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Summary

EU Water "framework directive priority contaminants" were analyzed in fish liver sampled in 14 Norwegian lakes (see map under). The concentration of different contaminants in liver tissue may differ from muscle tissue because they have various chemical properties. EU has established European Quality Standards (EQS) for prioritized environmental contaminants and the EQSs are given in wet weight values. The EQSs are established to prevent the negative effects in the aquatic ecosystem (ensuring protection for the most sensitive species). An EQS has been defined as "the concentration of a particular pollutant or group of pollutants in water, sediment or biota that should not be exceeded in order to protect human health and the environment".

The levels of PBDEs, mercury and octylphenol in fish liver exceed EU Environmental Quality Standards (EQS) in all 14 lakes included in this monitoring program and PCBs exceeded EQS in 11 of the 14 lakes. The EQS for PFOS was exceeded in two lakes (Lake Bergesvatnet and Lake Lyseren). PFOS has specific affinity to liver tissue, and it is most likely that the concentration in muscle are substantially lower than in liver. Furthermore, the EQSs are set lower than the European limit values (Minimum Residual Limit Levels (MRLs)) for foodstuffs and animal feed, to protect the entire ecosystem (ensuring protection for the most sensitive species), suggesting that the concentrations in fish muscle do not exceed the MRL for human consumption. The results from the present survey, suggest that background levels of PBDEs, PCBs mercury and octylphenol in Norwegian lakes do not meet the environmental requirements in Europe. However, these results are comparable with results from different European countries, which may indicate an environmental problem for these contaminants across Europe.

Sammendrag

EUs vannrammedirektivs prioriterte forurensninger ble analysert i fiskelever prøvetatt i 14 norske innsjøer (se kart under). Konsentrasjonen av forskjellige stoffene i levervev kan avvike fra muskelvev fordi de har forskjellige kjemiske egenskaper. EU har etablert europeiske kvalitetsstandarder (EQS) for prioriterte miljøkjemikalier og EQS er gitt i våtvektverdier. EQS er etablert for å forhindre negative effekter i det vannlevende organismer (sikre beskyttelse for de mest følsomme artene). En EQS er blitt definert som "konsentrasjonen av en bestemt miljøgift eller en gruppe miljøgifter i vann, sediment eller biota som ikke bør overskrides for å beskytte menneskers helse og miljø".

Nivåene av PBDE, kvikksølv og oktylfenol overstiger EUs miljøkvalitetsstandarder (EQS) i alle 14 innsjøer som inngår i dette overvåkingsprogrammet og PCB overskrider EQS i 11 av de 14 innsjøene. EQS for PFOS ble overskredet i to innsjøer (Bergesvatnet og Lyseren). PFOS har spesifikk affinitet til levervev, og det er mest sannsynlig at konsentrasjonen i muskel er betydelig lavere enn i leveren. Videre er EQS-ene satt lavere enn de europeiske grenseverdiene (minimum restnivåer (MRLs)) for matvarer og dyrefôr, for å beskytte hele økosystemet (sikre beskyttelse for de mest følsomme artene), noe som tyder på at

konsentrasjonene i fiskemuskulaturen ikke overskrider maksimalgrensen for mat- og forvarer. Resultatene fra denne undersøkelsen antyder at bakgrunnsnivåene av PBDE, PCB, kvikksølv og oktylfenol i norske innsjøer ikke oppfyller miljøkravene i Europa. Imidlertid er disse resultatene sammenlignbare med resultater fra forskjellige europeiske land, noe som kan tyde på et miljøproblem for disse miljøgiftene i hele Europa.

MAP: The map shows the localization of the lakes from which fish livers were analyzed for priority environmental contaminants.

Contents

1. Introduction

On behalf of the Norwegian Environment Agency, the Laboratory of Environmental Toxicology, Norwegian University of Life Sciences (NMBU) is monitoring contaminants in fish from Norwegian lakes. The current monitoring program started in 2017, proceeding the sampling strategy from previous years. A wide range of environmental contaminants has been determined in fish from 14 Norwegian lakes (see map). The selection criteria for the lakes were that they should have relative low impact from human activity thereby containing background levels of anthropogenic pollution and they should be located throughout the country.

Main goals for the monitoring program are:

- To report the concentrations of selected contaminants in fish from Norwegian lakes.

- Evaluate the potential for harmful effects on different levels in the food chain by comparing the levels in biota (fish) with the environmental quality standards (EQS) for biota.

Ideally, monitoring programs should be based on measurement on the same species. However, sampling of fish from different lakes and different parts of Norway is challenging because of the variation in fish species and size distribution between lakes. Therefore, in the present survey the analyses were conducted on four fish species (trout, char, perch, whitefish; table 1). The analytical methods are getting more precise and accurate, but for some contaminants, procedures, extraction, standards etc., are not yet fully implemented in standardized tests. However, the contributing laboratories from the Norwegian University of Life Sciences (NMBU), the Institute of Marine Research (IMR), the Institute for Energy Technology (IFE) and the Institute of Environmental Science and Health, Geesthacht, Germany (MINJIE), are all experienced and have completed the annual analytical program with high quality. In this report, the occurrence and levels of EU Water framework directive priority contaminants in Norwegian freshwater fish are reported. Individual and groups of contaminants analyzed include organochlorine pesticides (OCP), Polychlorinated Biphenyls (PCBs), brominated flame-retardants (BFR), per and polyfluorinated substances (PFAS), alkylphenols, siloxanes, heavy metals and a wide range of environmental chemicals of emerging concern.

Environmental quality standards (EQS)

EQS (Environmental quality standard) is the concentration of a particular pollutant or group of pollutants in water, sediments or biota, which should not be exceeded in order to protect human health and the environment (EU directive 2000/60/EC, Article 2). EQSs serve as a tool to distinguishing between a “good” and a “poor” environmental condition in a water body. The EQS values are determined based on risk assessments for human health and the environment, such as an aquatic ecosystem. For water, two different EQSs are established, the annual average (AA-EQS) and the maximum value (Mac-EQS), representing chronic and acute exposure. To understand the environmental impact caused by contaminants over time, biota samples are preferred over abiotic samples. As an example, mercury (Hg) is a contaminant which tends to biomagnify in food chains, and a low EQSbiota-value for Hg may indicate high toxicity and a high bioaccumulation and biomagnifying factor (Direktoratsgruppen vanndirektivet, 2018). The EQS value for Hg in freshwater biota is considered low (0.02 µg/g w.w.) but should, based on risk assessments, protect the most sensitive species within the ecosystem from adverse effects. There are several objectives for protecting various organisms from exposure to contaminants, such as protecting top predators from secondary poisoning through the consumption of contaminated prey. Another objective is to prevent the risk of toxic effects in humans caused by consumption of contaminated fish. Persistent pollutants such as persistent organic pollutants (POPs) and heavy metals, which accumulate in biota and biomagnify in food chains, may be very low in water and high in biota.

2. Materials and Methods

Collection of fish

Fish were sampled by the Norwegian Institute for Nature Research (NINA) as part of an assignment for ecosystem monitoring. Two stations, Vaggatem and Tangenfossen, were sampled by Svanhovd (NIBIO). Frozen fish were brought to the Norwegian School of Veterinary Science at the Norwegian University of Life Sciences (NMBU), where pooled samples was prepared. A project number was assigned to each sample (appendix 1). The samples were prepared from pooled livers.

In the present report, the monitoring program included fish caught during summer and autumn 2018 from 14 lakes. Pooled samples were prepared by pooling 15 specimens from each lake into three samples. In one lake two samples were collected, and in one lake one sample, because of lack of fish from these lakes. In total 39 samples. Trout (Salmo trutta) was analyzed in three lakes. Arctic char (Salvelinus alpinus) was analyzed in two lakes. Perch (Perca fluviatilis) was analyzed in four lakes. Whitefish (Coregonus lavaretus), was analyze in two lakes. A combination of trout and perch was analyzed in one lake and a combination of trout and char were analyzed in two lakes.

A rough overview of the available fish was first presented to Miljødirektoratet for final choice of specimens for each sample. Individual data for fish used to prepare each sample is shown in appendix 1 including location, length, weight and species. The individual fish were assigned a letter to show how the pooled samples had been made. For each lake, all individual fish with the same letter were pooled into one sample.

Analyses at the Institute for Energy Technology (IFE)

Isotope analyses

Pooled muscle samples were used for measurements of Isotopes, δ 13C and δ 15N. Approximately 1.5 mg sample was placed in a Sn- capsule for combustion with access to O_2 and Cr_2O_3 1700 ºC in a Eurovector EA3028 element instrument. The reduction of NOx to N_2 took place in a Cu heater at 650 ºC. H_2O was removed in a chemical Mg $(ClO_4)_2$ trap before separation of N_2 and CO_2 in a 2 m Poraplot Q GC column. N_2 and CO_2 were injected directly on-line to a Horizon Isotope Ratio Mass Spectrometer (IRMS) from Nu-Instruments for δ 15 N and δ 13 C determination.

Analyses at the Norwegian University of Life Sciences (NMBU)

Metal analyses

The following metals were analysed in liver samples at the Metal Laboratory at the Norwegian University of Life Sciences (NMBU): Li, Al, V, Cr, Fe, Co, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Hg and Pb. Hg was also analysed in muscle. The samples were weighed, with approximately 250 mg (liver) or 500 mg (muscle) in ultra-pure teflon tubes. Then 5 mL HNO3 (Ultrapure. subboiled) was added, and HCl to prevent loss of Hg. Internal standards consisting of Sc. Ge. Rh. In and Bi were added. Then the samples were decomposed at 260 ºC for at least 20 min in an UltraClave from Milestone. For each series, at least one certified reference material (CRM) was analysed, with at least 3 blanks. After decomposing, the samples were diluted to 50.0 mL using distilled water in centrifuge tubes from Sarstedt. Glass and filters are avoided to reduce contamination. The samples were then analysed on Agilent 8800 QQQ ICP-MS against standards for each element.

Analyses of organic chemicals at NMBU

The extraction of chemicals from the fish samples were performed using one method for fluorinated components, and another method for the rest of the components. Most of the analyzed chemicals were extracted, using nonpolar solvents in the laboratory's multimethod (MT 2.2). For the fluorinated components, a different method (M-MT.2.7) was applied.

Analyses of fluorinated chemicals

Perfluorinated sulfonates and Perfluorinated carboxylic acids were extracted and quantified. The following perfluorinated sulfonates were analyzed (CAS nr): PFBS (375-73-5), PFHxS (355-46-4) and PFOS (1763-23-1), The following perfluorinated carboxylic acids (6 – 14 C-atoms) were analyzed: PFHxA (307-24-4), PFHpA (375-85-9), PFOA (335-67-1), PFNA (375-95-1), PFDA (335-76-2), PFUnDA (2058-94-8), PFDoDA (307-55-1), PFTrDA (72629-94-8), PFTeDA (376-06-7). The two groups were analyzed using the same method (M-MT.2.7). Because of the possible adhesion to glass for these chemicals, all extraction equipment are made of plastic. A 0.5 g sample was weighed in a 15 mL centrifuge tube with isotopically labeled internal standards added. After adding 5 mL methanol, samples were homogenized using an Ultra-Turrax®, IKA homogenizer. The samples were then shaken, using an IKA Vibrax VXR®, 2000 rpm, 30 min, and centrifuged at 3000 rpm for 10 min. The upper phase was transferred to a new tube, and a new extraction with 3 mL methanol was performed. After evaporation to 2 mL on a TurboVap®, under a flow of N2. 0.3 g Envi-Carb® was added. This compound is actively using carbon for lipid removal from the samples. The tubes were shaken, centrifuged and the upper phase transferred to a new tube. The precipitate was extracted again, and the sample reduced to 1 mL before analysis on a LC/MS/MS system. This consists of Agilent 6460 MS/MS and an Agilent 1100 series HPLC with Penomenex C18 column (100 x 2,1 mm, 2,6 µm). Mobil phases A: 2 mM ammonium acetate in methanol, B: 2 mM ammonium acetate in water.

Analyses of other organic chemicals

The laboratory's multimethod (M-MT.2.2.) was used for extraction. First around 3 grams fish sample (liver or whole fish) was weighed. Internal standards for PCBs, HCB, DDTs and phenols were added: PCB-29, -112 and -207 (Ultra Scientific. RI, USA). For brominated compounds: BDE-77, -119 and -181 and 13C12-BDE-209 (Cambridge Isotope Laboratories. Inc., MA, USA). 2 mL of a 6% salt solution was added to each sample, along with cyclohexane (CHX), acetone and distilled water (20:15:10 mL) before sonication for two minutes. After centrifuging (3000 rpm, 10 min), the organic upper phase was transferred to a Zymark® evaporation unit, and the water phase extracted a second time with CHX and acetone (10:5 mL). After evaporation, the upper phase was volume adjusted to 5 mL. One mL of this extract was used for gravimetric lipid determination.

Analyses of HCB, PCB, DDTs, PBDE and HBCDD

The extracts were cleaned using ≥ 97.5% H2SO4 (Fluka Analytical®). Then the extracts were up-concentrated to 0.25 mL under a flow of N2. The following OCs were analysed: HCB, PCB 7 (PCB-28, -52, -101, -118, -138, -153 and -180). DDTs (p,p'-DDE, o,p'-DDD, p,p'-DDD, o,p'-DDT and p,p'-DDT). Separation and detection of PCB, HCB and DDTs were done on a «high resolution gas chromatograph" (HRGC) (Agilent 6890 Series gas chromatography system; Agilent Technologies, PA, USA) equipped with an auto sampler (Agilent 7683 Series; Agilent Technologies) and configured with a programmed temperature evaporation (PTV) injector (Agilent Technologies), coupled to an ECD detector for analysis of PCB-28 and 52 and an MS detector (Agilent 5975C Agilent Technologies) run in a negative chemical ionization (NCI) condition with selected ion monitoring (SIM). The components were separated using a DB-5 MS column (J&W Scientific, Agilent Technologies) (60 m, 0.25 mm i.d., 0.25 µm film thickness). The temperature program was: 90 ˚C (2 min hold); 25 ˚C/min increase to 180 ˚C (2 min hold); 1.5 ˚C/min increase to 220 ˚C (2 min hold); and 3 ˚C/min increase to 275 ˚C (12 min hold) and 25 ˚C/min increase to 300 ˚C (4 min hold). Total run time was 71.6 min. The following brominated diphenyl ethers (PBDE) were quantified: BDE-28, -47, -99, -100, -153, -154, -183, -196, -202, -206, -207 and -209, and total HBCDD (α-HBCDD, ß-HBCDD, γ-HBCDD). BDE -28, -47, -99, -100, -153, -154, -183, and HBCDD (sum) were quantified on a HRGC–LRMS (Agilent 6890 Series; Agilent Technologies), with an auto sampler (Agilent 7683 Series; Agilent Technologies) connected to a MS detector (Agilent 5973 Network; Agilent Technologies). Separation and identification of the components were done using a DB-5 MS column (30 m, 0.25 mm i.d., 0.25 µm film thickness; J&W Scientific). The temperature program was: start 90 °C; 25 °C/min increase to 180 °C; 2.5 °C/min increase to 220 °C (hold 1 min); 20 °C/min increase to 320 °C (hold 5 min); total run time 31.60 min. For detection of BDE 196, -202, -206, -207 and -209, samples (10 µL) were injected on a GC-MS (Agilent 6890 Series/5973Network) configured with a programmed temperature evaporation (PTV) injector (Agilent Technologies). For separation and identification, a DB-5-MS column (10 m, 0.25 mm i.d., 0.10 µm film thickness; J&W Scientific. Agilent Technologies) was used. The temperature program was: start 80 °C (hold 2 min); 30 °C/min increase to 315 °C (hold 6 min); total run time 15.83 min. For PBDE and HBCDD detection, negative chemical ionizing (NCI) in selected ion monitoring (SIM) (with m/z 79/81, BDE-209 m/z 484/486 and 13C12-BDE-209 at m/z 495/497) was used. For all three GC-MS instruments, helium was the carrier gas, and methane 5.5 was the reagent gas. For the ECD detector, the make-up gas was 5% methane in argon.

Analyses of phenols

The following phenols were analysed: 4-nonylphenol (84852-15-3) and 4-tert-oktylphenol (140-66-9). 2mL lipid extract was cleaned using gel permeation chromatography, Bio-Beads S-X3, 200-400 mesh (Bio-Rad Laboratories, Inc., CA. USA) with mobile phase 1:1 Chx/ethyl acetate on a «Freestyle Robotic System, Type Basic, 740 mm Working Area and GPC-module". After pentafluorobenzoyl chloride derivatization and evaporation to 0.5 mL, 1 mL 1M NaHCO3 and 0.5 mL 1 M NaOH were added and the samples were shaken. Then 1 mL CHX and 50 µL 10% pentafluorobenzoyl chloride were added, and the samples were shaken and kept hot (60 ºC for 30 min). After cooling, 4 mL 1 M NaOH was added and the samples kept cool overnight. Room temperature samples were extracted with 2 x 2 mL CHX and the volume reduced to 150µL under a gentle stream of N_2. Phenols were then quantified on a HRGC–LRMS (Agilent 6890 Series; Agilent Technologies), with an auto sampler (Agilent 7683 Series; Agilent Technologies) and coupled to a MS detector (Agilent 5973Network; Agilent Technologies). Component separation and identification were done using a DB-5 MS column (30 m, 0.25 mm i.d., 0.25 µm film thickness; J&W Scientific). Carrier gas was Helium and reagent gas Methane 5.5. The temperature program was: start 90 °C; 20 °C/min to 140 °C; 5 °C/min increase to 260 °C; 25 °C/min to 310 °C (hold 2 min); total run time 31.50 min.

Quality assurance

The laboratory is accredited by the Norwegian Accreditation for testing the analyzed chemicals in biological material according to the requirements of the NS-EN ISO/IEC 17025 (TEST 137). Every analytical series included three procedural blanks (solvents), one blind (non-spiked brown trout (*Salmo trutta*)), two spiked samples of brown trout for recoveries and the laboratory's own reference materials (LRMs) of blubber of harp seal (*Pagophilus groenlandicus*). The lowest levels of detection (LODs) for individual compounds were defined as three times the noise level. The quality control parameters were within the accepted ranges for the method. In addition to the laboratory's own blubber RLM, analytical quality was successfully approved by routinely analyzing relevant Certified Reference Materials (CRM). One of them was mackerel oil (CRM 350). Further, the laboratory participates in relevant inter calibration tests such as the 2011 MOE Inter laboratory study for the Northern Contaminants Program (NCP) III — phase 6 on lake trout (*Salvelinus namaycush*) and brown trout organized by the Ontario Ministry of the Environment. Laboratory Services Branch.

Analyses at Institute of Environmental Science and Health, Geesthacht, Germany (MINJIE)

Chemicals and materials

The analyses were performed at Institute of Environmental Science and Health, Geestacht, Germany. The native standards, including short-chain chlorinated paraffin (SCCPs, C10-13) and medium-chain chlorinated paraffins (MCCPs, C14-17), decamethylcyclopentasiloxane (D5), polycyclic aromatic hydrocarbon (naphthalene, anthracene, fluoranthene and benzo(a)pyrene), hexachlorobutadiene (HCBD), trichlorobenzene isomers (135-TCB, 124-TCB, 123-TCB), dicofol, diethylhexyl phthalate (DEHP), tris(2-chloroethyl) phosphate (TCEP), triclosan (TCS), pentachlorophenol (PCP), tributyltin, and triphenyltin isomers, were purchased from LGC Standards (Wesel, Germany) and Sigma Aldrich Germany, respectively. D5-$^{13}C_{10}$, DEP-d4, DnBP-d4, Naphthalene d8, Anthracene d10, Fluoranthene d10 and TCEP-d12 were supplied from Cambridge Isotope Laboratories, Inc. USA. The standards including tributyltin chloride (TBT, 90%), dibutyltin dichloride (DBT, 97%), monobutyltin trichloride (MBT, 97%), tetrabutyltin (TeBT, 96%) and triphenyltin were purchased from Acros Organics (New Jersey, USA). TeBT was used as an internal standard. Organic solvents e.g., acetone, *n*-hexane and dichloromethane (DCM) were for residual analysis. Neutral silica gel (0.1-0.2 mm, Macherey-Nagel, Düren, Germany) and anhydrous sodium sulfate (Merck purity 99%, Darmstadt, Germany) were baked at 450°C for 12 h. Silica gel was deactivated with 10% (w:w) of Millipore water. The organic solvents e.g., acetone, n-hexane and dichloromethane (DCM) were of residual analysis grade and redistilled using glass system. Laboratory glassware was baked at 250 °C for 12 h, and then rinsed with acetone and n-hexane.

Sample extraction and fractionation

The fish liver samples (0.5 – 2.0 g) were homogenized with 10 g anhydrous sodium sulfate and packed in 50 mL centrifuge glass vial, 10 ng of Naphthalene d8, Anthracene d10, Fluoranthene d10, benzo(a)pyrene d12, DEP-d4, DnBP-d4 and 20 ng of TCEP-d15 were added as internal standards. The samples were then extracted with 20 mL n-hexane/DCM (1:1v:v) by 30-min sonication for three times. After centrifugation, the clear extracts were combined and concentrated down to 2 mL. The samples were equally split into part A and B for analysis of different substances. Part A was purified using a GPC column with SX-3 Bio-Beads (40 g), eluted with a mixture of n-hexane/DCM (3:7) at 5 mL/min. The fraction 1 containing SCCP and MCCP was further cleaned on a column packed with 20 g of acidified silica gel and eluded with 150 mL n-hexane/DCM (1:1). The elute was concentrated to dryness with nitrogen. The sample volume was redefined with addition of 50 µL of isooctane, 10 ng ^{13}C labeled chloroparaffin (1.5.5.6.6,10-$C_{10}Cl_5$) and 20 ng Dechlorane 603 were spiked as internal standards (Ma et al., 2014). Fraction 2 was concentrated down to 150 µL and spiked with 20 ng of D5-$^{13}C_{10}$ as injection standards. Fraction 2 was used for the analysis of TCEP, DEHP, dicofol, TCS and PCP. Part B was cleaned on a neutral silica gel column (2.5 g, 10 % water deactivated) topped on 3 g anhydrous granulated sodium sulfate. The extract was purified by eluting with 20 mL hexane (fraction 1) and 20 mL acetone/DCM ($1:1_{V/V}$) (fraction 2), respectively. Fraction 1 was concentrated down to 150 µL and spiked with 20 ng D5-$^{13}C_{10}$ as injection standard. Fraction 1 was used for the determination of D4, D5, HCBD, 135-TCB, 124-TCB, 123-TCB, naphthalene, anthracene, fluoranthene, benzo(a)pyrene and HCB.

Extraction for tributyltins (TBT) and triphenyltin (TPhT)

About 1 g fish liver sample was used to measure organotin concentrations. After it was mixed with appropriate amount of internal standard TeBT, 10 mL of THF–HCl (11:1, v/v) solution was added and then extracted with 25 mL 0.01% (m/v) tropolone–hexane solution under vigorous shaking for 40 min. The supernatant was transferred to a flask and the residue was extracted again in the same way with another 10 mL of hexane for 10 min. The combined extract was concentrated to about 2–3 mL and subjected to Grignard propylation. The analytes were purified using a chromatography column packed with anhydrous Na_2SO_4 (2 g), silica gel (2 g) and Florisil (2 g) in turn from the top. The elution was conducted with 10 mL of hexane and concentrated down to 200 µL under a gentle stream of pure nitrogen.

Instrumental analysis of SCCP, MCCP, PAH, DEHP, TCEP, TCS, PCP.

Method 1 was applied for the determination of D4, D5, HCBD, 135-TCB, 124-TCB, 123-TCB, naphthalene, anthracene, fluoranthene, benzo(a)pyrene and HCB using GC-MS-EI. The samples were analyzed with an Agilent 6890N gas chromatography coupled to an Agilent 5975 mass spectrometer (GC-MS) (Agilent Technologies, Avondale, PA, USA), operating in electron impact and selective ion monitoring modes (SIM), and a HP-5MS capillary column (30 m × 250 μm i.d.; 0.25 μm film thickness, J&W Scientific) for chromatographic separation. The transfer line and the ion source temperature were maintained at 280 and 230 °C, respectively. The column temperature program was initiated at 60 ºC for 2.0 min, increased to 120 °C at a rate of 10 ºC/min held for 10 min. The oven temperature was further ramped at 2 °C/min to 240 °C and then ramped at 30°C/min to 300°C and kept for 10 min. The flow rate of the carrier gas helium was kept constant at 1.3 mL min^{-1}. The flow rate of the carrier gas helium was kept constant at 1.3 mL min^{-1}. The extracts (1.0 μL) were injected onto GC-MS in splitless mode with an inlet temperature of 280 °C. Quantitation was performed using the internal calibration method based on 5-point calibration curve for individual substances. The response factors were derived from the calibration curves (7-points) made for response ratio between targets compounds and internal standards.

Method 2 was applied for the determination of TCEP, dicofol, DEHP, DEP, DiBP and DnBP using GC-MS-EI. The samples were analyzed with an Agilent 6890N gas chromatography coupled to an Agilent 5975 mass spectrometer (GC-MS) (Agilent Technologies, Avondale, PA, USA), operating in electron impact and selective ion monitoring modes (SIM), and a HP-5MS capillary column (30 m × 250 μm i.d.; 0.25 μm film thickness, J&W Scientific) for chromatographic separation. The transfer line and the ion source temperature were maintained at 280 and 230 °C, respectively. The column temperature program was initiated at 60 ºC for 2.0 min, increased to 120 °C at a rate of 10 ºC/min held for 10 min. The oven temperature was further ramped at 2 °C/min to 240 °C and then ramped at 30°C/min to 300°C and kept for 10 min. The flow rate of the carrier gas helium was kept constant at 1.3 mL min^{-1}. The extracts (1.0 μL) were injected onto GC-MS in splitless mode with an inlet temperature of 280 °C. Quantitation was performed using the internal calibration method based on 5-point calibration curve for individual substances. The response factors were derived from the calibration curves (7-points) made for response ratio between targets compounds and internal standards (Xie et al., 2007).

Method 3 was applied for the determination of PCP and TCS using GC-MS-EI. The samples were analyzed with an Agilent 6890N gas chromatography coupled to an Agilent 5975 mass spectrometer (GC-MS) (Agilent Technologies, Avondale, PA, USA), operating in electron impact and selective ion monitoring modes (SIM), and a HP-5MS capillary column (30 m × 250 μm i.d.; 0.25 μm film thickness, J&W Scientific) for chromatographic separation. The column temperature program was initiated at 60 ºC for 2.0 min, increased to 120 °C at a rate of 10 ºC/min held for 10 min. The oven temperature was further ramped at 2 °C/min to 240 °C and then ramped at 30°C/min to 300°C and kept for 10 min. The flow rate of the carrier gas helium was kept constant at 1.3 mL min^{-1}. The flow rate of the carrier gas helium was kept constant at 1.3 mL min^{-1}. Before the injection, a derivatization step was carried out following the method reported by xie et al, (2018). Briefly, 50 µL of BSTFA+1% TMS was added for derivatization and 5 ng octylphenol 13C6 (OP-$_{13}C^6$) was spiked as internal standard for quantitation. The reaction was carried out for 60 min at 60°C. The samples (1.0 μL) were injected onto GC-MS in splitless mode with an inlet temperature of 280 °C. Quantitation was performed using the internal calibration method based on 5-point calibration curve for individual substances. The response factors were derived from the calibration curves (7-points) made for response ratio between targets compounds and internal standards OP-13C6.

Method 4 for the determination of SCCP and MCCP using GC-QTOF-MS

An Agilent 7200 GC–QTOF-MS (Agilent Technologies, Santa Clara, USA) operated in negative chemical ionization (NCI) mode and controlled by Mass Hunter Acquisition B.10 was used in this work (Gao et al. 2016). A volume of 2 ìL purified sample was introduced into an Agilent DB-5MSUI (30 m length, 0.25 mm i.d., 0.25 ìm film thickness) capillary column using splitless mode. The injector temperature was 280°C. Helium gas was used as the carrier gas at a constant flow of 1.2 mL/min while methane acted as the reagent gas. The oven temperature program for the chromatographic separation was as follows: 1 min isothermal at 60 °C, increased to 150 °C at 30 °C min^{-1}, then ramped to 310 °C at 20 °C $min^{-1}$and finally held for 12.5 min. The transfer line temperature and ion source temperature were set to 280 °C and 150 °C, respectively. QTOF MS was operated at 5 spectra/s in the m/z range 50–700, with a resolution of approximately 45,000 at m/z 300–600. The TOF scan mode was used under NCI conditions, and the most abundant and second most abundant isotope ions of [M-Cl] - were selected for each congener group as the quantification and confirmation ions, respectively. The quantification of the CPs was adapted from our previous work. The accurate masses of the 96 quantitative and qualitative ions (those with a carbon chain length of 10-17 containing 5–10 chlorine atoms) along with their retention times were added to the method, and the mass accuracy window was set at 50 ppm, which is sufficient to distinguish the 96 quantitative and qualitative ions. In addition, a Universal Integrator was employed. New batch files were built, and the data files were imported. Finally, the integration results were obtained in CSV form. The result was then imported to our programed excel to get the quantification results of SCCPs and MCCPs. All the chemicals and extracts were analyzed in n-hexane to be consistent with the solvent of the chain length standards. 10 ng ^{13}C-labeled trans-chlordane were spiked as internal standards, and 0.5 ng ^{13}C labeled PCB 208 was spiked as standard.

Method 5 for the determination of tributyltin (TBT), dibutyltin (DBT) and monobutyltin (MBT), triphenyltin (TPT), diphenyltin (DPT) and monophenyltin (MPT) using GC-MS.

The samples were analyzed with an Agilent 7890B gas chromatography coupled to 5977B mass spectrometer. Organotin compounds were separated with a HP-5 fused-silica capillary column (30m× 0.25 mm×0.25 ìm). . High pure helium (99.999%) severed as carrier gas and kept at 1.3 ml/min and the injector were kept at 280 °C, respectively. The oven temperature program conditions were 50 °C held for 2 min, ramped at 10 °C/min to 240 °C then ramped at 30 °C/min to 300 °C held for 2 min. one µl sample was injected into the GC-MS.

Quality assurance

In this report, the concentrations of the target compounds in fish liver samples are defined as the masses of the analysts divided by the masses of fish liver, and normally expressed as µg/kg. Quantification was performed by the internal standard method. Three procedural blanks were performed to check the interference and cross-contamination. The method detection limits (MDLs) were calculated by the means of three procedure blanks plus 3 times of the standard diversions. The recoveries of the sample preparation were determined by spiking target compounds to the matrixes. The analytical method adopted for TBT, DBT, MBT, TPT, DPT and MPT have been certified with international laboratory inter calibration. The recoveries for TBTs were achieved by analyzing certified reference materials. As the analytical methods adopted for other compounds have not been certified through laboratory inter calibration exercises, the measurement uncertainty were estimated roughly between 10 and 50 % (TA-2564/ 2009). The concentrations reported in this work were not subtracted from procedure blanks.

Analyses at Institute of Marine Research (IMR)

Diflubenzuron and teflubenzuron

The analytes were extracted with acetone. Solid phase extraction was used for sample clean up. The samples were analysed and quantified by LC-MS/MS as described in (Samuelsen et al. 2014). The method is accredited as a screening method in liver.

Dioxins, dl-PCBs

This method is an adaptation to modern clean-up equipment of the US-EPAs (Environmental Protection Agency) methods No. 1613 and 1668. Separation and quantification were performed by high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS). The method determines all of the 29 compounds on the WHO list: 17 PCDD / PCDF congeners, four non-ortho substituted PCBs: PCB -77, -81, -126 and -169 and eight mono-ortho substituted PCBs: PCB-105, -114, -118, -123, -156, --157, 167 and 1-89. The method has been further described in Berntssen et al, (2010). The PCBs included in PCB-6, PCBs no. -28, -52, -101, -138, -153 and -180, were analysed by GC-MS/MS. The method is accredited for the analysis of fish liver.

Poly-aromatic hydrocarbons (PAH)

Samples were freeze-dried and mixed with hydromatrix (Agilent, Santa Clara Cal, USA) and internal standard (US EPA 16 PAH Cocktail (13C, 99 %), CIL ES-4087) were added, before the PAH are extracted using dichloromethane : cyclohexane (1:3) with use of Accelerated Solvent Extractor (ASE) at 100ºC and 1500 psi. Fat is partly removed on-line using silica gel. The extracts are evaporated on a TurboVap®, and purified further on SPE columns (Envichrom). The solvent is changed to isooctane and the samples concentrated to 50 µL before addition of recovery standard (3-Fluorchrysene, Chiron 1317,18-100-T). The samples were subsequently analysed by GCMSMS. A calibration curve is included in each series for quantification. The method determines 16 PAHs, and is accredited for most of these as specified in table

Quality assurance

The laboratory routines and the analytical methods at Institute of Marine Research (IMR) are accredited in accordance with the standard ISO 17025. A summary of the analytical methods, their limit of quantification (LOQ) and accreditation status are shown in table 1. The LOD is the lowest level at which the method is able to detect the substance, while the LOQ is the lowest level for a reliable quantitative measurement. For all methods, a quality control sample (QC) with a known composition and concentration of target analyte, is included in each series. The methods are regularly verified by participation in inter laboratory proficiency tests, and by analysing certified reference material (CRM), where such exist.

3. Results

3.1.1 Fish species, tissue, weight, length and fat percentage and stabile isotopes

The fish species and the tissues analyzed are shown in table 1. Weight, length, and fat percentage of the analyzed tissue are also given in Table 1. The species analyzed were trout from three lakes, perch from three lakes, char from two lakes, whitefish from two lakes, a mix of trout and char from two lakes and a mix of trout and perch from one lake. The mean fish weight differed between lakes from a min weight of 212 g in Lake Møsvatn to a max weight of 659 g in Lake Steinvatn.

Table 1. Overview over tissues and species analyzed and mean weight, length and fat percentage for the fish in each lake.

Lake	Species	Tissue	Mean Weight (g)	Mean Lenght (cm)	Fat%
Altevann Bardu	Char	Liver	346.9	31.5	3.2
Bergesvatnet	Trout	Liver	247.3	28.8	3.0
Geitvatnet	Trout/Char	Liver	273.8	29.4	6.0
Kangsvatnet	Trout	Liver	343.8	32.2	3.3
Krøderen	Perch	Liver	391.8	30.3	2.9
Langevann	Trout	Liver	314.3	30.5	3.5
Lešjávri	Char	Liver	465.1	35.8	3.1
Lyseren	Trout/Perch	Liver	478.0	34.3	2.3
Møsvatn	Char	Liver	212.4	27.2	5.2
Steinvatn	Trout/Char	Liver	553,5	36.6	2.9
Storbørja	Perch	Liver	519.0	32.9	3.5
Stuorajávri	Perch	Liver	284.6	28.0	5.8
Tangenfossen	Whitefish	Liver	591.0	39.5	2.8
Vaggatem	Whitefish	Liver	573.2	39.6	3.4

Table 2. Mean, min and max values of stabile isotopes in fish liver.

Lake	Weight	d13CVPDB			d15NAIR		
	g	Mean	Min	Max	Mean	Min	Max
Altevann Bardu	346.9	-27.03	-27.56	-26.08	7.38	7.38	7.38
Bergesvatnet	247.3	-25.62	-25.92	-25.46	8.74	8.74	8.74
Geitvatnet	273.8	-28.10	-31.55	-25.11	8.08	8.08	8.08
Kangsvatnet	343.8	-24.35	-24.76	-23.68	7.58	7.58	7.58
Krøderen	391.8	-23.35	-24.11	-22.75	10.21	10.21	10.21
Langevann	314.3	-27.44	-27.44	-27.44	8.44	8.44	8.44
Lešjávri	465.1	-21.92	-22.20	-21.75	7.56	7.56	7.56
Lyseren	478.0	-26.52	-27.29	-25.61	6.36	6.36	6.36
Møsvatn	212.4	-27.75	-27.85	-27.61	5.67	5.67	5.67
Steinvatn	553.4	-26.43	-28.64	-23.95	7.55	7.55	7.55
Storbørja	519.0	-27.96	-28.32	-27.73	7.17	7.17	7.17
Stuorajávri	284.6	-22.90	-23.60	-22.19	7.13	7.13	7.13
Tangenfossen	591.0	-28.54	-29.93	-27.78	8.51	8.51	8.51
Vaggatem	573.2	-23.02	-24.41	-21.53	8.48	8.48	8.48

3.1.2 Organochlorine pesticides (OCP)

The wet weight (µg/kg ww) concentrations of hexachlorobenzene (HCB), pentachlorobenzene (PeCB), ∑hexachlorocyclohexane (∑HCH), heptachlor and ∑endosulfan in fish from the different lakes are shown in table 3 and the lipid weight (lw) concentrations of the respective chemicals are shown in table 4. The lipid weight (lw) concentrations are also shown in figure 1. The wet weight and lipid weight of ∑DDT are shown in table 5 and table 6, respectively. The lipid weight concentrations of fat-soluble compounds enables the estimation the body-burden, which is used to compare the total concentrations of Organochloride Pesticides (OCP) and other POPs between individuals and populations. The OCPs, which occurred at the highest concentrations (lw) in fish liver were heptachlor, DDTs and HCB. The highest levels of ΣDDTs were found in fish liver from Lake Lyseren (83 µg/kg) followed by Lake Vaggatem (56 µg/kg) and Lake Storbørja (55 µg/kg). The lowest concentrations were found in Lake Stuorajávri (6 µg/kg) and Lake Altevann Bardu (7 µg/kg). The levels of DDT in the study lakes were substantially lower than the levels measured in burbot liver from Mjøsa in 2017, which ranged from 350 to 2500 ng/g (unpublished data). The concentration (lw) of HCB were highest in fish liver from Lake Steinvatn (13 µg/kg) and Lake Møsvatn (13 µg/kg) followed by Lake Lešjávri (11 µg/kg). The lowest concentrations of HCB were detected in Lake Bergesvatnet (4 µg/kg) and Lake Storbørja (5 µg/kg). Relative high levels of Heptachlor was detected in Lake Tangenfossen (37 µg/kg and Lake Vaggatam (11 µg/kg). Available data on levels of heptachlor in Norwegian biota is scarce. However, one study measured heptachlor levels in perch, roach and pike livers from Lake Årungen (Sharma et al., 2010) and the wet weight levels in perch and roach livers were under the detection limit, whereas the levels in pike (0.60 ng/g; mean weight 1.6 kg) were comparable to the levels in whitefish liver from Lake Tangenfossen (0.87 mg; weight 0.6 kg) and Lake Veggatam (0.38 ng/g; weight 0.7 kg) These two lakes are located in Finnmark nearby the Russian not far from Nickel.

EU has established European Quality Standards (EQS) for prioritized environmental contaminants and the EQSs are given in wet weight values. The EQSs are established to prevent the entire ecosystem (ensuring protection for the most sensitive species). The limit of detection (LOD) were lower than the EQS for the OCPs except for heptachlor for which LOD exceeded the EQS. The EU EQS (0.0067 µg/kg ww) for heptachlor were exceeded in fish liver from the lakes with levels above the LOD (LOD = 0.073 µg/kg ww).

Table 3: Mean wet weight (µg/kg ww) concentrations of HCB, PeCB, ∑HCH, ∑Endosulfan and ∑DDT. Under the detection limit=not detected (nd).

Lake	HCB ww	PeCB ww	∑HCH ww	∑Heptachlor ww	∑Endosulfan ww	∑DDTs
Altevann Bardu	0.35	0.01	0.03	nd	0.01	0.21
Bergesvatnet	0.13	0.02	0.03	nd	nd	1.24
Geitvatnet	0.55	0.03	0.04	0.06	0.01	0.40
Kangsvatnet	0.37	0.02	0.03	0.09	nd	0.33
Krøderen	0.20	0.01	0.02	nd	0.03	0.82
Langvatnet	0.30	0.02	0.03	nd	nd	0.62
Lešjávri	0.35	0.01	0.03	0.04	0.02	0.62
Lyseren	0.13	0.01	0.02	nd	0.02	1.91
Møsvatn	0.68	0.03	0.06	0.10	0.07	2.11
Steinvatnet	0.38	0.02	0.03	0.06	0.01	0.16
Storbørja	0.18	0.01	0.04	nd	0.04	1.91
Stuorajávri	0.38	0.02	0.04	nd	nd	0.34
Tangenfossen	0.27	0.01	0.03	0.87	nd	0.92
Vaggatem	0.21	0.01	0.03	0.38	nd	2.09

Table 4: Mean lipid weight (μg/kg lw) concentrations of HCB, PeCB, ∑HCH, ∑Endosulfan and ∑DDT. Under the detection limit=not detected (nd).

Lake	HCB lw	PeCB lw	∑HCH lw	∑Heptachlor lw	∑Endosulfan lw	∑DDTs lw
Altevann Bardu	10.99	0.41	0.83	0.00	0.26	6.72
Bergesvatnet	4.39	0.50	1.10	0.00	0.00	40.45
Geitvatnet	9.41	0.50	0.74	0.53	0.11	9.38
Kangsvatnet	11.42	0.46	0.85	3.14	0.00	10.21
Krøderen	6.87	0.35	0.76	0.00	0.82	28.59
Langvatnet	8.63	0.43	0.83	0.00	0.00	17.60
Lešjávri	11.38	0.49	1.03	0.92	0.45	20.01
Lyseren	5.47	0.28	1.08	0.00	0.68	82.99
Møsvatn	12.70	0.49	1.20	1.83	1.27	38.67
Steinvatnet	13.13	0.61	0.89	2.07	0.20	5.59
Storbørja	5.01	0.27	1.07	0.00	1.18	54.51
Stuorajávri	6.51	0.33	0.71	0.00	0.00	6.00
Tangenfossen	9.78	0.43	1.25	37.00	0.00	33.50
Vaggatem	6.24	0.29	0.96	10.60	0.00	56.39

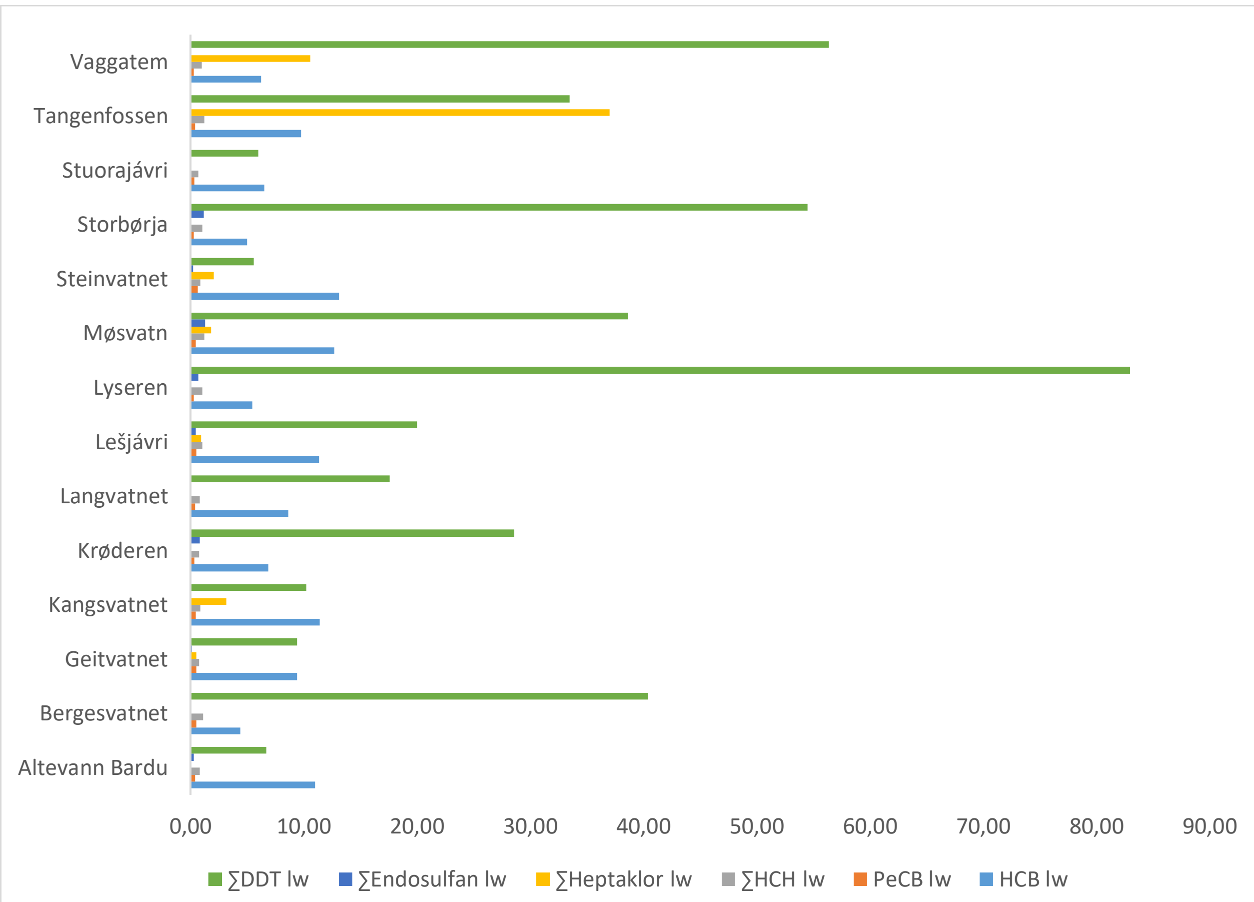

Figure 1: Mean lipid weight (μg/kg lw) concentrations of HCB, PeCB, HCH, Heptaklor and Endosulfan

3.1.3 PCBs and Brominated Flame Retardants (PBDEs and HBCDD)

The mean wet weight (ww) concentrations of Polychlorinated Biphenyls (PCBs). Polybrominated diphenyl ethers (PBDEs) and Hexabromocyclododecane (HBCD or HBCDD) in fish from the different lakes are given in table 5 and the lipid weight (lw) concentrations of the respective chemicals are given in table 6. The lipid weight concentrations are also shown in figure 2. The lipid weight concentrations of fat-soluble compounds are used to compare the levels of fat-soluble PCB and Brominated Flame Retardants between tissues, individuals and populations. The lipid weight concentrations of ∑PCB7 in fish liver were highest in Lake Langevann (350 µg/kg) followed by Lake Lyseren (160 µg/kg) and Lake Tangenfossen (142 µg/kg). The highest concentrations (lw) of ∑PBDEs were measured in Lake Lyseren (38 µg/kg). Lake Storbørja (24 µg/kg) and Lake Langevann (19 µg/kg), whereas the highest concentrations of HBCDD were measured in Lake Lyseren (7 µg/kg) and Lake Storbørja (7 µg/kg).

The concentration of POPs in the study lakes are relatively low compared to other lakes in Norway, which have a location nearer to areas with industrial and human activity such as Lake Øyeren (liver), Lake Eikeren (liver) and Lake Mjøsa (muscle). The concentrations are also relatively low compared to the levels in European freshwater fish (Fliedner et al., 2016; Luigi et al., 2015).

Despite the relatively low concentration of POPs detected in the study lakes the wet weight concentrations of PBDEs exceeded the EQS in fish from all the lakes and the wet weight concentrations of PCBs exceeded the EQS in fish from 11 out of 14 lakes. Fish in Lake Altevann Bardu. Lake Stuorajávri and Lake Vaggatem had PCBs levels below the EQS for PCB7. The detection limits were lower than the EQS for all the PCBs PBDEs and HBCDDs.

Table 5: Mean wet weight (µg/kg ww) concentrations of the sum of PCBs (ΣPCB), thirteen PBDEs (ΣPBDE) and HBCDD in liver samples. Under the detection limit=not detected (nd).

Lake	∑PCB7 liver	∑PBDE liver	HBCDD liver
Altevann Bardu	0.15	0.05	0.01
Bergesvatnet	2.70	0.92	0.08
Geitvatnet	1.53	0.08	0.03
Kangsvatnet	0.96	0.20	0.03
Krøderen	1.51	0.30	0.02
Langvatnet	12.26	0.66	0.05
Lešjávri	2.95	0.13	0.01
Lyseren	3.67	0.88	0.17
Møsvatn	2.54	0.66	0.08
Steinvatnet	2.01	0.20	0.07
Storbørja	3.26	0.85	0.26
Stuorajávri	0.14	0.14	nd
Tangenfossen	3.64	0.05	0.02
Vaggatem	0.23	0.02	nd

Table 6: Mean lipid weight (µg/kg lw) concentrations of the sum of PCBs (ΣPCB), thirteen PBDEs and HBCDD in liver samples. Under the detection limit=not detected (nd).

Lake	∑PCB7 lw	∑PBDE lw	∑HBCDD lw
Altevann Bardu	5.62	1.49	0.34
Bergesvatnet	87.08	29.95	2.48
Geitvatnet	39.14	1.87	0.72
Kangsvatnet	30.98	6.48	0.92
Krøderen	55.18	11.92	0.77
Langvatnet	350.29	18.86	1.46
Lešjávri	94.32	3.96	0.31
Lyseren	159.61	38.19	7.38
Møsvatn	48.73	12.82	1.55
Steinvatnet	72.86	7.05	2.45
Storbørja	93.01	24.16	7.38
Stuorajávri	2.52	2.49	nd
Tangenfossen	141.99	1.61	0.92
Vaggatem	6.66	0.67	nd

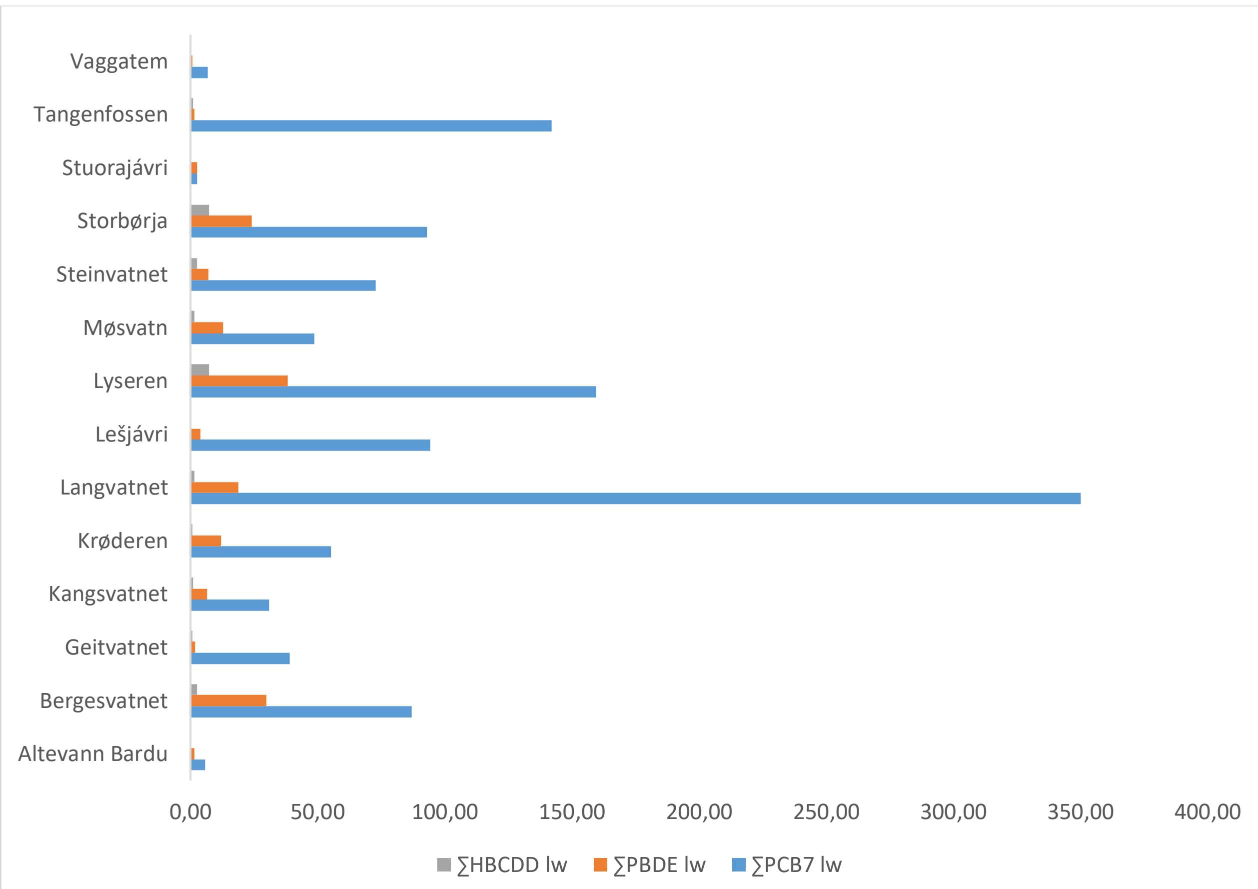

Figure 2: Mean lipid weight (µg/kg lw) concentrations of ΣPCBs. thirteen PBDEs and HBCDD in liver samples.

3.1.4 Dioxins

The mean toxic equivalency (TEQ) values in pg/g wet weight (pg/g TEQ ww) of dioxin-like PCBs (dl-PCBs). Polychlorinated dibenzodioxins (PCDDs) and Polychlorinated dibenzofurans (PCDFs) and the sum of PCDDs and PCDFs and dl-PCBs are given in table 7 and figure 3. The mean TEQ in lipid weight are given in table 8 and figure 4. Toxic equivalency factor (TEF) expresses the individual toxicity of each dioxin. dibenzofurans and dl-PCB, which may vary by orders of magnitude. The toxic equivalency (TEQ) is a single figure resulting from the product of the concentration and individual TEF values of each dioxin. dibenzofurans and dl-PCB and express the additive toxicity of a mixture of dioxins and dioxin-like compounds (van den Berg et al. 2006). The highest additive dioxin toxicity (sum of PCDDs + PCDFs + dl-PCBs) was detected in fish from Lake Langevann followed by Lake Bergesvatnet, Lake Storbørja and Lake Lyseren. Fish from these lakes had also the highest levels of the other POPs.

All the lakes had levels of dioxins below the EQS for biota.

Table 7: Mean wet weight TEQ (pg/g TEQ ww) values of ∑dl-PCB, ∑PCDD+PCDF and ∑PCDD+PCDF+dl-PCB in fish from each lake. Under the detection limit=not detected (nd).

Lake	∑dl-PCB	∑PCDD+PCDF	∑PCDD+PCDF+dl-PCB
Altevann Bardu	0.11	nd	0.11
Bergesvatnet	0.31	0.75	1.06
Geitvatnet	0.18	0.03	0.22
Kangsvatnet	0.13	0.02	0.15
Krøderen	0.11	nd	0.11
Langvatnet	1.05	0.06	1.11
Lešjávri	0.42	0.03	0.45
Lyseren	0.51	0.00	0.51
Møsvatn	0.37	0.04	0.41
Steinvatnet	0.28	0.02	0.30
Storbørja	0.44	0.31	0.75
Stuorajávri	0.06	0.01	0.07
Tangenfossen	0.15	0.03	0.17
Vaggatem	0.12	0.05	0.17

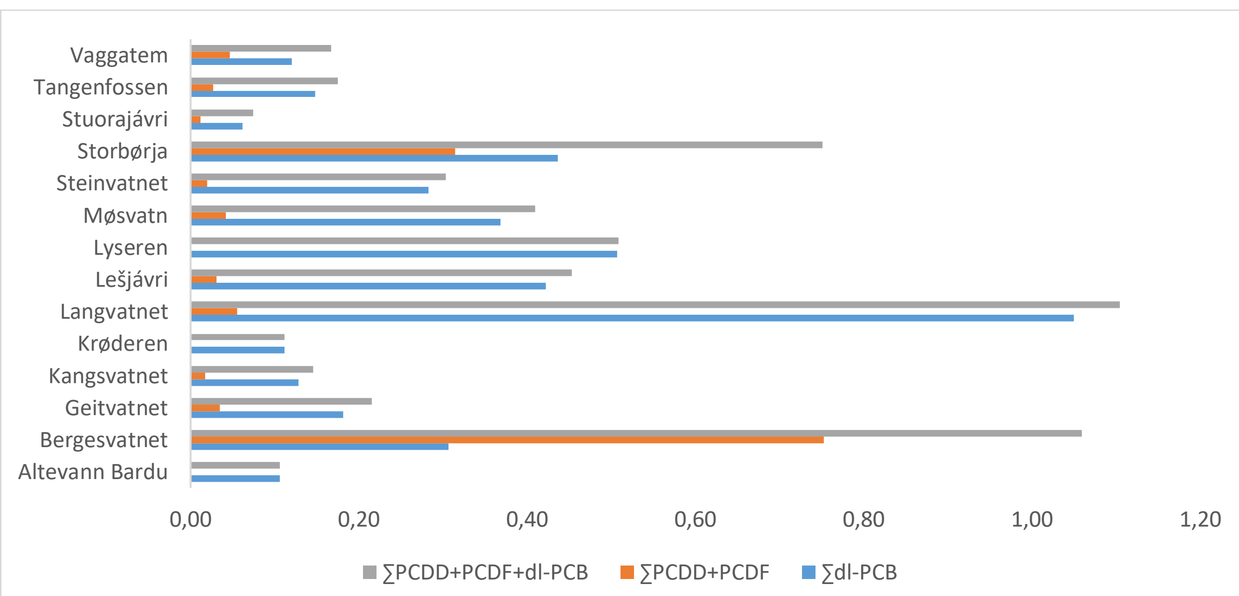

Figure 3: Mean wet weight TEQ (pg/g TEQ ww) values of ∑dl-PCB, ∑PCDD+PCDF and ∑PCDD+PCDF+dl-PCB in fish from each lake.

Table 8: Mean lipid weight TEQ (pg/g TEQ lw) values of ∑dl-PCB, ∑PCDD+PCDF and ∑PCDD+PCDF+dl-PCB in fish from each lake. Under the detection limit=not detected (nd).

Lake	∑dl-PCB	∑PCDD+PCDF	∑PCDD+PCDF+dl-PCB
Altevann Bardu	3.47	nd	3.47
Bergesvatnet	10.04	24.02	34.07
Geitvatnet	4.36	0.56	4.92
Kangsvatnet	4.14	0.58	4.72
Krøderen	3.91	nd	3.91
Langvatnet	30.00	1.57	31.57
Lešjávri	13.85	1.12	14.97
Lyseren	22.01	0.05	22.06
Møsvatn	6.94	0.76	7.70
Steinvatnet	10.17	0.70	10.89
Storbørja	12.49	8.82	21.30
Stuorajávri	1.09	0.20	1.28
Tangenfossen	4.98	0.86	5.84
Vaggatem	3.50	1.35	4.85

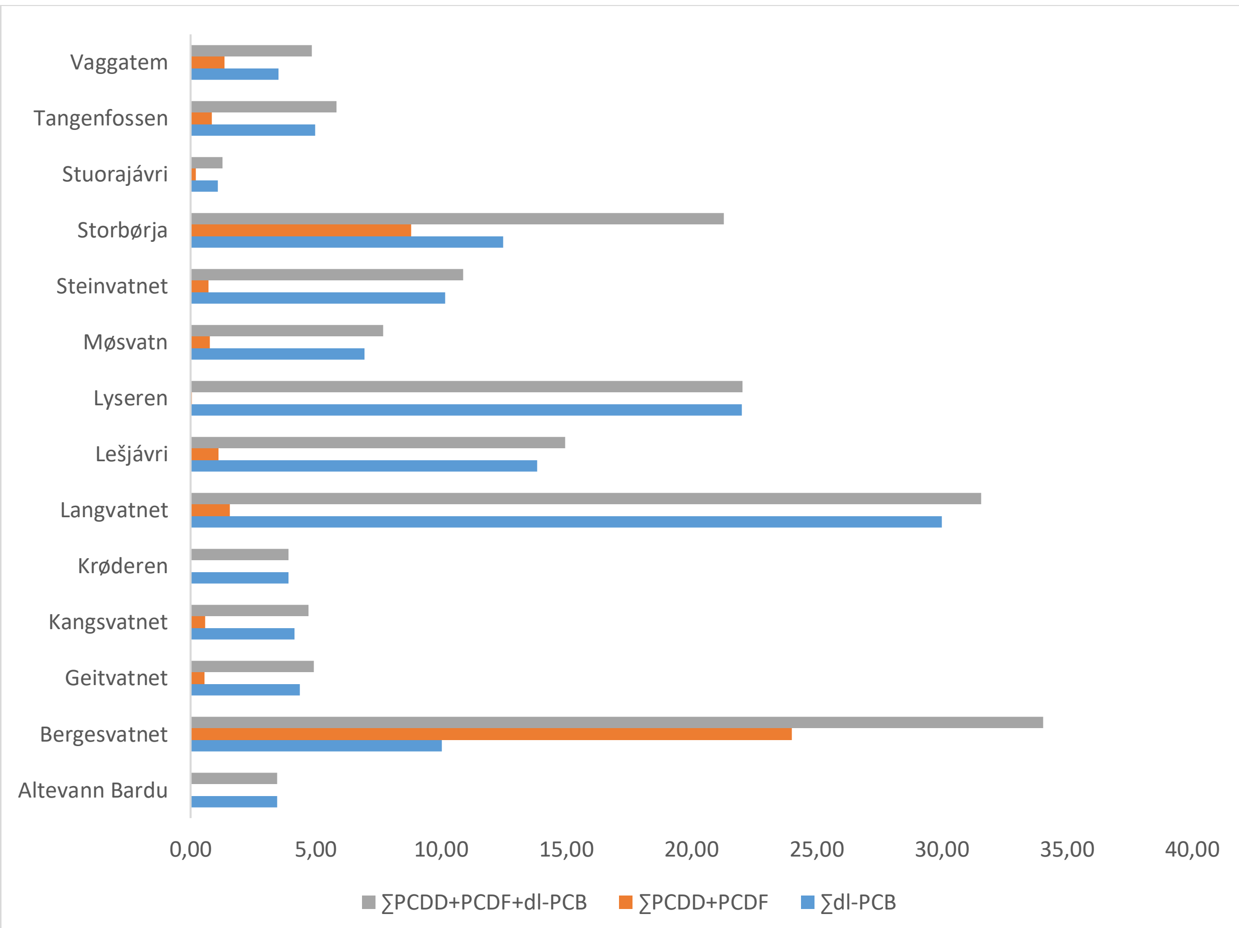

Figure 4: Mean lipid weight TEQ (pg/g TEQ lw) values of ∑dl-PCB, ∑PCDD+PCDF and ∑PCDD+PCDF+dl-PCB in fish from each lake.

3.1.5 Polyaromantic Hydrocarbons (PAH)

The mean wet weight concentrations of the polyaromatic hydrocarbons Naphthalene, Anthracene, Fluoranthene and Benzo[a]pyrene in fish from each lake are given in table 9 and figure 4. Among the four PAHs measured naphthalene showed the highest levels in fish liver from the lakes. The highest level of naphthalene was detected in Lake Steinvatn. The levels of benzo[a]pyrene were under the detection limit in all the lakes.

The detection limit for benzo[a]pyrene was 0.65 µg/kg. which are lower than the EQS (5 µg/kg ww). indicating that the levels of benzo[a]pyrene did not exceed the EQS in any of the lakes.

Table 9: Mean wet weight concentrations (µg/kg ww) of Naphthalene and Fluoranthene. Under the detection limit=not detected (nd).

Row Labels	Naphthalene	Fluoranthene	Benzo[a]pyrene	Anthracene
Altevann Bardu	0.80	0.17	ND	0.03
Bergesvatnet	0.73	0.12	ND	0.01
Geitvatnet	0.79	0.13	ND	0.03
Kangsvatnet	0.91	0.71	ND	0.05
Krøderen	0.94	0.15	ND	0.01
Langvatnet	0.95	0.14	ND	0.01
Lešjávri	0.63	0.12	ND	0.17
Lyseren	0.96	0.20	ND	0.03
Møsvatn	0.91	0.24	ND	0.04
Steinvatnet	1.01	0.11	ND	0.02
Storbørja	0.91	0.13	ND	0.01
Stuorajávri	0.90	0.32	ND	0.07
Tangenfossen	0.76	0.13	ND	0.02
Vaggatem	0.82	0.13	0.00	0.02

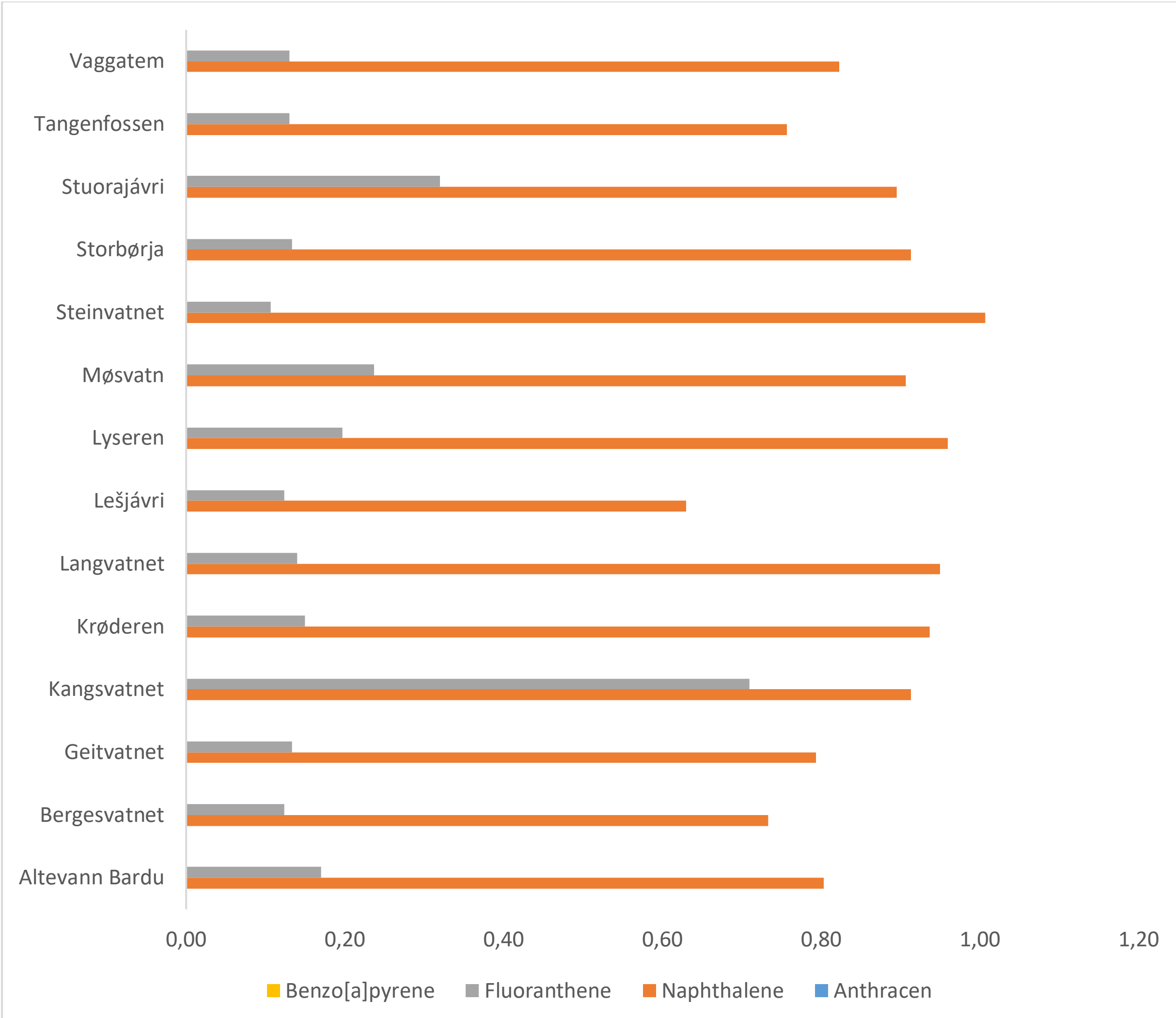

Figure 4: Mean wet weight concentrations (µg/kg ww) of Naphthalene, Anthracene, Fluoranthene and Benzo[a]pyrene.

3.1.6 Per- and polyfluorinated Compounds (PFAS)

The mean wet weight (ww) concentrations of 12 different PFAS in fish from each lake are given in tables 10 and 11 and in figures 5 and 6. The mean ww concentrations of the sum of the 12 PFAS are given table 12 and figure 10. The highest concentrations of PFOS were detected In Lake Bergesvatnet (13 µg/kg ww) followed by Lake Lyseren (10 µg/kg ww) and Lake Storbørja (8 µg/kg ww). The sum of PFAS (∑PFAS) were highest in Lake Lyseren (51 µg/kg ww) followed by Lake Storbørja (35 µg/kg ww) and Lake Bergesvatnet (28 µg/kg ww). PFUnDA was the individual PFAS detected at highest levels in most of the lakes. The same trend was found in a previous study on PFAS levels in Lake Femunden, Lake Mjøsa and Lake Randsfjorden (Miljødirektoratet. 2017). PFOS was highest in Lake Bergesvatnet and PFNA was highest in Lake Lešjávri and Lake Stuorajávri.

EU has established EQS for PFOS (9.1 µg/kg ww) but not for PFOA. However, Norway has established an EQS for PFOA. In this survey, it was found that fish from Lake Bergesvatnet and Lake Lyseren had PFOS levels which exceeded the EQS. However, The PFOA levels in fish did not exceed the Norwegian EQS (91.3 µg/kg ww) in any of the lakes.

Table 10: Mean wet weight concentrations of (µg/kg ww) 8 individual PFASs in fish from each lake.

Lake	PFNA	PFOS	PFOA	PFDA	PFTeDA	PFDoDA	PFUdA	PFTrDA
Altevann Bardu	0.07	0.25	0.83	0.14	0.04	0.10	0.24	0.16
Bergesvatnet	0.30	12.70	3.78	1.60	0.74	1.77	3.93	2.86
Geitvatnet	0.44	0.67	1.28	0.40	0.19	0.29	0.79	0.61
Kangsvatnet	0.19	1.22	1.22	0.64	0.33	0.79	1.92	1.24
Krøderen	0.24	1.27	1.41	0.77	0.57	1.39	1.86	1.65
Langvatnet	0.00	1.59	3.58	0.99	0.88	1.22	2.66	1.99
Lešjávri	3.12	1.27	1.70	1.10	0.21	0.53	2.23	1.04
Lyseren	0.71	9.54	4.91	5.67	1.95	5.54	12.27	9.09
Møsvatn	0.00	0.22	1.41	0.21	0.31	0.57	0.67	1.28
Steinvatnet	0.40	1.15	0.74	0.63	0.38	0.63	1.60	1.37
Storbørja	0.09	7.61	2.13	3.49	2.38	3.64	7.25	7.56
Stuorajávri	2.42	0.45	0.85	1.12	0.13	0.46	1.92	1.04
Tangenfossen	0.31	1.37	1.08	0.44	0.12	0.43	1.47	0.63
Vaggatem	0.43	0.49	2.41	0.38	0.11	0.41	1.40	0.55

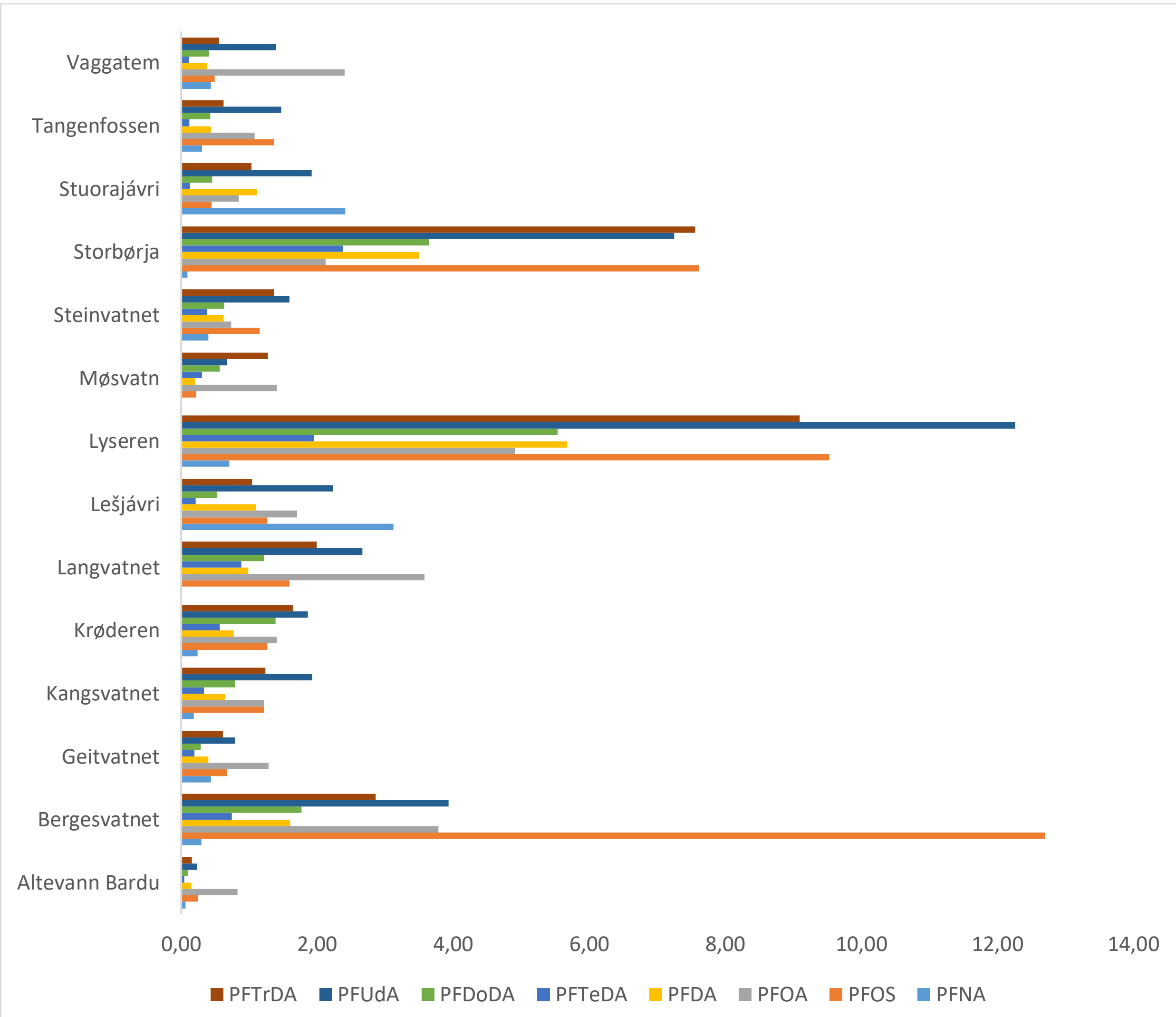

Figure 5: Mean wet weight concentrations (µg/kg ww) of 8 individual PFAS in fish from each lake

Table 11: Mean wet weight concentrations (µg/kg ww) of 4 individual PFASs in fish from each lake. Under the detection limit= not detected (nd).

Lake	PFBS	PFHxS	PFHpA	PFHxA
Altevann Bardu	nd	0.21	nd	0.02
Bergesvatnet	0.05	0.34	nd	nd
Geitvatnet	nd	0.36	nd	nd
Kangsvatnet	nd	0.47	nd	0.04
Krøderen	0.18	0.21	nd	0.20
Langvatnet	nd	0.27	nd	nd
Lešjávri	nd	0.17	nd	nd
Lyseren	0.42	1.14	nd	0.14
Møsvatn	nd	0.86	nd	0.13
Steinvatnet	0.02	0.20	nd	nd
Storbørja	0.16	0.53	nd	0.08
Stuorajávri	0.46	0.07	0.06	nd
Tangenfossen	0.41	1.16	0.06	0.14
Vaggatem	0.27	1.35	0.06	0.09

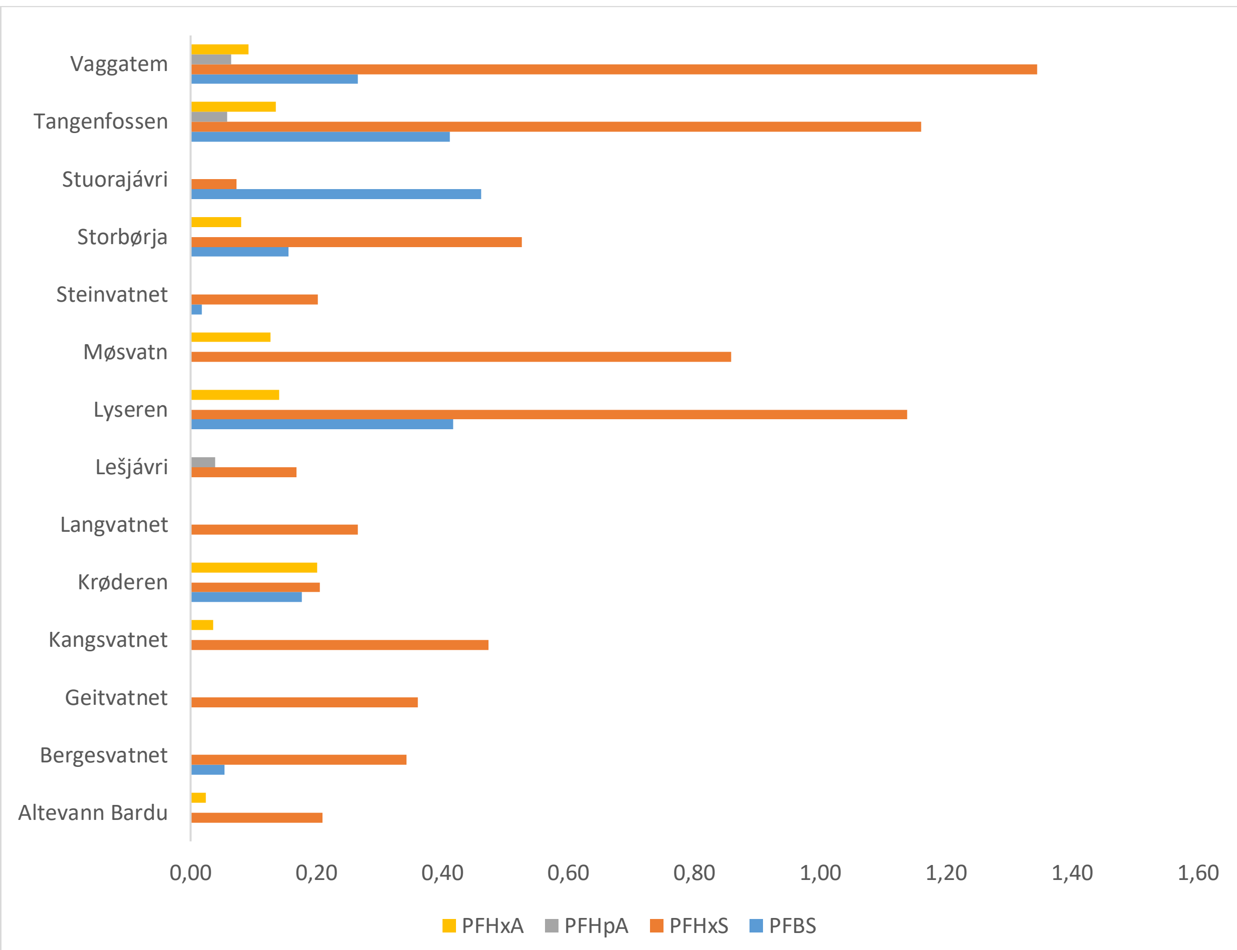

Figure 5: Mean wet weight concentrations (µg/kg ww) of 4 individual PFASs in fish from each lake.

Table 12: Mean wet weight concentrations (µg/kg ww) of the sum of 12 PFASs in fish from each lake.

Lake	∑PFAS
Altevann Bardu	2.06
Bergesvatnet	28.09
Geitvatnet	5.03
Kangsvatnet	8.07
Krøderen	9.74
Langvatnet	13.18
Lešjávri	11.41
Lyseren	51.38
Møsvatn	5.65
Steinvatnet	7.11
Storbørja	34.90
Stuorajávri	8.90
Tangenfossen	7.61
Vaggatem	7.94

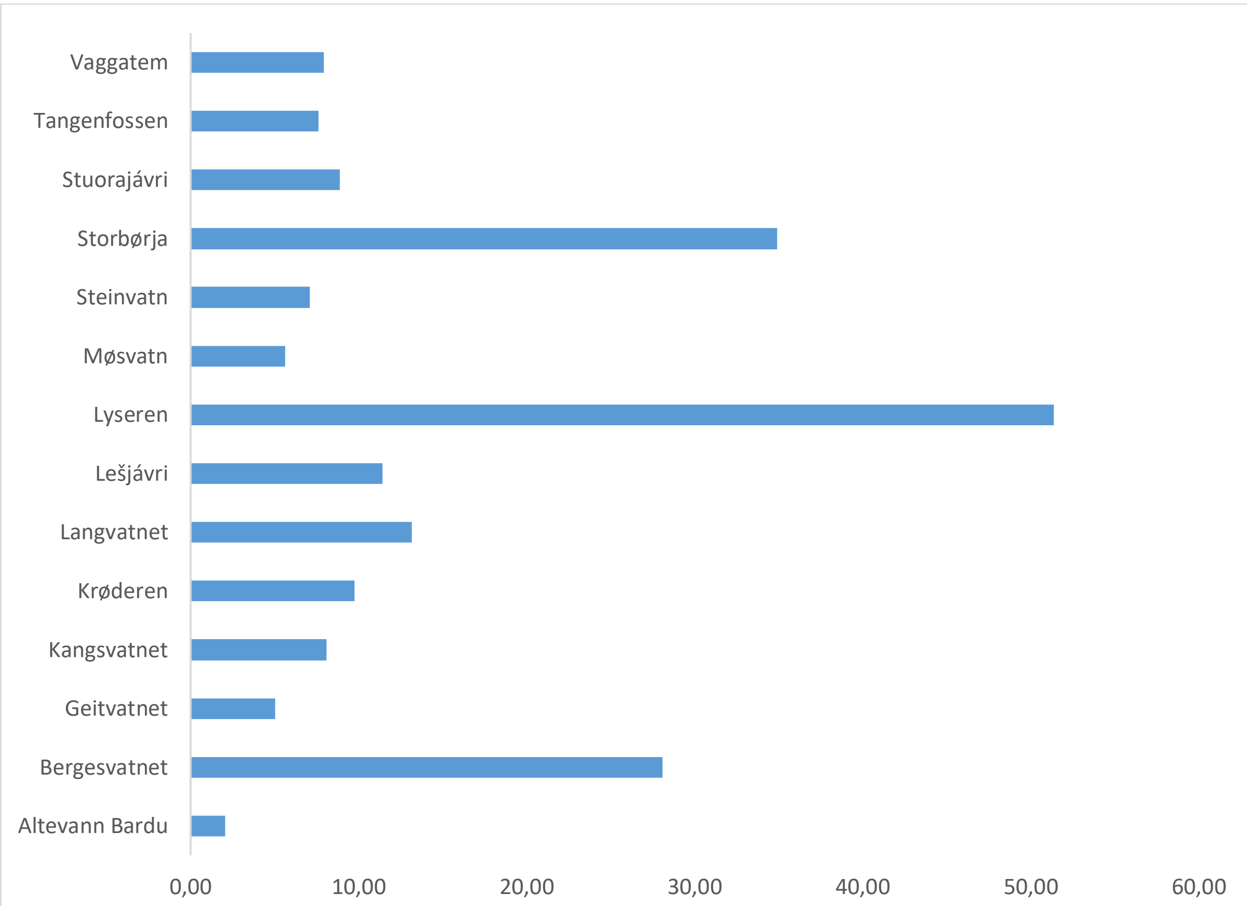

Figure 6: Mean wet weight (µg/kg ww) concentrations of the sum of 16 PFASs in fish from each lake.

3.1.7 Phenols

The mean wet weight concentrations of the phenols, 4-tert-octylphenol and p-nonylphenol in fish from each lake are given in table 13 and figure 7.

The highest level of p-nonylphenol was detected in Lake Stuorajávri (16 µg/kg ww) followed by Lake Geitvatnet (14 µg/kg ww) and Lake Tangenfossen (9 µg/kg ww).

The highest level of 4-tert-oktylfenol was detected in Lake Møsvatn (0.69 µg/kg ww) followed by Lake Tangenfossen (0.65 µg/kg ww) and Lake Lešjávri (0.46 µg/kg ww).

The EQS for 4-tert-oktylfenol was exceeded in fish livers from all the lakes except three, which had levels under the detection limit, whereas the levels of p-nonylfenol were below the EQS in all lakes. The detection limit for 4-tert- octylphenol was higher than the EQS for this chemical.

Table 13: Mean wet weight concentrations (µg/kg ww) of 4-tert-oktylfenol and p-nonylfenol in fish from each lake. Under the detection limit= not detected (nd).

Lake	4-tert- octylphenol	p-nonylphenol
Altevann Bardu	0.38	6.04
Bergesvatnet	nd	nd
Geitvatnet	0.43	14.07
Kangsvatnet	0.17	1.51
Krøderen	nd	1.80
Langvatnet	nd	nd
Lešjávri	0.46	8.33
Lyseren	0.19	nd
Møsvatn	0.69	3.27
Steinvatnet	0.31	5.90
Storbørja	0.15	4.97
Stuorajávri	0.14	16.35
Tangenfossen	0.65	9.31
Vaggatem	0.17	4.33

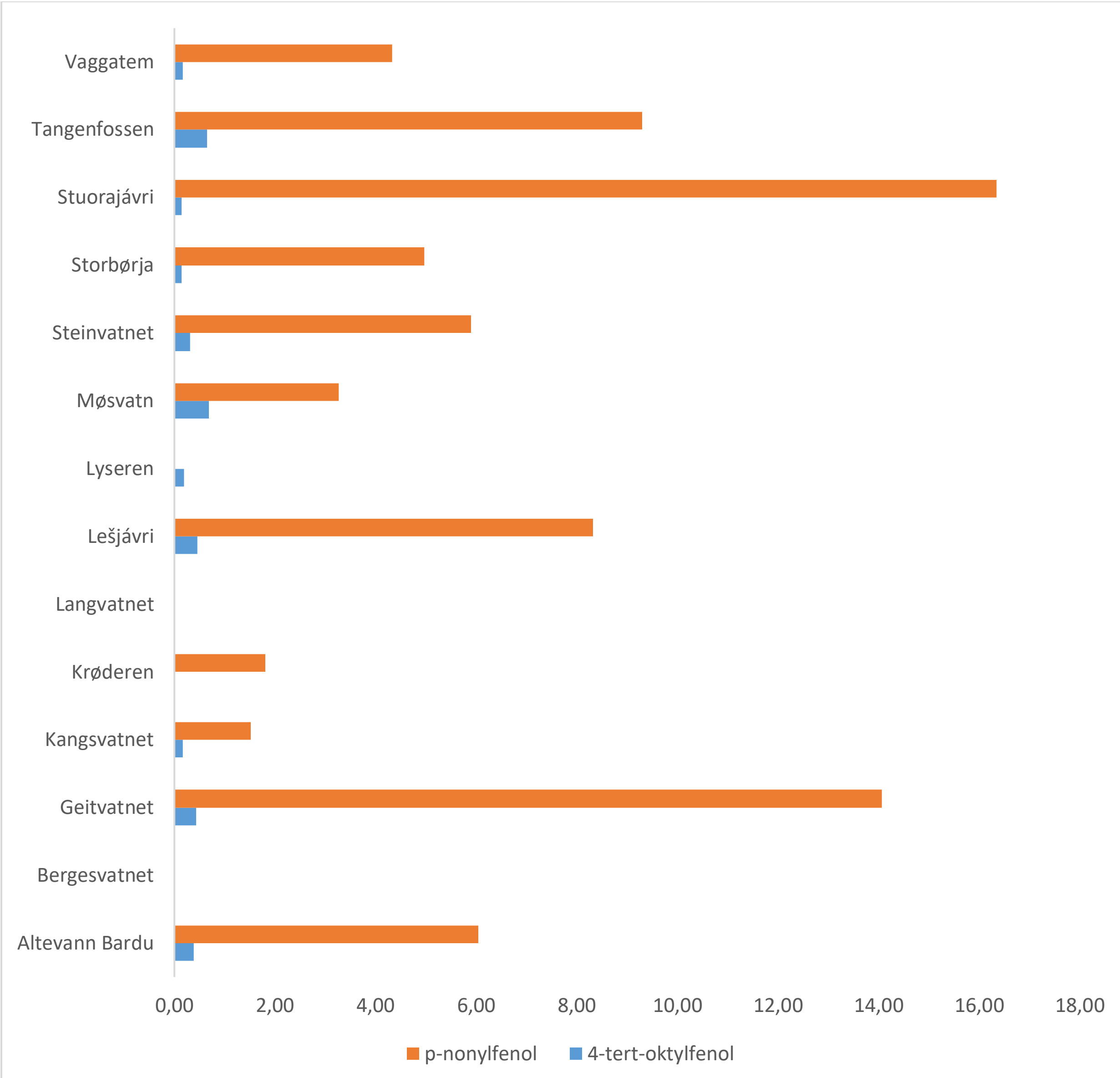

Figure 7: Mean wet weight concentrations (µg/kg) of 4-tert-octylphenol and p-nonylphenol in fish from each lake.

3.1.8 Organotin Compounds

The mean wet weight concentrations of the organotins. Dibutyltin (DBT), Tributyltin (TBT), Monobutyltin (MBT), Triphenyltin (TPT), Diphenyltin (DPT) and Monophenyltin (MPT) in fish from each lake are given in table 14 and figure 8.

The highest level of dibutyltin was detected in Lake Altevann Bardu (0.32 µg/kg ww) followed by Lake Tangenfossen (0.29 µg/kg ww) and Lake Møsvatn (0.28 µg/kg ww). The highest levels of tributyltin were detected in Lake Stuorajávri (1.37 µg/kg ww) followed by Lake Langevann (0.99 µg/kg ww) and Tangenfossen (0.33 µg/kg ww).

The levels of tributyltin did not exceed the EQS for this contaminant in any of the lakes.

Table 14: Mean wet weight concentrations (µg/kg ww) of the organotins, DBT, TBT, MBT, TPT, DPT and MPT in fish from each lake.

Lake	DBT	TBT	MBT	TPT	DPT	MPT
Altevann Bardu	0.32	0.19	0.08	0.07	0.02	0.08
Bergesvatnet	0.24	0.30	0.04	0.04	0.01	0.06
Geitvatnet	0.15	0.06	0.06	0.10	0.03	0.06
Kangsvatnet	0.14	0.22	0.06	0.02	0.01	0.82
Krøderen	0.28	0.20	0.12	0.15	0.04	0.31
Langvantnet	0.14	0.99	0.10	0.01	0.06	2.31
Lešjávri	0.14	0.04	0.05	0.14	0.01	0.06
Lyseren	0.11	0.08	0.09	0.07	0.03	0.10
Møsvatn	0.28	0.18	0.08	0.08	0.02	0.06
Steinvatnet	0.18	0.10	0.04	0.04	0.02	0.32
Storbørja	0.10	0.29	0.08	0.06	0.02	0.09
Stuorajávri	0.26	1.37	0.13	0.75	0.05	0.16
Tangenfossen	0.29	0.33	0.05	0.14	0.02	0.04
Vaggatem	0.17	0.13	0.07	0.06	0.02	0.06

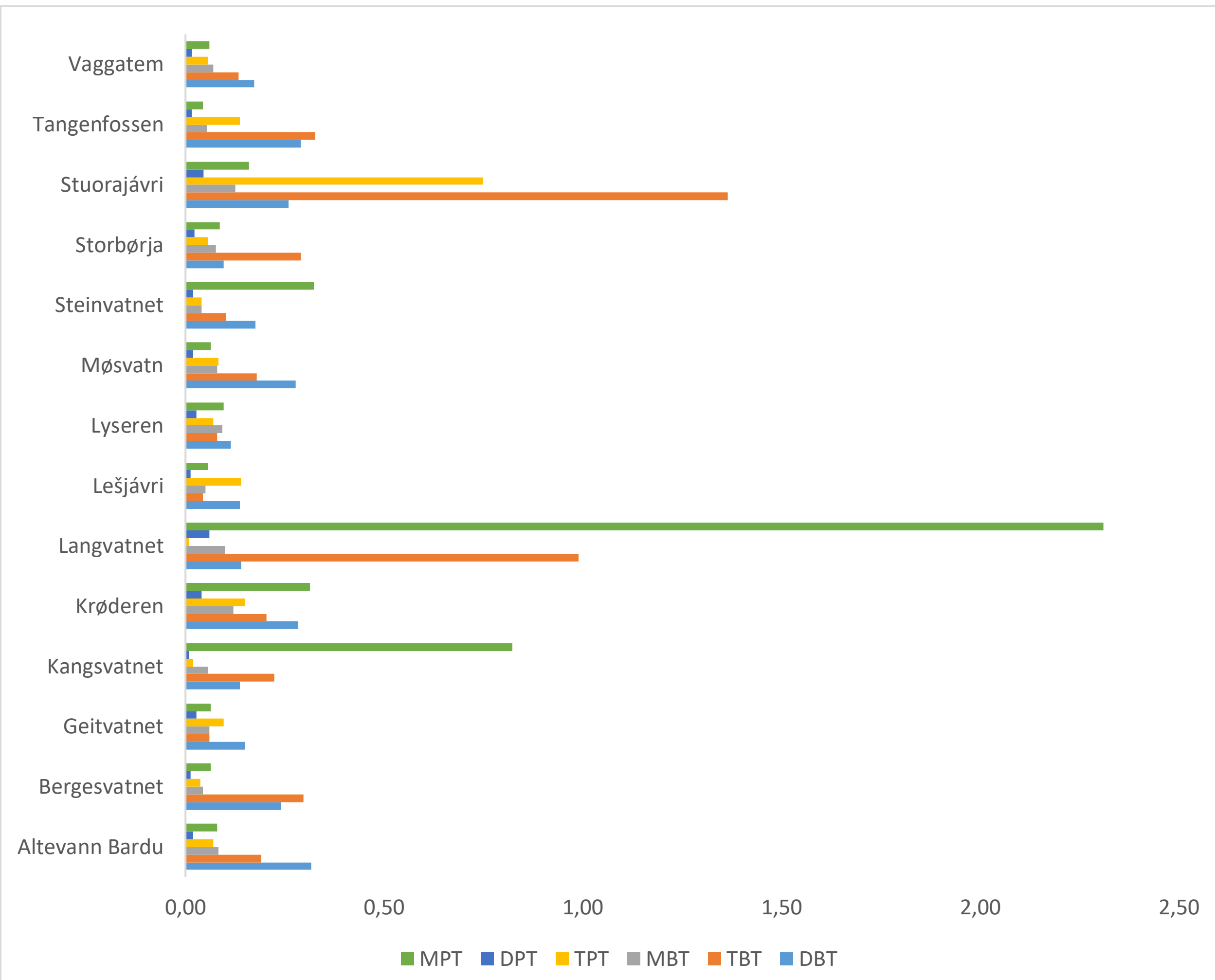

Figure 8: Mean wet weight concentrations (µg/kg) of organotins in fish from each lake.

3.1.9 Siloxane, Triclosan, Dicofol and Short-Chain (SCCPs) and Medium-Chain (MCCPs) Chlorinated Paraffins

The mean wet weight concentrations of siloxane, triclosan, dicofol and short-chain (SCCPs) and medium-chain (MCCPs) chlorinated paraffins in fish from each lake are given in table 15 and figure 9.

The highest level of siloxane (D5) was detected in Lake Steinvatn (3.87 µg/kg ww) followed by Lake Lyseren (3.07 µg/kg ww) and lake Krøderen (2.92 µg/kg ww).

The levels of D5 were lower than EQS in fish from all the lakes.

The highest level of triclosan was detected in Lake Langevann (0.18 µg/kg ww) followed by Lake Storbørja (0.17 µg/kg ww) and Lake Lyseren (0.15 µg/kg ww).

The levels of Triclosan did not exceed the EQSs.

The highest level of dicofol was detected in Lake Langevann (1.74 µg/kg ww) followed by Lake Storbørja (1.73 µg/kg ww) and Lake Lyseren (1.45 µg/kg ww).

The levels of Dicofol did not exceed the EQSs.

The levels of SCCPs and MCCPs ranged from 0.84 to 4.78 µg/kg and from 1.56 to 7.04 µg/kg for SCCPs and MCCPs, respectively, which are much lower than the EQS for SCCPs (6000 µg/kg) and MCCPs (170 µg/kg), indicating that these chemicals did not exceed the EQS for biota.

The levels of SCCP and MCCP in the samples from the present study were lower than the corresponding levels in freshwater fish in the same program from 2017. However, the levels of other POPs, such as PCBs and DDTs, from this year's analyses were relatively low, suggesting that these lakes are moderate affected by human activity.

Analyses of SCCP and MCCP from large Norwegian lakes (Fjeld et al. 2014), show that the detected levels of these contaminants in freshwater fish are within the same range as the present study. In the marine environment, the levels in cod liver appear to be clearly higher than in freshwater fish (Green et al. 2018)

Table 15: Mean wet weight concentrations (µg/kg) of D5, TCS, dicofol, SCCPs and MCCPs. Under the detection limit=not detected (nd).

Lake	Siloxane (D5)	Triclosan (TCS)	Dicofol	SCCPs	MCCPs
Altevann Bardu	1.91	0.09	0.92	0.91	1.91
Bergesvatnet	1.40	0.08	0.84	0.82	2.40
Geitvatnet	2.64	0.09	0.91	1.14	5.82
Kangsvatnet	2.79	0.11	1.06	1.06	1.88
Krøderen	2.92	0.10	0.96	1.14	2.15
Langvantnet	2.27	0.18	1.74	1.26	2.26
Lešjávri	2.03	0.09	0.92	3.39	4.64
Lyseren	3.07	0.15	1.45	1.90	1.57
Møsvatn	2.28	0.09	0.89	1.83	7.04
Steinvatnet	3.87	0.12	1.17	4.78	5.13
Storbørja	1.81	0.17	1.73	1.75	2.78
Stuorajávri	1.96	0.11	1.06	2.30	4.91
Tangenfossen	2.06	0.07	0.67	0.99	1.56
Vaggatem	1.78	0.09	0.89	1.00	2.38

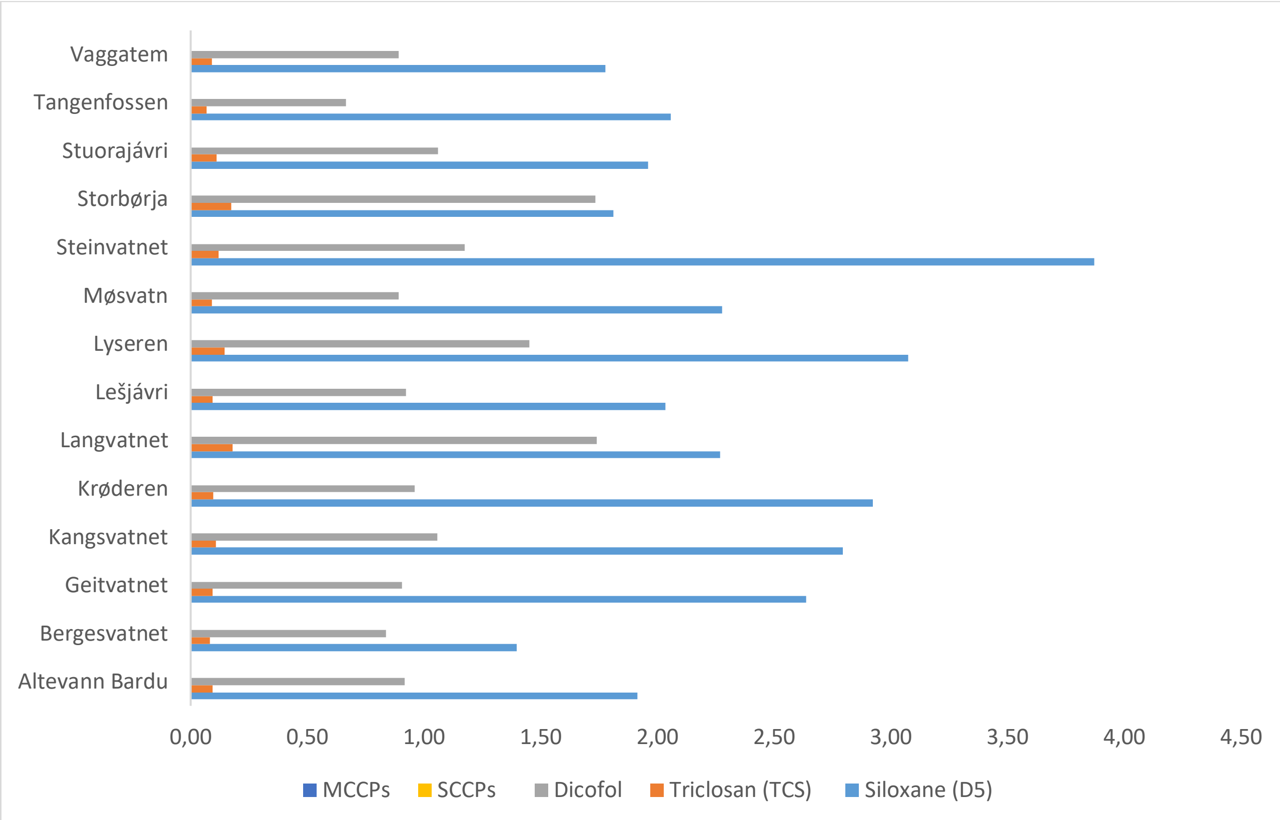

Figure 9: Mean wet weight concentrations (µg/kg) of D5, TCS, Dicofol, SCCPs and MCCPs

3.1.10 Hexachlorobutadien (HCBD), Trichlorobenzene (TCBs), Pentachlorophenol (PCP) and TCEP (tris(2-kloretyl)fosfat)

The mean wet weight concentrations of Hexachlorobutadien (HCBD), Trichlorobenzene (TCBs). Pentachlorophenol (PCP) and TCEP (tris(2-kloretyl)fosfat) in fish from each lake are given in table 16 and figure 10.

The highest level of HCBD was detected in Lake Steinvatn (0.08 µg/kg ww) followed by Lake Stuorajávri (0.06 µg/kg ww) and Lake Geitevatnet (0.06 µg/kg ww).

The highest level of TCBs (0.03 µg/kg ww) was detected in Lake Steinvatn. Lake Storvatn and Lake Tangenfossen.

The highest level of PCP was detected in Lake Krøderen (1.26 µg/kg ww) followed by Lake Kangsvatnet (1.13 µg/kg ww) and Lake Storbørja (0.85 µg/kg ww).

The highest level of TCEP was detected in Lake Steinvatn (0.86 µg/kg ww) followed by Lake Geitevatnet (0.77 µg/kg ww) and Lake Lyseren (0.75 µg/kg ww).

The levels of HBCD, TCBs, PCP and TCEP in fish were lower than the EQSs for these contaminants in all the lakes.

Table 16: Mean wet weight concentration (µg/kg) of HBCD, TCBs, PCP and TCEP in fish from each lake.

Lake	HCBD	TCBs	PCP	TCEP
Altevann Bardu	0.03	0.01	0.31	0.18
Bergesvatnet	0.05	0.02	0.19	0.19
Geitvatnet	0.06	0.01	0.24	0.77
Kangsvatnet	0.04	0.01	1.13	2.94
Krøderen	0.03	0.01	1.26	0.13
Langvatnet	0.03	0.01	0.40	0.24
Lešjávri	0.04	0.02	0.10	0.14
Lyseren	0.04	0.03	0.23	0.75
Møsvatn	0.05	0.01	0.32	0.11
Steinvatnet	0.08	0.03	0.54	0.86
Storbørja	0.05	0.02	0.85	0.47
Stuorajávri	0.06	0.02	0.64	0.15
Tangenfossen	0.02	0.03	0.44	0.11
Vaggatem	0.03	0.01	0.41	0.28

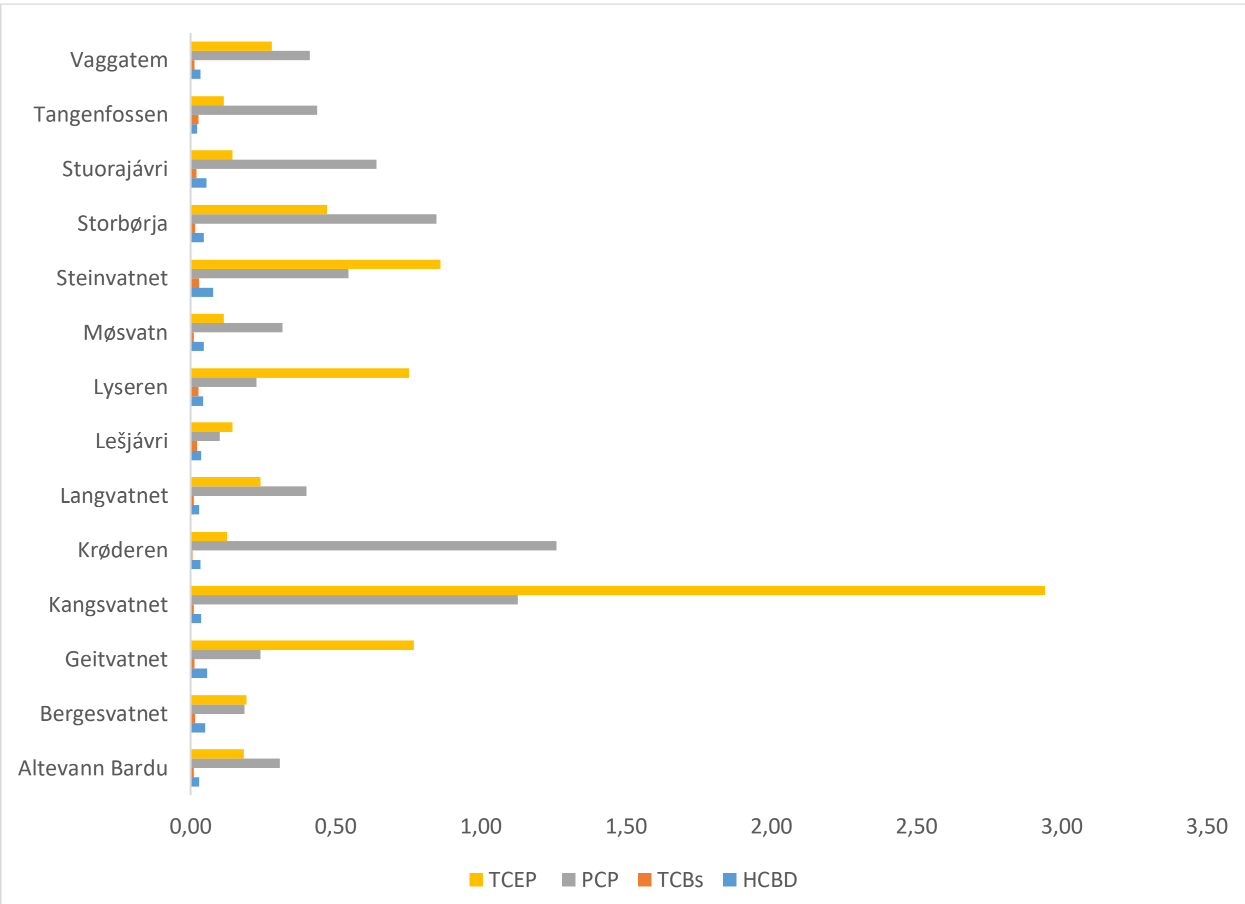

Figure 10: Mean wet weight concentration (µg/kg) of HBCD, TCBs, PCP and TCEP in fish from each lake.

3.1.11 Bis (2-etylheksyl) phthalate (DEHP)

The mean wet weight concentrations of Bis (2-etylheksyl) phthalate (DEHP) in fish from each lake are given in table 17 and figure 11 and the lipid weight concentrations of DEHP are given in table 17 and figure 12.

The highest level of DEHP was detected in Lake Kangsvatnet (305 µg/kg ww) followed by Lake Lyseren (244 µg/kg ww) and Lake Lešjávri (231 µg/kg ww).

The levels of DEHP in fish were lower than the EQSs for these contaminants in all the lakes.

Table 17: Mean wet weight (ww) and lipid weight (lw) concentrations (µg/kg) of DEHP in fish from each lake.

Row Labels	DEHP ww	DEHP lw
Altevann Bardu	138.83	4302.31
Bergesvatnet	84.97	2928.38
Geitvatnet	86.97	2120.55
Kangsvatnet	305.23	10249.05
Krøderen	50.97	1939.51
Langvatnet	158.40	4525.71
Lešjávri	231.33	8065.20
Lyseren	244.10	10599.22
Møsvatn	139.53	2897.43
Steinvatnet	85.37	2867.23
Storbørja	119.83	3449.85
Stuorajávri	82.60	1418.30
Tangenfossen	148.40	5506.44
Vaggatem	162.80	4842.57

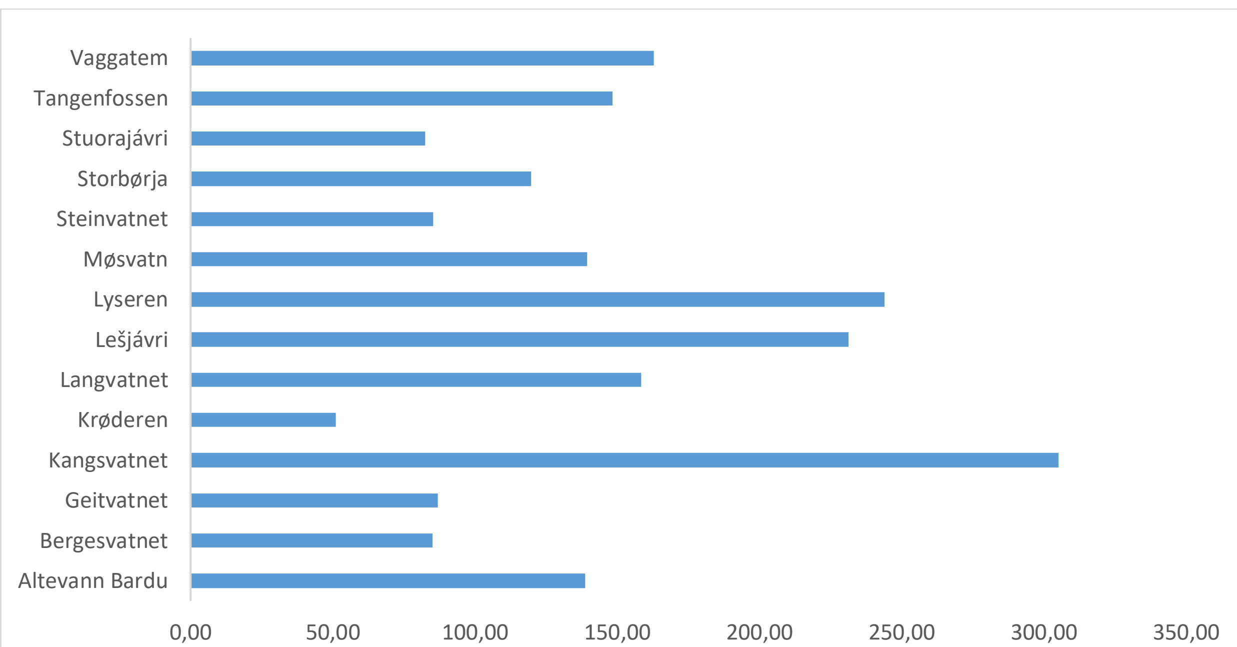

Figure 11: Mean wet weight (ww) concentrations (µg/kg) of DEHP in fish from each lake.

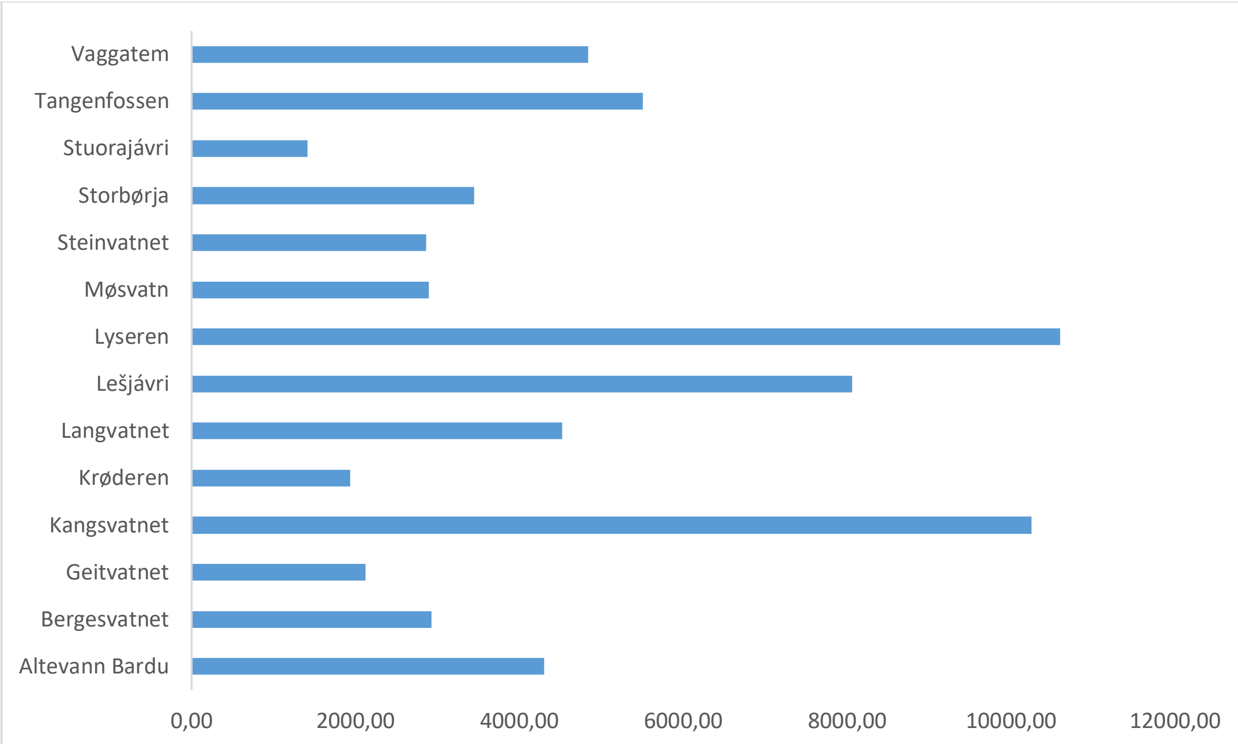

Figure 12: Mean lipid weight (lw) concentrations (µg/kg) of DEHP in fish from each lake.

3.1.12 Metals

The mean wet weight concentrations of Magnesium (Mg), Iron (Fe), Copper (Cu), Zinc (Zn) and Selenium (Se) in fish from each lake are given in table 18 and figure 13. The mean wet weight concentrations of Aluminium (Al), Silver (Ag), Molybdenum (Mo), Cobalt (Co) and Vanadium (V) are given in table 19 and figure 14 and the mean wet weight concentrations of Lead (Pb) Arsenic (As), Cadmium (Cd), Mercury (Hg) in liver and Hg in muscle are given in table 20 and figure 15.

The levels of Hg in muscle were highest in Lake Storbørja (2867 µg/kg ww) followed by Lake Lyseren (396 µg/kg ww), Lake Kangsvatnet (300 µg/kg ww) and Lake Bergesvatnet (293 µg/kg ww).

The levels of Cd in liver was highest in Lake Lyseren (3500 µg/kg ww) followed by Lake Krøderen (927 µg/kg ww), Lake Møsvatn (780 µg/kg ww) and Lake Storbørja (508 µg/kg ww).

The levels of Hg in fish muscle exceeded the EQS in all the lakes.

EU has not established an EQS for Cd in biota. However, the high levels of Cd detected Lake Lyseren. Lake Krøderen. Lake Møsvatn and Lake Storbørja, suggest that these lakes are polluted from local sources. Lake Lyseren, which had high levels of Hg and the highest levels of Cd and Pb, had also the highest levels of Al suggesting low pH in the lake (Miljødirektoratet, 2015). High concentration of Al in lakes with low pH may also harm the fish (Wauer and Teien, 2010).

Table 18: Mean wet weight concentration (µg/kg) of Mg, Fe, Cu, Zn and Se in fish from each lake

Lake	Mg (µg/kg)	Fe (µg/kg)	Cu (µg/kg)	Zn (µg/kg)	Se (µg/kg)
Altevann Bardu	296667	316667	12533	30000	1100
Bergesvatnet	150000	156667	76667	34667	8167
Geitvatnet	236667	189000	36400	35667	3300
Kangsvatnet	156667	140000	68667	35000	16667
Krøderen	180000	84333	2367	26000	797
Langvatnet	170000	140000	34000	44000	11000
Lešjávri	203333	576667	19667	31667	1967
Lyseren	156667	353333	37333	34000	4533
Møsvatn	210000	600000	8800	38667	1333
Steinvatnet	159000	300000	92333	35333	17467
Storbørja	150000	97667	2000	22667	1567
Stuorajávri	195000	165000	2000	24000	1050
Tangenfossen	180000	186667	8133	40667	973
Vaggatem	166667	92333	10667	28000	743

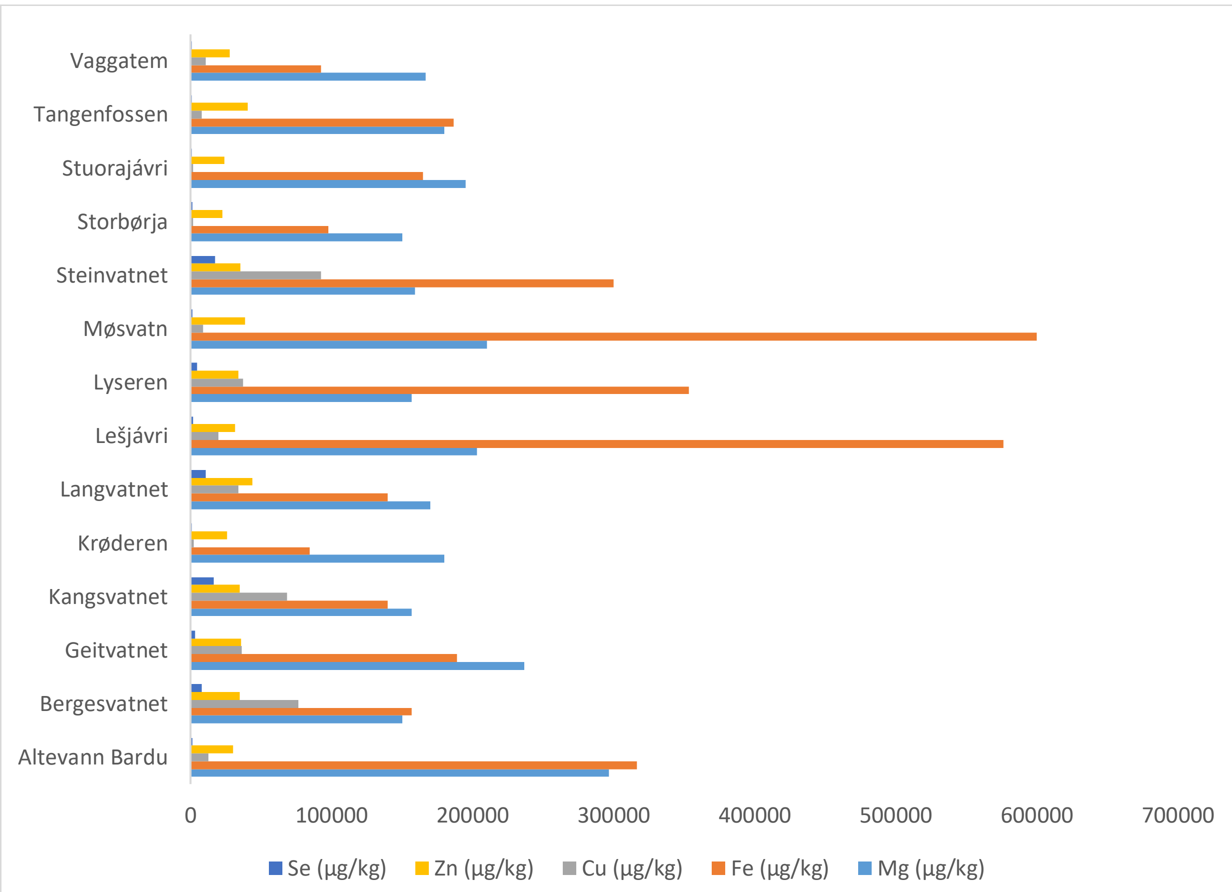

Figure 13: Mean wet weight concentration (µg/kg) of Mg, Fe, Cu, Zn and Se in fish from each lake.

Table 19: Mean wet weight concentration (µg/kg) of Al, Ag, Mo, V, Ni and Co in fish from each lake.

Lake	Al (µg/kg)	Ag (µg/kg)	Mo (µg/kg)	V (µg/kg)	Ni (µg/kg)	Co (µg/kg)
Altevann Bardu	4000	82	147	75	17	197
Bergesvatnet	1073	1267	143	12	8	67
Geitvatnet	727	716	153	8	12	66
Kangsvatnet	2133	2700	153	8	14	150
Krøderen	3500	4	118	22	7	267
Langvatnet	2200	1900	180	10	13	59
Lešjávri	8700	139	177	113	30	250
Lyseren	28000	386	124	77	6	239
Møsvatn	2700	89	110	16	10	116
Steinvatnet	977	1773	183	4	13	81
Storbørja	4800	2	72	23	9	213
Stuorajávri	10750	1	130	95	11	114
Tangenfossen	3667	62	110	77	66	52
Vaggatem	4967	157	95	37	46	39

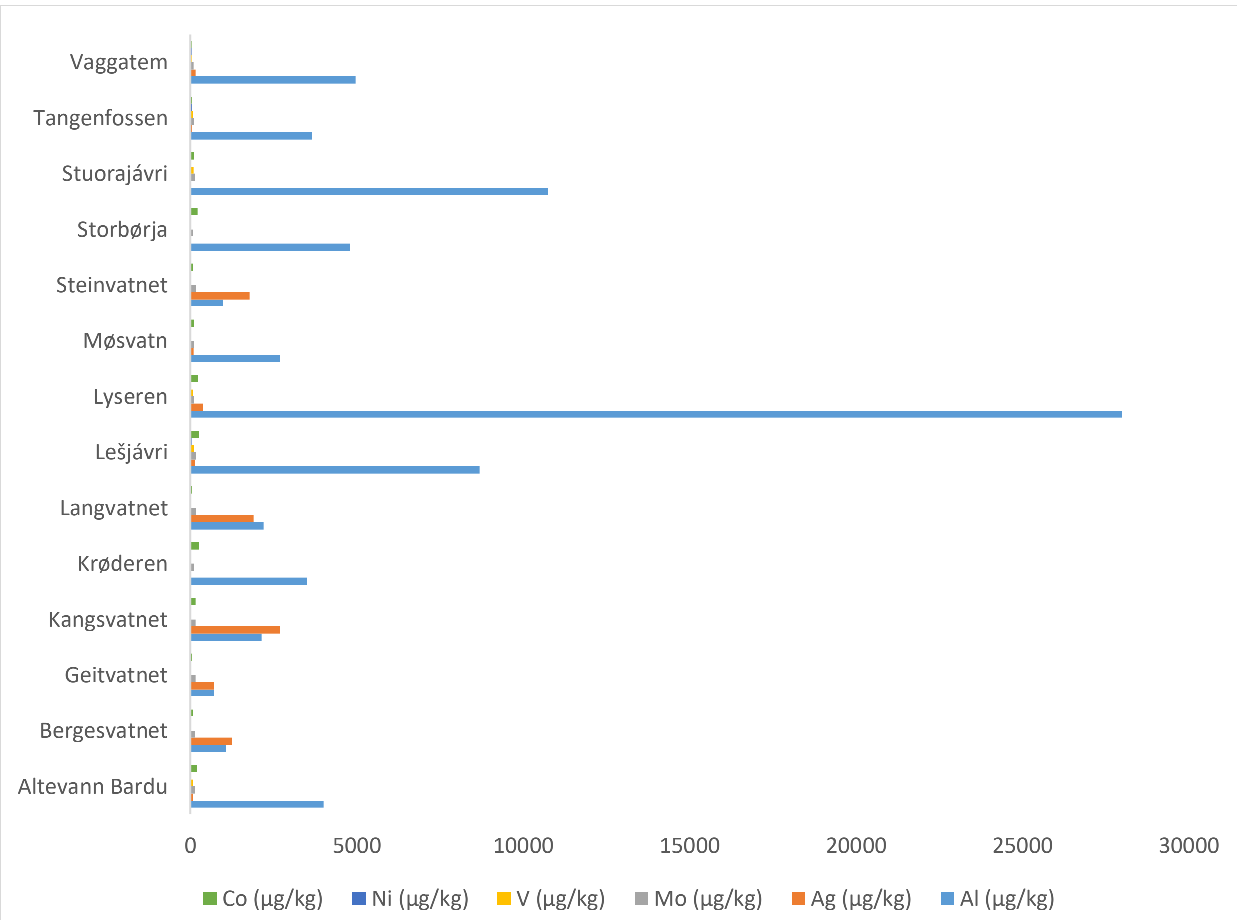

Figure 14: Mean wet weight concentration (µg/kg) of Al, Ag, Mo, V, Ni and Co in fish from each lake.

Table 20: Mean wet weight concentration (µg/kg) of As, Cd, Pb, Hg in liver and Hg muscle in fish from each lake.

Lake	As (µg/kg)	Cd (µg/kg)	Pb (µg/kg)	Hg liver (µg/kg)	Hg muscle (µg/kg)
Altevann	37	106	4	56	57
Bergesvatnet	30	297	26	540	293
Geitvatnet	20	70	3	163	183
Kangsvatnet	48	250	7	440	300
Krøderen	92	780	2	85	168
Langvatnet	16	290	16	420	240
Lešjávri	41	101	17	78	87
Lyseren	33	3500	44	417	396
Møsvatn	8	927	9	123	143
Steinvatnet	79	134	7	287	155
Storbørja	18	503	23	2933	2867
Stuorajávri	87	180	6	40	85
Tangenfossen	32	112	10	200	92
Vaggatem	187	40	4	65	51

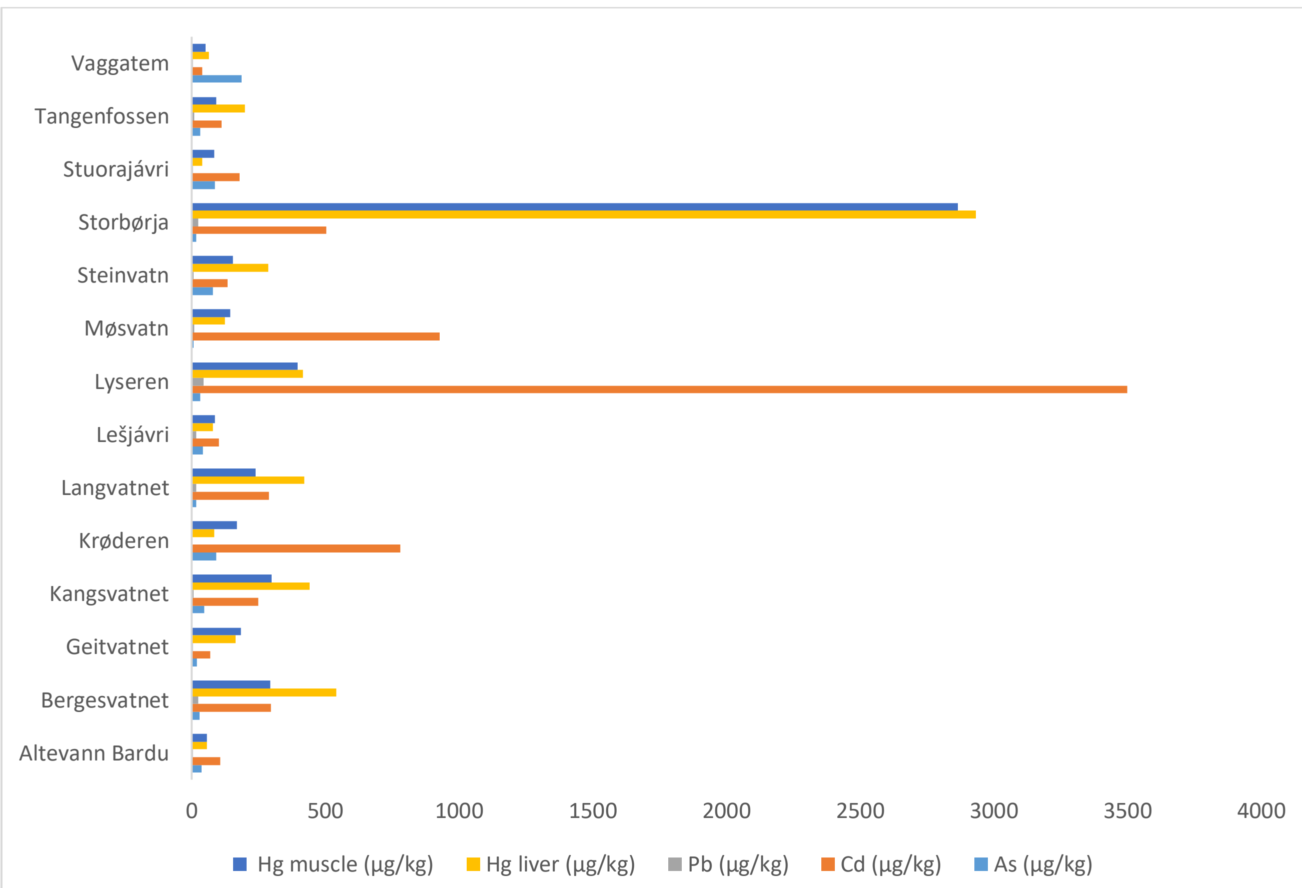

Figure 15: Mean wet weight concentration (µg/kg) of As, Cd, Pb, Hg in liver and Hg in muscle in fish from each lake.

4. Levels of environmental contaminants in fish compared to environmental quality standards (EQS)

Table 21- 32: Levels of individual chemical and groups of pollutants given in µg / kg wet weight and environmental quality standards (EQS) for these chemicals given in µg / kg wet weight, except for levels for dioxins and dioxin-like PCBs which are given on pg/gTEQ. **All the contaminants were analyzed in the fish liver except for Hg, which was analyzed in fish muscle.** Red numbers indicate exceedance of EQS.

Table 20: Lake Altevann Bardu, water code: 196-38195

Chemical(s) Species: Char Tissue: Liver **Fish weight (mean): 367 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	138.83
Decmethylcyclosiloxane (D5)	541-02-6	15217	1.91
Endosulfan	115-29-7	370	0.01
Hexachlorobutadien (HBCD)	87-68-3	55	0.03
HCB	A 118-74-1	10	0.35
Naphthalene	91-20-3	2400	0.80
Pentachlorophenol (PCP)	87-86-5	180	0.31
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.19
Trichlorobenzene (TCBs)	12002-48-1	490	0.01
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.18
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.07
PCB7	1336-36-3	0.6	0.15
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.11
PBDE	A 32534-81-9	0.0085	0.05
HBCDD	134237-51-7	167	0.01
PFOA	3825-261	91.3	0.83
PFOS	1763-21-1	9.1	0.25
p-nonylphenol	A 84852-15-3	3000	6.04
4-tert- octylphenol	140-66-9	0.004	0.38
Hg (muscle)	A 7439-97-6	20	57
Triclosan	3380-34-5	15217	0.09
Dicofol	115-32-2	33	0.92
Heptachlor	1024-57-3	0.0067	0.00

Table 22: Lake Bergesvatnet, water code: 043-29689

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 256 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	84.97
Decmethylcyclosiloxane (D5)	541-02-6	15217	1.50
Endosulfan	115-29-7	370	0.00
Hexachlorobutadien (HBCD)	87-68-3	55	0.05
HCB	A 118-74-1	10	0.13
Naphthalene	91-20-3	2400	0.73
Pentachlorophenol (PCP)	87-86-5	180	0.19
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.30
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.19
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.04
PCB7	1336-36-3	0.6	2.70
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	1.06
PBDE	A 32534-81-9	0.0085	0.92
HBCDD	134237-51-7	167	0.08
PFOA	3825-261	91.3	3.78
PFOS	1763-21-1	9.1	12.70
p-nonylphenol	A 84852-15-3	3000	0.00
4-tert- octylphenol	140-66-9	0.004	0.00
Hg (muscle)	A 7439-97-6	20	293
Triclosan	3380-34-5	15217	0.08
Dicofol	115-32-2	33	0.84
Heptachlor	1024-57-3	0.0067	0.00

Table 23: Lake Geitvatnet, water code: 194-84806

Chemical(s) Species: Trout/char Tissue: Liver **Fish weight (mean):** 306 g	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	86.97
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.64
Endosulfan	115-29-7	370	0.01
Hexachlorobutadien (HBCD)	87-68-3	55	0.06
HCB	A 118-74-1	10	0.55
Naphthalene	91-20-3	2400	0.91
Pentachlorophenol (PCP)	87-86-5	180	0.24
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.06
Trichlorobenzene (TCBs)	12002-48-1	490	0.01
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.77
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.10
PCB7	1336-36-3	0.6	1.53
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.22
PBDE	A 32534-81-9	0.0085	0.08
HBCDD	134237-51-7	167	0.03
PFOA	3825-261	91.3	1.28
PFOS	1763-21-1	9.1	0.67
p-nonylphenol	A 84852-15-3	3000	14.07
4-tert- octylphenol	140-66-9	0.004	0.43
Hg (muscle)	A 7439-97-6	20	183
Triclosan	3380-34-5	15217	0.09
Dicofol	115-32-2	33	0.91
Heptachlor	1024-57-3	0.0067	0.06

Table 24: Lake Kangsvatnet, water code: 137-91154

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 393 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	305.23
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.79
Endosulfan	115-29-7	370	0.00
Hexachlorobutadien (HBCD)	87-68-3	55	0.04
HCB	A 118-74-1	10	0.37
Naphthalene	91-20-3	2400	0.91
Pentachlorophenol (PCP)	87-86-5	180	1.13
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.22
Trichlorobenzene (TCBs)	12002-48-1	490	0.01
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	2.94
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.02
PCB7	1336-36-3	0.6	0.96
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.15
PBDE	A 32534-81-9	0.0085	0.20
HBCDD	134237-51-7	167	0.03
PFOA	3825-261	91.3	1.22
PFOS	1763-21-1	9.1	1.22
p-nonylphenol	A 84852-15-3	3000	1.51
4-tert- octylphenol	140-66-9	0.004	0.17
Hg (muscle)	A 7439-97-6	20	300
Triclosan	3380-34-5	15217	0.11
Dicofol	115-32-2	33	1.06
Heptachlor	1024-57-3	0.0067	0.09

Table 25: Lake Krøderen, water code: 012-43517

Chemical(s)	CAS-nr.[1]	EQS	Mean measured concentration
Species: Perch Tissue: Liver		(µg/kg ww)	
Fish weight (mean): 519 g			
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	50.97
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.92
Endosulfan	115-29-7	370	0.03
Hexachlorobutadien (HBCD)	87-68-3	55	0.03
HCB	A 118-74-1	10	0.20
Naphthalene	91-20-3	2400	0.94
Pentachlorophenol (PCP)	87-86-5	180	1.26
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.20
Trichlorobenzene (TCBs)	12002-48-1	490	0.01
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.13
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.15
PCB7	1336-36-3	0.6	1.51
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.11
PBDE	A 32534-81-9	0.0085	0.30
HBCDD	134237-51-7	167	0.02
PFOA	3825-261	91.3	1.41
PFOS	1763-21-1	9.1	1.27
p-nonylphenol	A 84852-15-3	3000	1.80
4-tert- octylphenol	140-66-9	0.004	0.00
Hg (muscle)	A 7439-97-6	20	168
Triclosan	3380-34-5	15217	0.10
Dicofol	115-32-2	33	0.96
Heptachlor	1024-57-3	0.0067	0.00

Table 26: Lake Langvatnet, water code: 13991162

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 314 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	158.40
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.27
Endosulfan	115-29-7	370	0.00
Hexachlorobutadien (HBCD)	87-68-3	55	0.03
HCB	A 118-74-1	10	0.30
Naphthalene	91-20-3	2400	0.95
Pentachlorophenol (PCP)	87-86-5	180	0.40
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.99
Trichlorobenzene (TCBs)	12002-48-1	490	0.01
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.24
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.01
PCB7	1336-36-3	0.6	12.26
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	1.11
PBDE	A 32534-81-9	0.0085	0.66
HBCDD	134237-51-7	167	0.05
PFOA	3825-261	91.3	3.58
PFOS	1763-21-1	9.1	1.59
p-nonylphenol	A 84852-15-3	3000	0.00
4-tert- octylphenol	140-66-9	0.004	0.00
Hg (muscle)	A 7439-97-6	20	240
Triclosan	3380-34-5	15217	0.18
Dicofol	115-32-2	33	1.74
Heptachlor	1024-57-3	0.0067	0.00

Table 27: Lake Lešjávri, water code: 234-37977

Chemical(s) Species: Char Tissue: Liver **Fish weight (mean): 495 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	231.33
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.03
Endosulfan	115-29-7	370	0.02
Hexachlorobutadien (HBCD)	87-68-3	55	0.04
HCB	A 118-74-1	10	0.35
Naphthalene	91-20-3	2400	0.63
Pentachlorophenol (PCP)	87-86-5	180	0.10
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.04
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.14
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.14
PCB7	1336-36-3	0.6	2.95
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.45
PBDE	A 32534-81-9	0.0085	0.13
HBCDD	134237-51-7	167	0.01
PFOA	3825-261	91.3	1.70
PFOS	1763-21-1	9.1	1.27
p-nonylphenol	A 84852-15-3	3000	8.33
4-tert- octylphenol	140-66-9	0.004	0.46
Hg (muscle)	A 7439-97-6	20	87
Triclosan	3380-34-5	15217	0.09
Dicofol	115-32-2	33	0.92
Heptachlor	1024-57-3	0.0067	0.04

Table 28: Lake Lyseren, water code: 002-37942

Chemical(s) Species: Trout/Perch Tissue: Liver **Fish weight (mean): 513 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	244.10
Decmethylcyclosiloxane (D5)	541-02-6	15217	3.07
Endosulfan	115-29-7	370	0.02
Hexachlorobutadien (HBCD)	87-68-3	55	0.04
HCB	A 118-74-1	10	0.13
Naphthalene	91-20-3	2400	0.96
Pentachlorophenol (PCP)	87-86-5	180	0.23
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.08
Trichlorobenzene (TCBs)	12002-48-1	490	0.03
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.75
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.07
PCB7	1336-36-3	0.6	3.67
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.51
PBDE	A 32534-81-9	0.0085	0.88
HBCDD	134237-51-7	167	0.17
PFOA	3825-261	91.3	4.91
PFOS	1763-21-1	9.1	9.54
p-nonylphenol	A 84852-15-3	3000	0.00
4-tert- octylphenol	140-66-9	0.004	0.19
Hg (muscle)	A 7439-97-6	20	396
Triclosan	3380-34-5	15217	0.15
Dicofol	115-32-2	33	1.45
Heptachlor	1024-57-3	0.0067	0.00

Table 29: Lake Møsvatn, water code: 016-38185

Chemical(s)	CAS-nr.[1]	EQS	Mean measured concentration
Speciest: Char Tissue: Liver		(µg/kg ww)	
Fish weight (mean): 212 g			
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	139.53
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.28
Endosulfan	115-29-7	370	0.07
Hexachlorobutadien (HBCD)	87-68-3	55	0.05
HCB	A 118-74-1	10	0.68
Naphthalene	91-20-3	2400	0.91
Pentachlorophenol (PCP)	87-86-5	180	0.32
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.18
Trichlorobenzene (TCBs)	12002-48-1	490	0.01
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.11
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.08
PCB7	1336-36-3	0.6	2.54
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.41
PBDE	A 32534-81-9	0.0085	0.66
HBCDD	134237-51-7	167	0.08
PFOA	3825-261	91.3	1.41
PFOS	1763-21-1	9.1	0.22
p-nonylphenol	A 84852-15-3	3000	3.27
4-tert- octylphenol	140-66-9	0.004	0.69
Hg (muscle)	A 7439-97-6	20	143
Triclosan	3380-34-5	15217	0.09
Dicofol	115-32-2	33	0.89
Heptachlor	1024-57-3	0.0067	0.10

Table 30: Lake Steinvatnet, water code: 177-84819

Chemical(s)	CAS-nr.[1]	EQS	Mean measured concentration
Species: Trout/Char Tissue: Liver		(µg/kg ww)	
Fish weight (mean): 659 g			
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	85.37
Decmethylcyclosiloxane (D5)	541-02-6	15217	3.87
Endosulfan	115-29-7	370	0.01
Hexachlorobutadien (HBCD)	87-68-3	55	0.08
HCB	A 118-74-1	10	0.38
Naphthalene	91-20-3	2400	1.01
Pentachlorophenol (PCP)	87-86-5	180	0.54
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.10
Trichlorobenzene (TCBs)	12002-48-1	490	0.03
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.86
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.04
PCB7	1336-36-3	0.6	2.01
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.30
PBDE	A 32534-81-9	0.0085	0.20
HBCDD	134237-51-7	167	0.07
PFOA	3825-261	91.3	0.74
PFOS	1763-21-1	9.1	1.15
p-nonylphenol	A 84852-15-3	3000	5.90
4-tert- octylphenol	140-66-9	0.004	0.31
Hg (muscle)	A 7439-97-6	20	155
Triclosan	3380-34-5	15217	0.12
Dicofol	115-32-2	33	1.17
Heptachlor	1024-57-3	0.0067	0.06

Table 31: Lake Storbørja, water code: 313-80085

Chemical(s) Species: Perch Tissue: Liver **Fish weight (mean): 658 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	119.83
Decmethylcyclosiloxane (D5)	541-02-6	15217	1.81
Endosulfan	115-29-7	370	0.04
Hexachlorobutadien (HBCD)	87-68-3	55	0.05
HCB	A 118-74-1	10	0.18
Naphthalene	91-20-3	2400	0.91
Pentachlorophenol (PCP)	87-86-5	180	0.85
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.29
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.47
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.06
PCB7	1336-36-3	0.6	3.26
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.75
PBDE	A 32534-81-9	0.0085	0.85
HBCDD	134237-51-7	167	0.26
PFOA	3825-261	91.3	2.13
PFOS	1763-21-1	9.1	7.61
p-nonylphenol	A 84852-15-3	3000	4.97
4-tert- octylphenol	140-66-9	0.004	0.15
Hg (muscle)	A 7439-97-6	20	2867
Triclosan	3380-34-5	15217	0.17
Dicofol	115-32-2	33	1.73
Heptachlor	1024-57-3	0.0067	0.00

Table 32: Lake Stuorajávri, water code: 212-80664

Chemical(s) Species: Perch Tissue: Liver **Fish weight (mean): 316 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	82.60
Decmethylcyclosiloxane (D5)	541-02-6	15217	1.96
Endosulfan	115-29-7	370	0.00
Hexachlorobutadien (HBCD)	87-68-3	55	0.06
HCB	A 118-74-1	10	0.38
Naphthalene	91-20-3	2400	0.90
Pentachlorophenol (PCP)	87-86-5	180	0.64
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	1.37
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.15
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.75
PCB7	1336-36-3	0.6	0.14
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.07
PBDE	A 32534-81-9	0.0085	0.14
HBCDD	134237-51-7	167	0.00
PFOA	3825-261	91.3	0.85
PFOS	1763-21-1	9.1	0.45
p-nonylphenol	A 84852-15-3	3000	16.35
4-tert- octylphenol	140-66-9	0.004	0.14
Hg (muscle)	A 7439-97-6	20	85
Triclosan	3380-34-5	15217	0.11
Dicofol	115-32-2	33	1.06
Heptachlor	1024-57-3	0.0067	0.00

Table 33: Lake Tangenfossen, water code: 246-91160

Chemical(s) Species: Whitefish Tissue: Liver **Fish weight (mean): 620 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	148.40
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.06
Endosulfan	115-29-7	370	0.00
Hexachlorobutadien (HBCD)	87-68-3	55	0.02
HCB	A 118-74-1	10	0.27
Naphthalene	91-20-3	2400	0.76
Pentachlorophenol (PCP)	87-86-5	180	0.44
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.33
Trichlorobenzene (TCBs)	12002-48-1	490	0.03
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.11
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.14
PCB7	1336-36-3	0.6	3.64
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.17
PBDE	A 32534-81-9	0.0085	0.05
HBCDD	134237-51-7	167	0.02
PFOA	3825-261	91.3	1.08
PFOS	1763-21-1	9.1	1.37
p-nonylphenol	A 84852-15-3	3000	9.31
4-tert- octylphenol	140-66-9	0.004	0.65
Hg (muscle)	A 7439-97-6	20	92
Triclosan	3380-34-5	15217	0.07
Dicofol	115-32-2	33	0.67
Heptachlor	1024-57-3	0.0067	0.87

Table 34: Lake Vaggatem, water code:246-59167

Chemical(s) Species: Whitefish Tissue: Liver **Fish weight (mean): 657 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.00
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	0.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	0.00
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	162.80
Decmethylcyclosiloxane (D5)	541-02-6	15217	1.78
Endosulfan	115-29-7	370	0.00
Hexachlorobutadien (HBCD)	87-68-3	55	0.03
HCB	A 118-74-1	10	0.21
Naphthalene	91-20-3	2400	0.82
Pentachlorophenol (PCP)	87-86-5	180	0.41
Benzo[a]pyrene	50-32-8	5	0.00
Tributyltin (TBT)	36643-28-4	150	0.19
Trichlorobenzene (TCBs)	12002-48-1	490	0.01
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.28
Diflubenzuron	35367-38-5	730	0.00
Teflubenzuron	83121-18.0	609	0.00
Triphenyltin	892-20-6	152	0.06
PCB7	1336-36-3	0.6	0.23
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.17
PBDE	A 32534-81-9	0.0085	0.02
HBCDD	134237-51-7	167	0.00
PFOA	3825-261	91.3	2.41
PFOS	1763-21-1	9.1	0.49
p-nonylphenol	A 84852-15-3	3000	4.33
4-tert- octylphenol	140-66-9	0.004	0.17
Hg (muscle)	A 7439-97-6	20	51
Triclosan	3380-34-5	15217	0.09
Dicofol	115-32-2	33	0.89
Heptachlor	1024-57-3	0.0067	0.38

5. Discussion

The levels of environmental pollutants measured in the 14 Norwegian lakes, were compared with environmental quality standards (EQS) set by EU (table 21-34). The wet weight concentrations of PBDEs exceeded the EQS in fish from all the lakes and the wet weight concentrations of PCBs exceeded the EQS in fish from 11 out of 14 lakes. Fish in Lake Altevann Bardu. Lake Stuorajávri and Lake Vaggatem had PCBs levels below the EQS for PCB7. In a German study published in 2018. PBDE also exceeded the EQS in all fish (Fliedner et al., 2018). The German fish contained levels, which were about four times higher than in Norwegian fish. In the same study, they analyzed fish from River Danube in the vicinity of industrial activity, which may explain the higher levels than in this Norwegian survey. Studies from Germany (Fliedner et al. 2016), Italy (Squadrone et al., 2013) and Spain (Bordajandi et al., 2003; Vives et al., 2005) show that the levels of PCB also exceed EU's EQS in these countries. The German study, published in 2018, and therefore most comparable with the present study, measured levels, which exceeded environmental quality standard for PCB7 in all fish.

EU has established EQS for the organochlorine pesticides, endosulfan, HCB and heptachlor. The EU EQSs for heptachlor (0.0067 µg/kg ww) were exceeded in fish liver from 7 lakes. Furthermore, the limit of detection for heptachlor was higher than the EQS indicating that the levels in the other lakes could be higher than the EQS. Relative high levels of Heptachlor was detected in Lake Tangenfossen (37 µg/kg and Lake Vaggatam (11 µg/kg). These two lakes are located in Finnmark nearby the Russian not far from Nickel. Available data on levels of Heptachlor in Norwegian biota is scarce. However one study measured heptachlor levels in perch, roach and pike livers from Lake Årungen (Sharma et al., 2010) and the wet weight levels in perch and roach livers were under the detection limit, whereas the levels in pike (0.60 ng/g; mean weight 1.6 kg) were comparable to the levels in whitefish liver from Lake Tangenfossen (0.87 mg; weight 0.6 kg) and Lake Veggatam (0.38 ng/g; weight 0.7 kg)

The EQS for mercury were exceeded in all lakes. The same trend was found in a study analyzing mercury levels in fish from all over Europe every year from 2007 to 2013 (Nguetseng et al., 2015). With the exception of in one lake, the Hg levels exceeded the EQS in all lakes and the highest level measured was 251 µg/kg (wet weight), which is over 12 times the EQS (Nguetseng et al., 2015). However, four of the Norwegian lakes had higher values in muscle than the highest level measured in the European survey and the highest level measured was 2867 µg/kg ww (Lake Storbørja). Other lakes with relatively high Hg levels include Lake Lyseren (396 µg/kg ww), Lake Kangsvatnet (300 µg/kg ww) and Lake Bergesvatnet (293 µg/kg ww). The mean concentration of Hg (mean 379 µg/kg ww) measured in the muscle in this survey was higher than the highest concentration measured in the European study from 2015 (Nguetseng et al., 2015). The European study measured Hg in a different fish species (bream; *Abramis brama*) than in the present study (perch, trout, char, whitefish), which may explain the higher Hg in the Norwegian lakes. A Swedish study summarized the mercury levels in perch from fresh water lakes from throughout Scandinavia (Norway, Sweden and Finland), with the aim to compile and evaluate available data for geographical and temporal trends. The study concluded that the levels of Hg are high in Scandinavia and that the Hg levels appear to have increased the last years (Danielsson et al., 2011). The mean concertation of Hg (328 µg/kg ww) in Norwegian lakes measured last year (samples from 2017) was comparable with the concentration measured this year (samples from 2018), whereas the highest concentration measured in 2017 (1070 µg/kg ww; Miljødirektoratet rapport, 2018) was lower than in 2018 (2867 µg/kg ww; Lake Storbørja).

EU has not established an EQS for Cd in biota. However, high levels of Cd were detected in fish from Lake Lyseren (3500 µg/kg ww) followed by Lake Krøderen (927 µg/kg ww), Lake Møsvatn (780 µg/kg ww) and Lake Storbørja (508 µg/kg ww). The high Cd levels, which are 5 – 35 times higher than the mean of the other lakes, may indicate local sources of Cd in these lakes. Lake Lyseren, which had high levels of Hg and the highest levels of Cd and Pb, had also the highest levels of Al (Miljødirektoratet. 2015). High concentration of Al may represent a health risk for the fish in lakes with low pH (Wauer and Teien. 2010). The mean concertation of Cd measured (537 µg/kg ww) in Norwegian lakes last year (samples from 2017) was comparable with the concentration measured (541 µg/kg ww) this year (samples from 2018), whereas the highest concentration measure in 2017 (3066 µg/kg ww; Lake Lundevannet); Miljødirektoratet rapport, 2018) was lower than in 2018 (3500 µg/kg ww; Lake Lyseren).

The mean concentrations of Cd in fish liver from Italian rivers (Squadrone et al., 2013), and from highland lakes in the Czech Republic (Vičarová et al., 2016) were 40 µg/kg ww and 258 µg/kg ww, respectively, which are lower than in the present survey (541 µg/kg ww). The European Union have recommended Minimum Residual Limit Levels (MRLs) for heavy metal residues in fish meat for human consumption. For cadmium, lead, and mercury the MRLs are 0.05, 0.30, and 0.50 mg/kg fish and fish products, respectively. These MRLs are included in the European Commission Regulation (EC) No. 629/2008. Even though the Cd levels in the liver of Norwegian freshwater fish exceeded the MRL (50 µg/kg ww) for human consume, it may not pose any health risk for consumers because fish liver from freshwater fish is not commonly consumed. However, the concentration of Hg in fish muscle from Lake Storbørja (2867 µg/kg ww) exceeded the MRL (500 µg/kg ww), suggesting that eating fish from this lake may pose a health risk for the consumers.

The EQS for 4-tert-octylphenol was exceeded in fish livers from all the lakes except three, which had levels under the detection limit. The levels of p-nonylphenol were below the EQS in all lakes. The scientific data on levels of octylphenol in fish are scarce. However, an Environmental Risk Evaluation on 4-tert-Octylphenol reported levels between 0.2 µg/kg and 5.5 µg/kg ww in German freshwater fish collected between 1992 and 1997, which are comparable (0.2 – 0.7 µg/kg) with the levels in the Norwegian lakes (UKEA. 2006).

For the perfluorinated compounds (PFAS), EU has established EQS for PFOS but not for PFOA. However, Norway have established an EQS for PFOA. In this survey, it was found that fish from Lake Bergesvatnet and Lake Lyseren had PFOS levels which exceeded the EQS. However, fish from none of the lakes had PFOA levels which exceeded the EQS. The highest PFOS level (13 µg/kg ww) in the Norwegian lakes was lower than the levels measured in two fish species in Germany (123 µg/kg ww and 295 µg/kg ww (Becker et a. 2010)). The higher German levels may be explained by the fact that they analyzed fish from a highly industrialized area, while no of the Norwegian study lakes are situated nearby heavy industry. Since PFOS was banned in 2009 (listed on Stockholm Convention), a temporal decrease in PFOS may in part explain the higher levels in the German fish sampled before 2010 compared to the Norwegian sampled in 2018 (Fliedner et al., 2016).

The EQS value for dioxin did not exceed the dioxin EQS for biota in any of the lakes. In a German survey, EQS for dioxin was exceeded in fish from about 40% of the sampling locations, suggesting that the dioxin contamination is lower in Norwegian freshwaters compared to German waters (Fliedner et al., 2016).

The fact that the levels of PBDE, mercury and octylphenol exceed EU EQS in all 14 lakes and PCBs in 11 of 14 lakes suggests that background levels of these substances in Norwegian lakes do not meet the environmental requirements in Europe. However, these results are comparable with results from different European countries, which may indicate an environmental problem across Europe. In order to protect the entire ecosystem (ensuring protection for the most sensitive species), the EU's EQSs are set lower than the European limit values (Minimum Residual Limit Levels (MRLs)) for foodstuffs and animal feed. Even though the Cd levels in the liver of Norwegian freshwater fish exceeded the MRL (50 µg/kg ww) for human consume, it may not pose any health risk for consumers because fish liver from freshwater fish is not commonly consumed. However, the concentration of Hg in fish muscle from Lake Storbørja (2867 µg/kg ww) exceeded the MRL (500 µg/kg ww), suggesting that eating fish from this lake may pose a health risk for the consumers.

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7. Fish data and analytical results

Table 35. Species distribution, lakes and size for the samples.

Project no	Species	Lake	Sampled date	Tissue	L, mean (cm)	W, mean (g)	Lipid %
1	Trout	Lyseren	07.09.2018	Liver	32	370	2,34
2	Perch	Lyseren	07.09.2018	Liver	36,5	650	2,31
3	Perch	Lyseren	07.09.2018	Liver	34,2	518	2,22
4	Perch	Lyseren	04.09.2018	Liver	39,5	1147	3,72
5	Perch	Storbørja	04.09.2018	Liver	33,4	592	3,17
6	Perch	Storbørja	04.09.2018	Liver	25,7	235	3,63
7	Trout	Bergesvatnet	22.08.2018	Liver	31,5	305	3,30
8	Trout	Bergesvatnet	22.08.2018	Liver	28,6	256	2,52
9	Trout	Bergesvatnet	22.08.2018	Liver	26,2	208	3,27
10	Trout	Kangsvatnet	03.10.2018	Liver	38,3	620	2,93
11	Trout	Kangsvatnet	03.10.2018	Liver	30,5	325	3,40
12	Trout	Kangsvatnet	03.10.2018	Liver	27,9	234	3,55
13	Trout	Langvatnet	17.10.2018	Liver	30,5	314	3,50
14	Trout	Steinvatnet	08.09.2019	Liver	43,0	1143	2,88
15	Trout	Steinvatnet	08.09.2019	Liver	35,0	455	2,68
16	Arctic char	Steinvatnet	08.09.2019	Liver	31,7	380	3,18
17	Trout	Geitvatnet	06.09.2019	Liver	32,0	389	3,16
18	Trout	Geitvatnet	06.09.2019	Liver	26,6	222	3,58
19	Arctic char	Geitvatnet	06.09.2019	Liver	29,6	308	11,11
20	Arctic char	Iešjávri	20.08.2019	Liver	37,0	619	1,92
21	Arctic char	Iešjávri	20.08.2019	Liver	36,0	466	2,80
22	Arctic char	Iešjávri	20.08.2019	Liver	34,4	399	4,55
23	Perch	Stuorajávri	22.08.2019	Liver	30,5	397	6,05
24	Perch	Stuorajávri	22.08.2019	Liver	25,5	235	5,55
25	Arctic char	Altevann Bardu	28.08.2019	Liver	32,8	467	3,26
26	Arctic char	Altevann Bardu	28.08.2019	Liver	32,8	382	3,75
27	Arctic char	Altevann Bardu	28.08.2019	Liver	29,0	253	2,54
28	Arctic char	Møsvatn	05.10.2019	Liver	27,2	212	7,02
29	Arctic char	Møsvatn	05.10.2019	Liver	26,8	203	4,37
30	Arctic char	Møsvatn	05.10.2019	Liver	27,7	222	4,32
31	Whitefish	Vaggatem	24.10.2018	Liver	44,5	933	3,11
32	Whitefish	Vaggatem	24.10.2018	Liver	38,8	608	3,39
33	Whitefish	Vaggatem	24.10.2018	Liver	35,5	430	3,74
34	Whitefish	Tangenfossen	09.10.2018	Liver	42,3	858	3,51
35	Whitefish	Tangenfossen	09.10.2018	Liver	40,5	581	4,57
36	Whitefish	Tangenfossen	09.10.2018	Liver	35,7	420	5,35
37	Perch	Krøderen	17-19.09 2018	Liver	40,7	1068	4,06
38	Perch	Krøderen	17-19.09 2018	Liver	26,1	280	6,16
39	Perch	Krøderen	17-19.09 2018	Liver	24,0	208	6,97

Table 36. Individual length and weight for the specimens included in each sample (project number 1-39). For each lake, all individual fish with the same project number are pooled

Project number	Species	Lake	Day of capture	Tissue	Length cm	Weight g
1	trout	Lyseren	07 Sep	Liver	28	227
1	trout	Lyseren	07 Sep	Liver	31	320
1	trout	Lyseren	07 Sep	Liver	29,5	250
1	trout	Lyseren	07 Sep	Liver	32	361
1	trout	Lyseren	07 Sep	Liver	36	524
1	trout	Lyseren	07 Sep	Liver	36	489
1	trout	Lyseren	07 Sep	Liver	30	302
1	trout	Lyseren	07 Sep	Liver	36	489
2	perch	Lyseren	07 Sep	Liver	38	798
2	perch	Lyseren	07 Sep	Liver	38	767
2	perch	Lyseren	07 Sep	Liver	34	471
2	perch	Lyseren	07 Sep	Liver	36	562
3	perch	Lyseren	07 Sep	Liver	34	520
3	perch	Lyseren	07 Sep	Liver	29	359
3	perch	Lyseren	07 Sep	Liver	37	659
3	perch	Lyseren	07 Sep	Liver	36	533
3	perch	Lyseren	07 Sep	Liver	35	520
4	perch	Storbørja	04 Sep	Liver	40	1282
4	perch	Storbørja	04 Sep	Liver	39	1011
5	perch	Storbørja	04 Sep	Liver	37	796
5	perch	Storbørja	04 Sep	Liver	35	712
5	perch	Storbørja	04 Sep	Liver	36	738
5	perch	Storbørja	04 Sep	Liver	30	406
5	perch	Storbørja	04 Sep	Liver	29	308
6	perch	Storbørja	04 Sep	Liver	28	291
6	perch	Storbørja	04 Sep	Liver	27	251
6	perch	Storbørja	04 Sep	Liver	26	279
6	perch	Storbørja	04 Sep	Liver	27	239
6	perch	Storbørja	04 Sep	Liver	26	237
6	perch	Storbørja	04 Sep	Liver	24	197
6	perch	Storbørja	04 Sep	Liver	22	153
7	trout	Bergesvatnet	22 Aug	Liver	37	321
7	trout	Bergesvatnet	22 Aug	Liver	30	298
7	trout	Bergesvatnet	22 Aug	Liver	30,5	320
7	trout	Bergesvatnet	22 Aug	Liver	30,5	300
7	trout	Bergesvatnet	22 Aug	Liver	31	354
7	trout	Bergesvatnet	22 Aug	Liver	30	288
7	trout	Bergesvatnet	22 Aug	Liver	31,5	252
8	trout	Bergesvatnet	22 Aug	Liver	28,5	262
8	trout	Bergesvatnet	22 Aug	Liver	31	292
8	trout	Bergesvatnet	22 Aug	Liver	30	277
8	trout	Bergesvatnet	22 Aug	Liver	28	253
8	trout	Bergesvatnet	22 Aug	Liver	28,5	254
8	trout	Bergesvatnet	22 Aug	Liver	27,5	225
8	trout	Bergesvatnet	22 Aug	Liver	29	266
8	trout	Bergesvatnet	22 Aug	Liver	26,5	218
9	trout	Bergesvatnet	22 Aug	Liver	25	193
9	trout	Bergesvatnet	22 Aug	Liver	24	172
9	trout	Bergesvatnet	22 Aug	Liver	26	212
9	trout	Bergesvatnet	22 Aug	Liver	27	233
9	trout	Bergesvatnet	22 Aug	Liver	26	209
9	trout	Bergesvatnet	22 Aug	Liver	27	235
9	trout	Bergesvatnet	22 Aug	Liver	28,5	236
9	trout	Bergesvatnet	22 Aug	Liver	26	193
9	trout	Bergesvatnet	22 Aug	Liver	27	220
9	trout	Bergesvatnet	22 Aug	Liver	26	209

9	trout	Bergesvatnet	22 Aug	Liver	26,5	209
9	trout	Bergesvatnet	22 Aug	Liver	25	175
10	trout	Kangsvatnet	03 Oct	Liver	39	565
10	trout	Kangsvatnet	03 Oct	Liver	38	622
10	trout	Kangsvatnet	03 Oct	Liver	38	617
10	trout	Kangsvatnet	03 Oct	Liver	38	674
11	trout	Kangsvatnet	03 Oct	Liver	31	373
11	trout	Kangsvatnet	03 Oct	Liver	33	360
11	trout	Kangsvatnet	03 Oct	Liver	30	267
11	trout	Kangsvatnet	03 Oct	Liver	30	314
11	trout	Kangsvatnet	03 Oct	Liver	30	336
11	trout	Kangsvatnet	03 Oct	Liver	29	298
12	trout	Kangsvatnet	03 Oct	Liver	27,5	215
12	trout	Kangsvatnet	03 Oct	Liver	28	231
12	trout	Kangsvatnet	03 Oct	Liver	28	230
12	trout	Kangsvatnet	03 Oct	Liver	28,5	248
12	trout	Kangsvatnet	03 Oct	Liver	28,5	250
12	trout	Kangsvatnet	03 Oct	Liver	29	278
12	trout	Kangsvatnet	03 Oct	Liver	28	210
12	trout	Kangsvatnet	03 Oct	Liver	26	202
12	trout	Kangsvatnet	03 Oct	Liver	28	242
13	trout	Langvatnet	17 Oct	Liver	36	510
13	trout	Langvatnet	17 Oct	Liver	28	218
13	trout	Langvatnet	17 Oct	Liver	27,5	215
14	trout	Steinvatnet	08 Sep	Liver	43	1143
15	trout	Steinvatnet	08 Sep	Liver	38	541
15	trout	Steinvatnet	08 Sep	Liver	32	369
16	Røye	Steinvatnet	08 Sep	Liver	36	550
16	Røye	Steinvatnet	08 Sep	Liver	34	460
16	Røye	Steinvatnet	08 Sep	Liver	30	280
16	Røye	Steinvatnet	08 Sep	Liver	37	573
16	Røye	Steinvatnet	08 Sep	Liver	26	180
16	Røye	Steinvatnet	08 Sep	Liver	27	237
17	trout	Geitvatnet	06 Sep	Liver	36	536
17	trout	Geitvatnet	06 Sep	Liver	30	315
17	trout	Geitvatnet	06 Sep	Liver	30	316
18	trout	Geitvatnet	06 Sep	Liver	28	274
18	trout	Geitvatnet	06 Sep	Liver	28	273
18	trout	Geitvatnet	06 Sep	Liver	27	231
18	trout	Geitvatnet	06 Sep	Liver	26	216
18	trout	Geitvatnet	06 Sep	Liver	26	210
18	trout	Geitvatnet	06 Sep	Liver	27	215
18	trout	Geitvatnet	06 Sep	Liver	26	210
18	trout	Geitvatnet	06 Sep	Liver	26	205
18	trout	Geitvatnet	06 Sep	Liver	26	196
18	trout	Geitvatnet	06 Sep	Liver	26	194
19	arctic char	Geitvatnet	06 Sep	Liver	28	244
19	arctic char	Geitvatnet	06 Sep	Liver	29	287
19	arctic char	Geitvatnet	06 Sep	Liver	30	311
19	arctic char	Geitvatnet	06 Sep	Liver	30	333
19	arctic char	Geitvatnet	06 Sep	Liver	31	363
20	arctic char	Iešjávri	20 Aug	Liver	37	704
20	arctic char	Iešjávri	20 Aug	Liver	37	610
20	arctic char	Iešjávri	20 Aug	Liver	37	542
21	arctic char	Iešjávri	20 Aug	Liver	38	534
21	arctic char	Iešjávri	20 Aug	Liver	34	468
21	arctic char	Iešjávri	20 Aug	Liver	38	466
21	arctic char	Iešjávri	20 Aug	Liver	36	433
21	arctic char	Iešjávri	20 Aug	Liver	34	430
22	arctic char	Iešjávri	20 Aug	Liver	35	457
22	arctic char	Iešjávri	20 Aug	Liver	35	438
22	arctic char	Iešjávri	20 Aug	Liver	34	408
22	arctic char	Iešjávri	20 Aug	Liver	34	404

22	arctic char	Iešjávri	20 Aug	Liver	33	383
22	arctic char	Iešjávri	20 Aug	Liver	37	368
22	arctic char	Iešjávri	20 Aug	Liver	33	332
23	perch	Stuorajávri	20 Aug	Liver	33	442
23	perch	Stuorajávri	20 Aug	Liver	32	429
23	perch	Stuorajávri	20 Aug	Liver	29	402
23	perch	Stuorajávri	20 Aug	Liver	28	316
24	perch	Stuorajávri	20 Aug	Liver	28	291
24	perch	Stuorajávri	20 Aug	Liver	28	272
24	perch	Stuorajávri	20 Aug	Liver	27	305
24	perch	Stuorajávri	20 Aug	Liver	26,5	257
24	perch	Stuorajávri	20 Aug	Liver	25	233
24	perch	Stuorajávri	20 Aug	Liver	24	197
24	perch	Stuorajávri	20 Aug	Liver	24	199
24	perch	Stuorajávri	20 Aug	Liver	24	190
24	perch	Stuorajávri	20 Aug	Liver	23	167
25	arctic char	Altevann Bardu	28 Aug	Liver	34	539
25	arctic char	Altevann Bardu	28 Aug	Liver	32	436
25	arctic char	Altevann Bardu	28 Aug	Liver	32	446
25	arctic char	Altevann Bardu	28 Aug	Liver	33	445
26	arctic char	Altevann Bardu	28 Aug	Liver	35	428
26	arctic char	Altevann Bardu	28 Aug	Liver	33	390
26	arctic char	Altevann Bardu	28 Aug	Liver	33	367
26	arctic char	Altevann Bardu	28 Aug	Liver	32	365
26	arctic char	Altevann Bardu	28 Aug	Liver	31	362
27	arctic char	Altevann Bardu	28 Aug	Liver	31	330
27	arctic char	Altevann Bardu	28 Aug	Liver	30	291
27	arctic char	Altevann Bardu	28 Aug	Liver	29	254
27	arctic char	Altevann Bardu	28 Aug	Liver	29	250
27	arctic char	Altevann Bardu	28 Aug	Liver	29	250
27	arctic char	Altevann Bardu	28 Aug	Liver	28	205
27	arctic char	Altevann Bardu	28 Aug	Liver	27	192
28	arctic char	Møsvatn	05 Oct	Liver	26	181
28	arctic char	Møsvatn	05 Oct	Liver	28	226
28	arctic char	Møsvatn	05 Oct	Liver	27	211
28	arctic char	Møsvatn	05 Oct	Liver	27	204
28	arctic char	Møsvatn	05 Oct	Liver	27	210
28	arctic char	Møsvatn	05 Oct	Liver	28	239
28	arctic char	Møsvatn	05 Oct	Liver	29	246
28	arctic char	Møsvatn	05 Oct	Liver	27	214
28	arctic char	Møsvatn	05 Oct	Liver	26	180
29	arctic char	Møsvatn	05 Oct	Liver	28	210
29	arctic char	Møsvatn	05 Oct	Liver	28	224
29	arctic char	Møsvatn	05 Oct	Liver	26	207
29	arctic char	Møsvatn	05 Oct	Liver	27	205
29	arctic char	Møsvatn	05 Oct	Liver	27	173
29	arctic char	Møsvatn	05 Oct	Liver	26,5	193
29	arctic char	Møsvatn	05 Oct	Liver	26	216
29	arctic char	Møsvatn	05 Oct	Liver	26	192
30	arctic char	Møsvatn	05 Oct	Liver	31	342
30	arctic char	Møsvatn	05 Oct	Liver	31	246
30	arctic char	Møsvatn	05 Oct	Liver	27	200
30	arctic char	Møsvatn	05 Oct	Liver	28	209
30	arctic char	Møsvatn	05 Oct	Liver	26	181
30	arctic char	Møsvatn	05 Oct	Liver	25,5	196
30	arctic char	Møsvatn	05 Oct	Liver	27	212
30	arctic char	Møsvatn	05 Oct	Liver	26	192
31	whitefish	Vaggatem	24 Oct	Liver	46	988
31	whitefish	Vaggatem	24 Oct	Liver	43	878
32	whitefish	Vaggatem	24 Oct	Liver	40	678
32	whitefish	Vaggatem	24 Oct	Liver	38	612
32	whitefish	Vaggatem	24 Oct	Liver	38	571
32	whitefish	Vaggatem	24 Oct	Liver	39	572

33	whitefish	Vaggatem	24 Oct	Liver	36	481
33	whitefish	Vaggatem	24 Oct	Liver	36	453
33	whitefish	Vaggatem	24 Oct	Liver	37	494
33	whitefish	Vaggatem	24 Oct	Liver	35	427
33	whitefish	Vaggatem	24 Oct	Liver	35	369
33	whitefish	Vaggatem	24 Oct	Liver	34	355
34	whitefish	Tangenfossen	09 Oct	Liver	43	903
34	whitefish	Tangenfossen	09 Oct	Liver	42	880
34	whitefish	Tangenfossen	09 Oct	Liver	42	847
34	whitefish	Tangenfossen	09 Oct	Liver	42	800
35	whitefish	Tangenfossen	09 Oct	Liver	41	629
35	whitefish	Tangenfossen	09 Oct	Liver	41	612
35	whitefish	Tangenfossen	09 Oct	Liver	40	554
35	whitefish	Tangenfossen	09 Oct	Liver	40	528
36	whitefish	Tangenfossen	09 Oct	Liver	39	492
36	whitefish	Tangenfossen	09 Oct	Liver	37	476
36	whitefish	Tangenfossen	09 Oct	Liver	36	430
36	whitefish	Tangenfossen	09 Oct	Liver	35	430
36	whitefish	Tangenfossen	09 Oct	Liver	34	433
36	whitefish	Tangenfossen	09 Oct	Liver	33	260
37	perch	Krøderen	17-19 Sep	Liver	43	1385
37	perch	Krøderen	17-19 Sep	Liver	40	936
37	perch	Krøderen	17-19 Sep	Liver	39	884
38	perch	Krøderen	17-19 Sep	Liver	25,5	236
38	perch	Krøderen	17-19 Sep	Liver	26	237
38	perch	Krøderen	17-19 Sep	Liver	27	307
38	perch	Krøderen	17-19 Sep	Liver	26	268
38	perch	Krøderen	17-19 Sep	Liver	29	402
38	perch	Krøderen	17-19 Sep	Liver	24	258
38	perch	Krøderen	17-19 Sep	Liver	25	255
39	perch	Krøderen	17-19 Sep	Liver	25	237
39	perch	Krøderen	17-19 Sep	Liver	25	206
39	perch	Krøderen	17-19 Sep	Liver	25	219
39	perch	Krøderen	17-19 Sep	Liver	24	197
39	perch	Krøderen	17-19 Sep	Liver	25	220
39	perch	Krøderen	17-19 Sep	Liver	24	198
39	perch	Krøderen	17-19 Sep	Liver	23	215
39	perch	Krøderen	17-19 Sep	Liver	23	200
39	perch	Krøderen	17-19 Sep	Liver	22	180

Table 36. Analytical results. Levels are given in ng/g wet weight unless otherwise indicated in the table

Nr	Lokalitet	Art	Fett %	HCB	PeCB	α-HCH	β-HCH	γ-HCH	∑ PCB	∑ DDT
1	Lyseren	Ørret	2,34	0,126	0,005	0,009	n.d.	0,015	3,18	2,35
2	Lyseren	Abbor	2,31	0,139	0,007	0,011	n.d.	0,017	5,26	2,39
3	Lyseren	Abbor	2,22	0,111	0,007	0,009	n.d.	0,013	2,56	1,00
4	Storbørja	Abbor	3,72	0,197	0,01	0,015	0,012	0,015	2,96	1,90
5	Storbørja	Abbor	3,17	0,165	0,009	0,011	n.d.	0,015	2,83	1,67
6	Storbørja	Abbor	3,63	0,164	0,009	0,011	0,017	0,018	4,00	2,16
7	Bergesvatnet	Ørret	3,3	0,16	0,018	0,011	n.d.	0,014	4,67	1,83
8	Bergesvatnet	Ørret	2,52	0,094	0,01	0,008	0,01	0,012	1,60	0,89
9	Bergesvatnet	Ørret	3,27	0,15	0,018	0,014	0,012	0,018	1,84	1,00
10	Kangsvatnet	Ørret	2,93	0,448	0,016	0,012	n.d.	0,008	1,93	0,46
11	Kangsvatnet	Ørret	3,4	0,307	0,014	0,016	n.d.	0,013	0,45	0,25
12	Kangsvatnet	Ørret	3,55	0,353	0,015	0,015	n.d.	0,021	0,49	0,27
13	Langevann	Ørret	3,5	0,302	0,015	0,018	n.d.	0,011	12,26	0,62
14	Steinvatn	Ørret	2,88	0,546	0,022	0,02	n.d.	0,012	2,55	0,00
15	Steinvatn	Ørret	2,68	0,32	0,015	0,015	n.d.	0,01	3,49	0,31
16	Steinvatn	Røye	3,18	0,27	0,016	0,01	n.d.	0,01	0,42	0,17
17	Geitvatnet	Ørret	3,16	0,348	0,02	0,012	n.d.	0,015	1,54	0,41
18	Geitvatnet	Ørret	3,58	0,295	0,013	0,011	n.d.	0,011	2,18	0,44
19	Geitvatnet	Røye	11,11	0,997	0,056	0,052	n.d.	0,032	0,88	0,34
20	Iešjávri	Røye	1,92	0,243	0,012	0,012	n.d.	0,01	1,06	0,25
21	Iešjávri	Røye	2,8	0,293	0,011	0,015	n.d.	0,013	4,73	0,87
22	Iešjávri	Røye	4,55	0,501	0,021	0,026	n.d.	0,017	3,68	0,74
23	Stuorajávri	Abbor	6,05	0,401	0,018	0,024	n.d.	0,012	0,00	0,20
24	Stuorajávri	Abbor	5,55	0,355	0,02	0,023	n.d.	0,023	0,28	0,49
25	ltevann Bardu	Røye	3,26	0,372	0,014	0,011	n.d.	0,016	0,15	0,19
26	ltevann Bardu	Røye	3,75	0,408	0,014	0,011	n.d.	0,009	0,00	0,20
27	ltevann Bardu	Røye	2,54	0,271	0,011	0,008	n.d.	0,021	0,31	0,23
28	Møsvatn	Røye	7,02	1,036	0,038	0,036	n.d.	0,043	3,39	3,38
29	Møsvatn	Røye	4,37	0,515	0,019	0,024	n.d.	0,028	1,30	1,11
30	Møsvatn	Røye	4,32	0,499	0,021	0,028	n.d.	0,028	2,95	1,83
31	Vaggatem	Sik	3,11	0,232	0,01	0,012	n.d.	0,015	0,26	0,21
32	Vaggatem	Sik	3,39	0,164	0,007	0,017	n.d.	0,017	0,00	0,23
33	Vaggatem	Sik	3,74	0,24	0,013	0,018	n.d.	0,02	0,43	5,82
34	Tangenfossen	Sik	3,51	0,265	0,015	0,015	n.d.	0,018	3,01	1,16
35	Tangenfossen	Sik	2,28	0,298	0,011	0,015	n.d.	0,02	6,37	1,12
36	Tangenfossen	Sik	2,68	0,234	0,01	0,015	n.d.	0,019	1,96	0,50
37	Krøderen	Abbor	2,03	0,132	0,007	0,006	n.d.	0,013	1,56	0,60
38	Krøderen	Abbor	3,08	0,229	0,01	0,008	n.d.	0,013	1,00	0,81
39	Krøderen	Abbor	3,48	0,232	0,013	0,009	n.d.	0,014	1,95	1,04

Nr	Lokalitet	Art	∑Heptaklor	∑ Endosulfan	∑ BDEs	Sum HBCDD	∑Fenoler	Diflubenzuron	Teflubenzuro	Oktylfenol	Nonylfen
1	Lyseren	Ørret	0,00	0,00	0,92	0,296	0,18	<3	<3	0,177	n.d.
2	Lyseren	Abbor	0,00	0,04	1,34	0,184	0,08	<3	<3	0,075	n.d.
3	Lyseren	Abbor	0,00	0,01	0,38	0,034	0,31	<3	<3	0,308	n.d.
4	Storbørja	Abbor	0,00	0,04	0,80	0,31	0,11	<3	<3	0,106	n.d.
5	Storbørja	Abbor	0,00	0,03	0,74	0,271	0,00	<3	<3	n.d.	n.d.
6	Storbørja	Abbor	0,00	0,06	1,00	0,191	15,2	<3	<3	0,338	14,9
7	Bergesvatnet	Ørret	0,00	0,00	1,31	0,08	0,00	<3	<3	n.d.	n.d.
8	Bergesvatnet	Ørret	0,00	0,00	0,61	0,052	0,00	<3	<3	n.d.	n.d.
9	Bergesvatnet	Ørret	0,00	0,00	0,85	0,097	0,00	<3	<3	n.d.	n.d.
10	Kangsvatnet	Ørret	0,28	0,00	0,37	0,065	0,00	<3	<3	n.d.	n.d.
11	Kangsvatnet	Ørret	0,00	0,00	0,11	n.d.	0,00	<3	<3	n.d.	n.d.
12	Kangsvatnet	Ørret	0,00	0,00	0,13	0,019	5,04	<3	<3	0,499	4,54
13	Langevann	Ørret	0,00	0,00	0,66	0,051	0,00	<3	<3	n.d.	n.d.
14	Steinvatn	Ørret	0,18	0,02	0,32	0,084	18,2	<3	<3	0,497	17,7
15	Steinvatn	Ørret	0,00	0,00	0,24	0,119	0,14	<3	<3	0,143	n.d.
16	Steinvatn	Røye	0,00	0,00	0,04	n.d.	0,28	<3	<3	0,278	n.d.
17	Geitvatnet	Ørret	0,00	0,00	0,10	0,04	33,2	<3	<3	1,3	31,9
18	Geitvatnet	Ørret	0,00	0,00	0,06	0,026	0,00	<3	<3	n.d.	n.d.
19	Geitvatnet	Røye	0,18	0,04	0,07	0,019	10,3	<3	<3	n.d.	10,3
20	Iešjávri	Røye	0,00	0,01	0,04	n.d.	7,94	<3	<3	0,763	7,18
21	Iešjávri	Røye	0,00	0,00	0,17	0,026	8,67	<3	<3	0,402	8,27
22	Iešjávri	Røye	0,13	0,03	0,17	n.d.	9,75	<3	<3	0,206	9,54
23	Stuorajávri	Abbor	0,00	0,00	0,05	n.d.	24,9	<3	<3	0,275	24,6
24	Stuorajávri	Abbor	0,00	0,00	0,23	n.d.	8,09	<3	<3	n.d.	8,09
25	Altevann Bardu	Røye	0,00	0,03	0,04	n.d.	11,7	<3	<3	0,998	10,7
26	Altevann Bardu	Røye	0,00	0,00	0,05	n.d.	7,56	<3	<3	0,137	7,42
27	Altevann Bardu	Røye	0,00	0,00	0,05	0,026	0,00	<3	<3	n.d.	n.d.
28	Møsvatn	Røye	0,14	0,10	0,79	0,094	0,58	<3	<3	0,576	n.d.
29	Møsvatn	Røye	0,00	0,04	0,31	0,048	0,85	<3	<3	0,846	n.d.
30	Møsvatn	Røye	0,15	0,06	0,87	0,096	10,5	<3	<3	0,651	9,82
31	Vaggatem	Sik	0,00	0,00	0,00	n.d.	0,00	<3	<3	n.d.	n.d.
32	Vaggatem	Sik	0,51	0,00	0,04	0,014	6,22	<3	<3	0,507	5,71
33	Vaggatem	Sik	0,63	0,00	0,03	n.d.	7,28	<3	<3	n.d.	7,28
34	Tangenfossen	Sik	0,00	0,00	0,06	n.d.	8,18	<3	<3	n.d.	8,18
35	Tangenfossen	Sik	2,05	0,00	0,05	0,019	8,32	<3	<3	0,781	7,54
36	Tangenfossen	Sik	0,57	0,00	0,03	0,052	13,4	<3	<3	1,17	12,2
37	Krøderen	Abbor	0,00	0,00	0,43	0,016	5,41	<3	<3	n.d.	5,41
38	Krøderen	Abbor	0,00	0,04	0,17	0,015	0,00	<3	<3	n.d.	n.d.
39	Krøderen	Abbor	0,00	0,05	0,31	0,036	0,00	<3	<3	n.d.	n.d.

Nr	Lokalitet	Art	PFHxA*	PFHpA*	PFOA*	PFNA*	PFDA*	PFUdA	PFDoDA*	PFTrDA*	PFTeDA*	PFBS*	PFHxS*	PFOS*
1	Lyseren	Ørret	0,259	n.d.	1,24	0,537	7,18	15,3	6,72	11,5	2,6	0,071	0,284	7,87
2	Lyseren	Abbor	n.d.	n.d.	1,69	0,38	7,19	16,1	7,57	12,2	2,63	0,197	0,611	13,2
3	Lyseren	Abbor	0,163	n.d.	11,8	1,21	2,65	5,41	2,32	3,58	0,625	0,982	2,52	7,54
4	Storbørja	Abbor	0,159	n.d.	0,877	0,275	3,28	6,9	3,56	6,79	2,94	0,054	0,3	6,45
5	Storbørja	Abbor	0,082	n.d.	2,09	n.d.	4	8,4	4,17	8,29	2	0,126	0,816	10,5
6	Storbørja	Abbor	n.d.	n.d.	3,41	n.d.	3,2	6,44	3,19	7,59	2,19	0,287	0,461	5,88
7	Bergesvatnet	Ørret	n.d.	n.d.	6,07	0,293	1,64	4,11	1,81	3,08	0,875	0,163	0,283	10,3
8	Bergesvatnet	Ørret	n.d.	n.d.	2,85	0,207	1,36	3,39	1,56	2,27	0,682	n.d.	0,205	10,6
9	Bergesvatnet	Ørret	n.d.	n.d.	2,43	0,402	1,81	4,3	1,93	3,23	0,674	n.d.	0,54	17,2
10	Kangsvatnet	Ørret	0,108	n.d.	0,502	0,272	0,576	1,83	0,704	1,23	0,33	n.d.	0,224	1,19
11	Kangsvatnet	Ørret	n.d.	n.d.	1,28	0,289	0,885	2,63	1,17	1,76	0,425	n.d.	0,346	1,61
12	Kangsvatnet	Ørret	n.d.	n.d.	1,89	n.d.	0,47	1,31	0,503	0,72	0,235	n.d.	0,851	0,869
13	Langevann	Ørret	n.d.	n.d.	3,58	n.d.	0,989	2,66	1,22	1,99	0,88	n.d.	0,266	1,59
14	Steinvatn	Ørret	n.d.	n.d.	n.d.	0,314	0,655	1,82	0,679	1,86	0,475	n.d.	0,126	0,631
15	Steinvatn	Ørret	n.d.	n.d.	0,927	0,872	1,06	2,77	1,15	2,09	0,612	n.d.	0,084	1,81
16	Steinvatn	Røye	n.d.	n.d.	1,29	n.d.	0,166	0,2	0,064	0,154	0,053	0,054	0,396	1,02
17	Geitvatnet	Ørret	n.d.	n.d.	0,738	0,812	0,59	1,14	0,392	0,554	0,173	n.d.	0,088	0,544
18	Geitvatnet	Ørret	n.d.	n.d.	0,788	0,495	0,6	1,16	0,443	0,73	0,256	n.d.	0,119	0,944
19	Geitvatnet	Røye	n.d.	n.d.	2,32	n.d.	n.d.	0,07	0,034	0,558	0,152	n.d.	0,875	0,508
20	Iešjávri	Røye	n.d.	0,116	1,26	3,03	0,607	1,39	0,272	0,239	0,064	n.d.	n.d.	0,911
21	Iešjávri	Røye	n.d.	n.d.	2,26	2,82	1,18	2,36	0,597	1,27	0,252	n.d.	0,201	1,45
22	Iešjávri	Røye	n.d.	n.d.	1,58	3,51	1,5	2,95	0,715	1,62	0,319	n.d.	0,304	1,45
23	Stuorajávri	Abbor	n.d.	n.d.	n.d.	3,23	1,16	1,88	0,449	1,06	0,136	0,818	n.d.	0,376
24	Stuorajávri	Abbor	n.d.	n.d.	1,69	1,6	1,08	1,95	0,465	1,01	0,124	0,104	0,145	0,519
25	Altevann Bardu	Røye	n.d.	n.d.	0,757	n.d.	0,112	0,12	0,036	0,052	n.d.	n.d.	0,056	0,129
26	Altevann Bardu	Røye	0,072	n.d.	0,741	n.d.	0,088	0,19	0,067	0,072	0,031	n.d.	0,314	0,344
27	Altevann Bardu	Røye	n.d.	n.d.	0,984	0,204	0,229	0,39	0,207	0,347	0,091	n.d.	0,259	0,284
28	Møsvatn	Røye	n.d.	n.d.	1,52	n.d.	0,223	0,91	0,783	1,86	0,329	n.d.	0,893	0,293
29	Møsvatn	Røye	n.d.	n.d.	1,08	n.d.	0,199	0,56	0,479	1,07	0,307	n.d.	0,783	0,137
30	Møsvatn	Røye	0,38	n.d.	1,62	n.d.	0,193	0,55	0,446	0,9	0,291	n.d.	0,9	0,233
31	Vaggatem	Sik	0,094	n.d.	1,04	0,203	0,306	1,12	0,337	0,506	0,093	0,182	0,385	0,439
32	Vaggatem	Sik	n.d.	0,125	5,24	0,605	0,427	1,71	0,446	0,542	0,117	0,26	2,01	0,592
33	Vaggatem	Sik	0,181	0,069	0,941	0,492	0,401	1,36	0,437	0,611	0,108	0,355	1,64	0,444
34	Tangenfossen	Sik	0,172	n.d.	1,57	0,355	0,478	1,29	0,275	0,506	0,073	0,479	1,44	1,5
35	Tangenfossen	Sik	0,086	0,099	0,622	0,227	0,371	1,48	0,488	0,759	0,17	0,185	0,952	1,08
36	Tangenfossen	Sik	0,148	0,074	1,05	0,348	0,459	1,64	0,52	0,611	0,123	0,57	1,09	1,53
37	Krøderen	Abbor	0,19	n.d.	1,08	0,437	0,691	1,66	1,31	1,76	0,601	0,099	0,104	0,887
38	Krøderen	Abbor	0,338	n.d.	1,17	0,291	1,03	2,53	1,92	1,91	0,768	0,166	0,214	1,62
39	Krøderen	Abbor	0,074	n.d.	1,97	n.d.	0,588	1,4	0,944	1,28	0,336	0,265	0,297	1,3

Nr	Lokalitet	Art	B(a)anthracen	Naphthalene	Anthracene	Fluoranthen	B[a]pyrene	D5	HBCD	TCBs
1	Lyseren	Ørret	<.69	0,8	0,03	0,22	<.69	4,49	0,04	0,03
2	Lyseren	Abbor	<.71	1,14	0,03	0,22	<.71	2,6	0,04	0,02
3	Lyseren	Abbor	<.65	0,94	0,02	0,15	<.65	2,13	0,05	0,03
4	Storbørja	Abbor	<.64	0,96	0,01	0,12	<.64	1,81	0,04	0,01
5	Storbørja	Abbor	<.65	0,75	0,01	0,1	<.65	1,6	0,05	0,02
6	Storbørja	Abbor	<.69	1,03	0,01	0,18	<.69	2,02	0,05	0,02
7	Bergesvatnet	Ørret	<.68	0,76	0,01	0,12	<.68	0,79	0,03	0,02
8	Bergesvatnet	Ørret	<.67	0,7	0,01	0,13	<.67	0,8	0,07	0,01
9	Bergesvatnet	Ørret	<.7	0,74	0,02	0,12	<.7	2,6	0,05	0,02
10	Kangsvatnet	Ørret	<.65	0,95	0,13	1,87	<.65	2,16	0,05	0,01
11	Kangsvatnet	Ørret	<.73	1,16	0,01	0,15	<.73	3,99	0,03	0,01
12	Kangsvatnet	Ørret	<.7	0,63	0,01	0,11	<.7	2,23	0,03	0,01
13	Langevann	Ørret	<.6	0,95	0,01	0,14	<.6	2,27	0,03	0,01
14	Steinvatn	Ørret	<.72	0,72	0,01	0,11	<.72	1,93	0,09	0,04
15	Steinvatn	Ørret	<.62	1,08	0,01	0,09	<.62	3,98	0,04	0,02
16	Steinvatn	Røye	<.54	1,22	0,03	0,12	<.54	5,71	0,1	0,03
17	Geitvatnet	Ørret	<.68	0,73	0,02	0,16	<.68	2,11	0,02	0,01
18	Geitvatnet	Ørret	<.56	0,9	0,01	0,1	<.56	1,57	0,05	0,01
19	Geitvatnet	Røye	<.53	0,75	0,05	0,14	<.53	4,23	0,1	0,02
20	Iešjávri	Røye	<.72	0,75	0,02	0,11	<.72	2,43	0,06	0,01
21	Iešjávri	Røye	<.68	0,64	0,05	0,12	<.68	2,48	0,02	0,03
22	Iešjávri	Røye	<.73	0,5	0,45	0,14	<.73	1,19	0,03	0,03
23	Stuorajávri	Abbor	<.74	0,9	0,12	0,52	<.74	2,01	0,05	0,02
24	Stuorajávri	Abbor	<.58	0,89	0,01	0,12	<.58	1,91	0,06	0,02
25	Altevann Bardu	Røye	<.58	0,96	0,03	0,22	<.58	1,8	0,04	0,01
26	Altevann Bardu	Røye	<.74	0,69	0,03	0,13	<.74	1,77	0,02	0,01
27	Altevann Bardu	Røye	<.67	0,76	0,02	0,16	<.67	2,17	0,03	0,01
28	Møsvatn	Røye	<.64	1,08	0,05	0,28	<.64	1,94	0,07	0,01
29	Møsvatn	Røye	<.74	0,87	0,02	0,14	<.74	2,18	0,03	0,01
30	Møsvatn	Røye	<.66	0,77	0,05	0,29	<.66	2,71	0,04	0,01
31	Vaggatem	Sik	<.63	0,91	0,01	0,14	<.63	1,29	0,03	0,01
32	Vaggatem	Sik	<.7	0,9	0,02	0,13	<.7	2,57	0,04	0,02
33	Vaggatem	Sik	<.66	0,66	0,02	0,12	<.66	1,47	0,03	0,01
34	Tangenfossen	Sik	<.74	0,53	0,02	0,14	<.74	1,59	0,01	0,04
35	Tangenfossen	Sik	<.75	0,9	0,02	0,13	<.75	2,56	0,03	0,02
36	Tangenfossen	Sik	<.7	0,84	0,01	0,12	<.7	2,02	0,03	0,02
37	Krøderen	Abbor	<.65	0,8	0,01	0,15	<.65	1,96	0,03	0,01
38	Krøderen	Abbor	<.75	0,86	0,01	0,15	<.75	3,94	0,02	0
39	Krøderen	Abbor	<.74	1,15	0,01	0,15	<.74	2,87	0,05	0,01

Nr	Lokalitet	Art	(PCP)	Triclosan	Dicofol	TCEP	(DEHP)	SCCPs	MCCPs
1	Lyseren	Ørret	0,09	0,11	1,05	1,2	198,9	1,5	1,2
2	Lyseren	Abbor	0,14	0,16	1,57	0,61	415,6	3,4	2,3
3	Lyseren	Abbor	0,45	0,17	1,73	0,45	117,8	0,9	1,3
4	Storbørja	Abbor	1,5	0,21	2,06	0,59	105,2	2,4	2,0
5	Storbørja	Abbor	0,49	0,17	1,72	0,38	129,1	1,6	5,1
6	Storbørja	Abbor	0,55	0,14	1,42	0,44	125,2	1,2	1,3
7	Bergesvatnet	Ørret	0,11	0,09	0,91	0,28	79,3	0,9	5,1
8	Bergesvatnet	Ørret	0,22	0,1	0,97	0,25	111,2	0,6	1,5
9	Bergesvatnet	Ørret	0,23	0,06	0,63	0,05	64,4	0,9	0,6
10	Kangsvatnet	Ørret	0,26	0,1	1	7,93	817,4	1,7	2,2
11	Kangsvatnet	Ørret	2,72	0,1	0,98	0,83	64,8	1,1	3,5
12	Kangsvatnet	Ørret	0,4	0,12	1,19	0,07	33,5	0,6	0,8
13	Langevann	Ørret	0,4	0,18	1,74	0,24	158,4	3,4	4,6
14	Steinvatn	Ørret	0,73	0,12	1,19	0,75	92,5	5,5	5,8
15	Steinvatn	Ørret	0,78	0,15	1,45	0,85	41,8	7,5	8,3
16	Steinvatn	Røye	0,12	0,09	0,88	0,98	121,8	1,3	1,3
17	Geitvatnet	Ørret	0,15	0,11	1,06	0,8	101,4	0,9	1,2
18	Geitvatnet	Ørret	0,2	0,07	0,7	0,67	90,7	0,9	0,8
19	Geitvatnet	Røye	0,37	0,1	0,96	0,84	68,8	1,7	15,5
20	Iešjávri	Røye	0,1	0,09	0,86	0,28	124,9	0,7	0,8
21	Iešjávri	Røye	0,09	0,12	1,19	0,05	377,3	0,8	2,0
22	Iešjávri	Røye	0,11	0,07	0,72	0,1	191,8	1,7	2,9
23	Stuorajávri	Abbor	0,67	0,11	1,08	0,04	94	1,4	7,2
24	Stuorajávri	Abbor	0,61	0,11	1,04	0,25	71,2	3,2	2,6
25	ltevann Bard	Røye	0,13	0,07	0,73	0,15	182,6	1,2	2,7
26	ltevann Bard	Røye	0,55	0,1	0,95	0,16	149,8	0,7	1,3
27	ltevann Bard	Røye	0,24	0,11	1,07	0,24	84,1	0,9	1,8
28	Møsvatn	Røye	0,38	0,07	0,68	0,12	108,6	2,6	8,5
29	Møsvatn	Røye	0,09	0,1	0,98	0,13	115,7	1,0	8,9
30	Møsvatn	Røye	0,48	0,1	1,01	0,09	194,3	1,9	3,7
31	Vaggatem	Sik	0,53	0,08	0,81	0,21	123,9	1,1	2,9
32	Vaggatem	Sik	0,21	0,12	1,17	0,5	289	1,4	1,1
33	Vaggatem	Sik	0,49	0,07	0,69	0,13	75,5	0,6	3,1
34	Tangenfossen	Sik	0,65	0,07	0,7	0,14	143,3	0,8	1,4
35	Tangenfossen	Sik	0,3	0,06	0,6	0,15	179	1,2	2,2
36	Tangenfossen	Sik	0,36	0,07	0,7	0,05	122,9	0,9	1,1
37	Krøderen	Abbor	0,44	0,09	0,9	0,11	63,8	1,2	2,0
38	Krøderen	Abbor	1,25	0,09	0,92	0,15	30,9	0,8	2,9
39	Krøderen	Abbor	2,09	0,11	1,06	0,12	58,2	1,8	1,9

Nr	Lokalitet	Art	Sum (pg/g w	Sum TEQ (pg	Sum(pg/g w	Sum (pg/g w	Sum (pg/g w	d13CVPDB	d15NAIR
1	Lyseren	Ørret	279,5	0,598	0	0	0,598	-26,66	6,15
2	Lyseren	Abbor	520,9	0,648	0	0	0,648	-27,29	6,47
3	Lyseren	Abbor	276,8	0,276	0,485	0,003	0,279	-25,61	6,45
4	Storbørja	Abbor	258,8	0,383	0,771	0,199	0,582	-27,73	7,78
5	Storbørja	Abbor	245,2	0,413	0,483	0,144	0,557	-27,84	7,15
6	Storbørja	Abbor	340,6	0,513	1,171	0,601	1,114	-28,32	6,58
7	Bergesvatnet	Ørret	339,3	0,395	6,2	1,292	1,687	-25,47	9,05
8	Bergesvatnet	Ørret	164,7	0,232	2,532	0,37	0,603	-25,46	8,68
9	Bergesvatnet	Ørret	185,1	0,292	4,914	0,596	0,888	-25,92	8,49
10	Kangsvatnet	Ørret	206,9	0,253	0,359	0,036	0,289	-24,76	7,49
11	Kangsvatnet	Ørret	3,3	0,052	0,739	0,017	0,069	-24,61	8,31
12	Kangsvatnet	Ørret	3,8	0,08	0	0	0,08	-23,68	6,94
13	Langevann	Ørret	1613,4	1,05	0,55	0,055	1,105	-27,44	8,44
14	Steinvatn	Ørret	212,6	0,196	0,84	0	0,197	-28,64	8,41
15	Steinvatn	Ørret	340,2	0,54	0,368	0,037	0,577	-23,95	8,24
16	Steinvatn	Røye	4,1	0,113	0,591	0,023	0,137	-26,69	6,01
17	Geitvatnet	Ørret	205,2	0,185	0	0	0,185	-25,11	8,86
18	Geitvatnet	Ørret	230,4	0,212	0,588	0,039	0,251	-27,63	8,87
19	Geitvatnet	Røye	6,5	0,146	1,177	0,064	0,211	-31,55	6,52
20	Iešjávri	Røye	171,9	0,205	0,311	0,031	0,236	-21,75	7,98
21	Iešjávri	Røye	546,7	0,549	0,274	0,027	0,576	-21,8	7,49
22	Iešjávri	Røye	434,4	0,513	0,345	0,035	0,548	-22,2	7,21
23	Stuorajávri	Abbor	4,4	0,042	0,243	0,024	0,066	-22,19	7,22
24	Stuorajávri	Abbor	156,8	0,082	0	0	0,082	-23,6	7,03
25	ltevann Bard	Røye	3,9	0,098	0	0	0,098	-26,08	7,41
26	ltevann Bard	Røye	4,4	0,097	0	0	0,097	-27,56	7,94
27	ltevann Bard	Røye	5,8	0,122	0	0	0,122	-27,46	6,79
28	Møsvatn	Røye	381,7	0,526	0,685	0,069	0,595	-27,79	5,6
29	Møsvatn	Røye	156,3	0,195	0	0	0,195	-27,61	5,3
30	Møsvatn	Røye	314,8	0,383	0,565	0,056	0,439	-27,85	6,12
31	Vaggatem	Sik	3,2	0,069	0,355	0,035	0,104	-24,41	8,75
32	Vaggatem	Sik	148,7	0,161	0,564	0,056	0,217	-21,53	8,12
33	Vaggatem	Sik	182,5	0,132	0,483	0,048	0,18	-23,12	8,58
34	Tangenfosser	Sik	1080,5	0,231	0,469	0,047	0,278	-27,91	8,38
35	Tangenfosser	Sik	1323,7	0,062	0	0	0,062	-27,78	8,69
36	Tangenfosser	Sik	304,5	0,151	0,333	0,033	0,184	-29,93	8,47
37	Krøderen	Abbor	228,4	0,1	0	0	0,1	-24,11	11,09
38	Krøderen	Abbor	147,6	0,02	0	0	0,02	-23,2	10,07
39	Krøderen	Abbor	255,9	0,214	0	0	0,214	-22,75	9,46

Nr	Lokalitet	Art	Li	Mg	Al	V	Cr	Fe	Co	Ni	Cu
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
1	Lyseren	Ørret	0,016	160	23	0,04	<0,006	290	0,24	0,003	5
2	Lyseren	Abbor	0,016	160	57	0,16	0,007	570	0,41	0,007	12
3	Lyseren	Abbor	0,004	150	4	0,032	<0,006	200	0,068	0,007	95
4	Storbørja	Abbor	0,006	140	4,3	0,014	<0,006	64	0,25	<0,003	2,4
5	Storbørja	Abbor	0,008	150	3,8	0,013	<LOD	79	0,25	0,014	2,1
6	Storbørja	Abbor	0,009	160	6,3	0,043	0,009	150	0,14	0,004	1,5
7	Bergesvatnet	Ørret	<0,001	150	1,1	0,012	<0,006	160	0,065	0,009	61
8	Bergesvatnet	Ørret	<0,001	160	0,92	0,011	<0,006	130	0,067	0,008	59
9	Bergesvatnet	Ørret	<0,001	140	1,2	0,014	0,0067	180	0,07	0,006	110
10	Kangsvatnet	Ørret	<0,001	130	1,6	0,008	<LOD	150	0,14	0,006	56
11	Kangsvatnet	Ørret	<0,001	160	2,3	0,008	0,012	130	0,16	0,027	51
12	Kangsvatnet	Ørret	<0,001	180	2,5	0,009	<0,006	140	0,15	0,009	99
13	Langevann	Ørret	0,001	170	2,2	0,01	0,008	140	0,059	0,013	34
14	Steinvatn	Ørret	<0,001	97	0,21	0,001	<0,006	190	0,042	0,006	98
15	Steinvatn	Ørret	<0,001	170	0,82	0,003	<LOD	110	0,052	0,009	120
16	Steinvatn	Røye	0,001	210	1,9	0,008	<0,006	600	0,15	0,025	59
17	Geitvatnet	Ørret	<0,001	280	0,94	0,015	<0,006	67	0,075	0,011	83
18	Geitvatnet	Ørret	<0,001	250	0,76	0,007	<0,006	110	0,049	0,008	23
19	Geitvatnet	Røye	<0,001	180	0,48	0,003	<0,006	390	0,073	0,017	3,2
20	Iešjávri	Røye	0,0044	230	7,1	0,099	0,018	490	0,19	0,011	13
21	Iešjávri	Røye	0,005	200	4	0,12	0,021	660	0,23	0,034	25
22	Iešjávri	Røye	0,007	180	15	0,12	0,036	580	0,33	0,044	21
23	Stuorajávri	Abbor	0,006	180	3,5	0,059	0,009	170	0,13	0,006	1,9
24	Stuorajávri	Abbor	0,012	210	18	0,13	0,036	160	0,098	0,015	2,1
25	ltevann Bard	Røye	0,001	310	5,1	0,085	<0,006	300	0,2	0,013	17
26	ltevann Bard	Røye	0,002	290	3,5	0,082	<0,006	310	0,19	0,021	12
27	ltevann Bard	Røye	0,001	290	3,4	0,058	<0,006	340	0,2	0,016	8,6
28	Møsvatn	Røye	0,004	230	1,9	0,008	<LOD	520	0,093	0,006	7,9
29	Møsvatn	Røye	0,003	210	1,7	0,008	<0,006	480	0,096	0,009	8,5
30	Møsvatn	Røye	0,004	190	4,5	0,033	0,007	800	0,16	0,014	10
31	Vaggatem	Sik	0,004	180	9,7	0,051	0,026	110	0,046	0,047	11
32	Vaggatem	Sik	0,001	150	2,1	0,034	0,012	67	0,035	0,035	10
33	Vaggatem	Sik	0,002	170	3,1	0,026	0,024	100	0,035	0,057	11
34	Tangenfosser	Sik	0,003	180	8,6	0,15	0,14	210	0,065	0,1	8
35	Tangenfosser	Sik	0,001	170	1,5	0,054	0,025	230	0,051	0,038	7,9
36	Tangenfosser	Sik	<0,001	190	0,9	0,026	0,016	120	0,041	0,059	8,5
37	Krøderen	Abbor	0,007	170	3,1	0,018	<0,006	87	0,25	<0,003	3,1
38	Krøderen	Abbor	0,008	190	3	0,021	<0,006	100	0,23	0,006	2,2
39	Krøderen	Abbor	0,008	180	4,4	0,026	0,009	66	0,32	0,008	1,8

Nr	Lokalitet	Art	Zn	As	Se	Mo	Ag	Cd	Hg	Hg muskel	Pb
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
1	Lyseren	Ørret	25	0,02	1,9	0,083	0,012	2,8	0,38	0,53	0,022
2	Lyseren	Abbor	33	0,03	2,8	0,13	0,046	6,7	0,77	0,58	0,032
3	Lyseren	Abbor	44	0,049	8,9	0,16	1,1	1	0,1	0,077	0,078
4	Storbørja	Abbor	23	0,015	1,7	0,069	0,0025	0,65	3,7	4	0,02
5	Storbørja	Abbor	23	0,018	1,7	0,084	0,0017	0,49	3,3	2,9	0,021
6	Storbørja	Abbor	22	0,02	1,3	0,063	0,0009	0,37	1,8	1,7	0,029
7	Bergesvatnet	Ørret	28	0,022	6,1	0,14	1,3	0,32	0,81	0,32	0,014
8	Bergesvatnet	Ørret	37	0,036	6,4	0,13	1	0,28	0,4	0,31	0,045
9	Bergesvatnet	Ørret	39	0,031	12	0,16	1,5	0,29	0,41	0,25	0,018
10	Kangsvatnet	Ørret	30	0,017	18	0,12	2,9	0,3	0,69	0,42	0,008
11	Kangsvatnet	Ørret	37	0,027	18	0,2	2,3	0,22	0,39	0,25	0,006
12	Kangsvatnet	Ørret	38	0,1	14	0,14	2,9	0,23	0,24	0,23	0,006
13	Langevann	Ørret	44	0,016	11	0,18	1,9	0,29	0,42	0,24	0,016
14	Steinvatn	Ørret	19	0,013	27	0,14	1,6	0,052	0,52	0,27	0,002
15	Steinvatn	Ørret	44	0,053	23	0,21	3,2	0,15	0,2	0,098	0,004
16	Steinvatn	Røye	43	0,17	2,4	0,2	0,52	0,2	0,14	0,096	0,016
17	Geitvatnet	Ørret	28	0,018	4,2	0,11	1,2	0,091	0,12	0,18	0,003
18	Geitvatnet	Ørret	55	0,021	3,9	0,16	0,94	0,08	0,22	0,23	0,003
19	Geitvatnet	Røye	24	0,022	1,8	0,19	0,0073	0,039	0,15	0,14	0,004
20	Iešjávri	Røye	27	0,033	1,3	0,12	0,068	0,078	0,067	0,07	0,012
21	Iešjávri	Røye	36	0,053	2,2	0,23	0,21	0,13	0,097	0,1	0,017
22	Iešjávri	Røye	32	0,037	2,4	0,18	0,14	0,095	0,071	0,092	0,023
23	Stuorajávri	Abbor	23	0,073	1,1	0,12	0,0008	0,17	0,046	0,11	0,002
24	Stuorajávri	Abbor	25	0,1	1	0,14	0,0019	0,19	0,034	0,059	0,009
25	ltevann Bardu	Røye	27	0,046	0,85	0,12	0,11	0,11	0,043	0,053	0,004
26	ltevann Bardu	Røye	28	0,033	0,95	0,14	0,1	0,098	0,055	0,065	0,005
27	ltevann Bardu	Røye	35	0,032	1,5	0,18	0,037	0,11	0,07	0,054	0,003
28	Møsvatn	Røye	38	0,007	1,3	0,1	0,064	0,86	0,12	0,14	0,008
29	Møsvatn	Røye	37	0,009	1,1	0,1	0,093	0,72	0,11	0,14	0,009
30	Møsvatn	Røye	41	0,007	1,6	0,13	0,11	1,2	0,14	0,15	0,011
31	Vaggatem	Sik	28	0,18	0,79	0,098	0,16	0,033	0,089	0,059	0,007
32	Vaggatem	Sik	28	0,2	0,71	0,087	0,17	0,04	0,053	0,05	0,003
33	Vaggatem	Sik	28	0,18	0,73	0,1	0,14	0,048	0,052	0,044	0,003
34	Tangenfossen	Sik	42	0,039	0,92	0,12	0,058	0,14	0,28	0,12	0,009
35	Tangenfossen	Sik	41	0,032	1	0,11	0,061	0,14	0,17	0,077	0,013
36	Tangenfossen	Sik	39	0,024	1	0,1	0,067	0,056	0,15	0,08	0,009
37	Krøderen	Abbor	26	0,025	0,74	0,083	0,002	0,53	0,13	0,34	0,003
38	Krøderen	Abbor	26	0,13	0,8	0,13	0,008	0,71	0,067	0,081	0,002
39	Krøderen	Abbor	26	0,12	0,85	0,14	0,0026	1,1	0,057	0,083	0,002