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EU Water Framework-Directive Priority Contaminants in Norwegian Freshwater Fish

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Summary

Priority substances under EU water framework directive, and other substances of concern, were analyzed in fish liver sampled from 12 Norwegian lakes (see map under). Fish were sampled by the Norwegian Institute for Nature Research (NINA) as part of an assignment for ecosystem monitoring. In the present report, the environmental monitoring program included fish caught during summer and autumn 2020 from 12 lakes. Pooled liver samples (muscle tissue for mercury analyses) were analyzed for organic chemicals, isotopes and metals. Trout (Salmo trutta was the preferred species, but in two lakes char (*Salvelinus alpinus*) or perch (*Perca fluvialis*) were the available species.

The concentration of POPs in the study lakes are among the lakes with relatively low levels compared to lakes from areas more affected by human activities in Norway. Still, the wet weight concentrations of PCB7 and PBDEs in fish liver exceed The Environmental Quality Standards (EQS) in 8 and 7 of the 12 lakes respectively. The concentration of PCB7 ranged from 0.5 µg/kg in Otervatnet to 13 µg/kg in Storavatnet. Lake Femunden, Lake Otervatnet, Lake Selbusjøen and Lake Storvatnet had levels above the EQS (0.0085 µg/kg) for ΣPBDEs. The detection limit for 4-tert-octylphenol was 0,011 µg/kg, which is higher than the EQS (0,004 µg/kg). PFAS levels were relatively low, and similar to previous results in this program, but clearly below the levels measured in Lake Tyrifjorden. Still, the EQS for 4-tert-octylphenol was exceeded in fish livers from all study lakes. Only fish from Lake Tunevannet (17 µg/kg ww,) had PFOS levels which exceeded the EQS. EQS were exceeded in three lakes for heptachlor (heptachlor epoxide).

The EQS for mercury were exceeded in all lakes, which is in accordance with the previous results of the present monitoring program. The highest level measured was 607 µg/kg ww (Lake Storavatnet). Further the highest levels of cadmium 1243 µg/kg ww were found in trout liver from Lake Storavatnet.

Sammendrag

EUs vannrammedirektivs prioriterte miljøgifter ble analysert i fiskelever prøvetatt i 12 norske innsjøer (se kart under). Prøver av fisk ble samlet inn av Norsk Institutt for Naturforskning (NINA) som en del av økosystemovervåking. Denne rapporten omfatter kartlegging av miljøgifter i fisk fanget sommeren og høsten 2020.

Blandprøver av lever (muskel til kvikksølv) ble analysert for organiske miljøgifter, isotoper og metaller. Den foretrukne arten var ørret, men i to vann var den tilgjengelige arten henholdsvis røye og abbor.

Konsentrasjonen av persistente organiske miljøgifter (POPs) var relativt lav i denne undersøkelsen sammenlignet med innsjøer i Norge som ligger nærmere industri og andre menneskelige aktiviteter. Likevel oversteg våtvekt konsentrasjonene av PCB7 og PBDEs i fiskelever miljøkvalitetsstandardene (EQS) i henholdsvis 8 og 7 av de 12 vannene. Konsentrasjonene av PCB7 var fra 0,5 til 13 µg/kg fettvekt i henholdsvis Otervatnet og Storavatnet. Lake Femunden, Lake Otervatnet, Lake Selbusjøen and Lake Storvatnet hadde nivåer over EQS (0.0085 µg/kg) for ΣPBDEs. For 4-tert-octylphenol var EQS overskredet i fiskelever fra alle innsjøer. Deteksjonsgrensen for 4-tert-octylphenol var på 0,011 µg/kg, hvilket er høyere enn EQS (0,004 µg/kg). PFAS nivåene var relativt lave, og avvek lite fra målinger fra tidligere år, men klart lavere enn nivåene tidligere målt i Tyrifjorden. Bare fisk fra Tunevannet (17 µg/kg ww,) hadde PFOS over EQS, mens tre vann hadde nivåer av heptaklor (heptaklor epoxide) som overskred EQS.

For kvikksølv ble EQS overskredet i alle vann, hvilket er i overenstemmelse med tidligere års undersøkelse i dette overvåkingsprogrammet. Det høyeste nivået var 607 µg/kg ww i fisk fra Storavatnet. Videre ble de høyeste nivåene av kadmium (1243 µg/kg ww) også målt i Storavatnet.

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 and monitoring strategy from previous years. In this yearly survey, a wide range of environmental contaminants has been measured in fish from 12 Norwegian lakes (see map). The lakes selected are located throughout the country (Map) and should have relatively low impact from human activity. With the exception of Lake Storavatnet, close to Bergen, and Tunevannet, close to Sarpsborg, the lakes in 2020 were located relatively remote from large industrial or population centres.

The main goal for the monitoring program are:

- To report the concentrations of selected contaminants in fish from Norwegian lakes for comparisons to environmental quality standards (EQS)

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 three fish species (trout, perch, char; table 1). 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) 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 (CECs).

Environmental quality standards (EQS)

EQS (Environmental quality standard) is the concentration of a 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; Direktoratsgruppen vanndirektivet , Miljødirektoratet 2018). 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 (Max-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 EQS biota-value for Hg indicates high toxicity and a high bioaccumulation and biomagnifying factor (Direktoratsgruppen vanndirektivet, 2018). The EQS value for Hg in freshwater biota is considered low (20 µg/kg 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. Frozen fish were brought to the Norwegian School of Veterinary Science at the Norwegian University of Life Sciences (NMBU), where pooled samples was prepared. Species and individual length, weight, lake, water code and capture date of each fish in the samples from 1 to 36 analysed in the project from 2020 is shown in Appendix 1. The samples were prepared from pooled livers.

In the present report, the monitoring program included fish caught during summer and autumn 2020 from 12 lakes. Pooled samples were prepared by pooling 15 specimens from each lake into three pooled samples (5 fish/pool). The same species were not available in all lakes, and in some lakes, the number of fish were smaller than needed. Consequently, trout (*Salmo trutta*) only was collected in 8 lakes and char (*Salvelinus alpinus*) and perch (*Perca fluvialis*) in 1 lake, respectively. In addition, a combination of trout and char were collected in 2 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 number to show how the pooled samples had been made. For each lake, all individual fish with the same number 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 °C in a Eurovector EA3028 element instrument. The reduction of NOx to N_2 took place in a Cu heater at 650 °C. 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 500 mg (liver) or 1000 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 °C 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 derivatives (PFAS), and Perfluorinated carboxylic acids were extracted and quantified. The following perfluorinated sulfonates and derivatives were analyzed (CAS nr): PFBS (375-73-5), PFHxS (355-46-4), PFOS (1763-23-1), FOSA (754-91-6), N-EtFOSA (4151-50-2), N-MeFOSA (31506-32-8) N-Et-FOSE (1691-99-2), N-MeFOSE (24448-09-7), N-Et-FOSEA (423-82-5), N-MeFOSEA (25268-77-3), 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 internal standards (^{13}C) 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 N_2. 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 triple quad 6460 LC/MS/MS1100 series (Auto sampler, quaternary pump, degasser), and API 3000 LC/MS/MS system equipped with Supelco, Discovery C18 column, 15 cm x 2.1 mm, 5 µm with pre column; Supelco, superguard Discovey 18.2 cm x 2.1 mm, 5 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 $^{13}C_{12}$-BDE-209 (Cambridge Isotope Laboratories. Inc., MA, USA). Cyclohexane (CHX), acetone and distilled water (20:15:10 mL) were added, before further homogenization with an Ultra-Turrax®, IKA homogenizer and an ultra sonicator. 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% H_2SO_4 (Fluka Analytical®). Then the extracts were up-concentrated to 0.25 mL under a flow of N_2. 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), coupled to a 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. Carrier gas helium, make up gas nitrogen. The following brominated diphenyl ethers (PBDE) were quantified: BDE-28, -47, -99, -100, -153, -154, -183, -196, -202, -206, -207 and -209, also in addition to 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. Carrier gas helium, makeup gas nitrogen. For detection of BDE 196, -202, -206, -207 and -209, the extracts (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. Carrier gas helium, makeup gas nitrogen. 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 $^{13}C_{12}$-BDE-209 at m/z 495/497) was used.

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 °C 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 °C for 2.0 min, increased to 120 °C at a rate of 10 °C/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 °C for 2.0 min, increased to 120 °C at a rate of 10 °C/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 was applied for the determination of SCCP, MCCP and LCCP using APCI-QTOF-MS, SCCP, MCCP and LCCP have been analyzed with the direct injection full scan method (scan range m/z 250 – 1000) using quadrupole time-of-flight high-resolution mass spectrometry (APCI-QTOF-MS) (QTOF Premier, Waters, Manchester, UK), which has developed by Bogdal et al, (2015) and Yuan et al, (2017). The observed resolution was 9.000 to 10.000 FWHM. All the chemicals and extracts were analyzed in cyclohexane to be consistent with the solvent of the chain length standards, 10 ng 13C labeled chloroparaffin (1.5.5.6.6.10-C10Cl5) and 20 ng Dechlorane 603 were spiked as internal standards.

Method 4 was applied for the determination of tributyltin (TBT), dibutyltin (DBT) and monobutyltin (MBT), triphenyltin (TPT), diphenyltin (DPT) and monophenyltin (MPT) using GC-FPD. The samples were analyzed with an Agilent 7890 gas chromatography coupled to a flame photometric detector equipped with Sn-filter (650 nm) (GC-FPD). Organotin compounds were based-line separated with a HP-5 fused-silica capillary column (30m× 0.32 mm×0.25 µm). The oven temperature program conditions were 80 °C held for 1 min, ramped at 5 °C/min to 190 °C then ramped at 10°C/min to 240°C held for 10min. The temperatures of the detector and the injector were kept at 250 °C. High pure nitrogen severed as carrier gas and kept at 2 mL/min, and the flow rate of hydrogen and air were 120 and 100 mL/min, respectively.

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 analyzed 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. 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 alone from eight lakes, and a combination of trout and char in two lakes. Perch alone and char alone were caught in one lake each, and a mix of trout and char in two lakes. The mean fish weight differed between lakes from a lowest mean weight of 279 g in Lake Finnåsvatnet to a highest mean weight of 711 g in Lake Tunevannet. Stable isotopes are shown in table 2

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

Lake	Species	Tissue	Weight (g)	Lenght (cm)	Fat %
Dalvatnet	Char	Liver	445,93	32,45	3,36
Femunden	Trout	Liver	492,83	34,75	2,46
Finnåsvatnet	Trout	Liver	279,12	29,24	3,93
Limingen	Trout/Char	Liver	465,47	34,80	3,67
Otervatnet	Trout	Liver	392,53	32,27	2,95
Røssvatnet	Trout/Char	Liver	457,53	33,80	3,16
Salsvatnet	Trout	Liver	521,00	37,40	2,57
Selbusjøen	Trout	Liver	490,18	35,10	3,20
Snåsavatnet	Trout	Liver	438,03	34,93	2,86
Storavatnet	Trout	Liver	475,88	35,27	2,13
Storvatnet	Trout	Liver	698,93	37,73	3,63
Tunevannet	Perch	Liver	710,53	36,33	2,82

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

Lake	δ^{15}NAIR			δ^{13}CVPDB		
	Mean	Min	Max	Mean	Min	Max
Dalvatnet	9,58	8,94	10,04	-27,20	-27,45	-27,01
Femunden	7,61	7,19	8,14	-20,01	-20,23	-19,78
Finnåsvatnet	8,02	6,64	9,40	-25,72	-26,54	-24,51
Limingen	5,93	5,60	6,25	-26,30	-26,85	-25,48
Otervatnet	7,21	6,88	7,59	-23,28	-23,48	-23,10
Røssvatnet	7,00	6,69	7,43	-22,72	-23,66	-20,95
Salsvatnet	9,16	8,79	9,62	-24,02	-25,67	-22,90
Selbusjøen	9,52	8,92	10,04	-24,23	-26,14	-23,00
Snåsavatnet	9,88	9,39	10,72	-20,85	-21,39	-19,85
Storavatnet	9,02	8,72	9,41	-25,55	-26,81	-24,85
Storvatnet	9,28	8,24	10,31	-27,40	-28,35	-26,62
Tunevannet	12,62	12,50	12,75	-25,26	-25,54	-25,07

3.1.2 Organochlorine pesticides (OCP)

The wet weight (ww) concentrations (µg/kg) of hexachlorobenzene (HCB), pentachlorobenzene (PeCB), ∑hexachlorocyclohexane (∑HCH), heptachlor, ∑endosulfan and ∑dichlorodiphenyltrichloroethanes∑DDTs 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 lipid weight concentrations of fat-soluble compounds enable 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 Storavatnet (1189 µg/kg lipid w) followed by Lake Tunevannet (122 µg/kg). The lowest concentrations were found in Lake Otervatnet (8 µg/kg) and Lake Storvatnet (17 µg/kg). The concentration (lw) of HCB were highest in fish liver from Lake Dalvatnet (5 µg/kg) followed by Lake Røssvatnet (3 µg/kg). The concentrations of HCB were under the detection limit (LOD) in Lake Femunden and Lake Tunevannet. Heptachlor (cis-Heptachlor epoxide) was detected in Lake Limingen (6 µg/kg), Lake Dalvatnet (3 µg/kg) and Lake Selbusjøen (2 µg/kg), whereas heptachlor was under the LOD in the other lakes. The concentration of endosulfan (Range: LOD-1.74 µg/kg lw) and HCH (Range: 0.36-1.73 µg/kg lw) were relatively low and the concentration of PeCB was under LOD in all lakes.

EU has established Environmental Quality Standards (EQS) for prioritized 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	∑DDT ww
Dalvatnet	0,15	ND	0,02	0,09	0,009	1,24
Femunden	ND	ND	0,02	ND	0,042	0,74
Finnåsvatnet	0,05	ND	0,03	ND	0,009	1,89
Limingen	0,03	ND	0,03	0,22	0,024	0,67
Otervatnet	0,03	ND	0,02	ND	ND	0,25
Røssvatnet	0,12	ND	0,02	ND	0,035	0,83
Salsvatnet	0,07	ND	0,02	ND	0,028	0,97
Selbusjøen	0,04	ND	0,01	0,07	ND	0,50
Snåsavatnet	0,02	ND	0,02	ND	0,005	0,57
Storavatnet	0,03	ND	0,02	ND	0,019	7,92
Storvatnet	0,06	ND	0,02	ND	ND	0,59
Tunevannet	ND	ND	0,05	ND	0,003	3,47

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	∑DDT lw
Dalvatnet	4,51	ND	0,56	2,63	0,28	36,90
Femunden	ND	ND	0,93	ND	1,74	30,35
Finnåsvatnet	1,28	ND	0,73	ND	0,23	49,72
Limingen	0,64	ND	0,69	5,92	0,65	18,15
Otervatnet	0,89	ND	0,60	ND	0,00	8,34
Røssvatnet	3,02	ND	0,73	ND	1,25	23,16
Salsvatnet	2,89	ND	0,89	ND	1,05	40,60
Selbusjøen	1,26	ND	0,36	1,87	ND	15,91
Snåsavatnet	0,83	ND	0,57	ND	0,16	19,96
Storavatnet	1,10	ND	1,62	ND	1,32	1188,73
Storvatnet	1,43	ND	0,49	ND	ND	16,52
Tunevannet	ND	ND	1,73	ND	0,15	122,43

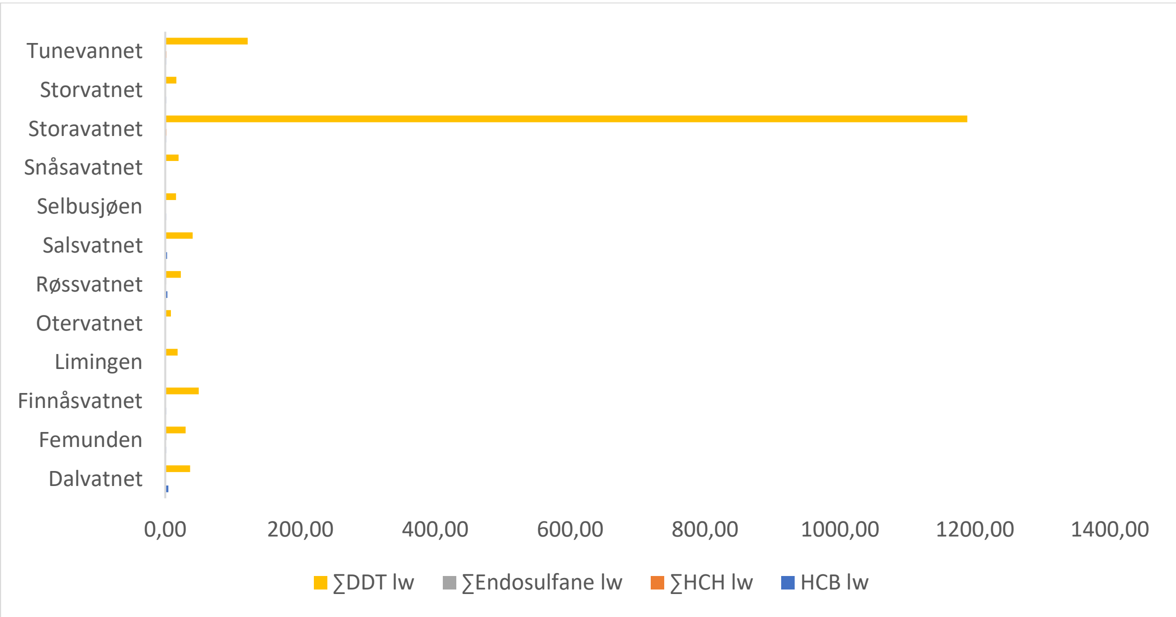

Figure 1: Mean lipid weight (µg/kg lw) concentrations of DDT, HCB, PeCB, HCH, Heptaklor and Endosulfan

3.1.3 PCBs and Brominated Flame Retardants (PBDEs and HBCDD)

The mean wet weight (ww) concentrations of Polychlorinated Biphenyls (PCBs) is given for the seven congeners PCB -28, 52, 101, 118, 138, 153, and 180 (PCB7). Polybrominated diphenyl ethers (PBDEs) is given for the pentabrominated congeners, PBDE -28, 47, 99, 100, 153 and 154. Also 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 Storavatnet (2113 µg/kg) followed by Lake Tunevannet (208 µg/kg) and Lake Dalvatnet (182 µg/kg). The concentrations (lw) of ∑PBDEs and HBCD were generally low with high concentration of PBDEs detected in Lake Storavatnet (777 µg/kg) and relatively low in the other lakes, whereas HBCD were low in all lakes with concentrations under LOD in 7 out 12 lakes. Likewise, 4 of the study lakes had PBDE concentrations under LOD

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	∑PCB ww	∑PBDE ww	∑HBCD ww
Dalvatnet	6,20	0,32	ND
Femunden	1,19	ND	ND
Finnåsvatnet	1,75	0,44	1,25
Limingen	0,99	0,17	0,04
Otervatnet	0,49	ND	ND
Røssvatnet	0,53	0,07	ND
Salsvatnet	2,15	0,51	ND
Selbusjøen	0,49	0,07	ND
Snåsavatnet	0,50	ND	0,19
Storavatnet	13,18	4,83	0,14
Storvatnet	1,64	ND	ND
Tunevannet	5,65	0,24	0,07

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).

Lakes	∑PCB lw	∑PBDE lw	HBCD lw
Dalvatnet	182	9	ND
Femunden	49	ND	ND

Finnåsvatnet	47	12	36
Limingen	27	5	1
Otervatnet	16	ND	ND
Røssvatnet	15	1	ND
Salsvatnet	88	21	ND
Selbusjøen	16	2	ND
Snåsavatnet	16	ND	6
Storavatnet	2113	777	4
Storvatnet	49	ND	ND
Tunevannet	208	9	3

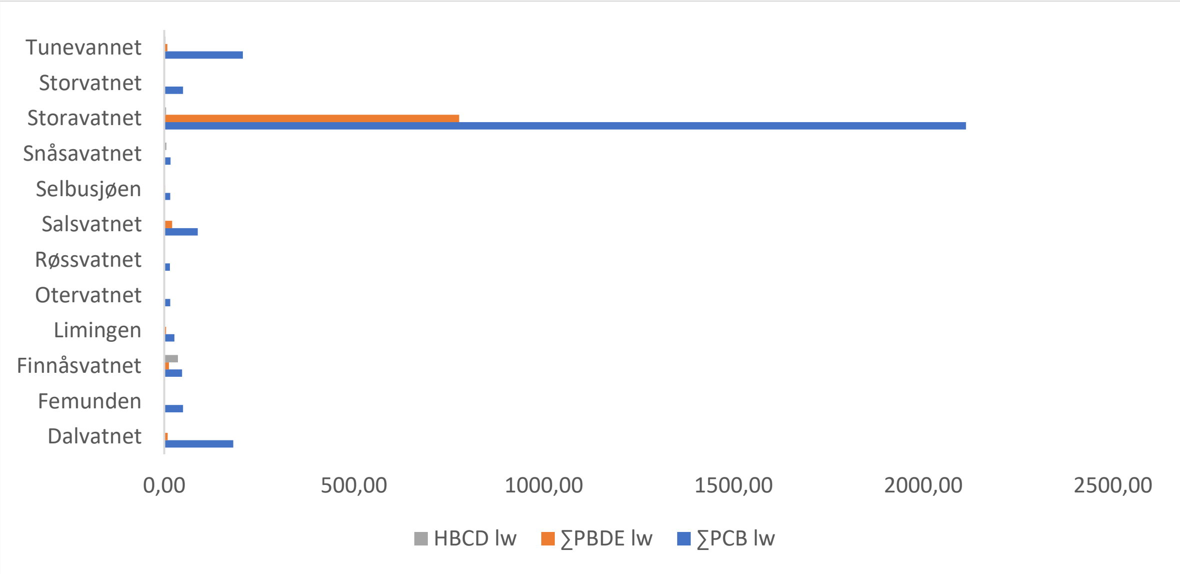

Figure 2: Mean lipid weight (µg/kg lw) concentrations of ΣPCBs. thirteen PBDEs and HBCDD in liver samples.

3.1.4 Dioxins and dioxin-like PCBs

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 values 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 wet weight additive dioxin toxicity (sum of PCDDs + PCDFs + dl-PCBs) was detected in fish from Lake Dalvatnet followed by Lake Storavatnet. 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) levels of Σdl-PCB, ΣPCDD+PCDF and ΣPCDD+PCDF+dl-PCB in fish from each lake. Under the detection limit=not detected (nd).

Lake	ΣTEQ dl-PCB	ΣTEQ PCDD+PCDF	ΣTEQ PCDD+PCDF+dl-PCB
Dalvatnet	1,07	0,11	1,18
Femunden	0,20	0,47	0,67
Finnåsvatnet	0,27	0,21	0,49
Limingen	0,41	0,06	0,46
Otervatnet	0,29	0,02	0,31
Røssvatnet	0,11	0,02	0,13
Salsvatnet	0,44	0,01	0,45
Selbusjøen	0,16	0,00	0,16
Snåsavatnet	0,09	0,01	0,10
Storavatnet	0,63	0,06	0,70
Storvatnet	0,35	0,03	0,37
Tunevannet	0,38	0,02	0,40

Dioxins and dioxin-like PCBs includes 7 polychlorinated dibenzo-p-dioksines (PCDDer):, 1,2,3,7,8-P5CDD (CAS 40321-76-4), 1,2,3,4,7,8- H6CDD (CAS 39227-28-6), 1,2,3,6,7,8- H6CDD (CAS 57653-85-7), 1,2,3,7,8,9-H6CDD (CAS 19408-74-3), 1,2,3,4,6,7,8-H7CDD (CAS 35822-46- 9), 1,2,3,4,6,7,8,9-O8CDD (CAS 3268-87-9) 10 polychlorinated dibenzofuranes (PCDFs): 2,3,7,8-T4CDF (CAS 51207-31-9), 1,2,3,7,8-P5CDF (CAS 57117-41-6), 2,3,4,7,8-P5CDF (CAS 57117-31-4), 1,2,3,4,7,8-H6CDF (CAS 70648-26-9), 1,2,3,6,7,8-H6CDF (CAS 57117-44-9), 1,2,3,7,8,9-H6CDF (CAS 72918- 21-9), 2,3,4,6,7,8-H6CDF (CAS 60851-34-5), 1,2,3,4,6,7,8-H7CDF (CAS 67562-39-4), 1,2,3,4,7,8,9-H7CDF (CAS 55673-89-7), 1,2,3,4,6,7,8,9-O8CDF (CAS 39001-02-0) 12 dioxin-like PCBs (PCB-DL): 3,3',4,4'-T4CB (PCB 77, CAS 32598-13-3), 3,3',4',5-T4CB (PCB 81, CAS 70362- 50-4), 2,3,3',4,4'-P5CB (PCB 105, CAS 32598-14-4), 2,3,4,4',5-P5CB (PCB 114, CAS 74472- 37-0), 2,3',4,4',5-P5CB (PCB 118, CAS 31508-00-6), 2,3',4,4',5'-P5CB (PCB 123, CAS 65510-44-3), 3,3',4,4',5-P5CB (PCB 126, CAS 57465-28-8), 2,3,3',4,4',5-H6CB (PCB 156, CAS 38380-08-4), 2,3,3',4,4',5'-H6CB (PCB 157, CAS 69782-90-7), 2,3',4,4',5,5'-H6CB (PCB 167, CAS 52663-72-6), 3,3',4,4',5,5'-H6CB (PCB 169, CAS 32774-16-6), 2,3,3',4,4',5,5'-H7CB (PCB 189, CAS 39635-31-9).

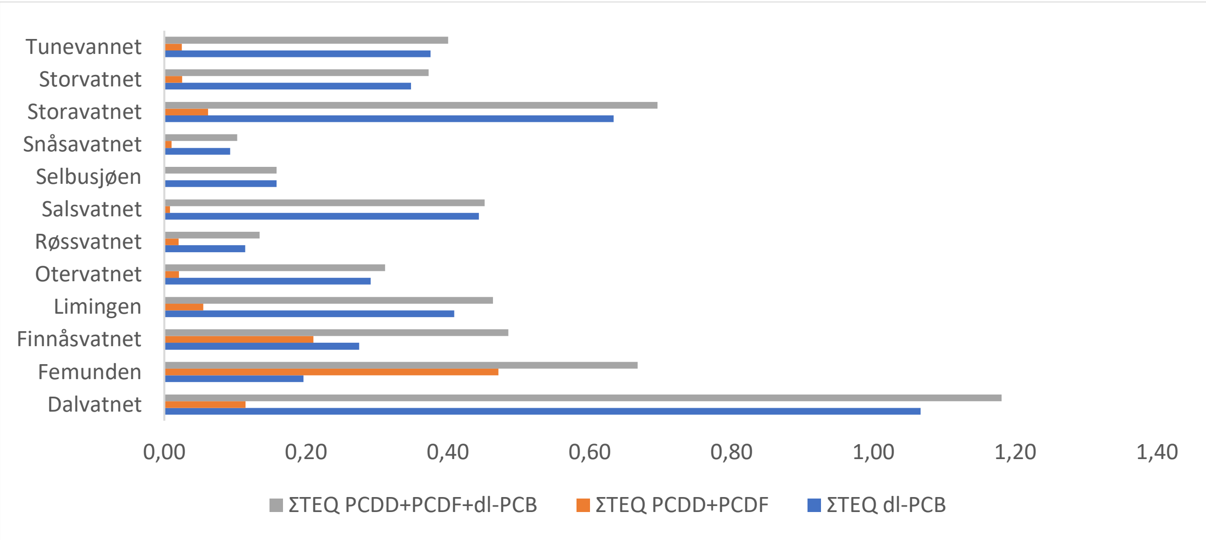

Figure 3: Mean wet weight TEQ (pg/g TEQ ww) values of Σdl-PCB, ΣPCDD+PCDF and ΣPCDD+PCDF+dl-PCB in fish from each lake.

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

Lake	ΣTEQ dl-PCB	Σ PCDD+PCDF	Σ PCDD+PCDF+dl-PCB
Dalvatnet	94,52	10,66	105,18
Femunden	24,01	57,22	81,24
Finnåsvatnet	22,17	16,35	38,53
Limingen	33,08	4,42	37,50
Otervatnet	29,21	2,18	31,39
Røssvatnet	10,82	2,05	12,87
Salsvatnet	56,05	1,01	57,06
Selbusjøen	14,89	0,01	14,90
Snåsavatnet	9,23	1,00	10,23
Storavatnet	277,85	10,50	288,35
Storvatnet	31,31	1,81	33,11
Tunevannet	41,64	2,49	44,13

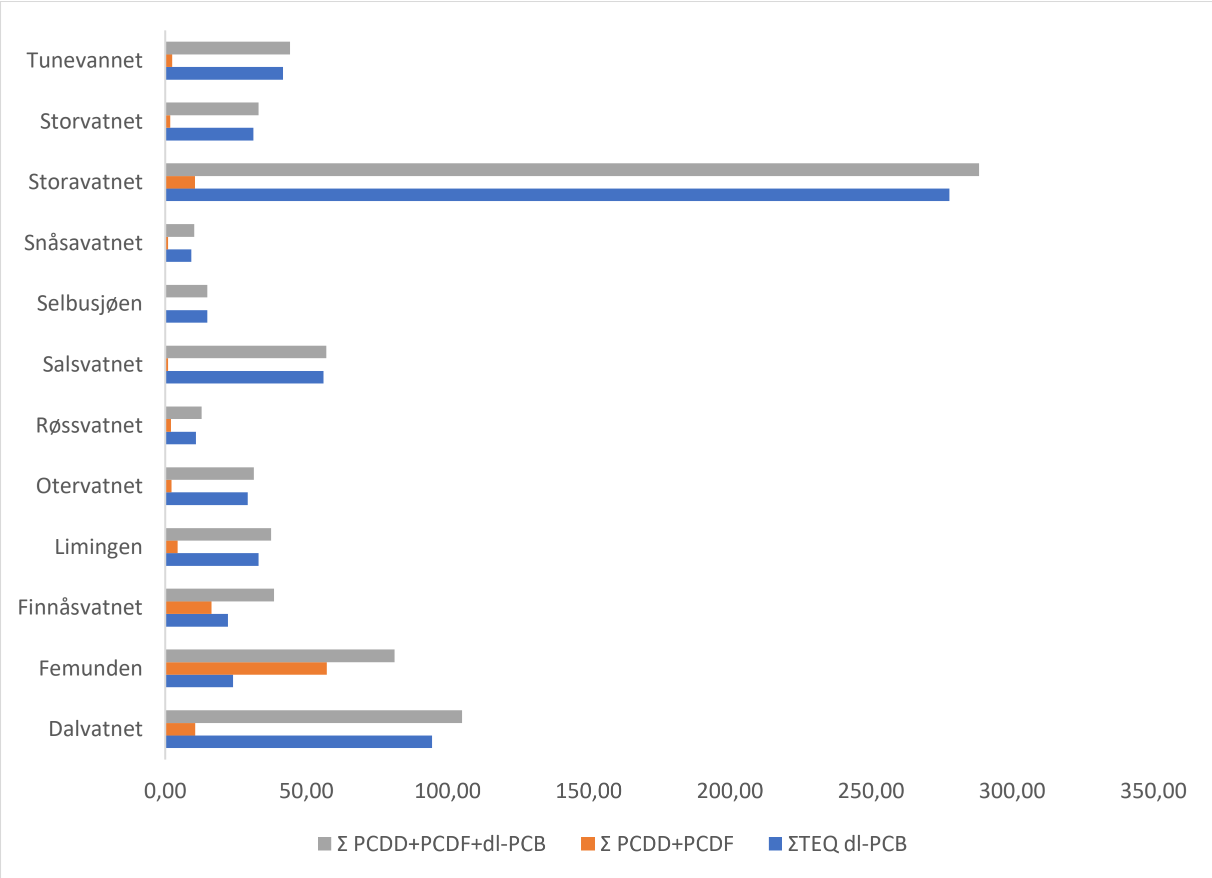

Figure 4: Mean lipid weight TEQ (pg/g TEQ lw) values of Σdl-PCB, ΣPCDD+PCDF and ΣPCDD+PCDF+dl-PCB in fish from each lake.

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 5. 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 Storvatnet followed by Lake Dalvatnet. 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]anthracen did not exceed the EQS in any of the lakes. The ability of fish to metabolize PAH makes it difficult to make certain conclusions about exposure based on fish tissue levels.

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

Lake	Naphthalene	Anthracene	Fluoranthene	Benzo[a]pyrene	Benz(a)anthracen
Dalvatnet	0,71	0,28	0,13	0,02	ND
Femunden	0,58	0,24	0,11	0,02	ND
Finnåsvatnet	0,83	0,28	0,13	0,02	ND
Limingen	0,67	0,22	0,12	0,02	ND
Otervatnet	0,65	0,29	0,15	0,02	ND
Røssvatnet	0,37	0,27	0,14	0,02	ND
Salsvatnet	0,59	0,29	0,16	0,02	ND
Selbusjøen	0,74	0,37	0,22	0,02	ND
Snåsavatnet	0,56	0,41	0,24	0,02	ND
Storavatnet	0,61	0,43	0,20	0,02	ND
Storvatnet	0,81	0,34	0,17	0,02	ND
Tunevannet	0,47	0,41	0,16	0,02	ND

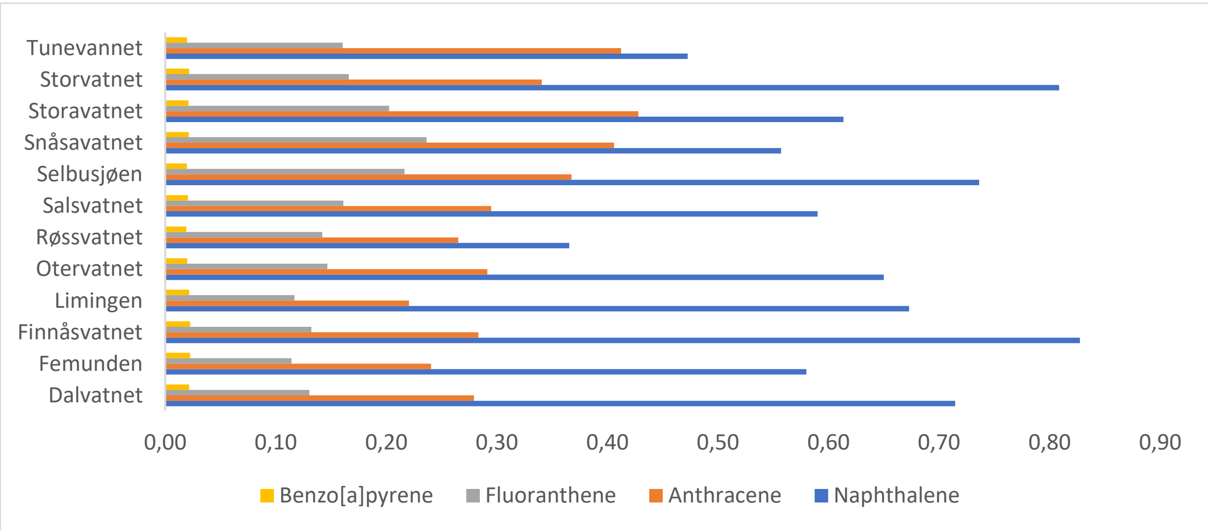

Figure 5: Mean wet weight concentrations (µg/kg ww) of Naphthalene, Anthracene, Fluoranthene and Benzo[a]pyrene.

3.1.6 **Per- and polyfluorinated Compounds (PFAS)**

The mean wet weight (ww) concentrations of 11 different PFAS in fish from each lake are given in tables 10 and 11 and in figures 6 and 7. The mean ww concentrations of the sum of the 11 PFAS are given table 12 and figure 8. The highest concentrations of PFOS were detected in Lake Tunevannet (17 µg/kg ww) followed by Lake Salsvatnet (7 µg/kg ww). The sum of PFAS (∑PFAS) were highest in Lake Tunevannet (26 µg/kg ww) followed by Lake Salsvatnet (18 µg/kg ww) and Lake Femunden (14 µg/kg ww). Except for PFOS, the long chained PFASs, PFDoDA, PFUnDA, PFTrDA were the individual PFASs 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).

Out of all PFASs detected in the environment, EU has established EQS for only PFOS (9.1 µg/kg ww) but not for PFOA. Norway has also established an EQS for PFOA (91 µg/kg ww). In this survey, no lakes had PFOS levels which exceeded the EQS, whereas the concentrations of PFOA wer below LOD in all lakes.

Table 10: Mean wet weight concentrations of (µg/kg ww) 6 individual PFASs in fish from each lake.

Lake	PFOS	PFDA	PFTeDA	PFDoDA	PFUnDA	PFTrDA
Dalvatnet	2,20	0,43	ND	0,33	0,99	0,67
Femunden	1,25	0,82	0,65	1,58	3,36	5,01
Finnåsvatnet	2,07	0,27	0,43	0,49	0,74	1,78
Limingen	0,99	0,60	0,26	0,43	1,22	0,93
Otervatnet	0,33	0,40	ND	0,30	1,05	0,49
Røssvatnet	1,86	0,52	0,30	0,34	0,99	0,56
Salsvatnet	6,85	1,24	0,42	1,27	3,95	2,63
Selbusjøen	1,53	0,63	0,22	0,81	1,53	1,45
Snåsavatnet	2,76	0,99	ND	0,27	1,18	0,39
Storavatnet	3,49	0,53	0,96	0,82	1,55	4,17
Storvatnet	1,75	0,72	ND	0,25	1,21	0,44
Tunevannet	16,96	2,52	0,20	0,89	3,36	1,27

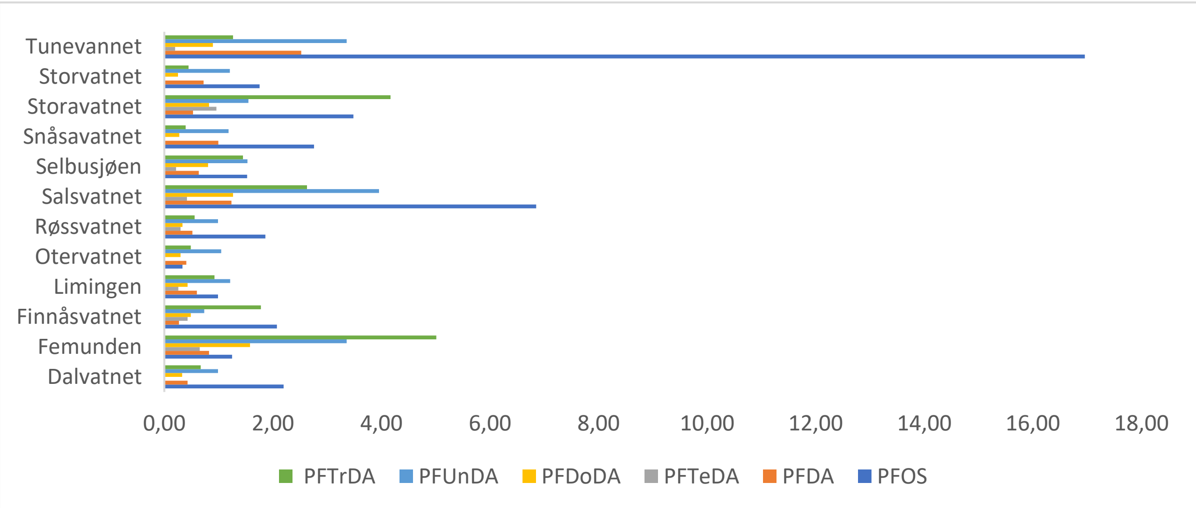

Figure 6: Mean wet weight concentrations (µg/kg ww) of 6 individual PFAS in fish from each lake

Table 11: Mean wet weight concentrations (µg/kg ww) of 5 individual PFASs in fish from each lake. Under the detection limit= not detected (nd).

Lake	PFOA	FOSA	PFNA	PFHxA	PFHpA
Dalvatnet	ND	0,18	0,43	ND	ND
Femunden	ND	0,82	0,40	ND	ND
Finnåsvatnet	ND	0,95	0,21	ND	ND
Limingen	ND	0,50	0,56	ND	ND
Otervatnet	ND	0,79	0,30	ND	ND
Røssvatnet	ND	0,53	0,72	ND	ND
Salsvatnet	ND	1,01	0,50	ND	ND
Selbusjøen	ND	2,43	0,52	ND	ND
Snåsavatnet	ND	0,96	1,83	ND	ND
Storavatnet	ND	0,60	0,22	ND	ND
Storvatnet	ND	0,46	1,08	ND	ND
Tunevannet	ND	0,53	0,58	ND	ND

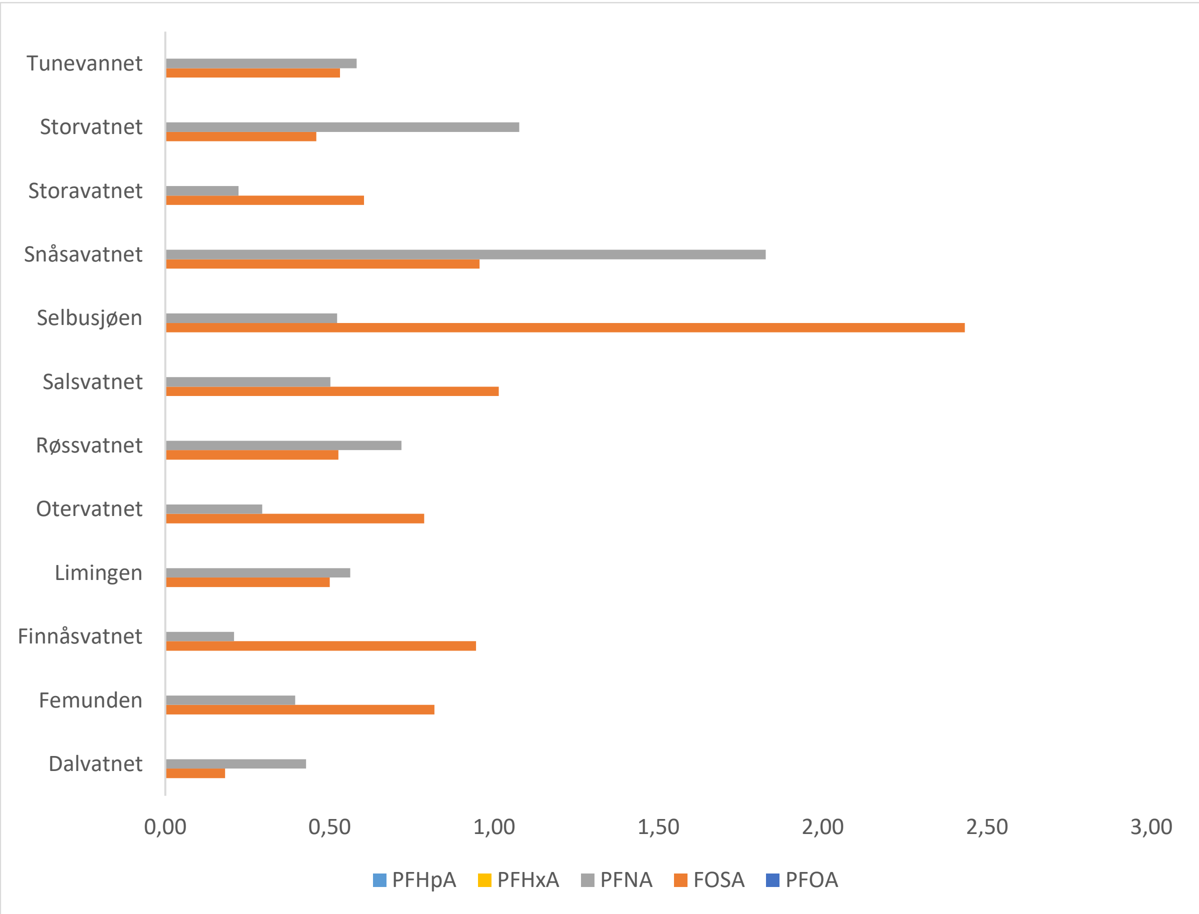

Figure 7: Mean wet weight concentrations (µg/kg ww) of 5 individual PFASs in fish from each lake.

Table 12: Mean wet weight concentrations (µg/kg ww) of the sum of 11 PFASs in fish from each lake.

Lake	∑PFAS
Dalvatnet	5,24
Femunden	13,89
Finnåsvatnet	6,86
Limingen	4,97
Otervatnet	3,65
Røssvatnet	5,60
Salsvatnet	17,87
Selbusjøen	9,12
Snåsavatnet	8,30
Storavatnet	12,34
Storvatnet	5,92
Tunevannet	26,25

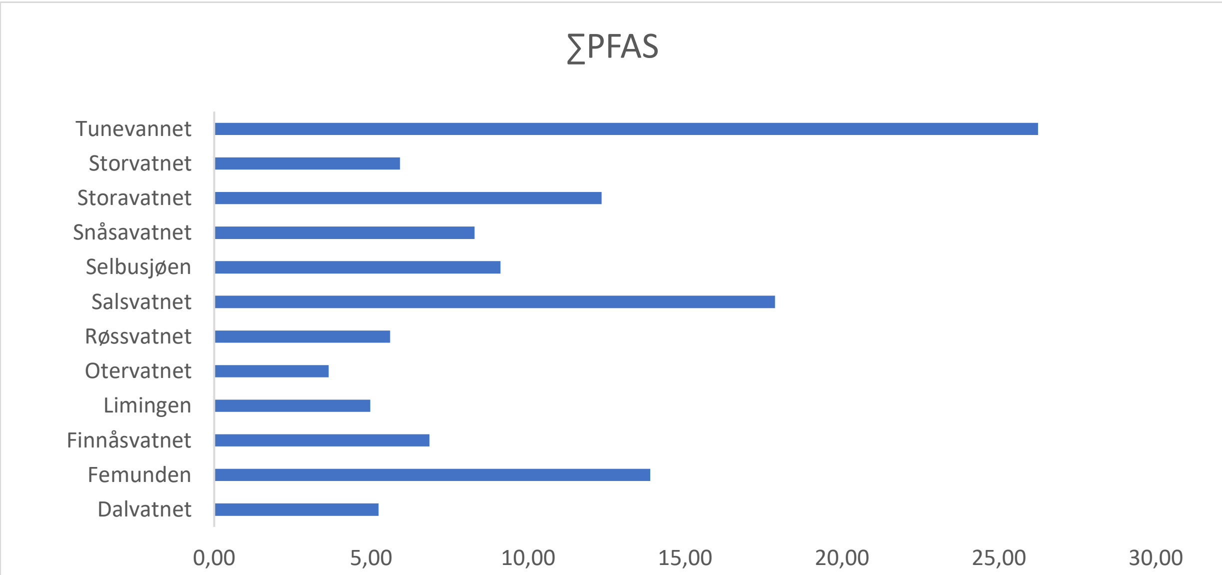

Figure 8: Mean wet weight (µg/kg ww) concentrations of the sum of 11 PFASs in fish from each lake.

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 9. The detection limit for 4-tert-octylphenol was 0,011 µg/kg, which is higher than the EQS (0,004 µg/kg).

The levels of nonylphenols were within the range previously seen in the program, but this component was observed in relatively higher part of the lakes in 2020 compared to previous years. For example in 2019 and 2018, the LOD was 1.5 and 4.0 respectively, and this may have reduced the number of lakes with levels in fish above the LOD.

The highest level of p-nonylphenol was detected in Lake Otervatnet (20 µg/kg ww) followed by Lake Dalvatnet (13 µg/kg ww) and Lake Salsvatnet (12 µg/kg ww).

The highest level of 4-tert-octylphenol was detected in Lake Dalvatnet (1.55 µg/kg ww) followed by Lake Storvatnet (1.34 µg/kg ww) and Lake Otervatnet (1.30 µg/kg ww).

The EQS for 4-tert-octylfenol (0.004 µg/kg ww) was exceeded in fish liver samples from 10 out the 12 study lakes, whereas the levels of p-nonylfenol were below the EQS in all lakes.

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

Lake	4-tert-Octylphenol	p-Nonylphenol
Dalvatnet	1,55	13,20
Femunden	0,48	3,78
Finnåsvatnet	0,36	8,52
Limingen	0,15	2,04
Otervatnet	1,30	19,88
Røssvatnet	0,41	6,49
Salsvatnet	0,60	12,00
Selbusjøen	0,58	8,54
Snåsavatnet	0,11	2,87
Storavatnet	0,26	3,89
Storvatnet	1,34	11,42
Tunevannet	0,23	1,63

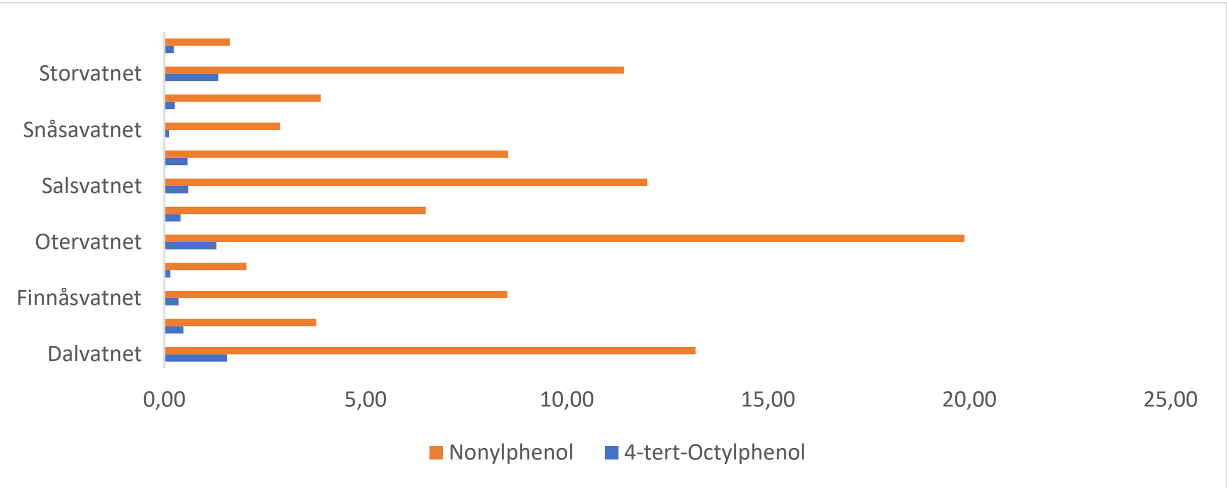

Figure 9: Mean wet weight concentrations (µg/kg) of 4-tert-octylphenol and p-nonylphenol in fish from each lake.

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 10.

The highest concentrations of TPT and TBT was detected in Lake Storavatnet and Lake Tunevannet. However, the levels of TPT and TBT did not exceed the EQS for these contaminants 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	TBT	DBT	MBT	TPT	DPT	MPT
Dalvatnet	0,13	0,09	0,08	0,01	0,001	0,01
Femunden	0,08	0,08	0,04	0,19	0,006	0,01
Finnåsvatnet	0,35	0,32	0,07	0,05	0,006	0,01
Limingen	0,11	0,12	0,07	0,03	0,002	0,01
Otervatnet	0,15	0,06	0,05	0,07	0,002	0,01
Røssvatnet	0,14	0,08	0,10	0,09	0,005	0,01
Salsvatnet	0,13	0,07	0,04	0,19	0,008	0,01
Selbusjøen	0,13	0,07	0,05	0,08	0,003	0,01
Snåsavatnet	0,14	0,08	0,05	0,05	0,003	0,02
Storavatnet	0,53	0,35	0,22	2,98	0,033	0,07
Storvatnet	0,13	0,09	0,06	0,13	0,012	0,01
Tunevannet	0,53	0,16	0,12	2,95	0,238	0,04

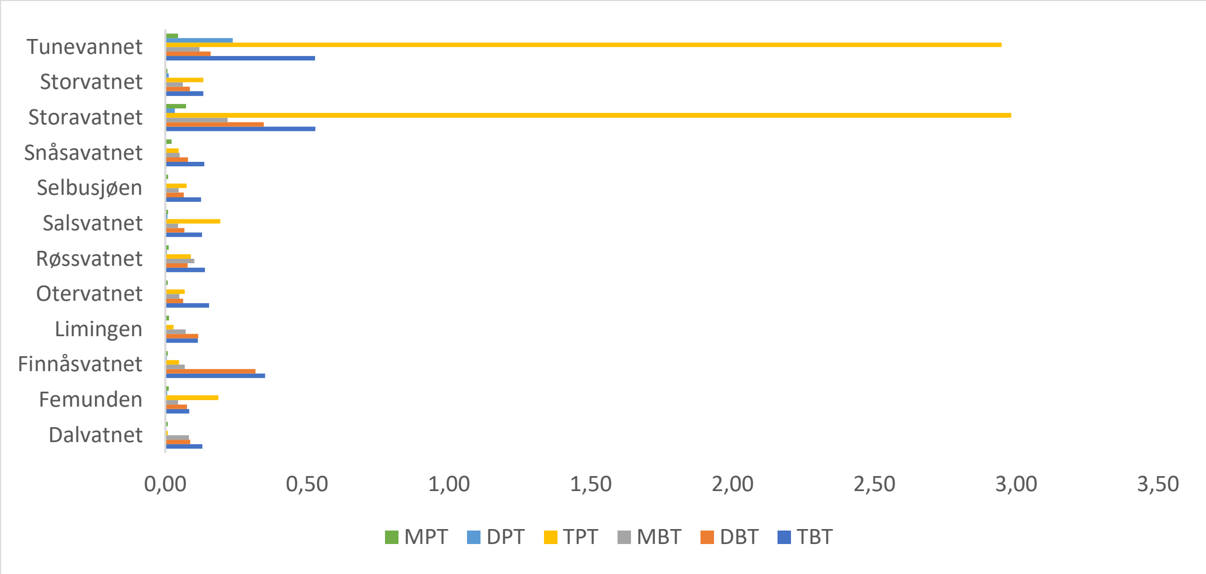

Figure 10: Mean wet weight concentrations (µg/kg) of organotins in fish from each lake.

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 11.

The highest level of siloxane (D5) was detected in Lake Salsvatnet (2.68 µg/kg ww) followed by Lake Otervatnet (2.48 µg/kg ww) and Lake Storevatnet (2.29 µg/kg ww). The levels of D5 were lower than EQS in fish from all the lakes.

The levels of triclosan ranged from 0.11 to 0.45 µg/kg ww and the highest concentration was detected in in Lake Limingen. The levels of Triclosan did not exceed the EQSs in any of the lakes.

The levels of dicofol ranged from 1.1 to 3.3 µg/kg ww and the highest concentration was detected in in Lake Dalvatnet. The levels of Dicofol did not exceed the EQSs in any of the lakes.

The levels of SCCPs ranged from 1.71 µg/kg in Lake Femunden to 2.67 µg/kg in Lake Storvatnet. The levels of MCCPs ranged from 2.92 µg/kg in Lake Selbusjøen to 6.43 µg/kg in Lake Storvatnet. These levels 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 similar to the corresponding levels in freshwater fish in the same program from 2019. 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 (C10-13)	MCCPs (C14-17)
Dalvatnet	2,24	0,17	3,28	1,87	3,36
Femunden	1,77	0,16	2,80	1,71	3,04
Finnåsvatnet	2,27	0,20	2,17	2,00	3,61
Limingen	2,04	0,45	2,59	2,24	3,33
Otervatnet	2,48	0,18	2,36	2,52	3,76
Røssvatnet	1,77	0,22	2,21	2,12	3,96
Salsvatnet	2,68	0,26	1,77	2,23	5,71
Selbusjøen	2,06	0,19	2,80	1,94	2,92
Snåsavatnet	2,10	0,15	2,74	2,55	4,66
Storavatnet	1,62	0,13	2,80	2,14	5,23
Storvatnet	2,29	0,23	1,98	2,67	6,43
Tunevannet	1,79	0,11	1,08	1,86	3,58

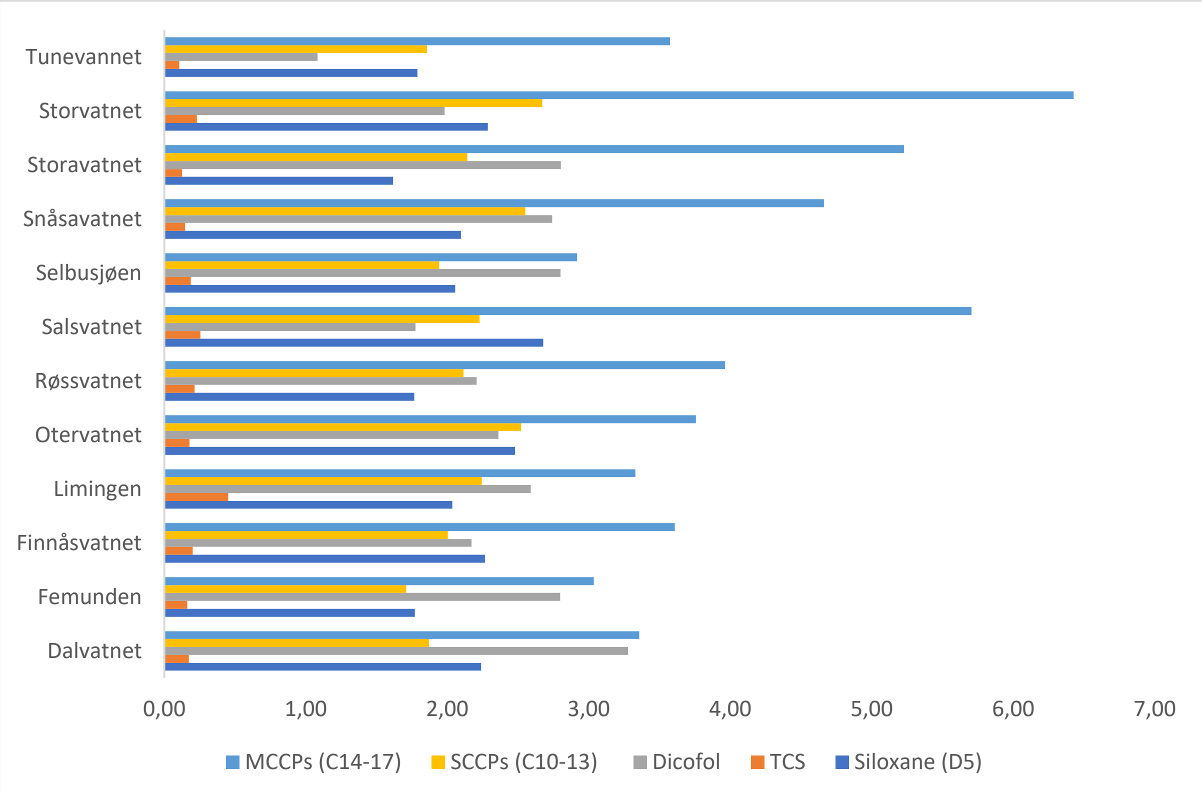

Figure 11: Mean wet weight concentrations (µg/kg) of D5, TCS, Dicofol, SCCPs and MCCPs

3.1.10 Hexachlorobutadien (HCBD), Trichlorobenzene (TCBs), Pentachlorophenol (PCP) and TCEP (Tris(2-chloroethyl)phosphate)

The mean wet weight concentrations of Hexachlorobutadien (HCBD), Trichlorobenzene (TCBs). Pentachlorophenol (PCP) and TCEP (Tris(2-chloroethyl)phosphate) in fish from each lake are given in table 16 and figure 12.

The levels of HBCD ranged from 0.003 to 0.008 µg/kg ww and the highest level of HCBD was detected in Lake Limingen. The levels of PCP ranged from 0.20 to 0.61 µg/kg ww and the highest level of PCP was detected in Lake Storavatnet. The levels of TCBs ranged from 0.01 to 0.02 µg/kg ww. The levels of TCEP ranged from 0.02 to 0.05 µg/kg ww and the highest level of TCEP was detected in Lake Tunevannet.

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
Dalvatnet	0,004	0,02	0,66	0,03
Femunden	0,004	0,02	0,46	0,02
Finnåsvatnet	0,005	0,02	0,20	0,02
Limingen	0,008	0,02	0,51	0,02
Otervatnet	0,003	0,02	0,54	0,02
Røssvatnet	0,003	0,02	0,46	0,04
Salsvatnet	0,003	0,01	0,24	0,02
Selbusjøen	0,004	0,02	0,51	0,03
Snåsavatnet	0,003	0,01	0,52	0,04
Storavatnet	0,004	0,02	0,61	0,06
Storvatnet	0,005	0,02	0,47	0,02
Tunevannet	0,003	0,02	0,52	0,05

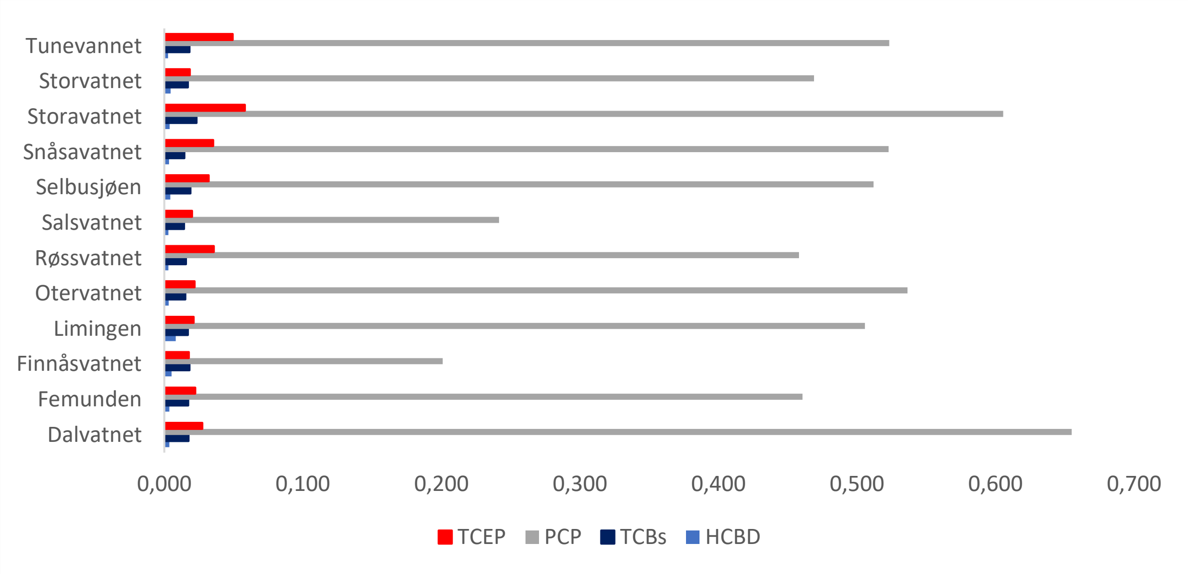

Figure 12: Mean wet weight concentration (µg/kg) of HBCD, TCBs, PCP and TCEP in fish from each lake.

3.1.11 Bis (2-ethylhexyl) phthalate (DEHP)

The mean wet weight (ww) and lipid weight (iw) concentrations of Bis (2-ethylhexyl) phthalate (DEHP) in fish from each lake are given in table 17 and the ww concentration are shown in figure 13.

The wet weight levels of DEHP ranged from 23 to 92 µg/kg and the highest concentration was detected Lake Dalvatnet followed by Lake Storvatnet. The levels of DEHP in fish were lower than the EQSs for this contaminant in all the lakes.

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

Lake	DEHP ww	DEHP lw
Dalvatnet	92	2618
Femunden	30	1184
Finnåsvatnet	27	744
Limingen	35	953
Otervatnet	30	994
Røssvatnet	49	1616
Salsvatnet	23	899
Selbusjøen	23	777
Snåsavatnet	41	1549
Storavatnet	61	5227
Storvatnet	27	1016
Tunevannet	27	1003

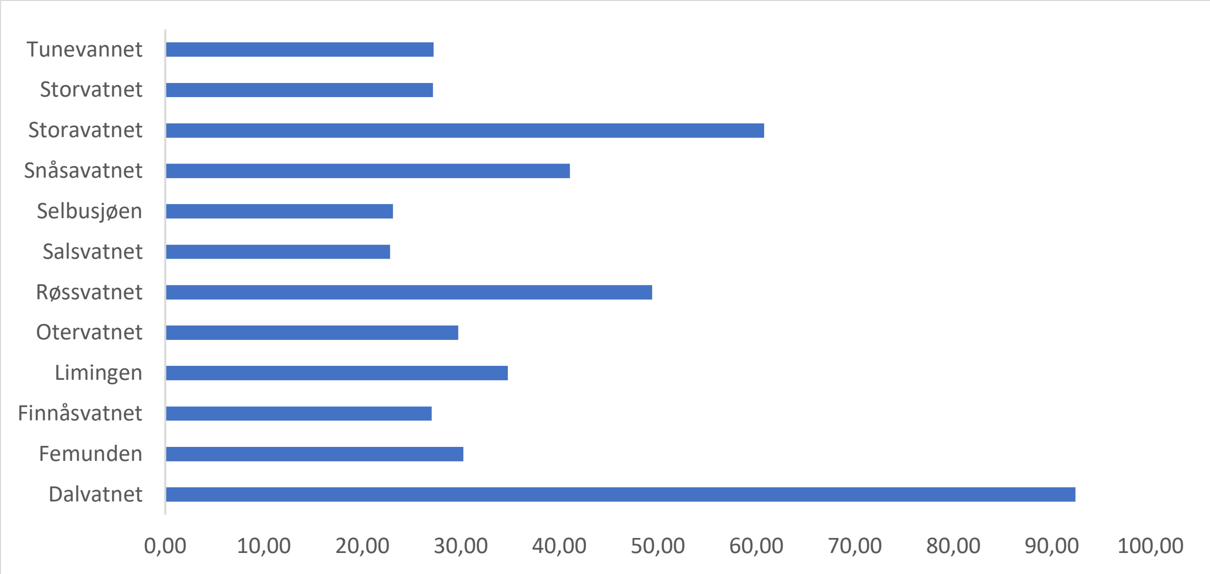

Figure 13. Mean wet weight concentrations of DEHP

3.1.12 Metals

The mean wet weight concentrations of Aluminum (Al) 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 Silver (Ag), Chromium (Cr) Molybdenum (Mo), Cobalt (Co), Lithium (Li), Nickel (Ni) 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 ranged from 53 to 607 µg/kg ww and were highest in Lake Storavatnet (607 µg/kg ww) followed by Lake Finnsåsvatnet (357 µg/kg ww) and Lake Salsvatnet (353 µg/kg ww).

The levels of Cd in liver ranged from 31 to 1243 µg/kg ww was highest in Lake Storavatnet (1243 µg/kg ww) followed by Lake Otervatnet (570 µg/kg ww) and Lake Dalvatnet (513 µg/kg ww).

The levels of Pb ranged from 6 to 69 with the highest concentration detected in Storavatnet

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

EU has not established an EQS for Cd and Pb in biota.

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

Lake	Al	Mg	Fe	Cu	Zn	Se
Dalvatnet	2033	216667	206667	4767	28333	3867
Femunden	2100	153333	196667	69000	40000	2433
Finnåsvatnet	950	216667	90333	29000	46000	6767

Limingen	10867	173333	366667	24000	37000	3900
Otervatnet	2567	163333	196667	250000	42333	16567
Røssvatnet	4800	200000	293333	20900	37000	2573
Salsvatnet	2800	156667	156667	153333	35333	21667
Selbusjøen	16323	163333	206667	114333	41333	6767
Snåsavatnet	6367	173333	203333	207000	33667	4933
Storavatnet	2500	173333	130667	68667	49000	16100
Storvatnet	543	190000	84000	55333	34667	7133
Tunevannet	1297	233333	43500	1400	25667	1100

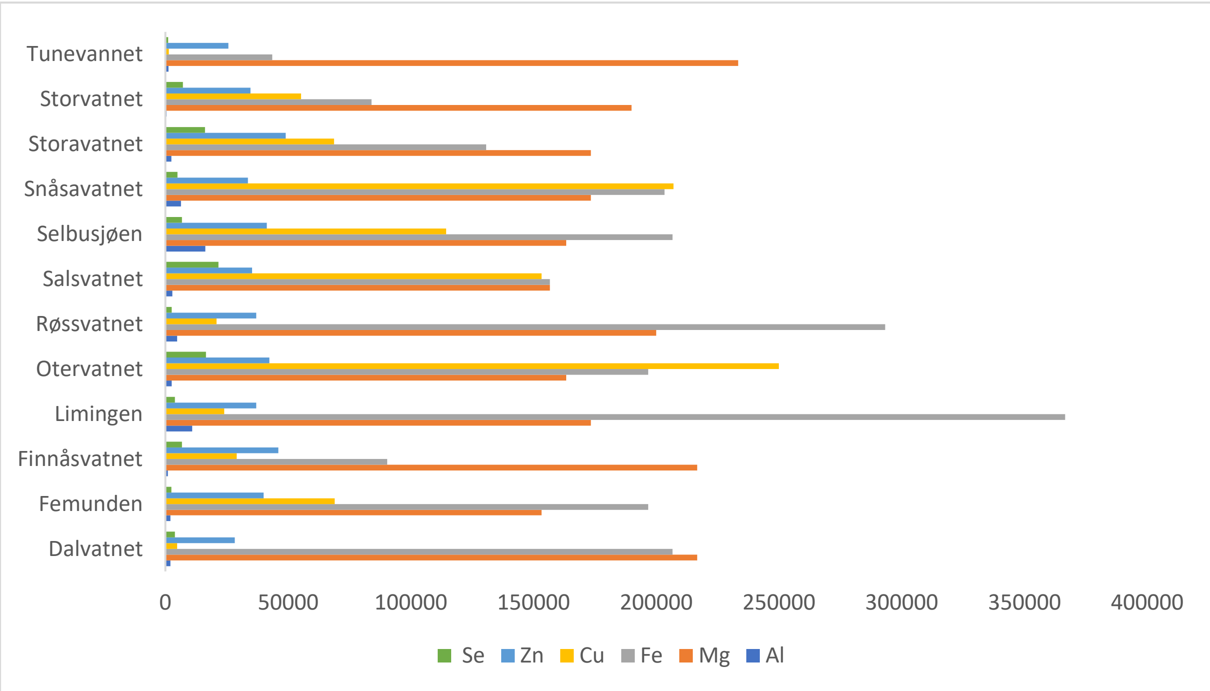

Figure 13: Mean wet weight concentration (µg/kg) of Mg, Fe, Cu, Zn and Se in fish from each lake.

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

Lake	Ag	Cr	Co	Li	Mo	Ni	V
Dalvatnet	21	11	193	3	140	183	12
Femunden	1067	14	29	ND	110	56	9
Finnåsvatnet	1667	20	55	ND	150	19	13
Limingen	357	25	150	11	173	38	30
Otervatnet	163	14	287	ND	167	723	203
Røssvatnet	256	22	140	3	113	43	24
Salsvatnet	3400	ND	2547	ND	207	22	30
Selbusjøen	943	141	187	10	187	81	65
Snåsavatnet	2833	48	88	4	163	37	36
Storavatnet	1253	ND	95	ND	200	32	25
Storvatnet	637	ND	25	ND	183	11	ND

Tunevannet	2	11	187	3	113	10	8

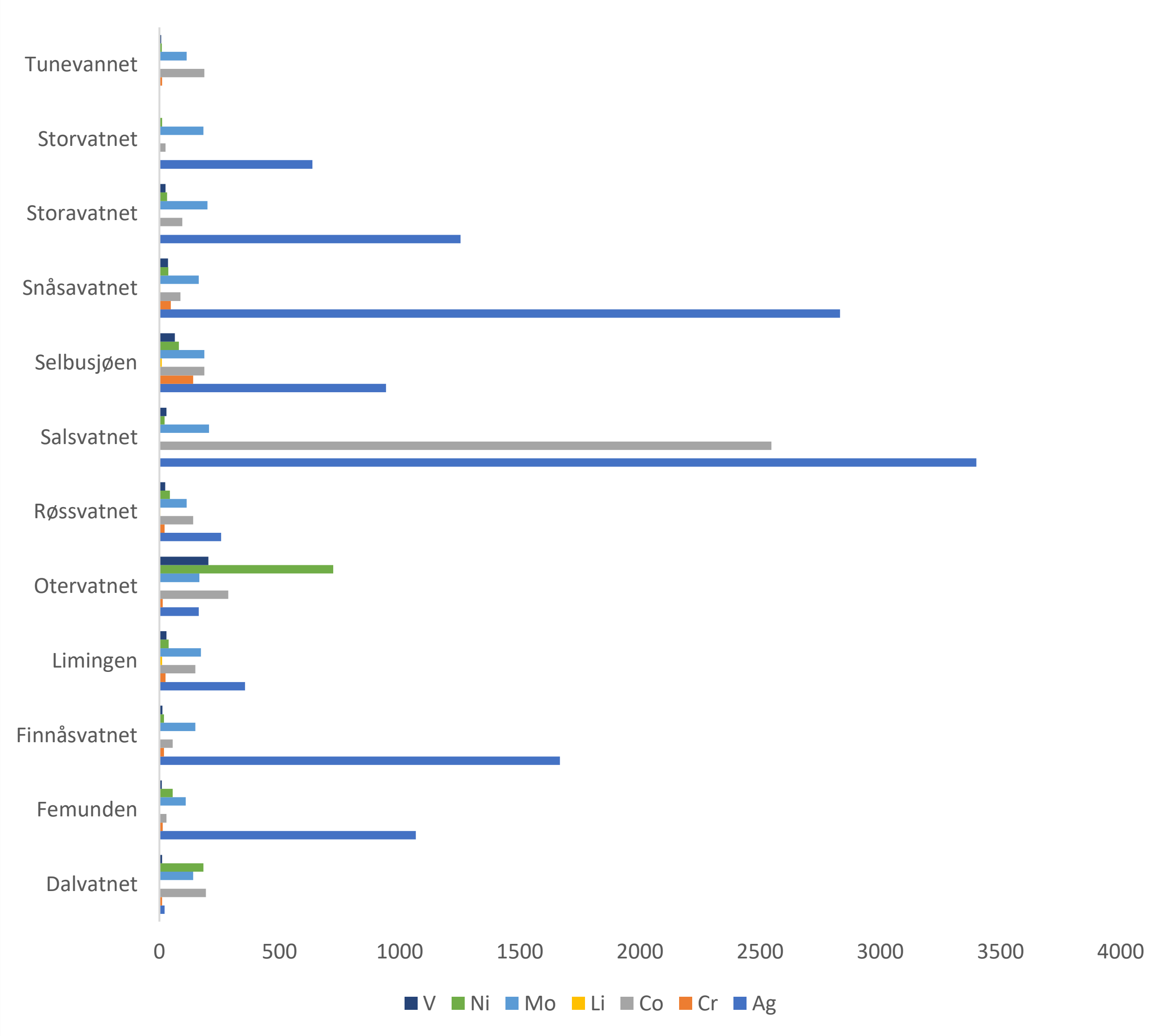

Figure 14: Mean wet weight concentration (µg/kg) of Al, Ag, Mo, V, Ni and Co in fish from each lake.

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	Cd	Pb	Hg liver	Hg muscle
Dalvatnet	27	513	13	103	150
Femunden	8	190	6	133	85
Finnåsvatnet	98	393	71	467	357
Limingen	68	323	8	116	91
Otervatnet	27	570	19	71	80
Røssvatnet	52	154	12	50	53
Salsvatnet	70	423	14	397	353
Selbusjøen	84	139	12	127	118
Snåsavatnet	67	143	16	193	157
Storavatnet	20	1243	69	1373	607
Storvatnet	65	31	ND	203	220

Tunevannet	533	118	10	160	177

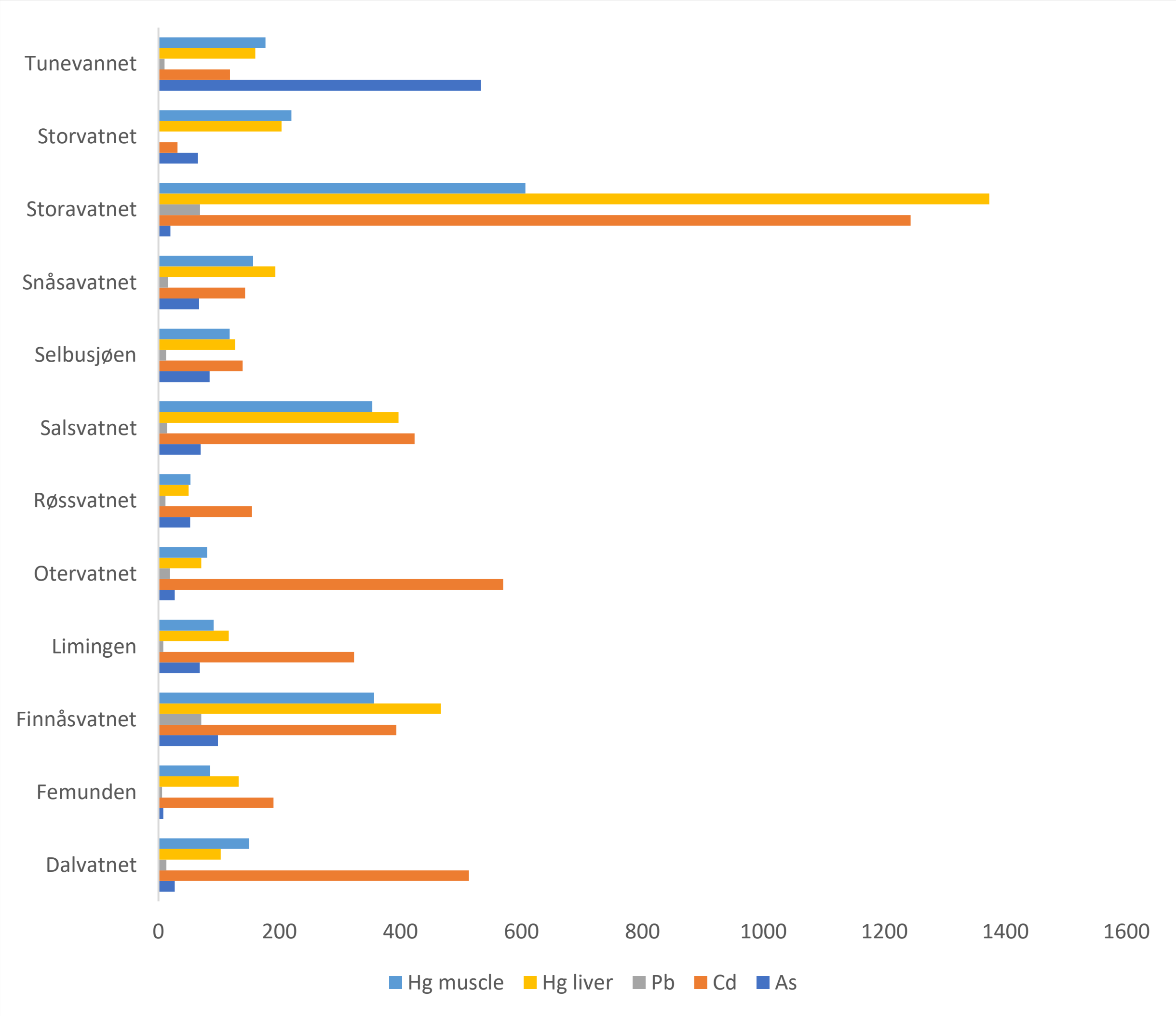

Figure 15: Mean wet weight concentration (µg/kg) of As, Cd, Pb, Hg in liver and Hg in muscle in fish from each lake

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

Table 21- 32: Levels of individual chemicals 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 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 and liver.** Red numbers indicate exceedance of EQS. Metals are given in mg/kg

Total DDTs includes the isomeres 1,1,1-trikloro-2,2 bis (p-klorofenyl) etane (CAS nummer 50-29-3); 1,1,1-trikloro-2 (o-klorofenyl)-2-(p-klorofenyl) etane (CAS nummer 789-02-6); 1,1-dikloro-2,2 bis (p-klorofenyl) etylen (CAS nummer 72-55-9); og 1,1-dikloro-2,2 bis (p-klorofenyl) etan (CAS nummer 72-54-8)

Pentabromodiphenyl ethers (PBDE) includes PBDE- 28, 47, 99, 100, 153 and 154.

Dioxins and dioxin-like PCBs includes 7 polychlorinated dibenzo-p-dioksines (PCDDer):, 1,2,3,7,8-P5CDD (CAS 40321-76-4), 1,2,3,4,7,8- H6CDD (CAS 39227-28-6), 1,2,3,6,7,8- H6CDD (CAS 57653-85-7), 1,2,3,7,8,9-H6CDD (CAS 19408-74-3), 1,2,3,4,6,7,8-H7CDD (CAS 35822-46- 9), 1,2,3,4,6,7,8,9-O8CDD (CAS 3268-87-9) 10 polychlorinated dibenzofuranes (PCDFs): 2,3,7,8-T4CDF (CAS 51207-31-9), 1,2,3,7,8-P5CDF (CAS 57117-41-6), 2,3,4,7,8-P5CDF (CAS 57117-31-4), 1,2,3,4,7,8-H6CDF (CAS 70648-26-9), 1,2,3,6,7,8-H6CDF (CAS 57117-44-9), 1,2,3,7,8,9-H6CDF (CAS 72918- 21-9), 2,3,4,6,7,8-H6CDF (CAS 60851-34-5), 1,2,3,4,6,7,8-H7CDF (CAS 67562-39-4), 1,2,3,4,7,8,9-H7CDF (CAS 55673-89-7), 1,2,3,4,6,7,8,9-O8CDF (CAS 39001-02-0) 12 dioxin-like PCBs (PCB-DL): 3,3',4,4'-T4CB (PCB 77, CAS 32598-13-3), 3,3',4',5-T4CB (PCB 81, CAS 70362- 50-4), 2,3,3',4,4'-P5CB (PCB 105, CAS 32598-14-4), 2,3,4,4',5-P5CB (PCB 114, CAS 74472- 37-0), 2,3',4,4',5-P5CB (PCB 118, CAS 31508-00-6), 2,3',4,4',5'-P5CB (PCB 123, CAS 65510-44-3), 3,3',4,4',5-P5CB (PCB 126, CAS 57465-28-8), 2,3,3',4,4',5-H6CB (PCB 156, CAS 38380-08-4), 2,3,3',4,4',5'-H6CB (PCB 157, CAS 69782-90-7), 2,3',4,4',5,5'-H6CB (PCB 167, CAS 52663-72-6), 3,3',4,4',5,5'-H6CB (PCB 169, CAS 32774-16-6), 2,3,3',4,4',5,5'-H7CB (PCB 189, CAS 39635-31-9).

Table 20: Lake Dalvatnet water code: 247-43280

Chemical(s) Species: Char Tissue: Liver **Fish weight (mean): 446 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.28
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	1.87
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	3.36
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	277
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.24
Endosulfan	115-29-7	370	2.24

Hexachlorobutadien (HBCD)	87-68-3	55	0.00
HCB	A 118-74-1	10	0.15
DDT total		609	1.16
Naphthalene	91-20-3	2400	0.71
Pentachlorophenol (PCP)	87-86-5	180	0.66
Benzo[a]pyrene	50-32-8	5	0.02
Tributyltin (TBT)	36643-28-4	150	0.13
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.03
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.01
PCB7	1336-36-3	0.6	6.20
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	1.18
PBDE	A 32534-81-9	0.0085	0.32
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	2.20
p-nonylphenol	A 84852-15-3	3000	13.20
4-tert- octylphenol	140-66-9	0.004	1.55
Hg (muscle)	A 7439-97-6	20	150
Triclosan	3380-34-5	15217	0.17
Dicofol	115-32-2	33	3.28
Heptachlor	1024-57-3	0.0067	0.09

Table 22: Lake Femunden, water code: 311-82851

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 493 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.24
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	1.71
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	3.04
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	91
Decmethylcyclosiloxane (D5)	541-02-6	15217	1.77
Endosulfan	115-29-7	370	1.77
Hexachlorobutadien (HBCD)	87-68-3	55	0.00

HCB	A 118-74-1	10	ND
DDT total		609	0.74
Naphthalene	91-20-3	2400	0.58
Pentachlorophenol (PCP)	87-86-5	180	0.46
Benzo[a]pyrene	50-32-8	5	0.02
Tributyltin (TBT)	36643-28-4	150	0.08
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.02
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.19
PCB7	1336-36-3	0.6	1.19
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.67
PBDE	A 32534-81-9	0.0085	ND
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	1.25
p-nonylphenol	A 84852-15-3	3000	3.78
4-tert- octylphenol	140-66-9	0.004	0.48
Hg (muscle)	A 7439-97-6	20	85
Triclosan	3380-34-5	15217	0.16
Dicofol	115-32-2	33	2.80
Heptachlor	1024-57-3	0.0067	ND

Table 23: Lake Finnåsvatnet, water code: 043-84829

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean):** 279 **g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.28
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	2.00
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	3.61
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	81
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.27
Endosulfan	115-29-7	370	2.27
Hexachlorobutadien (HBCD)	87-68-3	55	0.01
HCB	A 118-74-1	10	0.05

DDT total		609	1.86
Naphthalene	91-20-3	2400	0.83
Pentachlorophenol (PCP)	87-86-5	180	0.20
Benzo[a]pyrene	50-32-8	5	0.02
Tributyltin (TBT)	36643-28-4	150	0.35
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.02
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.05
PCB7	1336-36-3	0.6	1.75
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.49
PBDE	A 32534-81-9	0.0085	0.44
HBCDD	134237-51-7	167	1.25
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	2.07
p-nonylphenol	A 84852-15-3	3000	8.52
4-tert- octylphenol	140-66-9	0.004	0.36
Hg (muscle)	A 7439-97-6	20	357
Triclosan	3380-34-5	15217	0.20
Dicofol	115-32-2	33	2.17
Heptachlor	1024-57-3	0.0067	ND

Table 24: Lake Limingen, water code: 307-83563

Chemical(s) Species: Trout/Char Tissue: Liver **Fish weight (mean): 465 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.22
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	2.24
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	3.33
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	104
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.04

Endosulfan	115-29-7	370	2.04
Hexachlorobutadien (HBCD)	87-68-3	55	0.01
HCB	A 118-74-1	10	0.03
DDT total		609	0.64
Naphthalene	91-20-3	2400	0.67
Pentachlorophenol (PCP)	87-86-5	180	0.51
Benzo[a]pyrene	50-32-8	5	0.02
Tributyltin (TBT)	36643-28-4	150	0.11
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.02
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.03
PCB7	1336-36-3	0.6	0.99
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.46
PBDE	A 32534-81-9	0.0085	0.17
HBCDD	134237-51-7	167	0.04
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	0.99
p-nonylphenol	A 84852-15-3	3000	2.04
4-tert- octylphenol	140-66-9	0.004	0.15
Hg (muscle)	A 7439-97-6	20	91
Triclosan	3380-34-5	15217	0.45
Dicofol	115-32-2	33	2.59
Heptachlor	1024-57-3	0.0067	0.22

Table 25: Lake Otervatnet, water code: 247-41612

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	0.29
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	2.52
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	3.76
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	89
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.48

Endosulfan	115-29-7	370	2.48
Hexachlorobutadien (HBCD)	87-68-3	55	0.00
HCB	A 118-74-1	10	0.03
DDT total		609	0.25
Naphthalene	91-20-3	2400	0.65
Pentachlorophenol (PCP)	87-86-5	180	0.54
Benzo[a]pyrene	50-32-8	5	0.02
Tributyltin (TBT)	36643-28-4	150	0.15
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.02
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.07
PCB7	1336-36-3	0.6	0.49
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.31
PBDE	A 32534-81-9	0.0085	ND
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	0.33
p-nonylphenol	A 84852-15-3	3000	19.88
4-tert- octylphenol	140-66-9	0.004	1.30
Hg (muscle)	A 7439-97-6	20	80
Triclosan	3380-34-5	15217	0.18
Dicofol	115-32-2	33	2.36
Heptachlor	1024-57-3	0.0067	ND

Table 26: Lake Røssvatnet, water code: 155-83564

Chemical(s) Species: Trout/Char Tissue: Liver **Fish weight (mean): 458 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.27
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	2.12
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	3.96
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	148

Decmethylcyclosiloxane (D5)	541-02-6	15217	1.77
Endosulfan	115-29-7	370	1.77
Hexachlorobutadien (HBCD)	87-68-3	55	0.00
HCB	A 118-74-1	10	0.12
DDT total		609	0.81
Naphthalene	91-20-3	2400	0.37
Pentachlorophenol (PCP)	87-86-5	180	0.46
Benzo[a]pyrene	50-32-8	5	0.02
Tributyltin (TBT)	36643-28-4	150	0.14
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.04
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.09
PCB7	1336-36-3	0.6	0.53
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.13
PBDE	A 32534-81-9	0.0085	0.07
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	1.86
p-nonylphenol	A 84852-15-3	3000	6.49
4-tert- octylphenol	140-66-9	0.004	0.41
Hg (muscle)	A 7439-97-6	20	53
Triclosan	3380-34-5	15217	0.22
Dicofol	115-32-2	33	2.21
Heptachlor	1024-57-3	0.0067	ND

Table 27: Lake Salsvatnet, water code: 140-83566

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 521 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.29
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	2.23
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	5.71
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	68

Decmethylcyclosiloxane (D5)	541-02-6	15217	2.68
Endosulfan	115-29-7	370	2.68
Hexachlorobutadien (HBCD)	87-68-3	55	0.00
HCB	A 118-74-1	10	0.07
DDT total		609	0.95
Naphthalene	91-20-3	2400	0.59
Pentachlorophenol (PCP)	87-86-5	180	0.24
Benzo[a]pyrene	50-32-8	5	0.02
Tributyltin (TBT)	36643-28-4	150	0.13
Trichlorobenzene (TCBs)	12002-48-1	490	0.01
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.02
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.19
PCB7	1336-36-3	0.6	2.15
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.45
PBDE	A 32534-81-9	0.0085	0.51
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	6.85
p-nonylphenol	A 84852-15-3	3000	12.00
4-tert- octylphenol	140-66-9	0.004	0.60
Hg (muscle)	A 7439-97-6	20	353
Triclosan	3380-34-5	15217	0.26
Dicofol	115-32-2	33	1.77
Heptachlor	1024-57-3	0.0067	ND

Table 28: Lake Selbusjøen, water code: 123-43562

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 490 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.37
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	1.94
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	2.92

Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	69
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.06
Endosulfan	115-29-7	370	2.06
Hexachlorobutadien (HBCD)	87-68-3	55	0.00
HCB	A 118-74-1	10	0.04
DDT total		609	0.50
Naphthalene	91-20-3	2400	0.74
Pentachlorophenol (PCP)	87-86-5	180	0.51
Benzo[a]pyrene	50-32-8	5	0.02
Tributyltin (TBT)	36643-28-4	150	0.13
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.03
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.08
PCB7	1336-36-3	0.6	0.49
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.16
PBDE	A 32534-81-9	0.0085	0.07
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	1.53
p-nonylphenol	A 84852-15-3	3000	8.54
4-tert- octylphenol	140-66-9	0.004	0.58
Hg (muscle)	A 7439-97-6	20	118
Triclosan	3380-34-5	15217	0.19
Dicofol	115-32-2	33	2.80
Heptachlor	1024-57-3	0.0067	0.07

Table 29: Lake Snåsavatnet, water code: 128-83565

Chemical(s) Speciest: Trout Tissue: Liver **Fish weight (mean): 438 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.41
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	2.55
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	4.66

Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	123
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.10
Endosulfan	115-29-7	370	2.10
Hexachlorobutadien (HBCD)	87-68-3	55	0.00
HCB	A 118-74-1	10	0.02
DDT total		609	0.57
Naphthalene	91-20-3	2400	0.56
Pentachlorophenol (PCP)	87-86-5	180	0.52
Benzo[a]pyrene	50-32-8	5	0.02
Tributyltin (TBT)	36643-28-4	150	0.14
Trichlorobenzene (TCBs)	12002-48-1	490	0.01
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.04
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.05
PCB7	1336-36-3	0.6	0.50
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.10
PBDE	A 32534-81-9	0.0085	ND
HBCDD	134237-51-7	167	0.19
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	2.76
p-nonylphenol	A 84852-15-3	3000	2.87
4-tert- octylphenol	140-66-9	0.004	0.11
Hg (muscle)	A 7439-97-6	20	157
Triclosan	3380-34-5	15217	0.15
Dicofol	115-32-2	33	2.74
Heptachlor	1024-57-3	0.0067	ND

Table 30: Lake Storavatnet, water code: 059-84836

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 476 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.43
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	2.14

Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	5.23
Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	182
Decmethylcyclosiloxane (D5)	541-02-6	15217	1.62
Endosulfan	115-29-7	370	1.62
Hexachlorobutadien (HBCD)	87-68-3	55	0.00
HCB	A 118-74-1	10	0.03
DDT total		609	7.71
Naphthalene	91-20-3	2400	0.61
Pentachlorophenol (PCP)	87-86-5	180	0.61
Benzo[a]pyrene	50-32-8	5	0.02
Tributyltin (TBT)	36643-28-4	150	0.53
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.06
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	2.98
PCB7	1336-36-3	0.6	13.18
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.70
PBDE	A 32534-81-9	0.0085	4.83
HBCDD	134237-51-7	167	0.14
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	3.49
p-nonylphenol	A 84852-15-3	3000	3.89
4-tert- octylphenol	140-66-9	0.004	0.26
Hg (muscle)	A 7439-97-6	20	607
Triclosan	3380-34-5	15217	0.13
Dicofol	115-32-2	33	2.80
Heptachlor	1024-57-3	0.0067	ND

Table 31: Lake Storvatnet, water code: 194-38203

Chemical(s) Species: Trout Tissue: Liver **Fish weight (mean): 699 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.34
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	2.67
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	6.43

Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	82
Decmethylcyclosiloxane (D5)	541-02-6	15217	2.29
Endosulfan	115-29-7	370	2.29
Hexachlorobutadien (HBCD)	87-68-3	55	0.00
HCB	A 118-74-1	10	0.06
DDT total		609	0.59
Naphthalene	91-20-3	2400	0.81
Pentachlorophenol (PCP)	87-86-5	180	0.47
Benzo[a]pyrene	50-32-8	5	0.02
Tributyltin (TBT)	36643-28-4	150	0.13
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.02
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	0.13
PCB7	1336-36-3	0.6	1.64
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.37
PBDE	A 32534-81-9	0.0085	ND
HBCDD	134237-51-7	167	ND
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	1.75
p-nonylphenol	A 84852-15-3	3000	11.42
4-tert- octylphenol	140-66-9	0.004	1.34
Hg (muscle)	A 7439-97-6	20	220
Triclosan	3380-34-5	15217	0.23
Dicofol	115-32-2	33	1.98
Heptachlor	1024-57-3	0.0067	ND

Table 32: Lake Tunevannet, water code: 002-28291

Chemical(s) Species: Perch Tissue: Liver **Fish weight (mean): 711 g**	CAS-nr.[1]	EQS (µg/kg ww)	Mean measured concentration
Anthracene	120-12-7	2400	0.41
Short-Chain (SCCPs) Chlorinated Paraffins	85535-84-8	6000	1.86
Medium-Chain Chlorinated Paraffins (MCCPs)	85535-26-1	170	3.58

Bis (2-etylheksyl) phthalate (DEHP)	117-81-7	2900	82
Decmethylcyclosiloxane (D5)	541-02-6	15217	1.79
Endosulfan	115-29-7	370	1.79
Hexachlorobutadien (HBCD)	87-68-3	55	0.00
HCB	A 118-74-1	10	ND
DDT total		609	3.39
Naphthalene	91-20-3	2400	0.47
Pentachlorophenol (PCP)	87-86-5	180	0.52
Benzo[a]pyrene	50-32-8	5	0.02
Tributyltin (TBT)	36643-28-4	150	0.53
Trichlorobenzene (TCBs)	12002-48-1	490	0.02
Tris(2-chloroethyl) phosphate (TCEP)	115-96-8	7304	0.05
Diflubenzuron	35367-38-5	730	ND
Teflubenzuron	83121-18.0	609	ND
Triphenyltin	892-20-6	152	2.95
PCB7	1336-36-3	0.6	5.65
Dioxins and dioxin-like PCBs		6.5 pg/gTEQ	0.40
PBDE	A 32534-81-9	0.0085	0.24
HBCDD	134237-51-7	167	0.07
PFOA	3825-261	91.3	ND
PFOS	1763-21-1	9.1	16.96
p-nonylphenol	A 84852-15-3	3000	1.63
4-tert- octylphenol	140-66-9	0.004	0.23
Hg (muscle)	A 7439-97-6	20	177
Triclosan	3380-34-5	15217	0.11
Dicofol	115-32-2	33	1.08
Heptachlor	1024-57-3	0.0067	ND

5. Discussion

The levels of environmental pollutants measured in fish liver from 12 Norwegian lakes sampled in 2020, were compared with previous findings in Norwegian and other European lakes, and the environmental quality standards (EQS) set by Norwegian water regulations (Vannforskriften) (table 21-34). The wet weight concentrations of PCB7 and PBDEs in fish liver exceed EQS in 8 and 7 of the 12 lakes respectively. The concentration of PCB_7 ranged from 0.5 in Otervatnet to 13 µg/kg in Storavatnet. Lake Sælbusjøen, Lake Snåsavatnet and Lake Røssvatnet had levels below the EQS (0.6 µg/kg) for PCBs. The PBDE congeners (28,47, 99, 100, 153 and 154) are the same as the EQS congeners (EU Directive 2000/60/EC). The concentration of ΣPBDEs ranged from LOD (0.36 µg/kg) to 5 µg/kg and Lake Femunden, Lake

Otervatnet, Lake Selbusjøen and Lake Storvatnet had levels above the EQS (0.0085 µg/kg) for ΣPBDEs.

In a time-trend study from Swedish lakes, the levels of PCB 153 in 2015 were around 10 ng/g lipid ww in arctic char, 20-40 ng/g in perch, and 100-200 ng/g in pike (Faxneld et al 2019). This is higher than the corresponding levels in the lakes from the present study. Fish from some lakes, such as Lake Storavatnet and Lake Tunevannet, had relatively high levels of PCBs. This could be a result of large fish size, because fish from these lakes had the highest weight (Table 1). For both these lakes, it can be seen that also DDE and PBDEs are relatively high. The levels of PCBs were not as high as some of the previous findings from the present program, such as Lake Setervannet (Lyche et al., 2018a), and the levels of PBDEs were lower than in Lake Mjøsa (Fjeld et al., 2015). In a German study, published in 2018, PBDEs exceeded the EQS in all fish (Fliedner et al., 2018). The German fish contained levels which were about four times higher than the mean levels 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.

Norwegian water regulation (Vannforskriften) has established EQS for the organochlorine pesticides, endosulfan, HCB and heptachlor. The EQSs for heptachlor (0.0067 µg/kg ww) were exceeded in fish liver from the 3 lakes, which had higher levels than LOD (0.091 µg/kg). Furthermore, the LOD for heptachlor was higher than the EQS indicating that the levels in the other lakes could also be higher than the EQS. Heptachlor was one of the original POPs listed in the Stockholm Convention (chm.pops.int). Primarily it was used to kill soil insects and termites, heptachlor has also been used more widely to kill cotton insects, grasshoppers, other crop pests, and malaria-carrying mosquitoes. Available data on levels of Heptachlor in Norwegian biota is scarce. However one study measured heptachlor epoxide 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 wet w; mean weight 1.6 kg) were higher than the corresponding levels in char from Lake Dalvatnet (0,03 ng/g wet weight) and a combination of trout and char from Lake Limingen (0.22 ng/g wet weight). The results of the present monitoring program from 2020, showed relatively high levels of Heptachlor in Lake Bjørnsund (24 µg/kg lipid weight), which are located nearby the Russian border in Troms and Finnmark not far from Lake Dalvatnet (Lyche et al., 2020).

The concentration of POPs in the study lakes are relatively low compared to some of the lakes in Norway with a location nearer to areas with industrial and human activity, such as Lake Øyeren (Lyche et al., 2018b), Lake Eikeren (Lyche et al., 2018a) and Lake Mjøsa (Fjeld et al., 2015). The concentrations are also relatively low compared to the levels in European freshwater fish (Fliedner et al., 2016; Luigi et al., 2015). The detection limits were lower than the EQS for all the PCBs PBDEs and HBCDDs.

The EQS for mercury were exceeded in all lakes, which is in accordance with the previous results of the present monitoring program (Lyche et al., 2018a,b, 2019, 2020). The same trend was found in a study analyzing mercury levels in fish from all over Europe yearly from 2007 to 2013 (Nguetseng et al., 2015). Except for one lake, the Hg levels exceeded the EQS in all lakes. However, three of the Norwegian lakes had higher values in muscle than the highest level measured in the European survey and, the highest level measured was 607 µg/kg ww (Lake Storavatnet). The mean concentration of Hg (mean 204 µg/kg ww) measured in the muscle in this survey was not far from 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, brown trout, Arctic char), which may explain the higher Hg in the Norwegian lakes. A Swedish study summarized the mercury levels in perch from freshwater 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 concentration of Hg (328 µg/kg ww) in Norwegian lakes measured in fish sampled in 2017 was comparable with the concentration in fish sampled in 2018 but higher than in fish from 2019 (187 µg/kg ww) and 2020 (this study).

EU has not established an EQS for Cd in biota. However, the concentrations ranged from 31 to 1243 µg/kg and relatively high levels were detected in fish from Lake Storavatnet (1343 µg/kg ww) followed by Lake Otervatnet (570 µg/kg ww), Lake Dalvatnet (513 µg/kg ww) and Lake Salsvatnet (423 µg/kg ww). The Cd levels in these lakes, which are 5 – 25 times higher than the mean of the other lakes, may indicate local sources of Cd. Interestingly, Lake Otervatnet and Lake Dalvatnet are located in the same area in Finnmark county not far from the Russian border. The mean concentration of Cd measured (537 µg/kg ww) in fish sampled in 2017 was comparable with the concentration measured (541 µg/kg ww) in fish sampled 2018 and 2019 (538 µg/kg ww) and higher than the present study (354 µg/kg ww). The highest concentration detected in the present study (1343 µg/kg; Lake Storavatnet) were lower than in 2019 (1833 µg/kg; Lake Fjellgardsvatnet), (Lyche et al., 2020), in 2017 (3066 µg/kg ww; Lake Lundevannet), (Lyche et al., 2017) ; and in 2018 (3500 µg/kg ww; Lake Lyseren) (Lyche et al., 2019).

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 3 of the lakes exceeded the MRL for fish meat (500 µg/kg ww), suggesting that eating fish from these lakes may pose a health risk for the consumers.

The EQS for 4-tert-octylphenol was exceeded in fish livers from all study lakes. 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 suggest that the levels of 4-tert-octylphenol in Norwegian (Range: 0.23 – 1.55 µg/kg) and German lakes are within the same range (UKEA. 2006).

For the perfluorinated compounds (PFAS), EU has established EQS only for PFOS, whereas Norway has also established an EQS for PFOA. This study showed that only fish from Lake Tunevannet (17 µg/kg ww,) had PFOS levels which exceeded the EQS (Range: 033-17 µg/kg). However, the PFOA levels were below LOD in all lakes. The highest PFOS level (17 µg/kg ww) in the Norwegian lakes was substantial lower than the levels measured in two fish species in Germany (123 µg/kg ww and 295 µg/kg ww (Becker et a. 2010)), sampled from a highly industrialized area. Previous analyses of fish from the present monitoring program (Lyche et al., 2020) showed that the levels of PFOS in large trout from lake Eikeren were higher (30 µg/kg ww), and the levels in perch from lake Tyrifjorden were much higher (270 µg/kg ww) than the levels in perch from lake Tunevannet. 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 2020 (Fliedner et al., 2016). Compared to the levels in Swedish screening data of PFAS in perch (Åkerblom et al. 2017), the levels in Norwegian freshwater fish seems to be clearly higher.

The fact that the levels of mercury and octylphenol exceed EU EQS in all 12 lakes and PCBs, PBDEs, and PFOS exceeded EQSs in several of the study lakes suggests that concentrations 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 3 lakes exceeded the MRL (500 µg/kg ww), suggesting that eating fish from these lakes may pose a health risk for the consumers.

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7. Attachments, fish data and analytical results

Appendix 1. Species and individual length, weight, lake, water code and capture date of each fish the samples from 1 to 36 analysed in the project from 2020.

Sample	Species	Length (cm)	Weight (g)	Lake	Water code	Capture date (2020)
1	Trout	252	186	Storavatn	059-84836	22.sep
1	Trout	254	180	Storavatn	059-84836	22.sep
1	Trout	254	254	Storavatn	059-84836	22.sep
1	Trout	256	191	Storavatn	059-84836	22.sep
1	Trout	259	190	Storavatn	059-84836	22.sep
1	Trout	260	184	Storavatn	059-84836	22.sep
1	Trout	261	199	Storavatn	059-84836	22.sep
1	Trout	267	185	Storavatn	059-84836	22.sep
1	Trout	268	224	Storavatn	059-84836	22.sep
1	Trout	271	224	Storavatn	059-84836	22.sep
1	Trout	271	183	Storavatn	059-84836	22.sep
1	Trout	272	233	Storavatn	059-84836	22.sep
1	Trout	273	234	Storavatn	059-84836	22.sep
1	Trout	281	247	Storavatn	059-84836	22.sep
2	Trout	285	210	Storavatn	059-84836	22.sep
2	Trout	286	256	Storavatn	059-84836	22.sep
2	Trout	286	240	Storavatn	059-84836	22.sep
2	Trout	286	255	Storavatn	059-84836	22.sep
2	Trout	289	249	Storavatn	059-84836	22.sep
2	Trout	295	233	Storavatn	059-84836	22.sep
2	Trout	298	279	Storavatn	059-84836	22.sep
2	Trout	300	339	Storavatn	059-84836	22.sep
2	Trout	300	261	Storavatn	059-84836	22.sep
2	Trout	318	313	Storavatn	059-84836	22.sep
3	Trout	500	956	Storavatn	059-84836	22.sep
4	Perch	40	1001	Tunevannet	002-28291	24.oct
4	Perch	41	1030	Tunevannet	002-28291	24.oct
4	Perch	40	929	Tunevannet	002-28291	24.oct
4	Perch	41	1007	Tunevannet	002-28291	24.oct
4	Perch	40	967	Tunevannet	002-28291	24.oct
5	Perch	37	764	Tunevannet	002-28291	24.oct
5	Perch	37	728	Tunevannet	002-28291	24.oct
5	Perch	38	763	Tunevannet	002-28291	24.oct
5	Perch	36	710	Tunevannet	002-28291	24.oct
5	Perch	36	697	Tunevannet	002-28291	24.oct
6	Perch	34	521	Tunevannet	002-28291	24.oct
6	Perch	32	428	Tunevannet	002-28291	24.oct
6	Perch	31	379	Tunevannet	002-28291	24.oct
6	Perch	31	372	Tunevannet	002-28291	24.oct
6	Perch	31	362	Tunevannet	002-28291	24.oct

7	Trout	28	214	Røssvatnet	155-83564	01.oct
7	Trout	30	318	Røssvatnet	155-83564	01.oct
7	Trout	35	509	Røssvatnet	155-83564	01.oct
8	Char	34	442	Røssvatnet	155-83564	01.oct
8	Char	38	500	Røssvatnet	155-83564	01.oct
8	Char	39	785	Røssvatnet	155-83564	01.oct
8	Char	41	790	Røssvatnet	155-83564	01.oct
8	Char	42	886	Røssvatnet	155-83564	01.oct
9	Char	34	477	Røssvatnet	155-83564	01.oct
9	Char	35	444	Røssvatnet	155-83564	01.oct
9	Char	32	321	Røssvatnet	155-83564	01.oct
9	Char	30	288	Røssvatnet	155-83564	01.oct
9	Char	27	195	Røssvatnet	155-83564	01.oct
10	Trout	41	584	Limingen	307-83563	26.sep
10	Trout	37	500	Limingen	307-83563	26.sep
10	Trout	35	404	Limingen	307-83563	26.sep
10	Trout	33	338	Limingen	307-83563	26.sep
10	Trout	31	323	Limingen	307-83563	26.sep
11	Char	34	470	Limingen	307-83563	26.sep
11	Char	34	462	Limingen	307-83563	26.sep
11	Char	34	488	Limingen	307-83563	26.sep
11	Char	34	480	Limingen	307-83563	26.sep
11	Char	34	416	Limingen	307-83563	26.sep
12	Char	36	530	Limingen	307-83563	26.sep
12	Char	35	490	Limingen	307-83563	26.sep
12	Char	35	510	Limingen	307-83563	26.sep
12	Char	35	506	Limingen	307-83563	26.sep
12	Char	34	481	Limingen	307-83563	26.sep
13	Trout	36	580	Femunden	311-82851	01.oct
13	Trout	37	589	Femunden	311-82851	01.oct
13	Trout	37	658	Femunden	311-82851	01.oct
13	Trout	37	546	Femunden	311-82851	01.oct
14	Trout	35	509	Femunden	311-82851	01.oct
14	Trout	34	480	Femunden	311-82851	01.oct
14	Trout	35	478	Femunden	311-82851	01.oct
14	Trout	36	477	Femunden	311-82851	01.oct
15	Trout	33	380	Femunden	311-82851	01.oct
15	Trout	32	390	Femunden	311-82851	01.oct
15	Trout	34	450	Femunden	311-82851	01.oct
15	Trout	31	377	Femunden	311-82851	01.oct
16	Trout	40	588	Snåsavatnet	128-83565	15.aug
16	Trout	40	540	Snåsavatnet	128-83565	15.aug
16	Trout	39	530	Snåsavatnet	128-83565	15.aug

16	Trout	39	563	Snåsavatnet	128-83565	15.aug
16	Trout	38	588	Snåsavatnet	128-83565	15.aug
17	Trout	38	535	Snåsavatnet	128-83565	15.aug
17	Trout	37	457	Snåsavatnet	128-83565	15.aug
17	Trout	35	467	Snåsavatnet	128-83565	15.aug
17	Trout	34	378	Snåsavatnet	128-83565	15.aug
17	Trout	34	420	Snåsavatnet	128-83565	15.aug
18	Trout	32	371	Snåsavatnet	128-83565	15.aug
18	Trout	32	361	Snåsavatnet	128-83565	15.aug
18	Trout	31	322	Snåsavatnet	128-83565	15.aug
18	Trout	31	330	Snåsavatnet	128-83565	15.aug
18	Trout	30	289	Snåsavatnet	128-83565	15.aug
18	Trout	29	260	Snåsavatnet	128-83565	15.aug
18	Trout	29	244	Snåsavatnet	128-83565	15.aug
18	Trout	26	230	Snåsavatnet	128-83565	15.aug
19	Trout	48	1158	Selbusjøen	123-43562	15.aug
19	Trout	36	514	Selbusjøen	123-43562	15.aug
19	Trout	36	541	Selbusjøen	123-43562	15.aug
20	Trout	36	480	Selbusjøen	123-43562	15.aug
20	Trout	35	436	Selbusjøen	123-43562	15.aug
20	Trout	35	441	Selbusjøen	123-43562	15.aug
20	Trout	33	389	Selbusjøen	123-43562	15.aug
20	Trout	34	397	Selbusjøen	123-43562	15.aug
21	Trout	31	324	Selbusjøen	123-43562	15.aug
21	Trout	30	282	Selbusjøen	123-43562	15.aug
21	Trout	33	372	Selbusjøen	123-43562	15.aug
21	Trout	31	311	Selbusjøen	123-43562	15.aug
21	Trout	29	235	Selbusjøen	123-43562	15.aug
21	Trout	30	290	Selbusjøen	123-43562	15.aug
21	Trout	31	316	Selbusjøen	123-43562	15.aug
22	Trout	50	1580	Storvatnet	194-38203	19.aug
22	Trout	48	1344	Storvatnet	194-38203	19.aug
22	Trout	42	1030	Storvatnet	194-38203	19.aug
22	Trout	43	1026	Storvatnet	194-38203	19.aug
22	Trout	40	799	Storvatnet	194-38203	19.aug
23	Trout	31	395	Storvatnet	194-38203	19.aug
23	Trout	32	418	Storvatnet	194-38203	19.aug
23	Trout	33	433	Storvatnet	194-38203	19.aug
23	Trout	33	435	Storvatnet	194-38203	19.aug
23	Trout	34	437	Storvatnet	194-38203	19.aug
24	Trout	35	450	Storvatnet	194-38203	19.aug
24	Trout	36	515	Storvatnet	194-38203	19.aug
24	Trout	36	547	Storvatnet	194-38203	19.aug
24	Trout	35	468	Storvatnet	194-38203	19.aug
24	Trout	38	607	Storvatnet	194-38203	19.aug
25	Trout	39	573	Otervatnet	247-41612	28.aug

25	Trout	36	457	Otervatnet	247-41612	28.aug
25	Trout	33	406	Otervatnet	247-41612	28.aug
25	Trout	33	450	Otervatnet	247-41612	28.aug
25	Trout	32	411	Otervatnet	247-41612	28.aug
26	Trout	32	395	Otervatnet	247-41612	28.aug
26	Trout	32	400	Otervatnet	247-41612	28.aug
26	Trout	31	392	Otervatnet	247-41612	28.aug
26	Trout	31	367	Otervatnet	247-41612	28.aug
26	Trout	32	378	Otervatnet	247-41612	28.aug
27	Trout	30	325	Otervatnet	247-41612	28.aug
27	Trout	32	359	Otervatnet	247-41612	28.aug
27	Trout	32	357	Otervatnet	247-41612	28.aug
27	Trout	30	321	Otervatnet	247-41612	28.aug
27	Trout	29	297	Otervatnet	247-41612	28.aug
28	Char	39	773	Dalvatnet	247-43280	27.aug
28	Char	38	618	Dalvatnet	247-43280	27.aug
28	Char	36	560	Dalvatnet	247-43280	27.aug
29	Char	32	424	Dalvatnet	247-43280	27.aug
29	Char	31	414	Dalvatnet	247-43280	27.aug
29	Char	32	443	Dalvatnet	247-43280	27.aug
29	Char	30	407	Dalvatnet	247-43280	27.aug
29	Char	32	430	Dalvatnet	247-43280	27.aug
30	Char	33	380	Dalvatnet	247-43280	27.aug
30	Char	32	349	Dalvatnet	247-43280	27.aug
30	Char	31	286	Dalvatnet	247-43280	27.aug
30	Char	29	270	Dalvatnet	247-43280	27.aug
30	Char	26	213	Dalvatnet	247-43280	27.aug
30	Char	23	147	Dalvatnet	247-43280	27.aug
30	Char	24	202	Dalvatnet	247-43280	27.aug
31	Trout	48	1120	Salvatnet	140-83566	15.jul
31	Trout	43	905	Salvatnet	140-83566	15.jul
31	Trout	39	610	Salvatnet	140-83566	15.jul
31	Trout	40	630	Salvatnet	140-83566	15.jul
31	Trout	38	530	Salvatnet	140-83566	15.jul
32	Trout	37	485	Salvatnet	140-83566	15.jul
32	Trout	36	480	Salvatnet	140-83566	15.jul
32	Trout	37	460	Salvatnet	140-83566	15.jul
32	Trout	37	435	Salvatnet	140-83566	15.jul
32	Trout	36	410	Salvatnet	140-83566	15.jul
33	Trout	33	315	Salvatnet	140-83566	15.jul
33	Trout	34	325	Salvatnet	140-83566	15.jul
33	Trout	37	460	Salvatnet	140-83566	15.jul
33	Trout	34	350	Salvatnet	140-83566	15.jul
33	Trout	32	300	Salvatnet	140-83566	15.jul
34	Trout	32	254	Finnåsvatnet	043-84829	25.sep
34	Trout	31	365	Finnåsvatnet	043-84829	25.sep

34	Trout	29	275	Finnåsvatnet	043-84829	25.sep
34	Trout	38	523	Finnåsvatnet	043-84829	25.sep
34	Trout	32	385	Finnåsvatnet	043-84829	25.sep
35	Trout	27	235	Finnåsvatnet	043-84829	25.sep
35	Trout	27	215	Finnåsvatnet	043-84829	25.sep
35	Trout	30	338	Finnåsvatnet	043-84829	25.sep
35	Trout	29	277	Finnåsvatnet	043-84829	25.sep
35	Trout	30	261	Finnåsvatnet	043-84829	25.sep
35	Trout	27	212	Finnåsvatnet	043-84829	25.sep
36	Trout	27	203	Finnåsvatnet	043-84829	25.sep
36	Trout	26	201	Finnåsvatnet	043-84829	25.sep
36	Trout	27	208	Finnåsvatnet	043-84829	25.sep
36	Trout	28	242	Finnåsvatnet	043-84829	25.sep
36	Trout	27	198	Finnåsvatnet	043-84829	25.sep
36	Trout	28	238	Finnåsvatnet	043-84829	25.sep
36	Trout	26	258	Finnåsvatnet	043-84829	25.sep
36	Trout	27	217	Finnåsvatnet	043-84829	25.sep

Appendix 2 Results of analyses and LOD (ng/g wet w for organic compounds, mg/kg for metals).

Lever	Innsjø	Art	Vekt (g) (g) snitt	Lengde (cm) (cm) snitt	Fett %	HCB	Pentaklor- benzen	α-HCH	β-HCH	γ-HCH	*p,p'*-DDE	*o,p'*-DDD	*p,p'*-DDD	*o,p'*-DDT	*p,p'*-DDT
det lim						0,005	0,004	0,004	0,004	0,004	0,014	0,012	0,014	0,008	0,004
						43	79	77	137	104	103	185	110	109	265
1	Storavatnet	Ørret	208	26	3,03	0,023	n.d.	0,005	n.d.	0,015	1,62	n.d.	n.d.	n.d.	0,033
2	Storavatnet	Ørret	264	29,4	2,78	0,040	n.d.	0,010	0,007	0,020	1,91	0,037	0,112	n.d.	0,117
3	Storavatnet	Ørret	956	50	0,58	n.d.	n.d.	0,004	n.d.	0,012	19,2	0,585	0,153	n.d.	n.d.
4	Tunevannet	Abbor	987	40,4	3,36	n.d.	n.d.	0,014	0,021	0,026	3,38	0,090	0,388	n.d.	0,017
5	Tunevannet	Abbor	732	36,8	2,84	n.d.	n.d.	0,012	0,010	0,024	3,56	0,075	0,445	n.d.	0,022
6	Tunevannet	Abbor	412	31,8	2,27	n.d.	n.d.	0,011	0,009	0,020	2,12	0,075	0,236	n.d.	0,013
7	Røssvatnet	ørret	347	31,0	2,25	n.d.	n.d.	0,011	n.d.	0,011	0,164	n.d.	n.d.	n.d.	0,016
8	Røssvatnet	Røye	681	38,8	2,77	0,047	n.d.	0,007	n.d.	0,007	0,626	n.d.	0,043	n.d.	0,026
9	Røssvatnet	Røye	345	31,6	4,45	0,193	n.d.	0,018	n.d.	0,015	1,17	0,063	0,205	0,038	0,145
10	Limingen	Ørret	430	35,4	3,55	n.d.	n.d.	0,010	n.d.	0,010	0,278	0,027	n.d.	n.d.	0,017
11	Limingen	Røye	463	34,0	4,05	0,043	n.d.	0,016	n.d.	0,016	0,637	0,034	n.d.	n.d.	0,173
12	Limingen	Røye	503	35,0	3,40	0,007	n.d.	0,012	n.d.	0,012	0,553	0,035	0,059	0,052	0,138
13	Femunden	Ørret	593	36,8	2,36	n.d.	n.d.	0,010	n.d.	0,012	0,502	n.d.	n.d.	n.d.	0,027
14	Femunden	Ørret	486	35	2,35	n.d.	n.d.	0,007	n.d.	0,012	1,12	n.d.	n.d.	n.d.	0,027
15	Femunden	Ørret	399	32,5	2,66	n.d.	n.d.	0,010	0,005	0,012	0,506	n.d.	n.d.	n.d.	0,027
16	Snåsa	Ørret	562	39,2	3,22	n.d.	n.d.	0,010	n.d.	0,015	0,589	n.d.	n.d.	n.d.	0,034
17	Snåsa	Ørret	451	35,6	2,34	n.d.	n.d.	0,007	n.d.	0,009	0,407	n.d.	n.d.	n.d.	0,017
18	Snåsa	Ørret	301	30,0	3,02	0,025	n.d.	0,005	n.d.	0,002	0,584	n.d.	0,060	n.d.	0,032
19	Selbusjøen	Ørret	738	40,0	2,88	0,044	n.d.	0,005	n.d.	0,005	0,495	n.d.	n.d.	n.d.	0,015
20	Selbusjøen	Ørret	429	34,6	3,66	0,022	n.d.	0,005	n.d.	0,005	0,379	n.d.	n.d.	n.d.	0,012
21	Selbusjøen	Ørret	304	30,7	3,05	0,050	n.d.	0,007	n.d.	0,007	0,524	n.d.	0,057	n.d.	0,010
22	Storvatnet	Ørret	1156	44,6	4,02	0,110	n.d.	0,010	n.d.	0,014	1,00	n.d.	n.d.	n.d.	0,038
23	Storvatnet	Ørret	424	32,6	4,46	0,042	n.d.	0,012	n.d.	n.d.	0,312	n.d.	n.d.	n.d.	0,015
24	Storvatnet	Ørret	517	36	2,42	0,015	n.d.	0,007	n.d.	0,007	0,397	n.d.	n.d.	n.d.	n.d.
25	Otervatnet	Ørret	459	34,6	3,28	0,050	n.d.	0,010	n.d.	0,007	0,350	n.d.	n.d.	n.d.	n.d.
26	Otervatnet	Ørret	386	31,6	2,81	n.d.	n.d.	0,008	n.d.	0,005	0,176	n.d.	n.d.	n.d.	n.d.
27	Otervatnet	Ørret	332	30,6	2,77	0,008	n.d.	0,010	0,008	0,005	0,224	n.d.	n.d.	n.d.	n.d.
28	Dalvatnet	Røye	650	37,7	3,54	0,144	n.d.	0,009	0,007	0,007	1,40	0,099	0,165	n.d.	0,068
29	Dalvatnet	Røye	424	31,4	3,65	0,173	n.d.	0,012	n.d.	0,007	0,659	0,070	0,168	0,040	0,094
30	Dalvatnet	Røye	264	28,3	2,90	0,136	n.d.	0,007	n.d.	0,007	0,679	0,085	0,158	n.d.	0,044
31	Salvatnet	Ørret	759	41,6	3,48	0,118	n.d.	0,016	0,004	0,013	1,12	0,038	0,084	n.d.	n.d.
32	Salvatnet	Ørret	454	36,6	2,45	0,034	n.d.	0,007	n.d.	0,005	0,519	n.d.	n.d.	n.d.	n.d.
33	Salvatnet	Ørret	350	34	1,79	0,070	n.d.	0,012	n.d.	0,010	1,05	0,029	0,077	n.d.	n.d.
34	Finnåsvatnet	Ørret	360	32,4	3,45	0,029	n.d.	0,005	0,007	0,007	1,07	0,034	0,173	n.d.	0,048
35	Finnåsvatnet	Ørret	256	28,3	3,46	0,066	n.d.	0,007	0,010	0,015	2,07	0,049	0,288	n.d.	0,136
36	Finnåsvatnet	Ørret	221	27	4,87	0,054	n.d.	0,010	0,012	0,012	1,52	0,035	0,161	n.d.	0,109

Lever	Innsjø	PCB-28	PCB-52	PCB-101	PCB-118	PCB-138	PCB-153	PCB-180	Heptaklor*	cis-Heptaklor	trans-Heptaklor
										epoksyd	epoxyd
det lim		0,29	0,29	0,18	0,005	0,49	0,73	0,31	0,091	0,048	0,048
										158	113
1	Storavatnet	< .29	< .29	< .18	< .0053	0,49	0,73	0,31	n.d.	n.d.	n.d.
2	Storavatnet	< .33	< .33	< .21	0,006	0,63	0,88	0,4	n.d.	n.d.	n.d.
3	Storavatnet	< .4	< .4	1,9	0,09	11	16	9,1	n.d.	n.d.	n.d.
4	Tunevannet	< .32	< .32	1	0,02	1,5	2,2	0,85	n.d.	n.d.	n.d.
5	Tunevannet	< .28	0,34	1,4	0,03	2,2	3,2	1,3	n.d.	n.d.	n.d.
6	Tunevannet	< .39	< .39	1,2	0,02	1,9	2,7	1,1	n.d.	n.d.	n.d.
7	Røssvatnet	< .35	< .35	< .22	< .0064	< .22	< .35	< .22	n.d.	n.d.	n.d.
8	Røssvatnet	< .29	< .29	< .18	< .0053	0,28	0,45	< .18	n.d.	n.d.	n.d.
9	Røssvatnet	< .26	< .26	0,18	0,005	0,35	0,5	< .16	n.d.	n.d.	n.d.
10	Limingen	< .38	< .38	< .24	< .0069	< .24	< .38	< .24	n.d.	0,076	n.d.
11	Limingen	< .33	< .33	< .21	0,008	0,5	0,77	0,23	n.d.	0,366	n.d.
12	Limingen	< .27	< .27	0,18	0,007	0,51	0,75	0,22	n.d.	0,225	n.d.
13	Femunden	< .31	< .31	< .19	< .0056	0,35	0,49	< .19	n.d.	n.d.	n.d.
14	Femunden	< .38	< .38	< .24	< .0068	0,65	0,98	0,43	n.d.	n.d.	n.d.
15	Femunden	< .33	< .33	< .21	< .006	0,26	0,41	< .21	n.d.	n.d.	n.d.
16	Snåsa	< .25	< .25	< .16	< .0046	0,24	0,44	< .16	n.d.	n.d.	n.d.
17	Snåsa	< .3	< .3	< .19	< .0054	< .19	< .3	< .19	n.d.	n.d.	n.d.
18	Snåsa	< .25	< .25	< .15	0,005	0,31	0,52	< .15	n.d.	n.d.	n.d.
19	Selbusjøen	< .23	< .23	0,14	< .0041	0,27	0,44	< .14	n.d.	n.d.	n.d.
20	Selbusjøen	< .28	< .28	< .17	< .005	0,2	0,28	< .17	n.d.	0,068	n.d.
21	Selbusjøen	< .25	< .25	< .16	< .0045	< .16	0,27	< .16	n.d.	n.d.	n.d.
22	Storvatnet	< .3	< .3	0,26	0,009	0,67	1,3	0,43	n.d.	n.d.	n.d.
23	Storvatnet	< .33	< .33	< .21	< .0059	0,28	0,55	< .21	n.d.	n.d.	n.d.
24	Storvatnet	< .24	< .24	0,18	0,007	0,5	0,89	0,3	n.d.	n.d.	n.d.
25	Otervatnet	< .27	< .27	< .17	0,01	0,44	0,54	< .17	n.d.	n.d.	n.d.
26	Otervatnet	< .36	< .36	< .23	< .0065	0,23	< .36	< .23	n.d.	n.d.	n.d.
27	Otervatnet	< .32	< .32	< .2	0,007	0,25	< .32	< .2	n.d.	n.d.	n.d.
28	Dalvatnet	< .27	< .27	0,81	0,06	4	4,5	1,6	n.d.	0,093	n.d.
29	Dalvatnet	< .31	< .31	0,38	0,03	1,9	2,1	0,7	n.d.	n.d.	n.d.
30	Dalvatnet	< .29	< .29	0,31	0,02	1,5	1,7	0,61	n.d.	n.d.	n.d.
31	Salvatnet	< .28	< .28	0,3	0,01	0,93	1,4	0,51	n.d.	n.d.	n.d.
32	Salvatnet	< .27	< .27	< .17	0,006	0,4	0,65	0,19	n.d.	n.d.	n.d.
33	Salvatnet	< .24	< .24	0,21	0,007	0,76	1,1	0,5	n.d.	n.d.	n.d.
34	Finnåsvatnet	< .26	< .26	< .16	0,006	0,46	0,72	0,36	n.d.	n.d.	n.d.
35	Finnåsvatnet	< .26	< .26	0,18	0,008	0,73	1,1	0,55	n.d.	n.d.	n.d.
36	Finnåsvatnet	< .29	< .29	< .18	< .0053	0,43	0,63	0,28	n.d.	n.d.	n.d.

Lever	Innsjø	Endosulfan	Endosulfan	Endosulfan*	PBDE 28	PBDE 47	PBDE 99	PBDE 100	PBDE 153	PBDE 154	sum HBCD
		I*	II*	sulfat							
det lim		0,012	0,012	0,010	0,018	0,015	0,09	0,08	0,08	0,07	0,035
		171	173	138							85
1	Storavatnet	n.d.	n.d.	0,020	< .018	0,25	0,074	0,099	< .074	0,13	0,14
2	Storavatnet	n.d.	n.d.	0,024	< .021	0,27	0,088	0,11	< .083	0,16	n.d.
3	Storavatnet	n.d.	n.d.	0,014	0,068	2,9	4,4	2,1	1,9	2	n.d.
4	Tunevannet	n.d.	n.d.	n.d.	< .02	0,19	< .079	< .079	< .079	< .079	n.d.
5	Tunevannet	0,014	n.d.	n.d.	< .017	0,23	0,078	< .069	< .069	< .069	n.d.
6	Tunevannet	n.d.	n.d.	0,010	< .024	0,21	< .097	< .097	< .097	< .097	0,07
7	Røssvatnet	n.d.	n.d.	0,046	< .022	< .18	< .089	< .089	< .089	< .089	n.d.
8	Røssvatnet	0,019	n.d.	0,029	< .018	< .15	< .073	< .073	< .073	< .073	n.d.
9	Røssvatnet	0,029	n.d.	0,029	< .016	< .13	0,065	< .064	< .064	< .064	n.d.
10	Limingen	n.d.	n.d.	0,018	< .024	< .19	< .096	< .096	< .096	< .096	n.d.
11	Limingen	0,045	n.d.	0,030	< .021	< .17	0,1	< .083	< .083	< .083	n.d.
12	Limingen	0,034	n.d.	0,024	< .017	0,14	0,1	< .068	< .068	< .068	0,04
13	Femunden	n.d.	n.d.	0,077	< .019	< .16	< .078	< .078	< .078	< .078	n.d.
14	Femunden	n.d.	n.d.	0,033	< .024	< .19	< .095	< .095	< .095	< .095	n.d.
15	Femunden	n.d.	n.d.	0,015	< .021	< .17	< .083	< .083	< .083	< .083	n.d.
16	Snåsa	n.d.	n.d.	n.d.	< .016	< .13	< .064	< .064	< .064	< .064	0,34
17	Snåsa	n.d.	n.d.	n.d.	< .019	< .15	< .075	< .075	< .075	< .075	0,04
18	Snåsa	n.d.	n.d.	0,015	< .015	< .12	< .062	< .062	< .062	< .062	n.d.
19	Selbusjøen	n.d.	n.d.	n.d.	< .014	< .11	0,063	< .057	< .057	< .057	n.d.
20	Selbusjøen	n.d.	n.d.	n.d.	< .017	< .14	0,074	< .07	< .07	< .07	n.d.
21	Selbusjøen	n.d.	n.d.	n.d.	< .016	< .13	< .063	< .063	< .063	< .063	n.d.
22	Storvatnet	n.d.	n.d.	n.d.	< .019	< .15	< .074	< .074	< .074	< .074	n.d.
23	Storvatnet	n.d.	n.d.	n.d.	< .021	< .16	< .082	< .082	< .082	< .082	n.d.
24	Storvatnet	n.d.	n.d.	n.d.	< .015	< .12	< .059	< .059	< .059	< .059	n.d.
25	Otervatnet	n.d.	n.d.	n.d.	< .017	< .14	< .068	< .068	< .068	< .068	n.d.
26	Otervatnet	n.d.	n.d.	n.d.	< .023	< .18	< .09	< .09	< .09	< .09	n.d.
27	Otervatnet	n.d.	n.d.	n.d.	< .02	< .16	< .08	< .08	< .08	< .08	n.d.
28	Dalvatnet	0,023	n.d.	n.d.	< .017	0,18	0,2	0,16	< .068	0,11	n.d.
29	Dalvatnet	0,019	n.d.	0,014	< .02	< .16	0,11	0,08	< .079	< .079	n.d.
30	Dalvatnet	0,018	n.d.	0,013	< .018	< .15	0,11	< .073	< .073	< .073	n.d.
31	Salvatnet	n.d.	n.d.	0,044	< .018	0,21	0,15	0,1	< .07	0,099	n.d.
32	Salvatnet	n.d.	n.d.	0,019	< .017	< .14	< .069	< .069	< .069	< .069	n.d.
33	Salvatnet	n.d.	n.d.	0,020	< .015	0,14	0,14	0,083	< .061	0,096	n.d.
34	Finnåsvatnet	n.d.	n.d.	0,014	< .016	0,14	0,071	0,077	< .065	0,14	1,25
35	Finnåsvatnet	n.d.	n.d.	n.d.	< .016	0,27	0,096	0,12	0,078	0,22	n.d.
36	Finnåsvatnet	n.d.	n.d.	0,015	< .018	< .15	0,099	< .073	< .073	0,12	n.d.

Lever	Innsjø	PFTrDA*	PFTeDA*	PFHxS*	PFOS*	FOSA*	Diflu-	Teflu	Benz(a)-	Naphthalene
							benzuron	benzuron	anthracen	
det lim		0,143	0,134	0,375	0,659	0,119	3,0	3,0		0,49
		96	71	90	98	103				
1	Storavatnet	0,89	0,20	n.d	1,83	0,68	<3	<3	< .43	0,54
2	Storavatnet	1,81	0,34	n.d	3,07	0,70	<3	<3	< .48	0,64
3	Storavatnet	9,82	2,33	n.d	5,56	0,43	<3	<3	< .44	0,66
4	Tunevannet	1,17	n.d	n.d	12,02	0,82	<3	<3	< .45	0,47
5	Tunevannet	1,55	0,23	n.d	17,18	0,35	<3	<3	< .44	0,51
6	Tunevannet	1,09	0,17	n.d	21,68	0,42	<3	<3	< .52	0,44
7	Røssvatnet	1,06	0,30	n.d	3,88	1,15	<3	<3	< .46	0,41
8	Røssvatnet	0,24	n.d	n.d	1,04	0,29	<3	<3	< .49	0,31
9	Røssvatnet	0,37	n.d	n.d	0,65	0,14	<3	<3	< .48	0,37
10	Limingen	1,92	0,26	n.d	1,75	1,07	<3	<3	< .49	0,40
11	Limingen	0,50	n.d	n.d	0,23	0,17	<3	<3	< .42	0,77
12	Limingen	0,35	n.d	n.d	n.d	0,26	<3	<3	< .51	0,85
13	Femunden	4,02	0,55	n.d	1,21	0,51	<3	<3	< .51	0,46
14	Femunden	6,87	0,84	n.d	1,51	0,66	<3	<3	< .46	0,69
15	Femunden	4,13	0,57	n.d	1,03	1,29	<3	<3	< .47	0,59
16	Snåsa	0,53	n.d	n.d	2,55	1,16	<3	<3	< .49	0,48
17	Snåsa	0,17	n.d	n.d	3,65	0,75	<3	<3	< .43	0,58
18	Snåsa	0,48	n.d	n.d	2,07	0,96	<3	<3	< .47	0,61
19	Selbusjøen	1,38	0,23	n.d	1,47	1,19	<3	<3	< .46	0,69
20	Selbusjøen	1,55	0,22	n.d	1,32	1,78	<3	<3	< .48	0,86
21	Selbusjøen	1,42	0,20	n.d	1,79	4,32	<3	<3	< .5	0,66
22	Storvatnet	0,17	n.d	n.d	1,60	0,37	<3	<3	< .49	0,97
23	Storvatnet	0,64	n.d	n.d	1,43	0,46	<3	<3	< .46	0,81
24	Storvatnet	0,53	n.d	n.d	2,24	0,55	<3	<3	< .5	0,65
25	Otervatnet	0,39	n.d	n.d	0,00	0,24	<3	<3	< .48	0,70
26	Otervatnet	0,59	n.d	n.d	0,63	1,20	<3	<3	< .44	0,64
27	Otervatnet	0,48	n.d	n.d	0,37	0,92	<3	<3	< .55	0,61
28	Dalvatnet	0,74	n.d	n.d	2,45	0,15	<3	<3	< .48	0,57
29	Dalvatnet	0,70	n.d	n.d	2,14	0,22	<3	<3	< .47	0,70
30	Dalvatnet	0,58	n.d	n.d	2,01	0,18	<3	<3	< .42	0,88
31	Salvatnet	2,88	0,43	n.d	9,07	1,39	<3	<3	< .42	0,52
32	Salvatnet	2,76	0,41	n.d	5,74	0,65	<3	<3	< .51	0,52
33	Salvatnet	2,25	0,40	n.d	5,73	1,00	<3	<3	< .5	0,73
34	Finnåsvatnet	1,03	0,16	n.d	1,59	0,85	<3	<3	< .47	0,71
35	Finnåsvatnet	1,95	0,52	n.d	2,48	0,97	<3	<3	< .47	0,99
36	Finnåsvatnet	2,36	0,60	n.d	2,14	1,02	<3	<3	< .44	0,78

Lever	Innsjø	Anthracene	Fluoranthene	Benzo[a]-	D5	HCBD	Trichloro	penta	TCS	Dicofol	TCEP
				pyrene			benzenes	chlorophenol			
det lim		0,27	0,13	0,04	1,57	0,01		0,59	0,09	1,64	0,01
1	Storavatnet	0,48	0,21	0,02	1,10	0,01	0,03	0,64	0,16	3,10	0,08
2	Storavatnet	0,34	0,17	0,02	1,95	0,00	0,02	0,66	0,14	2,18	0,06
3	Storavatnet	0,46	0,23	0,02	1,80	0,00	0,02	0,52	0,08	3,13	0,04
4	Tunevannet	0,45	0,18	0,02	1,84	0,00	0,02	0,49	0,10	1,27	0,04
5	Tunevannet	0,43	0,16	0,02	1,76	0,00	0,02	0,54	0,10	1,19	0,06
6	Tunevannet	0,36	0,15	0,02	1,77	0,00	0,02	0,55	0,11	0,78	0,05
7	Røssvatnet	0,22	0,12	0,02	1,80	0,00	0,02	0,50	0,13	1,73	0,04
8	Røssvatnet	0,22	0,14	0,02	1,68	0,00	0,01	0,47	0,08	2,90	0,04
9	Røssvatnet	0,35	0,17	0,02	1,82	0,00	0,01	0,41	0,43	1,99	0,02
10	Limingen	0,21	0,12	0,02	1,96	0,00	0,01	0,50	0,11	1,65	0,02
11	Limingen	0,20	0,11	0,02	1,96	0,01	0,02	0,50	0,64	3,77	0,02
12	Limingen	0,26	0,12	0,02	2,19	0,01	0,02	0,53	0,60	2,35	0,03
13	Femunden	0,24	0,11	0,02	1,68	0,00	0,02	0,51	0,16	3,80	0,03
14	Femunden	0,23	0,11	0,02	1,76	0,00	0,02	0,41	0,23	2,21	0,02
15	Femunden	0,24	0,13	0,02	1,87	0,00	0,02	0,46	0,10	2,38	0,02
16	Snåsa	0,18	0,09	0,02	1,80	0,00	0,02	0,49	0,08	2,83	0,03
17	Snåsa	0,58	0,33	0,02	2,80	0,00	0,01	0,54	0,15	2,77	0,04
18	Snåsa	0,46	0,29	0,02	1,69	0,00	0,01	0,55	0,20	2,63	0,03
19	Selbusjøen	0,47	0,22	0,02	1,90	0,00	0,02	0,58	0,27	3,33	0,04
20	Selbusjøen	0,30	0,21	0,02	2,10	0,01	0,02	0,46	0,19	1,00	0,02
21	Selbusjøen	0,34	0,21	0,02	2,17	0,00	0,02	0,50	0,10	4,06	0,03
22	Storvatnet	0,31	0,17	0,02	2,47	0,01	0,02	0,46	0,21	2,24	0,02
23	Storvatnet	0,47	0,20	0,02	2,11	0,00	0,02	0,45	0,20	2,21	0,02
24	Storvatnet	0,24	0,12	0,02	2,28	0,00	0,01	0,50	0,27	1,50	0,02
25	Otervatnet	0,33	0,17	0,02	2,38	0,00	0,01	0,54	0,13	1,97	0,02
26	Otervatnet	0,25	0,12	0,02	2,57	0,00	0,02	0,55	0,14	3,09	0,03
27	Otervatnet	0,29	0,15	0,02	2,49	0,00	0,01	0,52	0,27	2,03	0,01
28	Dalvatnet	0,25	0,14	0,02	2,07	0,00	0,02	0,63	0,18	2,21	0,03
29	Dalvatnet	0,29	0,12	0,02	2,03	0,00	0,02	0,64	0,15	4,37	0,02
30	Dalvatnet	0,31	0,14	0,02	2,62	0,00	0,02	0,70	0,19	3,26	0,03
31	Salvatnet	0,33	0,16	0,02	1,84	0,00	0,01	0,25	0,23	1,23	0,02
32	Salvatnet	0,24	0,13	0,02	2,02	0,00	0,02	0,16	0,28	2,68	0,01
33	Salvatnet	0,32	0,19	0,02	4,18	0,00	0,02	0,31	0,26	1,41	0,02
34	Finnåsvatnet	0,24	0,13	0,02	2,32	0,00	0,02	0,30	0,18	3,22	0,02
35	Finnåsvatnet	0,35	0,15	0,02	2,40	0,01	0,02	0,09	0,19	1,92	0,02
36	Finnåsvatnet	0,26	0,11	0,02	2,08	0,01	0,02	0,21	0,23	1,37	0,01

Lever	Innsjø	DEHP	SCCPs	MCCPs	TBT	DBT	MBT	TPT	DPT	MPT
			(C10-13)	(C14-17)						
det lim		17	1,9	4,0	0,33	0,11	0,08	0,02	0,00	0,03
1	Storavatn	40	2,07	4,06	0,11	0,17	0,10	0,07	0,01	0,01
2	Storavatn	75	2,38	6,01	0,10	0,07	0,05	0,13	0,01	0,02
3	Storavatn	68	1,97	5,62	1,38	0,80	0,50	8,75	0,08	0,19
4	Tunevann	28	2,17	5,21	0,39	0,16	0,12	2,19	0,24	0,06
5	Tunevann	22	1,76	2,68	0,52	0,16	0,16	4,57	0,27	0,04
6	Tunevann	32	1,64	2,84	0,68	0,16	0,08	2,09	0,21	0,03
7	Røssvatn	20	1,78	2,27	0,13	0,10	0,08	0,21	0,01	0,01
8	Røssvatn	79	2,96	6,68	0,18	0,07	0,09	0,04	0,00	0,01
9	Røssvatn	49	1,61	2,94	0,11	0,06	0,13	0,02	0,00	0,01
10	Limingen	33	2,81	4,35	0,13	0,17	0,10	0,03	0,00	0,01
11	Limingen	35	2,75	4,26	0,06	0,08	0,06	0,03	0,00	0,01
12	Limingen	36	1,18	1,38	0,15	0,10	0,06	0,03	0,00	0,01
13	Femunde	27	1,20	1,80	0,10	0,05	0,04	0,11	0,00	0,02
14	Femunde	2	2,03	4,20	0,09	0,07	0,05	0,28	0,01	0,01
15	Femunde	62	1,90	3,11	0,06	0,11	0,05	0,17	0,00	0,01
16	Snåsa	14	4,33	7,01	0,11	0,04	0,03	0,07	0,00	0,01
17	Snåsa	62	2,07	4,13	0,23	0,15	0,08	0,03	0,00	0,04
18	Snåsa	47	1,26	2,85	0,07	0,05	0,05	0,05	0,00	0,01
19	Selbusjøe	37	1,86	3,28	0,16	0,06	0,06	0,05	0,00	0,01
20	Selbusjøe	3	2,17	2,73	0,13	0,09	0,04	0,08	0,00	0,01
21	Selbusjøe	30	1,80	2,75	0,08	0,04	0,05	0,10	0,00	0,01
22	Storvatne	17	1,88	2,59	0,14	0,06	0,07	0,08	0,01	0,01
23	Storvatne	2	4,33	11,40	0,13	0,07	0,06	0,08	0,01	0,01
24	Storvatne	62	1,81	5,29	0,12	0,13	0,05	0,25	0,02	0,01
25	Otervatn	39	3,36	4,08	0,06	0,07	0,06	0,16	0,00	0,01
26	Otervatn	49	1,84	3,66	0,20	0,05	0,03	0,02	0,00	0,01
27	Otervatn	1	2,37	3,53	0,21	0,07	0,06	0,02	0,00	0,01
28	Dalvatne	23	2,15	4,02	0,18	0,07	0,07	0,01	0,00	0,01
29	Dalvatne	221	1,52	2,79	0,07	0,10	0,09	0,01	0,00	0,01
30	Dalvatne	33	1,95	3,26	0,15	0,09	0,10	0,01	0,00	0,00
31	Salvatnet	31	2,43	7,56	0,11	0,05	0,04	0,14	0,01	0,01
32	Salvatnet	18	2,49	4,24	0,12	0,10	0,05	0,23	0,01	0,01
33	Salvatnet	19	1,77	5,32	0,16	0,04	0,04	0,21	0,01	0,01
34	Finnåsva	33	2,31	4,61	0,60	0,77	0,08	0,10	0,01	0,01
35	Finnåsva	34	1,85	2,87	0,29	0,13	0,07	0,02	0,00	0,01
36	Finnåsva	14	1,85	3,35	0,17	0,05	0,05	0,03	0,00	0,01

Lever	Innsjø	moPCB+noPCB	moPCB+noPCB	PCDD+PCDF	TEQ PCDD+PCDF	dioksiner/furaner dl-PCB
		Sum (ng/g ww)	Sum TEQ (ng/g ww)	Sum(ng/g ww)	Sum (ng/g ww)	Sum (ng/g ww) TEQ
det lim						
1	Storavatnet	0,03773	0,00012	0,00090	0,00013	0,00025
2	Storavatnet	0,27260	0,00024	0,00027	0,00003	0,00027
3	Storavatnet	5,31930	0,00154	0,00031	0,00003	0,00157
4	Tunevannet	1,11870	0,00037	0,00021	0,00002	0,00039
5	Tunevannet	1,62207	0,00031	0,00018	0,00005	0,00036
6	Tunevannet	1,22110	0,00045	0,00000	0,00000	0,00045
7	Røssvatnet	0,00370	0,00005	0,00060	0,00003	0,00008
8	Røssvatnet	0,00447	0,00015	0,00000	0,00000	0,00015
9	Røssvatnet	0,17263	0,00014	0,00030	0,00003	0,00017
10	Limingen	0,00467	0,00016	0,00026	0,00003	0,00018
11	Limingen	0,28243	0,00059	0,00085	0,00009	0,00067
12	Limingen	0,24543	0,00048	0,00054	0,00005	0,00054
13	Femunden	0,00557	0,00020	0,00102	0,00080	0,00101
14	Femunden	0,00490	0,00019	0,00050	0,00005	0,00024
15	Femunden	0,00577	0,00020	0,00056	0,00056	0,00076
16	Snåsa	0,00283	0,00009	0,00050	0,00000	0,00009
17	Snåsa	0,00210	0,00002	0,00000	0,00000	0,00002
18	Snåsa	0,17153	0,00016	0,00030	0,00003	0,00019
19	Selbusjøen	0,00451	0,00013	0,00047	0,00000	0,00013
20	Selbusjøen	0,00538	0,00017	0,00043	0,00000	0,00017
21	Selbusjøen	0,00463	0,00017	0,00063	0,00000	0,00017
22	Storvatnet	0,37753	0,00049	0,00051	0,00005	0,00054
23	Storvatnet	0,00610	0,00020	0,00024	0,00002	0,00023
24	Storvatnet	0,27517	0,00036	0,00000	0,00000	0,00036
25	Otervatnet	0,57900	0,00041	0,00057	0,00000	0,00041
26	Otervatnet	0,00593	0,00009	0,00160	0,00006	0,00015
27	Otervatnet	0,24507	0,00038	0,00270	0,00000	0,00038
28	Dalvatnet	3,46973	0,00173	0,00098	0,00010	0,00183
29	Dalvatnet	1,65200	0,00072	0,00084	0,00008	0,00080
30	Dalvatnet	1,28630	0,00075	0,00285	0,00016	0,00091
31	Salvatnet	0,58277	0,00056	0,00304	0,00001	0,00056
32	Salvatnet	0,20850	0,00022	0,00577	0,00001	0,00023
33	Salvatnet	0,28237	0,00056	0,00293	0,00001	0,00056
34	Finnåsvatnet	0,23953	0,00026	0,00074	0,00013	0,00039
35	Finnåsvatnet	0,37433	0,00036	0,00163	0,00028	0,00064
36	Finnåsvatnet	0,00507	0,00020	0,00139	0,00023	0,00043

Lever	Innsjø	Li	Mg	Al	V	Cr	Fe	Co	Ni	Cu	Zn
det lim		0,0007	0,09	0,06	0,002	0,002	10	0,001	0,003	0,004	0,2
1	Storavatnet	<LOD	210	2,9	0,022	<0,008	93	0,11	0,013	23	52
2	Storavatnet	<0,0025	200	2,3	0,019	<0,008	99	0,13	0,048	63	50
3	Storavatnet	<0,0025	110	2,3	0,034	<LOD	200	0,045	0,036	120	45
4	Tunevannet	<0,0025	240	1,7	0,009	<0,008	50	0,16	0,010	1,3	26
5	Tunevannet	0,0031	230	1,2	0,008	0,011	<36	0,22	0,010	1,3	25
6	Tunevannet	0,0025	230	0,99	0,007	<0,008	37	0,18	<0,01	1,6	26
7	Røssvatnet	<0,0025	170	2,5	0,014	<0,008	140	0,15	0,068	46	57
8	Røssvatnet	<0,0025	200	6,0	0,037	<0,008	460	0,13	0,034	14	30
9	Røssvatnet	0,0034	230	5,9	0,020	0,022	280	0,14	0,027	2,7	24
10	Limingen	<0,0025	150	1,7	0,012	0,010	150	0,22	0,059	39	35
11	Limingen	<0,0025	210	5,9	0,020	0,019	480	0,10	0,022	12	38
12	Limingen	0,011	160	25	0,057	0,047	470	0,13	0,034	21	38
13	Femunden	<0,0025	140	1,7	0,009	<0,008	190	0,03	0,028	110	40
14	Femunden	<0,0025	150	1,4	0,007	0,014	220	0,032	0,12	37	45
15	Femunden	<0,0025	170	3,2	0,012	0,013	180	0,025	0,019	60	35
16	Snåsa	<0,0025	160	3,6	0,038	<LOD	220	0,11	0,042	230	32
17	Snåsa	<0,0025	170	5,9	0,036	0,016	200	0,10	0,037	330	38
18	Snåsa	0,0037	190	9,6	0,033	0,080	190	0,053	0,031	61	31
19	Selbusjøen	0,0069	160	16	0,10	0,042	260	0,34	0,11	170	43
20	Selbusjøen	<0,0025	150	0,97	0,020	<0,008	150	0,11	0,04	85	33
21	Selbusjøen	0,014	180	32	0,074	0,24	210	0,11	0,093	88	48
22	Storvatnet	<0,0025	190	0,28	<0,005	<LOD	65	0,017	<0,01	28	26
23	Storvatnet	<0,0025	190	0,83	<0,005	<0,008	92	0,031	0,011	95	41
24	Storvatnet	<0,0025	190	0,52	<0,005	<0,008	95	0,028	<0,01	43	37
25	Otervatnet	<0,0025	160	4,0	0,36	0,019	250	0,12	0,43	340	27
26	Otervatnet	<0,0025	170	2,3	0,14	0,011	190	0,35	0,75	240	54
27	Otervatnet	<0,0025	160	1,4	0,11	0,011	150	0,39	0,99	170	46
28	Dalvatnet	0,0025	200	2,2	0,011	<0,008	160	0,17	0,22	4,1	25
29	Dalvatnet	<0,0025	230	1,5	0,009	<0,008	110	0,15	0,17	3,4	27
30	Dalvatnet	<0,0025	220	2,4	0,015	0,011	350	0,26	0,16	6,8	33
31	Salvatnet	<0,0025	150	3,6	0,026	<0,008	120	7,5	0,016	160	27
32	Salvatnet	<0,0025	150	3,3	0,047	<0,008	190	0,09	0,024	120	37
33	Salvatnet	<0,0025	170	1,5	0,016	<0,008	160	0,052	0,025	180	42
34	Finnåsvatnet	<0,0025	210	0,60	0,012	<LOD	71	0,039	<0,01	18	44
35	Finnåsvatnet	<0,0025	230	1,3	0,011	0,011	100	0,053	<0,01	31	42
36	Finnåsvatnet	<0,0025	210	0,95	0,016	0,028	100	0,074	0,019	38	52

Lever	Innsjø	As	Se	Mo	Ag	Cd	Hg	HgM	Pb	d15NAIR	d13CVPDB
det lim		0,001	0,001	0,002	0,0001	0,0001	0,001	0,001	0,002		
1	Storavatnet	0,025	3,8	0,15	0,96	0,88	0,43	0,36	0,045	8,72	-24,85
2	Storavatnet	0,024	7,5	0,17	1,4	0,85	0,59	0,46	0,051	8,93	-24,99
3	Storavatnet	0,011	37	0,28	1,4	2,0	3,1	1,0	0,11	9,41	-26,81
4	Tunevannet	0,42	1,1	0,11	0,0050	0,095	0,16	0,20	0,009	12,61	-25,18
5	Tunevannet	0,51	1,1	0,11	0,0006	0,16	0,18	0,19	0,010	12,75	-25,07
6	Tunevannet	0,67	1,1	0,12	0,0003	0,099	0,14	0,14	0,012	12,50	-25,54
7	Røssvatnet	0,090	5,7	0,12	0,66	0,093	0,049	0,036	0,011	7,43	-23,66
8	Røssvatnet	0,033	0,92	0,11	0,10	0,22	0,056	0,065	0,011	6,88	-20,95
9	Røssvatnet	0,034	1,1	0,11	0,0093	0,15	0,045	0,057	0,013	6,69	-23,53
10	Limingen	0,064	7,0	0,17	0,80	0,27	0,089	0,064	0,007	6,25	-25,48
11	Limingen	0,077	2,2	0,16	0,11	0,34	0,12	0,10	<0,006	5,60	-26,85
12	Limingen	0,064	2,5	0,19	0,16	0,36	0,14	0,11	0,009	5,95	-26,56
13	Femunden	0,009	3,2	0,11	1,5	0,19	0,083	0,073	0,006	7,50	-20,23
14	Femunden	0,008	1,8	0,11	0,72	0,19	0,23	0,12	0,006	8,14	-20,02
15	Femunden	0,007	2,3	0,11	0,98	0,19	0,085	0,063	0,006	7,19	-19,78
16	Snåsa	0,069	3,9	0,15	3,4	0,14	0,14	0,15	0,009	9,54	-21,39
17	Snåsa	0,080	7,2	0,17	3,8	0,16	0,17	0,13	0,030	9,39	-19,85
18	Snåsa	0,052	3,7	0,17	1,3	0,13	0,27	0,19	0,009	10,72	-21,32
19	Selbusjøen	0,084	4,6	0,20	1,4	0,22	0,15	0,16	0,016	10,04	-23,00
20	Selbusjøen	0,12	10	0,20	0,50	0,077	0,11	0,093	<0,006	9,60	-23,55
21	Selbusjøen	0,049	5,7	0,16	0,93	0,12	0,12	0,10	0,009	8,92	-26,14
22	Storvatnet	0,075	4,3	0,16	0,79	0,031	0,31	0,35	<0,006	10,31	-28,35
23	Storvatnet	0,057	10	0,20	0,59	0,038	0,10	0,12	<0,006	8,24	-26,62
24	Storvatnet	0,063	7,1	0,19	0,53	0,025	0,20	0,19	<0,006	9,29	-27,24
25	Otervatnet	0,018	19	0,16	0,23	0,68	0,089	0,11	0,019	7,59	-23,25
26	Otervatnet	0,026	21	0,18	0,16	0,57	0,080	0,061	0,023	6,88	-23,10
27	Otervatnet	0,037	9,7	0,16	0,10	0,46	0,043	0,070	0,014	7,16	-23,48
28	Dalvatnet	0,027	4,4	0,14	0,028	0,51	0,15	0,21	0,011	10,04	-27,45
29	Dalvatnet	0,023	3,4	0,12	0,015	0,43	0,095	0,14	0,012	9,76	-27,01
30	Dalvatnet	0,030	3,8	0,16	0,020	0,60	0,064	0,10	0,017	8,94	-27,13
31	Salvatnet	0,047	27	0,21	3,7	0,36	0,49	0,40	0,013	9,06	-22,90
32	Salvatnet	0,043	15	0,20	2,8	0,45	0,32	0,24	0,016	9,62	-23,49
33	Salvatnet	0,12	23	0,21	3,7	0,46	0,38	0,42	0,014	8,79	-25,67
34	Finnåsvatnet	0,20	5,3	0,14	1,0	0,24	0,45	0,33	0,006	9,40	-24,51
35	Finnåsvatnet	0,034	5,6	0,14	1,5	0,39	0,48	0,44	0,056	8,01	-26,11
36	Finnåsvatnet	0,061	9,4	0,17	2,5	0,55	0,47	0,30	0,15	6,64	-26,54