extraction

Biological samples

Two grams of sample was homogenized in anhydrous Na_2SO_4 and placed in an extraction column and a PFR deuterated internal standard added and extracted using a solvent of ethylacetate/cyclohexane. The extract was concentrated and liquid-liquid partition extraction performed using n-hexane and acetonitrile. The n-hexane phase was discarded while the acetonitrile fraction was further cleaned using SPE using Supelclean™ PSA and the analytes extracted using methyl tert-butyl ether. The sample was concentrated to dryness and 0.5 ml of toluene added and transferred to analytical vials.

Sediment and particle samples

Sediment samples were dried before extraction at 35 °C until constant weight. Internal standard was added and the sample soxhlet extracted using ethylacetate/cyclohexane for 8 hr with activated copper in the collection vessel. Samples were concentrated and cleaned-up using activated florisil and the analytes collected using etylacetate/cyclohexane. The extract was concentrated and transferred to vials for analysis. Particles from water samples were filtered out on a microfiber filter GF/C. The filter was dried at 35 °C and extraction and clean-up was done as for the sediment samples.

Water samples

Water samples (150-250 ml), containing the internal standard, were extracted by SPE using pre-conditioned Strata-X columns. Following extraction the cartridges were dried and the analytes eluted using dichloromethane. The samples were concentrated and transferred to vials for analysis.

Analysis

Analysis of the PFRs was performed on a Waters Quattro micro GC/MSMS using a Restek Sil5-MS column.

2.2.5 Fluorinated siloxanes

Materials

The standards TFP-D3 and TFP-D4 were purchased from ABCR (Germany), tris(trimethylsiloxy)silane (M3Q) were purchased from Aldrich (Germany), and internal standards dodecamethylcyclohexasiloxane (13C-D6) were purchased from Laordan Fine Chemicals (Sweden).

Sample Preparation and Extraction

Water samples

Wastewater samples (15 ml) were spiked with internal standard (^{13}C-D6; 20 ng) prior to analysis.

Sediment samples

Sediment samples (0.5 g) were spiked with internal standard ^{13}C-D6; (20 ng) and extracted with hexane by sonification (3 x 15 min), with vortexing in between. Following centrifugation tris(trimethylsiloxy)silane (M3Q) was added as recovery standard to an aliquot of the sample prior to analysis.

Sample Analysis

GC-MSD

Waste water analysis were carried out on a headspace auto sampler (Teledyne Tekmar HT3 from Teledyne Tekmar, Mason OH, USA) coupled to a Agilent 7890A gas chromatograph equipped with a single quadrupole mass spectrometer (MSD), 5975C VL MSD (Agilent Technologies). Chromatography was performed on a J&W DB-WAX ETR column (30 m × 0.25 mm id × 0.25 µm from Agilent Technologies). The GC temperature program incorporated an initial temperature of 40 °C with a hold time of 3 min, increased by 25 °C/min to 190 °C,

followed by a second temperature ramp of 40 °C/min to 240 °C and held for 4 min. The MSD was operated in single ion monitoring (SIM) mode and Electron ionization (EI) was used as ionization method. Linearity and response was assessed with a calibration curve ranging from 0-250 ng/ml. See Table 12 for details.
The chromatographic analysis of sediment extract was performed on an Agilent 5890N gas chromatograph equipped with a J&W DB-WAX ETR column (30 m × 0.25 mm id × 0.25 µm from Agilent Technologies) and Agilent 7683B autosampler. A volume of 1 µl was injected using a split/splitless injector in splitless mode. Injection temperature of 200 °C was used with helium as a carrier gas at 1 ml/min at constant flow. The GC temperature program incorporated an initial temperature of 40 °C with a hold time of 3 min, increased by 25 °C/min to 190 °C, followed by a second temperature ramp of 40 °C/min to 240 °C and held for 4 min. The isomer identification was performed by SIM mode on a 5975C inert XL MSD (Agilent Technologies), and Positive Chemical Ionisation (PCI) was used as ionization method. See Table 12 for details.

Table 12: Analytical parameters for GC analysis

Analyte	Headspace/GC/EI		GC/PCI	
	Retention time (min)	m/z	Retention time (min)	m/z
13C D6	7.03	434.1 + 435.1	6.84	434.0 + 435.0
TFP-D3	7.69	137.0 + 159.0 + 215.0 + 292.9	7.38	137.0 + 215.0 + 237.0 + 273.0
TFP-D4	8.84	137.0 + 159.0 + 215.0 + 292.9	8.54	137.0 + 215.0 + 237.0 + 273.0
M3Q	5.01	281.0 + 282.0	-	-

2.3 Supporting parameters

2.3.1 Particle Size Analysis

Wet sediment was shaken by mechanical fractionater with < 63 µm sieves. Dry weight measurements were used for the particle size calculations.

2.3.2 Sediment TOC

Freeze dried sediment sample aliquots (0.5-10 mg) were heated in a furnace at 1800 ºC in the presence of oxygen free helium. The carbon dioxide gas produced was passed through a chromatography column and the total organic carbon was measured.

2.3.3 Water DOC

Samples (4 ml) were injected into an inorganic carbon chamber and 0.5 ml 21% phosphoric acid was added. The inorganic bound carbon from carbonates, bicarbonates and dissolved CO_2 is released to an NDIR detector for CO_2 quantification.

2.3.4 Lipid content

An aliquot of homogenised biota (approx 2 g) was weighed. 40 ml of cyclohexane/isopropanol (50/50) was added and the samples shaken for 2 hours. The samples were centrifuged at 2000 g for 10 minutes. The solvent phase was decanted into a clean tube and the extraction repeated with 30 ml of cyclohexane/isopropanol (50/50) and the extracts combined. 20 ml of 0.5% NaCl was added to the combined extracts and shaken before again centrifuging at 2000 g for 10 minutes. The cyclohexane layer was transferred to pre-weighed tubes and then evaporated under nitrogen. When the cyclohexane had been removed the tubes were heated at 60 ºC to a constant weight (approx 24 hrs) and the lipid content calculated.

2.3.5 $\delta^{13}C/\delta^{13}N$ ratio analysis

Samples were dried at 60 ºC for 24 hours before grinding to fine powder. Approx 1 mg of were combuted in the resence of O_2 and Cr_2O_3 at 1700 ºC in a Eurovector element analyser. Reduction of NO_x to N_2 was done in a Cu oven at 650 ºC. H_2O was removed in a chemical trap of $Mg(ClO_4)_2$ before separation of N_2 and CO_2 on a 2 m Porapolt Q GC column. The C/N ratio was quantified on the basis of the m/z 44/28 ratio. N_2 and CO_2 were directly injected online to an isotope ratio mass spectrometer (Nu Instruments Horizon) for the determination of $\delta^{13}C$ and $\delta^{13}N$. The mean stable N-isotope ratios, δ15N, reflects the relative trophic position of the organisms. Likewise, the stable C-isotope ratio, δ13C, reflects the carbon sources of the organism. A low $\delta^{13}C/\delta^{13}N$ ratio indicates influence from a pelagic food chain whereas a higher ratio indicates a more littoral food chain. We have lipid-adjusted all the δ13C-ratios in order to remove the effect of 13C-depleted lipids in the fatty burbot samples.

2.4 Uncertainties

When performing environmental screening studies for contaminants of emerging concern, all steps in the process, starting with study design, selection of the sampling sites, sampling frequency, time of sampling, performing the sampling, the transport and storage of samples, chemical analysis and data treatment, to some extent generate some degree of uncertainty. To quantitatively estimate the contribution of all steps is an extreme difficult task. However, we will discuss the relevance of the different contributors in a qualitative way.

Study design

The concentrations of the different compounds of interest in environmental samples vary considerably due to variations in sample types and by biological, temporal, or local variations. Different important decisions may have an influence on the outcome of the study such as the selection of sample sites, relevant season, relevant selection of sample types, right balance between number of individual samples contra number of different sampling sites.

Sampling and sample handling

Factors with influence on sampling uncertainty are analyte loss due to adsorption to sample containers, wastewater flow and particle content, contamination (for some compounds), and degradation during transport and storage. An important factor especially for sewage is the problem in preparation of representative and homogenous sub-samples. Sludge and to a lesser degree effluent are very heterogeneous matrices. In theory it is possible to prepare a sludge sample in a way that identical subsamples can be taken. However, this would require several days of specialized treatment for each sample. The complete homogenisation of all sludge samples, aiming for identical subsamples, would consume the whole budget for chemical analysis. In addition extensive sample treatment can have negative impact on the integrity of the true concentration of the analytes, either due to contamination or due to loss by adsorption to the homogenisation instruments in use. Therefore, normal practice is to find an acceptable balance between homogeneity and limited sample pre-treatment.

The following example may illustrate the consequence for this study: Given that most of the BPA-load of sludge sample is bound to only five plastic particles in this sample, it will be impossible to make ten identical sub-samples without disintegrating and milling these particles. This example is obviously quite extreme but it illustrates that the concentration of particle bound pollutants will vary considerable from sub-sample to sub-sample. The consequence for this study is that a variation from week to week may not be significant. However, if all samples from one plant are high and all samples from another plant are low, this should be treated as a significant difference.

Chemical analysis

The uncertainty of the chemical analysis is governed by loss during extraction and clean-up, interference from other compounds, trueness of analytical standards, instrumental parameters, and contamination. A normal approach to estimate and quantify these factors is the participation in a laboratory intercalibration. However, at this initial stage the analysis of some of the selected compounds is not done routinely and intercalibration studies have not been available. The uncertainty is expected to be larger for compounds which are analysed infrequently than for compounds which are analyzed commonly. That means that most compounds will probably have analytical uncertainties in the range of 20 to 40 % and in special cases even higher. For all analytes we consider the analytical uncertainty as fit-for-purpose that means adequate for a screening study, however, to use these results for future time trend studies is not advisable.

3. Results and Discussion

3.1 Wastewater treatment works effluent

3.1.1 UV-Chemicals

Total UV filter concentrations in effluent were measured in the range 300-8900 ng/L with OC, BP-3 and EHMC dominating the effluent streams (Figure 6). Total sludge concentrations however were 2 orders of magnitude higher and in the range 5-51 µg/g with OC, EHMC, UV-327 and UV-328 dominating. Lui et al., (2012) also noted higher concentrations of BP-3 in effluent than in sludge and the reverse for OC with a negligible amount in the effluent relative to sludge concentrations. The concentrations of OC in effluent from Tomasjord (median concentration 2,167 ng/l) were over an order of magnitude higher than in samples from VEAS or HIAS (median concentrations of 258 and 158 respectively) which both have more advanced treatment processes. There was no loss of OC observed in an Australian study (Liu et al., 2012) during primary treatment but during secondary treatment some loss was observed which, in combination with the high concentrations detected at Tomasjord, may indicate that mechanical treatment alone is not sufficient for OC removal.

In this study the concentrations of UV-327 in sludge from VEAS and HIAS were an order of magnitude higher than those measured in sludge from a STW in China (Zhang et al., 2011; Figure 6). BP-3 measured in sludge from HIAS was 2 orders of magnitude higher. 100% removal efficiency of UV-326, -327 and -328 was observed at a wastewater treatment plant in Spain and over 30% removal was observed at another wastewater treatment plant in Portugal (Carpinteiro et al., 2012). In the present study, benzotriazoles were not detected in any effluent samples with the exception of 3 samples from Tomasjord (4.6-5.6 ngl), UV-327 and UV-329 were however detected in the sludge from HIAS and VEAS (sludge was not collected from Tomasjord). UV-327 was detected in the range 30.4-159.6 ng/g and UV-329 was more than an order of magnitude higher (1172-3075 ng/g).

DEET is often poorly removed during wastewater treatment processes and its removal rates are very dependent on the treatment processes involved. Activated sludge treatment for example, has demonstrated greater removal rates than trickling filters and low hydraulic or sludge retention times significantly reduce removal (Nakada et al., 2006; Reemtsma et al., 2006; Weigel et al., 2004). Its physico-chemical properties indicate that sorption to sludge will not be a significant removal mechanism either. The results from this study support other reported hypotheses that wastewater effluent is a significant source of DEET to receiving waters. Sandstrom et al., (2005) observed a positive correlation between DEET and other personal care products detected in receiving waters where no correlation was observed between DEET and industrial chemicals. DEET is not considered to be a PBT compound and the concentrations measured in effluent, before dilution in receiving waters, remain well below chronic and acute effect concentrations. A comprehensive summary of toxicity data (Weeks et al., 2012) found acute effects concentrations of 4-388 mg/L and chronic NOEC of 0.5-24 mg/L? in selected aquatic species. The maximum concentrations measured in effluent were 1109, 4261 and 15010 ng/L? at VEAS, HIAS and Tomasjord respectively which all fall below any effect concentrations.

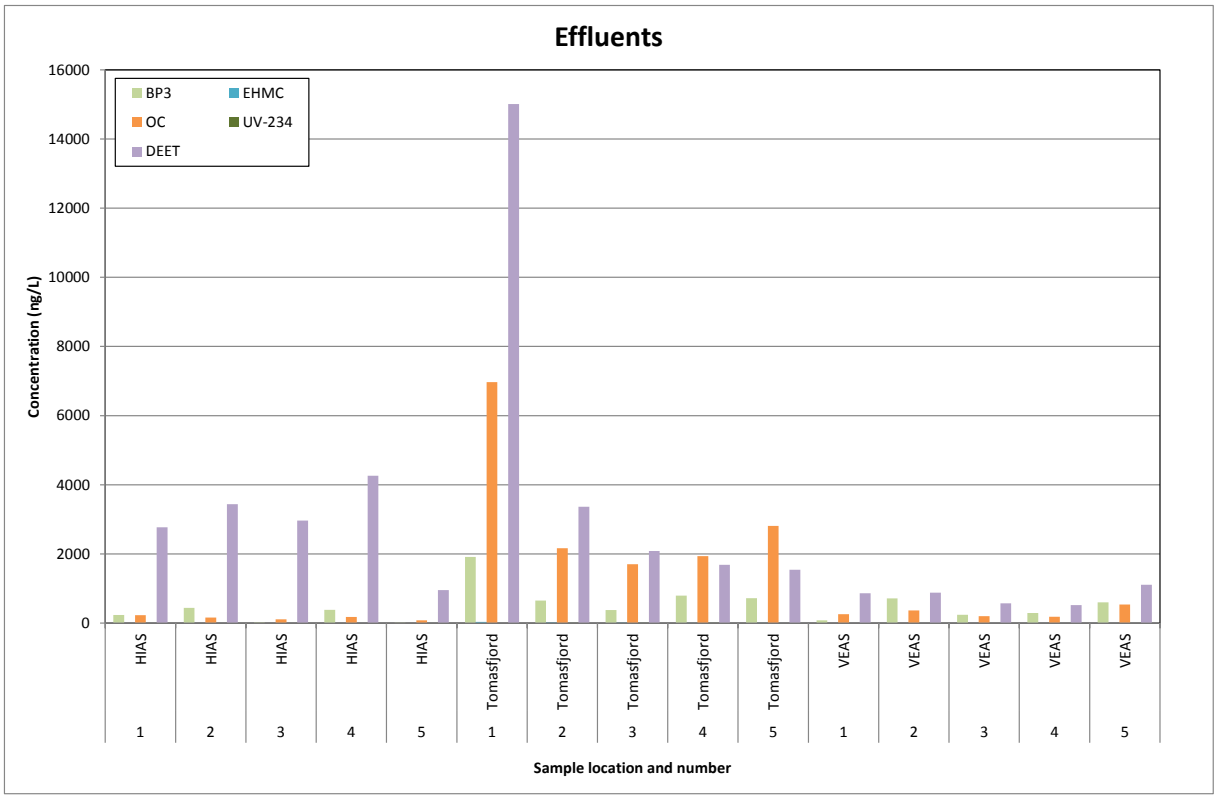


Figure 5. Concentrations of BP3, EHMC, OC, UV-234 and DEET in WWTW effluent

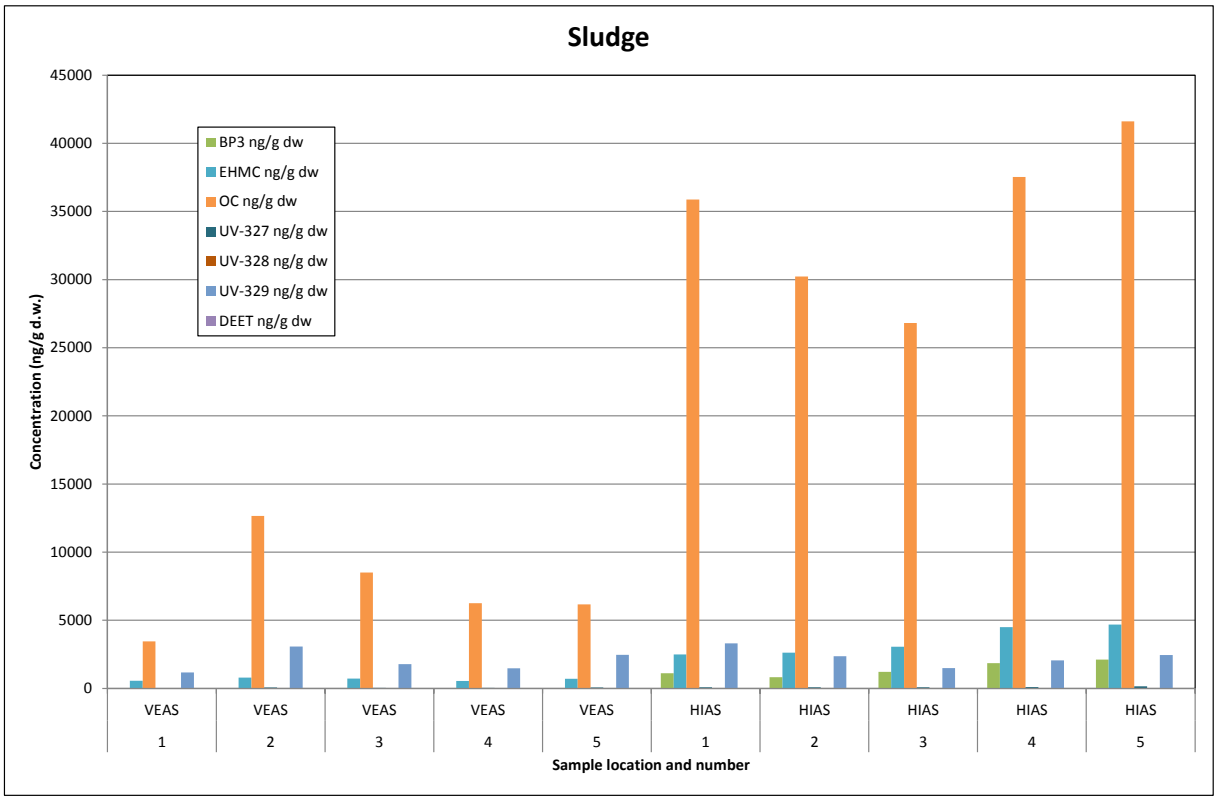


Figure 6. Concentrations (ng/g dw) of organic UV filters and DEET in sludge.

Table 13: Median daily effluent loadings of selected organic UV filters and DEET
(mg/day/1000 people)

	BP3	EHMC	OC	UV-234	DEET	Total UV
VEAS	137	nd	127	nd	417	221
HIAS	148	nd	70.0	nd	1658	218
Tomasjord	169	3.1	561	1.3	678	794

nd. Not detected

3.1.2 Organic peroxides

The only organic peroxide detected in effluent above the LOD was dicumyl peroxide, which was present at concentrations of between <5 and 11 ng/L in the effluent samples collected from HIAS and Tomasjord (Figure 7). None of the peroxides were detected in sludge above the LOD.

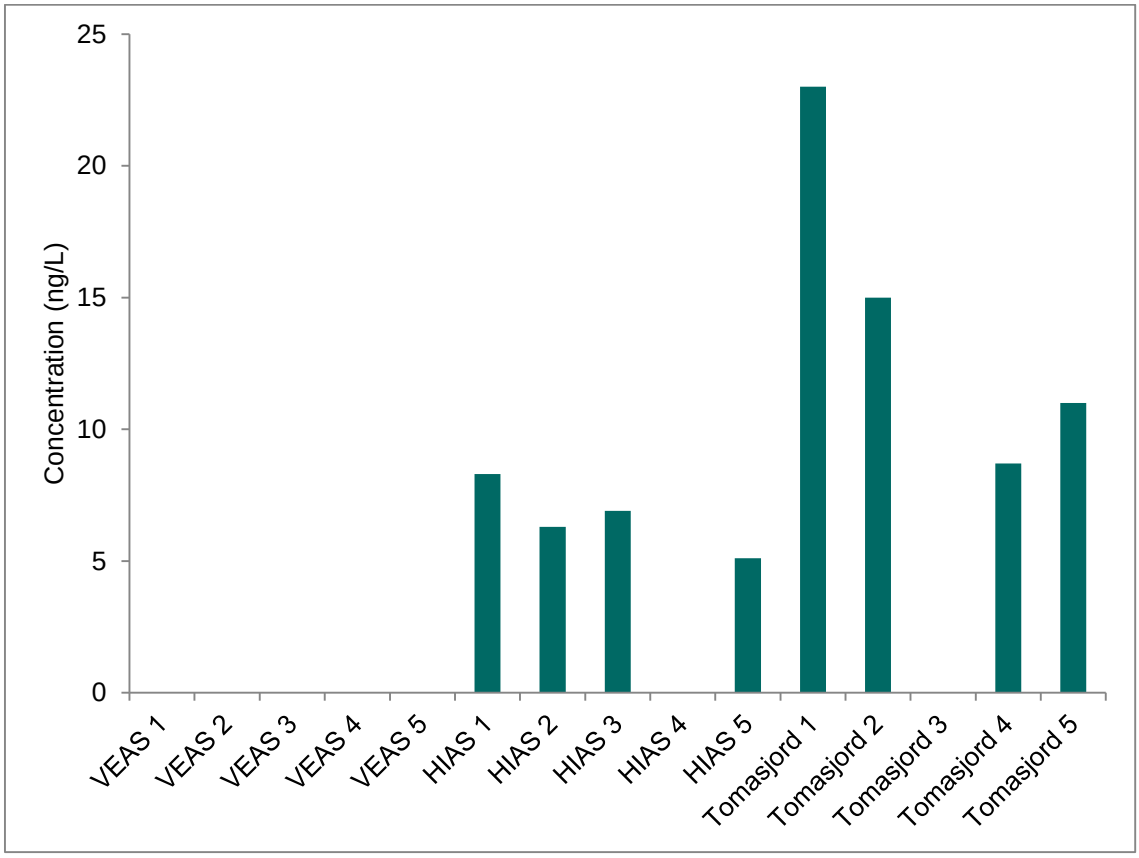


Figure 7. Concentrations of dicumyl peroxide in WWTW effluent

3.1.3 Selected PBT substances

The individual PBT substances in effluent were measured in the range of between <LOD and 4,000 ng/L (Figure 8). The different measured PFRs were in the range of <LOD-4,000 ng/L with TCPP measured at VEAS dominating. TCP concentrations were below the LOD (3 ng/L) in the effluent of all WWTWs. In sludge TCPP dominated with levels of between the LOD and 920 ng/g dw. However, in sludge TCP could be detected with the Sum TCP in the range of between the LOD and 66 ng/g dw. The fragrance HHCB showed a very even effluent distribution in the range of 1,600 – 4,340 ng/L with nearly no difference

between the different WWTWs. Sludge concentrations of HHCB were in the range of 3,800 – 6,400 ng/L with HHCB dominating. DIPN effluent concentrations ranged from <LOD to 11 ng/L. However, the two measured DIPN isomers 2,6- and 2,7DIPN were detected in all sludge samples between 36 and 110 ng/g dw (Figure 9).

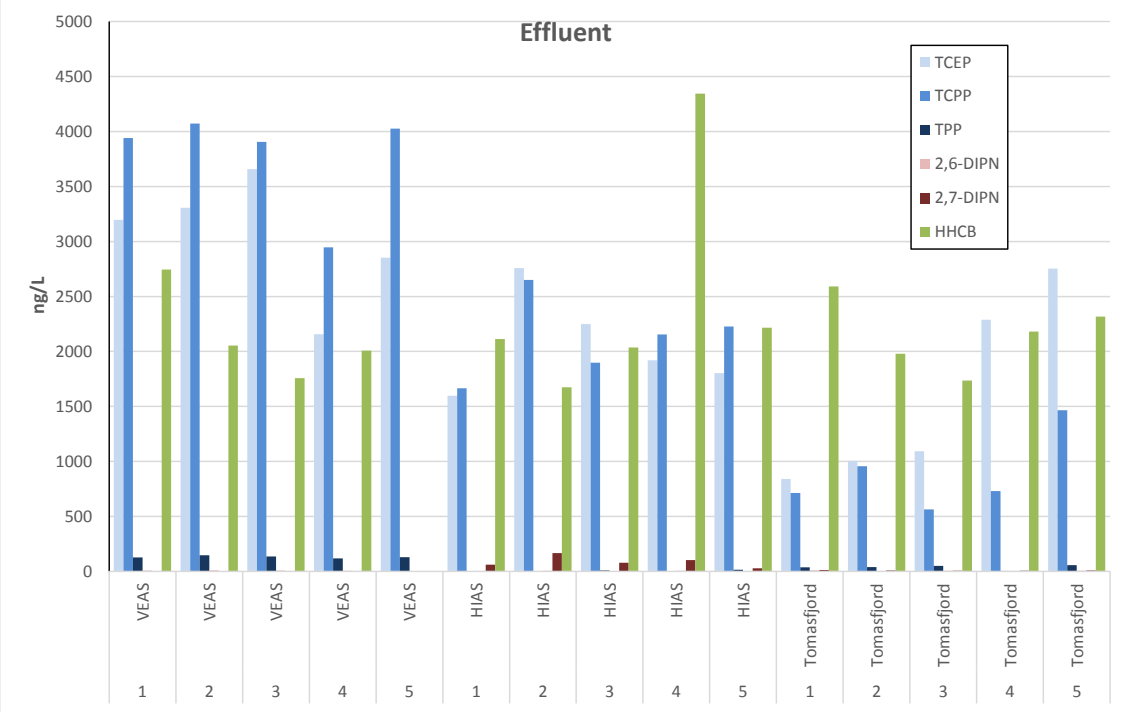


Figure 8: Concentrations of selected PBT compounds in WWTW effluent

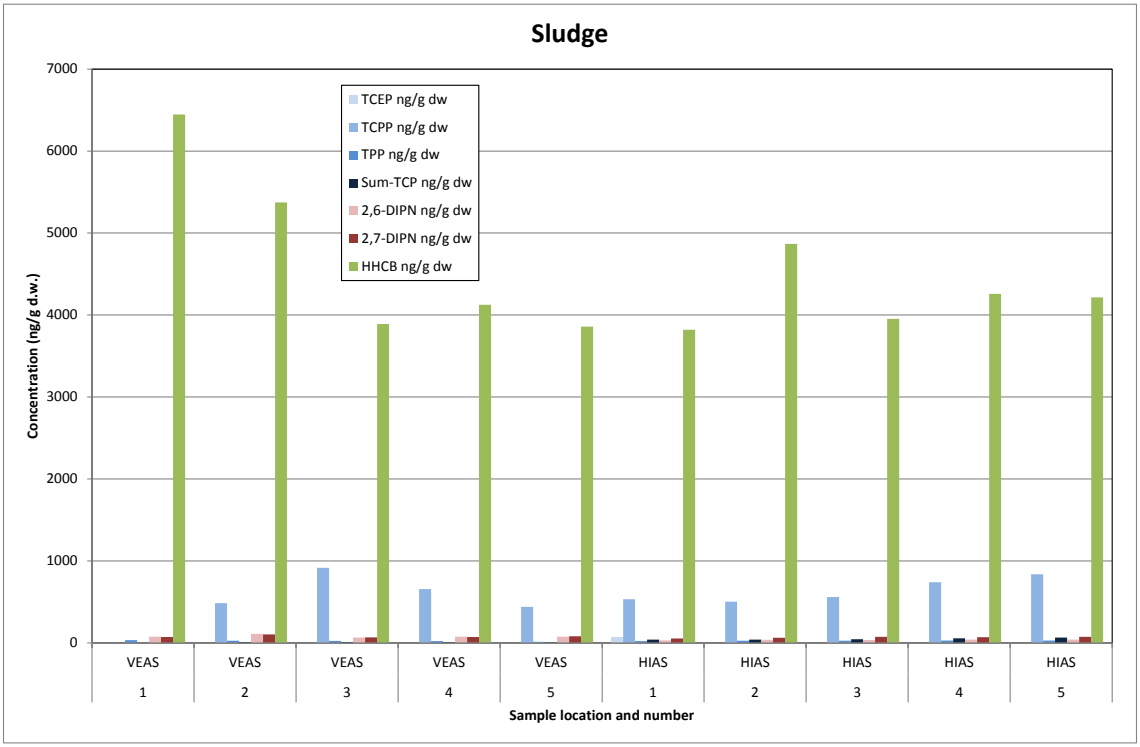


Figure 9: Concentrations of selected PBT compounds in sludge

3.1.4 New bisphenols

New bisphenols were determined to be present in effluent at a range of between LOD – 6,200 ng/L. BPF (both isomers) and BPA were dominating bisphenols in effluent (Figure 10). The sulphur containing BPS was found in HIAS effluent (<LOD – 1,140 ng/L) and at much lower concentration in VEAS effluent (<LOD – 85 ng/L), but not in the effluent from Tomasjord WWTW in Tromsø. Bisphenol BP (BP-BP) was only found in two of five HIAS samples, however at high concentrations (1,000 and 2,900 ng/L). The occurrences of the fluorinated bisfenol BPAF in effluents could not be ascertained safely, since it were only occasionally found at concentrations < LoQ. When comparing the different sewage treatment plants the highest concentrations of bisphenols in effluents were measured at HIAS WWTW.

In sludge from the VEAS WWTW, only low concentrations of BPA, BPF BPAF, and BPS were detected (<LOD – 390 ng/g dw; Figure 11). However, in sludge from HIAS all of the selected bisphenols were detected. BPA was found at very high concentrations (median: 4,100 ng/g dw), which is 3 times higher than found in 2011 (median 1,360 ng/g dw). BPFs and BPS were detected at a median concentration of 320, 132, and 296 ng/g dw respectively. Also BPAF and BP-BP were detected in most of the HIAS sludge samples, however, with much lower median concentrations (11 and 12 ng/g dw).

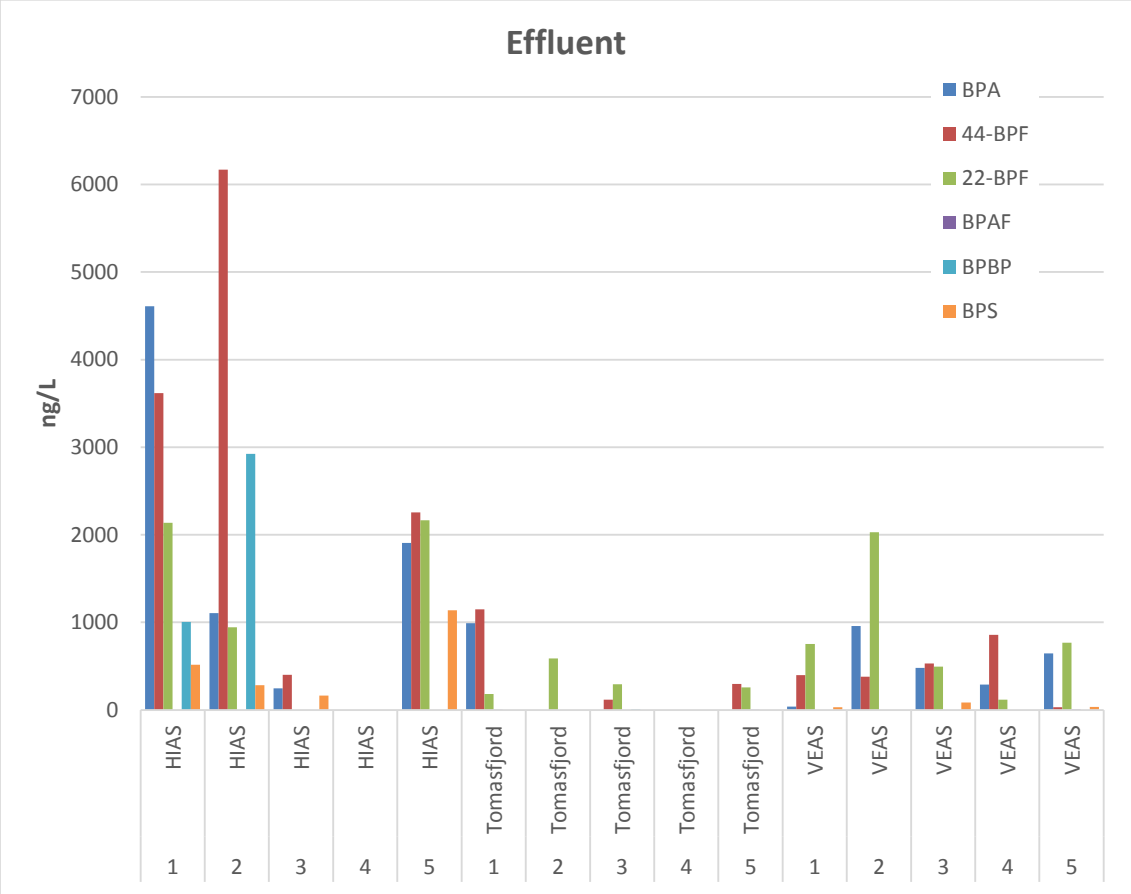


Figure 10: Concentrations (ng/L) of new bisphenols in WWTW effluent

Figure 11: Concentrations of new bisphenols in sludge with and without BPA.

3.2 Leachate

3.2.1 UV-filters

Concentrations of DEET measured at Lindum were lower than at ISI and in the range 59-8,777 ng/L (Figure 12). The median daily load discharged from Lindum was 0.28 g/day compared to 24.4 g/day discharged from ISI. High concentrations of DEET in landfill leachate have been reported elsewhere and thought to come mainly from the disposal of discarded insect repellent containers still containing DEET. In the US, leachate concentrations were up to 13 µg/L (Barnes et al., 2004) which is similar to this study with a median concentration at ISI of 13.9 µg/L. In Germany, consistently higher concentrations were observed with a maximum of 320 µg/L (Schwarzbauer et al., 2002).

The opposite pattern was observed for UV filters used in personal care products, and the concentrations in effluent from Lindum were significantly higher than those from ISI (Figure 12). The total daily load of UV filters discharged from ISI was 71 mg/day compared to 45080 mg/day from Lindum. The largest contribution to the loading to Lindum effluent was OC with a median concentration of almost 11,000 ng/L compared to <5 ng/L from ISI. Other UV filters were also present in higher concentrations at Lindum than at ISI. BP-3 was in the range <10-372 ng/L and 32-646 ng/L at ISI and Lindum respectively and the same was observed for EHMC where none was detected at ISI and it was detected in all 3 samples from Lindum (26-85 ng/L). This may be partly explained by the suspended solids loading in the effluent streams. ISI was analysed as a total sample due to very low particulate content. Lindum however had very high particulate content and the aqueous and solid fraction were analysed separately. 100% of BP-3, EHMC and UV-234 were found in the particulate fraction, and 84-100% of OC was in the particulate fraction. All 4 UV filters have Log K_{ow} values greater than 4 so partitioning to solids would be expected. The DOC content of ISI effluent (32.5-37.6 mg/L) was an order of magnitude lower than was measured at Lindum (376-565 mg/L) indicting a greater potential for compounds with high Log Kow values to sorb to the solid phase at Lindum compared to ISI.

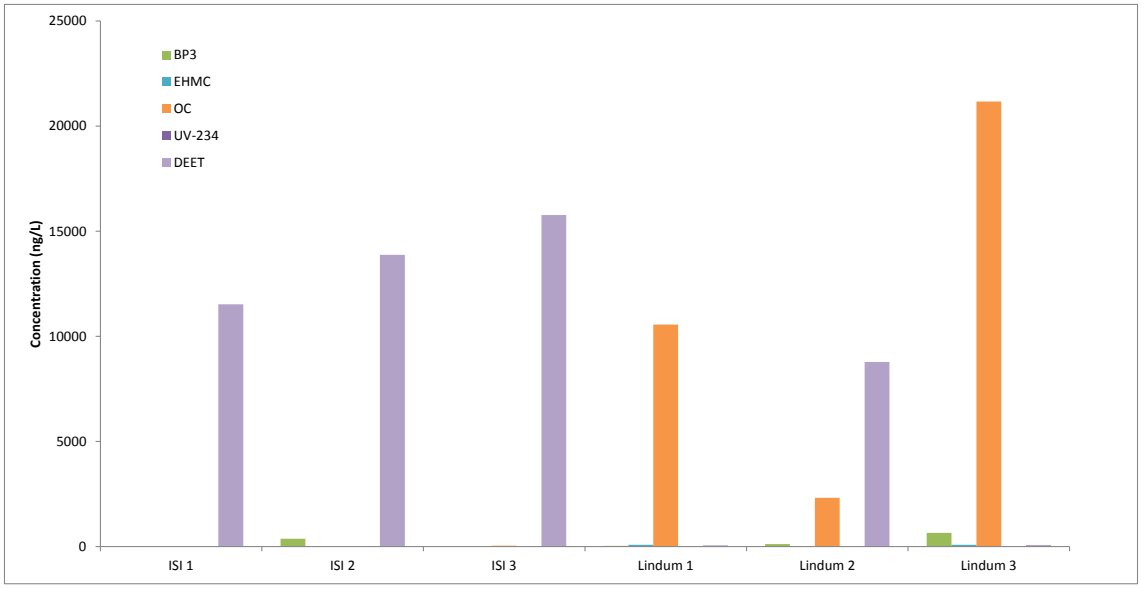


Figure 12. UV filter concentrations in total (dissolved and particulate sorbed) leachate

3.2.2 Organic peroxides

Di(tert-butylperoxyisopropyl)benzene was the only organic peroxide detected in landfill leachate and was detected in the particulate phase in leachate from Lindum at concentrations of between 19 and 99 ng/L (Table 14).

Table 14. Di(tert-butylperoxyisopropyl)benzene concentrations in landfill leachate

Location	Sample type and number	Concentration (ng/L)
Lindum	Effluent 1	<1
	Effluent 2	<1
	Effluent 3	<1
	Particulate 1	58
	Pariculate 2	99
	Particulate 3	19
ISI	Effluent 1	<1
	Effluent 2	<1
	Particulate 1	<1
	Pariculate 2	<1

3.2.3 Selected PBT substances

The individual PBT substances in leachate were measured at concentrations of between <LOD - 14000 ng/L (Figure 13). The different measured PFRs were in the range of LOD – 14,000 ng/L with TCEP measured at Lindum dominating. TCP could be detected in the particulate phase of two of the Lindum samples (27 – 34 ng/L).

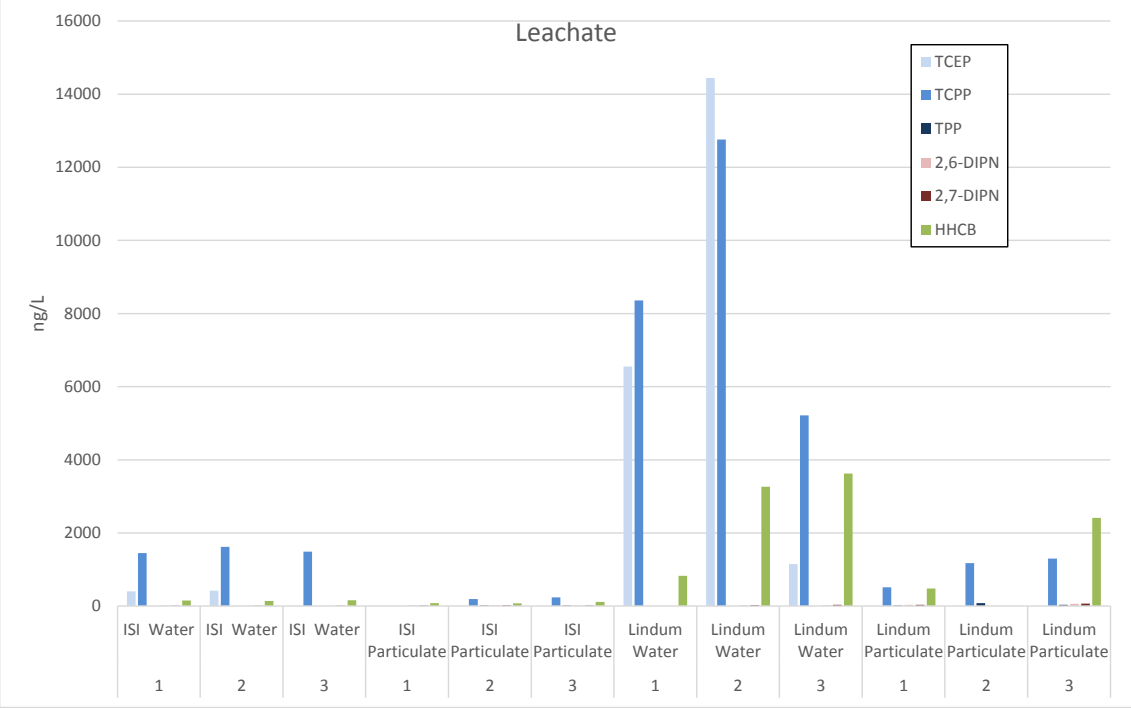


Figure 13: Concentrations (ng/L) of selected PBT compounds in leachates.

The fragrance HHCB were in the range of 210 – 6,000 ng/L with significant lower levels at ISI compared to Lindum. At both sites HHCB were evenly distributed between the aqueous and particulate phase.

DIPN leachate concentrations ranged from 10 to 100 ng/L (2,6- and 2,7-isomer respectively). The levels at ISI were slightly lower than at Lindum. At both sites the two measured isomers were evenly distributed between the aqueous and particulate phase.

3.2.4 New bisphenols

New bisphenols were detected in leachates at concentrations of between <LOD and 17,000 ng/L (Figure 14). BPF (both isomers) and BPA dominated in leachates. In some samples from both sites BPS and BP-BP were found in elevated concentrations (<LOD – 3,100 and <LOD – 2,900 ng/L). The occurrences of the fluorinated bisfenol BPAF in leachates could not be ascertained safely, since it was only occasionally found at concentrations lower than LoQ.

The concentrations measured in this study are in the lower range of what was measured in leachates from Norwegian landfill sites (Arp et al., 2012).

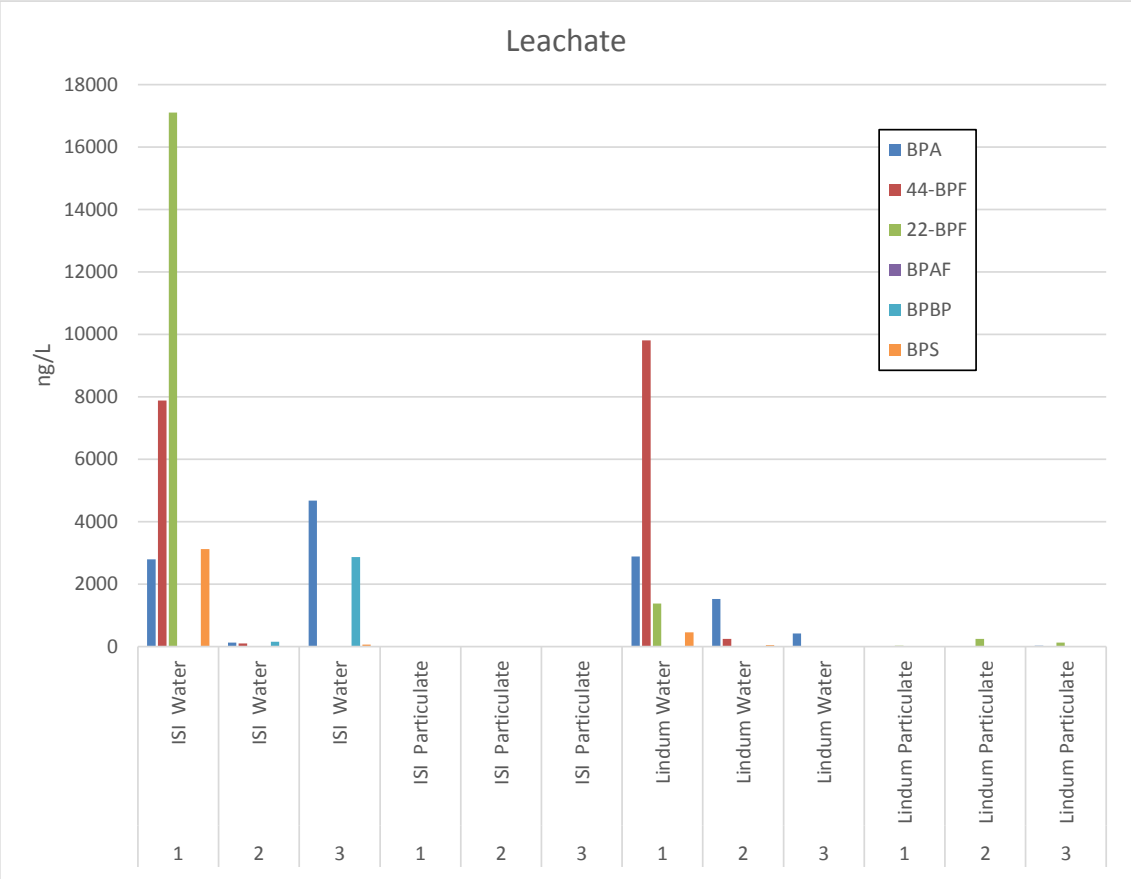


Figure 14: Concentrations (ng/L) of new bisphenols in leachates.

3.3 Oslofjord and Lake Mjøsa Sediment

3.3.1 UV-filters

All of the sediments in the receiving waters contained certain organic UV filters, with EHMC being detected in all samples (Figure 15). UV-328 (3.2-25.1 ng/g) was the dominant benzotriazole found in Oslofjord sediment as has been previously reported in Japan (6.3 ± 4 ng/g) (Haruhiko Nakata, 2009). UV-327 (<4-8.1 ng/g) was also detected in the Oslofjord but at lower concentrations and with less frequency. This has also been reported in Japan. Lake Mjøsa did not contain any benzotriazoles above the detection limit. EHMC and ODPABA have been shown to be rapidly degraded during UV radiation (Haruhiko Nakata, 2009). Only OC showed a gradient which highest concentrations close to the VEAS discharge diffuser. The other compounds showed an even distribution.

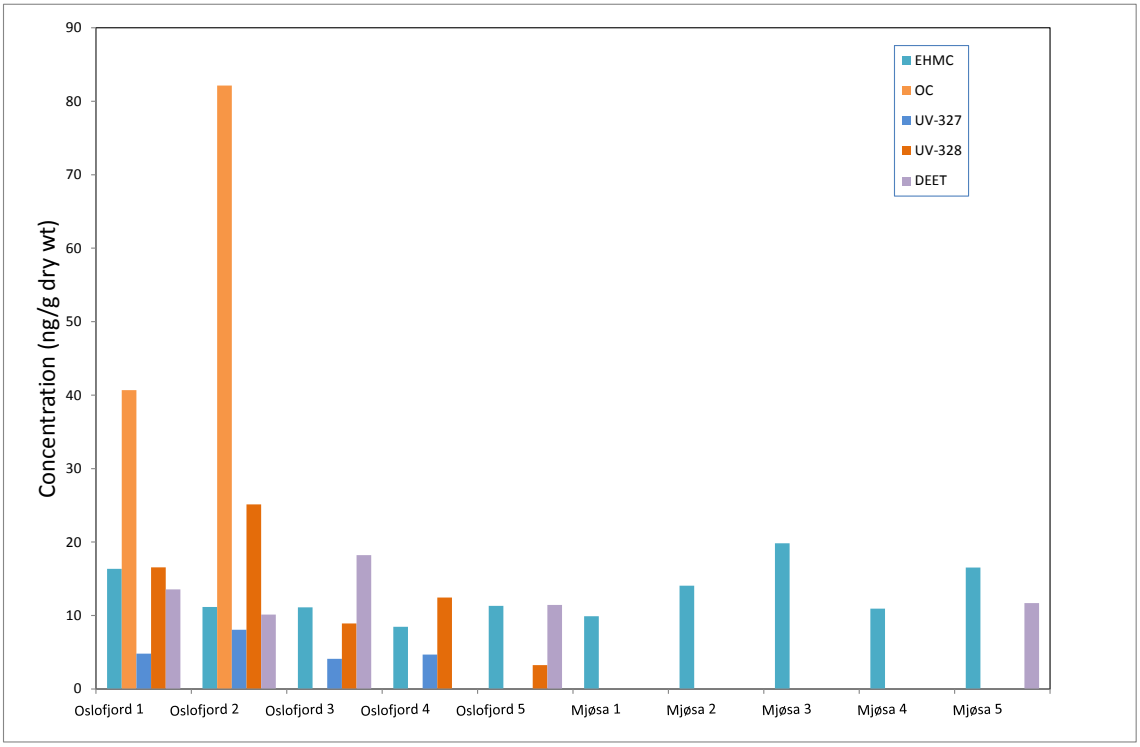


Figure 15: Concentrations (ng/g dw) of EHMC, OC, UV-327, UV-328 and DEET in sediment

3.3.2 Selected PBT substances

The different PFRs measured in sediments were in the range of between the <LOD and 59 ng/g dw with TCEP measured dominating (Figure 16). SumTCP could be detected in most sediment samples (Oslofjord: 2.5 – 6.4 ng/g dw and Mjøsa: LOD – 0.6 ng/g dw). HHCB could not be found in sediments with an LOD of ~45 ng/g dw. Levels in Central European river, lake and marine sediments were in the range of <1 – 850 ng/g dw (European Commission, 2008). There might be a gradient in the Oslofjord sediments for both TCEP, TCPP, and DIPN with highest concentrations close to the VEAS discharge diffuser.

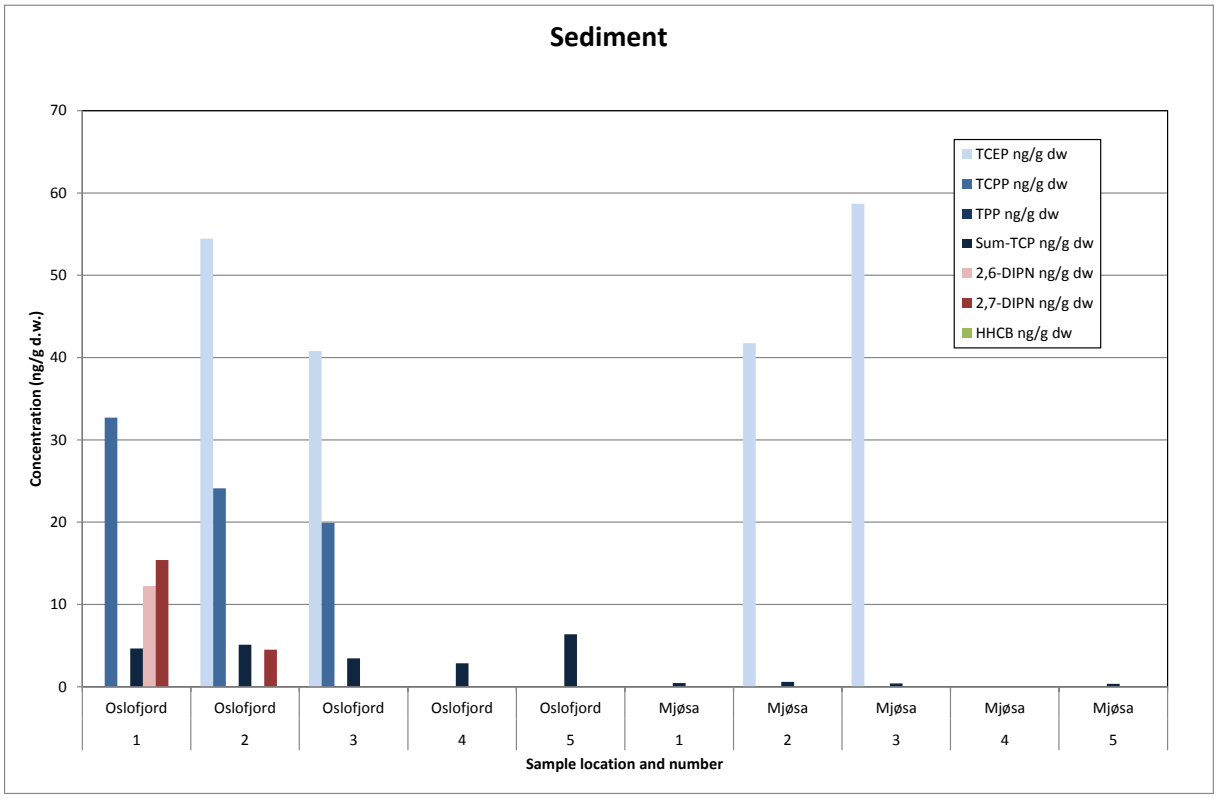


Figure 16: Concentrations of selected PBT compounds in Oslofjord and Lake Mjøsa sediments

3.3.3 New bisphenols

Bisphenols in sediment from Oslofjord were only detected in 2 single cases (Sample 1, o,o'-BPF: 47 ng/g dw and sample 4 BPA: 44 ng/g dw; Figure 17). All other samples and compounds have bisphenol concentrations below LOD (~1 – 12 ng/g dw). In a 2008 study with slightly lower LOD it was found between 0.3 and 0.9 ng/g dw in Oslo harbor and Outer Oslofjord (Arp et al., 2012). Only two samples from Mjøsa could be successfully analyzed. In both samples all new bisphenols could be detected. The concentrations ranged from 0.06 to 47 ng/g dw. The two BPF isomers were dominating. The obtained results are too scattered to identify an emission gradient.

In a recent study from Korea (Liao et al., 2012) the sum concentrations of eight bisphenols in sediments ranged from LoQ to 25,300 ng/g dw, and a mean value of 201 ng/g dw. Sediment samples from a Korean lake contained the highest concentrations of both individual and total bisphenols. Among individual bisphenols, BPA and bisphenol F (BPF) were the predominant compounds, accounting for 64% and 30% of the total bisphenol concentrations in sediment. The research group examined vertical profiles of concentrations of bisphenol analogues in sediment cores from the U.S. and Japan. Sediment cores from the US showed a gradual decline in the concentrations of bisphenols as compared to the past decade. BPA concentrations were found to decline in a sediment core from Tokyo Bay, but bisphenol S (BPS) was more frequently detected in core sections that represent the most recent decade, which is consistent with the replacement of BPA with BPS in some applications since 2001 in Japan.

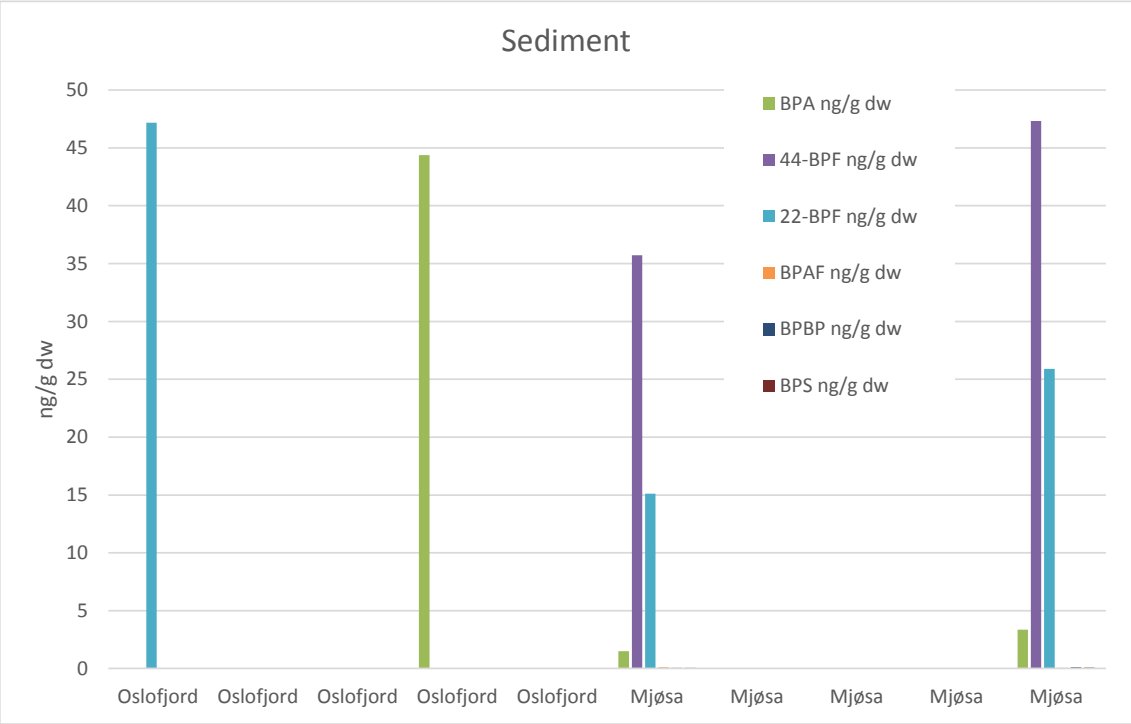


Figure 17: Concentrations of new bisphenols in Oslofjord and Lake Mjøsa sediments

3.4 Oslofjord biota

3.4.1 Biota characteristics and trophic descriptors

Statistics for biota characteristics and trophic descriptors for the different species are given in Table 15: Size, the fraction of soft tissue and liver as percent of total weight, lipid content and trophic descriptors (δ15N, δ13C) for biota sampled from Inner Oslofjord. The mean size of the cod was 60 cm and about 3 kg. The fish sample matrix was liver with a mean lipid content of about 30 %. The sample matrix of the crustacean was soft tissue with a substantially lower lipid content of about 1 %.

The mean stable N-isotope ratios, $\delta^{15}N$, varied from 10.9 ‰ in shore crabs to 15.8 ‰ in cod. A difference of about 3.4 ‰ is regarded to represent a difference of one trophic level (Minagawa and Wada, 1984; Post, 2002). Likewise, the stable C-isotope ratio, $\delta^{13}C$, reflects the carbon sources of the fish and the mean ratios were in the range -18.5 – -19.6 ‰, lowest for shrimps and highest for cod. A low ratio indicates influence from a pelagic food chain whereas a higher ratio indicates a more benthic food chain (France, 1995; Bosley et al., 2004; Miller et al., 2008). We have lipid-adjusted all the $\delta^{13}C$-ratios according to Post et al. (2007) in order to remove the effect of ^{13}C-depleted lipids in the fatty cod samples.

In Figure 18 we have presented scatter plots of the relationships between stable N- and C-isotope ratios and fish length. These illustrates that the different species had distinctive different trophic positions (crab < shrimp < cod) with no overlap in $\delta^{15}N$-ratios. Although there were no large differences in the mean $\delta^{13}C$-ratios between species, the variation increased substantially from shrimps to cod — indicating a diversification in the food/carbon sources.

Table 15: Size, the fraction of soft tissue and liver as percent of total weight, lipid content and trophic descriptors ($\delta^{15}N$, $\delta^{13}C$) for biota sampled from Inner Oslofjord.
The $\delta^{13}C$-ratios are based on lipid adjusted values (Post et al. 2007). Means and standard deviations are given ($\bar{x}$, SD). n = 15 (for each species).

Species	Length (cm)		Weight (g)		Liver (%)		Lipid (%)		$\delta^{15}N$ (‰)		$\delta^{13}C$ (‰)	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Northern shrimp							0.82	0.04	13.9	0.1	18.5	0.1
Shore crab	4.6*	1.1	21.3	12.8			1.02	0.55	10.9	0.8	-19.2	0.9
Cod	60	14	2910	2399	2.3	1.5	29.89	18.18	15.8	0.8	-19.6	1.7

*Carapax width

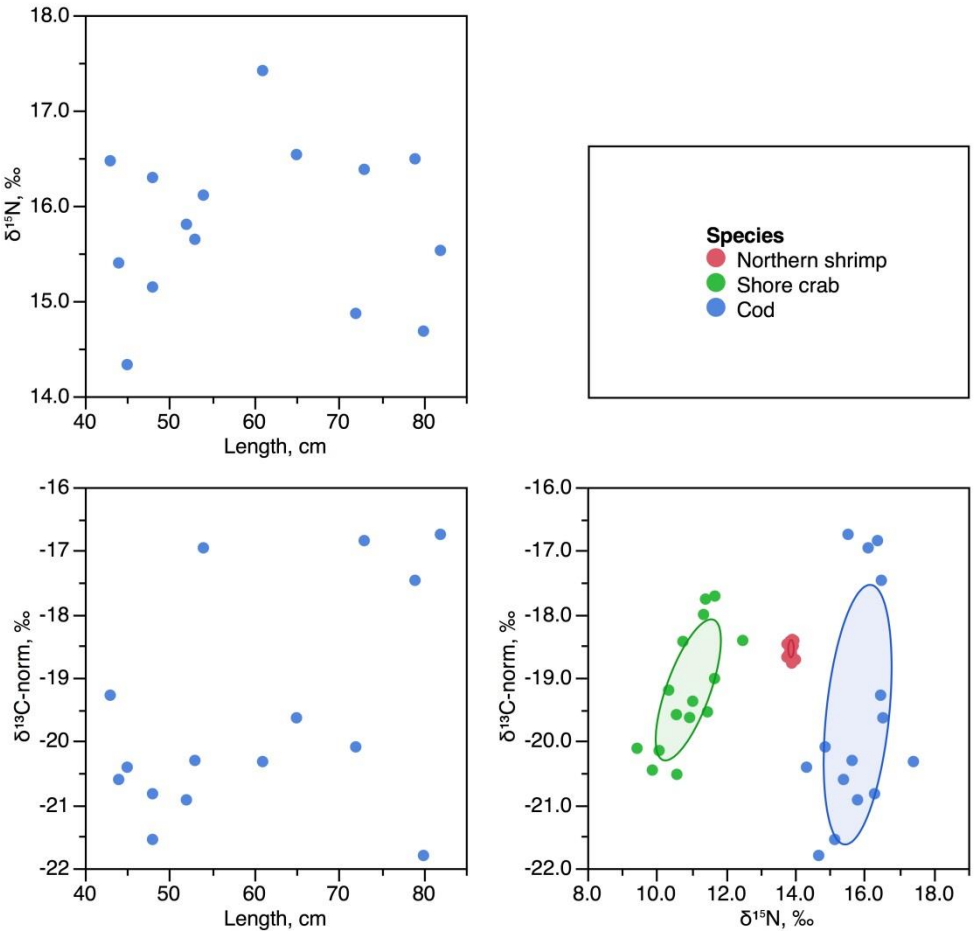


Figure 18. Scatter plots between fish length and trophic descriptors ($\delta^{15}N$, $\delta^{13}C$) for biota from Inner Oslofjord, caught in 2013. 90 % confidence ellipses are shown for the trophic descriptors. $\delta^{13}C$ are adjusted for lipids according to Post et al. (2007).

3.4.2 UV-filters and DEET

The concentrations for most of the analysed UV-chemicals and DEET were in general low, and only for BP3 in shrimp and cod, and for OC in cod, were concentrations above levels of quantification (>LoQ) detected for more than about half of the samples (Table 16). Due to the low detection frequency any meaningful assessment of their relationship with trophic level was prevented.

For BP3 the concentration varies from < 30 to 1037 ng/g wet weight. Although the median concentrations in shrimp and cod were about the same (45 vs. 55 ng/g wet weight), cod tended to have the highest levels — as illustrated by their 90th percentiles that were 67 and 1000 ng/g wet weight, respectively.

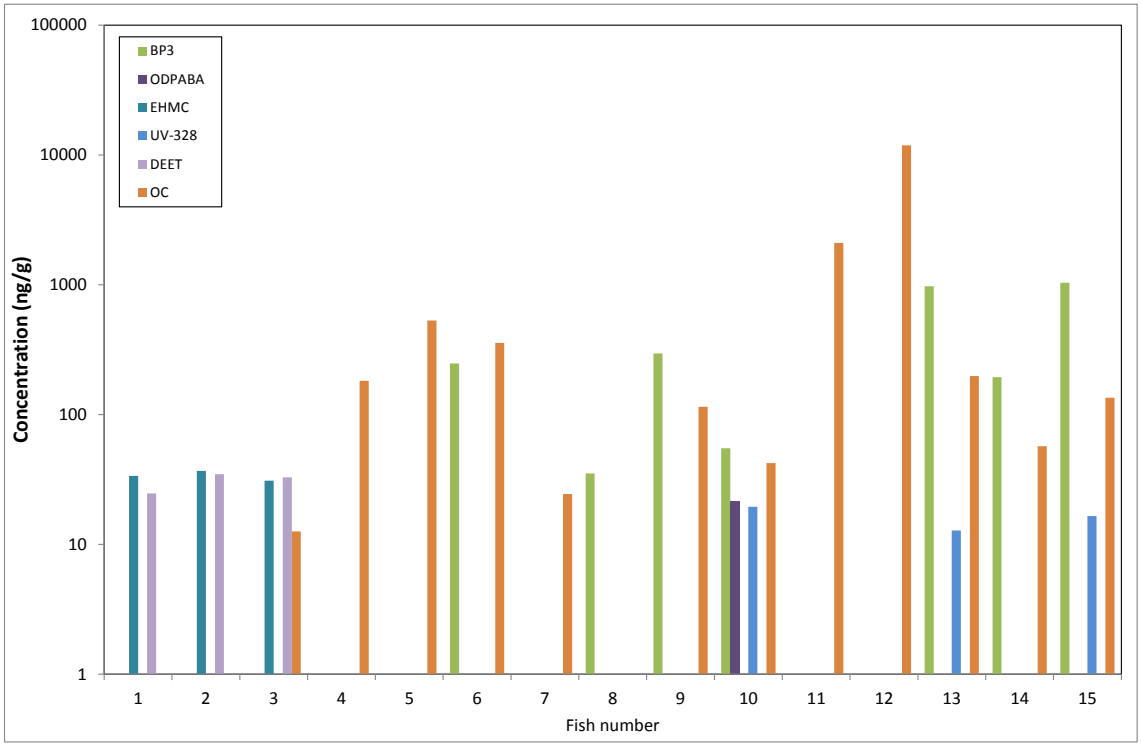


Figure 19. Logarithmic concentrations of UV filters in Oslofjord cod liver

OC was detected in 80% of the liver from Atlantic cod collected in the inner Oslofjord in an extremely large concentration range and up to a maxiumum concentration of 11 µg/g. The 90th percentile was also clearly elevated (6 x) compared to BP3, whereas the median value of 115 ng/g wet weight was only slightly elevated (2 x). This distribution has a long right tail and indicates that OC in cod accumulates in a different manner than BP3. 47% of samples contained BP-3 above detection limits. ODPABA, EHMC and UV-327 were detected in a few individuals. The median total UV compound concentration was 151 ng/g. An interesting observation is the correlating occurrence of DEET and EHMC. The data set is too small to draw any conclusions but it is worth noting that the only 3 cod livers containing DEET were the same 3 also containing EHMC, and in similar concentrations. For the remaining UV-chemicals were the concentrations chiefly less than LoQ (<10 – <250 ng/g wet weight) and with a few quantified concentrations in the range of about 18 – 50 ng/g wet weight.

Only a few samples (20 %) had quantifiable concentrations of the insecticide DEET in the range of 25 –35 ng/g wet weight.

All 5 crab samples were below detection limits for all compounds. OC, BP-3 and UV-327 were detected in prawn samples. Median concentrations of OC and UV-327 were below detection limits but the median BP-3 concentration detected was 45 ng/g.

UV-326 (not included in the present study), UV-327 and UV-328 dominated higher trophic level species, such as shark and porpoise, collected from Asian marine waters (Nakata et al., 2009) and here we report comparable data in cod from the inner Oslofjord. Spatial variations were observed between mussels analysed from different countries in Asian, with Korea, Japan, and Hong Kong containing higher concentrations than India and Vietnam. A positive correlation was observed between UV-327 and UV-328 and the authors suggest that both compounds originate for the same source (Nakata et al., 2009).

Table 16: Concentration statistics for the selected organic UV-chemicals and DEET in samples of biota from the Oslofjord caught in 2013 (ng/g wet weight).
Sample matrix: cod liver, soft tissue of shrimps and crabs. % > LoQ: percent of samples with concentrations above level of quantification. n = 45.

Compound	Species	Minimum	Median	90th percentile	Maximium	% > LoQ
BP3	shrimp	<30	45.2	66.6	68.9	53%
BP3	crab	<30			<30	0%
BP3	cod	<20	55a	1000	1037	47%
ODBAPA	all	<20			21.7b	2%
EHMC	shrimp, crab	<20			<20	0%
EHMC	cod	<20		35	36.9	20%
OC	shrimp, crab	<10			<10	0%
OC	cod	<20	114.5	6012	11875	87%
MBT	all	<250			<250	0%
MBTS	all	<250			<250	0%
DCHA	all	<250			<250	0%
UV-234	all	<10			<10	0%
UV-237	all	<10c/<50d			51.8e	2%
UV-328	shrimp, crab	<10			<10	0%
UV-328	cod	<10		17.7	19.5	20%
UV-329	all	<25			<25	0%
UV-360	all	<250			<250	0%
UV-571	all	<250			<250	0%
DEET	shrimp, crab	<10			<10	0%
DEET	cod	<10		33.7	34.8	20%

a) 53th percentile; b) one cod > LoQ; c) LoQ for shrimp and crab; d) LoQ for cod; e) one shrimp sample

3.4.3 Selected PBT substances

Quantifiable concentrations were detected for all the phosphorous flame retardants, except for ooo-TCP and sum-TCP. The highest concentrations were found in cod liver, with median TCEP and TCPP values of about 130 and 50 ng/g wet weight and maximum values of about 2 600 and 780 ng/g wet weight, respectively.

The median concentration of TCPP in shrimps was almost an order of magnitude lower than for cod (5 ng/g wet wt). However, as it is slightly lipophilic (log Kow = 2.59 (van der Veen and Boer 2012)), the

higher lipid content in cod liver than in shrimps (≈ 30 x) should be considered when these concentrations are compared and evaluated.

Again, the concentrations of TCPP and TPP we report here exceed those in Arctic char from Lake Ellasjøen (0.5 and 5 ng/g wet weight) reported by Evenset et al. (2009). They are also substantially higher than those reported for Arctic capelin (0.2 and 2.2 ng/g wet weight, (Sagerup et al., 2011)).

The concentrations of the different (bi)isopropylnaphtalenes, (D)IPN, were generally LoQ (<4 ng/g wet weight) for shrimps and crabs, whereas their detection frequency in cod were about 30 % and concentrations up to 11 ng/g wet weight.

Quantifiable concentrations of HHCB were only found in cod, but here almost all samples had levels > LoQ (45 ng/g wet weight). The median and maximum concentrations were 122 and 271 ng/g wet weight, respectively. These are concentrations in the same range as Subedi et al. (2012) found in German freshwater fish from 14 different sites; range: 6–480 ng/g wet weight, median: 65 ng/g wet weight.

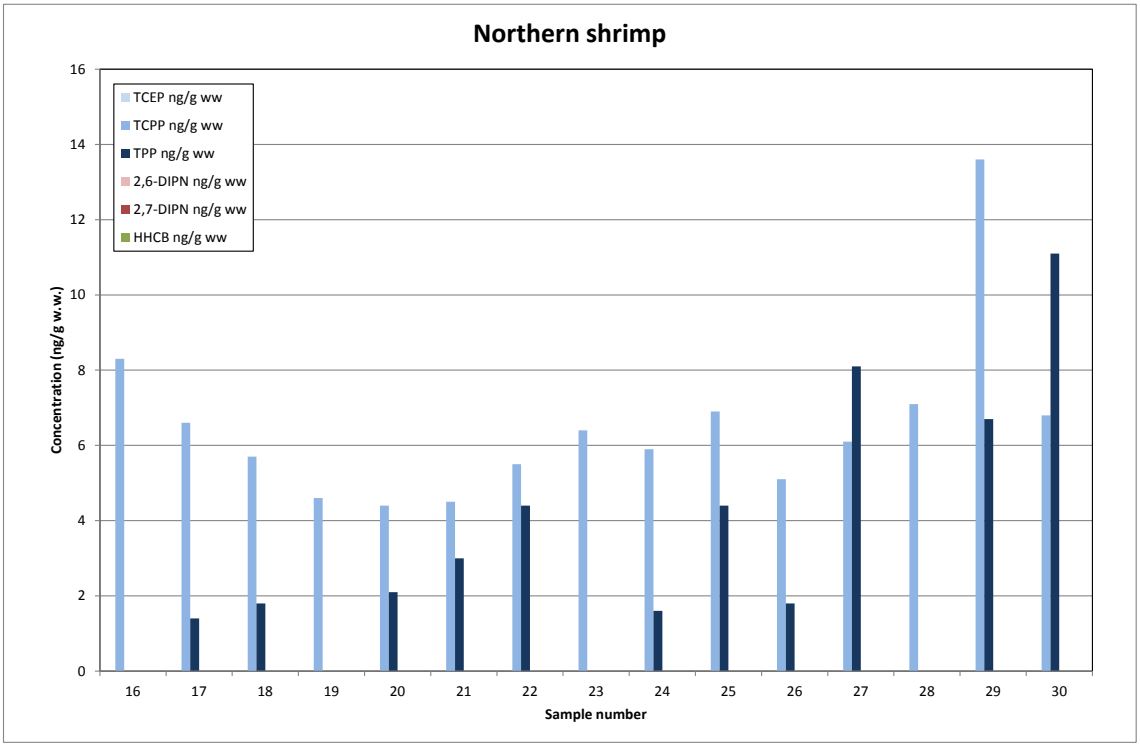


Figure 20: Concentrations of selected PBT compounds in Northern shrimp from Oslofjord.

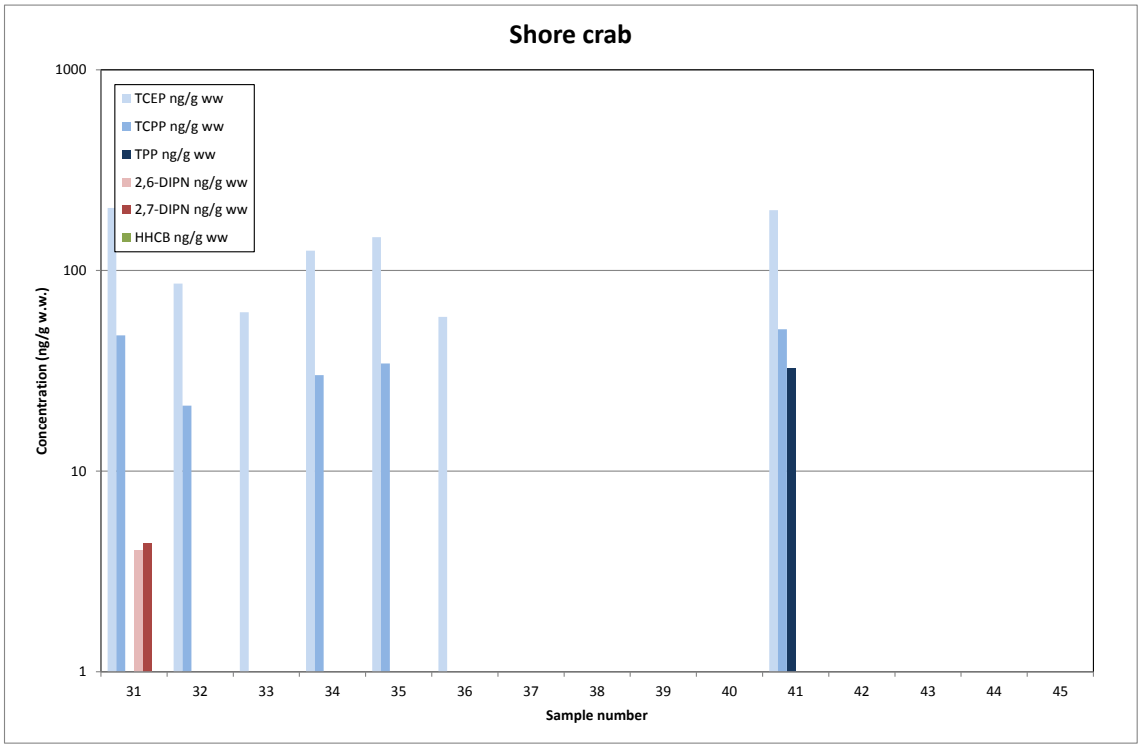


Figure 21: Logarithmic concentrations of selected PBT compounds in shore crab from Oslofjord.

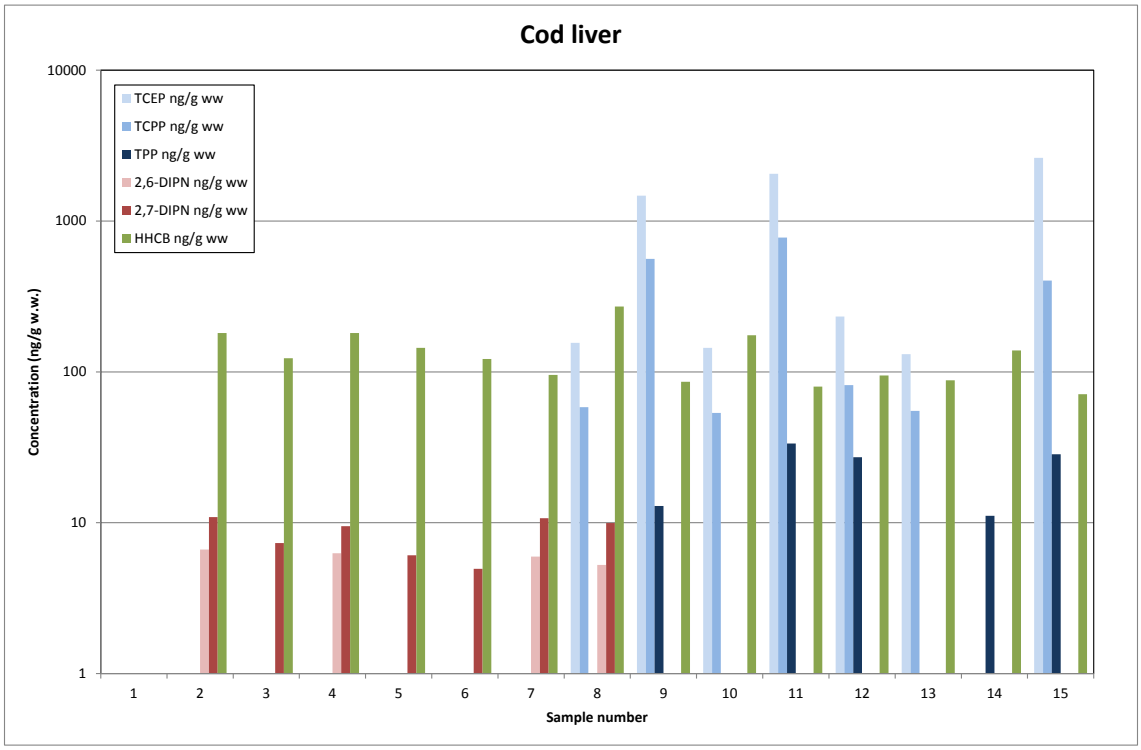


Figure 22: Logarithmic concentrations of selected PBT compounds cod liver from Oslofjord.

There were also a significant correlation between TCEP and TCPP and between TCPP and TPP in the marine samples (Table 18, Figure 23), indicating similar behaviour in the food web. There was a tendency for TCEP to increase with $\delta^{15}N$ – in contrast to the freshwater food web, but the correlation coefficient here was on the borderline of statistical significance (p = 0.06).

Table 17: Concentration statistics for organic phosphorus flame retardants (TCEP, TCPP, ooo-TCP, sum-TCP), (di)-isopropylnaphtalenes (DIPN, IPN) and the musk compound HHCB (Galaxolide) in biota samples from Inner Oslofjord, (ng/g wet weight).

Sample matrix: cod liver, crustacean soft tissue.
%>LoQ: percent of samples with concentrations greater than level of quantification. n = 60.

Compound	Species	Min	10th percentile	Median	90th percentile	Max	%>LoQ
TCEP	shrimp	<43.8				<43.8	0%
TCEP	crab	<53.8		59 a	202	205	47%
TCEP	cod	<53.8		131 a	2280	2620	47%
TCPP	shrimp	4	4	6	8	14	100%
TCPP	crab	<17.1			49	51	30%
TCPP	cod	<17.1		53a	648	778	47%
TPP	shrimp	<1.2		2	9	11	73%
TPP	crab	<8.7				33	7%
TPP	cod	<8.7			30	34	30%
ooo-TCP	all	<0.06 b <0.11 c <0.13 d				<0.06 b <0.11 c <0.13 d	0%
sum-TCP	all	<0.06 b <0.11 c <0.13 d				<0.06 b <0.11 c <0.13 d	0%
2-IPN	all	<4				<4	0%
2,6-DIPN	shrimp, crab	<4				4 e	3%
2,6-DIPN	cod	<4			6	7	27%
2,7-DIPN	shrimp, crab	<4				4 e	3%
2,7-DIPN	cod	<4			11	11	27%
HHCB	shrimp, crab	<45				<45	0%
HHCB	cod	<45	25	122	217	271	97%

a) 53rd percentile; b) cod; c) shrimp; d) crab; e) one crab sample, f) one shrimp sample

Table 18: Correlations (Pearson's r) between organic phosphorus flame retardants (log-transformed) and trophic level ($\delta^{15}N$) in biota samples from Inner Oslofjord.

Only samples with concentrations above level of quantification (>LoQ) are included. Sample matrix: cod liver, shrimp and crab soft tissue.

Variable	by Variable	Correlation	n	p
log TCEP	$\delta^{15}N$, ‰	0.52	14	0.06
log TCPP	$\delta^{15}N$, ‰	0.31	27	0.12
log TCPP	log TCEP	0.97	12	<0.0001
log TPP	$\delta^{15}N$, ‰	0.21	17	0.42
log TPP	log TCEP	-0.24	5	0.70
log TPP	log TCPP	0.80	16	0.0002

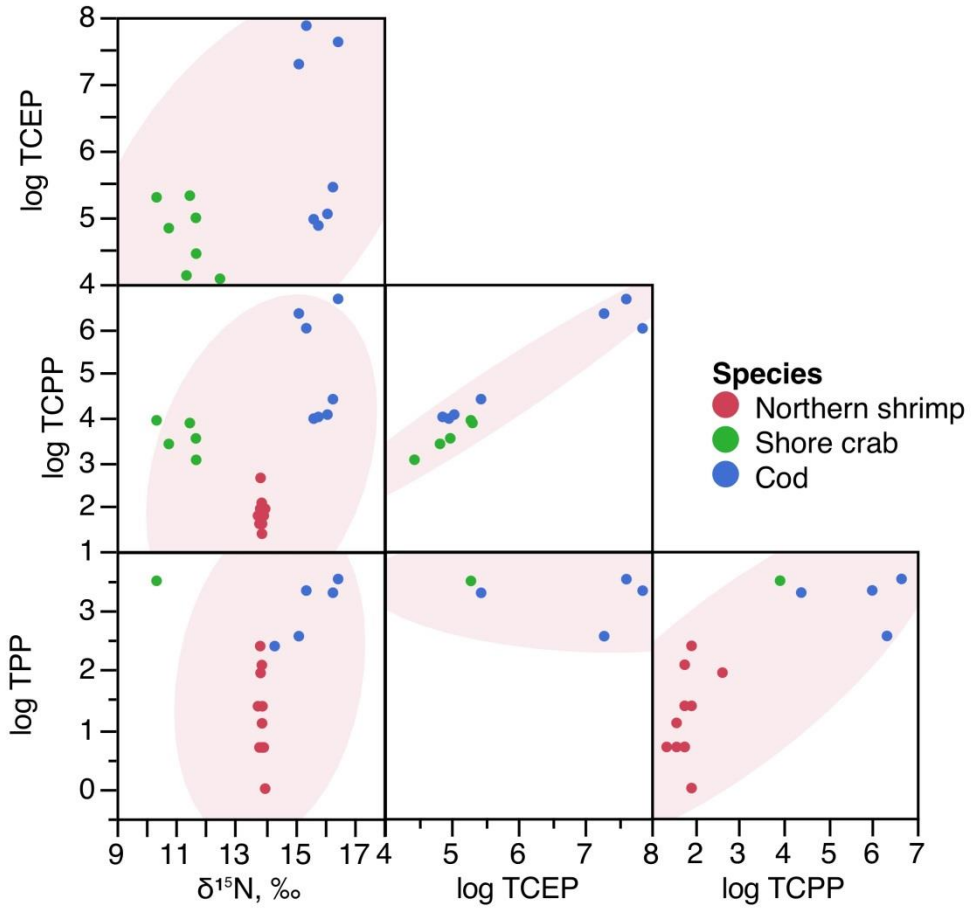


Figure 23. Scatter plot matrix for organic phosphorus flame retardants (log-transformed, ng/g wet weight) and trophic level ($\delta^{15}N$, ‰) in biota samples from Inner Oslofjord. Only samples with concentrations above level of quantification (>LoQ) are included. Sample matrix: cod liver, crab and shrimp soft tissue. 90 % confidence ellipses are shown.

3.4.4 New bisphenols

In biota samples from Oslofjord the different bisphenols were frequently detected in Northern shrimps (median concentration: 0.06 – 19.7 ng/g ww; Figure 24) and cod liver (median concentration: 1 – 590 ng/g ww; Figure 25). In Shore crabs they are only occasionally detected which may probably be attributed to slightly higher detection in this type of samples. In Northern shrimps the BPFs were dominating, whereas in Cod liver the BPA was the bisphenol with highest concentrations. It is remarkable that all measured bisphenols could be detected in marine biota samples.

The change of the BPA/BPF ratio from northern shrimp to cod may be explained by more efficient biodegradation of BPF compared to BPA. This trend was also found by degradation studies in sea water (Danzl et al., 2009) and the authors conclude as following: BPF showed better degradation efficiency than BPA. BPS degradation was not observed. The biodegradability of the three BPs in seawater could be ranked as BPF > BPA > BPS. BPF is more biodegradable than BPA in seawater and BPS is more likely to accumulate in the aquatic environment

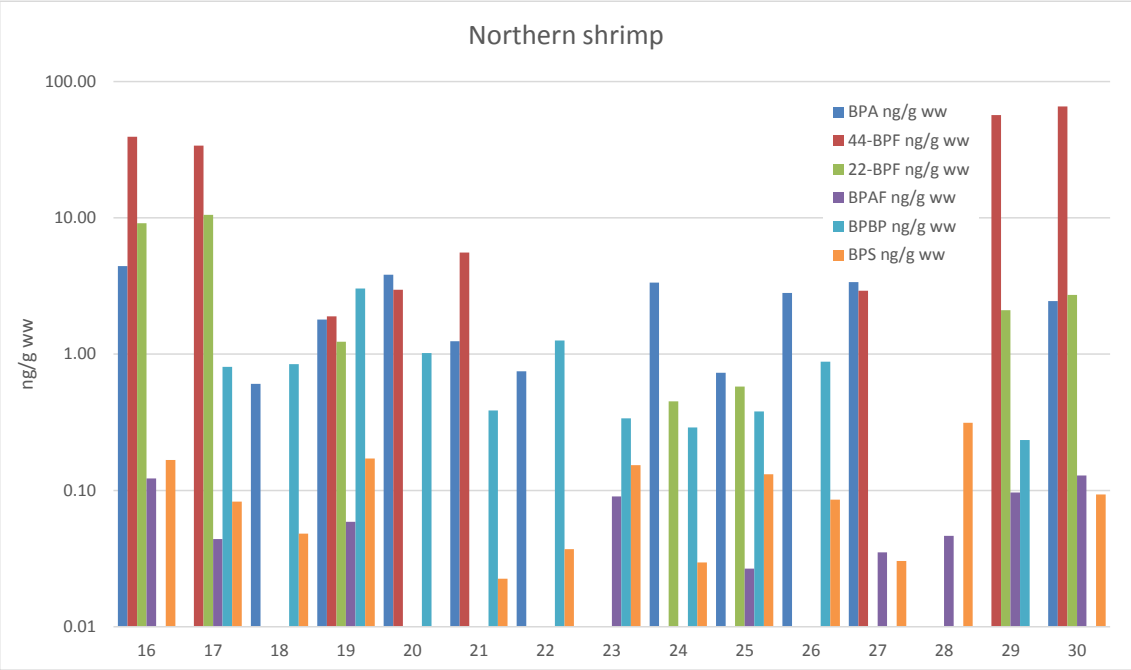


Figure 24. Concentrations of bisphenols in Northern shrimps from Oslofjord.

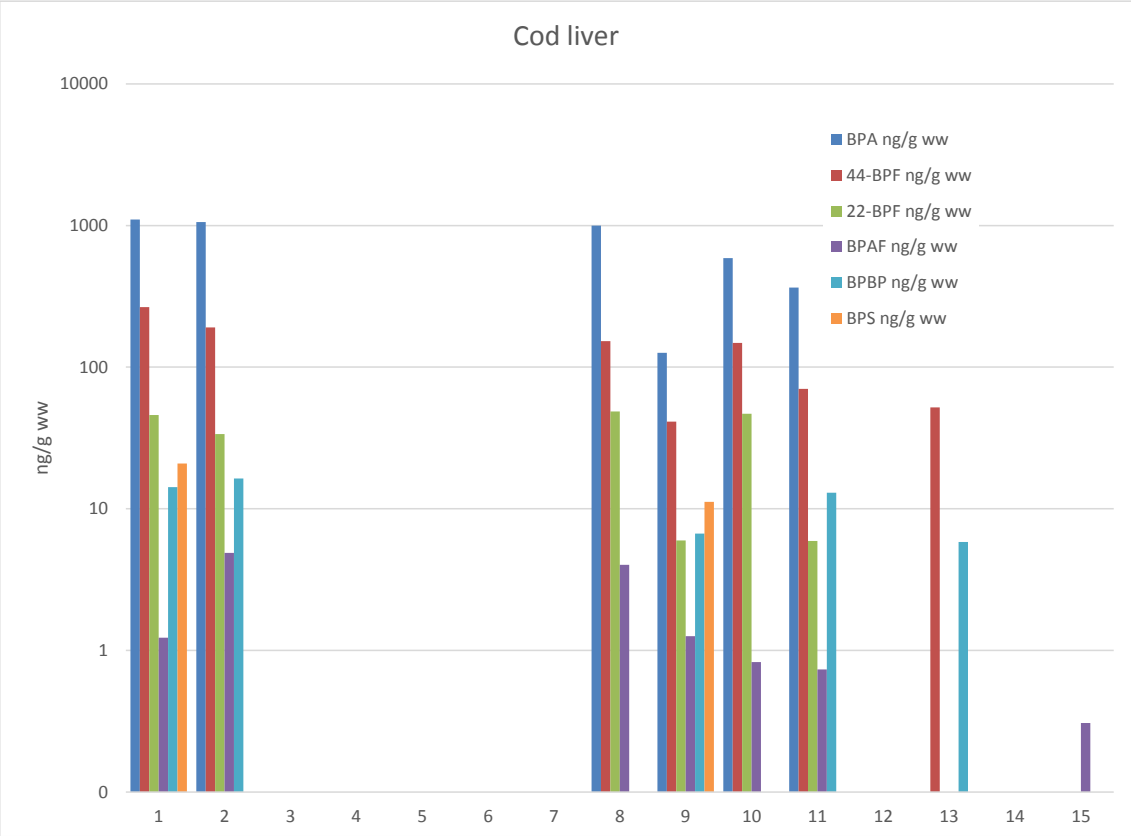


Figure 25. Concentrations of bisphenols in cod liver from Oslofjord.

3.5 Lake Mjøsa biota

3.5.1 Fish characteristics and trophic descriptors

Statistics for fish characteristics and trophic descriptors for the different groups/species are given in Table 19. Perch was in general the smallest fish with a mean length and weight of 29.3 cm and 308 g, whereas brown trout was the largest, with mean length and weight of 59.6 cm and 2587 g. The soft tissue samples represented about half of the total fish weight, whereas the liver represented about 1-5 % of the total weight - with burbot having the largest liver. The mean lipid content of the samples varied from 1.3 % for whitefish to 4.4 % for burbot.

The mean stable N-isotope ratios $\delta^{15}N$, reflects the relative trophic positions of the fish and were in the range of 14.4 – 16.5 ‰, lowest for perch and highest for burbot. A difference of about 3.4 ‰ is regarded to represent a difference of one trophic level. Likewise, the stable C-isotope ratio, $\delta^{13}C$, reflects the carbon sources of the fish and the mean ratios were in the range -28.3 – -26.8 ‰, lowest for brown trout and highest for burbot. A low ratio indicates influence from a pelagic food chain whereas a higher ratio indicates a more littoral food chain. We have lipid-adjusted all the $\delta^{13}C$-ratios in order to remove the effect of ^{13}C-depleted lipids in the fatty burbot samples.

In Figure 26 we have presented scatter plots of the relationships between stable N- and C-isotope ratios and fish length. These illustrates that there can be a rather wide range in trophic position both between and within each species, and that brown trout are more connected to the pelagic food chain than the other species, especially compared to burbot.

Table 19. Fish size, the fraction of soft tissue and liver as percent of total weight, lipid content and trophic descriptors ($\delta^{15}N$, $\delta^{13}C$) for the fish sampled from Lake Mjøsa.
The $\delta^{13}C$-ratios are based on lipid adjusted values. Means and standard deviations are given ($\bar{x}$, SD). n = 15 (for each species).

	Length, cm		Weight, g		Soft tissue, %		Liver, %		Lipid, %		$\delta^{15}N$, ‰		$\delta^{13}C$, ‰	
Species	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
White -fish	36.6	3.6	369	119	55.6	5.5	0.9	0.2	1.34	0.80	14.8	1.0	-27.9	0.7
Perch	29.3	3.8	308	119	53.9	4.7	1.2	0.3	1.58	1.35	14.4	0.6	-27.3	0.6
Burbot	45.2	6.2	644	245	49.3	5.1	5.4	1.6	4.38	1.43	16.5	0.4	-26.8	0.3
Brown trout	59.6	9.1	2587	1459					1.96	1.54	15.6	0.2	-28.3	1.0

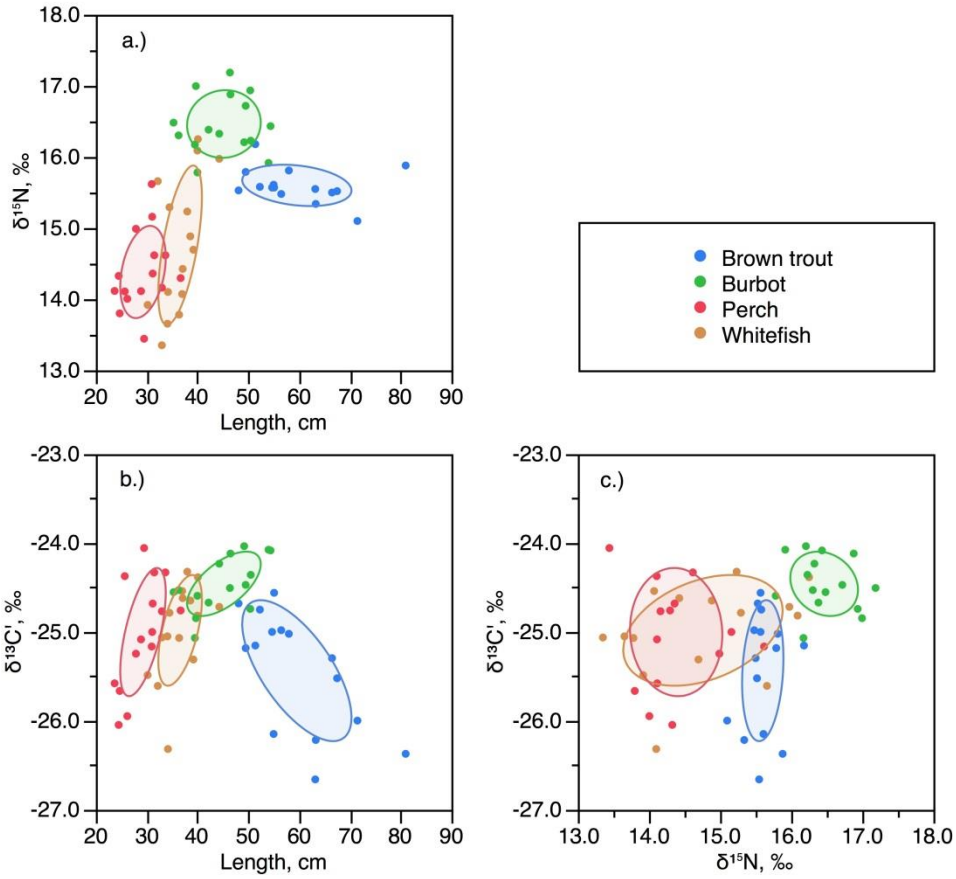


Figure 26. Scatter plots between fish length and trophic descriptors ($\delta^{15}N$, $\delta^{13}C'$) for fish from Lake Mjøsa, caught in 2013. 90 % confidence ellipses are shown. The $\delta^{13}C$-ratio are adjusted

3.5.2 UV-chemicals and DEET

The concentrations for most of the analysed UV-chemicals and DEET were low, and only for BP3, EHMC and OC in whitefish and perch could we detect concentrations above levels of quantification (LoQ) and as such a further assessment of biomagnification is not possible (Table 20).

For these three chemicals only a small percentage (2–11 %) of the samples was above LoQ, and it is therefore not possible to determine any central tendency parameter for their distributions. The best estimate would be use LoQ as an upper boundary for their median concentrations, which translates to <5 ng/g wet weight for BP3 and EHMC, and <2 ng/g wet weight for OC.

Maximum levels for BP3 and EHMC were substantially higher (5-6 x) than their 90th percentiles and should in a statistical sense be regarded as outliers. The 90th percentiles are more robust alternatives for extreme value estimates and were 31 and 21 ng/g wet weight, respectively. Perhaps an interesting observation is the correlation between BP3 and EHMC in whitefish; where BP3 was detected in whitefish muscle, so was EHMC. BP3 and EHMC were only detected in 4 out of 15 fish so it is not possible to draw any conclusions from such limited occurrence but the correlation is nonetheless worthy of note, particularly since the ratio of the 2 compounds is similar in each case suggesting a similar source, with EHMC being the dominant compound.

In a survey of the occurrence of UV-filters in rivers in Switzerland in 2006-2007, Fent *et al.* (2010) report of average concentrations of EHMC about 50–170 ng/g lipid in muscle samples of fish (Chub, *Leuciscus*

cephalus; barb, *Barbus barbus*; brown trout) and a total range of <LoQ–337 ng/g lipid. Concentrations of BP3 were by and large <LoQ. The corresponding lipid content is not adequately reported, only to be in the range of 3–12 % although biomagnification between gammarus and chub, and chub and barb to cormorant, is suggested. In comparison, if we in our study set the upper bond of median EHMC and BP3 concentrations to equal LOQ and the average lipid content to be 1.5%, the median concentrations in our study will be <420 ng/g lipid. The empirically determined 90th percentiles for EHMC and BP3 in our study are 2150 and 1820 ng/g lipid, respectively.

Table 20: Concentration statistics for the different UV-chemicals and DEET in samples of fish Lake Mjøsa (ng/g wet weight).
Sample matrix: soft tissue of whitefish, perch and burbot. % > LoQ: percent of samples with concentrations above level of quantification. n = 45.

Compound	Minimum	90th percentile	Maximium	fraction > LoQ
BP3	<5	31	181.9	11%
ODBAPA	<20		<20	0%
EHMC	<5	21	116.6	11%
OC	<2		2.2	2%
MBT	<250		<250	0%
MBTS	<250		<250	0%
DCHA	<10		<333	0%
UV-234	<10		<10	0%
UV-237	<5		<50	0%
UV-328	<10		<10	0%
UV-329	<25		<25	0%
UV-360	<250		<250	0%
UV-571	<250	-	<250	0%
DEET	<5	-	<5	0%

3.5.3 Selected PBT compounds

Quantifiable concentrations were detected for all the phosphorous flame-retardants, except for ooo-TCP (Table 21). For TPP and TCPP the percentage of samples above LoQ were 63 % and 100 %, and their median values were 1.6 and 9 ng/g wet weight, respectively. For TCEP only 22 % of the samples had quantifiable concentrations and the upper boundary for an estimate of the median concentration should be 43.8 ng/g wet weight (LoQ). Only one sample had a sum-TCP concentration >LoQ.

Whitefish tended to have the highest concentrations of TCPP with a median value of 22 ng/g wet weight, whereas the other species had median values of 6–8 ng/g wet weight.

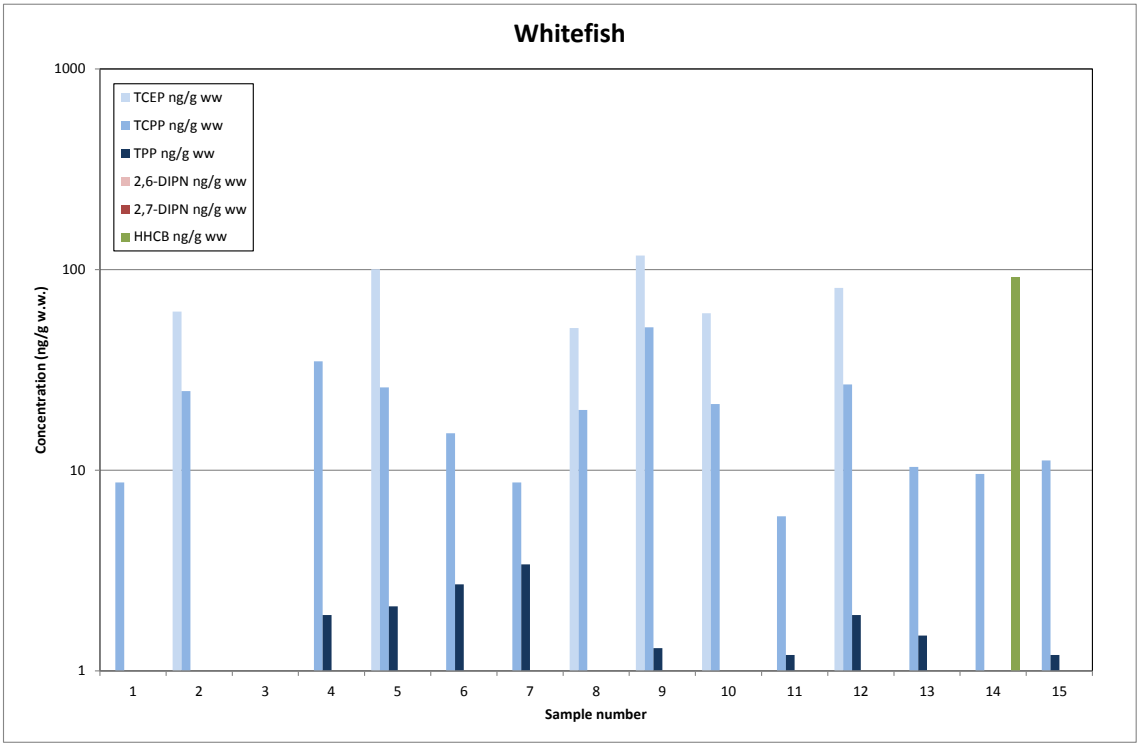


Figure 27: Logarithmic concentrations of selected PBT compounds in soft tissue samples of White fish from Lake Mjøsa.

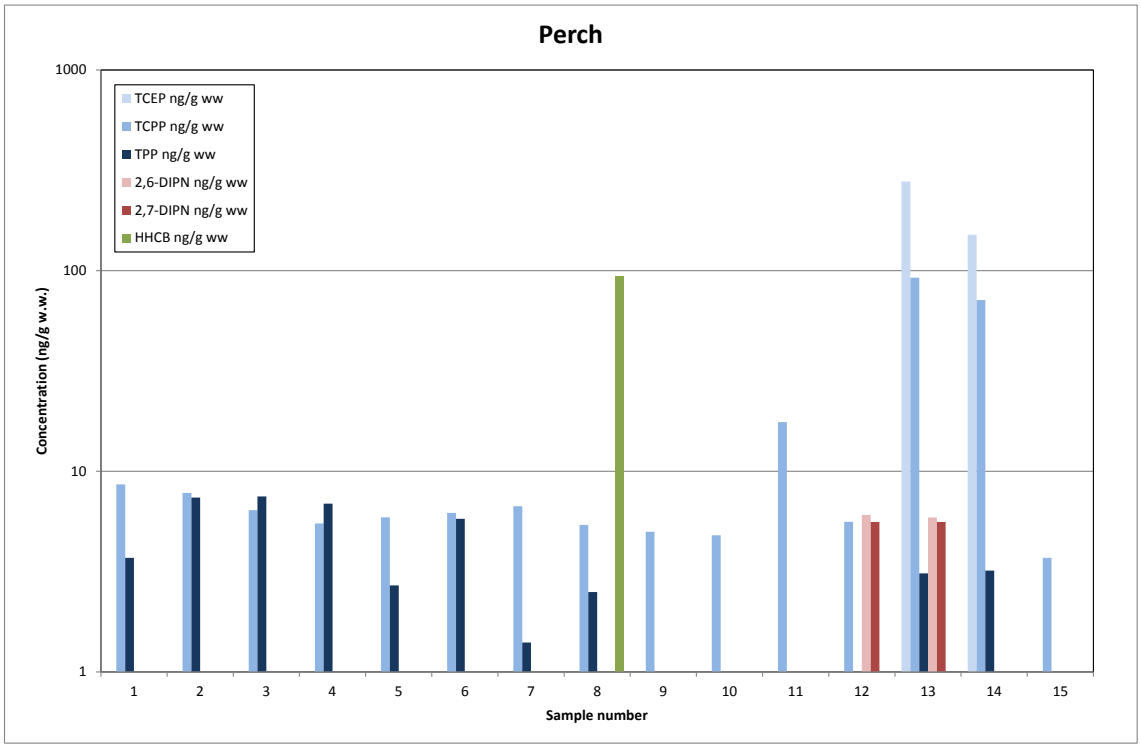


Figure 28: Logarithmic concentrations of selected PBT compounds in soft tissue samples of perch from Lake Mjøsa.

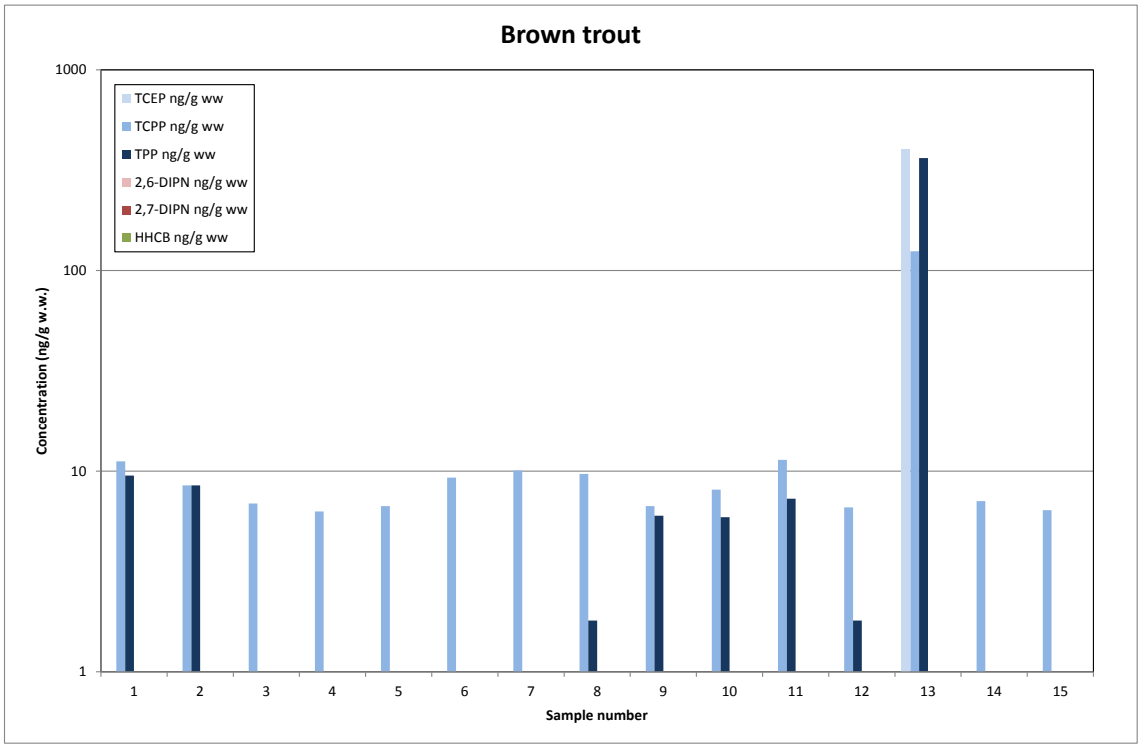


Figure 29: Logarithmic concentrations of selected PBT compounds in filet samples of brown trout from Lake Mjøsa.

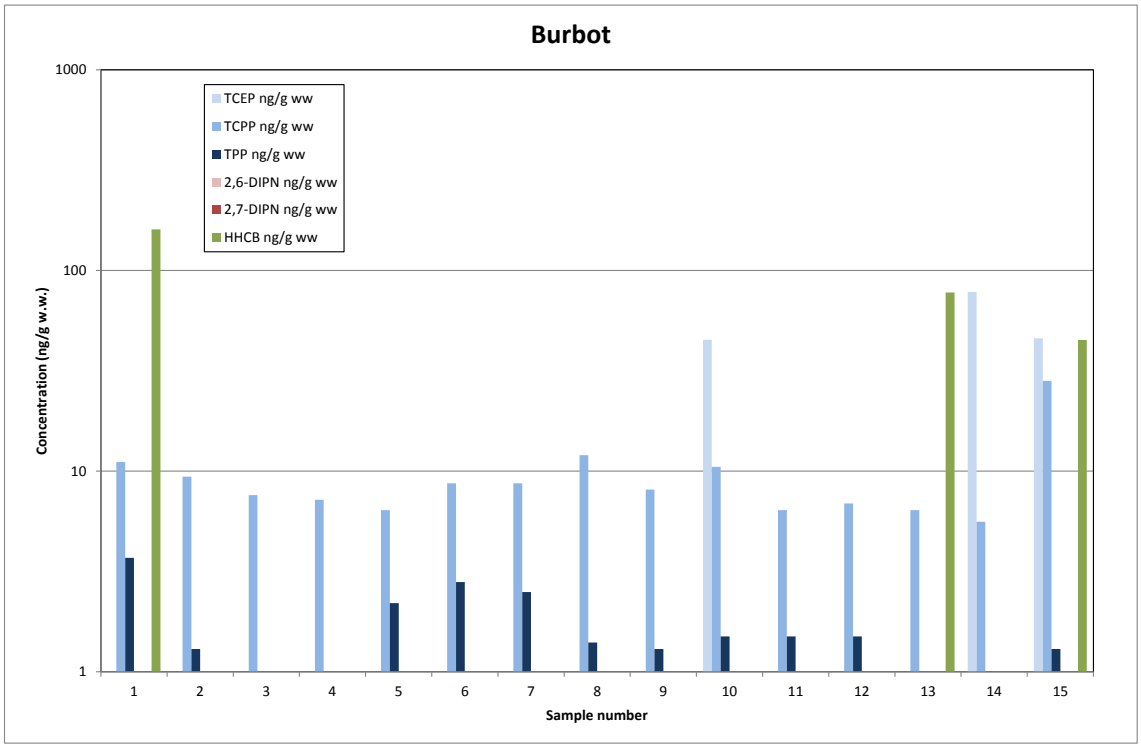


Figure 30: Logarithmic concentrations of selected PBT compounds in soft tissue samples of burbot from Lake Mjøsa.

Again, the maximum levels for the phosphorous flame retardants were substantially higher than their 90th percentiles and should in a statistical sense be regarded as outliers. The 90th percentiles, which are more robust alternatives for extreme value estimates, were in the range of 7–99 ng/g wet weight.

The concentrations of TCPP and TPP we report here exceed those in Arctic char from Lake Ellasjøen (0.5–5 ng/g wet weight) reported by Evenset et al. (2009). Lake Ellasjøen at Bjørnøya Island (Norwegian Arctic) is significantly polluted with a multitude of contaminants due to its link to the marine food web by colonies of nesting seabirds.

The concentrations of the different (bi)isopropylnaphtalenes, (D)IPN, were by and large below LoQ (<4 ng/g wet weight), and only 3 % of the samples (two perch) had quantifiable concentrations of 6 ng/g wet weight.

Only a few samples (8 %) had HHCB concentrations above LoQ (<45 ng/g wet weight) with levels in the range of 46–160 ng/g wet weight.

The phosphorous flame retardants showed significant intercorrelations (Table 22, Figure 31). The correlation between TCEP and TCPP was robust and indicated similar sources and behaviour in the aquatic food web. There was a tendency for decreasing concentrations with increasing $\delta^{15}N$, which may indicate biodillution or species specific uptake and metabolism/excretion rates.

For TPP was the correlation with the two other phosphorous compounds strongly influenced (ruled) by one extreme sample and the correlation structure broke up when this sample was excluded.

Table 21. Concentration statistics for organic phosphorus flame retardants (TCEP, TCPP, ooo-TCP, sum-TCP), (di)-isopropylnaphtalenes (DIPN, IPN) and the musk compound HHCB (Galaxolide) samples of Lake Mjøsa fish(ng/g wet weight).
Sample matrix: soft tissue (whitefish, perch, burbot) and muscle tissue (brown trout).%>LoQ: percent of samples with concentrations greater than level of quantification. n = 60.

Compound	Min	10th percentile	Median	90th percentile	Max	%>LoQ
TCEP	<43.8			99	12009	22%
TCPP	4	6	9	34.3	2426	100%
TPP	<1		1.6	7	364	63%
ooo-TCP	<0.11				<0.25	0%
sum-TCP	<0.11				2	2%
2-IPN	<4				<4	0%
2,6-DIPN	<4				6	3%
2,7-DIPN	<4				6	3%
HHCB	<45				160	8%

Table 22. Correlations (Pearson's r) between organic phosphorus flame retardants (log-transformed) and trophic level ($\delta^{15}N$) in fish samples from Lake Mjøsa.
Only samples with concentrations above level of quantification (>LoQ) are included. Sample matrix: soft tissue (whitefish, perch, burbot) and muscle tissue (brown trout).

Variable	by Variable	Correlation	n	p
log TCEP	$\delta^{15}N$, ‰	-0.55	12	0.065
log TCPP	$\delta^{15}N$, ‰	-0.60	12	0.037*
log TCPP	log TCEP	0.80	12	0.002*
log TPP	$\delta^{15}N$, ‰	-0.02	8	0.969
log TPP	log TCEP	0.72	8	0.044*
log TPP	log TCPP	0.59	8	0.122

* Statistically significant, $p<0.05$

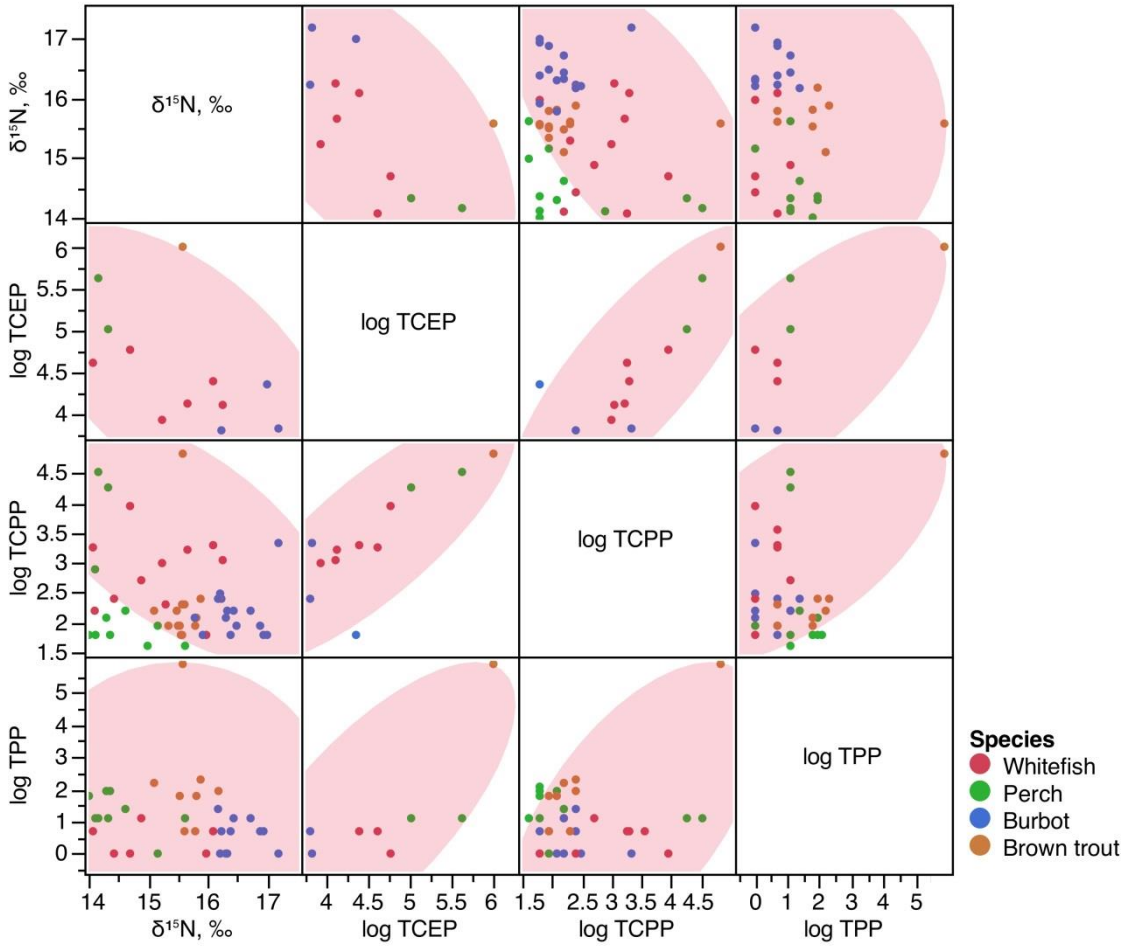


Figure 31. Scatter plot matrix for organic phosphorus flame retardants (log-transformed, ng/g wet weight) and trophic level ($\delta^{15}N$, ‰) in fish samples from Lake Mjøsa. Only samples with concentrations above level of quantification (>LoQ) are included. Sample matrix: soft tissue (whitefish, perch, burbot) and muscle tissue (brown trout). 90 % confidence ellipses are shown.

3.5.4 New bisphenols

In biota samples from Lake Mjøsa the different bisphenols were frequently detected in perch (median concentration: 0.3 – 260 ng/g ww; Figure 32), whitefish (median range: 0.3 – 250 ng/g ww; Figure 33), brown trout (0.2 – 60 ng/g ww; Figure 34), and burbot liver (median concentration: 1.0 – 18 ng/g ww; Figure 35). In perch, whitefish, and brown trout the BPFs were dominating, whereas in burbot liver the BPA was the bisphenol with highest concentrations. It is remarkable that all measured bisphenols could be detected in freshwater biota samples. Only a few samples (8 %) had HHCB concentrations above LoQ (<45 ng/g wet weight) with levels in the range of 46–160 ng/g wet weight.

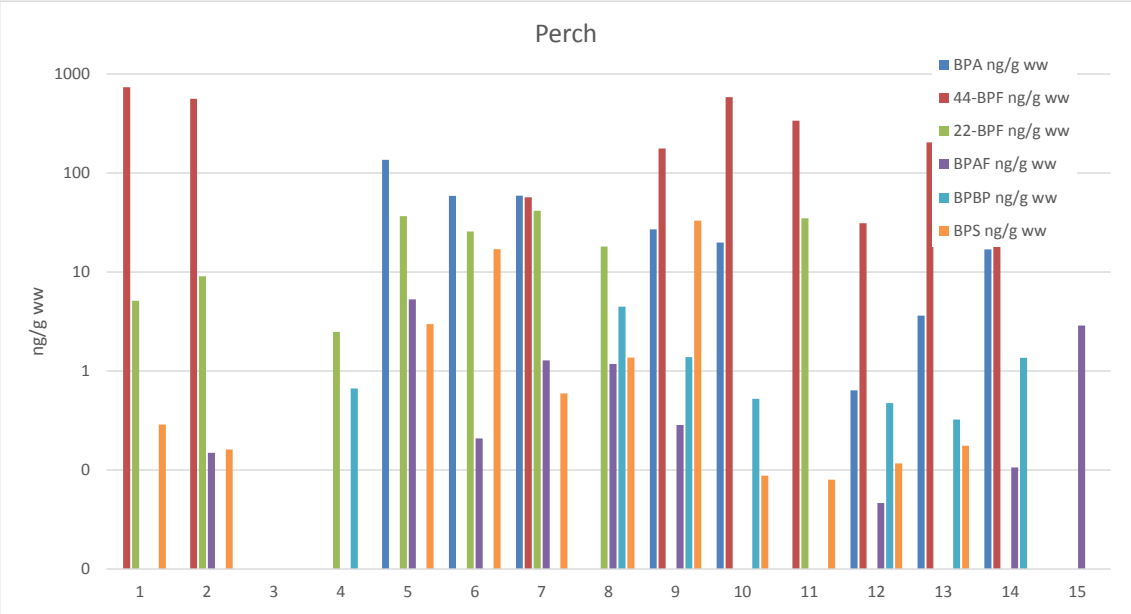


Figure 32: Logarithmic concentrations of new bisphenols in soft tissue samples of perch from Mjøsa.

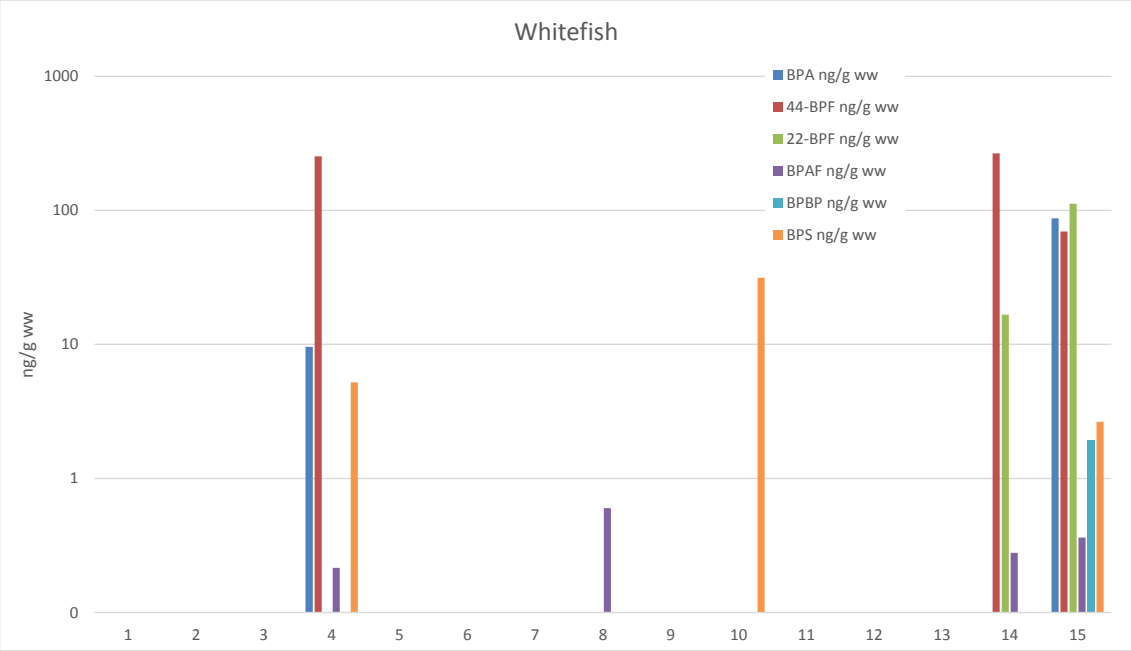


Figure 33: Logarithmic concentrations of new bisphenols in soft tissue samples of white fish from Mjøsa.

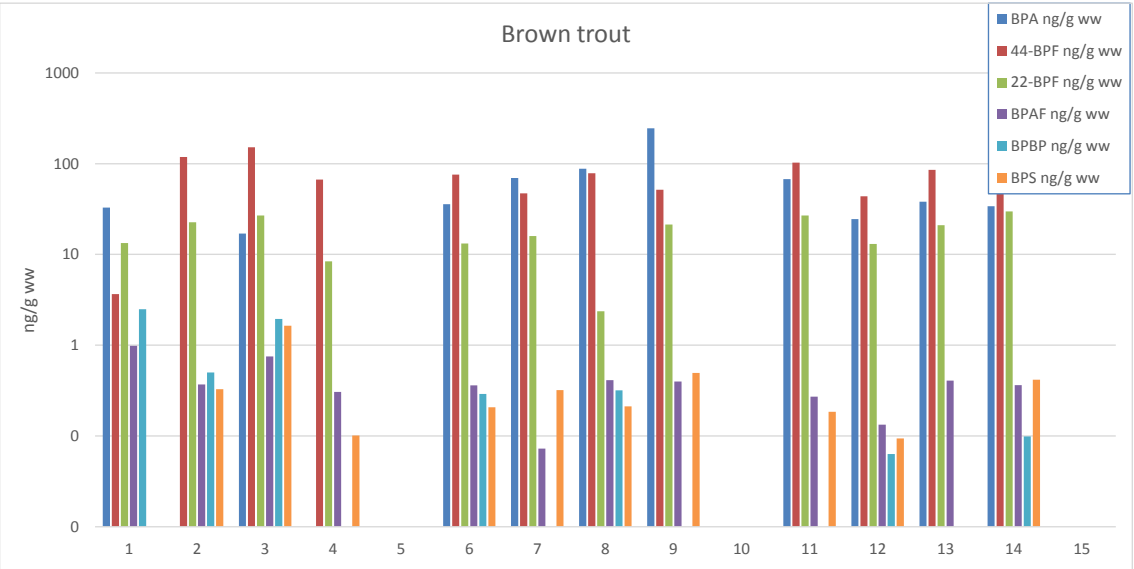


Figure 34: Logarithmic concentrations of new bisphenols compounds in filet samples of brown trout from Mjøsa.

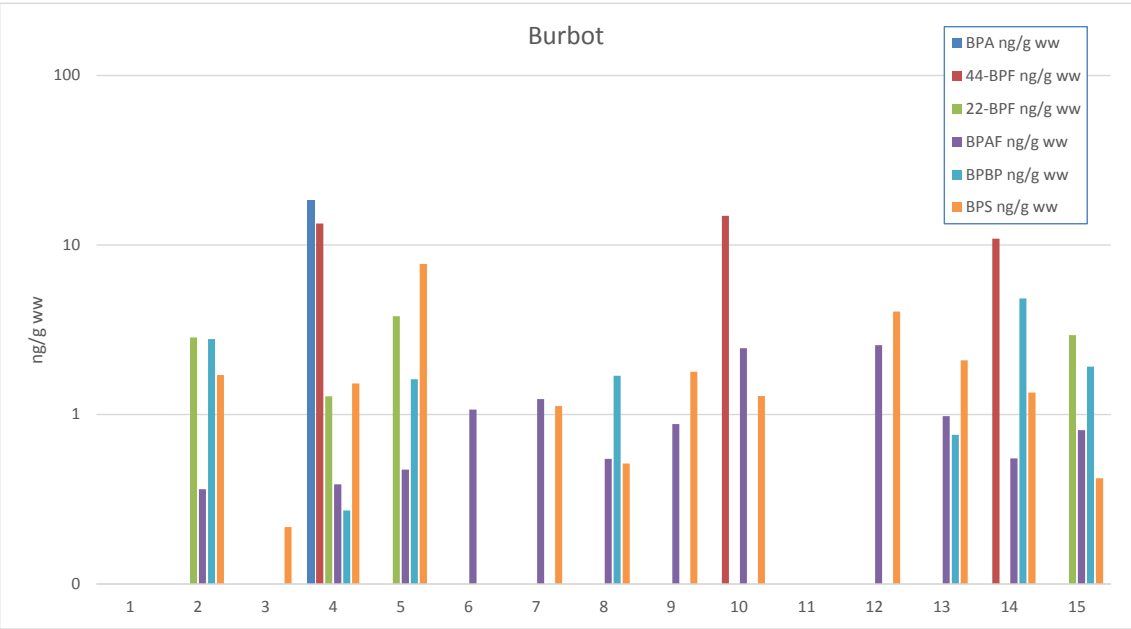


Figure 35: Concentrations of new bisphenols compounds in soft tissue samples of burbot from Mjøsa.

3.1 Fluorinated siloxanes

Fluorinated siloxanes were not detected in any of the samples collected. This can be attributed to the extreme analytical challenge these compounds present. Although these compounds contain volatility similar or greater to other siloxanes under current environmental scrutiny, incomplete volatilization was observed when analyzed by GC-MS. Full mass spectra of standard injections showed two chromatographic peaks corresponding to TFP-D3 whereas 4 separate chromatographic peaks had the same mass spectra corresponding to TFP-D4. Given the limited time, further method optimisation was not possible. Positive chemical ionization (PCI) achieved greater sensitivity compared to electron impact and was utilized for sample analysis. The 3 most dominant ions present in TFP-D3 and TFP-D4 PCI mass spectra, together with the chromatographic pattern observed in the standards, were used to perform a semi-quantitative screening. However, no detectable concentrations were observed.

Standards of TFP-D3 and TFP-D4 prepared in hexane and analyzed by GC-MS showed detectable signals, despite chromatographic issues. However, high concentration standards prepared in water for headspace analysis of water samples showed no detectable signals for either TFP-D3 or TFP-D4. This result is surprising given the extreme hydrophobicity and volatility of these compounds and indicates that these compounds are undergoing rapid hydrolysis or other breakdown processes within water matrices.

These results indicate that despite their extreme volatility, other unique physical chemical properties of these chemicals do not make them amendable for GC analysis. Analytical analysis may be improved by using other sample analysis techniques (i.e., liquid chromatography mass spectrometry) and should be explored in future screening efforts for these compounds and their degradation products.

4. Environmental risk

An attempt was made to make a simple assessment of the environmental risk for each compound using the maximum and median measured environmental concentration (MEC) and dividing this by the published predicted no-effect concentration (PNEC), where available (Table 23). This method of risk assessment will provide a general indication if there is any risk posed to the environment from the levels of an individual chemical. This evaluation does not rule out the risks associated with the combined effects of mixtures of chemicals, which may have a combined effect when present at concentrations below the PNEC.

4.1 UV filters

There are limited published toxicological data for the organic UV chemicals included in this study, however published PNEC from ECHA were available for BP3, EHMC, OC and UV-329 (Table 23). Effluent concentrations BP3 and OC exceeded a $PNEC_{Marine}$ and suggests that there may be the potential for BP3 and OC to pose a risk to receiving marine surface waters under certain low dilution conditions. It is difficult to generalise with regard to the environmental risks associated with the levels detected in sludge since it is very much dependent on how the sludge will be used or disposed of. A detailed risk assessment based on different scenarios would be required. This is beyond the scope of the current study. BP3, EHMC, OC, UV-327 and UV-329 were all detected in sludge. The $PNEC_{Soil}$ was exceeded by the median and maxiumum levels of BP3 in sludge suggesting the need for a more detailed assessment. It was not possible to evaluate whether EHMC and UV-327 pose a risk to soil dwelling organisms when sludge has been applied to land due to an absence of PNEC data. The occurrence of BP3, EHMC, ODBAPA, OC, UV-328 and UV-237 in selected biota samples suggests the potential to bioaccumulate. The accumulation of EHMC, OC, UV-327 and UV-328 was also observed in sediments.

4.2 Organic peroxides

The only organic peroxide detected in WWTW effluent and leachate was dicumyl peroxide. Based upon a PNECs published by ECHA the risk to any receiving waters is very low.

Table 23: Simple evaluation of median and maximum measured environmental conecntrations (MEC) versus predicted-no-effect concentrations (PNEC)

Compound	Measured Environmental Concentration (MEC)						Predicted No-Effect Concentration (PNEC)			MEC/PNEC							
	Effluent (ng/L)		Leachate (ng/L)		Sludge (ng/g)		Surface water (ng/L)	Effluent (ng/L)	Soil (ng/g)	Surface $water_{Effluent}$		Surface $water_{Leachate}$		Effluent		Soil	
	Median	Max.	Median	Max.	Median	Max.	Marine/ freshwater			Median	Max.	Median	Max.	Median	Max.	Median	Max.
BP3	381	1915	195	372	1218	2113	[a]670/6700	[a]1×10^6	[a]13	0.6	2.9	0.3	0.6	0.0004	0.0019	94	163
EHMC					1647	4689	[a]1000/10000	[a]1×10^6									
OC	258	6969	40	380	19741	41609	[a]2300	[a]1×10^6	[a]8.2×10^5	0.1	3.0	0.02	0.2	0.0003	0.007	0.02	0.05
UV-327					80	160											
UV-329					2210	3302	[a]1×10^4/1×10^5	[a]1×10^6	[a]2.6×10^5							0.01	0.01
DEET	1686	15010	11521	15767			43000			0	0.3	0.3	0.4				
Di-Cup	9	23	58	99			[a]2.34×10^3	[a]1×10^6	[a]4.5×10^5	0.02	0.04	9×10^{-6}	2×10^{-5}				
TCEP	2248	3657	1146	14442			6500	32000000	0.341	0.3	0.6	0.2	2.2	0	0		
TCPP	2154	4073	3417	12759	560	916	640000	1700	0.341	0	0	0.0	0	1.3	2.4	0	0.5
HHCB	2083	4343	492	3626	4170	6447	4400	2000000	154000	0.5	1	0.1	0.8	0	0	11	0
∑-DIPN					53	110	[a]260	[a]1.5×10^5	[a]187							0.7	1.1
BPA	802	4611	2157	4672	4143	4534	150	320	6.3	5.3	31	14	31	2.5	14.4	658	720
44-BPF	464	6169	4064	9804	95	286											
22-BPF	670	2166	9239	17103	212	390											
BPAF	3	4	1	1	3	4	[b]										

Table 23: Simple evaluation of median and maximum measured environmental conecntrations (MEC) versus predicted-no-effect concentrations (PNEC)

Compound	Measured Environmental Concentration (MEC)						Predicted No-Effect Concentration (PNEC)			MEC/PNEC							
	Effluent (ng/L)		Leachate (ng/L)		Sludge (ng/g)		Surface water (ng/L)	Effluent (ng/L)	Soil (ng/g)	Surface $water_{Effluent}$		Surface $water_{Leachate}$		Effluent		Soil	
	Median	Max.	Median	Max.	Median	Max.	Marine/ freshwater			Median	Max.	Median	Max.	Median	Max.	Median	Max.
BP-BP	1003	2926	1512	2868	2	3											
BPS	162	1138	66	3123	67	81	[a,b] 2.7×10^4 / 2.7×10^5	[a] 2×10^7	[a] 512	0.006	0.04	0.002	0.1	8×10^{-6}	5×10^{-6}	0.13	0.15

[a] PNEC taken from European Chemicals Agency (ECHA; www.echa.europa.eu) [b] known to be estrogenic

4.3 Selected PBT compounds

None of the selected PBT compounds was present at concentrations in WWTW effluent at concentrations above the PNECs for receiving waters and therefore pose little direct risk. TCPP does pose a risk to WWTW microorganisms. Risks to soils receiving sludge containing these compounds are evaluated to be low, although a thorough assessment is recommended. TCEP, TCPP, 2,6-DIPN and 2,7-DIPN were shown to accumulate in sediments, whilst all selected PBT compounds were shown to occur in marine and freshwater biota.

4.4 New bisphenols

BPA occurs in WWTW effluents and leachates collected at concentrations above the PNEC, suggesting potential for risk to aquatic organisms under certain conditions. As stated above a detailed risk assessment of sludge application to soil is outside the scope of this study but may be warranted as further work in light of the risk quotients obtained when sludge levels are compared to $PNEC_{Soil}$. The PNECs published by ECHA suggest that BPS poses little or no risk to the environment, but since BPS has been shown to estrogenic and the PNECs are based upon acute toxicity endpoints it may be worth considering whether the risk quotients used are sufficiently protective. Assessing the risk from the other bisphenols is very difficult in the absence of ecotoxicological data, although a number have been identified as having endocrine effects in a similar way to BPA (i.e. BPS and BPAF). The absence of ecotoxciological data for these compounds is a concern since they are being released into the environment without an understanding of the potential risks that they pose. Selected new bisphenols were detected in Lake Mjøsa sediments, whilst also being detected in shrimp and cod liver samples from Oslofjord and the fish samples from Lake Mjøsa suggesting the potential to bioaccumulate.

4.5 Fluorinated siloxanes

The absence of occurrence data for fluorinated siloxanes prevented any risk being evaluated.

5. Conclusions

- The organic UV filters BP3, EHMC, OC, UV-234, UV-327 and UV-329 as well as the insect repellant DEET are entering the environment through WWTW effluent and sludge. Dicumyl peroxide was the only of the selected organic peroxides to be detected in WWTW effluent at low ng/L concentrations. WWTW effluent and sludge are also a source of the selected PBT substances and new bisphenols.

- Landfill leachate is a source of the organic UV filters UV-234, OC, BP3 and EHMC. The organic peroxide di(tert-butylperoxyisopropyl)benzene was associated with leachate particulates. All of the selected PBT substances occurred in leachate along with the bisphenols BPA, 44-BF, 22BPF, BP-BP and BPS.

- The UV filters EHMC, OC, UV-327, UV-328, the insect repellant DEET, the selected PBT substances TCEP, TCPP, 2,6-DIPN and 2,7-DIPN and the bisphenols BPF and BPA were shown to accumulate in marine and freshwater sediments receiving treated wastewater.

- BP3, ODPABA, EHMC, OC, UV-238, UV-327, DEET, TCEP, TCPP, 2,6-DIPN, 2,7-DIPN, HHCB, BPA, BPF, BPAF, BP-BP and BPS were shown to accumulate in Oslofjord biota.

- BP3, EHMC, OC, TPP, TCEP, TCPP, 2,6-DIPN, 2,7-DIPN, HHCB, BPA, BPF, BPAF, BP-BP and BPS were shown to accumulate in Lake Mjøsa biota.

- Available data suggests that under certain conditions the organic UV filters BP3 and OC may pose a risk to surface waters and that further evaluation of the risk posed by BP3 in sludge is considered. The absence of ecotoxicity data make it difficult to assessment the potential risks associated with a number of the compounds released into the environment. There are potential risks associated with the accumulation of these chemicals in sediments and biota, however these have not been evaluated.

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Appendix: Results of all analyses

Tables with all analytical results follow. Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota).

Table 24. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	KORN<63µm	TOC/F	NPOC/DC,m	BP3	ODPABA	EHMC	OC	MBT	MBTS	DCHA	UV-234	UV-327	UV-328
Effluent	VEAS			8.3	81	81	81	81	81	81	81	81	81	81
Effluent	VEAS			7.7	712	<5	<5	368	<125	<125	<125	<5	<10	<5
Effluent	VEAS			7.7	239	<5	<5	198	<125	<125	<125	<5	<10	<5
Effluent	VEAS			7.8	293	<5	<5	181	<125	<125	<125	<5	<10	<5
Effluent	VEAS			7.8	598	<5	<5	538	<125	<125	<125	<5	<10	<5
Sludge	VEAS		175		<10	<4	565	3448	<125	<125	<125	<10.7	30	<9.8
Sludge	VEAS		187		<10	<4	793	12661	<125	<125	<125	<8.8	77	<8.9
Sludge	VEAS		197		<10	<4	717	8503	<125	<125	<125	<9.8	44	<9.3
Sludge	VEAS		188		<10	<4	551	6257	<125	<125	<125	<10.9	35	<10.7
Sludge	VEAS		183		<10	<4	714	6172	<125	<125	<125	<8.3	67	<10.1
Effluent	HIAS			23.0	233	<5	<5	227	<125	<125	<125	<5	<10	<5
Effluent	HIAS			18.8	438	<5	<5	158	<125	<125	<125	<5	<10	<5
Effluent	HIAS			19.8	15	<5	<5	108	<125	<125	<125	<5	<10	<5
Effluent	HIAS			18.9	381	<5	<5	179	<125	<125	<125	<5	<10	<5
Effluent	HIAS			16.0	10	<5	<5	79	<125	<125	<125	<5	<10	<5
Sludge	HIAS		288		1122	<7	2501	35873	<125	<125	<125	<10.1	83	<25
Sludge	HIAS		281		824	<9	2627	30230	<125	<125	<125	<13.1	87	<25
Sludge	HIAS		284		1218	<4	3059	26823	<125	<125	<125	<6.6	89	<25
Sludge	HIAS		281		1861	<4	4504	37526	<125	<125	<125	<7.5	97	<25

Table 24. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	KORN<63µm	TOC/F	NPOC/DC,m	BP3	ODPABA	EHMC	OC	MBT	MBTS	DCHA	UV-234	UV-327	UV-328
Sludge	HIAS		270		2113	<4	4689	41610	<125	<125	<125	<6.9	160	<25
Effluent	Tomasfjord			22.0	1915	<5	37	6969	<125	<125	<125	<5	<10	<5
Effluent	Tomasfjord			11.7	649	<5	16	2167	<125	<125	<125	5	<10	<5
Effluent	Tomasfjord			9.4	374	<5	10	1701	<125	<125	<125	5	<10	<5
Effluent	Tomasfjord			6.8	794	<5	4	1937	<125	<125	<125	6	<10	<5
Effluent	Tomasfjord			10.9	721	<5	7	2808	<125	<125	<125	<5	<10	<5
Leachate	ISI Water			37.6	18	<5	<5	<5	<125	<125	<125	<5	<10	<5
Leachate	ISI Water			32.5	372	<5	<5	<5	<125	<125	<125	<5	<10	<5
Leachate	ISI Water			33.2	<10	<5	<5	40	<125	<125	<125	<5	<10	<5
Leachate	ISI Particulate				na	na	na	na	na	na	na	na	na	na
Leachate	ISI Particulate				na	na	na	na	na	na	na	na	na	na
Leachate	ISI Particulate				na	na	na	na	na	na	na	na	na	na
Leachate	Lindum Water			565	<10	<5	<5	<5	<125	<125	<125	<5	<10	<5
Leachate	Lindum Water			448	<10	<5	<5	381	<125	<125	<125	<5	<10	<5
Leachate	Lindum Water			376	<10	<5	<5	16	<125	<125	<125	<5	<10	<5
Leachate	Lindum Particulate				32	<15	85	10557	<125	<125	<125	19	<65	<25
Leachate	Lindum Particulate				114	<15	26	1937	<125	<125	<125	<15	<65	<25
Leachate	Lindum Particulate				646	<15	81	21144	<125	<125	<125	16	<65	<25
Sediment	Oslofjord	42.0	36.2		<5	<4	16	41	<125	<125	<125	<15	5	17

Table 24. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	KORN<63µm	TOC/F	NPOC/DC,m	BP3	ODPABA	EHMC	OC	MBT	MBTS	DCHA	UV-234	UV-327	UV-328
Sediment	Oslofjord	34.0	35.2		<5	<4	11	82	<125	<125	<125	<15	8	25
Sediment	Oslofjord	36.0	33.2		<5	<5	11	<7	<125	<125	<125	<15	4	9
Sediment	Oslofjord	46.0	28.2		<5	<4	8	<7	<125	<125	<125	<15	5	12
Sediment	Oslofjord	44.0	35.4		<5	<5	11	<7	<125	<125	<125	<15	<4	3
Sediment	Mjøsa	52.0	20.1		<5	<4.1	10	<7	<125	<125	<125	<15	<4	<25
Sediment	Mjøsa	58.0	35.5		<5	<4.7	14	<7	<125	<125	<125	<15	<65	<25
Sediment	Mjøsa	58.0	41.3		<5	<5	20	<7	<125	<125	<125	<15	<65	<25
Sediment	Mjøsa	60.0	27.3		<5	<4.7	11	<7	<125	<125	<125	<15	<65	<25
Sediment	Mjøsa	56.0	38.6		<5	<5.9	17	<7	<125	<125	<125	<15	<65	<25

Table 25. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	UV-329	UV-360	UV-571	DEET	Di-Cup	TB-Cup	DiTBPib	DMTBH	TCEP	TCPP	TPP	ooo-TCP	Sum-TCP
Effluent	VEAS	81	81	81	81	81	81	81	81	81	81	81	81	81
Effluent	VEAS	<5	<50	<125	879	<5	nf	<1	<10	3306	4073	146	<3.4	<3.4
Effluent	VEAS	<5	<50	<125	572	<5	nf	<1	<10	3657	3906	136	<3.4	<3.4
Effluent	VEAS	<5	<50	<125	519	<5	nf	<1	<10	2158	2946	118	<3.4	<3.4
Effluent	VEAS	<5	<50	<125	1109	<5	nf	<1	<10	2853	4026	130	<3.4	<3.4
Sludge	VEAS	1172	<125	<125	<4	<5	nf	<1	<10	<1.24	<18.0	33	<0.12	<0.12
Sludge	VEAS	3075	<125	<125	<3	<5	nf	<1	<10	<39.5	485	25	0	10
Sludge	VEAS	1789	<125	<125	<4	<5	nf	<1	<10	<39.5	916	24	0	11
Sludge	VEAS	1474	<125	<125	<4	<5	nf	<1	<10	<39.5	656	22	0	9
Sludge	VEAS	2461	<125	<125	<3	<5	nf	<1	<10	<39.5	439	13	<0.12	7
Effluent	HIAS	<5	<50	<125	2770	8	nf	<1	<10	1597	1665	<3.4	<3.4	<3.4
Effluent	HIAS	<5	<50	<125	3436	6	nf	<1	<10	2758	2651	<3.4	<3.4	<3.4
Effluent	HIAS	<5	<50	<125	2964	7	nf	<1	<10	2248	1897	8	<3.4	<3.4
Effluent	HIAS	<5	<50	<125	4261	<5	nf	<1	<10	1921	2154	<3.4	<3.4	<3.4
Effluent	HIAS	<5	<50	<125	956	5	nf	<1	<10	1803	2227	16	<3.4	<3.4
Sludge	HIAS	3303	<125	<125	<5	<5	nf	<1	<10	62	533	21	1	41
Sludge	HIAS	2362	<125	<125	<5	<5	nf	<1	<10	<39.5	502	26	1	40
Sludge	HIAS	1493	<125	<125	<5	<5	nf	<1	<10	<39.5	560	27	1	45

Table 25. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	UV-329	UV-360	UV-571	DEET	Di-Cup	TB-Cup	DiTBPib	DMTBH	TCEP	TCPP	TPP	ooo-TCP	Sum-TCP
Sludge	HIAS	2060	<125	<125	<5	<5	nf	<1	<10	<39.5	739	29	1	56
Sludge	HIAS	2449	<125	<125	<5	<5	nf	<1	<10	<39.5	836	28	1	66
Effluent	Tomasfjord	<5	<50	<125	15010	23	nf	<1	<10	841	713	38	<3.4	<3.4
Effluent	Tomasfjord	<5	<50	<125	3363	15	nf	<1	<10	1005	958	39	<3.4	<3.4
Effluent	Tomasfjord	<5	<50	<125	2083	<5	nf	<1	<10	1093	564	50	<3.4	<3.4
Effluent	Tomasfjord	<5	<50	<125	1686	9	nf	<1	<10	2289	731	5	<3.4	<3.4
Effluent	Tomasfjord	<5	<50	<125	1541	11	nf	<1	<10	2754	1465	57	<3.4	<3.4
Leachate	ISI Water	<5	<50	<125	11521	<5	nf	<1	<10	399	1448	<6.1	<1.7	<1.7
Leachate	ISI Water	<5	<50	<125	13876	<5	nf	<1	<10	421	1620	<6.1	<1.7	<1.7
Leachate	ISI Water	<5	<50	<125	15767	na	na	na	na	<346	1491	<6.1	<1.7	<1.7
Leachate	ISI Particulate	na	na	na	na	<5	nf	<1	<10	<563	<169	<10.2	<0.8	<0.8
Leachate	ISI Particulate	na	na	na	na	<5	nf	<1	<10	<563	194	13	<0.8	<0.8
Leachate	ISI Particulate	na	na	na	na	na	na	na	na	<563	239	15	<0.8	<0.8
Leachate	Lindum Water	<5	<50	<125	15	<5	nf	<1	<10	6554	8359	<6.1	<1.7	<1.7
Leachate	Lindum Water	<5	<50	<125	8650	<5	nf	<1	<10	14442	12759	<6.1	<1.7	<1.7
Leachate	Lindum Water	<5	<50	<125	<10	<5	nf	<1	<10	1146	5214	<6.1	<1.7	<1.7
Leachate	Lindum Particulate	<15	<125	<125	43	<5	nf	58	<10	<563	513	15	<0.8	<0.8
Leachate	Lindum Particulate	<15	<125	<125	127	<5	nf	99	<10	<563	1176	80	<0.8	28
Leachate	Lindum Particulate	<15	<125	<125	76	<5	nf	19	<10	<563	1302	35	<0.8	35

Table 25. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	UV-329	UV-360	UV-571	DEET	Di-Cup	TB-Cup	DiTBPib	DMTBH	TCEP	TCPP	TPP	ooo-TCP	Sum-TCP
Sediment	Oslofjord	<15	<125	<125	14	<5	nf	<1	<10	<39.5	33	<5.8	0	5
Sediment	Oslofjord	<15	<125	<125	10	<5	nf	<1	<10	54	24	<5.8	0	5
Sediment	Oslofjord	<15	<125	<125	18	<5	nf	<1	<10	41	20	<5.8	0	3
Sediment	Oslofjord	<15	<125	<125	<8	<5	nf	<1	<10	<39.5	<18.0	<5.8	0	3
Sediment	Oslofjord	<15	<125	<125	11	<5	nf	<1	<10	<39.5	<18.0	<5.8	0	6
Sediment	Mjøsa	<15	<125	<125	<5	<5	nf	<1	<10	<39.5	<18.0	<5.8	0	0
Sediment	Mjøsa	<15	<125	<125	<8	<5	nf	<1	<10	42	<18.0	<5.8	0	1
Sediment	Mjøsa	<15	<125	<125	<5	<5	nf	<1	<10	59	<18.0	<5.8	0	0
Sediment	Mjøsa	<15	<125	<125	<8	<5	nf	<1	<10	<39.5	<18.0	<5.8	<0.05	<0.05
Sediment	Mjøsa	<15	<125	<125	12	<5	nf	<1	<10	<39.5	<18.0	<5.8	<0.05	0

Table 26. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	2-IPN	2,6-DIPN	2,7-DIPN	2-IPN	2,6-DIPN	2,7-DIPN	HHCB	BPA	44-BPF	22-BPF	BPAF	BPBP	BPS
Effluent	VEAS	81	81	81	81	81	81	81	81	81	81	<0.7	<3.0	30.6
Effluent	VEAS	<4	11	<4	<4	11	<4	2053	958	379	2028	<1.3	<5.8	<0.9
Effluent	VEAS	<4	10	<4	<4	10	<4	1758	479	529	495	<0.6	<2.8	85.4
Effluent	VEAS	<4	7	<4	<4	7	<4	2008	291	858	118	<0.8	<3.9	<0.9
Effluent	VEAS	na	na	na	na	na	na	na	646	31	768	4.0	<3.4	35.9
Sludge	VEAS	14	76	72	14	76	72	6447	34	<8.0	16	<0.9	<4.0	<0.1
Sludge	VEAS	15	110	103	15	110	103	5374	<3.5	<8.0	<14.0	<0.9	<4.0	<0.1
Sludge	VEAS	11	65	68	11	65	68	3889	<3.5	<8.0	<14.0	<0.9	<4.0	<0.1
Sludge	VEAS	13	76	71	13	76	71	4124	<3.5	<8.0	<14.0	<0.9	<4.0	<0.1
Sludge	VEAS	<4	77	81	<4	77	81	3858	33	286	390	3.6	<0.9	2.1
Effluent	HIAS	<4	5	61	<4	5	61	2114	4611	3619	2135	<2.4	1003	514
Effluent	HIAS	<4	7	166	<4	7	166	1675	1105	6169	945	<1.8	2926	282
Effluent	HIAS	<4	<4	78	<4	<4	78	2037	245	399	<19.5	<0.6	<2.9	162
Effluent	HIAS	<4	6	103	<4	6	103	4343	<1.2	<2.2	<8.8	<0.3	<1.3	<0.2
Effluent	HIAS	<4	<4	30	<4	<4	30	2217	1905	2254	2166	<37.8	<173.8	1137.9
Sludge	HIAS	<4	30	53	<4	30	53	3820	3263	53	107	2.4	2.1	61.7
Sludge	HIAS	<4	38	63	<4	38	63	4867	4143	143	212	3.0	<0.5	71.7
Sludge	HIAS	<4	36	73	<4	36	73	3953	4534	65	212	2.6	2.1	80.8

Table 26. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	2-IPN	2,6-DIPN	2,7-DIPN	2-IPN	2,6-DIPN	2,7-DIPN	HHCB	BPA	44-BPF	22-BPF	BPAF	BPBP	BPS
Sludge	HIAS	<4	40	70	<4	40	70	4259	4433	100	244	2.4	<0.4	61.4
Sludge	HIAS	<4	40	75	<4	40	75	4216	4149	91	221	1.8	3.3	80.0
Effluent	Tomasfjord	<4	11	14	<4	11	14	2590	991	1148	180	2.5	<1.8	<0.3
Effluent	Tomasfjord	<4	5	8	<4	5	8	1978	<1.2	<2.2	588	<0.3	<1.3	<0.2
Effluent	Tomasfjord	<4	6	7	<4	6	7	1736	<0.9	119	292	<0.2	6.0	<0.2
Effluent	Tomasfjord	<4	4	6	<4	4	6	2181	<1.1	<2.0	<8.3	<0.3	<1.2	<0.2
Effluent	Tomasfjord	<4	6	8	<4	6	8	2316	<1.1	298	257	0.6	<1.2	<0.2
Leachate	ISI Water	<4	10	11	<4	10	11	152	2791	7877	17103	<5.0	<23.0	3123
Leachate	ISI Water	<4	10	11	<4	10	11	141	128	105	<3.6	0.6	156.5	19
Leachate	ISI Water	<4	9	11	<4	9	11	156	4672	<17.1	<30.7	<1.5	2868.1	66
Leachate	ISI Particulate	<4	12	13	<4	12	13	79	1	1	<1.4	0.0	<0.2	<0.0
Leachate	ISI Particulate	<4	22	24	<4	22	24	76	1	<0.2	2	0.0	0.6	<0.0
Leachate	ISI Particulate	<4	16	17	<4	16	17	116	0	<0.3	13	0.0	0.6	<0.0
Leachate	Lindum Water	10	<4	<4	10	<4	<4	828	2885	9804	1375	<7.6	<34.4	461
Leachate	Lindum Water	<4	21	32	<4	21	32	3262	1522	250	<5.3	<0.2	<0.8	42
Leachate	Lindum Water	<4	23	34	<4	23	34	3626	422	<1.9	<7.6	<0.2	<1.1	<0.2
Leachate	Lindum Particulate	16	34	38	16	34	38	482	<0.2	3	25	<0.1	<0.3	<0.0
Leachate	Lindum Particulate	na	na	na	na	na	na	na	<0.7	7	243	<0.2	6.8	<0.1

Table 26. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	2-IPN	2,6-DIPN	2,7-DIPN	2-IPN	2,6-DIPN	2,7-DIPN	HHCB	BPA	44-BPF	22-BPF	BPAF	BPBP	BPS
Leachate	Lindum Particulate	<4	61	70	<4	61	70	2413	29	14	127	0.7	5.5	<0.1
Sediment	Oslofjord	<4	12	15	<4	12	15	<45	<0.8	<12.0	47	<3.0	<3.0	<0.9
Sediment	Oslofjord	<4	<4	5	<4	<4	5	<45	<0.8	<12.0	<12.0	<3.0	<3.0	<0.9
Sediment	Oslofjord	<4	<4	<4	<4	<4	<4	<45	<0.8	<12.0	<12.0	<3.0	<3.0	<0.9
Sediment	Oslofjord	<4	<4	<4	<4	<4	<4	<45	44	<12.0	<12.0	<3.0	<3.0	<0.9
Sediment	Oslofjord	<4	<4	<4	<4	<4	<4	<45	<0.8	<12.0	<12.0	<3.0	<3.0	<0.9
Sediment	Mjøsa	<4	<4	<4	<4	<4	<4	<45	2	36	15	0.1	0.1	0.1
Sediment	Mjøsa	<4	<4	<4	<4	<4	<4	<45	na	na	na	na	na	na
Sediment	Mjøsa	<4	<4	<4	<4	<4	<4	<45	na	na	na	na	na	na
Sediment	Mjøsa	<4	<4	<4	<4	<4	<4	<45	na	na	na	na	na	na
Sediment	Mjøsa	<4	<4	<4	<4	<4	<4	<45	3	47	26	0.1	0.1	0.1

Table 27. Concentrations of analysed compounds with the exception of fluorinated siloxanes in biota samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	lipid	$\delta^{13}C_{VPDB}$	$\delta^{15}N_{AIR}$	W% C/N	BP3	ODPABA	EHMC	OC	MBT	MBTS	DCHA	UV-234	UV-327
Cod liver	Oslofjord	55.0	-23.42	15.53	32.64	<20	<20	34	<20	<250	<250	<250	<10	<50
Cod liver	Oslofjord	55.0	-23.52	16.38	12.71	<20	<20	37	<20	<250	<250	<250	<10	<50
Cod liver	Oslofjord	53.0	-23.89	16.49	12.14	<20	<20	31	13	<250	<250	<250	<10	<50
Cod liver	Oslofjord	36.0	-26.01	14.68	21.26	<20	<20	<30	182	<250	<250	<250	<10	<50
Cod liver	Oslofjord	33.0	-23.91	14.87	26.11	<20	<20	<30	530	<250	<250	<250	<10	<50
Cod liver	Oslofjord	11.0	-21.28	17.42	6.45	248	<20	<30	356	<250	<250	<250	<10	<50
Cod liver	Oslofjord	26.0	-22.54	16.54	18.17	<20	<20	<30	24	<250	<250	<250	<10	<50
Cod liver	Oslofjord	61.0	-24.42	16.11	11.19	35	<20	<30	<10	<250	<250	<250	<10	<50
Cod liver	Oslofjord	15.0	-23.03	15.15	10.41	296	<20	<30	115	<250	<250	<250	<10	<50
Cod liver	Oslofjord	24.0	-22.95	15.65	10.91	55	21	<30	42	<250	<250	<250	<10	<50
Cod liver	Oslofjord	10.0	-20.11	16.47	10.26	<20	<20	<30	2103	<250	<250	<250	<10	<50
Cod liver	Oslofjord	9.4	-21.58	16.29	6.16	<20	<20	<30	11875	<250	<250	<250	<10	<50
Cod liver	Oslofjord	15.0	-22.40	15.80	8.19	974	<20	<30	198	<250	<250	<250	<10	<50
Cod liver	Oslofjord	27.0	-23.45	14.33	11.66	194	<20	<30	57	<250	<250	<250	<10	<50
Cod liver	Oslofjord	18.0	-22.47	15.40	8.69	1037	<20	<30	135	<250	<250	<250	<10	<50
Shore crab	Oslofjord	0.5	-19.14	11.47	3.71	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	0.9	-17.36	11.68	3.46	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	0.4	-17.59	11.36	3.32	<30	<20	<10	<10	<250	<250	<250	<10	<10

Table 27. Concentrations of analysed compounds with the exception of fluorinated siloxanes in biota samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	lipid	$\delta^{13}C_{VPDB}$	$\delta^{15}N_{AIR}$	W% C/N	BP3	ODPABA	EHMC	OC	MBT	MBTS	DCHA	UV-234	UV-327
Shore crab	Oslofjord	0.8	-18.06	10.76	3.39	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	0.8	-18.65	11.67	3.49	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	0.5	-18.01	12.49	3.28	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	0.4	-17.34	11.41	3.39	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	0.9	-19.01	11.04	4.02	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	0.6	-19.24	10.96	3.90	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	1.4	-19.29	10.57	4.08	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	1.2	-18.88	10.35	4.35	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	1.9	-20.30	10.59	4.43	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	1.6	-20.19	9.88	4.90	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	2.2	-19.96	10.07	4.59	<30	<20	<10	<10	<250	<250	<250	<10	<10
Shore crab	Oslofjord	1.1	-19.78	9.44	4.43	<30	<20	<10	<10	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	0.9	-18.27	13.89	2.78	54	<20	<15	<10	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	0.9	-18.36	14.01	2.80	<30	<20	<20	23	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	0.8	-18.14	13.95	2.80	45	<20	<10	<10	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	0.9	-18.20	13.89	2.77	56	<20	<16	<10	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	0.8	-18.41	13.90	2.77	55	<20	<20	<10	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	0.8	-18.08	13.91	2.78	46	<20	<13	<10	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	0.7	-18.10	13.77	2.76	58	<20	<11	<10	<250	<250	<250	<10	<10

Table 27. Concentrations of analysed compounds with the exception of fluorinated siloxanes in biota samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	lipid	$\delta^{13}C_{VPDB}$	$\delta^{15}N_{AIR}$	W% C/N	BP3	ODPABA	EHMC	OC	MBT	MBTS	DCHA	UV-234	UV-327
Northern shrimp	Oslofjord	0.8	-18.31	13.76	2.76	65	<20	<17	<10	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	0.8	-18.05	13.96	2.76	<30	<20	<13	<10	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	0.8	-18.03	13.92	2.75	<30	<20	<16	<10	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	0.8	-18.27	13.82	2.73	<30	<20	<9	<10	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	0.9	-18.13	13.90	2.77	<30	<20	<20	<10	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	0.8	-18.14	13.87	2.75	<30	<20	<13	<10	<250	<250	<250	<10	<10
Northern shrimp	Oslofjord	84.0	-18.07	13.86	2.73	69	<20	<9	<10	<250	<250	<250	<10	52
Northern shrimp	Oslofjord	0.8	-18.17	13.84	2.75	<30	<20	<10	<10	<250	<250	<250	<10	<10
Burbot soft tissue	Mjøsa	5.9	-27.41	16.17	2.70	<5	<20	<5	<2	<250	<250	<250	<10	<50
Burbot soft tissue	Mjøsa	1.7	-26.53	16.33	2.65	<5	<20	<5	<2	<250	<250	<250	<10	<50
Burbot soft tissue	Mjøsa	6.5	-26.97	15.78	2.73	<5	<20	<5	<2	<250	<250	<250	<10	<50
Burbot soft tissue	Mjøsa	6.3	-27.03	16.48	2.83	<5	<20	<5	<2	<250	<250	<250	<10	<50
Burbot soft tissue	Mjøsa	3.6	-27.08	16.94	2.69	<5	<20	<5	<2	<250	<250	<250	<10	<50
Burbot soft tissue	Mjøsa	4.4	-26.39	16.43	2.66	<5	<20	<5	<2	<250	<250	<10	<10	<50
Burbot soft tissue	Mjøsa	3.9	-26.78	16.72	2.66	<5	<20	<5	<2	<250	<250	<115	<10	<50
Burbot soft tissue	Mjøsa	1.9	-26.35	16.21	2.67	<5	<20	<5	<2	<250	<250	<55	<10	<50
Burbot soft tissue	Mjøsa	3.4	-26.83	16.30	2.65	<5	<20	<5	<2	<250	<250	<22	<10	<50
Burbot soft tissue	Mjøsa	5.5	-26.70	16.23	2.70	<5	<20	<5	<2	<250	<250	<22	<10	<50
Burbot soft tissue	Mjøsa	4.6	-27.03	16.38	2.72	<5	<20	<5	<2	<250	<250	<22	<10	<50

Table 27. Concentrations of analysed compounds with the exception of fluorinated siloxanes in biota samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	lipid	$\delta^{13}C_{VPDB}$	$\delta^{15}N_{AIR}$	W% C/N	BP3	ODPABA	EHMC	OC	MBT	MBTS	DCHA	UV-234	UV-327
Burbot soft tissue	Mjøsa	5.3	-26.51	16.88	2.75	<5	<20	<5	<2	<250	<250	<22	<10	<50
Burbot soft tissue	Mjøsa	4.2	-26.43	15.92	2.72	<5	<20	<5	<2	<250	<250	<22	<10	<50
Burbot soft tissue	Mjøsa	3.7	-27.18	17.00	2.70	<5	<20	<5	<2	<250	<250	<22	<10	<50
Burbot soft tissue	Mjøsa	4.8	-26.83	17.19	2.68	<5	<20	<5	<2	<250	<250	<22	<10	<50
Perch soft tissue	Mjøsa	0.5	-26.58	14.62	2.61	<5	<20	<5	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	1.1	-27.06	14.30	2.66	<5	<20	<5	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	4.9	-26.42	13.44	2.72	<5	<20	<5	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	0.8	-26.98	14.36	2.66	<5	<20	<5	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	2.7	-27.43	14.11	2.70	<5	<20	<5	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	3.2	-28.26	14.01	2.68	<5	<20	<5	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	0.6	-27.27	15.16	2.62	<5	<20	<5	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	1.2	-27.49	15.62	2.69	<5	<20	<5	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	0.5	-27.95	13.80	2.65	<5	<20	<5	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	0.6	-27.54	14.99	2.65	<5	<20	36	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	3.4	-26.65	14.11	2.63	7	<20	<5	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	1.7	-27.96	14.12	2.74	<5	<20	<5	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	1.3	-26.98	14.16	2.57	<5	<20	<5	<2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	0.7	-28.37	14.33	2.69	<5	<20	<5	2	<250	<250	<250	<10	<5
Perch soft tissue	Mjøsa	1.4	-28.01	14.96	2.78	<5	<20	<5	<2	<250	<250	<250	<10	<5

Table 27. Concentrations of analysed compounds with the exception of fluorinated siloxanes in biota samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	lipid	$\delta^{13}C_{VPDB}$	$\delta^{15}N_{AIR}$	W% C/N	BP3	ODPABA	EHMC	OC	MBT	MBTS	DCHA	UV-234	UV-327
Whitefish soft tissue	Mjøsa	0.7	-28.63	14.10	2.67	182	<20	117	<2	<250	<250	<333	<10	<50
Whitefish soft tissue	Mjøsa	1.1	-27.98	15.66	2.73	47	<20	23	<2	<250	<250	<32	<10	<50
Whitefish soft tissue	Mjøsa	0.8	-29.29	13.35	4.61	56	<20	19	<2	<250	<250	<12	<10	<50
Whitefish soft tissue	Mjøsa	2.5	-28.40	13.66	3.71	<20	<20	<5	<2	<250	<250	<10	<10	<50
Whitefish soft tissue	Mjøsa	0.5	-27.59	14.07	3.42	89	<20	48	<2	<250	<250	<10	<10	<50
Whitefish soft tissue	Mjøsa	1.7	-27.72	14.88	3.44	<20	<20	<5	<2	<250	<250	<10	<10	<50
Whitefish soft tissue	Mjøsa	3.0	-28.35	13.78	3.65	<20	<20	<5	<2	<250	<250	<10	<10	<50
Whitefish soft tissue	Mjøsa	0.9	-27.22	15.23	3.27	<20	<20	<5	<2	<250	<250	<10	<10	<50
Whitefish soft tissue	Mjøsa	1.6	-28.40	14.70	3.46	<20	<20	<5	<2	<250	<250	<10	<10	<50
Whitefish soft tissue	Mjøsa	0.8	-27.11	16.25	3.09	<20	<20	<5	<2	<250	<250	<10	<10	<50
Whitefish soft tissue	Mjøsa	1.6	-27.36	15.97	3.00	<20	<20	<5	<2	<250	<250	<10	<10	<50
Whitefish soft tissue	Mjøsa	0.9	-28.01	16.09	3.56	<20	<20	<5	<2	<250	<250	<10	<10	<50
Whitefish soft tissue	Mjøsa	2.6	-28.52	13.92	3.40	<20	<20	<5	<2	<250	<250	<10	<10	<50
Whitefish soft tissue	Mjøsa	0.7	-27.49	15.29	3.06	<20	<20	<5	<2	<250	<250	<10	<10	<50
Whitefish soft tissue	Mjøsa	0.6	-27.06	14.43	2.80	<20	<20	<5	<2	<250	<250	<10	<10	<50
Brown trout filet	Mjøsa	4.5	-30.04	15.88	4.04	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	4.0	-29.29	15.10	3.66	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	2.4	-28.34	15.50	3.41	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	3.2	-30.10	15.55	3.81	na	na	na	na	na	na	na	na	na

Table 27. Concentrations of analysed compounds with the exception of fluorinated siloxanes in biota samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	lipid	$\delta^{13}C_{VPDB}$	$\delta^{15}N_{AIR}$	W% C/N	BP3	ODPABA	EHMC	OC	MBT	MBTS	DCHA	UV-234	UV-327
Brown trout filet	Mjøsa	3.9	-28.20	15.52	3.04	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	1.3	-27.61	15.48	2.99	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	0.8	-27.11	15.57	2.91	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	0.1	-29.47	15.61	3.69	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	0.1	-27.22	15.53	2.90	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	2.9	-27.69	15.81	3.03	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	1.5	-28.02	16.18	3.23	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	1.2	-27.93	15.79	3.11	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	0.4	-27.22	15.58	2.83	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	3.2	-29.31	15.34	3.46	na	na	na	na	na	na	na	na	na
Brown trout filet	Mjøsa	0.2	-27.55	15.57	2.91	na	na	na	na	na	na	na	na	na

Table 28. Concentrations of analysed compounds with the exception of fluorinated siloxanes in biota samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	UV-328	UV-329	UV-360	UV-571	DEET	Di-Cup	TB-Cup	DiTBPib	DMTBH	TCEP	TCPP	TPP	ooo-TCP
Cod liver	Oslofjord	<10	<25	<250	<250	25	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.05
Cod liver	Oslofjord	<10	<25	<250	<250	35	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.05
Cod liver	Oslofjord	<10	<25	<250	<250	33	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.05
Cod liver	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.05
Cod liver	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.05
Cod liver	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.05
Cod liver	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.05
Cod liver	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	156	58	<8.7	<0.05
Cod liver	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	1472	561	13	<0.05
Cod liver	Oslofjord	19	<25	<250	<250	<5	<5	nf	<1	<10	144	53	<8.7	<0.05
Cod liver	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	2054	778	34	<0.05
Cod liver	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	233	82	27	<0.05
Cod liver	Oslofjord	13	<25	<250	<250	<5	<5	nf	<1	<10	131	55	<8.7	<0.05
Cod liver	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	11	<0.05
Cod liver	Oslofjord	17	<25	<250	<250	<5	<5	nf	<1	<10	2620	403	28	<0.06
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	205	48	<8.7	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	86	21	<8.7	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	62	<17.1	<8.7	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	126	30	<8.7	<0.11

Table 28. Concentrations of analysed compounds with the exception of fluorinated siloxanes in biota samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	UV-328	UV-329	UV-360	UV-571	DEET	Di-Cup	TB-Cup	DiTBPib	DMTBH	TCEP	TCPP	TPP	ooo-TCP
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	147	34	<8.7	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	59	<17.1	<8.7	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	200	51	33	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.11
Shore crab	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<53.8	<17.1	<8.7	<0.11
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	8	<1.2	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	7	1	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	2	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	5	<1.2	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	4	2	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	5	3	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	4	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	<1.2	<0.13

Table 28. Concentrations of analysed compounds with the exception of fluorinated siloxanes in biota samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	UV-328	UV-329	UV-360	UV-571	DEET	Di-Cup	TB-Cup	DiTBPib	DMTBH	TCEP	TCPP	TPP	ooo-TCP
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	2	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	7	4	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	5	2	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	8	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	7	<1.2	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	14	7	<0.13
Northern shrimp	Oslofjord	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	7	11	<0.13
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	11	4	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	9	1	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	8	<1.2	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	7	<1.2	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	2	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	9	3	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	9	3	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	12	1	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	8	1	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	45	11	2	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	2	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	7	2	<0.15

Table 28. Concentrations of analysed compounds with the exception of fluorinated siloxanes in biota samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	UV-328	UV-329	UV-360	UV-571	DEET	Di-Cup	TB-Cup	DiTBPib	DMTBH	TCEP	TCPP	TPP	ooo-TCP
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	<1.2	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	78	6	<1.2	<0.15
Burbot soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	46	28	1	<0.15
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	9	4	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	8	7	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	8	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	7	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	3	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	6	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	7	1	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	5	3	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	5	<1.2	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	5	<1.2	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	18	<1.2	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	<1.2	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	278	92	3	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	151	71	3	<0.11
Perch soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	4	<1.2	<0.11
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	9	<1.2	<0.25

Table 28. Concentrations of analysed compounds with the exception of fluorinated siloxanes in biota samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	UV-328	UV-329	UV-360	UV-571	DEET	Di-Cup	TB-Cup	DiTBPib	DMTBH	TCEP	TCPP	TPP	ooo-TCP
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	62	25	<1.2	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	12009	2426	<1.2	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	35	2	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	101	26	2	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	15	3	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	9	3	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	51	20	<1.2	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	118	52	1	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	61	21	<1.2	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	6	1	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	81	27	2	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	10	2	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	10	<1.2	<0.25
Whitefish soft tissue	Mjøsa	<10	<25	<250	<250	<5	<5	nf	<1	<10	<43.8	11	1	<0.25
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	11	10	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	9	9	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	7	<1.2	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	6	<1.2	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	7	<1.2	<0.13

Table 28. Concentrations of analysed compounds with the exception of fluorinated siloxanes in biota samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	UV-328	UV-329	UV-360	UV-571	DEET	Di-Cup	TB-Cup	DiTBPib	DMTBH	TCEP	TCPP	TPP	ooo-TCP
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	9	<1.2	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	10	<1.2	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	10	2	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	7	6	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	8	6	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	na	na	na	na	<43.8	11	7	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	7	2	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	na	na	na	na	405	125	364	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	7	<1.2	<0.13
Brown trout filet	Mjøsa	na	na	na	na	na	<5	nf	<1	<10	<43.8	6	<1.2	<0.13

Table 29. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	Sum-TCP	2-IPN	2,6-DIPN	2,7-DIPN	HHCB	BPA	44-BPF	22-BPF	BPAF	BPBP	BPS
Cod liver	Oslofjord	<0.05	<4	<4	<4	<45	1105	266	46	1.2	14.2	20.9
Cod liver	Oslofjord	<0.05	<4	7	11	181	1058	191	34	4.9	16.3	<1.4
Cod liver	Oslofjord	<0.05	<4	<4	7	123	na	na	na	na	na	na
Cod liver	Oslofjord	<0.05	<4	6	9	181	na	na	na	na	na	na
Cod liver	Oslofjord	<0.05	<4	<4	6	144	na	na	na	na	na	na
Cod liver	Oslofjord	<0.05	<4	<4	5	122	na	na	na	na	na	na
Cod liver	Oslofjord	<0.05	<4	6	11	95	na	na	na	na	na	na
Cod liver	Oslofjord	<0.05	<4	5	10	271	996	153	49	4.0	<10.3	<2.5
Cod liver	Oslofjord	<0.05	<4	<4	<4	86	126	41	6	1.3	6.7	11.2
Cod liver	Oslofjord	<0.05	<4	<4	<4	175	588	148	47	0.8	<3.2	<0.8
Cod liver	Oslofjord	<0.05	<4	<4	<4	80	364	70	6	0.7	13.0	<0.4
Cod liver	Oslofjord	<0.05	<4	<4	<4	95	na	na	na	na	na	na
Cod liver	Oslofjord	<0.05	<4	<4	<4	88	<3.1	52	<1.1	<0.6	5.8	<0.6
Cod liver	Oslofjord	<0.05	<4	<4	<4	139	na	na	na	na	na	na
Cod liver	Oslofjord	<0.06	<4	<4	<4	71	<0.3	<0.5	<2.0	0.3	<0.3	<0.0
Shore crab	Oslofjord	<0.11	<4	4	4	<45	<0.4	<0.8	23	0.2	<0.3	0.7
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.2	167	<1.5	0.4	<0.2	0.1
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.5	<1.0	5	0.2	2.7	6.9
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.5	<6.0	<3.2	<4.0	<2.0	<2.0

Table 29. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples
Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	Sum-TCP	2-IPN	2,6-DIPN	2,7-DIPN	HHCB	BPA	44-BPF	22-BPF	BPAF	BPBP	BPS
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.5	<6.0	<3.2	<4.0	<2.0	<2.0
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.5	<6.0	<3.2	<4.0	<2.0	<2.0
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.5	<6.0	<3.2	<4.0	<2.0	<2.0
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.5	<6.0	<3.2	<4.0	<2.0	<2.0
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.5	<6.0	<3.2	<4.0	<2.0	<2.0
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.5	<6.0	<3.2	<4.0	<2.0	<2.0
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.5	<6.0	<3.2	<4.0	<2.0	<2.0
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.5	<6.0	<3.2	<4.0	<2.0	<2.0
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	55	<6.0	<3.2	<4.0	<2.0	<2.0
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.5	<6.0	<3.2	<4.0	<2.0	<2.0
Shore crab	Oslofjord	<0.11	<4	<4	<4	<45	<0.5	<6.0	<3.2	<4.0	<2.0	<2.0
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	4	39	9	0.1	<0.0	0.2
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	<0.0	34	11	0.0	0.8	0.1
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	1	<0.4	<0.6	<0.0	0.8	0.0
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	2	2	1	0.1	3.0	0.2
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	4	3	<0.8	<0.0	1.0	<0.0
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	1	6	<0.4	<0.0	0.4	0.0
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	1	<0.3	<0.6	<0.0	1.3	0.0
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	<0.2	<0.3	<0.6	0.1	0.3	0.2

Table 29. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	Sum-TCP	2-IPN	2,6-DIPN	2,7-DIPN	HHCB	BPA	44-BPF	22-BPF	BPAF	BPBP	BPS
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	3	<0.2	0	<0.0	0.3	0.0
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	1	<0.3	1	0.0	0.4	0.1
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	3	<0.3	<0.5	<0.0	0.9	0.1
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	3	3	<0.6	0.0	<0.1	0.0
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	<0.2	<0.4	<0.8	0.0	<0.2	0.3
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	<0.0	57	2	0.1	0.2	<0.0
Northern shrimp	Oslofjord	<0.13	<4	<4	<4	<45	2	66	3	0.1	<0.1	0.1
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	160	na	na	na	na	na	na
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	<45	<0.7	<1.4	3	0.4	2.8	1.7
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	<45	<0.5		<3.5	<0.1	<0.5	0.2
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	<45	18	13	1	0.4	0.3	1.5
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	<45	<0.8	<1.7	4	0.5	1.6	7.7
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	<45	<2.8	<5.6	<10.0	1.1	<2.2	
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	<45	<0.6	<1.3	<2.3	1.2	<0.5	1.1
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	<45	<0.5	<1.1	<1.9	0.5	1.7	0.5
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	<45	<0.7	<1.4	<2.6	0.9	<0.6	1.8
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	<45	<0.9	15	<3.3	2.5	<0.7	1.3
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	<45	na	na	na	na	na	na
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	<45	<1.5	<3.1	<5.6	2.6	<1.2	4.0

Table 29. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	Sum-TCP	2-IPN	2,6-DIPN	2,7-DIPN	HHCB	BPA	44-BPF	22-BPF	BPAF	BPBP	BPS
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	78	<0.9	<1.8	<3.2	1.0	0.8	2.1
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	<45	<0.8	11	<2.8	0.6	4.8	1.3
Burbot soft tissue	Mjøsa	<0.15	<4	<4	<4	45	<0.7	<1.5	3	0.8	1.9	0.4
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	<45	<0.4	735	5	<0.4	<0.3	0.3
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	<45	<0.3	561	9	0.1	<0.3	0.2
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	<45	<0.5	<1.0	<4.0	<0.1	<0.6	<0.1
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	<45	<0.2	<0.4	2	<0.1	0.7	<0.0
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	<45	136	<2.0	37	5.3	<0.8	3.0
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	<45	59	<2.1	26	0.2	<0.8	17.0
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	<45	59	57	42	1.3	<0.6	0.6
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	94	<4.3	<8.7	18	1.2	4.5	1.4
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	<45	27	176	<3.1	0.3	1.4	33.1
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	<45	20	583	<1.7	<0.1	0.5	0.1
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	<45	<0.2	337	35	<0.1	<0.3	0.1
Perch soft tissue	Mjøsa	<0.11	<4	6	6	<45	1	31	<1.3	0.0	0.5	0.1
Perch soft tissue	Mjøsa	<0.11	<4	6	6	<45	4	204	<1.3	<0.0	0.3	0.2
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	<45	17	256	<3.0	0.1	1.4	<0.1
Perch soft tissue	Mjøsa	<0.11	<4	<4	<4	<45	<2.5	<4.6	<18.6	2.9	<2.8	<0.4
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	na	na	na	na	na	na

Table 29. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	Sum-TCP	2-IPN	2,6-DIPN	2,7-DIPN	HHCB	BPA	44-BPF	22-BPF	BPAF	BPBP	BPS
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	na	na	na	na	na	na
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	na	na	na	na	na	na
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	10	253	<1.4	0.2	<0.3	5.2
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	na	na	na	na	na	na
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	na	na	na	na	na	na
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	na	na	na	na	na	na
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	<1.1	<2.2	<3.9	0.6	<0.8	<0.2
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	na	na	na	na	na	na
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	<3.3	<6.6	<11.8	<0.6	<2.6	31.4
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	na	na	na	na	na	na
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	na	na	na	na	na	na
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	na	na	na	na	na	na
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	92	<0.3	266	17	0.3	<0.3	<0.0
Whitefish soft tissue	Mjøsa	<0.25	<4	<4	<4	<45	87	69	112	0.4	1.9	2.6
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	33	4	13	1.0	2.5	<0.2
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	<0.1	119	23	0.4	0.5	0.3
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	17	152	27	0.8	1.9	1.6
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	<0.1	67	8	0.3	<0.1	0.1
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	<0.1	<0.2	<0.6	<0.0	<0.1	<0.0

Table 29. Concentrations of analysed compounds with the exception of fluorinated siloxanes in abiotic samples

Concentrations are given in ng/L (water), ng/g dry weight (sludge and sediment), and ng/g wet weight (biota). <: below Limit of Detection (LoD);na: not analyzed; nf: not found and LoD not known

Matrix	Location	Sum-TCP	2-IPN	2,6-DIPN	2,7-DIPN	HHCB	BPA	44-BPF	22-BPF	BPAF	BPBP	BPS
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	36	76	13	0.4	0.3	0.2
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	69	47	16	0.1	<0.1	0.3
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	88	78	2	0.4	0.3	0.2
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	245	52	21	0.4	<0.1	0.5
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	na	na	na	na	na	na
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	68	103	27	0.3	<0.2	0.2
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	24	44	13	0.1	0.1	0.1
Brown trout filet	Mjøsa	2	<4	<4	<4	<45	na	na	na	na	na	na
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	38	85	21	0.4	<0.2	<0.0
Brown trout filet	Mjøsa	<0.13	<4	<4	<4	<45	34	48	30	0.4	0.1	0.4

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The Norwegian Environment Agency's primary tasks are to reduce greenhouse gas emissions, manage Norwegian nature, and prevent pollution.

We are under the Ministry of Climate and Environment and have over 700 employees at our two offices in Trondheim and Oslo and at the Norwegian Nature Inspectorate's more than sixty local offices.
Our principal functions include monitoring the state of the environment, conveying environment-related information, exercising authority, overseeing and guiding regional and municipal authorities, cooperating with relevant industry authorities, acting as an expert advisor, and assisting in international environmental efforts.