Norsk institutt for luftforskning
Norwegian Institute for Air Research

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Environmental pollutants in the terrestrial and urban environment 2020

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ABSTRACT

Samples from the urban terrestrial environment in the Oslo area were analysed for metals and a large number of organic environmental pollutants. The selected species were earthworm, fieldfare, tawny owl, red fox and brown rat. Air- and soil-samples were also included in the study to further the understanding on sources and uptake of pollutants. A food-chain approach was used to investigate trophic magnification of the different compounds.

NORWEGIAN TITLE

Miljøgifter i terrestrisk og bynært miljø 2020

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POPs | PFAS | Heavy Metals

ABSTRACT (in Norwegian)

Prøver fra det urbane terrestriske miljøet i Oslo-området ble analysert for metaller og et stort antall av organiske miljøgifter. De utvalgte artene var meitemark, gråtrost, kattugle, rødrev og brunrotte. Luft- og jordprøver ble analysert for å øke forståelsen av kilder og opptak av miljøgifter. En næringskjedetilnærming ble valgt for å undersøke trofisk magnifisering av de forskjellige stoffene.

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Summary

On behalf of the Norwegian Environment Agency, NILU- Norwegian Institute for Air Research, in collaboration with the Norwegian Institute for Nature Research (NINA) and the Norwegian Institute for Water Research (NIVA), analysed air, soil and biological samples from the terrestrial and urban environment for various inorganic and organic environmental pollutants.

The monitoring programme has the following key goals:

- Report concentrations of selected environmental pollutants in different trophic levels of a terrestrial food web in an urban area;
- Compare the concentration of the selected pollutants across samples and species;
- Evaluate potential trophic magnification of the different pollutants using a food chain approach

This report presents the findings from the eighth year of the urban terrestrial programme. Samples for this monitoring period were collected in 2020.

A broad range of environmental pollutants, consisting of persistent organic pollutants, organic phenolic pollutants, biocides, ultraviolet (UV) stabilizing substances, per- and polyfluorinated alkylated substances (PFAS), siloxanes, chlorinated paraffins, organic phosphorous flame retardants and metals, were measured in air-, soil- and biota-samples. The concentrations of the selected pollutants were compared across species and to data from previous years. In addition, the levels of the various pollutant groups were evaluated for each species. Potential biomagnification was also investigated.

Below follows a short summary for each compound-class investigated. Comparison of concentrations across species and organs for hydrophobic pollutants (polychlorinated biphenyls (PCB), polybrominated diphenyl ethers (PBDE), chlorinated paraffins (CP), cyclic siloxanes, biocides, UV stabilizing substances) were done on a lipid weight basis.

Metals: The concentrations of the metals Cr and Ni in soil at some locations exceeded the threshold for when soil is considered contaminated. Of the biological matrices analysed, earthworms, brown rats and red foxes contained the highest levels of the metals. Cd-concentrations in earthworms at all sites exceeded the PNECoral value of 160 ng/g food for predators of earthworms. Eight out of ten rat liver samples had As-concentrations exceeding the PNECoral value for predators of 1000 ng/g ww.

PCB: PCB-congeners were detected in many samples, and, as expected, PCB-153 was the dominating PCB-congener in most biota samples, except in red fox liver where PCB-180 had highest concentration. On a lipid weight basis, the highest mean sumPCB-concentrations were detected in fieldfare eggs and red fox livers.

PBDE & newBFR: In the various samples, PBDE-congeners were found in lower concentrations than PCBs, except for brown rat samples which had similar concentrations to PCB. Highest detection rate and concentrations were detected in fieldfare eggs followed by tawny owl eggs. NewBFRs were first and foremost detected in air samples where α–TBECH and β-TBECH dominated and were only sporadically detected in low concentration in other samples.

PFAS: Among the PFASs analysed, PFOS was the dominating compound in the PFAS group in all matrices, except for air where PFHxS dominated. This year's data (i.e. samples collected in 2020) revealed that fieldfare eggs had the highest concentrations of PFOS. The highest concentrations of

PFOS in fieldfare eggs exceeded PNEC for predators where fieldfare eggs are substantial part of the diet. In agreement with results from previous years, highest PFOS and sumPFAS concentration were detected for fieldfare eggs from Grønmo (sumPFAS 322 ng/g ww) followed by Alna site I (sumPFAS 245 ng/g ww). As last year, 8:2 FTS and 10:2 FTS were detected in several samples, and the highest concentrations were detected in fieldfare egg samples from Alna site I; 8:2 FTS (55 ng/g ww) and 10:2 FTS (30 ng/g ww). Extractable organic Fluorine (EOF) analysis was conducted for the first time in this monitoring program and was performed on selected samples from 2020 and previous years. The EOF results were in overall agreement with sumPFAS concentrations.

SCCP/MCCP: SCCP and MCCP were detected in many samples. The concentration ranges were in general lower than results from 2019 when more samples were below and near method limit of detection. Detection rates were highest in fieldfare eggs, red fox liver samples and tawny owl eggs. The highest concentration on a lipid weight basis of SCCP was detected in one red fox liver sample (3336 ng/g lw), and the highest concentration of MCCP was detected in a pooled fieldfare egg sample (4218 ng/g lw).

Cyclic siloxanes (cVMS): Siloxanes were as previous years the dominating compound class in air samples. The air sample collected at the pipe outlet at VEAS wastewater plant had highest concentrations for all three siloxanes D4, D5 and D6, and D5 was the dominating compound. Brown rat liver samples had the highest concentrations for all three siloxanes on a lipid weight basis among the biota samples. Second highest biota concentrations on lipid weight were found in earthworm samples and fieldfare eggs. D4 dominated in most animal samples, except for brown rat liver samples where D5 dominated in 60 % of the samples.

OPFR: OPFR-compounds were only analysed for in five air samples, one pooled soil sample and one pooled earthworm sample. Many OPFR were detected in the air samples. TCPP was the dominating compound in air, soil and earthworm samples. Analysis of TCPP in soil samples from 2019 revealed very high TCPP concentration at Bøler (170 102 ng/g dw) which exceeded the PNECsoil of 1700 ng/g dw for soil living organisms.

UV stabilizing compounds: UV-compounds were only analysed for in pooled samples. In the one pooled soil sample, four UV compounds were detected. In pooled samples from red fox liver, tawny owl eggs and brown rat liver only UV-326, UV-327 and UV-328 were detected. For each of these species three pooled samples were analysed. UV-328 dominated in all samples. UV-326 and UV-328 were detected in all of the three pooled sampled of brown rat liver, and with highest concentrations among the species.

Biocides (rodenticides): As previous years have revealed, bromadiolone dominated both in red fox and brown rat liver with higher concentrations in the red fox than in the target species; the rats. The highest levels of bromadiolone were lower than in previous years. The five rodenticides (bromadiolone, brodifacoum, flocumafen, difenacoum and difethialone) analysed for in red fox and rat livers had not previously been analysed in raptor eggs in this monitoring program. This was therefore done in 2020. Analysis in previous sampled tawny owl and sparrowhawk egg from the years 2015 to 2020 revealed that only bromadiolone was detectable in low concentration of 0.26 ng/g ww in one tawny owl egg sample from 2017.

Phenols: The analysed phenols (Bis-A, Bis-S, Bis-F, TBBPA, octylphenol and nonylphenol) were only sporadically detected in the samples. Bis-F isomers were detected in only a few of the bird egg samples, Bis-A isomers in one red fox liver samples and all three rat liver samples. The liver samples had highest concentrations and the levels were lower than in 2019.

Dominant pollutant groups in each matrix

The median of sum-concentrations of the dominant pollutant group for each matrix in the investigated species in 2020 is given below. Metals is the sum of Hg, Cd, Pb and As.

- Air	:	cVMS >> CP > OPFR >>PCB
- Soil	:	Metals >>CP > OPFR
- Earthworm	:	Metals >> PFAS >OPFR
- Fieldfare eggs	:	PFAS >CP > Metals ~cVMS
-Tawny owl eggs	:	CP~PFAS~PCB> Metals
- Red fox liver	:	Metals > Biocides>> CP
- Brown rat liver	:	Metals >> cVMS> Biocides~CP

Biomagnification:

A food chain approach with earthworm-fieldfare-sparrowhawk was used in order to calculate trophic magnification factors (TMF) based on concentrations and $\delta^{15}N$ data from the years 2014 to 2020 for the Oslo urban area. In addition, biomagnification factor (BMF) was calculated for some compounds. The typical hydrophobic and well-known POPs, such as PCB- and PBDE-congeners, were found to have TMF and BMF values well above 1, indicating a high potential for biomagnification. PFOS had a TMF of 1.5 and the long chain perfluorinated carboxylates PFUnA to PFTeA had TMF values from 1.6 to 1.8.

Sammendrag

På oppdrag fra Miljødirektoratet, analyserte NILU - Norsk institutt for luftforskning, i samarbeid med Norsk institutt for naturforskning (NINA) og Norsk institutt for vannforskning (NIVA), en lang rekke uorganiske og organiske miljøgifter i luft, jord og dyrearter fra bynært og terrestrisk miljø.

Prosjektet hadde følgende delmål:
- Rapportere konsentrasjoner av utvalgte miljøgifter på flere trofiske nivå av et terrestrisk næringsnett i urbane strøk
- Sammenstille og vurdere fordeling av miljøgiftklassene på tvers av prøver og arter
- Vurdere biomagnifiseringspotensialet av miljøgifter ved bruk av næringskjedetilnærming

Denne rapporten presenterer funnene fra det åttende året av det urbane terrestriske programmet. Prøver fra denne overvåkingsperioden ble samlet inn i 2020.

Et stort spekter av kjemiske stoffer ble analysert; persistente organiske miljøgifter, bisfenoler, biocider, ultrafiolette (UV) stabiliserende forbindelser, regulerte og nye per- og polyfluorterte alkylstoffer (PFAS), siloksaner, klorerte parafiner, organiske fosforflammehemmere og metaller i de ulike prøvene. For hver stoffgruppe ble forurensingsnivåene sammenlignet på tvers av arter og prøver. I tillegg har vi vurdert hvilke stoffgrupper som dominerte i de ulike prøvene og artene. Potensialet for biomagnifisering ble også undersøkt.

Under følger en kort oppsummering for hver komponentgruppe som ble analysert i prøvene. Der vi har sammenlignet på tvers av arter og ulike organer, er konsentrasjoner av hydrofobe miljøgifter normalisert til fettvekt (fv).

Metaller: Konsentrasjonene av metallene Cr og Ni i jord for noen lokaliteter oversteg terskelverdien for når jord anses å være forurenset. Av de biologiske prøvene inneholdt meitemark, brunrotter og rødrev de høyeste nivåene av metallene. Cd-konsentrasjoner i meitemark på alle lokaliteter overskred PNECoral-verdien på 160 ng/g for de dyrene der meitemark er viktig føde. Åtte av ti rotteleverprøver hadde As-konsentrasjoner som oversteg PNECoral på 1000 ng/g for rovdyr.

PCB: PCB ble detektert i mange prøver, og som forventet dominerte PCB-153 mønsteret i de fleste biotaprøvene for PCB-gruppen, bortsett fra i rødrevlever der PCB-180 hadde høyest konsentrasjon. På lipidvektbasis ble høyeste gjennomsnittlige sumPCB-konsentrasjoner funnet i gråtrostegg og rødrevlever.

PBDE og nyBFR: PBDE-kongenere ble funnet i lavere konsentrasjoner enn PCBene i prøvene, bortsett fra lever fra brunrotte der PBDE hadde sammenlignbare konsentrasjoner med PCB. Flest detekterte og høyeste konsentrasjoner ble målt i gråtrostegg etterfulgt av egg fra kattugle. Nye BFR-forbindelser ble først og fremst påvist i luftprøver der α-TBECH og β-TBECH dominerte, og bare sporadisk detektert i lave konsentrasjoner i andre prøver.

PFAS: Blant PFAS forbindelsene som ble analysert, dominerte PFOS i alle prøvene, bortsett fra luft der PFHxS dominerte. Gråstrostegg hadde de høyeste konsentrasjonene av PFOS blant de biologiske prøvene. De høyeste konsentrasjonene av PFOS i gråtrostegg oversteg PNEC for rovdyr hvor gråtrost er en vesentlig del av dietten. I samsvar med resultatene fra tidligere år, ble høyeste PFOS- og sumPFAS-konsentrasjon påvist i gråstrostegg fra Grønmo (sumPFAS 322 ng/g vv) etterfulgt av Alna I (sumPFAS 245 ng/g vv). Som i år 2019 ble 8:2 FTS og 10:2 FTS påvist i flere prøver, og høyeste konsentrasjoner ble detektert i gråtrostegg fra Alna I; 8:2 FTS (55 ng/g vv) og 10:2 FTS (30 ng/g vv). Analyse av ekstraherbart organisk fluorinnhold (EOF) ble for første gang utført i programmet på

utvalgte prøver fra 2020 og tidligere år. EOF_resultatene var i overensstemmelse med sumPFAS konsentrasjonene der høye summer av PFAS-konsentrasjoner samsvarte med høye EOF-konsentrasjoner.

SCCP/ MCCP: SCCP og MCCP ble påvist i mange prøver. Konsentrasjonene var generelt lavere enn i 2019 da flere prøver var under og nær metode deteksjonsgrense. Høyest prosentvis deteksjon ble funnet i egg fra gråtrost, lever fra rødrev og egg fra kattugle. Høyeste konsentrasjon på en lipidvektbasis av SCCP ble påvist i en rødrevlever på 3336 ng/g fv, og høyeste konsentrasjon av MCCP ble påvist i en samleprøve (to gråtrostegg) på 4218 ng/g fv.

Sykliske siloksaner (cVMS): Siloksanene, som tidligere år, var den dominerende gruppen i luftprøvene. Luftprøven installert ved pipeutslippet ved VEAS avløpsanlegg hadde høyeste konsentrasjoner for alle de tre siloksanene D4, D5 og D6, og D5 var den dominerende forbindelsen. Lever fra brunrotte hadde de høyeste konsentrasjonene blant artene for alle tre forbindelsene på lipidvektbasis. Nest høyeste konsentrasjoner på lipidvekt ble funnet i meitemarkprøver og gråtrostegg. D4 dominerte i de fleste biologiske prøver, bortsett fra brunrotte der D5 dominerte i 60 % av prøvene.

OPFR: OPFR-forbindelsene ble bare analysert i fem luftprøver, en samleprøve for jord og en samleprøve for meitemark. Mange OPFR forbindelser ble detektert i luftprøvene. TCPP var den dominerende komponenten i alle prøvene. Analyse av TCPP i jord samlet inn i 2019 viste svært høy TCPP-konsentrasjon ved Bøler (170 102 ng/g tv) som overskred PNECsoil for TCPP på 1700 ng/g tv for jordlevende organismer.

UV stabiliserende forbindelser: UV forbindelser ble bare analysert i enkelte samleprøver. I samleprøven av jord ble fire UV-forbindelser detektert. I de tre samleprøvene fra rødrev, kattugle og brunrotte ble kun UV-326, UV-327 og UV-328 detektert. For hver av artene så ble tre samleprøver analysert. UV-328 dominerte i alle prøvene. UV-326 og UV-328 ble detektert i alle tre samleprøvene av brunrotte, og med høyeste konsentrasjoner blant artene.

Biocider (rodenticider): Som tidligere år dominerte bromadiolon både i lever fra rødrev og brunrotte, og nivåene var mye høyere hos rødrev. De høyeste nivåene av bromadiolon var lavere enn data fra tidligere år. De fem rodenticidene (bromadiolon, brodicafoum bromadiolone, brodifacoum, flocumafen, difenacoum and difethialon) som ble analysert i lever fra rødrev og brunrotte hadde ikke blitt analysert i kattugle og spurvehauk i dette programmet. Dette ble derfor gjort i 2020. Analyser i tidligere innsamlete egg fra kattugler og spurvehauk viste at kun bromadiolon ble detektert i lav konsentrasjon på 0.26 ng/g vv i et kattugleegg samlet inn i 2017.

Fenoler: De analyserte fenolene (Bis-A, Bis-S, Bis-F, TBBPA, octylphenol and nonylphenol) ble bare sporadisk påvist i prøvene. Bis-F-isomere ble påvist i noen få av fugleeggprøvene, Bis-A-isomere i en rødrevlever og alle de tre rotteleverprøvene. Leverprøvene hadde høyeste konsentrasjoner, og nivåene var lavere enn i 2019.

Dominerende stoffgrupper i de ulike miljøprøvene

Median for sumkonsentrasjoner av den dominerende forurensningsgruppen for hver matrise i den undersøkte arten i 2020 er gitt nedenfor. Metals er summen av Hg, Cd, Pb og As

- Luft	:	cVMS >> CP > OPFR >>PCB
- Jord	:	Metals >>CP > OPFR
- Meitemark	:	Metals >> PFAS >OPFR
- Gråstrostegg	:	PFAS >CP > Metals ~cVMS
-Kattugle egg	:	CP~PFAS~PCB> Metals
- Rødrev lever	:	Metals > Biocides>> CP
- Brunrotte lever	:	Metals >> cVMS> Biocides~CP

Biomagnifisering: En næringskjedetilnærming med meitemark-gråtrost-spurvehauk ble anvendt for å beregne trofisk magnifiseringsfaktor (TMF) basert på konsentrasjoner og δ^{15}N -data av ulike miljøgifter fra årene 2014 til 2020 for byområder i Oslo. I tillegg ble biomagnifiseringsfaktorer (BMF) beregnet for enkelte stoffer. De typiske hydrofobe og velkjente POP-ene, som PCB og PBDE, hadde høyest BMF og TMF-verdier vel over 1, som indikerer et stort potensial for magnifisering. PFOS hadde en TMF på 1.5 og de langkjedete perfluorerte karboksylatene PFUnA til PFTeA hadde TMF verdier fra 1.6 til 1.8.

Abbreviations

BAF	bioaccumulation factor
BFR	brominated flame retardants
CI	confidence interval
CP	chlorinated paraffins
cVMS	cyclic volatile methyl siloxanes
dw	dry weight
EI	electron impact ionization
ESI	electrospray ionization
fv	fettvekt
GC-MS	gas chromatography – mass spectrometry
GC-HRMS	gas chromatography – high resolution mass spectrometry
GPC	gel permeation chromatography
ICP MS	inductive coupled plasma – mass spectrometry
LC-MS	liquid chromatography – mass spectrometry
LOD	limit of detection
LOEL	lowest observed effect level
MEC	measured environmental concentration
lw	lipid weight
MCCP	medium-chain chlorinated paraffins
M-W U	Mann–Whitney *U* test
N	detected/measured samples
n.a.	not analysed
NCI	negative chemical ionization
NOEC	no observed effect concentration
NOAEL	no observed adverse effect level
NOEL	no observed effect level
n-PFAS	neutral polyfluorinated compounds
newPFAS	new polyfluorinated compounds
NP-detector	nitrogen-phosphorous detector
OPFR	organophosphorus compounds
PBDE	polybrominated diphenylethers
PCA	principal component analysis
PCB	polychlorinated biphenyls
PCI	positive chemical ionization
PEC	predicted environmental concentration
PFAS	per- and polyfluorinated alkylated substances
PNEC	predicted no effect concentration
PSA	primary/secondary amine phase
SCCP	short-chain chlorinated paraffins
SSD	species sensitivity distribution
SIR	selective ion reaction
SPE	solid phase extraction
TL	Trophic level
TMF	Trophic magnification factor
UHPLC	ultra high pressure liquid chromatography
vv	våtvekt
ww	wet weight

1 Introduction

The main objective of this monitoring programme is to assess the presence of selected environmental pollutants in a terrestrial urban environment in Norway, and their bioaccumulation potential. A description of the various species, pollutants, and how the samples were handled and prepared, is provided in the Appendix 1 to this report, as is the chemical analysis and the quality assurance measures taken. Sampling has to a minor degree varied among years, e.g. locations and sample size. Not all species have been sampled in all years due to the availability of samples from European badger, eggs form sparrowhawk and tawny owl. Samples collected for year 2020 are described in chapter 2.
Due to the different physicochemical properties of the pollutants of interest, several different sample preparations methods were applied. Lipophilic compounds such as PCB, PBDE and CP were analysed together. PFAS, metals, phenols, siloxanes, UV compounds and biocides required each a dedicated sample preparation. Briefly samples were homogenized and extracted with appropriate solvent. After extraction solvents were aliquoted out and reduced, followed by a by a clean-up procedure to remove lipids and other interferences prior to analysis.
GPS coordinates of the samples are given in Appendix 2. Concentrations of pollutants and isotope values in the samples are given in Appendix 3.

2 Sampling in 2020

Samples for all matrices were collected, except European badger and sparrowhawk eggs. Sparrowhawk eggs were not available due to no active nests found in the study area, and samples from European badger were not available. Samples were collected at the same locations as previous years when possible. This was most relevant for sampling of air, soil, earthworms and, was also, when possible, done for fieldfare eggs, see Table 1. In addition, locations were selected to reflect the different area uses in an urban setting: Three different sites at Alnabru, an industrialised site; Slottsparken, a central urban park surrounded by traffic; Kjelsås, one of the northern suburbs of Oslo near the lake Maridalsvannet which is the main drinking water supply for the city; Frognerseteren, a popular recreational and skiing area, also used for international competitions; Grønmo, a former landfill site in Oslo (the largest in the city) which was shut down in 2007, which is now regulated for sports- and recreational activities and that also has reuse and recycling station for waste; and VEAS, Vestfjorden Wastewater Treatment Plant, Norway's largest sewage treatment plant.

The different biota species included in the study were selected to represent different trophic levels, from primary consumers (earthworm) via secondary consumers (fieldfare and tawny owl). In addition, two omnivore generalists representing a truly urban environment, the red fox and the brown rat, were chosen. An overview over the analysed species and samples is given in Table 1. All samples were sampled and handled according to the guidelines given in OSPAR/ JAMP, 2009.

Table 1: Location and selection of samples (Coordinates can be found in the Appendix 2).

Sample type	Sampling strategy	No. of samples	Location	Year
Air	Passive air samples	5	Oslo	2020
Soil	Pool of 3 soil samples at each site	5	Oslo	2020
Earthworms (*Lumbricidae*)	Pool of 15-20 individual samples	5	Oslo	2020
Fieldfare (*Turdus pilaris*)	Pool of 2 eggs from the same nest	8	Oslo	2020
Tawny owl (*Strix aluco)*	One addled egg per nest	10	Oslo	2020
Brown rat (*Rattus norvegicus*)	Pool of 2-3 individual samples for those with low weight	10	Oslo	2020
Red fox (*Vulpes vulpes*)	Individual liver samples	10	Oslo	2020/2019

Figure 1: Sampling locations in the 2020 monitoring project. See table below for overview of sample types sampled in different locations, and Appendix 2 for coordinates of the various sites. Blue triangle: air samplers, black star: soil and earthworm, red circle: fieldfare eggs, black open square: brown rat (BR), black filled square: red fox

Table 2: Locations, species and matrices sampled along with sample size. Locations are shown in the map in Figure 1.

Locations	Air	Soil	Earthworm	Brown rat	Fieldfare	Red fox	Tawny owl
Alnabru	1	1	1		3[1]		
Oslo city (two "BR" locations)				10[2]			
Bøler					1		
Ekeberg					1		
Frognerseteren	1						
Grønmo	1	1	1		1		
Holmen					1		
Kjelsås		1	1		1		
Hellerudmyra						7	
Ring 3[3]						3	
South-East of Oslo[4]							10
Slottsparken	1	1	1				
VEAS (Arnestad)	1	1	1				

[1]Three locations, Alnabru 1, 2 and 3, [2] Two locations for brown rats, see Appendix 2 for details. [3]Unspecified location in Oslo city, road killed red foxes delivered by local authorities. [4]Sout-east location of tawny owl egg are not shown in the map.

Air

Air concentrations were measured using two types of passive air samplers (PAS) at the five locations; Slottsparken, Frognerseteren, Grønmo, Alnabru and VEAS. These were the same sites as for soil and earthworms, except from Frognerseteren. The PAS were prepared, deployed and retrieved by NILU personnel. Each PAS type was exposed for three months (Table 3) according to standard routines in the guidance document for the Global Monitoring Plan of the Stockholm convention, GMP (UNEP, 2015). Field blanks for air samples were continuously included. These were transported and stored together with the exposed samples to provide information about any contamination during sampling or storage. For the sampling at VEAS, the air samplers were installed at the pipe outlet in order to capture potential polluted air directly from the plant.

Table 3: Locations and number of exposure days for passive air samples

Air samples	Deployed 2020	Retrieved 2020	Number of exposure days
Slottsparken (Dronningparken)	June 04	September 04	92
Frognerseteren (Holmenkollen)	June 04	September 04	92
Grønmo	June 04	September 04	92
Alnabru	June 04	September 04	92
VEAS	June 04	September 04	92

Figure 2. Air samples (PUF <and XAD) installed at Grønmo site

Soil

Soil samples were collected at the same five locations as earthworm samples, Table 4. The upper layer of 0-20 cm of soil was sampled and at three locations at each site. In cases where the site was connected to a transition between forest and open field, samples were taken in the forest, in the field and between. The soil site for Grønmo and Kjelsås is shown in Figure 3.

Figure 3: Soil and earthworm sampling site at Grønmo (left) and Kjelsås (right)

Earthworms (*Lumbricidae*)

Earthworms were collected at the same five locations in Oslo as the soil to allow direct comparison between soil and earthworm. All pooled samples consisted of 15-20 individuals. To purge their guts, earthworms were kept in aluminium covered plastic containers, and lined with moist paper sheets for three days before being frozen at -21°C.

Table 4: Locations for soil and earthworm sampling.

Location for soil and earthworms	Date	Soil depth	Site description
Slottsparken	July 17	10-20 cm	Park area in the centre of Oslo used for recreational purposes, also a tourist attraction; good soil
Grønmo	May 9	10-15 cm	Near landfill, golf course, road; roots and some clay in soil
Alnabru	May 9	7-15 cm	Industrial and commercial area with shopping centres and a cargo handling station/railway; compact soil with clay. The area is under development. The samples were collected in the green corridor along the river Alna.
Arnestad (VEAS)	May 24	13 cm	Urban area in vicinity of VEAS STP with roads, commercial activity, and schools nearby; soil with clay, some plastics wate nearby.
Kjelsås	August 5	~15 cm	Birch forest near soccer field; good soil with some clay

Fieldfare *(Turdus pilaris)*

Two fieldfare eggs were collected from each of eight nests in the Oslo area, 16 eggs in total,

Table 5, under permission from the Norwegian Environment Agency. The laying order of the eggs was not taken into account when collecting the eggs to avoid disturbing the nest more than necessary. The eggs were kept individually in polyethylene bags in a refrigerator (+4°C), before being shipped by express mail to NINA for measurements and emptying. When emptying, the whole content of the eggs was removed from the shell and transferred to clean glass vials for storage at − 21 °C. The dried eggshells were measured (length, breadth and weight of shell) in order to calculate the eggshell index, which is a measure of eggshell quality (Ratcliffe, 1970). In addition, the shell thickness was measured using a special calliper (Starrett model 1010).

Table 5: Locations and collection date for fieldfare egg sampling (coordinates for the sites are given in Appendix 2)

Location for fieldfare egg sampling	Collection date	Information on the two eggs
Grønmo	03.05.2020	No development
Bøler	03.05.2020	Embryo
Ekeberg	09.05.2020	No development
Alna I	09.05.2020	Chick; no development
Alna II	09.05.2020	No development; Embryo
Alna III	09.05.2020	Embryo
Holmen	20.05.2020	No development
Kjelsås	20.05.2020	No development; Embryo

Brown rat *(Rattus norvegicus)*

Brown rats were caught during winter time using clap-traps (no rat poison involved) in residential areas of Oslo city. The traps were usually inspected daily, and the rats were placed in the freezer as fast as possible on the day of collection. All samples were from the Oslo city centre (Fredensborgveien and Thereses gate). Seven liver samples were individual samples, two samples from Fredensborgveien and one sample from Thereses gate consisted of two individuals each, using individuals of same gender and age, see Appendix 2. This was done in order to obtain sufficient material for all the component analyses. The final sample number was eight liver samples of female rats and two liver samples of male rats. The bodyweight of the rats ranged between 228 and 407 g.

Red fox *(Vulpes vulpes)*

Of the ten red foxes, seven were shot by a local hunter at Hellerudmyra, Oslo, at the same location where samples were collected in 2019. This hunting location is in a large forest area, but only 5- 10 km away from highly populated areas of Oslo and Bærum. The area between the forest and city, is a mix of agriculture and forest. The home ranges of the foxes will therefore include both forest-, agriculture- and urban areas. Three road killed red foxes were delivered by the local authorities in Oslo (Bymiljøetaten). These foxes were assumed to be collected from the inner part of Oslo city, and we refer to this unspecified location as 'Ring road 3' (Fig. 1). The weight of the ten animals varied from 4.8 to 8.4 kg and the body length from 69 to 78 cm. Among the sampled foxes, there were six males and four females. Their sex was determined by inspection of the gonads (Morris, 1972).

Tawny owl (*Strix aluco*)

The tawny owl eggs were sampled south-east of Oslo, in Viken County. Six eggs came from Vestby municipality, two from Ås, and one from nedre Follo and Frogn. These eggs were addled eggs and were collected at the time of ringing of the chicks, and later handled by the same method as the fieldfare eggs at NINA.

3 Results

A list of the selected environmental pollutants with abbreviations and CAS no. can be found in Appendix 1, Table 37. In addition, Appendix 1 gives information about the various species, compound classes and the analytical and statistical methods. Concentrations and isotope data for the singe samples are available in Appendix 3.

In total, 130 selected environmental pollutants were analysed. Metals were not measured in air samples, and biocides only in liver samples of fox and brown rat in the core program. Some compounds such as OPFR and UV substances were only analysed in one or three pooled samples prepared from single samples. OPFR compounds were only analysed in air, one pooled sample each of soil and earthworm.

In the chapters below, tables with mean, minimum and maximum concentrations are given for each component in the various compound classes. In addition, box and whiskers plots (Plotly Chart Studio[1]) are provided. The upper and lower boundaries of the box represent the 25th and 75th percentile, and the horizontal line in the box marks the median. The whiskers represent the minimum and maximum values without outliers. To improve readability, most box plots are presented with a log-scaled y-axis due to the high variation in concentrations among samples and species. In general, we mainly compare this year's results to results from previous years.

Table 6 shows the percentage detection of the components in the different sample types. For environmental pollutants not analysed in the samples, these are denoted n.a. in the table. As can be seen, metals were detected in almost all samples which is also the case with PCB, for cyclic siloxanes and many of the perfluorinated sulfonates (PFSA) and carboxylates (PFCA).

In addition to the 130 compounds in included in the core monitoring program, additional biocide analysis was performed on tawny owl and sparrowhawk eggs previously sampled in the program. In addition, TCPP, a compound in the OPFR group, was analysed in each soil sample from the seven sites from 2019 due to a very high combined TCPP concentration in the one mixture soil sample from 2019. Extractable organic fluorine content (EOF) was tested and analysed in some samples from previous years and from 2020. These data are not shown in Table 6, but considered in the chapter of biocides, OPFR and PFAS, respectively.

[1] Plotly Technologies Inc. Title: Collaborative data science Publisher: Plotly Technologies Inc. Place of publication: Montréal, QC Date of publication: 2015 URL: https://plot.ly

Table 6: Percentage detection of components in various sample types. n.a.: not analysed

Components	Air	Soil	Earthworm	Fieldfare egg	Tawny owl	Red fox liver	Rat liver
Cr	n.a.	100	100	100	100	100	100
Ni	n.a.	100	100	100	100	100	100
Cu	n.a.	100	100	100	100	100	100
Zn	n.a.	100	100	100	100	100	100
As	n.a.	100	100	100	90	100	100
Ag	n.a.	100	100	100	90	100	100
Cd	n.a.	100	100	100		100	100
Pb	n.a.	100	100	100	100	100	100
Hg	n.a.	100	100	100	100	100	100
PCB28	100	20	100	75	100		100
PCB52	100	40	80	100		10	
PCB101	100	100	80	100	100		100
PCB118	100	100	60	100	100	20	100
PCB138	100	100	40	100	100	100	100
PCB153	100	100	100	100	100	100	100
PCB180	100	100	100	100	100	100	100
BDE47	100		20	100	100	30	100
BDE99	100	20	20	100	100		100
BDE100	100		100	100	100	10	100
BDE126	40	40	20	38	10		10
BDE153	60	40	20	88	100	90	100
BDE154	60	40	20	88	90		90
BDE175/BDE180	60	40	20	88	90	10	90
BDE191	20	40					
BDE196		40		50	50	10	40
BDE202		40		50	50	30	50
BDE206	60	20				10	
BDE207	60	20		50		10	
BDE209	60			13	10	60	10
PFBS							
PFPS							
PFHxS	100		20	100	50	90	90
PFHpS	60			100	30	40	
brPFOS				100	100	10	30
PFOS	40	100	100	100	100	100	100
PFNS	20	20		100	50	50	80
PFDcS				100	80	10	20
PFBA		80	20			10	
PFPA		60	60	13	20		80
PFHxA	20	80				20	10
PFHpA		80	100	100	10	30	
PFOA	20	100	100	100	70	100	20
PFNA		40	100	100	100	100	20
PFDcA		100	100	100	100	100	100
PFUnA	20	80	100	100	100	100	100
PFDoA		40	100	100	100	100	100
PFTriA	60		100	100	100	100	100
PFTeA			100	100	100	100	100
PFHxDA	40		100	100		10	
PFOcDA	20		100	13		10	

Table 6 cont.

Components	Air	Soil	Earthworm	Fieldfare egg	Tawny owl	Red fox liver	Rat liver
PFOSA	60	20	80	100	70	80	70
meFOSA	n.a.		n.a.				
etFOSA	n.a.		n.a.				
meFOSEA	n.a.		n.a.				
meFOSE	n.a.		n.a.				
etFOSE	n.a.		n.a.				
6:2 FTOH	n.a.		n.a.				
8:2 FTOH	n.a.		n.a.				
10:2 FTOH	n.a.		n.a.				
12:2 FTOH	n.a.		n.a.				
4:2 FTS			n.a.				
6:2 FTS			n.a.	63			
8:2 FTS			n.a.	100	100	50	100
10:2 FTS			n.a.	100	20		20
SCCP	60	40	20	75	60	80	0
MCCP	0			100	50	50	60
D4	100	100	100	100	100	100	100
D5	100	100	100	100	100	100	100
D6	100	100	100	100	70	100	100
TCEP	60		n.a.	n.a.	n.a.	n.a.	n.a.
TPrP			n.a.	n.a.	n.a.	n.a.	n.a.
TCPP	60	100	n.a.	n.a.	n.a.	n.a.	n.a.
TiBP	40		n.a.	n.a.	n.a.	n.a.	n.a.
TPP	60		n.a.	n.a.	n.a.	n.a.	n.a.
TnBP	60		n.a.	n.a.	n.a.	n.a.	n.a.
DBPhP			n.a.	n.a.	n.a.	n.a.	n.a.
BdPhP			n.a.	n.a.	n.a.	n.a.	n.a.
TDCPP			n.a.	n.a.	n.a.	n.a.	n.a.
TBEP			n.a.	n.a.	n.a.	n.a.	n.a.
TCP	80	100	n.a.	n.a.	n.a.	n.a.	n.a.
EHDP			n.a.	n.a.	n.a.	n.a.	n.a.
TXP			n.a.	n.a.	n.a.	n.a.	n.a.
TIPPP	20		n.a.	n.a.	n.a.	n.a.	n.a.
TEHP	60	100	n.a.	n.a.	n.a.	n.a.	n.a.
ATE (TBP-AE)							
a-TBECH	80						
b-TBECH	40						
g/d-TBECH	20						
BATE			20		20		20
PBT	80						
PBEB	40		40		30		30
PBBZ	40						
HBB	20				10		10
DPTE	80				30	10	30
EHTBB	40						
BTBPE	20				20	10	20
TBPH (BEH /TBP)	20						
DBDPE							

Table 6 cont.

Components	Air	Soil	Earthworm	Fieldfare egg	Tawny owl	Red fox liver	Rat liver
BP3	n.a.		n.a.	n.a.			
EHMC-Z	n.a.		n.a.	n.a.			
ODPABA	n.a.		n.a.	n.a.			
EHMC-E	n.a.		n.a.	n.a.			
UV-320	n.a.		n.a.	n.a.			
UV-326	n.a.	100	n.a.	n.a.	67	67	100
UV-329	n.a.		n.a.	n.a.			
UV-328	n.a.	100	n.a.	n.a.	67	67	100
UV-327	n.a.	100	n.a.	n.a.	100		67
OC	n.a.	100	n.a.	n.a.			
Bromadiolone	n.a.	n.a.	n.a.	n.a.	n.a.	100	100
cis-Brodaficoum	n.a.	n.a.	n.a.	n.a.	n.a.	100	10
trans-Brodaficoum	n.a.	n.a.	n.a.	n.a.	n.a.	100	10
trans-flocumafen	n.a.	n.a.	n.a.	n.a.	n.a.		
cis-Flocumafen	n.a.	n.a.	n.a.	n.a.	n.a.		
cis-Difenacoum	n.a.	n.a.	n.a.	n.a.	n.a.	100	
trans-Difenacoum	n.a.	n.a.	n.a.	n.a.	n.a.	80	
trans-Difethialone	n.a.	n.a.	n.a.	n.a.	n.a.		
cis-Difethialone	n.a.	n.a.	n.a.	n.a.	n.a.		
4,4-bis A	n.a.		n.a.			10	
2,4-bis A	n.a.		n.a.				
4,4-bis- S	n.a.		n.a.				
2,4-bis-S	n.a.		n.a.	25			
4,4-bis-F	n.a.		n.a.	25	20		20
2,4-bis-F	n.a.		n.a.		10		10
2,2-bis-F	n.a.		n.a.		10		10
TBBPA	n.a.		n.a.				
4-tert-octylphenol	n.a.		n.a.				
4-octylphenol	n.a.		n.a.				
4-nonylphenol	n.a.		n.a.				

3.1 Metals

Metals were analysed in all samples, except air samples, see Figure 4, Figure 5 and Table 7. The concentrations of metals in the various samples are in agreement with data from previous years in this urban terrestrial monitoring program (Heimstad et al., 2020). Zn was the dominating metal in all samples. In soil, second highest concentrations were detected for Cr, followed by Ni and Pb. In all animal samples, Cu had the second highest concentration.

Soil: According to the Norwegian guidelines on classification of environmental quality of soil (normative values), 8 000 ng/g dw of As, 60 000 ng/g dw of Pb, 1 500 ng/g dw of Cd, 1 000 ng/g dw of Hg, 100 000 ng/g Cu, 200 000 ng/g Zn, 50 000 ng/g dw of Cr (III) and 60 000 ng/g dw of Ni represent the threshold value for when soil is considered contaminated (Lovdata, kap.2, vedlegg 1[2]).

Threshold values were exceeded for Cr and Ni at the following locations:

- Cr: VEAS, Alnabru, Grønmo and Slottsparken
- Ni: VEAS

For As, Zn, Cd, Cu and Hg, no locations exceeded the threshold values.

This year the sites Slottsparken, Grønmo and Alnabru had the highest and comparable sum concentration of toxic metals (As, Cd, Pb, Hg) with the range 41896-48751 ng/g dw (see also chapter 3). The dominating metals were Pb and As. The site Frognerseteren which had rather high Pb concentrations in previous years was not sampled in 2020 and was replaced by the site Kjelsås. When comparing mean concentrations in soil from Bristol (Giusti, 2011) to our data from Oslo in 2018-2020, only mean value of Ni was comparable with the results from Bristol; Cr from Oslo was higher, and the rest of metals from Oslo had lower mean concentrations than Bristol. With 450 000 inhabitants, Bristol is of comparable size as Oslo, and both are coastal cities.

Earthworm: The sum concentration of the toxic metals in the five pooled earthworm samples ranged from 3065-4234 ng/g dw). The Grønmo sample had the highest sum concentration and was dominated by Pb and Cd. Cd concentrations (1000 -2265 ng/g ww) at all sites exceeded the secondary poisoning for predators (PNECoral value) of 160 ng/g food for oral consumption of earthworms[3].

Fieldfare eggs: In agreement with results from previous years, Zn and Cu dominated in fieldfare eggs. However, Zn and Cu are physiologically regulated and supposed to have little toxicological effect (Lukkari et al. 2004). Of the toxic metals investigated, Pb and Hg were the most abundant ones and in agreement with previous years' results. The mean value of Pb (36 ng/g ww) was slightly higher than data from 2019. Hg, Cd and As concentrations were in agreement with the 2019 results.

Pb levels as low as 0.4 ppm (400 ng/g) in blood can result in adverse physiological effects in passerine birds, while 4 ppm in feathers is associated with negative effects on behaviour, thermoregulation, locomotion, and depth perception resulting in lowered nestling survival (Tsipoura et al, 2008).

As previous years have revealed, the egg sample from Kjelsås had the maximum Pb concentration of 186 ng/g ww which is comparable to results from 2017 (206 ng/g ww) and higher than the concentration detected in 2019 (51 ng/g) and 2018 (136 ng/g ww). The same location Kjelsås had highest Pb concentration of 494 ng/g ww in 2016, an exceptionally elevated level, crossing the effect-level mentioned above. Eggs from Alnabru 1 had the highest concentration of Ni of 55.6 ng/g ww, ten

[2] https://lovdata.no/dokument/SF/forskrift/2004-06-01-931/KAPITTEL_1-2#KAPITTEL_1-2

[3] https://echa.europa.eu/brief-profile/-/briefprofile/100.028.320

times higher than the second highest concentration. In 2019, Alna 3 revealed highest concentration of 182 ng/g ww. As in 2019, the same sample from Alnabru with highest Ni concentration also had the highest Cr concentration (135 ng/g ww). Maximum concentration of 10 ng/g ww of As was also detected in the same egg sample.

Tawny owl eggs: Similar to fieldfare eggs, the results from this year's sampling showed that Zn and Cu were the dominating metals in tawny owl eggs. Cu, with a median of 1103 ng/g ww was comparable to median value from 2017 (1079 ng/g ww) when tawny owl where collected from the same area and nests. As also seen for fieldfare eggs, one tawny owl egg contained the maximum concentrations of Cr (100 ng/g ww) and Ni (39.1 ng/g ww). Ni concentrations (median value of 2.1 ng/g ww) were lower than in 2017. Cd concentrations were all below LOD, and Pb concentrations were lower than in fieldfare eggs and lowest across all samples. Hg concentrations in tawny owl eggs were comparable to the Hg levels detected in fieldfare eggs in this year's sampling, and well below the reported Hg reproductive effect thresholds of 600- 2700 ng/g ww in bird egg (Fuchsman et al. 2017).

Red fox: As for the other samples, Zn and Cu were the dominating metals in the individual red fox liver samples. The findings are in agreement with previous years' data. However, the concentrations of Cr, Ni and Pb in 2020 were lower than in 2019when reported Cr, Ni and Pb concentrations were 598 ng/g ww, 270 ng/g ww and 1734 ng/g ww, respectively. The mean concentrations of As (26.1 ng/g ww), Cd (189 ng/g ww) and Hg (125 ng/g ww) were higher in 2020 compared to 2019 mean concentrations of As (11.6 ng/g ww), Cd (158 ng/g ww) and Hg (88.8 ng/g ww).

Metal levels in red foxes from Oslo in this study are higher than previously reported for suburban foxes from Croatia. Bilandžić et al., 2010 reported Pb levels in liver from suburban red foxes (n=12) from Croatia in the range 0.024 - 0.584 mg/kg ww (24 – 584 ng/g ww) with a mean concentration of 131 ng/g ww which is slightly lower than mean Pb concentration from red fox livers from Oslo area in 2020 (178 ng/g ww). The average Cd (125 ng/g ww), Hg (25 ng/g ww) and As (16 ng/g ww) concentrations in red fox livers from Croatia were lower than the mean concentrations of Cd (189 ng/g ww), Hg (178 ng/g ww) and As (26.1 ng/g ww) found in red fox livers from Oslo, 2020.

Brown rat: Metals were analysed in ten liver samples consisting of seven individual samples and three pooled samples, see chapter 2 and Appendix 2. Metals in rat liver from 2020 were, as in previous years, mostly represented by high levels of Zn followed by Cu and As, see Table 7. In agreement with data from previous years, 2020 data also revealed that rats contained the highest levels of As of all analysed species with mean value of 1600 ng/g ww. Rat samples have been caught by trap without using poison, but high levels of As has been detected in some of the rat liver samples over the years in this project. Hazard for predators for secondary poisoning has been set to 1000 ng/g food[4]. Eight out of ten samples were above 1000 ng/g ww. The levels of As in brown rat liver samples were in general lower in 2020 compared to 2019 data. As shown in the other species, the samples with highest Cr concentrations had also the highest Ni concentrations.

Summary metals

The concentrations of the metals Cr and Ni in soil at some locations exceeded the threshold for when soil is considered contaminated. Of the biological matrices analysed, earthworms, brown rats and foxes contained the highest levels, see Figure 4 and Table 7. Cd concentrations in earthworms at all sites exceeded the PNECoral value of 160 ng/g food for predators of earthworms. Eight out of ten rat liver samples had As concentrations exceeding the PNECoral vale for predators of 1000 ng/g ww.

[4] https://echa.europa.eu/brief-profile/-/briefprofile/100.028.316

Table 7: Mean concentrations with min-max interval below in grey colour of the various metals in Soil (ng/dw), Earthworm, Fieldfare, Tawny owl, Red fox and Brown rat. All concentrations in biological samples are given in ng/g ww.

Compounds	Soil ng/g dw	Earthworm	Fieldfare	Tawny owl	Red fox	Brown rat
Cr	53 113 180-81861	1 429 545-2490	23.3 2.47-135	23.1 4.51-100	194 97.7-374	562 32.6-1656
Ni	33 046 180-67368	963 463-1310	9.57 1.16-55.6	5.68 1.02-39.1	84 34.2-184	257 8.89-725
Cu	24 975 4022-39504	2 869 2050-3799	395 240-680	1 522 629-3257	12 700 3813-33033	2 961 2186-3594
Zn	83 477 28177-185370	171 091 143028-214832	10 931 4703-16962	9 489 2525-15719	38 043 27734-68240	23 584 18046-27790
As	4 694 1290-6571	778 566-1110	4.61 1.94-10.3	0.99 <LOD-1.85	26.1 4.11-182	1 600 329-3822
Ag	143 42.7-278	26.5 16.2 47.0	0.67 0.13-1.22	0.37 <LOD-1.36	3.22 0.78-13.2	1.10 0.60-1.64
Cd	212 195-223	1 682 1000-2265	0.41 0.12-0.88	<LOD	189 36.2-302	32.0 5.32-93.7
Pb	31 646 14351-42493	979 290-1989	36.3 7.65-186	1.65 0.57-4.78	178 22.4-419	66.2 9.75-258
Hg	116 39.7-227	137 48.7-325	11.6 6.27-18.8	8.31 4.52-10.7	125 19.8-300	6.87 3.37-9.76

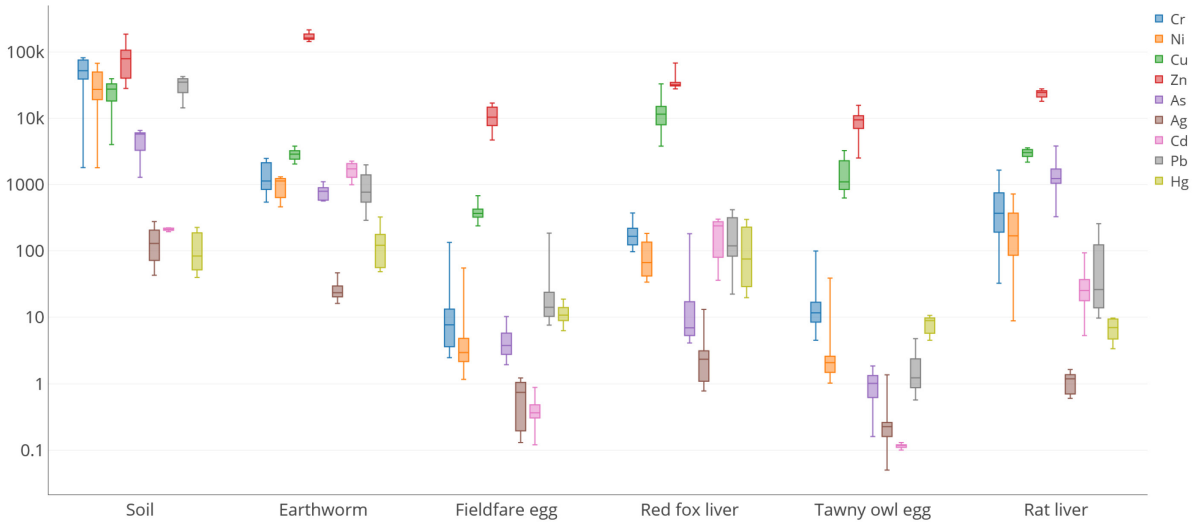

Figure 4: Box plot of metals in environmental samples. Concentrations are given in ng/g ww, except ng/g dw in soil. The upper and lower boundaries of the box are representing the 25th and 75th percentile. The whiskers represent the minimum and maximum values without outliers.

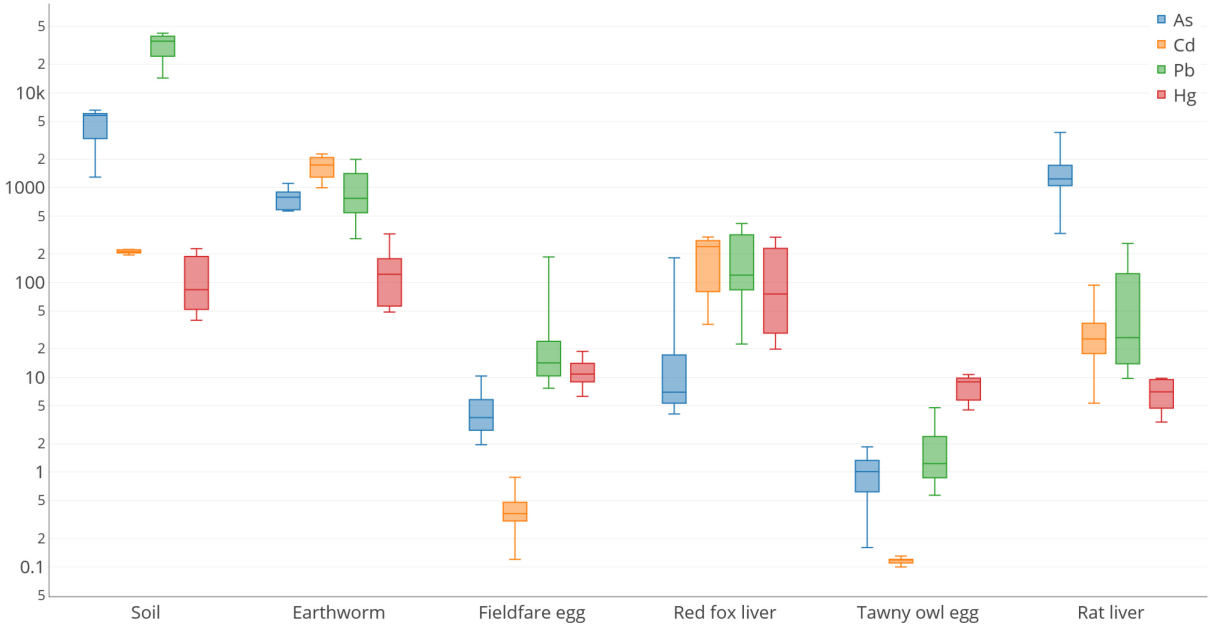

Figure 5: Box plot of selected toxic metals in environmental samples. Concentrations are given in ng/g ww, except ng/g dw in soil. The upper and lower boundaries of the box are representing the 25th and 75th percentile. The whiskers represent the minimum and maximum values without outliers.

3.2 PCB

Seven PCB congeners were analysed in all samples, see Table 8 and Figure 6. The lower chlorinated and more volatile congeners (PCB-28 to PCB-101) dominated the air samples. The result is in agreement with previous years' data. As also shown in results from previous years, PCB-153 dominated earthworm and bird egg samples, PCB-138 and 153 in soil samples, and PCB-180 in red fox liver samples. The lowest concentrations were detected in brown rat on a wet weight basis.

Air: The results in 2020 were in agreement with results from previous years. All seven congeners were detected. PCB-101 and PCB-52 were the dominating congeners. Also as found in previous years, the highest concentrations were found for the sampling site in Slottsparken (475 pg/day) followed by Alnabru (133 pg/day), see also chapter 4.

The calculated estimate of air concentrations for sumPCB7, using an uptake rate of 4 m^3/day, ranged from 6.2 pg/m^3 at Grønmo to 119 pg/m^3 at Slottsparken. This range is similar to 2019 data with a range of 6.5 pg/m^3 at Grønmo to 121 pg/m^3 at Slottsparken. For comparison, the concentration of sumPCB7 in air from the background air monitoring station at Birkenes in southern Norway (2.7 pg/m3 in 2019) is up to 12 to 40 times lower than those measured at Alnabru and Slottsparken in this study from 2020, but comparable to sumPCB at Grønmo (Bohlin-Nizzetto et al, 2020). The dominating congeners of PCB7 were 28, 52 and 101 at Birkenes, in accordance with the results from the PAS measurements in Oslo in 2020. A direct comparison to data from active samplers used at monitoring stations (for example Zeppelin and Birkenes stations) should be done with caution as the accumulation in PAS and the applied uptake rates introduce factors of uncertainty.

The higher concentrations observed at Slottsparken and Alnabru in this study indicates that some specific sites in the urban area of Oslo act as significant source to PCB concentrations in air. For information, the deployment of PAS in Slottsparken had to be done using a protection felt below the samplers during all the sampling period (in order to protect the trees). Experiments in clean room at NILU has revealed that the congeners PCB-28, 52 and 101 in the felt might contaminate the PAS sampler, but this was not likely for the higher chlorinated congeners. Since the findings of PCB in air from Alnabru, in both soil and earthworms from the other sites in Oslo were comparable or higher than Slottsparken, this indicates several PCB sources in central areas of Oslo.

Soil: The concentrations in soil were slightly higher than in 2019. PCB-138 and -153 were the dominating congeners at all sites. The site at Kjelsås, which was not sampled in 2019, had the highest concentrations with sumPCB7 of 17.3 ng/g dw followed by Grønmo (6.6 ng/g dw), see also Table 23. Only congeners PCB-28 and PCB-52 had some detections below LOD, the other congeners were detected at all sites.

According to the Norwegian guidelines on classification of environmental quality of soil (normverdi), 10 ng/g dw sumPCB7 corresponds to a good environmental status. The soil sample from the site Kjelsås exceeded this threshold value.

Earthworm: SumPCB concentrations in 2020 ranged from 0.35 to 5.06 ng/g ww. PCB-28, -153 and -180 was found in detectable concentrations in pooled earthworm samples from all sites. The other congeners were below LOD at some sites. All congeners were detected in earthworms from Slottsparken and Alnabru, which also had the highest sumPCB concentrations of 5.06 and 3.68 ng/g ww, respectively. As in 2019, Slottsparken had highest concentration (see also chapter 4).

Fieldfare: All congeners were detected in pooled egg samples from fieldfare, except PCB-28 in two samples. PCB-153 was the dominating congener with concentrations from 3.93 to 26.9 ng/g ww.

SumPCB concentrations (9-56 ng/g ww) were slightly lower than in 2019 (8-71 ng/g ww), and the median sumPCB of 20 ng/g ww was comparable to 2019 (27 ng/g ww) and 2018 (31 ng/g ww).

A study on starling eggs (*Sturnus vulgaris*), sampled worldwide revealed a mean sumPCB7 concentration of 218 ng/g lw, where PCB153 dominated with 96 ng/g lw, at one Norwegian rural location in Northern Trøndelag (Eens et al. 2013). In comparison, the mean sumPCB concentration in urban fieldfare eggs form this study was 518 ng/g lw where PCB153 dominated with a mean value of 226 ng/g lw. The highest sumPCB7 concentration in our study from 2020 was detected in egg from Kjelsås (1126 ng/g lw), and the lowest sum concentration was detected at Alna II (171 ng/g lw).

Tawny owl:
All but one congener PCB-52, were detected in the ten individual egg samples. PCB-153, -180 and -138 had the highest concentrations. The sumPCB values in 2020 varied between 8 and 69 ng/g ww with a mean and median value of 21 ng/g ww and 17 ng/g ww, respectively. The mean sumPCB value from 2020 is comparable and lower to the mean sum values from the years 2015, 2016 and 2017 with 26, 42 and 34 ng/g ww, respectively. For comparison, Bustnes et al., (2011), found higher mean SumPCB (193 ng/g ww) in tawny owl eggs collected 2009 in Trøndelag, Norway.

A study from Sweden of 11 addled eggs from tawny owl collected in 2014 from different provinces revealed sumPCB7 concentrations from 167 to 2886 ng/g lw and a median sumPCB7 of 594 ng/g lw (Lind, 2015). Our data from 2020 revealed a range from 186 to 833 ng/g lw and a median sumPCB7 of 386 ng/g lw.

Red fox
In total, 10 individual fox livers were analysed for PCB. First and foremost, the higher chlorinated congeners PCB-138, -153 and 180 were detected and PCB-180 was the dominant congener. As last year, PCB-28 and -101 were not detected in any samples, and PCB-52 and -118 were only detected in one and two samples, respectively. The sumPCB concentration ranged from 1 to 52 ng/g ww compared to 2 - 19 ng/g ww in 2019, 7- 310 ng/g ww in 2018, and 2 -261 ng/g ww in 2017. This years' median sumPCB was 13 ng/g ww compared to 6 ng/g ww in 2019, 15 ng/g ww in 2018, 9.2 ng/g ww in 2017 and 14 ng/g ww in 2016.

For comparison, in a study by Mateo et al., 2012, sumPCB concentrations of 1262 ng/g ww were reported in fox liver samples from a natural reserve in south west Andalucia in Southern Spain, i.e. levels significantly higher than the maximum sumPCB concentration in our present study.

A study of 19 red fox liver samples from suburban areas in Poland revealed mean sumPCB7 concentration 290 ng/g lw where congeners PCB-180, -153 and 138 dominated with 90 % (Tomza-Marciniak et al., 2012). PCB concentrations were in general higher for male red foxes than female ones. The mean sumPCB7 value from 2020 of red foxes in urban areas of Oslo was higher with 510 ng/g lw.

Andersen et al. reported in Arctic fox liver from Svalbard, Norway, a median sumPCB of 342 ng/g ww, more than thirty times higher than median sumPCB of 13 ng/g ww for the urban foxes in this study. The higher concentration in Arctic fox are explained by their marine diet (Andersen et al., 2015).

Brown rat
PCB was analysed in ten liver samples consisting of seven individual samples and three pooled samples, see chapter 2. SumPCB varied between 0.05 to 4.5 ng/g ww (mean 0.8 ng/g ww) compared to 0.6 to 27.1 ng/g in 2019 (mean of 7.8 ng/g ww). Maximum sumPCB was lower than data from 2017

to 2019. As in previous years, PCB-138, PCB-153 together with 180 dominated the PCB pattern, and only PCB180 was detected in all ten samples.

Summary PCB

PCB congeners were detected in many samples and as expected PCB-153 dominated the pattern in most biota samples. In red fox liver PCB-180 had highest concentration, see Table 8 and Figure 6. On a lipid weight basis, highest mean sumPCB concentration was detected in fieldfare eggs and red fox livers.

Table 8: Mean concentrations with min-max interval in grey below for the various PCB congeners in Air (pg/day), Soil (ng/dw), Earthworm, Fieldfare, Tawny owl, Red fox and Brown rat. All concentrations in biological samples are given in ng/g ww. <LOD in light grey colour is given for compounds with no detected concentrations.

Compounds	Air pg/day	Soil ng/g dw	Earthworm	Fieldfare egg	Tawny owl	Red fox	Brown rat
PCB-28	21.8 5.18-45.8	0.15 <LOD-0.26	0.35 0.09-1.27	0.06 <LOD-0.10	0.15 0.02-0.69	<LOD	<LOD <LOD-0.03
PCB-52	35.3 6.75-110	0.26 <LOD-0.62	0.22 <LOD-0.62	0.54 0.09-2.11	<LOD	<LOD <LOD-0.03	<LOD <LOD-0.01
PCB-101	37.5 5.20-142	1.02 0.22-2.75	0.42 <LOD-0.90	1.67 0.60-4.26	0.12 0.04-0.29	<LOD	<LOD <LOD-0.02
PCB-118	8.6 1.34-29.5	0.96 0.16-3.16	0.21 <LOD-0.41	1.43 0.19-6.82	1.29 0.35-6.15	<LOD <LOD-0.22	<LOD <LOD-0.13
PCB-138	13.5 2.28-51.6	1.61 0.24-4.93	0.46 <LOD-1.37	6.00 2.24-11.2	4.10 1.57-13.6	0.77 <LOD-3.66	0.23 <LOD-1.28
PCB-153	21.0 3.26-82.7	1.52 0.28-4.52	0.65 0.19-1.75	10.4 3.93-26.9	9.45 3.81-31.5	4.09 0.36-17.2	0.29 <LOD-1.32
PCB-180	4.62 0.81-17.6	0.58 0.10-1.56	0.16 0.05-0.37	3.83 1.66-7.75	5.96 2.17-16.5	12.3 0.86-31.1	0.27 0.03-1.73

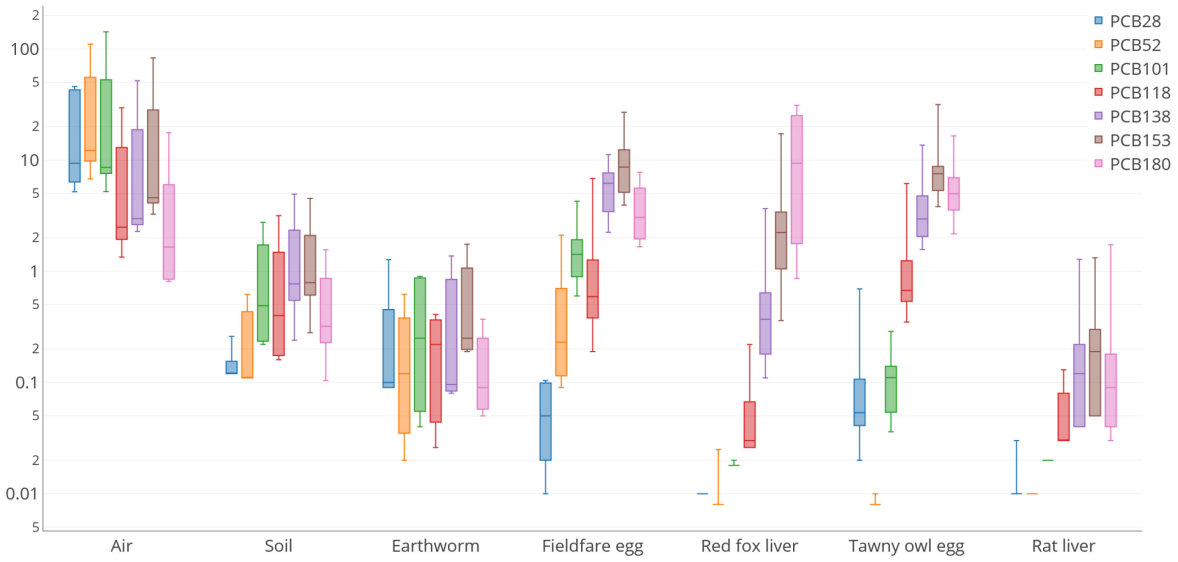

Figure 6: Box plot of PCB congeners in the various samples. The upper and lower boundaries of the box are representing the 25th and 75th percentile, the horizontal line in the box marks the median. The whiskers represent the minimum and maximum values without outliers. Concentrations given in ng/g ww for species, soil given in ng/g dw and air in pg /day.

3.3 PBDE and newBFR

Concentrations of PBDEs in 2020 (Table 9 and Figure 7) were in agreement with 2019 data, except for tawny owl eggs, where concentrations were higher in 2019 when eggs were sampled in urban/rural surroundings in Halden and Aremark, near the Swedish border, around 90-100 km south-east of Oslo. As previous years, concentrations of PBDEs were in general much lower than PCB in the various samples, except in brown rat samples where PBDEs were found in similar concentration range as for PCBs. One air sample from Alnabru revealed much higher sumPBDE concentration than sumPCB due to a very high BDE-209 concentration.

Air: In agreement with 2019 results, BDE-47, -99 and-100 were detected at all five sites. As last year, BDE-196 and -202 were not detected at any sites. Also as last year, sumPBDE was highest at the site Alnabru where BDE-209 was detected in a very high concentration of 1196 pg/day compared to 133 pg/day in 2019. The second highest concentration of BDE-209 in 2020 was detected at the site Slottsparken with 10.3 pg/day.

The sum of the annual mean concentrations of PBDE-47,-99 and 100 in 2019 at Zeppelin was 0.16 pg/m^3 and 0.06 pg/m^3 at Birkenes (Bohlin-Nizzetto et al., 2020). Using an estimated uptake rate of 2 m^3/day for the Oslo sites gave 0.64 to 5.09 pg/m^3 for the sum pf BDE-47, 99 and 100 at the five Oslo sites, where Frognerseteren had lowest concentration and Alnabru highest. These air results from Oslo sites indicate urban sources for PBDEs.

Of the targeted new BFRs, α-TBECH, β-TBECH, PBT and PBBZ were detected in highest concentrations across sites, Table 10. The highest detection rate of the various BFR compounds was found for Slottsparken, Alnabru and VEAS. α-TBECH was detected at four sites with highest concentrations at Slottsparken (21.5 pg/day). β-TBECH was detected at Slottsparken (11.4 pg/day) and Alnabru (1.7 pg/day). For PBT, VEAS had highest concentration of 11.5 pg/day. DBDPE were not detected at any sites. PBBZ was only detected at Slottsparken and VEAS.

Soil: As in 2019, few PBDE congeners were detected above LOD at the five sites,
Table 9. None of the PBDEs were detected at Slottsparken and Grønmo, and only BDE-99 at Kjelsås. Alnabru and VEAS had detections in more than 50 % of the samples with sumPBDE of 0.97 and 0.43 ng/g dw, respectively. BDE-209 was not detected at any sites, and none of the new BFR were detected above LOD.

Earthworm: Only BDE-100 was detected at all five sites (0.01-0.05 ng/g ww). BDE-47 and-99 were detected at four sites. For the higher brominated congeners, only VEAS site had concentrations above LOD. Of new BFR, only BATE and PBEB was detected at VEAS, and PBEB at Slottsparken.

Fieldfare: Several BDE congeners were detected in pooled samples of fieldfare eggs, only BDE-191 was not detected at all and BDE-209 was only detected in one sample (0.73 ng/g ww) at the Alna I site. BDE-47, -99 and -100 had highest concentrations and were detected in all samples. The egg samples form Alna III had highest concentrations for all congeners (except BDE-209) with a sumPBDE of 22.7 ng/g ww, four times higher than second highest sumPBDE concentration. The sumPBDE concentrations were in agreement with 2019 results. Median sumPBDE was 2.6 ng/g ww and comparable to median sumPBDE from previous years.

Data for great tits (*Parus major*) were available from a Belgian study (Voorspoels et al. 2007). The authors reported that PBDE were found in eggs of great tits with levels averaging 220 ng/g lw. In our study from 2020, sumPBDE varied from 9 to 724 ng/g lw with a mean sumPBDE of 135 ng/g lw.

Mean concentrations of BDE-47, -99 and -100 in starling eggs from a breeding area near a former landfill in British Columbia, Canada, sampled in 2012, were 541, 1426 and 379 ng/g lw, respectively (Currier et al., 2020). In the same study, eggs from a reference rural area 40 km east of the landfill had 8.8, 14.2 and 2.7 ng/g for the same congeners. The mean concentrations of BDE-47, -99 and -100 based on the ten sampling sites from Oslo were 26, 55 and 29 ng/g lw in 2020 which are lower concentrations than the landfill concentrations, and higher than the results from the more rural area in the Canadian study. As seen from both the Canadian study and our study from Oslo, BDE 100 was the dominating congener. None of the new BFR compounds were detected in the fieldfare eggs from Oslo.

Tawny owl: Similar to fieldfare eggs, BDE-47, -99 and -100 were detected in all tawny owl eggs. In addition, BDE-153 was detected in all samples, and BDE-154 and -191 were detected in 90 % of the samples. BDE-153 had highest median concentration of 0.31 ng/g ww followed by BDE99 (0.20 ng/g w) and BDE47 (0.18 ng/g ww). SumPBDE varied from 0.6 to 9.9 ng/g ww with a median of 1.1 ng/g ww compared to 2.7 ng/g in 2017 with eggs from the same area. The highest sumPBDE concentration was found in the same egg with highest sumPCB and sumToxic metals. The percentage detection of new BFR were also low in tawny owl eggs. No congeners were above 30 % detection. Only PBEB and DTPE were detected in three of ten samples, Table 10.

A Swedish study detected median concentrations of 2.7, 5.9, 1.41 and 2.6 ng/g lw of BDE47, 99, 100 and 153, respectively, in eleven addled tawny owl eggs collected in 2014 (Lind, 2015). The tawny owl eggs from Oslo in 2020 showed median concentrations of 3.9, 4.9, 1.9 and 9.3 ng/g lw for BDE47, 99, 100 and 153, respectively.

Red fox: Only BDE-153 and -209 had detection rate above 50 % in the ten red fox liver samples, where BDE-153 was detected in 90 % of the samples and BDE-209 in 60 %. The sumPBDE ranged from <LOD to 5.4 ng/g ww compared to 0.14 to 2.14 ng/g ww in 2019 and 0.32 - 5.59 ng/g ww in 2018. Median sumPBDE was 0.5 ng/g ww compared to 0.6 ng/g ww in 2019. As in 2019, highest concentrations among the congeners was detected for BDE-209 (<LOD-3.8 ng/g ww).

Andersen et al. reported PBDE in Arctic fox liver from Svalbard, Norway, with median BDE-47 and -153 concentrations of 0.16 and 0.08 ng/g ww respectively (Andersen et al., 2015). Median concentration for BDE-153 was 0.02 ng/g ww in the Oslo samples from 2020. BDE-47 in 2020 samples was only detected in three samples with a median of 0.04. For new BFR compounds, only DPTE and BTPE were detected in one sample each.

Brown rat: Only BDE-207 and -209 were detected in 100% and 70 % of the brown rat liver samples, respectively. BDE-154, -191 and -196 were not detected in any samples. The rest of the congeners were only detected in 10 or 20 % of the samples. Highest concentrations were found for BDE-209 (<LOD-20.8 ng/g ww). SumPBDE varied from 0.1 to 24.8 ng/g ww with a median value of 0.6 ng/g ww compared to 1.2 ng/g ww in 2019. No new BFR compounds were detected in the samples.

Summary for PBDEs and newBFR

PBDE congeners in the various samples were found in lower concentrations than PCB congeners, except for brown rat livers which had similar PBDE concentrations to PCB. Highest detection rate and concentrations of PBDEs and newBFR were detected in fieldfare eggs followed by tawny owl eggs.

Table 9: Mean concentrations with min-max interval below in grey colour of the various PBDE congeners in Air (pg/day), Soil (ng/dw), Earthworm, Fieldfare, Tawny owl, Red fox, and Brown rat. All concentrations in biological samples are given in ng/g ww. <LOD in light grey colour is given for compounds with no detected concentrations.

Comp.	Air pg/day	Soil ng/g dw	Earthworm	Fieldfare	Tawny owl	Red fox	Brown rat
BDE-47	2.44 0.94-5.16	<LOD	0.06 <LOD-0.13	1.00 0.15-3.76	0.34 0.06-1.72	<LOD <LOD-0.04	<LOD LOD-0.06
BDE-99	1.20 0.23-4.24	<LOD <LOD-0.17	0.04 <LOD-0.11	2.01 0.18-9.39	0.70 0.11-4.60	<LOD	<LOD LOD-0.02
BDE-100	0.29 0.09-0.77	<LOD	0.02 0.1-0.05	1.04 0.06-5.34	0.24 0.04-1.45	<LOD LOD-0.01	<LOD LOD-0.02
BDE-126	0.04 <LOD-0.06	<LOD <LOD-0.03	<LOD <LOD-0.01	0.02 <LOD-0.1	<LOD <LOD-0.05	<LOD	<LOD LOD-0.01
BDE-153	0.18 <LOD-0.48	<LOD <LOD-0.08	<LOD <LOD-0.02	0.35 <LOD-1.48	0.70 0.19-2.57	0.10 <LOD-0.65	<LOD <LOD-0.02
BDE-154	0.15 <LOD-0.38	0.03 <LOD-0.07	<LOD <LOD-0.01	0.33 <LOD-1.71	0.07 <LOD-0.32	<LOD	<LOD
BDE-175/183	0.23 <LOD-0.73	0.04 <LOD-0.08	<LOD <LOD-0.01	0.08 <LOD-0.27	0.05 <LOD-0.11	<LOD LOD-0.35	<LOD <LOD-0.02
BDE-191	<LOD <LOD-0.11	<LOD <LOD-0.07	<LOD	<LOD	<LOD	<LOD	<LOD
BDE-196	<LOD	<LOD <LOD-0.08	<LOD	0.04 <LOD-0.13	<LOD <LOD-0.05	<LOD LOD-0.24	<LOD
BDE-202	<LOD	0.08 <LOD-0.18	<LOD	0.11 <LOD-0.38	<LOD <LOD-0.06	<LOD LOD-0.04	<LOD <LOD-0.02
BDE-206	5.28 <LOD-24.3	<LOD <LOD-0.21	<LOD	<LOD	<LOD	<LOD LOD-0.19	<LOD
BDE-207	2.64 <LOD-11.5	<LOD <LOD-0.17	<LOD	0.07 <LOD-0.19	<LOD	0.06 LOD-0.18	0.16 0.04-0.94
BDE-209	**243** <LOD-1196	<LOD	<LOD	<LOD <LOD-0.73	<LOD <LOD-0.6	1.00 LOD-3.81	2.47 <LOD-20.1

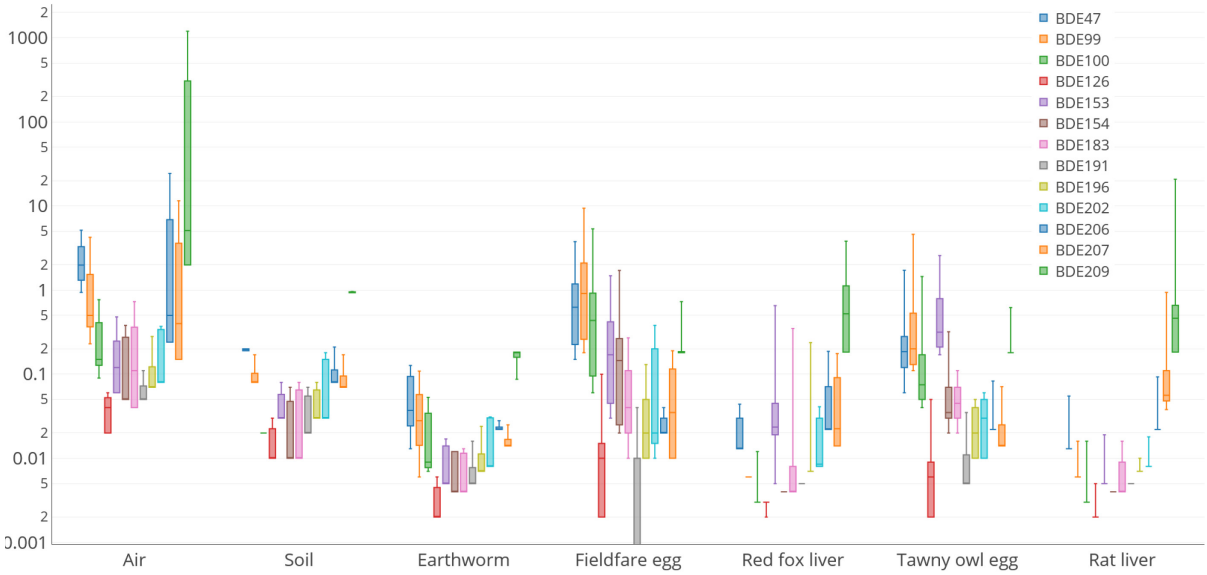

Figure 7: Box plot of PBDE congeners in the various samples. The upper and lower boundaries of the box are representing the 25th and 75th percentile, the horizontal line in the box marks the median. The whiskers represent the minimum and maximum values without outliers. Concentrations given in ng/g ww for species, soil given in ng/g dw and air in pg /day.

Table 10: Mean concentrations in with min-max interval below in grey colour of the various new BFR compounds in Air (pg/day), Soil (ng/dw), Earthworm, Fieldfare, Tawny owl, Red fox and Brown rat. All concentrations in biological samples are given in ng/g ww. <LOD in light grey colour is given for compounds with no detected concentrations.

Compounds	Air pg/day	Soil ng/g dw	Earthworm	Fieldfare egg	Tawny owl	Red fox	Brown rat
ATE (TBP-AE)	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
α-TBECH	6.24 <LOD-21.5	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
β-TBECH	3.26 <LOD-11.4	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
γ/δ-TBECH	0.30 <LOD-0.6	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
BATE	<LOD <LOD-0.2	<LOD	<LOD <LOD-0.02	<LOD	<LOD <LOD-0.02	<LOD	<LOD
PBT	3.07 <LOD-11.5	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
PBEB	0.20 <LOD-0.6	<LOD	<LOD LOD-0.02	<LOD	<LOD <LOD-0.03	<LOD	<LOD
PBBZ	1.97 <LOD-3-18	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
HBB	1.38 <LOD-4.78	<LOD	<LOD	<LOD	<LOD <LOD-0.12	<LOD	<LOD
DPTE	0.28 <LOD-0.75	<LOD	<LOD	<LOD	0.01 <LOD-0.07	<LOD <LOD-0.01	<LOD
EHTBB	0.31 <LOD-1.04	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
BTBPE	0.41 <LOD-1.36	<LOD	<LOD	<LOD	<LOD <LOD-0.04	<LOD LOD-0.04	<LOD
TBPH(BEH /TBP)	<LOD <LOD-1.24	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
DBDPE	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

3.4 PFAS

The PFAS group consists of numerous per- and polyfluorinated compounds. We have chosen to separate this large class of compounds into four subgroups dependent on functional groups and properties: The perfluorinated sulfonates (PFSA), the perfluorinated carboxylates (PFCA), the neutral polyfluorinated compounds (nPFAS) with the compounds PFOSA, meFOSA, etFOSA, meFOSE, etFOSE, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH and 12:2 FTOH; and the relatively new fluorotelomer sulfonates (newPFAS) with the compounds 4:2 FTS, 6:2 FTS, 8:2 FTS and 10:2 FTS. In this chapter and in the summary, SumPFAS is the sum of all sub-groups. For the compound PFOS, br-PFOS consists of the group of branched isomers, and PFOS is the linear isomer.

PFOS had highest concentration across all PFAS groups for all type of samples, except for air where PFHxS dominated.

Air: Across all PFAS groups, PFHxS was detected in all air samplers and had highest concentrations followed by PFHpS and PFOS, where some concentrations were below field blanks for the two latter compounds. PFBS, the dominating PFAS compound in air samplers in 2019 and 2018 was not detected at any sites in 2020. PFTriA, PFOA and PFOSA were detected in three samples. The other PFSA, PFCA and new PFAS compounds were only sporadically detected in one sample, or not detected. PFHxA and PFOA were only detected at the VEAS station, and at relatively high concentration of 11.7 and 6.9 pg/day, respectively. The sumPFCA at VEAS was 4-5 times higher than the other stations.

The data for the PFAS cannot be converted to estimated air concentrations due to lack of uptake rates for this compound class in the samplers. This hampers the comparison to active air sampling data from Birkenes. However, air measurements at Birkenes station in year 2019 revealed that the perfluorinated carboxylates dominated the pattern of detected PFAS compounds with PFOA>PFHxA> PFHpA~PFNA for the annual mean concentrations (Bohlin-Nizzetto et al., 2020). The different profiles at the background station at Birkenes in Southern Norway and the urban sites in the Oslo area might suggest different sources, but it may also be a reflection of the different sampling methodologies and that the passive XAD samplers were not optimal for measuring PFAS.

Soil: As previous years, PFOS was the dominating compound and was detected at all five sites in 2020. The site Kjelsås, which was not sampled in previous years, had the highest concentration (2.9 ng/g dw). The PFOS concentrations were in agreement with 2019 data, and soil from Alnabru had much lower concentrations in the year 2018 to 2020 compared to the years 2016 and 2017. Of the other sulfonates only PFNS was detected at one site, Kjelsås. In 2019, more PFSA compounds were detected.

As in 2019, several PFCA were detected in the soil samples in 2019 with 70-100 % frequency. PFOA and PFDcA were detected at all sites. PFBA was detected at four sites and had highest concentrations among the PFCA compounds.

The site Kjelsås had highest sumPFAS with 9.2 ng/g dw followed by Alnabru (3.7 ng/g dw) and Slottsparken (2.1 ng/g dw). Neutral PFAS (nPFAS) and new PFAS (newPFAS) compounds were not detected in the soil samples.

Earthworm: PFOS was detected in all five samples and was the dominating compound across all PFAS groups and ranged from 3.5 to 22.4 ng/g ww. The highest concentration was found in earthworms from the site Grønmo. PFOS concentrations in 2019 were higher with 41 ng/g ww at the site Grønmo and 52 ng/g ww at the site Alnabru. None of the earthworm samples in 2020 exceeded the PNECoral of 37 ng/g ww for PFOS (Moermond et al., 2010) for predators such as fieldfare where earthworm is a substantial part of the diet. Second highest concentrations were detected for PFHxS (2.37 ng/g ww) and PFTeA (2.17 ng/g ww) and PFPA (1.72 ng/g ww) across all PFAS compounds. The detection rate

was very high and 100 % of all the carboxylates PFOA to PFHxDA and highest sumPFCA was detected at Slottsparken. In the nPFAS and newPFAS group 8:2 FTS dominated followed by PFOSA and 6:2 FTS. sumPFAS concentrations ranges from 12.2 ng/g ww (VEAS) to 40.4 ng/g ww (Slottsparken), see also Table 24.

Fieldfare: All PFSA compounds, except PFBS and PFPS, were detected in the eight pooled egg samples with 100 % detection rate. As previous years, PFOS dominated in all the samples, where the sample from Grønmo had highest concentration with 231 ng/g ww compared to 278 ng/g ww in 2019 and 250 ng/g ww in 2018. As in 2019, earthworm from Grønmo in 2020 had the highest PFOS and PFAS concentration among the earthworm sites, and earthworm are important food for fieldfare. The concentrations of PFOS in fieldfare from 2018 to 2020 are lower than reported reference value for PFOS of 1900 ng/g ww in bird egg (ECCC, 2017) for hatching success. However, the PFOS in the pooled egg samples from Grønmo (231 ng/g ww) and Alna I (89.1 ng/g ww) exceeded the PNECoral (37 ng/g ww) for predators where fieldfare is an important food item. sumPFSA ranged from 13 to 276 ng/g ww with highest sum concentration at Grønmo, and sumPFCA ranged from 15 to 56 ng/g ww with highest sum concentration at Alna I.

In agreement with last year, PFOSA was the only compound detected as part of the neutral group, nPFAS. Highest concentration was found at Grønmo with 0.4 ng/g ww compared to 0.9 ng/g ww in 2019. Of the newPFAS group, 8:2 FTS and 10:2 FTS were detected at all eight sites and 6:2 FTS were detected at five sites. The concentrations of 8:2 and 10:2 FTS were higher in 2020 compared to the results in 2019. The highest 8:2 FTS concentration was detected at Alna I (55 ng/g ww) followed by Alna III (19 ng/g ww). The highest 10:2 FTS concentration was also detected at Alna I (30.3 ng/g ww), followed by Alna III (5.6 ng/g ww).

Highest sumPFAS was detected in eggs from Grønmo, Alna I and Alna III with 322, 245 and 76 ng/g ww. The maximum sumPFAS concentration detected in the period 2018 to 2020 is much lower than in 2017 when sumPFAS at Grønmo was 1015 ng/g ww.

Geometric mean for total perfluorinated chemicals in ten tree swallow eggs, Clarks Marsh, Oscoda, northeast in Michigan, from 2014 to 2017 ranged from 554 to 954 ng/g ww (Custer et al., 2019). PFOS dominated with geometric means of 662 ng/g ww followed by PFHxS (55.1 ng/g ww), PFOSA (7.4 ng/g ww) and PFOA (2.3 ng/g ww). This area in northeast Michigan has some of the highest recorded PFAS exposure in birds in United States. There were no demonstrable effects of PFAS exposure on reproduction nor on most physiological responses. (Custer et al., 2019).

Perfluorinated chemicals were investigated in a large study of European starling eggs across Canada; eggs collected in 2009-2012 and 2014 at locations such as landfills, industrial and urban environments (Gewurtz et al., 2018). In general PFAS concentrations in eggs collected at landfill and industrial areas had highest concentrations. The PFOS concentrations in starling eggs from landfills, industrial and urban areas in Canada had both higher and lower concentrations than the highest concentrations detected in fieldfare eggs from the Grønmo and Alna sites in 2020. The median PFOS concentrations in starling eggs from year 2014 at landfills across Canada had large variations in data with median values of PFOS from 41 to 659 ng/g ww.

Tawny owl: SumPFAS concentrations varied from 6 to 34 ng/g ww in the ten egg samples from 2020. PFOS was the dominating compound ranging from 2 to 21 ng/g ww. In 2017 and 2016 when tawny owl eggs were sampled from the same area, PFOS concentrations ranged from to 8 to 61 ng/g ww and from 2 to 50 ng/g, respectively. Branched (br-PFOS) and linear (PFOS) PFOS was detected in 100 % of the samples, the other PFSA compounds varied from <LOD to 80 % detection.

Among the carboxylates, PFNA to PFTriA were detected in 100 % of the samples. As observed for fieldfare, PFTeA and PFTriA had highest concentration in the PFCA group, but concentrations were lower in tawny owl compared to fieldfare eggs. For nPFAS, only PFOSA was detected in 70% of the samples. In the newPFAS group, 8:2 FTS was detected in all samples and 10:2 FTS in two samples.

Bustnes et al. reported a median of 9 ng/g ww of PFOS in tawny owl eggs collected in an area around Trondheim in Sør-Trøndelag County, Central Norway, sampled in the years 2001-2009 (Bustnes et al., 2015). In a Swedish study with ten eggs of tawny owl collected in 2014, the median total PFOS was 7.9 ng/g ww (linear PFOS was 7.6 ng/g ww); Eriksson et al., 2016. Our study from Oslo in 2020 revealed a median total PFOS (branched and linear) value of 7.8 ng/g ww. In the same study from Sweden, the PFTriA dominated the carboxylates with a median value of 1.4 ng/g ww, which is in agreement with the median value of PFTriA in our study of tawny owl in 2020 with 1.3 ng/g ww. The Swedish study also included the species common kestrel and osprey where PFUnA had highest concentrations among the carboxylates.

Red fox: As for all the other biological samples, PFOS was the dominating PFSA compound and was detected in all the ten red fox liver samples in 2020 with a maximum concentration of 50 ng/g ww, compared to 35 ng/g in 2019 and 22 ng/g ww in 2018. The branched isomer, br-PFOS, was only detected in one sample. PFHxS had 90% detection rate, PFNS 50 % and PFHpS 40 % detection rate. The PFCA compounds from PFOA to PFTEA were detectable in 100 % of the samples. A maximum value of 4.8 ng/g ww was detected for PFDcA which was comparable to results from year 2018.

PFOSA was detected in 80 % of the samples with maximum concentration of 1 ng/g ww. None of the other nPFAS compounds were detected. In the newPFAS group, 8:2 FTS had 50 % detection rate with maximum concentration of 0.1 ng/g ww, the rest of compounds were below LOD.

The sumPFAS concentrations ranged from 4 to 75 ng/g ww (median of 12 ng/g ww) compared to 7 to 71 ng/g ww (median value of 22 ng/g ww) in 2019. For comparison, in polar fox from Svalbard, PFOS concentrations in liver ranged between 10 and 220 ng/g ww. The high levels in this polar fox species were most probably explained by the partly marine diet (Aas et al., 2014).

Brown rat: SumPFAS varied from 4 to 19 ng/g ww with much lower concentrations compared to results from2019 (13- 399 ng/g ww) and 2018 (31-129 ng/g ww). This difference in concentrations might be explained by fewer sampling sites and only two locations in 2020. PFOS was detected in all samples with a maximum value of 5 ng/g ww. This is much lower than maximum value of 272 ng/g ww in 2019 and 62.4 ng/g ww in 2018.

For PFCA compounds, PFDcA to PFTeA, were detected in all ten samples, and at lower concentrations than PFOS. The highest concentration was detected for PFUnA (1 ng/g ww). 8:2 FTS was detected in 50 % of the samples, 6:2 FTS and 10:2 FTS was detected in 20 % of the samples, at low concentrations. Among the FTS compounds, 8:2 FTS had highest concentrations with a maximum value of 0.7 ng/g ww. PFOSA was detected in 60 % of the samples at low concentrations.

Summary PFAS

PFAS compounds could be detected in all the investigated matrices. PFOS was the dominating compound in all matrices, except for air where PFHxS dominated, see Table 11-Table 13, and Figure 8 and Figure 9. This year's data revealed that fieldfare eggs had the highest concentrations of PFOS. The highest concentrations of PFOS in fieldfare eggs exceeded PNEC for predators where fieldfare eggs are substantial part of the diet. In agreement with results from previous years, highest PFOS and sumPFAS concentration were detected for fieldfare eggs from Grønmo (sumPFAS 322 ng/g ww) followed by Alna I (sumPFAS 245 ng/g ww). As last year, 8:2 FTS and 10:2 FTS were detected in several samples,

and highest concentrations were detected in fieldfare egg samples from Alna I for 8:2 FTS (55 ng/g ww) and 10:2 FTS (30 ng/g ww).

Table 11: Mean concentrations in with min-max interval below in grey colour of the various perfluorinated sulfonates (PFSA compounds) in Air (pg/day), Soil (ng/dw), Earthworm, Fieldfare, Red fox, Tawny owl and Brown rat. All concentrations in biological samples are given in ng/g ww. <LOD in light grey colour is given for compounds with no detected concentrations. Highest concentrations in each sample type is shown in bold font type.

Compounds	Air pg/day	Soil ng/g dw	Earthworm	Fieldfare	Tawny owl	Red fox	Brown rat
PFBS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
PFPS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
PFHxS	**5.25** 4.56-5.90	<LOD	2.37 <LOD-3.55	0.49 0.22-1.29	0.21 <LOD-1.04	0.41 <LOD-2.07	0.28 <LOD-0.65
PFHpS	4.13 <LOD-9.49	<LOD	<LOD	0.40 0.12-1.18	<LOD <LOD-0.16	0.13 <LOD-0.43	<LOD
brPFOS	<LOD	<LOD	<LOD	4.09 1.22-15.2	2.06 0.57-5.63	<LOD <LOD-4.19	0.39 <LOD-1.24
PFOS	2.96 LOD-6.58	**1.23** 0.33-2.92	**10.0** 3.53-22.4	**53.3** 10.2-**231**	**7.63** 2.46-21.4	**11.0** 2.26-50.3	**2.89** 1.33-4.94
PFNS	<LOD <LOD-6.49	0.04 <LOD-0.14	<LOD	0.13 0.03-0.51	0.03 <LOD-0.05	0.03 <LOD-0.09	0.07 <LOD-0.12
PFDcS	<LOD	<LOD	<LOD	5.75 0.45-27.5	1.10 <LOD-3.94	<LOD <LOD-0.84	1.21 <LOD-9.76

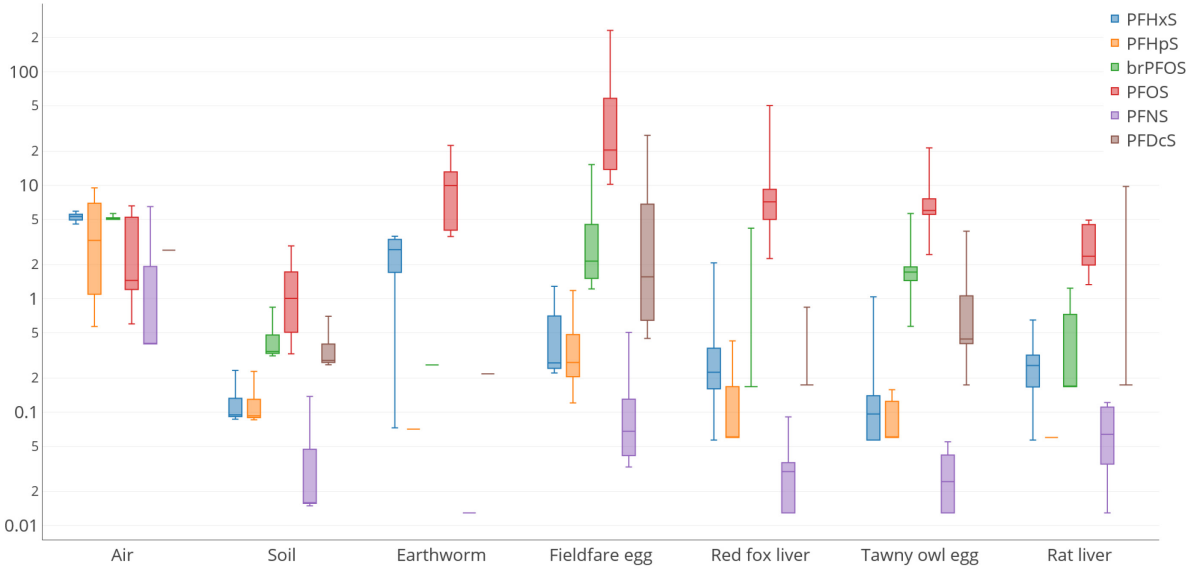

Figure 8: Box plot of PFSA compounds in the various samples. The upper and lower boundaries of the box are representing the 25th and 75th percentile, the horizontal line in the box marks the median. The whiskers represent the minimum and maximum values without outliers. Concentrations given in ng/g ww for species, soil given in ng/g dw and air in pg /day

Table 12: Mean concentrations in with min-max interval below in grey colour of the various perfluorinated carboxylates (PFCA compounds) in Air (pg/day), Soil (ng/dw), Earthworm, Fieldfare, Red fox, Tawny owl and Brown rat. All concentrations in biological samples are given in ng/g ww. <LOD in light grey colour is given for compounds with no detected concentrations.

Compounds	Air pg/day	Soil ng/g dw	Earthworm	Fieldfare	Tawny owl	Red fox	Brown rat
PFBA	<LOD	**0.83** <LOD-2.43	0.84 <LOD-4.09	<LOD	<LOD	<LOD <LOD-6.47	<LOD
PFPA	<LOD	0.07 <LOD-0.14	1.72 <LOD-4.07	<LOD <LOD-6.03	0.09 <LOD-0.44	<LOD	**1.15** <LOD-2.35
PFHxA	<LOD <LOD-11.7	0.13 <LOD-0.26	<LOD	<LOD	LOD	0.05 <LOD-0.22	<LOD <LOD-0.03
PFHpA	<LOD	0.17 <LOD-0.44	0.95 <LOD-3.17	0.05 0.03-0.08	<LOD <LOD-0.03	0.03 <LOD-0.13	LOD
PFOA	<LOD <LOD-6.93	0.55 0.25-1.42	0.99 0.25-3.31	0.68 0.29-1.20	0.05 <LOD-0.08	0.26 0.09-0.64	<LOD <LOD-0.28
PFNA	LOD	0.22 <LOD-0.80	0.47 0.17-1.25	1.11 0.58-2.13	0.17 0.09-0.29	**1.13** 0.45-3.26	<LOD <LOD-0.31
PFDcA	LOD	0.16 0.03-0.48	0.45 0.13-0.94	2.67 0.96-5.75	0.49 0.21-0.86	1.08 0.29-4.77	0.45 0.23-0.58
PFUnA	<LOD <LOD-1.46	0.11 <LOD-0.37	0.51 0.21-0.83	2.67 1.19-4.73	0.81 0.38-1.23	0.94 0.20-4.06	0.44 0.19-1.04
PFDoA	LOD	<LOD <LOD-0.08	1.03 0.51-2.31	7.78 3.20-17.5	1.29 0.73-2.67	0.64 0.11-3.23	0.34 0.20-0.51
PFTriA	0.84 <LOD-1.37	<LOD	1.18 0.62-2.28	6.45 3.35-11.7	**1.45** 0.86-2.48	0.57 0.08-2.33	0.39 0.14-0.93
PFTeA	<LOD	<LOD	**2.13** 1.04-5.53	**8.06** 3.41-13.9	1.40 0.58-3.94	0.41 0.06-2.15	0.17 0.08-0.36
PFHxDA	**1.10** <LOD-3.82	<LOD	0.49 0.22-1.38	0.47 0.25-0.93	<LOD	<LOD <LOD-0.18	<LOD
PFOcDA	0.81 <LOD-3.31	<LOD	0.29 0.18-0.56	<LOD <LOD-0.55	<LOD	<LOD	<LOD

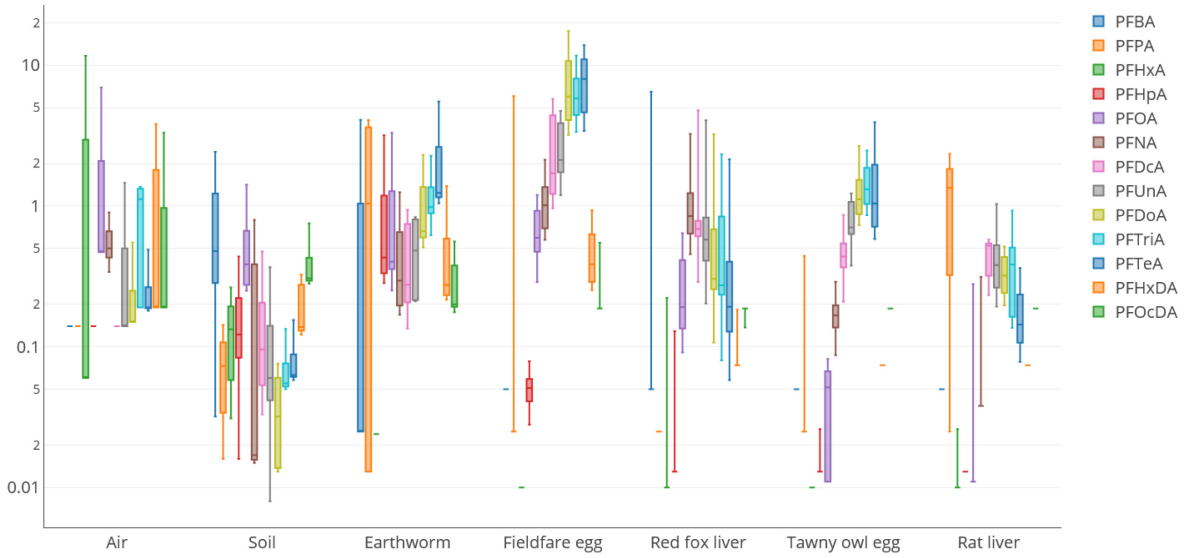

Figure 9: Box plot of PFCA compounds in the various samples. The upper and lower boundaries of the box are representing the 25th and 75th percentile, the horizontal line in the box marks the median. The whiskers represent the minimum and maximum values without outliers. Concentrations given in ng/g ww for species, soil given in ng/g dw and air in pg /day.

Table 13: Mean concentrations in with min-max interval below in grey colour of the nPFAS and newPFAS compounds in Air (pg/day), Soil (ng/dw), Earthworm, Fieldfare, Red fox, Tawny owl and Brown rat. All concentrations in biological samples are given in ng/g ww. <LOD in light grey colour is given for compounds with no detected concentrations.

Compounds	Air pg/day	Soil ng/g dw	Earthworm	Fieldfare	Tawny owl	Red fox	Brown rat
PFOSA	0.92 <LOD-1.21	<LOD <LOD-0.23	0.16 <LOD-0.25	0.20 0.07-0.42	0.08 <LOD-0.23	0.23 <LOD-1.01	0.05 <LOD-0.09
4:2 FTS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
6:2 FTS	<LOD	<LOD	0.09 <LOD-0.23	0.19 <LOD-0.80	<LOD	<LOD	0.03 <LOD-0.14
8:2 FTS	<LOD	<LOD	0.24 <LOD-0.69	**9.69** 0.21-55.1	0.10 0.04-0.18	0.04 <LOD-0.09	0.16 <LOD-0.67
10:2 FTS	n.a.	<LOD	n.a.	5.23 LOD-13.4	<LOD <LOD-0.50	<LOD	<LOD <LOD-0.60

Extractable organic Fluorine (EOF) analysis

Measuring EOF is a way of measuring the sum of organic fluorinated substances in samples without identifying the chemical structure of the present organic fluorinated compounds. This is a method only recently used to increase the understanding of the presence of unknown PFAS in a sample, and was applied for the first time in this program in 2020, using samples from 2020 but also earlier years. The resulting concentration of organic fluorine is a sum parameter for both known and unknown PFAS as well as other organic compounds containing fluorine as f.ex. monofluorinated pesticides or pharmaceuticals (Koch et al., 2021). One would therefore expect that the amount of organic fluorine would be higher for EOF compared to the amount of fluorine calculated based on the sum of targeted PFAS.

For the EOF we chose samples/species that preferably were part of the food chain and that preferably were from the same site and year; i.e. soil, earthworm and bird eggs. Due to lack of material, specifically for earthworm, some additional samples of soil and earthworm, not previously analysed, were also included for EOF analysis. These were samples from Kjelsås and Kjelsåsmyra.

Limit of detection (LOD) in the EOF analysis was 10 ng F/ml and higher than LOD for target analysis of PFAS. Presence of high amount of chlorine in some sample extracts could hamper the accuracy of EOF analysis.

The Fluorine contribution of sumPFAS determined by target analysis in our project is estimated to be approximately 65 %. In the table below this sum is denoted: EOF by PFAS. The results revealed that samples with low EOF by PFAS also had low EOF; and for some samples the EOF was below LOD, indicating a low presence of additional fluorinated organic compounds. The highest EOF concentrations were reported for egg from fieldfare and sparrowhawk where the target PFAS concentrations also were high. Two samples revealed higher PFAS than EOF could explain, while the other samples had a ratio of 'EOF by PFAS'/EOF below or near 1. Samples exhibiting a 'EOF by PFAS'/EOF ratio < 1 indicate the presence of unknown organic fluorinated compounds which is the case for most samples. Soil and fieldfare eggs show the highest contribution of unknown PFAS, suggesting following up with suspect screening to identify the unknown PFAS. When a 'EOF by PFAS'/EOF ratio of >1 is found, here only in fieldfare eggs, inhomogeneity of the sample matrix could be the explanation. Since eggs can have different developmental stages, the presence of embryos is potentially causing challenges when subsampling.

Table 14: Comparison of EOF contribution from sumPFAS and total EOF in selected samples collected in the years 2016 to 2020. An estimated fluorine content of 65% of sumPFAS was used in order to compare EOF to fluorine content of sum PFAS (=EOF by PFAS).

Samples	Site	Year	EOF by PFAS ng/g ww	EOF ng/g ww	(EOF by PFAS)/EOF
Soil	Alnabru	2020	2	<7	-
Earthworm	Alnabru	2020	9	<22	-
Fieldfare egg	Alna I	2020	159	106	1.5
Soil	Kjelsås	2019	n.a.	13	-
Earthworm	Kjelsås	2019	n.a.	<20	-
Soil	Alnabru	2019	4	60	0.07
Fieldfare egg	Alnabru	2019	18	25	0.7
Sparrowhawk egg		2019	229	261	0.9
Fieldfare egg	Grønmo	2018	192	391	0.5
Soil	Kjelsåsmyra	2017	n.a.	10	-
Earthworm	Kjelsåsmyra	2017	n.a.	44	-
Fieldfare egg	Grønmo	2016	480	224	2.2
SRM	IRMM427 pike		18	28	0.7

3.5 Chlorinated paraffins, CP

SCCP was detected in most samples, except in brown rat liver samples. MCCP compounds were not detected in air, soil and earthworm. Method LOD values for SCCP and MCCP in air samples were still as high in 2020 as they were in 2019. For other matrixes than air, the method LOD levels were much lower in 2020 than in 2019, especially for soil and tawny owl egg samples.

Air: SCCP and MCCP were detected at three sampling sites in 2020. SCCP were detected in the range of <LOD to 9.9 ng/day where Slottsparken had highest level and in agreement with last year results for Slottsparken (9.5 ng/day). Air samplers from Alnabru (4.8 ng/day) and Grønmo (3.9 ng/day) had second highest levels. The levels at VEAS and Frognerseteren were below method LOD value of 2 ng/day. MCCP were below method LOD value (4 ng/day) at all stations in 2020. In 2019, the range of MCCP was from <LOD to 4.0 ng/day.

The estimated air concentrations, using an uptake rate of 4 m^3/day according to Li et al. (2012), were 0.97-2.4 ng/m^3 for the detected levels of SCCP. Annual mean concentrations of SCCP and MCCP at Birkenes were 0.38 ng/m^3 and 0.12 ng/m^3, in 2017 (Nizzetto et al., 2018).

Soil: SCCP was only detected in two soil samples in 2020. The concentrations ranged from <LOD to 101 ng/g dw where the site Kjelsås had highest concentration followed by Grønmo (18 ng/g dw). These levels were more than ten times lower than the concentrations detected in 2019 (<LOD to 1218 ng/g dw) when the results were influenced by high method LOD. MCCP was not detected at any site. The maximum concentrations of SCCP in 2020 were well below the PNECsoil value[5] of 5950 ng/g dw (5.95 mg/kg dw).

Halse et al. reported CP concentrations with an average of 12 +/- 50 ng/g dw (<0.8-281 ng/g dw) in background soil sampled in 2008 from 32 Norwegian locations (Halse et al., 2015).

In a recent study of soils from Dongguan City, South China, SCCP ranged from 7 to 993 ng/g dw (mean 172) and MCCP from 24 to 2426 ng/g dw (mean 369) (Wu et al., 2020). From the comparison of other reported levels, Wu et al., 2020 concluded that the CP concentrations in soils from Dongguan City were at a medium level and much lower than those from CP production plants, but higher than reported levels from other countries (Wu et al., 2020). Our results of SCCP in Oslo revealed lower levels of SCCP to the levels detected in soil from Dongguan City.

Earthworm: Only SCCP was detected in one sample of 5.5 ng/g ww at Slottsparken site. This concentrations was lower than the 2019 results which ranged from LOD to 78.8 ng/g ww in 2019.

Fieldfare: SCCP and MCCP were detected in several of the pooled egg samples. SCCP was detected in six of the pooled samples (LOD- 32 ng/g ww) and MCCP was detected in all eight samples (21-132 ng/g ww). The concentrations were in general lower than in 2019. The highest concentrations of SCCP and MCCP in 2020 were well below PNECoral[6] values of 5500 ng/g food and 10 000 ng/g food for SCCP and MCCP, respectively. PNECoral values indicate the risk for organisms with fieldfare as important food item, for instance sparrowhawk.

Tawny owl: SCCP were detected in 60 % of the samples and MCCP in 50 % of the samples. The levels were comparable to fieldfare eggs, but with lower maximum levels. SCCP concentrations varied from <LOD to 10 ng/g ww and MCCP varied from <LOD to 26 ng/g ww. When converted to lipid weight this corresponds to <LOD to 150 ng/g lw (mean 102 ng/g lw) and <LOD to 544 ng/g lw (mean 230 ng/g lw) for SCCP and MCCP, respectively.

In a recent study of SCCP and MCCP in marine and terrestrial animals from Scandinavia, the levels of SCCP and MCCP in four eggs of tawny owl and three eggs of common kestrel ranged from 85–88 and 85–87 ng/g lw respectively (Yuan et al., 2019).

[5] ECHA Chemical Information, https://echa.europa.eu/information-on-chemicals

[6] ECHA Chemical Information, https://echa.europa.eu/information-on-chemicals

Red fox: In 2020, SCCP and MCCP were detected in 80 and 50 % of the samples, respectively. The concentrations varied from <LOD to 130 ng/g ww for SCCP and <LOD to 9 ng/g ww for MCCP. In 2019 SCCP ranged from LOD to 49.5 and MCCP ranged from LOD to 147 ng/g ww.

Ten muscle samples of lynx sampled 2012-2016 in Scandinavia revealed 800 and 750 ng/g lw for SCCP and MCCP, respectively (Yuan et al., 2019). For comparison, the red fox liver samples from Oslo collected in 2020 were in the range of <LOD-3336 ng/g lw (mean value 497 ng/g lw for SCCP, and <LOD-573 ng/g lw (mean value of 293 ng/g lw) for MCCP. In the study of Du et al., 2018 of CP in wildlife in the Yangtze river delta (YRD), yellow weasel contained the highest level of SCCP (43 000 ng/g lw) followed by a reptile short-tailed mamushi (22 000 ng/g lw) and peregrine falcon (14 000 ng/g lw), which were much higher than our maximum concentrations from the Oslo area.

Brown rat: For rat liver samples only MCCP were detected in 60 % of the samples. The concentrations ranged from <LOD to 66 ng/g ww. In 2019 SCCP ranged from LOD to 49.5 and MCCP ranged from LOD to 120 ng/g ww in 2019.

Yuan et al. 2019 investigated SCCP and MCCP in ten muscle samples of bank vole collected in 2014, and the concentrations were 400 and 370 ng/g lw for SCCP and MCCP, respectively. Our data from 2020 revealed a mean value of 570 ng/g lw for MCCP.

Summary S/MCCP

SCCP and MCCP were detected in many samples, see Table 15 and Figure 10. The concentration ranges were in general lower than results from 2019 when more samples were below and near method LOD. The highest detection rates for SCCP and MCCP were found in fieldfare eggs, red fox liver samples and tawny owl eggs. Highest detected concentrations on a lipid weight basis of SCCP was detected in red fox liver samples where a concentration of up to 3336 ng/g lw was detected in one sample. The highest concentration of MCCP was detected in fieldfare eggs where a maximum concentration of 4218 ng/g lw was found.

Table 15: Mean concentrations with min-max interval below in grey colour of chlorinated paraffins SCCP and MCCP in Air (pg/day), Soil (ng/dw), Earthworm, Fieldfare, Red fox, Tawny owl and Brown rat. All concentrations in biological samples are given in ng/g ww.

Compounds	Air pg/day	Soil ng/g dw	Earthworm	Fieldfare	Tawny owl	Red fox	Brown rat
SCCP	4113 <LOD-9958	24.2 <LOD-101	<LOD <LOD-5.46	10.2 <LOD--32.5	5.06 <LOD-10.0	18.1 <LOD-130	<LOD
MCCP	<LOD	<LOD	<LOD	48.5 21.0-132	10.4 <LOD-26.0	9.73 <LOD-19.1	19.4 <LOD-66.5

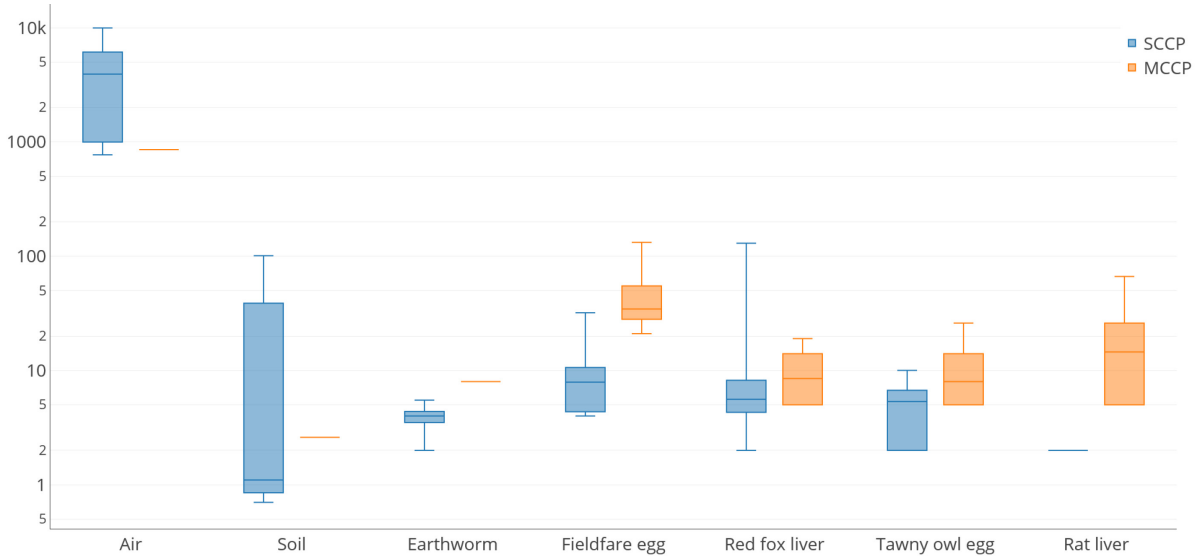

Figure 10: Box plot of SCCP and MMCP in the various samples. The upper and lower boundaries of the box are representing the 25th and 75th percentile, the horizontal line in the box marks the median. The whiskers represent the minimum and maximum values without outliers. Concentrations given in ng/g ww for species, soil given in ng/g dw and air in pg /day. For samples where all data for SCCP (rat liver) and MCCP (air, soil and earthworm) were below LOD, one average value for LOD was used in the box plot.

3.6 Cyclic siloxanes (cVMS)

In 2020, the three siloxanes were detectable in many samples, see Table 16 and Figure 11. Only three samples of D6 in tawny owl eggs were below LOQ. D4 was in general found in higher concentration than D5, except for in air and brown rat liver samples where D5 dominated.

Air: All three siloxanes were detected at the five sites in Oslo. Siloxanes are very volatile, and highest concentrations of all three targeted cVMS oligomers were detected at VEAS. VEAS is the largest wastewater treatment plant in Norway, and D4, D5 and D6 were 22, 58 and 3.9 ng/day, respectively. Siloxanes are volatile compounds, and high concentrations are expected in ambient air at wastewater treatment plants. D5 dominated at all sites, followed by D4 and D6. As in previous years Slottsparken had the second highest concentrations of cVMS.

The estimated air concentrations in 2019, using an uptake rate of 0.5 m^3/day (Krogseth et al., 2013a), were 5 - 44 ng/m^3 for D4, 9 -115 ng/m^3 for D5 and 0.9- 4 ng/m^3 for D6. The estimated concentrations of D5 and D6 in this study are significantly higher than the concentrations measured at background stations in summer 2017: Zeppelin; 0.08 and 0.03 ng/m^3, and Birkenes; 0.5 and 0.04 ng/m^3 of D5 and D6, respectively (Bohlin-Nizzetto et al 2018). This considerable concentration difference reflects the emission sources in urban areas. Genualdi et al., reported in 2011 in a global review, D5 concentrations ranging from 0.3 (Barrow, Alaska) to 280 ng/m^3 in Paris (Genualdi et al., 2011). The authors suggest that D5 and D6 have elevated concentrations in urban areas, which is most likely due to personal care product use. D4 cannot be compared to background air as the adsorbent used in active air samplers at the background site do not give trustworthy results for D4.

A high D5/D4 ratio has been associated with vicinity to emission source areas. D5 was higher than D4 at four sites with a ratio from 2 to 4. Highest ratio of 4 was found for the site Slottsparken, followed by VEAS with a ratio of 3.

Soil: D4, D5 and D6 were detected at all five sites at relatively low levels from 0.45 to 1.34 ng/g dw across all three compounds. The levels were comparable with the 2019 concentrations from Grønmo site. The site at Bøler, which showed very high concentrations in 2019, was not sampled in 2020.

Earthworm: For earthworm, D4 (3.54-4.37 ng/g ww) had the highest concentrations, and D5 concentrations (1.55-1.75 ng/g ww) were slightly higher than D6 (1.00-1.23 ng/g ww).

Fieldfare: Also for fieldfare eggs, D4 (2.45-38.4 ng/g ww) had higher concentrations than D5 (3.86-26.6 ng/g ww), and D6 (1.91-11.9 ng/g ww) had lowest levels. The detected concentrations were comparable with the 2019 results.

Tawny owl: As for fieldfare eggs, D4 concentrations were approximately twice the concentrations of D5. The lowest concentrations were found for D6. In general, the concentrations of D4, D5 and D6 were lower in tawny owl compared to fieldfare eggs. The concentrations in 2020 were lower than in 2019 when concentrations were close to high LOD and therefore more uncertain.

Red fox: Also for red fox liver samples, D4 dominated and were approximately the double of D5 concentrations and D6 had lowest concentrations. The D4 and D5 concentrations were slightly higher than in tawny owl on a lipid weight basis, and lower than in fieldfare eggs and earthworm on a lipid weight basis.

Brown rat: Among the species, brown rat liver samples had the highest concentrations for all three compounds D4, D5 and D6 on a lipid weight basis. 60 % of the brown rat liver samples had higher D5 concentrations compared to D4, and the maximum D5 concentration was 535 ng/g ww.

Summary cVMS

The siloxanes measured in the air sampler installed at the pipe outlet at VEAS wastewater plant had highest concentrations for all three siloxanes D4, D5 and D6. VEAS dominated especially for the D4 compound. The second highest cVMS concentrations were detected in air from Slottsparken.

Brown rat liver samples had the highest concentrations for all three compounds on a lipid weight basis among the species. Second highest concentrations on lipid weight were found in earthworm samples and fieldfare eggs. D4 dominated in most samples, except for brown rat liver samples were D5 dominated in 60 % of the samples.

Table 16 Mean concentrations with min-max interval below in grey colour of cyclic siloxanes in Air (pg/day), Soil (ng/dw), Earthworm, Fieldfare, Red fox, Tawny owl and Brown rat. All concentrations in biological samples are given in ng/g ww.

Compounds	Air pg/day	Soil ng/g dw	Earthworm	Fieldfare	Tawny owl	Red fox	Brown rat
D4	9438 2515-22273	1.05 0.76-1.34	4.06 3.54-4.37	16.1 2.45-38.4	4.38 2.86-6.38	7.31 2.49-11.3	26.6 9.10-64.5
D5	23302 4677-57661	0.85 0.66-1.10	1.64 1.55-1.75	11.5 3.86-26.6	2.31 1.14-4.67	3.63 0.78-5.37	85.5 12.4-535
D6	2016 458-3866	0.63 0.45-0.83	1.09 1.00-1.23	5.83 1.91-11.9	0.94 <LOQ-1.96	2.24 0.44-3.71	11.7 1.58-30.7

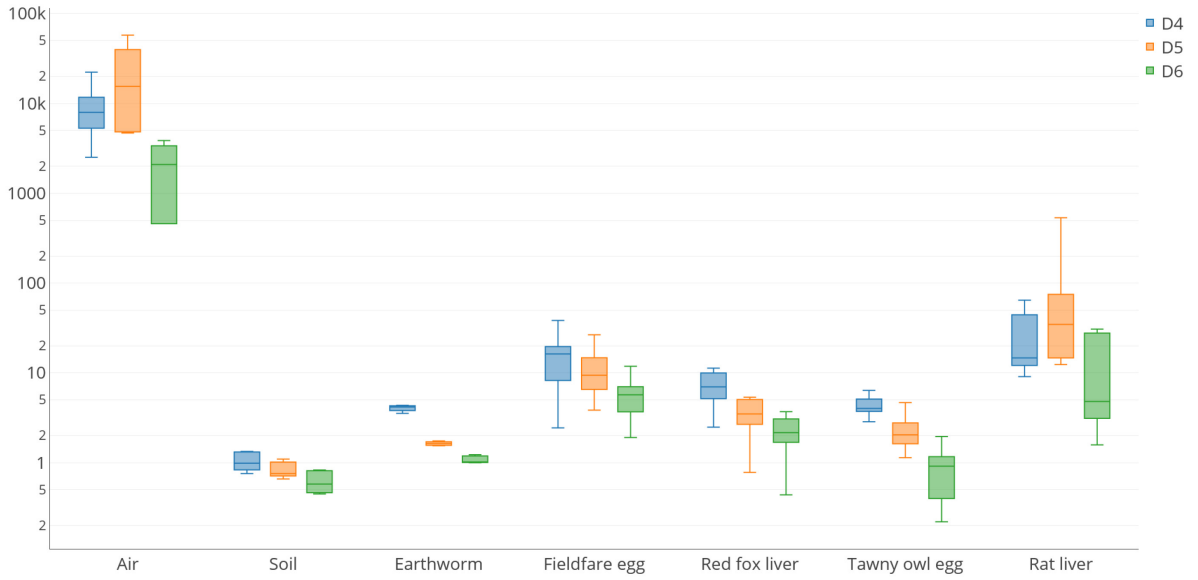

Figure 11: Box plot of cyclic siloxanes in the various samples. The upper and lower boundaries of the box are representing the 25th and 75th percentile, the horizontal line in the box marks the median. The whiskers represent the minimum and maximum values without outliers. Concentrations given in ng/g ww for species, soil given in ng/g dw and air in pg /day.

3.7 OPFR

OPFR compounds were only analysed for in five air samples, one pooled soil sample and one pooled earthworm sample, see Table 17. TCEP is regulated in the EU and in Norway. In the EU, further information is collected in support of a possible restriction proposal to regulate TCEP, TCPP and TDCP, in flexible polyurethane foam, in child products and furniture and other products.[7]

Air: Many of the target OPFR compounds were detected by passive air samplers at all sites, but more concentrations were below LOD in 2020 compared to 2019. For comparison of sumOPFR at the various sites, see chapter 3. The dominating compound was TCPP which is in agreement with results from Oslo in 2018. TCPP was also the dominant OPFR compound at Zeppelin-station at Svalbard in 2018 (Bohlin-Nizzetto et al., 2019).

The concentrations range of TCPP (<LOD-3124 pg/day) and TCEP (<LOD-426 pg/day) in Oslo air in 2020 were in agreement with 2019 data. The dominating compound, EDHP in the air samples from 2019, was not detected in 2020.

Soil: For OPFR analyses, a single pooled sample was prepared to represent all five locations from Oslo. Only the compounds TCPP, TCP and TEHP were detected in 2020 with maximum concentration of TCPP of 6.5 ng/g dw. In 2019, an extreme concentration of TCPP was detected in the one pooled sample from soil prepared of soil from seven sites. Additional analysis of the single pooled soil samples from the seven sites revealed that the site Bøler/Bølerskogen area had a very high concentration of 170102 ng/g dw for TCPP, see Table 18. This high concentration at Bøler exceeded the PNECsoil value of 1700 ng/g dw for TCPP (Herzke et al., 2017). The source for this high concentration is not known, and if it is a fresh source or not.

Earthworm: As for soil, a single pooled sample was prepared to represent all five locations from Oslo. Five OPFR compounds were detected, and TCPP had highest concentration with 3.9 ng/g ww. TCPP was also the dominating compound in 2019 with 5.2 ng/g ww.

Summary OPFR

OPFR compounds were only analysed for in five air samples, one pooled soil sample and one pooled earthworm sample. Many OPFR were detected in the air samples. TCPP was the dominating compound in air, soil and earthworm samples. Analysis of TCPP in soil from each of the seven soil sites from year 2019, revealed very high TCPP concentration at Bøler (170 102 ng/g dw) which exceeded the PNECsoil of 1700 ng/g dw for soil living organisms.[8] The one pooled soil sample from 2020, prepared from all five soil locations, had a TCPP concentration of 6 ng/g dw.

[7] https://echa.europa.eu/view-article/-/journal_content/title/echa-weekly-3-april-2019

[8] https://echa.europa.eu/en/brief-profile/-/briefprofile/100.033.766

Table 17: Mean concentrations with min-max interval below in grey colour of organophosphorus compounds (OPFR) in Air (pg/day), Soil (ng/dw), Earthworm (ng/g ww). OPFR were only analysed in one pooled sample of soil and one pooled sample of earthworm. <LOD in light grey colour is given for compounds with no detected concentrations.

Compounds	Air pg/day	Soil ng/g dw	Earthworm ng/g ww
TCEP	204 <LOD-426	<LOD	<LOD
TPrP	<LOD	<LOD	<LOD
TCPP	**1623** <LOD-3124	**6.03**	**3.94**
TiBP	184 <LOD-377	<LOD	1.53
TPP	144 <LOD-216	<LOD	0.42
TnBP	135 <LOD-354	<LOD	2.09
DBPhP	<LOD	<LOD	<LOD
BdPhP	<LOD	<LOD	<LOD
TDCPP	<LOD	<LOD	<LOD
TBEP	<LOD	<LOD	<LOD
TCP	180 <LOD-774	**6.56**	0.33
EHDP	<LOD	<LOD	<LOD
TXP	<LOD	<LOD	<LOD
TIPPP	<LOD <LOD-59.6	<LOD	<LOD
TEHP	132 <LOD-424	1.62	<LOD

Table 18: TCPP concentration detected in soil samples from seven 2019 sampling sites

Soil sampling site from 2019	TCPP (ng/g dw)
Slottsparken	12.5
Alnabru	<0.9
Frognerseteren	1.1
VEAS	< 0.9
Kjelsrud	3.8
Grønmo	3.5
Bøler	**170 102**

3.8 Phenolic compounds

Phenolic compound (bis-A, bis-S, bis-F, TBBPA, octyl- and nonylphenols) were not analysed in air samples, and these compounds were only sporadically detected in the other samples, see Table 19. Due to lack of material, these compounds were not analysed in earthworm samples. For brown rat, only three pooled samples of rat liver were analysed.

None of the compounds were detected in soil samples. or fieldfare and tawny owl egg samples, the 4,4-Bis-F and 2,4-Bis-F were detected in 10-28 % of the samples at comparable levels. 2,2-Bis F was detected in one sample of tawny owl. In red fox liver samples, only 4,4-Bis-A was detected in one sample at 34 ng/g ww. 4,4-Bis-A and 2,4-Bis-A were detected in all three pooled samples of rat liver. 2,4-Bis-A was the dominating compound with maximum concentration of 33 ng/g ww. In general, the pattern of dominating compounds were in agreement with results from 2019.

Summary phenols

Phenols were only sparsely detected in the samples. First and foremost, Bis-F isomers were detected in few of the bird egg samples, Bis-A isomers in one red fox liver samples and all three rat liver samples. The liver samples had highest concentrations, and the levels were lower than in 2019 and 2018.

Table 19: Mean concentrations with min-max interval below in grey colour of phenolic compounds in Soil, Earthworm, Fieldfare eggs, Sparrowhawk eggs, Red fox liver and Brown rat liver (three pooled samples). All concentrations are given in ng/g ww. <LOD in light grey colour is given for compounds with no detected concentrations.

Compounds	Soil	Earthworm	Fieldfare	Tawny owl	Red fox	Brown rat
4,4-Bis-A	<LOD	n.a.	<LOD	<LOD	<LOD <LOD -34.1	0.10 0.10-0.10
2,4- Bis-A	<LOD	n.a.	<LOD	<LOD	<LOD	23.7 11.9-33.4
4,4-Bis-S	<LOD	n.a.	<LOD	<LOD	<LOD	<LOD
2,4- Bis-F	<LOD	n.a.	<LOD	<LOD	<LOD	<LOD
4,4-Bis-F	<LOD	n.a.	<LOD LOD-11.4	<LOD <LOD-12.5	<LOD	<LOD
2,4- Bis-F	<LOD	n.a.	<LOD LOD-13.3	<LOD <LOD-17.7	<LOD	<LOD
2,2- Bis-F	<LOD	n.a.	<LOD	<LOD <LOD-1.26	<LOD	<LOD
TBBPA	<LOD	n.a.	<LOD	<LOD	<LOD	<LOD
4-t-Octylphenol	<LOD	n.a.	<LOD	<LOD	<LOD	<LOD
4-octylphenol	<LOD	n.a.	<LOD	<LOD	<LOD	<LOD
Nonylphenol	<LOD	n.a.	<LOD	<LOD	<LOD	<LOD

3.9 UV compounds

Pooled samples were used for analyses of UV compounds; One sample for soil prepared by pooling soil from five locations in Oslo and three samples for each of the species red fox, tawny owl and brown rat. Fieldfare and earthworm samples were not analysed due to lack of material.

As in 2019, many compounds were below LOD, see Table 20. UV-326 and UV-328 were detected in all of the four sample types. UV-328 had highest concentration in the four sample types. As in 2019, rat liver samples had highest detection rate and concentrations, both on wet and lipid weight, among the species.

Under the European REACH regulation, UV-328 has been identified as a substance of very high concern (SVHC) due to its PBT/vPvB (persistent, bioaccumulative, toxic/very persistent and very bioaccumulative) properties. On these grounds, in February 2020, UV-328 was added to Annex XIV (Authorisation List) of the REACH regulation. UV-328 is also a potential POP. In the 16th Meeting of the POPs Review Committee, 11 to 16 January 2021, it was concluded that UV-328 satisfies all criteria set out in Annex D to the Stockholm Convention on Persistent Organic Pollutants (POPs), namely persistence, bioaccumulation, potential for long-range environmental transport and adverse effects to humans and/or the environment. UV-328 now goes forward to the next stage of the review by the Committee.[9]

Summary UV compounds

UV-326 and UV-328 were detected in all pooled samples of soil, tawny owl egg and liver from red fox and rat. UV-328 had highest concentration in all samples. As in 2019, rat liver samples had highest detection rate where UV-326 and UV-328 were detected in all three samples. Highest concentrations on a wet and lipid weight basis were detected in rat liver samples.

[9] http://chm.pops.int/Implementation/PublicAwareness/PressReleases/POPRC16PressReleaseUV328elimination/tabid/8747/Default.aspx

Table 20: Mean concentrations with min-max interval below in grey colour of UV compounds in pooled samples of Soil (one sample), Red fox liver (three samples), Tawny owl egg (three samples) and Brown rat liver (three samples). All biota concentrations are given in ng/g ww and soil in ng/g dw. <LOD in light grey colour is given for compounds with no detected concentrations.

Compounds	Soil	Red fox	Tawny owl	Brown rat
BP3	<LOD	<LOD	<LOD	<LOD
EHMC-Z	<LOD	<LOD	<LOD	<LOD
ODPABA	<LOD	<LOD	<LOD	<LOD
EHMC-E	<LOD	<LOD	<LOD	<LOD
UV-320	<LOD	<LOD	<LOD	<LOD
UV-326	0.14	0.05 <LOD-0.06	0.09 <LOD- 0.13	0.28 0.19-0.35
UV-329	<LOD	<LOD	<LOD	<LOD
UV-328	**2.4**	0.09 <LOD-0.18	0.11 <LOD-0.23	**0.58** 0.09-1.37
UV-327	0.16	<LOD	0.08 0.04-0.15	0.05 <LOD-0.08
OC	1.30	<LOD	<LOD	<LOD

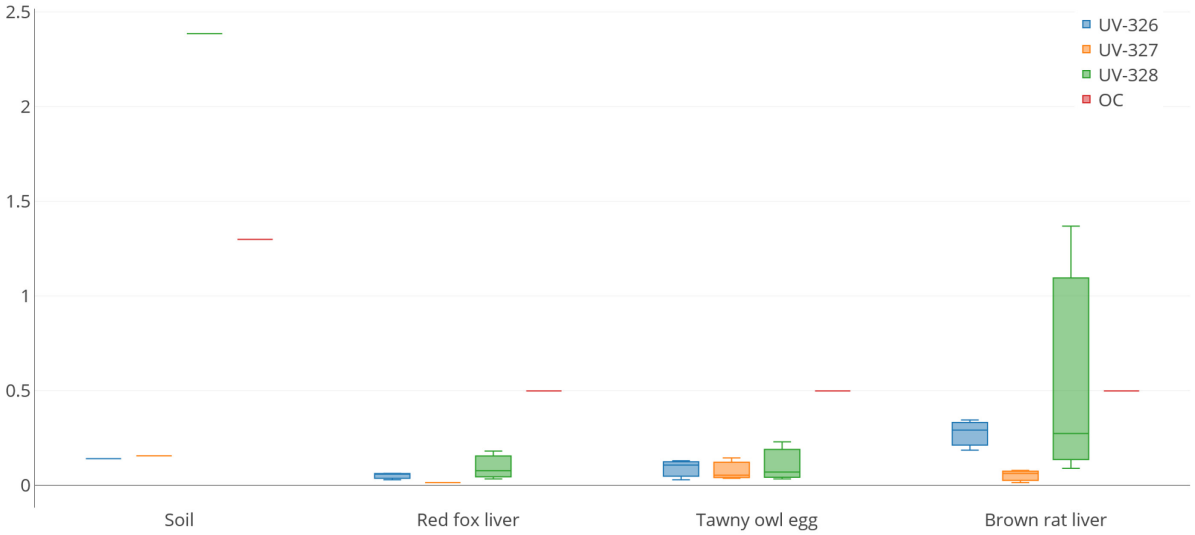

Figure 12: : Box plot of detected UV compounds in one pooled soil sample, and three pooled samples of red fox, tawny owl and brown rat. OC is below LOD (1 ng/g ww) in egg and liver samples, and is set as LOD/2 in the plot. Concentrations in ng/g ww for biota samples and ng/g dw for soil. The upper and lower boundaries of the box are representing the 25th and 75th percentile, the horizontal line in the box marks the median. The whiskers represent the minimum and maximum values without outliers.

3.10 Biocides (rodenticides)

As previous years, biocides (rodenticides) were analysed for in red fox and rat liver samples. Five biocides (bromadiolone, brodifacoum, flocumafen, difenacoum and difethialone) were selected for analyses in these samples.

Bromadiolone, brodifacoum and difenacoum (cis isomer) were detected in 100 % of the red fox liver samples. Bromadiolone was also detected in all samples of brown rat. Brodifacoum was only detected in 10 % of the rat liver samples. The levels of bromadiolone were in general lower than previous years, and only one sample in red fox liver was above 1000 ng/g ww. The other compounds were comparable or lower with last year's results.

In order to investigate if tawny owl and sparrowhawk could be affected by secondary poisoning of rodenticides, rest materials of egg samples from previous years' sampling campaigns were analysed for the same rodenticides. 27 samples of tawny owl egg samples and 38 sparrowhawk egg samples were analysed. Only bromadiolone was detectable in low concentration of 0.26 ng/g ww in one tawny owl egg sample from 2017.

Summary biocides

As previous years have revealed, bromadiolone dominated both in red fox and brown rat liver, and the levels of rat poisons were much higher in the red fox than in the target species; the rats. A possible explanation for this may be the fact that in our study all the rats sampled were taken by clap-traps, not in traps baited with poison. So maybe poisoned rats are an easy prey for the fox, as sick animals are a much easier prey than healthy ones. The highest levels of bromadiolone were lower than data from previous years. Analysis of the same components in previous sampled tawny owl egg and 38 sparrowhawk eggs revealed that only bromadiolone was detectable in low concentration of 0.26 ng/g ww in one tawny owl egg sample from 2017.

Table 21: Mean concentrations with min-max interval below in grey colour of biocides in red fox liver and brown rat liver. All concentrations are given in ng/g ww. <LOD in light grey colour is given for compounds with no detected concentrations.

Compounds	Red fox	Brown rat
Bromadiolone	302 17.9-1090	29.3 0.85-65.1
cis-Brodifacoum	73.3 0.95-197	<LOD <LOD-0.62
trans-Brodifacoum	39.7 0.85-86.5	<LOD <LOD-0.95
Flocumafen	<LOD	<LOD
cis-Difenacoum	6.60 0.55-34.0	<LOD
trans-Difenacoum	3.15 <LOD-22.8	<LOD
Difethialone	<LOD	<LOD

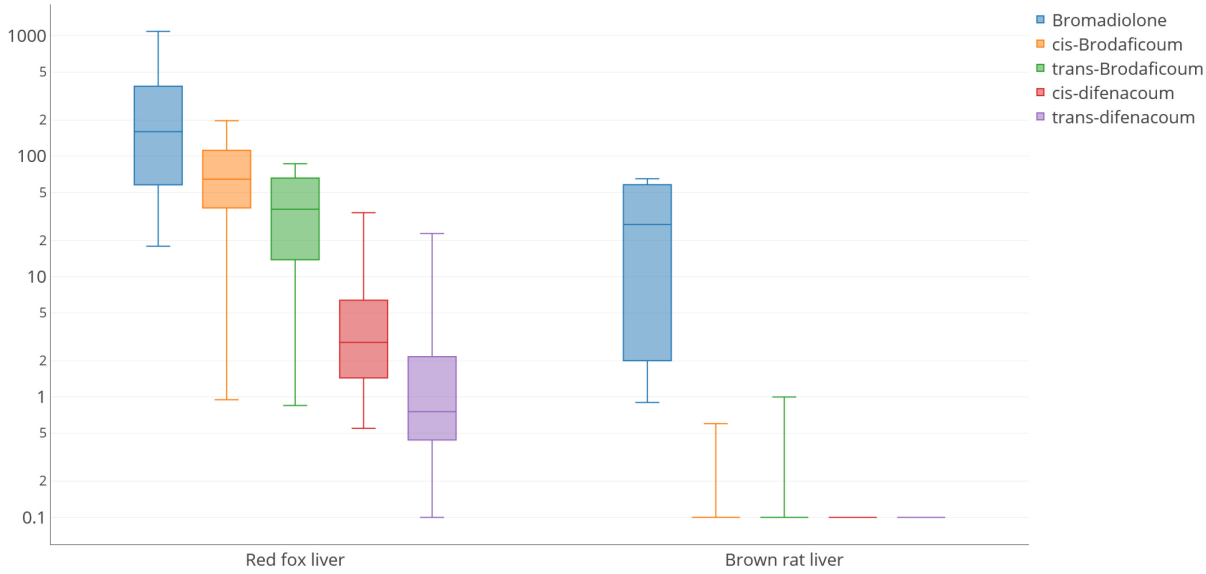

Figure 13: Box plot of rodenticides in liver samples of brown rat and red fox. Concentrations in ng/g ww. The upper and lower boundaries of the box are representing the 25th and 75th percentile, the horizontal line in the box marks the median. The whiskers represent the minimum and maximum values without outliers.

4 Compound classes in air, soil and species

In the following chapter we will only give a short summary of similarities and the dissimilarities in the load of the major compound classes across matrices. The main findings for each compound class has been discussed in the previous chapters. In this chapter we will summarize findings for the dominating compound classes in the various environmental matrices using sum values and median sum concentrations. For air, soil and earthworm, we have chosen to report sum values per site since at least soil and earthworm samples are closely site related, and possibly air too. Birds and mammals move and migrate over larger distances in the Oslo area and median or mean sum values are more relevant for these species. The overview will first and foremost be given in form of graphical information in figures.

Air: Air concentrations from passive samplers given in pg/day (or ng/day) cannot be directly compared to concentrations in other environmental matrices, but spatial distribution and comparison of contaminant pattern in soil and earthworms can be performed. More importantly, comparison across sites for the air data has revealed that there are areas in Oslo that have higher concentrations than other places in Oslo for some of the pollutant groups.

The total load of pollutants in air from the Oslo sites can be a combination of local and more distant sources. However, a dominance of urban sources are most likely since the levels from the passive samplers in Oslo are elevated, compared to data from background stations such as Zeppelin (Svalbard) and Birkenes. This indicates the existence of a number of point sources/emissions caused by human activities in Oslo. As in previous year's results, the emerging pollutants cyclic siloxanes (cVMS), chlorinated paraffins (CP) and OPFR were observed at highest concentrations in the air samples at the five locations. cVMS were measured at highest concentrations (pg/day), followed by SCCP and OPFR. As last year, highest concentration of cVMS was detected at VEAS followed by Slottsparken. The very high sumPBDE concentration at Alnabru was due to high concentration of PBDE209 (1196 pg/day)

Overview of locations with highest sum concentrations in air for the various compound classes:

PCB:	Slottsparken > Alnabru> VEAS~ Frognerseteren>Grønmo
PBDE:	Alnabru >> other locations
NewBFR:	Slottsparken> VEAS> Alnabru> Frognerseteren> Grønmo
PFSA:	Frognerseteren > Slottsparken>Grønmo>Alnabru>VEAS
PFCA:	VEAS > Frognerseteren ~ Grønmo>Alnabru>Slottsparken
OPFR:	Slottsparken~ Alnabru> VEAS>>Grønmo
CP:	Slottsparken> Alnabru> Grønmo
cVMS:	VEAS> Slottsparken> Alnabru> Frognerseteren> Grønmo

Table 22: Sum concentrations (pg/day) of the various pollutant groups in air at the five sites in the Oslo area. <LOD concentrations were not included in the sum concentrations.

Site	PCB	PBDE	newBFR	PFSA	PFCA	OPFR	CP	cVMS
Slottsparken	**475**	16.7	**40.9**	15.1	<LOD	**4441**	**9958**	44984
Frognerseteren	36.8	1.27	3.23	**19.3**	4.93	<LOD	<LOD	13337
Grønmo	24.8	8.52	0.11	12.4	4.77	133	3920	7844
Alnabru	133	**1243**	8.58	10.6	1.31	4317	4844	23812
VEAS	41.0	2.53	23.9	5.44	**21.1**	3039	<LOD	**83801**

Soil: In soil, as last years, the main contributors to the overall pollution were metals, SCCP and PCB, see Table 23. Grønmo had highest SumToxicMetal concentration. Frognerseteren with highest sumToxicMetal concentration in previous years (102 257 ng/g dw in 2019), was replaced by Kjelsås site in 2020. After metals, SCCP was the dominating organic pollutant class followed by PCB. Kjelsås had higher sumPCB concentrations compared to 2019 data, and sumPBDE concentrations were lower. The levels of PFSA and PFCA were comparable and slightly lower than 2019 data, and sumCP concentrations were much lower than in 2019 when blank values most probably influenced the concentrations.

Toxic metals:	Grønmo > Slottsparken> Alnabru>Kjelsås>VEAS
PCB:	Kjelsås > Grønmo>Slottsparken ~Alnabru>VEAS
PBDE:	Alnabru ~ VEAS> Kjelsås
PFSA:	Kjelsås > Alnabru~Grønmo>Slottsparken>VEAS
PFCA:	Kjelsås > Alnabru~Slottsparken~VEAS >Grønmo
SCCP:	Kjelsås > Grønmo>other locations
cVMS:	Kjelsås ~ Slottsparken>VEAS~Grønmo~Alnabru

Table 23: Sum concentrations (ng/g dw) of the various pollutant groups in soil at the seven sites in the Oslo area. <LOD concentrations were not included in the sum. OPFR and UV compounds are not included due to only one pooled sample. NewBFR and Phenols are not included due to most data <LOD.

Site	Toxic Metals	PCB	PBDE	PFSA	PFCA	SCCP	cVMS
Slottsparken	44797	2.77	<LOD	0.57	1.50	<LOD	3.11
Kjelsås	29300	**17.3**	0.17	**3.06**	**6.18**	**101**	**3.27**
Grønmo	**48751**	6.57	<LOD	1.01	0.28	18	2.17
Alnabru	41896	2.01	**0.97**	1.33	2.12	<LOD	1.87
VEAS	18598	1.04	0.43	0.33	1.02	<LOD	2.22

When comparing air and soil data, Slottsparken, VEAS and Alnabru dominated the air concentrations, while for soil, the site Kjelsås revealed high or elevated pollutant concentrations for all of the tested contaminants, and was the site with highest concentrations of PCB, PFAS and SCCP. However, the toxic metal concentrations at Kjelsås were the second lowest among the five sites. While volatile compounds cVMS compounds dominate air samples, soil samples are dominated by toxic metals.

Earthworm: The sum concentration of sum of toxic metals in earthworms was highest at Grønmo, and comparable to 2019 data for the same sites. sumPCB was highest at Slottsparken followed by Alnabru, which was also the case for the air samples. Grønmo had highest sumPFSA due to highest PFOS concentration of 22.4 ng/g ww, and Slottsparken had highest sumPFCA. Earthworm from Grønmo and Alnabru have shown highest PFOS and sumPFSA in previous years. Fieldfare egg from Grønmo had in 2020 (and in previous years) the highest PFOS, sumPFSA and sumPFAS concentrations. Earthworms are known to be important part of the diet of fieldfare.

Overview of locations with highest sum concentrations in earthworms for the various compound classes:

Toxic metals:	Grønmo > Alnabru> VEAS>Kjelsås~Slottsparken
PCB:	Slottsparken > Alnabru> Kjelsås> VEAS> Grønmo
PBDE:	Alnabru~ Slottsparken> other locations
PFSA:	Grønmo > Slottsparken~Alnabru> VEAS> Kjelsås
PFCA:	Slottsparken > Kjelsås> Grønmo> Alnabru~VEAS
CP:	Slottsparken> other locations
cVMS:	VEAS~Kjelsås~Alnabru~other locations

Table 24: Sum concentrations (ng/g ww) of the various pollutant groups in earthworms at the seven sites in the Oslo area. <LOD concentrations were not included in the sum. OPFR and UV compounds are not included due to only one pooled sample. NewBFR and Phenols are not included due to most data below LOD.

Site	Toxic Metals	PCB	PBDE	PFSA	PFCA	SCCP	cVMS
Slottsparken	3065	**5.06**	0.19	13.2	**26.4**	5.5	6.47
Kjelsås	3121	2.38	0.03	3.53	10.4	<LOD	7.02
Grønmo	**4234**	0.35	0.07	**26.0**	7.92	<LOD	6.46
Alnabru	3946	3.68	0.25	12.3	5.31	<LOD	6.75
VEAS	3512	0.54	0.07	6.88	5.09	<LOD	**7.23**

4.1 Dominating pollutant groups in the species

Figure 14 shows the most dominating pollutant groups in the various species on a wet weight basis. As previous years, sum concentrations of metals dominated in earthworm and liver samples from red fox and brown rat, Figure 14. The sum concentration of metals was especially dominating in earthworm and brown rat liver. In red fox liver sum concentrations of metals and biocides were comparable. PFAS was first and foremost a dominating group in fieldfare eggs, and also in earthworm, when excluding the metal concentrations. In red fox liver and tawny owl egg, PFAS concentrations were comparable to other component groups (PCB, CP etc.), see also Figure 15 with only organic pollutant classes analysed in all species. PBDE is the pollutant group with lowest concentrations in all species, except rat liver where also PCB show low concentrations. In rat liver samples, cyclic siloxanes (cVMS) were detected in relatively high concentrations compared to other groups.

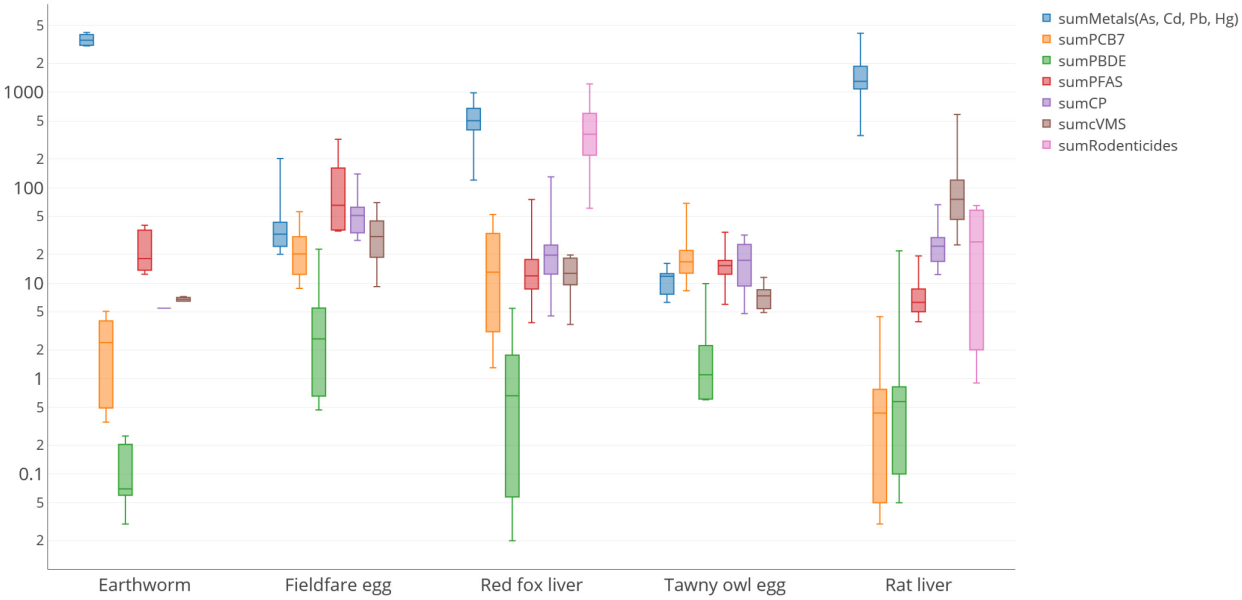

Figure 14: Box plot of sum concentrations in ng/g ww of important compound classes in the various species in 2020. <LOD concentrations were not included in the sum concentrations.The upper and lower boundaries of the box are representing the 25th and 75th percentile, the horizontal line in the box marks the median. The whiskers represent the minimum and maximum values without outliers. Note that biocides only were analysed of in liver of red fox and brown rat.

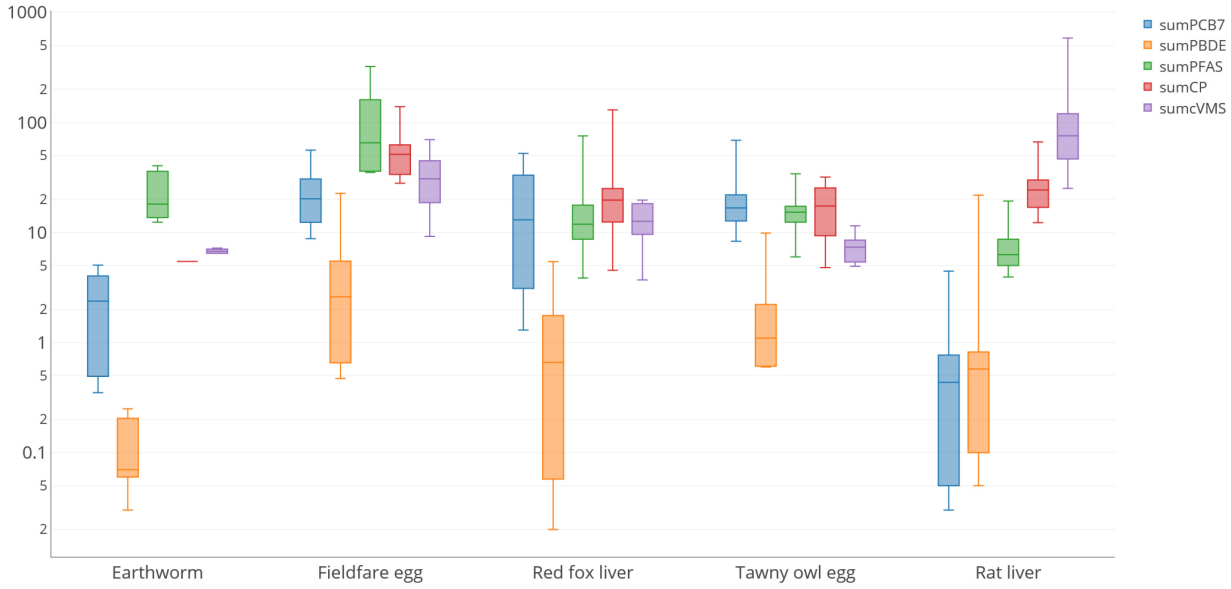

Figure 15: Box plot of sum concentrations (ng/g ww) of common organic compound classes in species. <LOD concentrations were not included in the sum concentrations. The upper and lower boundaries of the box are representing the 25th and 75th percentile, the horizontal line in the box marks the median. The whiskers represent the minimum and maximum values without outliers.

5 Bioaccumulation and biomagnification

Results from stable nitrogen and carbon isotope analyses

$\delta^{15}N$ values were used to estimate the relative trophic positions of the different organisms. Terrestrial food chains are in general very short, and biomagnification is generally assumed to be positively linked to food chain length such that the longer the food chain is, the higher the pollutant concentrations will be at the top of the food chain. Thus, despite bioaccumulation capabilities of some pollutants, top predators in the terrestrial food webs may be at lower risk for experiencing secondary poisoning than top predators in marine food webs, which are typically long. The strength of the relationship between tissue concentrations and trophic position is however also influenced by the properties of the chemicals, the types of tissue analysed, sampling period and location, and feeding habits of the species. In general, more lipophilic chemicals show stronger relationships between measured tissue concentrations and trophic position.

Table 25: $\delta^{15}N$ in the different sample types from the Oslo area.

Species	N	Mean	Minimum	Maximum
Soil	5	5.72*	0.73	12.9
Earthworm	5	3.47	0.71	6.48
Fieldfare	8	6.08	5.35	6.84
Tawny owl	10	7.62	5.80	9.61
Red fox	10	8.97	7.39	9.99
Brown rat	10	7.51	6.95	8.25

*Mean value of 3.97 when excluding the maximum value of 12.9

Figure 16 shows the signature of the investigated species. Differences between soil and earthworms to the other species are quite considerable, with moderate $\delta^{15}N$ enrichment further up the food web. One of the soil samples had a very high $\delta^{15}N$ value and was most probably contaminated from animals, for instance animal faeces. This value of 12.9 was therefore treated as an outlier.

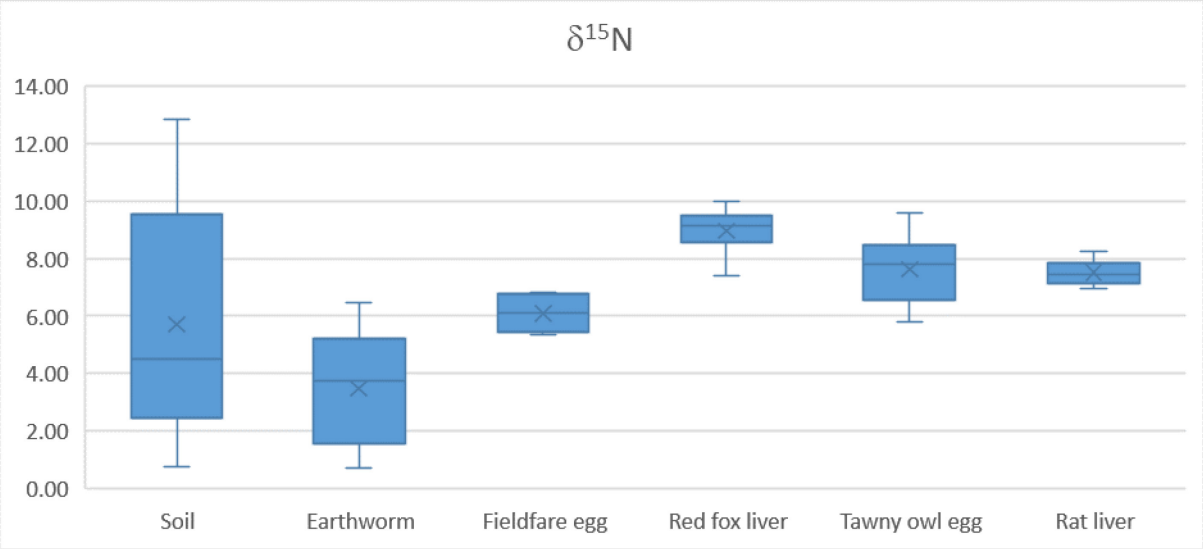

Figure 16: Box and whiskers plot of δ15N (‰) values in all species analysed.

Nitrogen in the protein of consumers is generally enriched in δ15N by 3–5‰ relative to prey nitrogen (i.e. δ15N = 3–5‰). This nitrogen heavy isotope enrichment appears to be caused by isotopic

fractionation occurring with transamination during protein catabolism (Doucett et al., 1999). This increase allows determination of an animal's trophic level (TL) in a food web (DeNiro and Epstein, 1978; Post, 2002).

In this present study from Oslo region, and as in 2019, the red fox liver and tawny owl eggs were characterized by the highest mean $\delta^{15}N$ values of 8.97 and 7.62, followed by brown rat liver (7.51), fieldfare (6.08) and earthworms (3.47) when excluding the results for soil.

$\delta^{13}C$ values provide information regarding the source of dietary carbon, e.g. whether and to what extent an organism feeds on marine or freshwater organisms or aquatic or terrestrial organisms. For example, samples from marine locations are expected to show a less negative $\delta^{13}C$ value than samples from terrestrial locations. However, direct comparison of the data presented in this report should be done with care, since different tissues were analysed for the different species in the study (eggs, liver, whole individuals). Different tissues may have different $\delta^{13}C$ turnover rates and may reflect the dietary exposure differently and in an optimal study design only data from the same tissue type should be compared (optimally muscle tissue due to slow turnover rates).

Table 26: $\delta^{13}C$ levels in the different sample types.

Species	N	Mean	Minimum	Maximum
Soil	5	-26.9	-27.5	-26.3
Earthworm	5	-26.4	-27.5	-25.1
Fieldfare	8	-26.7	-27.7	-25.9
Tawny owl	10	-28.5	-30.0	-26.9
Red fox	10	-26.4	-27.4	-25.0
Brown rat	10	-25.1	-25.5	-24.6

Of the organisms, and in agreement with results from 2019 and previous years, tawny owl and fieldfare eggs revealed the lowest $\delta^{13}C$ mean values. The $\delta^{13}C$ values for tawny owl are lowest and may indicate a more terrestrial diet compared to the other species, especially when compared to brown rat liver $\delta^{13}C$ values. The mean value of $\delta^{13}C$ values for fieldfare eggs and earthworm were similar to the 2019 mean values.

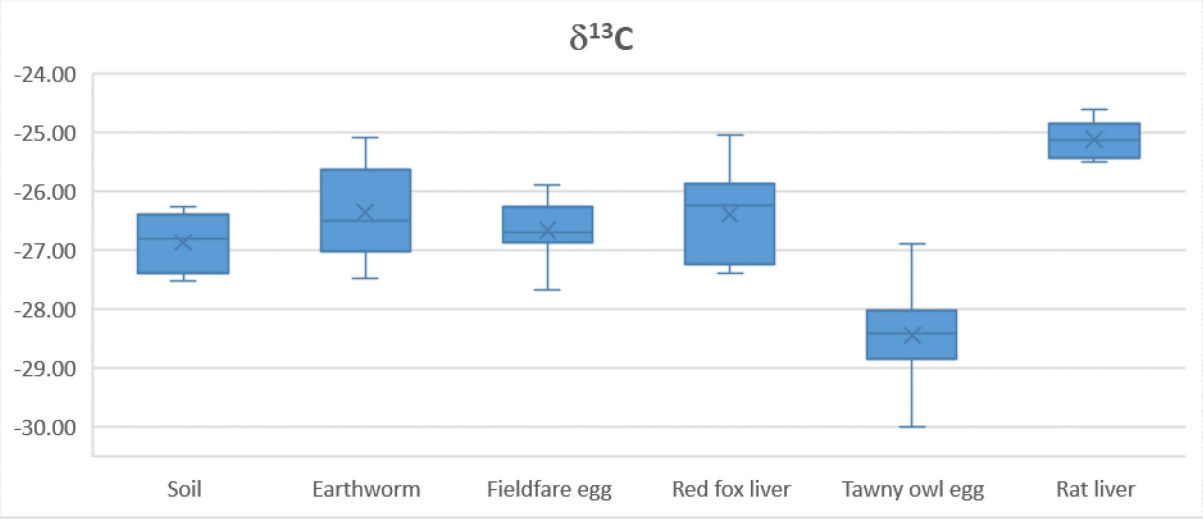

Figure 17: Box and whiskers plot of δ13 C values in the different species analysed.

$\delta^{34}S$ values provide information regarding the foraging ecology of certain species. Marine sulfate generally has higher $\delta^{34}S$ values than terrestrial materials or waters (Michener and Schell 1994). The mean $\delta^{34}S$ values in 2020 had in general higher mean values compared to results from 2019. As in 2019, $\delta^{34}S$ values in earthworm revealed highest variance, and as in 2019, earthworm from VEAS had lowest $\delta^{34}S$ value (-9.5).

Table 27: $\delta^{34}S$ levels in the different sample types.

Species	N	Mean	Minimum	Maximum
Soil	5	6.00	3.36	8.65
Earthworm	5	0.16	-9.47	4.28
Fieldfare	8	3.22	0.49	5.92
Tawny owl	10	6.24	5.24	7.18
Red fox	10	5.85	5.09	6.91
Brown rat	10	5.65	4.83	6.41

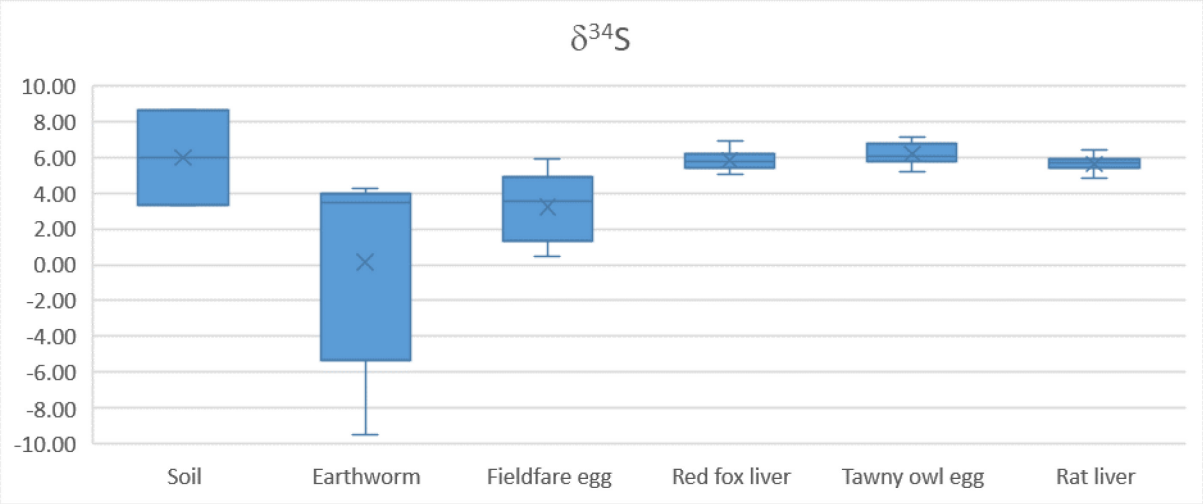

Figure 18: Box and whiskers plot of δ34 S values in the urban terrestrial environment in the Oslo area

Fieldfare as a terrestrial omnivore (seeds, berries, earthworms and insects), shows a distinction to the tawny owl and other species, overlapping earthworm data. $\delta^{34}S$ levels are not enriched in the foodchain and stay stable within the same location, allowing comparison of foraging habits.

5.1 Estimation of biomagnification by calculation of TMF values

When relating all samples in 2020 against $\delta^{13}C$ and $\delta^{15}N$, the graph in Figure 19 is achieved. In this figure, tawny owl is clearly not part of the same predator-prey relationship, clustering isolated on the left upper corner, while all other species follow along a similar slope: soil and earthworm samples are the lowest followed by, fieldfare, brown rat and red fox. There is some overlap between the species, but rather distinct clustering. Tawny owl eggs and earthworm data revealed a quite broad variation, covering several orders of stable isotope concentrations.

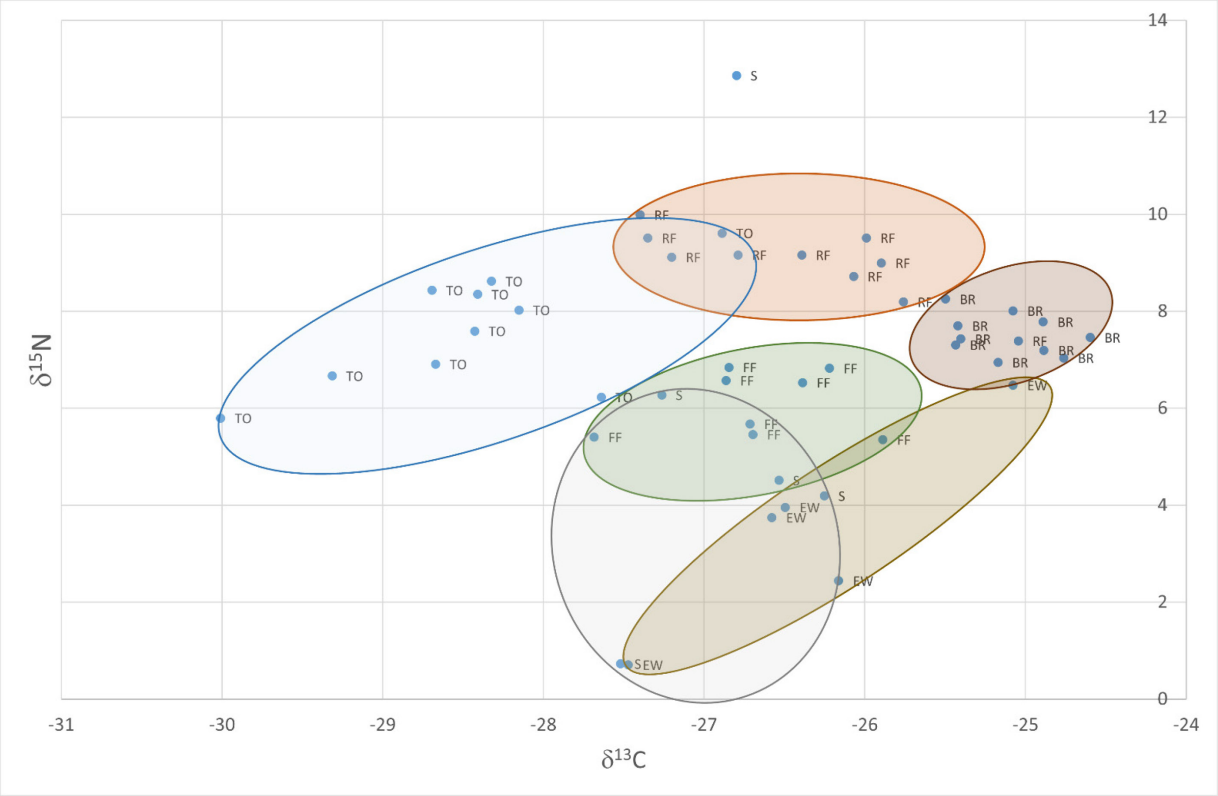

Figure 19: Relationship between the dietary descriptors $\delta^{15}N$ and $\delta^{13}C$ in soil and biota samples from urban terrestrial environment in Oslo, 2020; soil (S), earthworm (EW), fieldfare (FF), tawny owl (TO), red fox (RF) and brown rat (BR)

The selected species in this study represent species from the 2nd trophic level (earthworms), 2nd to 3rd (fieldfare and tawny owl) and the 3rd and 4th trophic level (brown rat, red fox). To assess the biomagnification of each chemical we correlated the lipid-corrected (except for the case of PFAS compounds, which are wet weight) log concentrations of the different pollutants in the different species of the food web with $\delta^{15}N$, i.e. information on the relative trophic position of the organisms.

TMF calculations with a food chain approach

Within the frame of this study, we applied a foodchain approach earthworm (EW) – fieldfare (FF)– sparrowhawk (SH) to estimate the TMF. The relationship between $\delta^{13}C$ and $\delta^{15}N$ for the foodchain EW-FF-SH with data from the years 2014 to 2020 is shown in Figure 20.

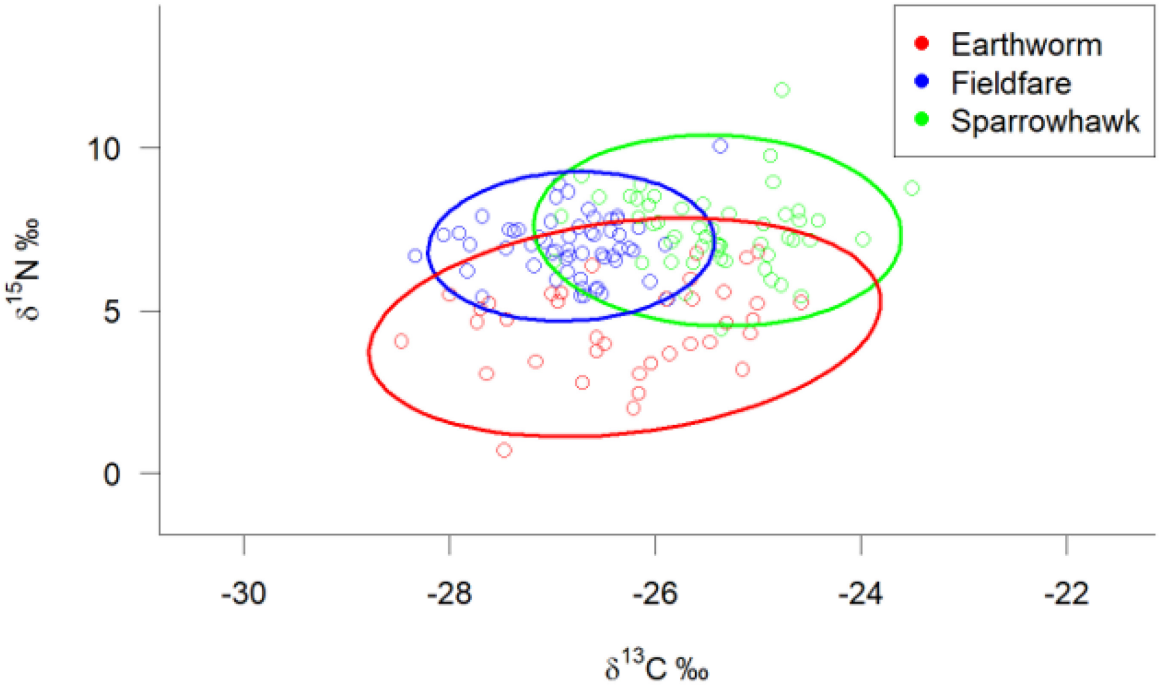

Figure 20: $\delta^{15}N$ and $\delta^{13}C$ values from 2014-2020 of earthworm (whole animal samples), fieldfare (eggs) and sparrowhawk (eggs). Isotopic niche space is illustrated with ellipses covering 95% of the stable isotope data for each species, calculated with the Stable isotope Bayesian ellipses (SIBER) package in R (Jackson et al. 2011, R Core Team 2020)

Equations for calculation of trophic levels (TL):

$TL_{EW} = 2 * (\delta^{15}N_{EW} / \delta^{15}N_{EWmean})$

$TL_{FF} = 3 + (\delta^{15}N_{FF} - (\delta^{15}N_{EWmean} + 2.4))/3.8$

$TL_{SH} = 4 + (\delta^{15}N_{SH} - (\delta^{15}N_{EWmean} + 2.4))/3.8$

Trophic magnification factors (TMFs) were calculated as the power of 10 of the slope (b) of the linear regression between log concentration and the samples TL.

Log [compound] = a + *b*TL, TMF = 10^b

The here estimated TMFs must be treated with caution since the recommended tissue type (muscle) could not be used which is the basis for the TL equation for birds. Instead egg samples were available which are characterized by a much shorter turnover rate and thus reflect the short term exposure rather than the long term one.

To ensure less uncertainty in the prediction, TMFs were only calculated for environmental pollutants that had a detection rate of 65 % or more in samples from the Oslo area (2014-2020) of this monitoring programme.

In the calculations, lipid weight concentrations for hydrophobic compounds, and wet weight basis for PFAS compounds were used. In cases with detection rate below 100 %, concentrations below LOD are included, and replaced by LOD/2. For PCBs, a well-studied pollutant group in the environment, only congeners PCB-153 (Figure 21) and PCB-138 (Figure 22) were selected as reference compounds, although other congeners fulfilled the detection criteria.

With sparrowhawk eggs from 2014 to 2019, earthworm from 2014-2020, and fieldfare eggs from 2015 to 2020, TMFs could be obtained for PCB-153, PCB138, PFHxS (Figure 23), PFOS (Figure 24), PFUnA (Figure 25), PFDcA, PFTriA, PFTeA, PFDoA, SCCP, 8:2 FTS, PFOA and PFNA, see Table 28.

The concentrations of PCB-153, PCB-138 on a lipid weight basis, PFOS, PFNA, PFDcA, PFUnA, PFDoA, PFTriA, PFTeA, 8:2 FTS on a wet weight basis, increased significantly with trophic level, and magnified across trophic levels (Table 28). Conversely, the concentrations of PFHxS (wet weight) and SCCP (lipid weight) decreased significantly with trophic level, showing trophic dilution.

PBDE congeners such as BDE-47, BDE-99 and BDE-100 did not fulfil the detection criteria of 65 % in earthworm, and biomagnification factors (BMF) using fieldfare and sparrowhawk data were calculated, see chapter 5.3. Only compounds fulfilling the detection criteria are shown in Table 28, and calculation of biota soil accumulation factor (BSAF) and BMF for some of the other compounds, are given in chapter 5.2 and 5.3.

Table 28: Calculated TMF values of selected organic pollutants based on the 2014-2020 data for earthworm, 2015-2020 data for fieldfare and 2014-2019 for sparrowhawk, along with Pearson correlation coefficient (R) and coefficient of determination (R^2). Beta is the slope estimate for the regression of log compound on trophic level. Significant P-value mean that Beta is different from zero. Note, positive values of Beta indicate magnification, while negative values indicate degradation- lw = lipid weight, ww = wet weight), NS = not significant.

Compound	TMF	R^2	R	P	Beta
PCB153 lw	6.76	0.71	0.84	<0.01	0.83
PCB138 lw	6.05	0.70	0.84	<0.01	0.78
PFHxS ww	0.58	0.08	-0.28	<0.01	-0.23
PFOS ww	1.46	0.06	0.25	<0.01	0.16
8:2 FTS ww	1.54	0.06	0.24	<0.05	0.19
PFOA ww	0.89	0.01	-0.09	NS	-0.05
PFNA ww	1.09	0.003	0.05	NS	0.04
PFDcA ww	1.55	0.10	0.31	<0.01	0.19
PFUnA ww	1.79	0.19	0.435	<0.01	0.25
PFDoA ww	1.69	0.14	0.37	<0.01	0.23
PFTriA ww	1.66	0.18	0.42	<0.01	0.22
PFTeA ww	1.56	0.11	0.34	<0.01	0.19
SCCP lw*	0.69	0.02	-0.14	<0.05	-0.16

*Detected data in sparrowhawk was 63 % , and below 65 % criteria

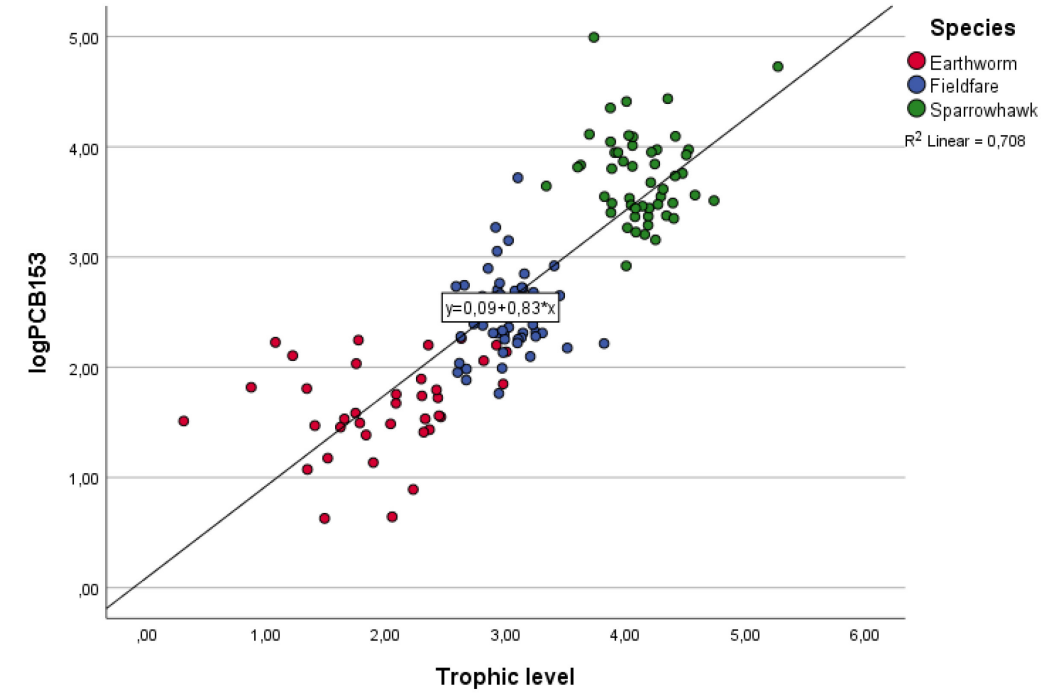

Figure 21: Relationship between trophic level (TL) and Log PCB-153 for the 2014-2020 dataset.

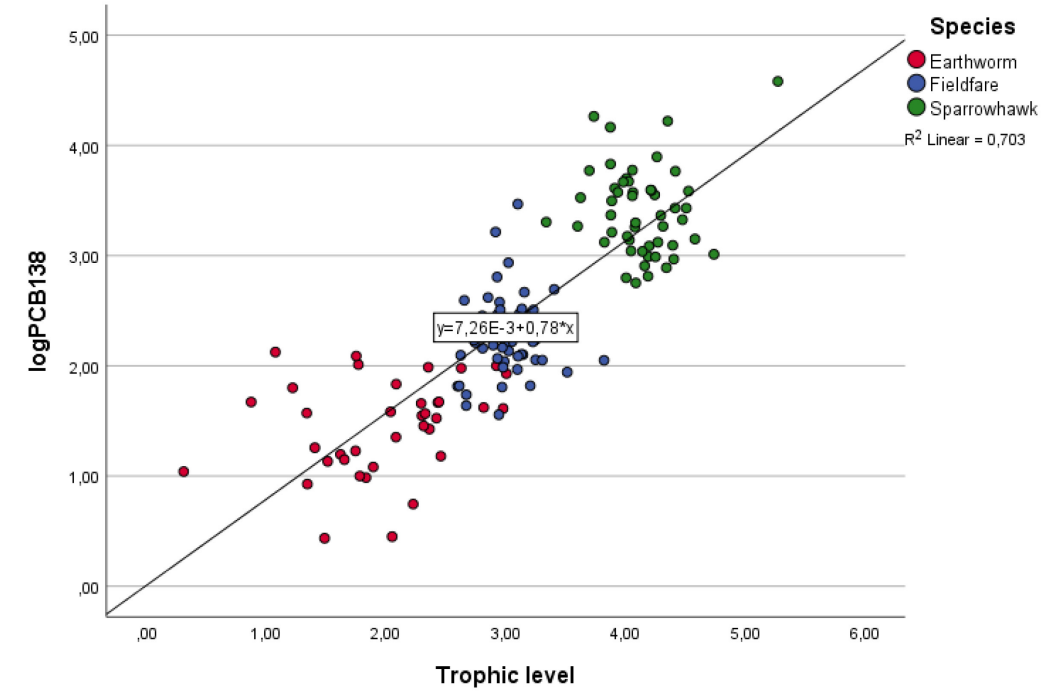

Figure 22: Relationship between trophic level (TL) and Log PCB-138 for the 2014-2020 dataset.

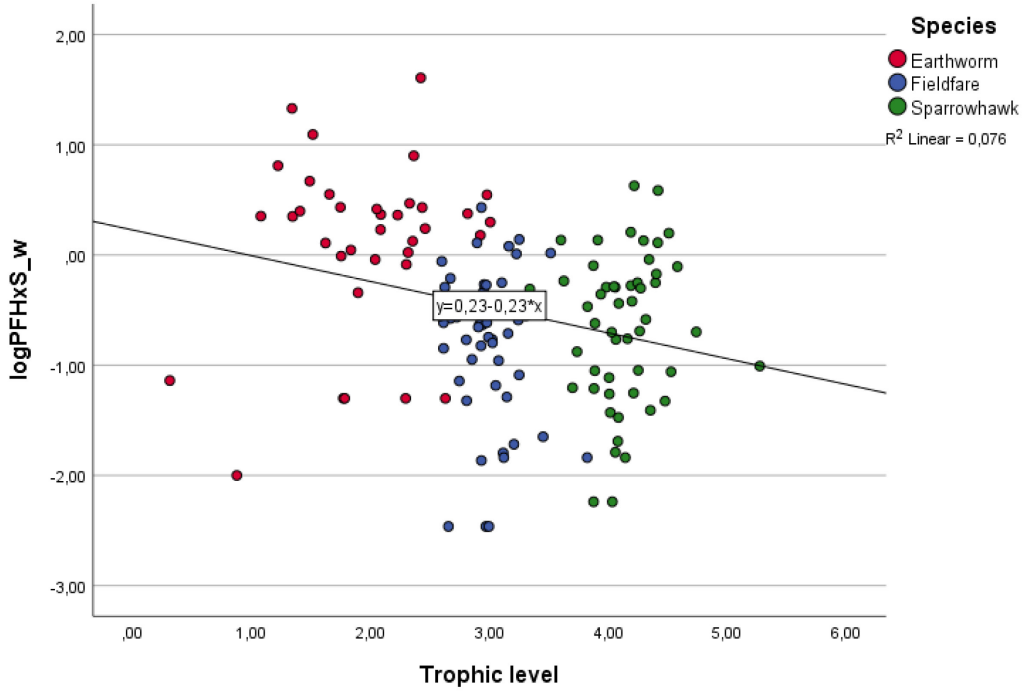

Figure 23: Relationship between trophic level (TL) and Log PFHxS for the 2014-2020 dataset.

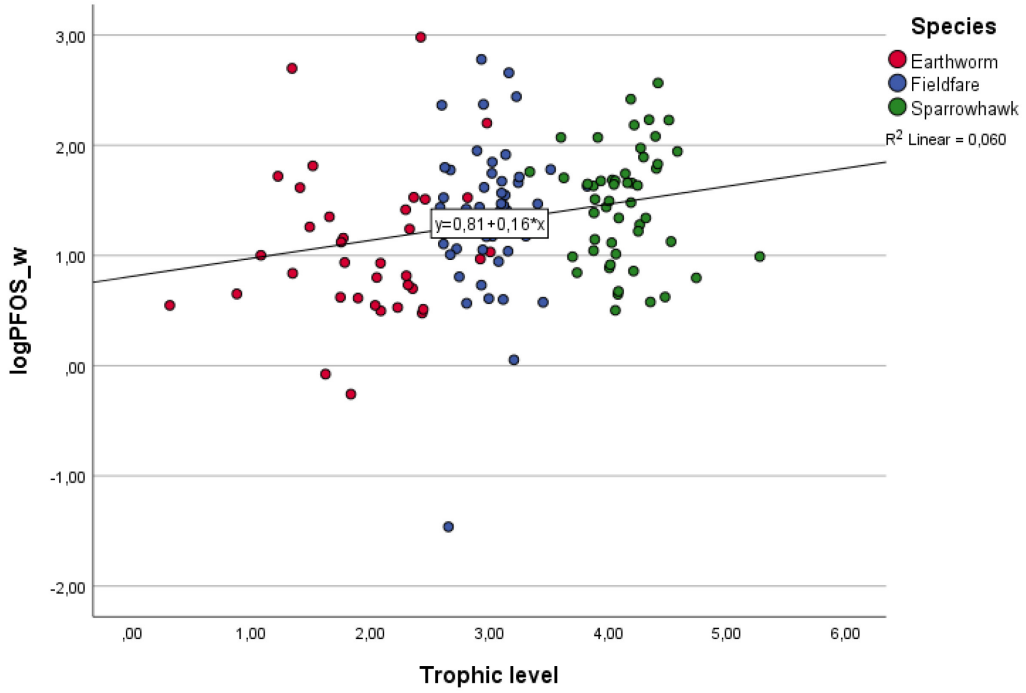

Figure 24: Relationship between trophic level (TL) and Log PFOS for the 2014-2020 dataset.

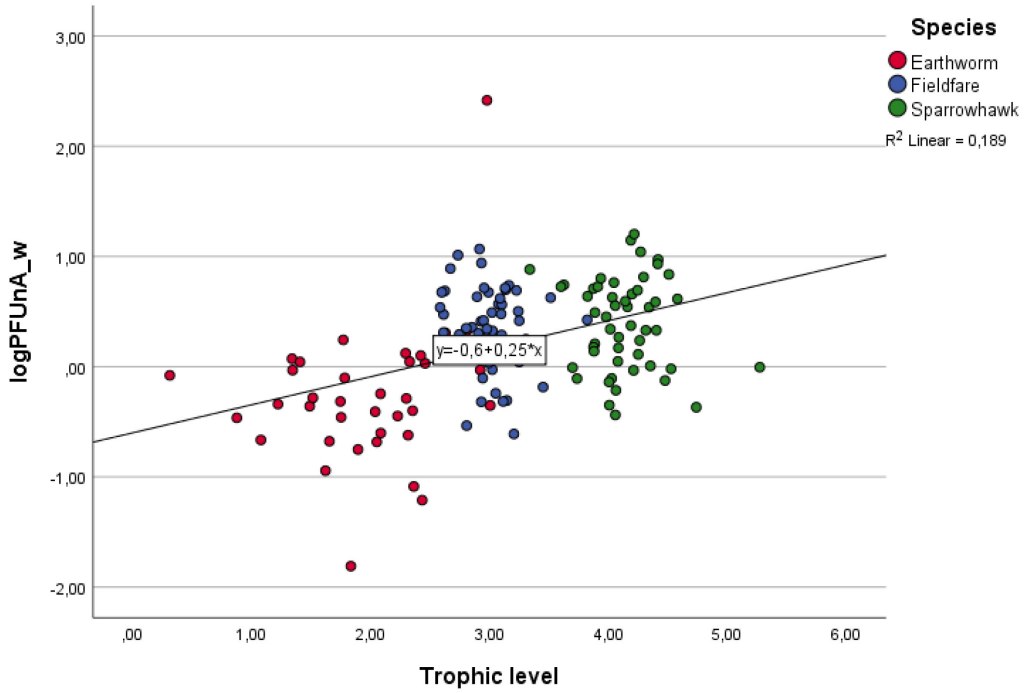

Figure 25: Relationship between trophic level (TL) and Log PFUnA for the 2014-2020 dataset.

5.2 BSAF or BAF

In addition to TMF and BMF, field based bioaccumulation factor (BAF) or biota-soil accumulation factor (BSAF) can be used to evaluate potential bioaccumulation from soil to soil living species such as earthworm. BSAF was calculated for some compounds at specific locations where contaminant data was detected for both soil and earthworm (EW) in the same year.

For hydrophobic compounds such as PCBs, PBDEs, the BSAF is normally calculated with concentrations normalized with respect to total organic content (TOC) in soil and lipid normalized concentrations in biota. TOC in soil samples was only measured in 2016.

BSAF= C_{EW} (ng/g lw) / C_{soil} (ng/g TOC)

PCB-153 as reference compound
BSAF was calculated for PCB-153, a well-studied PCB congener as a reference compound. The locations Slottsparken and Alnabru were chosen since these two locations were sampled over several of years and with detectable data for other emerging contaminants, where the detection criteria of 65 % for TMF was not fulfilled. PCB-153 was detected in both soil and earthworm at both sites in 2016.

Table 29: % TOC in soil samples from year 2016. Slottsparken and Alnabru are shown in bold font since these sites was monitored from 2017-2020 and had most detected data

Sites	TOC mg/g dw in soil (2016)	TOC % dw (2016)
Slottsparken	**46.6**	**4.66**
Alnabru	**50.3**	**5.03**
Voksenkollen	42.8	4.28
Frognerseteren	107.4	10.7
Svartdalsparken	39.6	3.96

Table 30: (a) BSAF for PCB-153 at Slottsparken and Alnabru, year 2016. (b) mean BSAF value for the same locations when using TOC value determined in 2016 in soil for all years.

(a)

Site	BSAF (PCB-153) year 2016
Slottsparken	8.4
Alnabru	4.7

(b)

Site	Mean BSAF (PCB-153)
Slottsparken (2016-2020)	7.9 (4.5-13.0)
Alnabru (2016-2020)	7.6 (1.7-12.3)

The other locations in 2016 (Voksenkollen, Frognerseteren, Svartdalsparken) revealed BSAF of 8.4 , 20.9 and 2.3 in the year 2016 for PCB-153, indicating a considerable variation across sites within one sampling year. The sampling locations for Slottsparken and Alnabru have been the same over the years, and we expect that the organic content in soil could remain more or less the same over years. If the TOC value determined in soil from 2016 were used for all soil data in the years 2016-2020, the mean BSAF value for Slottsparken and Alnabru for PCB-153 became 7.9 (4.5-13.0) and 7.6 (1.7-12.3), respectively, see Table 30 (b).

BDE-congeners did not have sufficient concentrations above LOD for soil and earthworm in order to do reliable BSAF calculations.

New BFR

The TOC value in soil from 2016 was used for evaluating BSAF for the new BFR compounds PBBZ and BTBPE. The concentration data of PBBZ and BTBPE for the soil and earthworm samples from 2018 for the sites Slottsparken and Alnabru were used. Lipid percentage in earthworm samples from both sites was 1.

Table 31: BSAF for PBBZ and BTBPE at Slottsparken and Alnabru in year 2018 using soil TOC determined in 2016, N: number of samples

BSAF ($EW_{lw}/Soil_{TOC}$)	PBBZ	BTBPE	N (soil)	N (earthworm)
Slottsparken (2018)	1.13	2.21	1	1
Alnabru (2018)	0.96	2.19	1	1

The BSAF ($EW_{lw}/Soil_{TOC}$) for PPBZ and BTBPE were in agreement for Slottsparken and Alnabru where PBBZ revealed a BSAF value of approximately 1, and BTBPE revealed higher potential for bioaccumulation with a BSAF of approximately 2. Since the TOC measurement was from a different year than the concentration data, the BSAF value should be interpreted with caution. In addition, the number of samples are very scarce with only one year with pair data of one sample of soil and one sample of earthworm at each site.

Dechloranes

Due to high detection rates, a BSAF ($EW_{lw}/Soil_{TOC}$) was also possible to be calculated for the 2017 data for the dechlorane compounds syn- and anti-DP, using TOC values determined in 2016 for soil. All BSAF values were below 1 for Slottsparken, Frognerseteren and Alnabru for both compounds.

PFAS compounds

Some previous studies have revealed correlation between organic content in soil and PFAS concentrations, and BSAF (or BAF) has in some cases been calculated with wet weight concentration for earthworm divided by soil concentration normalized to TOC (Rich et al. 2015; Conder et al. 2020). The BAF (BSAF) calculations in the present study were done on a wet weight basis for both soil and earthworm. PFOS was first tested as a representative model compound for the PFAS group, followed by other compounds where detection criteria were not fulfilled for TMF calculations.

PFOS had a high detection frequency over years in soil and earthworm from 2015 to 2020, and BAF EW/Soil for PFOS was calculated for selected sites with highest amount of data. As shown in the table below there is high variability of BAF values for the same site over the years, although the mean BAF value is comparable across some of the sites.

BAF= C_{EW} (ng/g ww) / C_{soil} (ng/g ww)

Table 32: Mean BAF (or BSAF) value for PFOS on a wet weight basis for soil and eartworm at sites sampled over several years.

	Mean BAF ($EW_{ww}/Soil_{ww}$)		
Sites	**PFOS**	Min-max	No of years
Slottsparken	23	0.80-60.4	6 (2015-2020)
Frognerseteren	17	8.7-39.2	4 (2016-2019)
Grønmo	17	15.4-18.9	3 (2018-2020)
Alnabru	16	9.5-30.1	5 (2016-2020)
VEAS	28	3.2-49.9	3 (2018-2020)

Doing the same exercise for Slottsparken, Alnabru and Frognerseteren over several years using the soil concentration normalized to TOC (determined in 2016 for soil at these sites) and wet weight concentration in earthworm, gave average BSAF values of 0.84 (0.03-2.37) for Slottsparken, 0.57 (0.30-1.10) for Alnabru and 1.02 (0.59-2.03) for Frognerseteren.

Other PFAS compounds
PFHxS, PFHpS and 8:2FTS did not have sufficient detected data for BAF calculations for soil-earthworm pairs at the same location. PFHxA and PFHpA had slightly more detected concentrations, and BAF was calculated for soil-earthworm pairs on a wet weight basis at locations, and only years with detectable concentrations.

The results revealed however very high variability of BAF from year to year for the same location (for example BAF value 2-27 for for PFHxA and 2-18 for PFHpA at Slottsparken). The same high variability was observed for several other locations. VEAS was the only site with low variability over three years with BAF in the range of 7 to 9.

UV-compounds
Since only one sample each of soil and earthworm were analysed per year, in addition to many non-detects, the data material was not sufficient for BSAF calculations. This was also not possible for the case for BMF calculations (predator-prey) since no UV-compounds were analysed in pooled fieldfare egg samples due to lack of material.

5.3 BMF

For compounds where TMF calculations were not possible, we evaluated if the biomagnification factor (BMF) could be calculated for predator-prey for some sampling years or over several years. BMF for hydrophobic compounds are calculated as lipid normalized concentration in predator divided by lipid normalized concentration in prey. This is normally done for whole body concentrations. In our study, the most relevant prey-predator pairs are earthworm-fieldfare and fieldfare-sparrowhawk, where only earthworm has whole body concentrations. Egg concentrations were used for fieldfare (FF) and sparrowhawk (SH).

BMF= $C_{predator}$ (ng/g lw) / C_{prey} (ng/g lw) for hydrophobic compounds

Sparrowhawk eggs and fieldfare eggs were chosen as the predator and prey, respectively since earthworm had many non-detects for PBDE and other pollutants. The time interval 2015 to 2019 was chosen since year 2015 was the first year fieldfare eggs were sampled from the urban locations in Oslo, and the year 2019 was the last year with sparrowhawk egg samples. For some compounds fewer years were chosen due too many non-detects in other years, or the compounds of interest were not analysed.

PCB-153 as reference and PBDE-congeners
All data for PCB-153 from 2015 to 2019 revealed 100 % detection in fieldfare egg (n=49) and sparrowhawk egg (n=41). Since fieldfare and sparrowhawk eggs were sampled at different locations, average values for lipid normalized concentrations were used for calculation of BMF for predator/prey. BMF(SH_{lw}/FF_{lw}) of PCB-153 was 13**.** Based on median concentrations, BMF (SH_{lw}/FF_{lw}) of PCB-153 was 18**.**

Some of the BDE congeners did not have sufficient detected concentrations in earthworm in order to determine TMF for the foodchain earthworm-fieldfare-sparrowhawk. Lipid normalized BMF using

mean concentration of sparrowhawk samples divided by mean concentration of fieldfare samples were calculated for some of the congeners. All congeners were detected in all samples of sparrowhawk. For fieldfare egg, BDE-154 had one non-detect set to LOD/2, the other congeners were detected at 100 %. Using median concentrations gave BMF of 3.9, 6.9, 15.5 and 6.2 for BDE-47, BDE-99, BDE-153 and BDE-154, respectively.

Table 33: BMF(SH_{lw}/FF_{lw}) based on averge lipid normalised concentration for PCB-153 and selected BDE-congeners in sparrowhawk and fieldfare using data from 2015-2019 (FF:n=49, SH:n=41)

	BMF(SH_{lw}/FF_{lw})
PCB-153	13
BDE-47	2.9
BDE-99	3.0
BDE-153	6.0
BDE-154	3.6

For comparison, a field derived BMF value of 9.9 for PCB-153 was determined based on median concentrations with common kestrel (n=23) as predator and Eurasian tree sparrow (n=40) as prey (Yu et al., 2013). The same study of Yu et al. determined a BMF of BDE-99, BDE-153 and BDE-154 for the common kestrel- Eurasian tree sparrow predator-prey pair of 0.42. 6.9 and 2.2, respectively.

Dechloranes

Dechloranes did not fulfil detection criteria in earthworm across several years for TMF calculation, and BMF was calculated using fieldfare as prey and sparrowhawk as predator across the years 2018 and 2019. The detection rate for sparrowhawk was 100 % for dec-602, dec-603 and anti-DP. Fieldfare eggs also had high detection rate for the same dechloranes with 100%, 89 % and 79 % for dec-602, dec-603 and anti-DP, respectively. The two datapoints <LOD were included in the calculations.

Table 34: BMF(SH_{lw}/FF_{lw}) of Dec-602, dec-603 and anti-DP for 2018-2019 (FF: n=19, SH: n=11) based on average lipid normalised concentrations in sparrowhawk and fieldfare.

	BMF(SH_{lw}/FF_{lw})
Dec-602	5.4
Dec-603	1.3
anti-DP	1.2

Using median concentrations gave 6.6, 1.2 and 1.8 for Dec-60, dec-603 and anti-DP, respectively. BMF for anti-DP was found to be 0.35 in the predator-prey pair common kestrel- Eurasian tree sparrow predator in the study of Yu et al., 2013.

New BFR

BMF for PBBZ and BTBPE was calculated for the year 2018. PBBZ and BTBPE had 100 % detection in fieldfare eggs and 89 % in sparrowhawk eggs. The two datapoints <LOD in sparrowhawk were included in the calculations. BTBPE had a mean BMF value slightly above 1.

Table 35: BMF(SH_{lw}/FF_{lw}) for PBBZ and BTBPE for the year 2018 (FF:n=10, SH:n=9) using average average lipid normalised concentrations in sparrowhawk and fieldfare.

	BMF(SH_{lw}/FF_{lw})
PBBZ	0.5
BTBPE	1.2

PFHpS and PFDcS

Since earthworm data did not fulfil the detection criteria for PFHpS and PFDcS for TMF calculations, BMF (SH/FF) on wet weight was calculated using data from all years. For PFHpS, the number of samples included three concentrations below LOD for fieldfare and one <LOD for sparrowhawk. PFDcS in fieldfare had eleven concentrations below LOD and two below LOD in sparrowhawk.

Table 36: BMF(SH_{ww}/FF_{ww}) for PFHpS and PFDcS (2015-2019; FF:n=49, SH: n=41) using average concentrations in sparrowhawk and fieldfare.

	BMF(SH_{ww}/FF_{ww})
PFHpS mean	1.8
PFDcS mean	0.7

Calculations using only detectable concentrations gave approximately the same BMF values for both compounds.

Cyclic siloxanes, cVMS

Cyclic siloxanes had many non-detects in the years 2015-2019, and no specific year or some years had sufficient detected concentrations for both the species fieldfare and sparrowhawk in order to do a reliable BMF calculation. For fieldfare only 48 % of the data was detected for D5 for the year 2015-2019, while for sparrowhawk 73 % was detected. Including all the non-detects (LOD/2) in fieldfare would most probably overestimate the BMF. BMF calculation on a lipid weight basis with average of detectable concentrations across the years 2015 to 2019 gave a BMF value of 1.5 for D5. Including non-detects with use of LOD/2 concentrations gave a BMF value of 2.4.

Conclusion

The calculations of i) field derived TMF (covering the foodchain earthworm-fieldfare-sparrowhawk), ii) the worm-soil BSAF/BAF and iii) predator-prey BMF from the terrestrial environment in the city of Oslo revealed that several compounds have the potential for bioaccumulation and biomagnification. BSAF/BAF values for specific sites with very low number of data revealed high variability in values from year to year, and is expected to have lower reliability compared to the data rich BMF calculations. PCB and PBDE congeners were chosen as reference compounds, due to both TMF available as well as data from international literature. The general conclusion is that these bioaccumulation calculations first and foremost can indicate which compounds that are more likely to bioaccumulate with TMF, BSAF/BAF and BMF well above 1, and others that are more uncertain with lower values below and near 1. As an example using PFOS, the food chain approach, covering EF-FF-SH, revealed a TMF of 1.5, while BMF(FF/EW) and BMF(SH/FF) based on average concentrations from all years, gave 1.4 and 0.9, respectively.

6 Changes over time of pollution loads

Data acquired for organic compound classes over the past five years of this project (2013/2014 – 2020) for birds and mammals were used to assess potential changes in levels over time. No statistical trend analysis was performed due to insufficient data material.

Data from air, soil and earthworm were not included because the sampling sites in Oslo for these matrixes have been changed since this monitoring program was started. Calculation of mean or median values were therefore less relevant for air, soil and earthworm than for birds and mammals that are moving over lager areas, although locations samples of red foxes have changed from year to year, and tawny owl egg samples did not come from the Oslo area in 2019. Recalculated LOD values were includes in the sum values of the various contaminant classes.

We have graphically displayed the median sum concentrations of the most dominating organic pollutant groups for birds and mammals over the years (see Figure 26) and the most dominating single congeners and compounds (see Figure 27). Median values were chosen due to some extreme concentrations in single samples from year to year which have high influence on the mean values. Note that tawny owl eggs were not available in 2018, brown rat liver were absent in 2014 and only two samples of sparrowhawk eggs were available in year 2019.

For both median sum and representative compounds in the various contaminant groups, a general finding is that the PFAS, PCB and CP dominated the organic pollutant loads in the samples during the years 2014 to 2020. For sparrowhawk eggs, PCBs (and PCB-153) were the dominating organic pollutant class, followed by PFAS. In fieldfare egg, the PFAS group (and PFOS) had highest median sum concentrations, followed by PCB and CP. In red fox and brown rat liver, PFAS (PFOS) and CP (SCCP) revealed highest levels, especially the last years, except for year 2020 where siloxanes (and D5) had highest concentrations.

CP (and SCCP) concentrations revealed high fluctuations of median values over the years, especially in sparrowhawk and tawny owl eggs. The CP concentrations have in general higher uncertainties compared to PCB and PFAS, in addition to laboratory blank challenges in some years, which may have influenced the sum concentrations.

We expect the pollution in the terrestrial environment around Oslo to origin from both local sources and long-range transport. Birds and mammals from Oslo are samplers of their terrestrial environment, and time series of their pollution loads are very useful to assess changes over time in environmental pollution. For persistent pollutants that magnify in the food chain, temporal trends for decreasing concentrations should be expected for compounds subjected to regulations and less use, while an increase is expected for pollutants with increasing use (e.g. Bustnes et al. 2007). Since birds and mammals take up pollutants via their diet, diet is a strong determinant of their pollution levels (refs Fisk et al. 2001, Leat et al. 2018). Diet may differ among individuals due to individual specialization, and diet may differ among locations and years due to different prey availability. Hence, we think diet is a strong source of variation in the observed levels, both within and between years (Figure 25, 26). For example, brown rats are typically opportunistic feeders and can feed on a wide range of prey items. We have (obviously) sampled different individuals in different years, and sampling locations in Oslo have also differed to some degree among years. Hence, we think dietary exposure is an important source for the high fluctuations of PCB and PFAS in brown rat liver samples. Red foxes are also opportunistic feeders with a wide dietary range, and diet may obviously by a source of variation in the observed pollution loads of red fox liver (Figure 26, Figure 27). Furthermore, a long-term study revealed high annual variation in PFAS load in Tawny owl eggs (Bustnes et al. 2014), and that vole

abundance, along with other environmental factors (North Atlantic Oscillation Index and temperature) significantly explained annual variation after controlling for temporal trends. In years with low vole abundance, the owls rely more on birds. Since insectivore birds feed on a higher trophic level and are more polluted compared to herbivore voles, diet and feeding conditions will effect annual variation in pollution load. Sparrowhawks and fieldfares may also feed on several prey types. They are also migratory species, and can be exposed to pollutants at migration stopover sites and wintering locations. However, we mainly attribute the pollution load in their eggs to the environmental conditions in the breeding area, since they are income breeders and produce their eggs from nutrients obtained in the breeding area. As many factors affect pollution load of individuals, high sample sizes are required to statistically explain variation among locations and years.

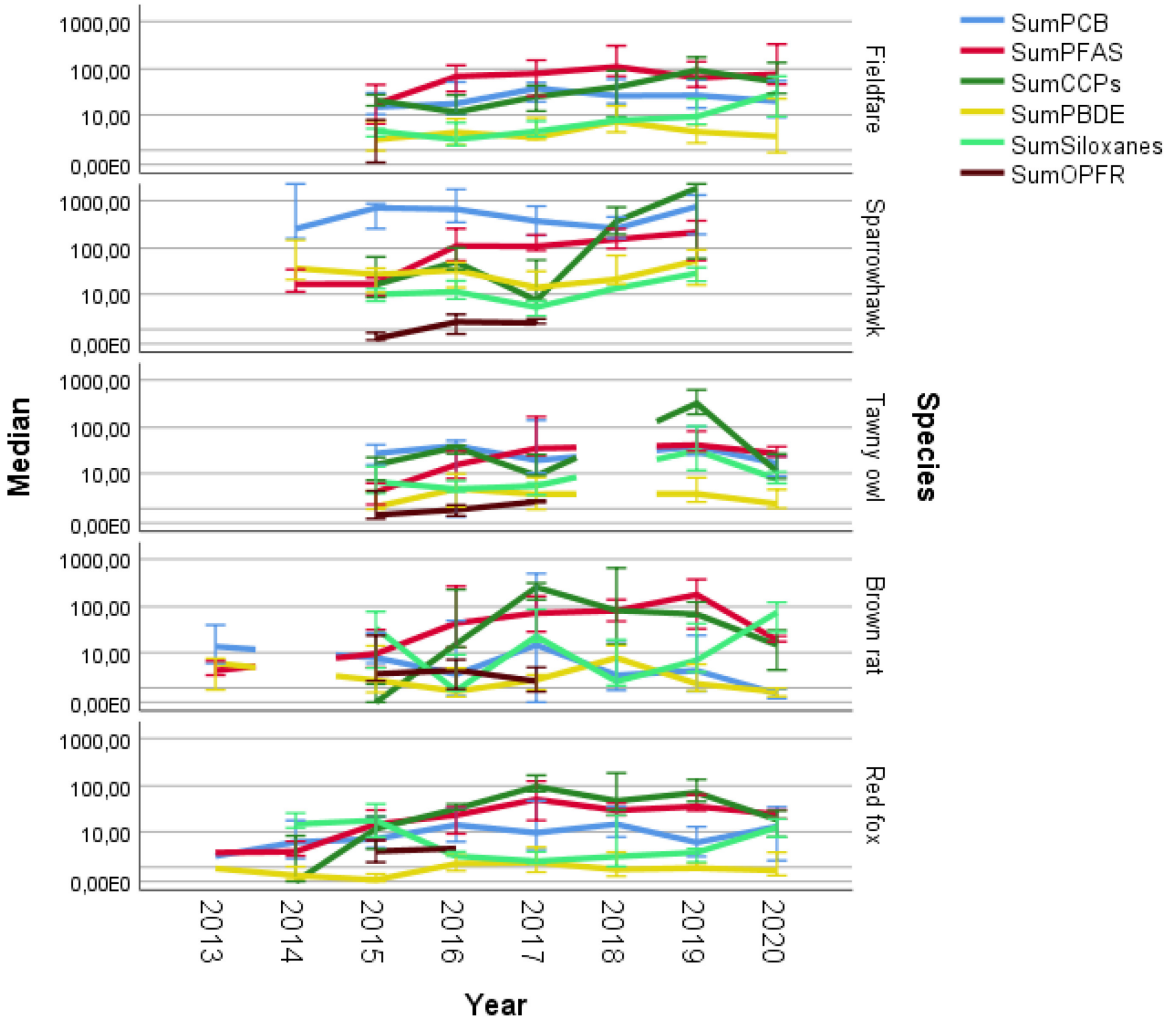

Figure 26: Changes over years of groups of organic pollutants in different biological sample types with Median value of sum concentrations including 95 % confidence interval. Concentrations are given in ng/g ww. <LOD values were included in the sum concentrations. Note that samplig areas in the Oslo area might differ from year to year, especially for brown rat, red fox and tawny owl (in 2019).). Only two egg samples were available of sparrowhawk in year 2019.

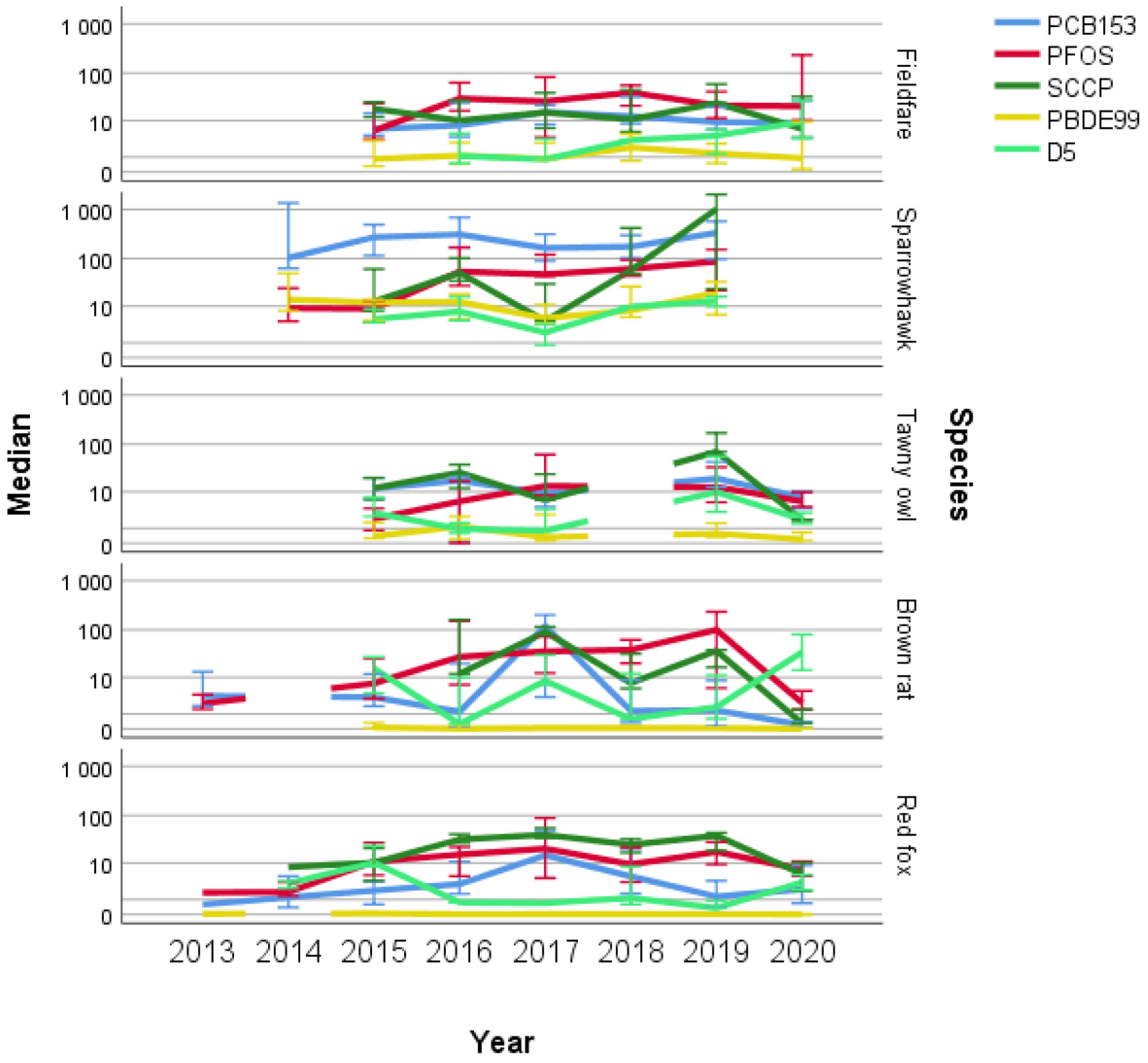

Figure 27 : Changes over years of selected organic pollutants in different biological sample types with Median concentrations including 95 % confidence interval. Concentrations are given in ng/g ww. <LOD values were included in calculation. Note that samplig areas in the Oslo area might differ from year to year, especially for brown rat, red fox and tawny owl (in 2019). Only two egg samples were avaialbel of sparrowhawk in year 2019.

7 Conclusion and recommendations

This report presents the findings from the sixth year of the urban terrestrial programme.

Data presented in this report were mostly from samples collected in 2020, but samples from 2019 was included for TCPP analysis in soil samples, selected samples from previous years were also included for the analysis of EOF, and for analysis in biocides in tawny and sparrowhawk eggs.

The median of sum concentrations of the various pollutant group in the investigated species was generally in agreement with the preceding years and as follows[1]:

- Air	:	cVMS >> CP > OPFR >>PCB
- Soil	:	Metals[1] >>CP > OPFR
- Earthworm	:	Metals >> PFAS >OPFR
- Fieldfare egg	:	PFAS >CP > Metals ~cVMS
-Tawny owl	:	CP~PFAS~PCB> Metals
- Red fox liver	:	Metals > Biocides>> CP
- Brown rat liver	:	Metals >> cVMS> Biocides~CP

[1]SumMetals is the sum of Hg, Cd, Pb and As.

As previous years have shown, the not so well known studied and more volatile compounds as cyclic siloxanes (cVMS), chlorinated paraffins (CP) and organic phosphorous compounds (OPFR) dominated the air samples, and the well known metals were the dominant group in soil, earthworm, and liver of red fox and brown rat. In agreement with previous years, in fieldfare and tawny owl eggs, PFAS, PCB together with CP were dominating compound groups. For sparrowhawk eggs, not sampled in 2020, PCB and PFAS were the dominating groups over the years.

The biomagnification potential was investigated with calculations of BBMF and TMF. The BMF and TMF calculations revealed that the typical hydrophobic and well known POPs such as PCBs and PBDEs, had TMF and BMF well above 1, and a high potential for magnification. This is in agreement with published literature of terrestrial, freshwater and marine food webs (Fremlin et al. 2020; Liu et al. 2020; Currier et al. 2020; Ruus et al., 2017; Munoz et al., 2017; Zhou et al., 2016; Walters et al, 2011). PFOS, PFNA, PFDcA, PFUnA, PFDoA, PFTriA, PFTeA, 8:2 FTS increased significantly with trophic level, and, indicating magnification across trophic levels. Conversely, the concentrations of PFHxS and SCCP decreased significantly with trophic level, and hence, indicating trophic dilution.

The following findings and recommendations should be followed up:

- Although lower PFOS-levels in general have been detected in 2020 and the last years, fieldfare egg from the location Grønmo (former landfill) still had high PFOS concentration, and in agreement with 276 and 235 ng/g ww in 2019 and 2018, and lower than 455 and 601 ng/g ww in 2017 and 2016, respectively. The fieldfare eggs samples from Grønmo had the highest concentrations of PFOS of all samples in 2020. Fieldfare eggs from the location Alna I had second highest PFOS in 2020, and had the highest 8:2 FTS and 10:2 FTS concentrations. Earthworms from both Grønmo and Alnabru had higher PFOS-concentration than the other sites in 2020, also in agreement with previous years in this program. Only some few sparrowhawk eggs during the years and a couple of earthworm samples from Alnabru in 2016 and 2017 had comparable PFOS concentrations to the highest concentrations detected in fieldfare from Grønmo and Alnabru.

- Egg from fieldfare from Kjelsås (near an artificial turf arena) revealed for the fifth year a high concentration of Pb (186 ng/g ww) compared to the other locations.

- Analysis of TCPP in soil from each of the seven soil sites from year 2019, revealed a very high TCPP concentration at Bøler (170 102 ng/g dw) which exceeded the PNECsoil of 1700 ng/g dw for soil living organisms. We recommended to sample a larger area at Bøler in order to assess if it is only a problem at that specific location, or if even larger areas of soil are affected.

- Although biocide (rodenticide) concentrations in red fox livers were lower in 2020 compared to previous years, the results from this monitoring program since 2013 indicate the potential of secondary poisoning of some of the red foxes. We therefore encourage future monitoring of rodenticides in red fox liver, especially the compound bromadiolone.

- As evidenced by their elevated levels in urban air cVMS, SCCP/MCCP, OPFR and PCB play an important role as air pollutants in Oslo.

- Campaigns to better clarify spatial variations of air pollutants in the city centre is needed, and continuous monitoring similar to that at Birkenes and Zeppelin is recommended.

- By continuing this monitoring scheme with the same sampling types and locations, we can expect to follow pollutant-levels over time and can establish temporal and spatial trends for these pollutants in Oslo. In addition, hotspots for pollution can be identified where mitigation and management measures can be implemented.

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Appendix 1

Materials & methods

Investigated samples

Sparrowhawk (*Accipiter nisus*).[10]
The sparrowhawk is a small bird of prey with a widespread distribution in Norway. It feeds mainly on birds of small to medium size, and thrushes (*Turdidae*) are preferred prey (Haftorn 1971, Hagen 1952). It commonly occurs close to human habitations, where it can breed in different types of forest patches. Most of the population migrates to south-western Europe during winter, but some individuals stay, and often feed on small garden birds during winter (Haftorn 1971). The sparrowhawk is on top of a terrestrial food-chain (invertebrates-small birds-sparrowhawk) and is therefore subjected to bioaccumulation of persistent organic pollutants (POPs). The sparrowhawk is a protected species in Norway, so the collection of eggs for analysis was carried out under a special license issued by the Norwegian Environment Agency. The species nests in stick-nests in forests or forest patches and lays 4-6 eggs. It has been documented that the sparrowhawk is one of the species most affected by environmental pollutants in Europe after World War II (Bennington 1971, Bennington 1974, Burgers et al. 1986, Cooke 1979, Newton et al. 1986, Ratcliffe 1960), and also in Norway (Bühler & Norheim 1981, Frøslie et al. 1986, Holt & Sakshaug 1968, Nygård et al. 2006, Nygård & Polder 2012). Estimated trophic level 4.

Tawny owl (*Strix aluco*)
The tawny owl is a medium sized owl, nesting at Østlandet, Vestlandet and in Trøndelag in Norway. Its habitat is connected to forest borders in cultivated areas, parks and old gardens. It is nesting in hollow trees, also in cities. In absence of hollow trees, it can nest in nestboxes. The Tawny owl lays 3-4 eggs, early in spring (March, April). Voles and other rodents contribute with almost 75% to its diet, with birds as an additional prey. Frogs, squirrel and other small owl species have been observed as prey too. The adult birds are mostly stationary, reflecting local pollution in its eggs. The Tawny owl is a protected species and only one egg from each nest was taken, under permission from the Norwegian Environment Agency. Estimated trophic level 3.

[10] Sparrowhawk egg were not sampled in year 2020, and data for previous years were used in TMF calculations.

Fieldfare (*Turdus pilaris*)
The fieldfare is a member of the thrush family and is a common breeding bird in Eurasia. It is a migratory species; birds that breed in the northern regions migrate to the south and south-west in the winter. The majority of the birds that breed in Norway spend the winter months in south-west Europe (Bakken et al. 2006). It is omnivorous, with its diet mainly consisting of invertebrates during spring and summer, especially earthworms. The diet changes more to berries, grain and seeds during autumn and winter (Haftorn 1971). Estimated trophic level 3.

Earthworms (*Lumbricidae*)
Earthworms are animals commonly living in soil feeding on live and dead organic matter. Its digestive system runs through the length of its body. It conducts respiration through its skin. An earthworm has a double transport system composed of coelomic fluid that moves within the fluid-filled coelom and a simple, closed blood circulatory system. Earthworms are hermaphrodites, having both male and female sexual organs. Earthworms form the base of many food chains. They are preyed upon by many species of birds (e.g. starlings, thrushes, gulls, crows), mammals (e.g. bears, badgers, foxes, hedgehogs), and invertebrates (e.g. ground beetles, snails). They are found almost anywhere in soil that contains some moisture (Macdonald 1983). Lumbricus terrestris was the most common species. Estimated trophic level 2 (Hui et al. 2012).

Red fox (*Vulpes vulpes*)
The red fox is the most abundant carnivore in Europe and is widespread. It is found over most of the world. It inhabits most of Norway, from the mountains, through the forests and the agricultural landscape and is also found in the cities. It primarily feeds on rodents, but it is a generalist predator feeding on everything from small ungulate calves, hares, game-birds and other birds, reptiles and invertebrates, to human offal. Estimated trophic level 3-4.

Brown rat (*Rattus norvegicus*)
The brown rat is one of the most common rats in Europe. This rodent can become up to 25 cm long. The brown rat can be found wherever humans are living, particularly in urban areas. It is a true omnivore, feeding on everything from bird eggs to earthworms and human waste. The brown rat breeds throughout the whole year, producing up to 5 litters a year. Estimated trophic level: 3-4.

Soil
Soil samples were taken from the surface layer (0-20 cm), combining three subsamples to one combined sample per location. The locations for soil samples were the same locations as for the earthworm samplings to make direct comparisons possible.

Air
Two types of PAS adsorbents were used at all sites: i) polyurethane foam (PUF), and ii) polystyrene-divinylbenzene copolymeric resin (XAD). The PAS were deployed over a period of three months (late June/early July to October 2018) giving time-weighted mean concentration over that time period. The two types of PAS were chosen to collect a wide spectrum of volatile and semi-volatile pollutants; i) PUF disks were used to collect semi-volatile non-polar pollutants (i.e. PCB, PBDE, nBFR, CP, and OPFR), and ii) XAD was used to collect more volatile and more polar pollutants (i.e. siloxanes and PFAS). While XAD is considered a pure gas-phase sampler, the PUF-PAS can also sample particle-associated compounds to some extent although with lower accuracy. Some particle-associated compounds (e.g. BDE-209) are collected by the PUF-PAS, but the results should be considered as less certain due to the uncertainties of the uptake in the sampler (which is not designed to sample particles, but gases) (Bohlin et al., 2014; Melymuk et al., 2016). The PUF disk and the XAD are placed in metal containers specially designed for each sampler type to control the uptake of chemicals. The use of PAS for volatile-semivolatile organic pollutants is considered as a good sampling strategy for screening at several sites simultaneously (Melymuk et al., 2016). It is important to highlight that the

PAS are designed as complementary tools to active air samplers and that the PAS provide semi-quantitative levels which should be treated with caution in further analyses. The data from PAS can be compared between sampling sites when normalized to ng/day or further converted to estimated concentrations in air (pg/m3). Conversion to estimated concentrations is done using class-specific uptake rates obtained from calibration studies (Bohlin et al. 2014; Melymuk et al., 2016). The estimated concentrations in air can then be compared with data from active air samplers in previous studies. However, a direct comparison to data from active samplers used at monitoring stations (for example Zeppelin and Birkenes stations) should be done with caution as the accumulation in PAS and the applied uptake rates introduce factors of uncertainty.

For the targeted pollutants in this study there are published uptake rates from calibration studies for PCB, PBDE, cVMS and CP, but not for PFAS, OPFR and dechloranes (Bohlin et al., 2014; Krogseth et al., 2013; Li et al., 2012). For PCB and CP, an uptake rate of 4 m^3/day is used in this study (Harner et al., 2006; Bohlin et al., 2014; Li et al., 2012). For PBDE an uptake rate of 2 m^3/day is used (Bohlin et al., 2014) and for siloxanes an uptake rate of 0.5 m^3/day was used (Krogseth et al 2013a). Data from the PAS in this study are presented as ng/day for all targeted pollutants and as estimated air concentrations (pg/m^3 or ng/m^3) for the pollutants with uptake rates as mentioned above, without including physical-chemical properties for the specific compounds and ambient temperature for the specific site in the sampling period. Due to the uncertainty of uptake rates, it is first recommended to make a relative comparison of levels (ng/day) across sites for the various pollutant groups in this present study.

Investigated environmental pollutants

In this study a total of 132 environmental pollutants were investigated. These included metals, seven PCB, PFAS, PBDE, new BFR, three siloxanes (D4, D5 and D6), chlorinated paraffins (SCCP and MCCP), organic phosphorous compounds (OPFR), UV compounds, biocides and phenolic compounds. In addition the stable isotopes $\delta^{15}N$, $\delta^{13}C$ and $\delta^{34}S$ were monitored. OPFR and UV compounds were measured in a selection of pooled samples, representing the species covered within the project. An overview over the analysed compounds is given in *Table 37*.

Table 37: Overview over analysed compounds.

Parameters	Abbreviation	CAS number
Metals		
Chromium	Cr	7440-47-3
Nickel	Ni	7440-02-0
Copper	Cu	7440-50-8
Zinc	Zn	7440-66-6
Arsenic	As	7440-38-2
Silver	Ag	7440-22-4
Cadmium	Cd	7440-43-9
Lead	Pb	7439-92-1
Total-Mercury	Hg	7440-02-0
Polychlorinated biphenyls (PCB)		
2,4,4'-Trichlorobiphenyl 28	PCB-28	7012-37-5
2,2',5,5'-Tetrachlorobiphenyl 52	PCB-52	35693-99-3
2,2',4,5,5'-Pentachlorobiphenyl 101	PCB-101	37680-73-2
2,3',4,4',5-Pentachlorobiphenyl 118	PCB-118	31508-00-6
2,2',3,4,4',5'-Hexachlorobiphenyl 138	PCB-138	35065-28-2
2,2',4,4',5,5'-Hexachlorobiphenyl 153	PCB-153	35065-27-1
2,2',3,4,4',5,5'-Heptachlorobiphenyl 180	PCB-180	35065-29-3
Per- and polyfluorinated alkyl substances (PFAS)		
PFCA (perfluorinated carboxylate acids)		
Perfluorinated butanoic acid	PFBA	307-24-4
Perfluorinated hexanoic acid	PFHxA	375-85-9
Perfluorinated heptanoic acid	PFHpA	335-67-1
Perfluorinated octanoic acid	PFOA	375-95-1
Perfluorinated nonanoic acid	PFNA	335-76-2
Perfluorinated decanoic acid	PFDcA	2058-94-8
Perfluorinated undecanoic acid	PFUnA	307-55-1
Perfluorinated dodecanoic acid	PFDoA	72629-94-8
Perfluorinated tridecanoic acid	PFTriA	376-06-7
Perfluorinated tetradecanoic acid	PFTeA	67905-19-5
Perfluorinated hexadecanoic acid	PFHxDA	16517-11-6
Perfluorinated octadecanoic acid	PFOcDA	375-73-5
PFSA (Perfluorinated sulfonates)		
Perfluorinated butane sulfonate	PFBS	
Perfluorinated pentane sulfonate	PFPS	2706-91-4
Perfluorinated hexane sulfonate	PFHxS	355-46-4
Perfluorinated heptane sulfonate	PFHpS	375-92-8
Perfluorinated octane sulfonate (linear)	PFOS	2795-39-3
Perfluorinated octane sulfonate (branched)	brPFOS	
Perfluorinated nonane sulfonate	PFNS	17202-41-4
Perfluorinated decane sulfonate	PFDcS	67906-42-7
Perfluoroundecane sulfonate	PFUnS	
Perfluorododecane sulfonate	PFDoS	
Perfluorotridecane sulfonate	PFTrS	

Perfluorotetradecane sulfonate	PFTS	
nPFAS (polyfluorinated neutral compounds)		
Perfluorooctane sulfonamide	PFOSA	754-91-6
N-Methyl perfluorooctane sulphonamide	meFOSA	31506-32-8
N-Ethyl perfluorooctane sulfonamide	etFOSA	4151-50-2
N-Methyl perfluorooctane sulfonamidoethanol	meFOSE	24448-09-7
N-Ethyl perfluorooctane sulfonamidoethanol	etFOSE	1691-99-2
6:2-Fluorotelomer alcohol	6:2 FTOH	647-42-7
8:2-Fluorotelomer alcohol	8:2 FTOH	678-39-7
10:2-Fluorotelomer alcohol	10:2 FTOH	865-86-1
12:2-Fluorotelomer alcohol	12:2 FTOH	39239-77-5
newPFAS		
6:2 Fluorotelomersulfonate	6:2 FTS	27619-97-2
8:2 Fluorotelomersulfonate	8:2 FTS	481071-78-7
10:2 Fluorotelomersulfonate	10:2 FTS	120226-60-0
12:2 Fluorotelomersulfonate	12:2 FTS	149246-64-0
Polybrominated diphenylethers (PBDE)		
2,2',4,4'-Tetrabromodiphenylether 47	BDE-47	5436-43-1
2,2',4,4',5-Pentabromodiphenylether 99	BDE-99	60348-60-9
2,2',4,4',6-Pentabromodiphenylether 100	BDE-100	189084-64-8
3,3',4,4',5-Pentabromodiphenylether 126	BDE-126	366791-32-4
2,2',4,4',5,5'-Hexabromodiphenylether 153	BDE-153	68631-49-2
2,2',4,4',5,6'-Hexabromodiphenylether 154	BDE-154	207122-15-4
2,2',3,3',4,5',6-Heptabromodiphenylether 175	BDE-175	446255-22-7
2,2',3,4,4',5',6-Heptabromodiphenylether 183	BDE-183	207122-16-5
2,3,3',4,4',5,6- Heptabromodiphenylether 190	BDE-190	189084-68-2
2,2',3,3',4,4',5,6'-Octabromodiphenylether196	BDE-196	446255-38-5
2,2',3,3',5,5'6,6'-Octabromodiphenylether 202	BDE-202	67797-09-5
2,2',3,3',4,4',5,5',6-Nonabromdiphenylether 206	BDE-206	63936-56-1
2,2',3,3'4,4',5,6,6'-Nonabromodiphenylether 207	BDE-207	437701-79-6
Cyclic volatile methyl siloxanes	D4	556-67-2
	D5	541-02-6
	D6	540-97-6
Chlorinated paraffins		
Short-chain chlorinated paraffins (C10-C13)	SCCP	85535-84-8
Medium-chain chlorinated paraffins (C14-C17)	MCCP	85535-85-9
Organic phosphorous flame retardants (OPFR)		
Tri(2-chloroethyl)phosphate	TCEP	115-96-8
Tris(2-chloroisopropyl) phosphate	TCPP/TCIPP	13674-84-5
Tris(1,3-dichloro-2-propyl)phosphate	TDCPP/TDCIPP	13674-87-8
Tris(2-butoxyethyl) phosphate	TBEP/TBOEP	78-51-3
2-etylhexyldiphenyl phosphate	EHDP/EHDPP	1241-94-7
Tricresyl phosphate	TCP	1330-78-5
Tri-n-butylphosphate	TBP/ TnBP	126-73-8
Tri-iso-butylphosphate	TBP/TiBP	126-71-6
Triethyl phosphate	TEP	78-40-0
Tripropyl phosphate	TPrP/TPP	513-08-6
Triisobutyl phosphate	TiBP	126-71-6
Butyl diphenyl phosphate	BdPhP	2752-95-6
Triphenyl phosphate	TPP/TPhP	115-86-6
Dibutylphenyl phosphate	DBPhP	2528-36-1
Trixylylphosphate	TXP	25155-23-1
Tris(4-isopropylphenyl)phosphate	TIPPP/T4IPP	26967-76-0
Tris(4-Tert-butylphenyl)phosphate	TTBPP	78-33-1
Tris(2-ethylhexyl)phosphate	TEHP	78-42-2
UV compounds		
Octocrylene	OC	6197-30-4
Benzophenone-3	BP3	131-57-7
Ethylhexylmethoxycinnamate	EHMC	5466-77-3
UV-327	UV-327	3864-99-1

UV-328	UV-328	25973-55-1
UV-329	UV-329	3147-75-9
Biocides (Rodenticides)		
Bromadiolone		28772-56-7
Brodifacoum		56073-10-0
Flocumafen		90035-08-8
Difenacoum		56073-07-5
Difethialone		104653-34-1
Phenols		
4,4- Bisphenol A	Bis-A	80-05-7
2,4- Bisphenol A	2,4-Bis-A	837-08-1
4,4- Bisphenol S	Bis-S	80-09-1
2,4- Bisphenol S	2,4-Bis-A	5397-34-2
4,4- Bisphenol F	Bis-F	620-92-8
2,4- Bisphenol F	2,4-Bis-F	2467-03-0
2,2- Bisphenol F	2,2-Bis-F	2467-02-9
4-n-Nonylphenol	4-n-nonylphenol	104-40-5
4-n-Octylphenol	4-n-octylphenol	1806-26-4
4-t-Octylphenol	4-t-octylphenol	140-66-9
Tetrabromobisphenol A	TBBPA	79-94-7

Metals

Because of their high degree of toxicity, even at low concentrations, mercury (Hg), lead (Pb) cadmium (Cd) and arsenic (As) are considered priority metals that are of environmental and public health concern (Tchounwou et al. 2012; AMAP, 2009). This group is therefore of main focus in this report and defined as the group 'toxic metals'. These metallic elements are considered systemic toxicants that are known to induce multiple organ damage, even at lower levels of exposure. Best studied is the uptake of metals from soil to invertebrates (Heikens et al. 2001). The impact these metals have on humans and animals is well known, and all four metals are considered as environmentally hazardous compounds (Latif et al. 2013). Recently, there has been an increased use of silver as nanoparticles. Nanotechnology makes it possible to combine silver (Ag) with other materials, such as different polymers. As a result, Ag now can be found in a variety of new products, which again lead to alteration of emission sources and patterns. Adsorbed Ag may have long residence time in the organism (Rungby 1990). Arsenic is also known as a toxic metalloid (Klaassen 2008). Among the different metals determined in the present work, Hg, Pb and Cd have a potential to bioaccumulate (Connell et al. 1984; Latif et al. 2013). However, Hg (as methyl-mercury (MeHg)) is the only metal with high bioaccumulation potential through food-chains.

Polychlorinated biphenyls (PCB)

Polychlorinated biphenyls (PCB) have been used in a variety of industrial applications since the 1930s. PCB were used in Norway until the 1980s, in cooling agents and insulation fluids, as plasticizers, lubricant oils, hydraulic fluids and sealants among others. Use of PCB was banned in Norway in 1980. They are known to degrade very slowly in the environment, are toxic, may bioaccumulate and undergo long-range environmental transport (Gai, et al. 2014). As a result, PCB are recognized as persistent organic pollutants (POPs) and are regulated under the Stockholm Convention and the convention on long-range transboundary air pollution (CLRTAP). They are widely distributed in the environment and can be found in air, water, sediments and biota. Most PCB are poorly water soluble, but dissolve efficiently in lipid-rich parts of organisms (hydrophobic and lipophilic). They can affect the reproduction success, impair immune response and may cause defects in the genetic material. PCB can be metabolized in organisms and form metabolites causing hormonal disturbances. This study includes the group of PCB found to be dominating in most environmental matrices, the non-dioxin like PCB, the so-called PCB7 group.

Polybrominated diphenylethers (PBDE)

Polybrominated diphenylethers (PBDE) is a group of additive flame retardants with a wide variety of uses in plastics/ polymers/composites, textiles, furniture, housings of computers and TVs, wires and cables, pipes and carpets, adhesives, sealants, coatings and inks. There are three commercial PBDE

products, technical or commercial penta-, octa- and deca-BDE. These are all technical mixtures containing different PBDE congeners. Tetra-, penta-, hexa- and heptaBDE congeners were listed in the Stockholm Convention and CLRTAP in 2009, due to being persistent, bioaccumulative, and toxic chemicals that can undergo long-range environmental transport (Darnerud, 2003; Law et al., 2014). As a result, the commercial penta- and octa-PBDE mixtures were globally banned. The use of commercial decaBDE was banned in Norway in 2008. In the same year a restriction on the use of commercial decaBDE in electrical and electronic products entered into force in the EU. A restriction on the manufacture, use and placing on the market of decaBDE in EU enter into force in 2019. In North-America voluntary agreements with the industry have led to reduced use of decaBDE. Globally, commercial deca-BDE is still widely used and remains a high production volume chemical. However, an agreement for including decaBDE in the Stockholm Convention as a POP was settled in May, 2017.

The tetra- and pentaBDE congeners BDE 47 and 99, which were the main components of commercial pentaBDE mixtures, are among the most studied PBDE. The early documentation of congeners of the technical mixtures penta- and octa-BDE detected in the Arctic was one of the main reasons to ban production, import, export, sales and use of products with more 0.1 % (by weight) of penta-, octa- and deca-BDE in Norway. The regulation and banning of the PBDE, and most probably better waste handling, have resulted in a decrease of most BDEs, except BDE 209, the main component of commercial deca-BDE, over time (AMAP 2009; Helgason et al. 2009). Spatial trends of PBDE in arctic seabirds and marine mammals indicate that Western Europe and eastern North America are important source regions of these compounds via long-range atmospheric transport and ocean currents. The tetra- to hexa-BDEs biomagnify in arctic food webs while results for the fully brominated PBDE congener, BDE 209 or deca-BDE, are more ambiguous. Several lines of evidence show that also BDE-209 bioaccumulates, at least in some species. The available bioaccumulation data largely reflects species and tissue differences in uptake, metabolism and elimination, as well as differences in exposure and also analytical challenges in measuring BDE-209 correctly. Moreover, in the environment and biota, BDE-209 can debrominate to lower PBDE congeners that are more persistent, bioaccumulative and toxic. PBDE concentrations are often lower in terrestrial organisms compared to marine top predators (de Wit et al. 2010 and references herein).

New brominated flame retardants (New BFR)

As a result of the regulation of the penta- and octa-BDEs and more recently also deca-BDE, new non-PBDE BFRs have been introduced into the market as replacement FRs. For example, firemaster 550 (containing BEHTBP) is a replacement product for penta-BDE (Venier and Hites, 2008) that was introduced to the market in 2003 (Stapleton et al., 2008). Saytex 8010 (Albemarle) and Firemaster 2100 (Chemtura), which are common trade names for decabromodiphenyl ethane (DBDPE), are replacement products for deca-BDE that were introduced into the market in the mid-1980s (Umweltbundesamt, 2001).

Per- and polyfluorinated alkyl substances (PFAS)

Per- and polyfluorinated alkyl substances (PFAS) have been widely used in many industrial and commercial applications. The chemical and thermal stability of a perfluoroalkyl moiety, caused by a very strong C-F bond, in addition to its hydrophobic and lipophobic nature, lead to highly useful and enduring properties in surfactants and polymers. Polymer applications include textile stain and water repellents, grease-proof, food-contact paper and other food contact materials used for cooking. Surfactant applications that take advantage of the unparalleled aqueous surface tension–lowering properties include processing aids for fluoropolymer manufacture, coatings, and aqueous film–forming foams (AFFFs) used to extinguish fires involving highly flammable liquids. Numerous additional applications have been described, including floor polish, ski waxes, and water-proof coatings of textile fibers (Buck et al 2011). Since they are so persistent and hardly degrade in the

environment, and due to their widespread use, PFAS have been detected worldwide in the environment, wildlife, and humans. Scientific studies focus on how these substances are transported in the environment, and to what extent and how humans and wildlife are exposed and their potential toxic effects (Butt et al. 2010; Jahnke et al. 2007; Kannan et al. 2005; Stock et al. 2007; Taniyasu et al. 2003; Trier et al. 2011). Studies have revealed the potential for atmospheric long-range transport of PFAS (Ahrens et al, 2011; AMAP Assessment 2015). Toxic effects on biological organisms and humans where for example discussed by Gai et al. (2014), Hagenaars et al. (2008), Halldorsson et al. (2012), Newsted et al. (2005), and Whitworth et al. (2012). Polyfluorinated acids are structurally similar to natural long-chain fatty acids and may displace them in biochemical processes and at receptors, such as PPARα and the liver-fatty acid binding protein (L-FABP). Perfluoroalkanoates, particularly PFOA, PFNA and PFDA, but not PFHxA, are highly potent peroxisome proliferators in rodent livers and affect mitochondrial, microsomal, and cytosolic enzymes and proteins involved in lipid metabolism. Beach et al. (2006) reported an increased mortality for birds (mallards *Anas platyrhynchos* and northern bobwhite quail *Colinus virginianus*) and a reduced reproduction success have been observed. PFOA and other PFAS are suspected to be endocrine disruptors and exposure during pregnancy has induced both early and later life adverse health outcomes in rodents. Associations between PFOA exposures and human health effects have been reported. PFOS, its salts and PFOSF are recognized as POPs, and are listed in the Stockholm Convention and CLRTAP. However globally, the production and use of PFOS, its salts and PFOSF is still allowed for certain applications. In Norway, PFOS and PFOA are banned, and the C9-C14 PFCAs and PFHxS[11] are on the Norway's Priority List of Hazardous substances as well as being included in the candidate list of substances of very high concern for Authorization in ECHA.

New PFAS

In addition to the well known PFAS, more than 5000 PFAS are on the global market for intentional uses, and the chemical identities of many are yet unknown (Wang et al., 2017). Emissions and leakage to the environment are unavoidable, and sooner or later, environmental concentrations will be reported. For example, in a recent study (MacInnis et al 2017) perfluoro-4-ethylcyclohexane-sulfonate (PFECHS) was detected for the first time in an atmospherically derived sample, and a potential source was attributed to aircraft hydraulic system leakage. Also, Pan reported the occurrence and bioaccumulation of hexafluoropropylene oxide trimer acid in surface water and fish (Pan et al., 2017). Gebbink et al. 2017, published findings of the PFOA replacement chemical GenX at all downstream river sampling sites with the highest concentration (812 ng/L) at the first sampling location downstream from a production plant in the Netherlands, proving the necessity of measuring for a broad range of emerging PFAS.

Cyclic volatile methyl siloxanes, (cVMS)

There are concerns about the properties and environmental fate of the three most common cVMS; D4, D5, and D6 (Wang et al., 2013). These compounds are used in large volumes in personal care products and technical applications and are released to the environment either through volatilization to air or through wastewater effluents. Once emitted to water, they can sorb to particles and sediments or be taken up by aquatic biota. They are persistent in the environment, can undergo long-range atmospheric transport, and can have high concentrations in aquatic biota, but often lower in the terrestrial environment. There is still limited knowledge on their toxicity, but D4 has been shown to display endrocrine disrupting effects. D4 and D5 are listed on Norway's priority list with the aim that emission and use of these hazardous substances must be eliminated. The European Commission has published its Regulation to restrict the use of octamethylcyclotetrasiloxane (D4) and decamethylcyclopentasiloxane (D5) in wash-off cosmetic products in a concentration equal to or greater than 0.1% by weight.

[11] https://echa.europa.eu/documents/10162/40a82ea7-dcd2-5e6f-9bff-6504c7a226c5

Chlorinated paraffins (CP)

CP have been produced since the 1930s and the world production of CP was 300,000 tonnes in 2009. CP are used in coolants and lubricants in metal manufacturing industry and as plasticizers and flame-retardant additives in plastic, sealants, rubber and leather (KEMI, 2013, WHO 1996). The non-flammability of CP, particularly at high chlorine contents, relies on their ability to release hydrochloric acid at elevated temperatures, thereby inhibiting the radical reactions in flames (WHO, 1996).

There exist some data on SCCP and MCCP detected in Norwegian environment and other parts of the world, including Arctic. Air monitoring at Zeppelin observatory, Svalbard, reports air concentrations of sum S/MCCP around 300 pg/m3. In air collected at Bear Island (Norway), concentrations were 1.8 to 10.6 ng/m^3 (Borgen et al. 2003). In a screening study (Harju et al., 2013), SCCP and MCCP were detected in Norwegian Arctic biota. Levels of SCCP were found to dominate compared to MCCP in polar bear and seal plasma, kittiwake eggs, cod liver and polar cod. However, the opposite trend was observed for glaucous gull plasma and eider duck eggs where MCCP were found at higher concentrations. The data indicated that SCCP and MCCP biomagnified in Arctic food webs with TMF > 1. A recent subtropical marine food web study also indicated that SCCP and MCCP biomagnified with trophic magnification factors for ∑SCCP and ∑MCCP were 4.29 and 4.79 (Zeng et al 2017). In a Canadian freshwater study in Lake Ontaio and Lake Michigan , SCCP and MCCP were found to biomagnify between prey and predators from both lakes with highest values observed for Diporeia-sculpin (Lake Ontario, C15Cl9 = 43; Lake Michigan, C10Cl5 = 26). Trophic magnification factors for the invertebrates−forage fish−lake trout food webs from the same study ranged from 0.41 to 2.4 for SCCP and from 0.06 to 0.36 for MCCP (Houde et al., 2008). SCCP and MCCP have been found in sediments from landfills in Norway at levels of up to 19,400 and 11,400 ng/g ww with peak levels associated with waste deposition from mechanical and shipping industries (Borgen et al., 2003). CP have been detected in biota samples collected in Norway, SCCP ranged from 14 to 130 ng/g wet weight (ww) in mussels and were also detected in moss samples (3–100 ng/g ww), revealing the potential transportation of SCCP in the atmosphere (Borgen et al., 2003). In fish livers collected from samples in the North and Baltic Seas, SCCP and MCCP ranged from 19 to 286 and <10 to 260 ng/g ww (Geiss et al. 2010; Reth et al. 2006). In a recent study (Yuan & de Wit, 2018), SCCP and MCCP were measured in Swedish terrestrial birds and animals; SCCP and MCCP concentrations in starling were 360 and 310 ng/g lw, respectively; in peregrine falcon SCCP and MCCP were 580 and 410 ng/g lw. Bank vole had 420 and 30 ng/g and lynx had 820 and 750 ng/g lw for SCCP and MCCP, respectively. SCCP was included in the POPs Regulation (EC) 850/2004 by the amendment (EU) 2015/2030 in 2015. So far MCCP are not globally regulated, however, SCCP has recently been included in the Stockholm Convention, and a global regulation will be effectuated within November 2019.

Organophosphorous flame retardants (OPFR)

The global use of phosphorous containing flame retardants in 2001 was 186 000 tonnes (Marklund et al., 2005). Arylphosphate is used as a flame retardant, but also as a softener in PVC and ABS. They are also used as flame retardants in hydraulic oils and lubricants. Some PFRs are known to be very toxic. PFRs can be either inorganic or organic, and the organic PFRs can be divided into non-halogen PFRs and halogenated PFRs. In the halogenated PFRs chlorine is the most common halogen (Hallanger et al., 2015). In this study both halogenated and non-halogen organic PFRs are included. The chlorinated OPFR compounds are thought to be sufficiently stable for short- and medium-range atmospheric transportation (Regnery and Püttmann, 2009), and observations of PFRs in the marine environment (Bollmann et al., 2012) and in remote areas (Aston et al., 1996; Regnery and Püttmann, 2009, 2010), such as glacier-ice in the Arctic and particulate organic matter in Antarctic (Ciccioli et al., 1994; Hermanson et al., 2005) suggests that some PFRs are subject to long-range transport (Möller et al., 2012).

Alkylphenols and bisphenols

Nonyl- and octylphenols are used in manufacturing antioxidants, lubricating oil additives, laundry and dish detergents, emulsifiers, and solubilizers. Nonylphenol has attracted attention due to its prevalence in the environment and due to its ability to act with estrogen-like activity. Nonyl- and octylphenols are also precursors of the degradation products alkylphenol ethoxylates.

Waste water treatment plants are recipients from relevant sources such as roads, industries etc. of nonyl- and octylphenols besides degradation in the environment (Loyo-Rosales et al., 2007). Nonylphenol is rated harmful and corrosive, as well as harmful for the aquatic ecosystem (Preuss et al., 2006).

Bisphenol A (Bis-A) is an industrial chemical with high production volumes used in the production of polycarbonate plastics and epoxy resins. Due to its versatile use, Bis-A is a pollutant found in all ecosystems worldwide (Fromme et al. 2002). Especially the endocrine disrupting capability is of concern. Following opinions of scientists, public and regulators, manufacturers have begun to remove bisphenol A from their products with a gradual shift to using bisphenol analogues in their products. In these days two of the analogues – bisphenol S (Bis-S) and bisphenol F (Bis-F) have been mostly used as bisphenol A replacements. Bis-S is used in a variety of applications, for example as a developer in a thermal paper, even in the products marketed as “BPA-free paper”(Liao et al., 2012). Bis-S is also used as a wash fastening agent in cleaning products, an electroplating solvent and constituent of phenolic resins (Clark, 2000). Bis-F is used to make epoxy resins and coatings such as tanks and pipe linings, industrial floors, adhesives, coatings and electrical varnishes (Fiege et al., 2000). The brominated version, tetrabromobisphenol A, is used as one of the major brominated flame-retardants.

The restrictions for the use of Bisphenol A by the polymer industry triggered its replacement with bisphenol S (Bis-S) in thermal paper and other products. Bisphenol F (Bis-F) and bisphenol B (Bis-B) can replace Bis-A in the production of epoxy resin and polycarbonate. They have been detected in canned foods and soft drinks. In addition to these analogues, bisphenol AF (Bis-AF) has broad application in the manufacture of phenolic resins or fluoroelastomers. Annual production is assumed to be in the range of 5 to 300 tons in the USA (Yang et al. 2014). Unfortunately, those new bisphenol compounds could have similar deleterious effects as Bis-A. Recent studies have indeed demonstrated possible estrogenic activity similar to that of Bis-A (Rosenmai et al. 2014).

UV compounds

Concern over our contribution to the loads of environmental pollutants originating from our use of personal care products is continuously growing. Due to their continuous release via wastewater effluent, personal care products have been termed pseudo-persistent (Barceló & Petrovic, 2007) irrespective of their PBT characteristics. The increase in public awareness over the dangers of over-exposure to sunlight has lead to an increase in products available to protect us. The first reported environmental occurrence of an organic UV filter was over 30 years ago when benzophenone was determined in the Baltic Sea (Ehrhardt et al., 1982), although personal care products were not identified as the source. UV filters and UV stabilizers all absorb UV light and in general can be loosely divided into 2 categories; UV filters used in personal care products to protect hair and cutaneous membranes from sun damage, and UV stabilizers used in technical products such as plastics and paints to protect polymers and pigments against photodegradation, and to prevent discolouring. Many of the compounds are used for both purposes and frequently used in combination to extend the UV range protection provided. It is widely reported that UV filters and stabilizers used in personal care products enter the aquatic environment indirectly via sewage effluent discharges and directly from water sports activities causing them to wash directly from skin surfaces into receiving waters (Langford et al., 2015). UV filter occurrence can be season- and weather dependent, higher concentrations were detected in wastewater influents in summer than in winter (Tsui et al., 2014)

and receiving waters have demonstrated the same patterns of distribution with higher concentrations in hot weather than in cold (Langford and Thomas, 2008).

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

Bioaccumulation has been observed in the marine environment in Japan for this group of UV stabilizers (Nakata et al., 2009). UV-320 (2-(3,5-di-t-butyl-2-hydroxyphenylbenzotriazole) for example is considered to be a PBT compound and has been banned from manufacture or use in Japan. Filter-feeding and sediment-dwelling organisms contained some of the high concentrations indicating sorption to particulates is a likely sink for some benzotraizole UV stabilizers. UV 328 was found in breastmilk of women in Korea by Lee et al. 2015, emphasising human exposure of these chemicals.

BP3 (Benzophenone-3)
Benzophenones have a high stability in UV light and absorb UV light in the UVA and UVB range. Benzophenones interact with the estrogen and androgen receptor and induce vitellogenin in male fathead minnow (*Pimephales promelas*), although *in vitro* BP-3 was up to 100,000 times less potent than estradiol. BP-3 demonstrated some limited agonistic activity at the androgen receptor, but significant anti-estrogenic activity in vitro. Androgen receptor antagonist activity using yeast cells possessing the androgen receptor was equally as potent as flutamide. It is possible that the estrogenic activity may have resulted from demethylation of BP-3 to the 4-hydroxy metabolite, which is a more potent estrogen receptor agonist than the BP-3 (Kunz and Fent, 2006).

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

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

OC (Octocrylene)
OC absorbs light in the UVB range and short wavelength UVA light also, and is frequently used to protect other UV filters from photodegradation in the UVB range. OC was one of the main UV filters detected during the Screening 2013, found in treated wastewater, sludge, sediments and cod liver, indicating bioavailability, but no biomagnification (Thomas, 2014).

Biocides
Rodenticides are classified as biocides, and in Europe they are regulated by the EU Biocidal Products Regulation (EU) no 528/2012. The first-generation rodenticides were introduced for pest control in the 1940s, but after some rodents developed resistance to these compounds, second-generation anticoagulant rodenticides (SGARs) were developed and introduced in the 1970s. The SGAR group includes brodifacoum, bromadiolone, difenacoum, difethialone, and flocoumafen. They act as

vitamin K antagonists and interfere with the synthesis of blood clotting agents in vertebrates making them vulnerable to haemorrhage (Stone *et al.* 2003; Vandenbroucke 2008).

Compared to the first generation of rodenticides such as warfarin, SGARs are more likely to have effects on non-target species due to their extremely slow elimination rate from the target species and their higher vertebrate liver toxicity. They are likely to accumulate in non-target species which consume either bait or poisoned prey. Exposed rodents for example, can survive for several days after consumption of SGARs and continue to consume bait which in turn increases their body burden allowing an even greater exposure potential to non-target predators. SGARs are considered high potency anticoagulants and the substances are retained in the liver for 6-12 months after exposure, compared to up to one month for warfarin, a first-generation rodenticide (Eason *et al.* 2002).

Exposure can occur indirectly as a result of avian and mammalian predators consuming exposed target or non-target rodent species (secondary poisoning), or directly through consumption of the baits (primary poisoning). The use of SGARs has been extensive in Norway and Europe. As a result of the risk assessment of the SGARs under the Biocidal Products Regulation (EU 528/2012), several risk mitigation measures have been implemented in Norway and other European countries. Limited data are available on the occurrence of SGAR residues in non-target species in Norway (Langford et al., 2013). However, monitoring data show that SGARs are found in non-target animals throughout Europe (Laakso et al. 2010; Elmeros et al. 2015). The environmental occurrence of brodifacoum was investigated in New Zealand (Ogilvie 1997). Aerial application of brodifacoum was used on a small island to eradicate rats. After an aerial application of cereal-based bait, no residues were detected in water or soil, or in the beetles found on the bait although it is possible that the sampling campaign was not extensive enough. However, residues were detected in one anthropod (*Gymnoplectron* spp), and in the livers of one owl (*Ninox novaeseelandiae*) and one parakeet (*Cyanoramphus novaezelandiae*). Clearly, it is difficult to draw conclusions from such a small study, but it does highlight the potential of exposure. The occurrence of residues in the anthropods raise concerns about insectivore exposure whereas other studies have all focused on carnivorous species such as raptors and vultures.

In a previous study of Norwegian raptors (Langford et al, 2013), brodifacoum, bromadiolone, difenacoum and flocoumafen were detected in golden eagle (*Aquila chrysaetos*) and eagle owl (*Bubo bubo*) livers at a total SGAR concentration of between 11 and 255 ng/g in approximately 70% of the golden eagles and 50% of the eagle owls examined. In the absence of specific golden eagle and eagle owl toxicity thresholds for SGARs, a level of >100 ng/g was used as a potential lethal range, accepting that poisoning may occur below this level. Thirty percent of the golden eagle and eagle owl livers contained total SGAR residue levels above this threshold.

A recent publication (Fourel et al., 2018) stated that liver samples of red fox from France had higher concentrations of trans compared to the cis isomer of bromadiolone. The cis-isomer were rarely found in the red fox samples and the authors concluded that the cis-isomer would not persist in the food chain. Further, they recommended that monitoring of rodenticides should differentiate diastereoisomers in non-target species.

Stable isotopes

Stable isotopes of carbon and nitrogen can be used to define the trophic position of an organism as well as assess the carbon sources in the diet of the organism (Peterson and Fry, 1987). The isotope ratio of carbon results in a unique signature, which is propagated upwards to the predators (DeNiro and Epstein 1978). The differentiation between terrestrial and marine diet is possible as well (Hobson and Sealy 1991). Predators feeding mostly on marine organisms will show a higher accumulation of ^{13}C than predators from the terrestrial food chain. The comparison of carbon

signatures of organisms from the same food chain will also give the possibility to identify their diet. The enrichment of the heavier ^{15}N-isotope in relation to the lighter ^{14}N-isotope in the predators, compared to the prey, is used to define the relative position in a food chain of an organism. Subsequently, the correlation between concentrations of pollutants relative to their trophic concentration can be used to estimate biomagnification (Kidd et al. 1995).

Quality assurance

NINA, NIVA and NILU are certified to both ISO 9001 and 14001. The laboratories of NILU and NIVA are furthermore accredited according to ISO 17025. In addition, the "Guidelines for field work in connection with environmental monitoring" were followed (JAMP; OSPAR, 2009). Moreover, special precautions were taken to prevent contamination of samples during field work. Sample collection manuals tested and adapted to special conditions to avoid materials which may contain PFAS, siloxanes and BFRs during sampling, handling and storage, were followed. Sampling materials such as bags, containers, knives, scalpels, gloves etc. were pre-cleaned or for disposable use. In addition, emphasis was placed on the use of disposable gloves, disposable knives and as little processing of the samples as practical and general cleanliness. For the same compound group, samples were dissected and prepared in the same laboratory which minimized sample handling, shipment, repeated freezing and thawing, etc. This was done to ensure minimum variation in sample quality in all steps and at the same time improve comparability of results. Fieldblanks for air samples were continuously included. These are transported and stored together with the exposed samples and give information about any contamination during sampling or storage.

Sample preparation and analysis

Sample preparation
In order to get sufficient material for analysis of the various chemical classes in each sample type, samples were pooled together for earthworms, fieldfare eggs and brown rat liver samples. Pooled earthworm samples per site consisted of as many individuals as possible, in general 15-20 individuals. Samples of fieldfare eggs consisted of two eggs from the same nest in order to get sufficient material for all the analysis. Both single and pooled samples were used for the brown rat liver dependent on the weight of the liver samples. When two-three liver samples were pooled together, the same gender and locations of the individual samples were pooled together.

For some chemical classes like OPFR and UV chemicals, one pooled soil and one pooled earthworm consisting of samples from all the sites were used. For the biological samples, three pooled samples consisting of the individual samples were used. Fieldfare eggs were not included for these analysis due to lack of material.

Most of the work with sample preparation were done in clean cabinet or clean room.

Chemical analysis
Due to the differing physicochemical properties of the pollutants of interest, several sample preparations methods were applied. Lipophilic compounds such as PBDE, PCB, CP were analysed together. PFAS, metals, phenols and siloxanes required a dedicated sample preparation each.

PBDE, CP, DDT group, pesticides and PCB. All biological samples were prepared in a similar manner. Briefly, 0.5-1 gram of sample were mixed and homogenized with a 20 fold amount of dry Na_2SO_4. Prior to extraction, the samples were added a mixture of several different isotope labelled compounds for quantification purposes. The samples were extracted with organic solvents and concentrated under nitrogen flow, followed by a clean-up procedure using concentrated sulphuric acid and a silica column to remove lipids and other interferences prior to analysis.
The compounds were quantified on GC-HRMS (Waters Autospec) and/or BG-QToF (Agilent 7200B).
Air and soil: Soxhlet extraction in acetone/hexane (1:1, v:v) were used for all samples prior to GC/MS analysis. Soil: Solvent acetone: hexane, Cu-treatment in order to remove sulphur. The extract was evaporated and treated 2-4 times with 3-4 mL of concentrated sulphuric acid. Following by adsorption chromatography (silica). Air: The extract was evaporated and treated 2-4 times with 3-4 mL of concentrated sulphuric acid. Following by adsorption chromatography (silica).

PFAS. Ionic and new PFAS: Air and soil samples were extracted with methanol whilst biological tissues were extracted with acetonitrile (ACN), subsequently evaporated to 1 ml and treated with emulsive clean-up prior to analyses with UPLC/MS/MS in ESI(-) mode. Neutral PFAS: Samples were homogenized and 2 g aliquots taken. Internal standards were added and the samples were shaken and sonicated for 1 hour with ACN (5 mL) and then centrifuged. The solvent was decanted off and the procedure was repeated and the two extracts were combined. Water was “salted out” with the addition of 1 g of NaCl and the ACN extract was finally centrifuged with a 0.2 um nylon Spin-X filter (Costar).UPLC-HighRes MS analysis: Neutral PFAS analytes were separated on a Acquity BEH C8 column (100 x 2 mm x 1.7 µm) with water and MeOH (both containing 0,2 % NH4OH) using a gradient elution program over a period of 10 minutes with a flow rate of 0.5 ml/min. Analytes were ionized with ESI in negative mode and ions measured with a TOF mass spectrometer.

Extractable Organic Fluorine (EOF).
Extraction method followed the same as for PFAS, but without internal standard. In brief, the CIC system had a combustion module and an autosampler (both from Analytik Jena, Germany), an

absorber module (920 Absorber Module) and an ion chromatograph (IC; 930 Compact IC Flex), both from Metrohm, Switzerland. The anions were separated with an ion exchange column (Metrosep A Supp 5–150/4), carbonate buffer as eluent and isocratic elution. The autosampler injected 100 µL of the extract on a quartz boat. The boat was inserted into the oven (1000–1050 °C) under a flow of oxygen and argon mixed with water vapor under hydropyrolytic condition. The hydrogen fluoride (HF) formed during combustion was absorbed in MilliQ water (in the absorber module). The F^- concentration was measured with the IC. A five-point calibration curve at 50, 100, 200, 500 and 1000 µg/L PFOS standards was constructed using the combustion method as samples and exhibited good linearity with R2>0.9999. Quality assurance[12]: The background fluoride levels varied from day to day; the background fluoride indicated as instrumental (boat) blank was found to be 8 ng F (geomean of 9 replicates). The analysis of organofluorine in samples was started when the RSD of three sequential combustion blanks (empty sample boat analysis) was below 5 %. An additional combustion blank was run after every 5 samples to monitor for carry-over. The combustion blank response (average of combustion blanks before and after the sample) was subtracted from the sample responses, before further data processing. A PFOA standard of 240 ng F/mL was injected in between every 10 samples to evaluate the stability of the system; the measured mean value of the standard injection was 251 ng F/mL (R.S.D.: 13%, n=10); intra-day variability: at most 14% and inter-day variability: 15%).

Metals. All biological samples were prepared in a similar manner. The samples were digested by microwave-assisted mineralization using an UltraClave. About 0.5-0.75 grams of sample were weighed in TFM tubes and 5 ml of diluted supra pure nitric acid was added. The samples were submitted to a four-step program with 220°C as maximum temperature. After digestion, the samples were split in two aliquots, where concentrated HCl were added to the aliquot used for Hg determination. Metals were analysed applying an ICP-MS.

Siloxanes. All operations were performed inside a clean cabinet to avoid contamination by siloxanes from the lab air. In addition, operators retained from using cosmetics or personal care products on the day of sample processing. Soil extraction: One gram of soil was extracted overnight using a biphasic mixture of acetonitrile and hexane (1:1) using a slightly modified method previously published by Sparham et al. (2008; 2011). Hexane fraction was collected and analyzed by Concurrent solvent recondensation large volume injection gas chromatography mass spectrometry (CSR-LVI-GC/MS) using a modified method previously published by Companioni-Damas et al., 2012. Biota extraction: One gram of homogenized egg, liver, or whole body worm was extracted using a biphasic mixture of acetonitrile and hexane (3:1). Extraction mixture was sonicated for 15 minutes followed by vigorous mixing on a horizontal mixer for one hour. Resulting hexane phase was collected and analysed using CSR-LVI-GC/MS. Air samples: Air samples were spiked with ISTD (C13 labeled siloxanes), extracted with hexane and, after addition of RSTD, the extracts were injected to GC-MS without further work-up or concentration (Krogseth et al., 2017).

OPFR. Samples of 1-2g was homogenized and internal standards were added to samples (d12-TCEP, d18-TCPP, d15-TDCPP, d15-TPP, d27-TnBP and d51-TEHP). Samples were extracted by ultrasonication and evaporated to near dryness. Cleanup of the samples was done using solid phase extraction. The sample was eluted using acetonitrile, and the eluate was evaporated to 100-200uL and recovery standard (2,4-TXP-d27) and 50uL of 0.2% formic acid in cleaned deionized water were added. Analysis was carried out on a UPLC/MSMS (TSQ Vantage, Thermo Scientific inc). Multiple reaction monitoring (MRM) of the M+H+ was used using Argon as collisions gas for the monitoring of two product ions for each analyte. Air and soil: The PUF-PAS used for air sampling were spiked with internal standard and extracted using Soxhlet with a solvent mix of Acetone/n-Hexane (1:1, v:v). Extract was concentrated and cleanup was performed using solid phase extraction as for biota and

[12] https://www.kemi.se/publikationer/pm/2021/pm-5-21-interlaboratory-comparison-of-extractable-organofluorine-eof

soil samples. Soil samples was added internal standard and extracted by ultra-sonication using acetonitrile. The extract was concentrated and diluted with purified water and cleanup was performed using solid phase extraction using acetonitrile as eluent. Cleaned extract was concentrated, transferred to analytical glass and added recovery standard and 50uL 0.2% formic acid in cleaned deionized water.

Biocides. Coumachlor was used as an internal standard for all samples.
Zinc chloride (200 µl) was added to rat livers (0.3-0.4 g), fox livers (0.6-0.8 g), worms (1 g) or soil (1 g). These were then extracted with 2.5 ml acetonitrile by vortex. Samples were centrifuged before extracts were analysed by LC-HRMS (liquid chromatography high-resolution mass spectrometry). Rodenticides were separated on a C8 column with a gradient elution of 0.01% formic acid in 75:25 methanol:acetonitrile and 0.01% formic acid in water. CIS-, and TRANS-, isomers were identified by retention time as per Fourel et al (2018). [Sci. Tot. Env. (622-623) pp 924-929]

UV compounds. Chrysene-d_{12} and benzophenone-d_{10} was used as internal standards.
Liver, worms (1.7 g) and soil (0.6-1.6 g) were extracted with iso-hexane/isopropanol (50/50) by ultrasonication for 1 hour. Samples were centrifuged and the solvent decanted. This extraction was repeated, and the extracts combined. The iso-hexane fraction was isolated by the addition of 0.5% NaCl and evaporated to approximately 1 ml before solvent exchange to cyclohexane. Different clean up methods were used for each matrix in response to differing interferences.

Phenolic compounds. Soil samples were extracted with accelerated solvent extraction and further cleaned with SPE. Egg samples were extracted using ultrasonic assisted liquid extraction, cleaned on a Florisil column and with dSPE (C18). Remaining interferences were removed with SPE. Biological samples were extracted with acetonitrile and water. Separation of the organic fraction including analytes was induced by the addition of salts. Fat was removed by liquid-liquid extraction with hexane and remaining interferences were removed with SPE. All samples were analyzed with the use the Agilent 1290 UHPLC coupled to Agilent 6550 HR-QTOF equipped with Agilent Dual Jet Stream electrospray source operating in a negative mode.

Quality control.
All chemical analyses followed international requirements for quality assurance and control (QA/QC), e.g. recommendations of the Arctic Monitoring and Assessment Programme (AMAP) and the requirements in the European quality norm EN 17049. The QA/QC of the sample preparation and analysis was assured through the use of mass labelled internal standards for the BFR (^{13}C DBDPE), PCB (^{13}C PCB) and PFAS (^{13}C PFAS). Quality of sample preparation and analysis was achieved through the use of certified reference materials and laboratory blanks. For each batch of samples, one standard reference material (SRM; EDF2525 for PCB and PBDE and PERFOOD intercal 2012 for PFAS) and one blank sample was prepared. The limits of detection (LOD) were calculated for each sample, using the accepted standard method, i.e. the average of blanks plus 3 times the standard deviation for blanks, for LOD.

CP (SCCP and MCCP) have higher uncertainties than the traditional POPs. It is not possible to separate the single compounds of SCCP and MCCP, and quantification is based on isomer groups. The applied internal standards are also difficult to characterise. There are no certified reference materials available for CP, and the opportunities for proficiency testing are few, and these tests contain too few participants to be regarded as significant. In addition, there are no standardized analytical methods for CP, but there are several different analytical approaches, and several different quantification approaches in use, which again provide different quantitative results. Furthermore, in contrast to other regulated POPs like PCB, which shows decreasing concentrations in most products of daily use, the use of CP has increased again in a lot of different industrial,

household products and consumer goods. All samples are treated solely with tested and validated methods. However, samples cannot be sampled, stored, extracted and prepared for analysis without any physical contact to a lot of different materials and instruments. This trend causes a raising number of blank samples exceeding the acceptance level, which in consequence raises the limit of detection for samples analyzed in parallel with those blank samples.

For siloxanes the greatest risk in the analysis is background contamination, as these chemicals (D4, D5 and D6) are applied in e.g. skin care products. Therefore, all sample preparation was performed within a clean cabinet (equipped with HEPA- and activated carbon filter) to avoid contamination from sources within the indoor environment and to allow trace analysis of these compounds in matrices from pristine environment (Krogseth et al. 2013b; Warner et al. 2013). Samples were analysed in groups with 3 procedural blanks with every extraction batch to account for background response and analytical variation. Variation observed within the procedural blanks has been used to determine the limit of detection (3 x blank std. dev.) and LOQ (10 x blank std. dev). LOQ was used as a conservative limit to ensure concentrations reported were well over blank levels and were not influenced by variation introduced by the co-extracted sample matrix. Field blanks were prepared for siloxane analyses by packing 2 or 3 grams of XAD resin in filter bags of polypropylene/cellulose, which were thereafter cleaned by ultrasonic treatment in hexane for 30 min followed by additional treatment with dichloromethane. After ultrasonic treatment, the field blanks were dried in a clean cabinet to avoid contamination. After drying, the field blanks were placed within solvent washed polypropylene /cellulose filter bags and put into sealed polypropylene containers and sent for sampling purposes. Several field-blanks were stored at NILU's laboratories and analysed to determine reference concentrations before sampling. The field blanks sent for sampling purposes were exposed and handled in the field during sampling and during preparation of samples.

Stable isotopes and other supporting information. Stable isotopes were analysed by the Institute for Energy Technology (IFE), Kjeller, Norway. Lipids were determined using a gravimetric method.

Biomagnification

For estimating trophic magnification factors (TMFs) as a measure for the bioaccumulation potential of a chemical within the food web the following species representing a terrestrial food chain were sampled: Soil, earthworms, fieldfare eggs and sparrowhawk eggs. In our case, we use fieldfare eggs as representatives of fieldfare chicks, which are potential prey items of sparrowhawks, along with adult fieldfares. All data from all years have been used in the calculation of TMF, also since sparrowhawk eggs were lacking in 2020.

In addition, stable isotopes were determined as supporting parameters on all biological samples within this study. TMFs differ from biomagnification factors, which apply to individual species and therefore can be highly variable between predator-prey combinations. The TMF is calculated from the slope of a regression between the chemical concentration and trophic level of organisms in the food web. The trophic level can be determined from stable nitrogen (N) isotope ratios (δ15N) (Borgå et al. 2012). The general scientific consensus is that chemicals are considered bioaccumulative if they exhibit a TMF > 1.

Like in the urban terrestrial study from 2019 (Herzke et et al., 2020) and previous years, a TMF on the basis of trophic levels was estimated. The trophic level (TL) was calculated for each species per individual relative to the species representing the lowest position, assuming a 3.8 ‰ increase of δ^{15} per full trophic level (Hallanger et al., 2011). Earthworm was used as a base level and defined as inhabiting TL 2.

Based on their known food-choice and their position in their food chain, their trophic levels (TL) would be as follows *a priori*: Earthworms = 2, red fox = 3, tawny owl = 3, fieldfare = 3, and sparrowhawk = 4.

For earthworms we modified the TL value by multiplying it with the ratio between the sample $\delta^{15}N_{sample}$ and the mean $\delta^{15}N$ value for earthworms.

For birds the trophic enrichment of δ^{15} changes with an isotopic enrichment factor of 2.4‰ causing a modification of the equation for TL calculations as follows (Hallanger et al., 2011):

$TL_{fieldfare} = 3 + (\delta^{15}N_{fieldfare} - (\delta^{15}N_{earthworm} + 2.4))/3.8$

$TL_{sparrowhawk} = 4 + (\delta^{15}N_{sparrowhawk} - (\delta^{15}N_{earthworm} + 2.4))/3.8$

For further data assessment of the biomagnification, all hydrophobic pollutants such as PCB and PBDE data were lipid normalized. PFAS are not lipophilic compounds (Kelly, 2009), and we calculations were performed on wet weight basis. Trophic magnification factors (TMFs) were calculated as the power of 10 of the slope (b) of the linear regression between log concentration and the samples TL.

Log [compound] = a + *b*TL

$TMF = 10^b$

In addition a comparison of $\delta^{15}N$ levels in each species was done.

The here estimated TMFs must be treated with caution since the recommended tissue type (muscle) could not be used. Instead liver and egg samples were available which are characterized by a much shorter turnover rate and thus reflect the short term exposure rather than the long term one.

Statistical methods

Statistics were performed using SPSS statistics, ver. 25 (® IBM). We tested differences between groups by using the non-parametric Mann-Whitney test. This test is conservative, as it does not require any assumptions of the distribution of the values (Zar, 1984).

In many of the sample groups, the values of measurement were below the detection limit (LOD). However, if some, but not all samples of a certain species and type were below LOD, the following calculation (Voorspoels et al., 2002) was made to substitute LOD with an expected concentration value (C_{exp})

C_{exp} = LOD* 1/2 (or LOQ *1/2)

In such cases, <LOD has been substituted with C_{exp} in the calculations of mean and median, and in box and whiskers plots. Where mean values are below LOD, <LOD is specified in the tables.

Appendix 2

GPS coordinates for sampling locations year 2020

GPS coordinates for sampling locations year 2020

ID	Location	UTM-zone	Latitude	Longitude
Air				
20/1946	Slottsparken/Dronningparken	32V	59.91703	10.72428
20/1950	Frognerseteren	32V	59.97695	10.68054
20/1947	Grønmo	32V	59.84078	10.8551
20/1948	Alnabru	32V	59.91461	10.82947
20/1949	VEAS (pipe outlet)	32V	59.79963	10.48716
Soil & earthworm				
20/1461	Slottsparken	32V	59.916876	10.723989
20/1462	Kjelsås	32V	59.9643	10.78736
20/1463	Grønmo	32V	59.84078	10.8551
20/1464	Alnabru	32V	59.914174	10.829139
20/1465	VEAS	32V	59.799631	10.487164
Fieldfare				
20/1477	Holmen (8239+8240)	32V	59.953312	10.680511
20/1471	Grønmo (8227+8228)	32V	59.840896	10.856091
20/1473	Alnabru 1 (8231+8232)	32V	59.914562	10.829522
20/1474	Alnabru 2 (8233+ 8234)	32V	59.913212	10.828571
20/1475	Alnabru 3 (8235+8236)	32V	59.916714	10.832347
20/1476	Bøler (8237+8238)	32V	59.8800017	10.8527189
20/1478	Kjelsås (8241+ 8242)	32V	59.964091	10.789806
20/1472	Ekeberg (8229+8230)	32V	59.891432	10.771185
Red fox				
20/1481	001-2020	32V	60.00834	10.46559
20/1482	002-2020	32V	60.00834	10.46559
20/1483	003-2020	32V	60.00834	10.46559
20/1484	004-2020	32V	60.00834	10.46559
20/1485	005-2020	32V	60.00834	10.46559
20/1486	006-2020	32V	60.00834	10.46559
20/1487	007-2020	32V	60.00834	10.46559
20/1488	008-2020	32V	59.93756	10.78459
20/1489	009-2020	32V	59.93756	10.78459
20/1490	010-2020	32V	59.93756	10.78459
Brown rat				
20/1491	1: 1320	32V	59.91786	10.74640
20/1492	2: 1322 &1333	32V	59.91786	10.74640
20/1493	3: 1323	32V	59.91786	10.74640
20/1494	4: 1324	32V	59.91786	10.74640
20/1495	5: 1332	32V	59.91786	10.74640
20/1496	6: 1334	32V	59.91786	10.74640
20/1497	7: 1335 & 1336	32V	59.91786	10.74640
20/1498	8: 1337 & 1339	32V	59.92816	10.73243

20/1499	9: 1338	32V	59.92816	10.73243
20/1500	10: 1341	32V	59.92816	10.73243
Tawny owl	Confidential for species protection	Confidential for species protection	Confidential for species protection	Confidential for species protection

Appendix 3

Isotope and concentration data of pollutants in individual samples year 2020

All biological samples are given in ng/g ww, air samples in pg/day and soil samples in ng/g dw.

Isotopes and lipid percentage

NILU-Sample number:	Sample type:	$\delta^{13}C_{VPDB}$	$\delta^{15}N_{AIR}$	W% C	W% N	C/N	$\delta^{34}S_{VCDT}$	W% S	% Lipids
20/1461	Soil	-27.26	6.27	6.65	0.23	29.11	-	0.08	
20/1462	Soil	-27.52	0.73	49.23	1.46	33.72	8.65	0.18	
20/1463	Soil	-26.80	12.87	5.39	0.14	38.83	3.36	0.15	
20/1464	Soil	-26.25	4.19	3.01	0.18	16.53	-	0.02	
20/1465	Soil	-26.53	4.51	6.89	0.45	15.21	-	0.07	
20/1466	Earthworm	-25.08	6.48	49.25	10.87	4.53	3.74	0.88	0.80
20/1467	Earthworm	-27.47	0.71	49.95	9.16	5.45	-1.22	0.74	0.77
20/1468	Earthworm	-26.58	3.75	44.23	7.23	6.12	3.47	0.65	0.60
20/1469	Earthworm	-26.16	2.44	49.09	9.94	4.94	4.28	0.83	0.50
20/1470	Earthworm	-26.49	3.96	48.84	10.28	4.75	-9.47	0.79	0.50
20/1471	Fieldfare egg	-27.68	5.40	53.56	7.47	7.17	3.32	0.59	6.20
20/1472	Fieldfare egg	-26.22	6.83	51.26	8.12	6.32	5.92	0.65	5.16
20/1473	Fieldfare egg	-26.39	6.53	51.91	8.01	6.48	1.29	0.69	5.04
20/1474	Fieldfare egg	-26.71	5.68	51.34	6.91	7.43	0.49	0.62	5.14
20/1475	Fieldfare egg	-26.86	6.57	55.20	7.02	7.86	1.36	0.61	3.13
20/1476	Fieldfare egg	-26.85	6.84	53.55	7.47	7.17	3.75	0.67	5.14
20/1477	Fieldfare egg	-26.70	5.46	53.89	7.74	6.96	4.64	0.64	4.30
20/1478	Fieldfare egg	-25.89	5.35	53.52	8.03	6.67	5.00	0.67	4.97
20/1481	Red fox liver	-26.07	8.72	51.93	10.30	5.04	5.53	0.82	4.61

NILU-Sample number:	Sample type:	$\delta^{13}C_{VPDB}$	$\delta^{15}N_{AIR}$	W% C	W% N	C/N	$\delta^{34}S_{VCDT}$	W% S	% Lipids
20/1482	Red fox liver	-25.90	9.00	50.10	11.18	4.48	5.09	0.92	3.33
20/1483	Red fox liver	-27.35	9.51	49.99	11.13	4.49	5.14	0.90	2.19
20/1484	Red fox liver	-25.99	9.51	48.56	10.17	4.77	6.17	0.82	3.21
20/1485	Red fox liver	-25.04	7.39	50.27	9.13	5.50	5.85	0.83	3.07
20/1486	Red fox liver	-25.76	8.19	49.99	11.31	4.42	5.60	1.01	2.59
20/1487	Red fox liver	-26.39	9.16	50.14	11.67	4.30	5.78	0.85	3.43
20/1488	Red fox liver	-27.20	9.12	49.63	10.34	4.80	6.25	0.71	3.31
20/1489	Red fox liver	-27.40	9.99	49.60	11.46	4.33	6.91	0.93	3.91
20/1490	Red fox liver	-26.79	9.16	52.05	8.97	5.80	6.18	0.65	6.07
20/1501	Tawny owl egg	-28.32	8.62	53.44	8.56	6.24	5.24	0.83	8.25
20/1502	Tawny owl egg	-26.89	9.61	51.06	9.83	5.20	5.76	0.87	4.70
20/1503	Tawny owl egg	-28.15	8.03	55.37	7.99	6.93	6.26	0.72	4.78
20/1504	Tawny owl egg	-28.41	8.35	53.71	7.32	7.33	5.92	0.66	4.48
20/1505	Tawny owl egg	-28.69	8.43	54.91	8.01	6.86	7.18	0.70	3.92
20/1506	Tawny owl egg	-29.31	6.67	57.28	6.94	8.25	6.97	0.62	6.78
20/1507	Tawny owl egg	-28.43	7.59	54.14	8.10	6.68	5.96	0.68	5.18
20/1508	Tawny owl egg	-27.64	6.23	52.45	8.62	6.09	6.72	0.80	1.38
20/1509	Tawny owl egg	-30.01	5.80	57.25	7.47	7.66	5.74	0.63	5.30
20/1510	Tawny owl egg	-28.67	6.91	54.15	7.11	7.61	6.61	0.64	5.48
20/1491	Rat liver	-24.60	7.46	50.61	12.70	3.98	6.03	0.81	3.15
20/1492	Rat liver	-25.42	7.70	50.85	12.11	4.20	5.67	0.75	2.24
20/1493	Rat liver	-24.89	7.78	50.99	12.11	4.21	6.41	0.77	2.60

NILU-Sample number:	Sample type:	$\delta^{13}C_{VPDB}$	$\delta^{15}N_{AIR}$	W% C	W% N	C/N	$\delta^{34}S_{VCDT}$	W% S	% Lipids
20/1494	Rat liver	-24.76	7.04	49.58	12.28	4.04	5.90	0.80	2.64
20/1495	Rat liver	-24.89	7.20	50.38	11.74	4.29	5.72	0.74	2.81
20/1496	Rat liver	-25.44	7.31	51.45	11.17	4.61	5.32	0.76	3.80
20/1497	Rat liver	-25.40	7.43	50.66	11.76	4.31	4.83	0.77	2.73
20/1498	Rat liver	-25.08	8.01	49.45	11.19	4.42	5.44	0.75	3.98
20/1499	Rat liver	-25.50	8.25	52.78	10.32	5.11	5.76	0.70	6.30
20/1500	Rat liver	-25.17	6.95	50.98	11.50	4.43	5.44	0.69	3.25

Metals

NILU-Sample number:	Sample type:	Cr	Ni	Cu	Zn	As	Ag	Cd	Pb	Hg
20/1461	Soil	51584	27173	22933	80303	5780	183	195	38595	227
20/1462	Soil	1806	1800	4022	28177	1290	43	212	27714	84
20/1463	Soil	51990	24893	39504	79147	5862	278	221	42493	175
20/1464	Soil	73321	43994	30929	185370	6571	130	209	35075	40
20/1465	Soil	81861	67368	27485	44391	3968	82	223	14351	56
20/1466	Earthworm	545	463	2050	159004	1110	23.6	1000	629	325
20/1467	Earthworm	2026	1310	2542	161920	566	21.8	1734	773	48.7
20/1468	Earthworm	2490	1210	3799	176670	795	47.0	1391	1989	58.9
20/1469	Earthworm	1137	699	3070	214832	591	23.9	2020	1213	122
20/1470	Earthworm	946	1133	2886	143028	828	16.2	2265	290	129
20/1471	Fieldfare egg	3.75	2.76	314	12998	4.48	1.22	0.34	18.01	18.8
20/1472	Fieldfare egg	2.47	1.57	343	10139	5.73	0.87	0.39	29.84	9.4
20/1473	Fieldfare egg	135	55.6	443	7720	10.3	0.22	0.39	9.40	15.9
20/1474	Fieldfare egg	3.47	1.16	240	7816	2.56	0.17	0.32	7.65	12.2
20/1475	Fieldfare egg	15.6	4.36	680	16962	2.97	0.61	0.88	14.3	11.1
20/1476	Fieldfare egg	9.78	5.26	393	10714	3.05	0.92	0.29	14.1	8.5
20/1477	Fieldfare egg	11.0	3.10	411	16396	1.94	1.17	0.57	11.3	6.3
20/1478	Fieldfare egg	5.66	2.79	334	4703	5.88	0.13	0.12	186	10.5
20/1481	Red fox liver	165	72.82	9992	30815	7.18	3.14	302	385	290
20/1482	Red fox liver	120	42.06	11597	31947	5.81	2.28	256	83.8	71.7

NILU-Sample number:	Sample type:	Cr	Ni	Cu	Zn	As	Ag	Cd	Pb	Hg
20/1483	Red fox liver	168	65.97	11647	33383	5.33	2.87	256	22.4	300
20/1484	Red fox liver	356	140	6443	30123	6.74	1.09	80.3	318	19.8
20/1485	Red fox liver	180	68.19	15074	31795	182	3.46	297	115	55.8
20/1486	Red fox liver	129	40.55	15943	68240	7.56	0.78	276	166	229
20/1487	Red fox liver	124	51.54	7997	31419	4.11	2.02	55.6	107	29.2
20/1488	Red fox liver	97.7	34	3813	34688	4.49	0.95	222	419	79.7
20/1489	Red fox liver	374	184	33033	60283	17.2	13.2	115	124	148
20/1490	Red fox liver	220	136	11462	27734	19.9	2.39	36.2	40.1	23.9
20/1501	Tawny owl egg	8.47	2.60	1099	10956	1.15	0.89	<0.26	2.37	10.36
20/1502	Tawny owl egg	100	39.12	846	14539	1.31	0.26	<0.20	2.44	8.71
20/1503	Tawny owl egg	8.74	1.48	1107	15719	1.44	1.36	<0.24	4.78	9.80
20/1504	Tawny owl egg	46.8	2.77	708	6768	0.40	0.22	<0.21	1.29	5.67
20/1505	Tawny owl egg	15.5	2.51	3257	8300	0.87	0.20	<0.24	0.92	8.71
20/1506	Tawny owl egg	4.51	1.89	872	9149	<0.31	0.12	<0.24	0.57	10.70
20/1507	Tawny owl egg	14.7	2.27	629	9750	0.62	0.16	<0.23	1.17	5.76
20/1508	Tawny owl egg	6.20	1.02	2291	2525	1.85	0.24	<0.21	0.69	9.65
20/1509	Tawny owl egg	8.52	1.38	3111	7034	0.78	<0.10	<0.24	0.87	4.52
20/1510	Tawny owl egg	16.9	1.71	1297	10151	1.33	0.23	<0.23	1.43	9.23
20/1491	Rat liver	302	115.8	3187	27277	1215	0.70	29.5	29.7	9.76
20/1492	Rat liver	127	60.3	2735	22613	329	0.61	5.38	13.9	3.81
20/1493	Rat liver	753	371.6	2665	20977	1258	1.37	27.5	22.8	9.47
20/1494	Rat liver	193	86.4	2913	25379	1066	0.60	21.7	37.2	9.60

NILU-Sample number:	Sample type:	Cr	Ni	Cu	Zn	As	Ag	Cd	Pb	Hg
20/1495	Rat liver	1165	535.5	3426	23800	1051	1.55	17.8	9.75	4.73
20/1496	Rat liver	415	200.4	3594	25285	1723	1.05	37.1	11.3	6.29
20/1497	Rat liver	32.6	8.89	3386	27790	344	0.79	5.32	16.2	3.37
20/1498	Rat liver	326	137.9	3321	26068	3493	1.64	93.7	124	6.92
20/1499	Rat liver	649	326.6	2197	18604	1701	1.32	23.3	139	7.15
20/1500	Rat liver	1656	724.9	2186	18046	3822	1.36	59.1	258	7.63

PCB

NILU-Sample number:	Sample type:	PCB-28	PCB-52	PCB-101	PCB-118	PCB-138	PCB-153	PCB-180
20/1946	Air	41.8	110	142	29.5	51.6	82.7	17.6
20/1950	Air	6.74	10.80	8.58	2.49	2.98	4.39	0.86
20/1947	Air	5.18	6.75	5.20	1.34	2.28	3.26	0.81
20/1948	Air	45.8	37.1	23.0	7.43	7.80	10.0	2.15
20/1949	Air	9.34	12.17	8.37	2.13	2.74	4.58	1.65
20/1461	Soil	<0.236	<0.216	0.49	0.40	0.77	0.79	0.32
20/1462	Soil	<0.236	0.37	2.75	3.16	4.93	4.52	1.56
20/1463	Soil	0.26	0.62	1.38	0.92	1.48	1.29	0.63
20/1464	Soil	<0.236	<0.216	0.22	0.16	0.65	0.72	0.27
20/1465	Soil	<0.236	<0.216	0.24	0.18	0.24	0.28	0.104
20/1466	Earthworm	0.18	0.12	0.86	0.41	1.37	1.75	0.37
20/1467	Earthworm	1.27	0.30	0.25	0.22	<0.169	0.25	0.09
20/1468	Earthworm	0.09	<0.032	<0.071	<0.103	<0.169	0.20	0.06
20/1469	Earthworm	0.10	0.62	0.90	0.35	0.67	0.84	0.21
20/1470	Earthworm	0.09	0.04	0.06	<0.052	0.096	0.19	0.05
20/1471	Fieldfare egg	<0.04	0.32	1.47	0.53	4.05	5.57	2.16
20/1472	Fieldfare egg	0.05	0.10	1.02	0.38	7.56	11.1	3.21
20/1473	Fieldfare egg	0.104	2.11	4.26	1.86	7.74	10.3	4.52
20/1474	Fieldfare egg	0.02	0.13	0.60	0.19	2.24	3.93	1.66
20/1475	Fieldfare egg	0.05	0.42	1.62	0.67	7.40	13.6	6.68

NILU-Sample number:	Sample type:	PCB-28	PCB-52	PCB-101	PCB-118	PCB-138	PCB-153	PCB-180
20/1476	Fieldfare egg	<0.02	0.14	1.36	0.65	4.98	6.99	2.89
20/1477	Fieldfare egg	0.097	0.09	0.77	0.38	2.83	4.68	1.74
20/1478	Fieldfare egg	0.101	0.98	2.23	6.82	11.2	26.9	7.75
20/1481	Red fox liver	<0.02	<0.016	<0.036	0.067	1.49	8.78	25.1
20/1482	Red fox liver	<0.02	<0.016	<0.036	<0.052	0.64	3.39	10.3
20/1483	Red fox liver	<0.02	<0.016	<0.036	<0.052	0.57	2.84	8.42
20/1484	Red fox liver	<0.02	<0.016	<0.036	<0.052	0.27	1.05	1.77
20/1485	Red fox liver	<0.02	<0.016	<0.036	<0.052	0.22	1.62	12.5
20/1486	Red fox liver	<0.02	<0.016	<0.036	<0.052	0.18	3.41	29.6
20/1487	Red fox liver	<0.02	<0.016	<0.036	<0.052	0.11	0.36	0.86
20/1488	Red fox liver	<0.02	<0.016	<0.036	<0.052	0.14	0.68	0.92
20/1489	Red fox liver	<0.02	<0.016	<0.036	0.22	3.66	17.2	31.1
20/1490	Red fox liver	<0.02	0.025	<0.036	0.07	0.47	1.59	2.83
20/1501	Tawny owl egg	0.694	<0.016	0.288	6.150	13.60	31.50	16.5
20/1502	Tawny owl egg	0.107	<0.016	0.131	0.994	4.760	10.40	7.44
20/1503	Tawny owl egg	0.051	<0.016	0.101	0.584	5.570	8.770	6.93
20/1504	Tawny owl egg	0.044	<0.016	0.140	0.400	1.760	3.810	2.17
20/1505	Tawny owl egg	0.056	<0.016	0.179	0.666	3.090	7.610	6.38
20/1506	Tawny owl egg	0.424	<0.016	0.044	0.677	2.050	7.450	5.66
20/1507	Tawny owl egg	0.041	<0.016	0.097	0.537	2.440	5.320	4.28
20/1508	Tawny owl egg	0.020	<0.016	0.036	0.349	1.570	4.070	2.51
20/1509	Tawny owl egg	0.026	<0.016	0.054	1.350	2.820	7.330	3.55

NILU-Sample number:	Sample type:	PCB-28	PCB-52	PCB-101	PCB-118	PCB-138	PCB-153	PCB-180
20/1510	Tawny owl egg	0.06	<0.016	0.12	1.24	3.32	8.22	4.19
20/1491	Rat liver	<0.02	<0.016	<0.036	<0.052	<0.085	0.12	0.03
20/1492	Rat liver	<0.02	<0.016	<0.036	0.09	0.23	0.30	0.15
20/1493	Rat liver	<0.02	<0.016	<0.036	<0.052	0.20	0.39	0.18
20/1494	Rat liver	<0.02	<0.016	<0.036	<0.052	<0.085	<0.095	0.03
20/1495	Rat liver	<0.02	<0.016	<0.036	<0.052	<0.085	0.13	0.04
20/1496	Rat liver	<0.02	<0.016	<0.036	<0.052	<0.085	<0.095	0.05
20/1497	Rat liver	0.03	<0.016	<0.036	0.08	0.22	0.27	0.13
20/1498	Rat liver	<0.02	<0.016	<0.036	0.13	1.28	1.32	1.73
20/1499	Rat liver	<0.02	<0.016	<0.036	<0.052	0.20	0.25	0.34
20/1500	Rat liver	<0.02	<0.016	<0.036	<0.052	<0.085	<0.095	0.05

PBDE

NILU-Sample number:	Sample type:	BDE-47	BDE-99	BDE-100	BDE-126	BDE-153	BDE-154	BDE-175/183	BDE -191	BDE 196	BDE-202	BDE-206	BDE-207	BDE-209
20/1946	Air	2.66	0.63	0.29	0.06	0.17	0.24	0.24	0.11	<0.14	<0.17	1.05	0.97	10.33
20/1950	Air	0.94	0.23	0.09	<0.03	<0.11	<0.09	<0.08	<0.10	<0.14	<0.17	<0.47	<0.30	<3.98
20/1947	Air	1.43	0.50	0.15	0.05	0.12	<0.09	0.11	<0.10	<0.14	0.33	0.55	0.43	5.13
20/1948	Air	5.16	4.24	0.77	0.04	0.48	0.38	0.73	<0.13	<0.56	<0.74	24.35	11.52	1196
20/1949	Air	1.98	0.41	0.14	<0.03	<0.11	<0.09	<0.09	<0.10	<0.14	<0.17	<0.47	<0.30	<3.98
20/1461	Soil	<0.388	<0.15	<0.05	<0.01	<0.05	<0.03	<0.02	<0.04	<0.06	<0.06	<0.16	<0.13	<1.85
20/1462	Soil	<0.39	0.17	<0.05	<0.01	<0.05	<0.03	<0.02	<0.04	<0.06	<0.06	<0.16	<0.13	<1.85
20/1463	Soil	<0.40	<0.16	<0.05	<0.01	<0.05	<0.03	<0.03	<0.04	<0.07	<0.06	<0.16	<0.14	<1.91
20/1464	Soil	<0.40	<0.16	<0.05	0.03	0.08	0.07	0.08	0.07	0.08	0.18	0.21	0.17	<1.91
20/1465	Soil	<0.40	<0.16	<0.05	0.02	0.05	0.04	0.06	0.05	0.06	0.14	<0.16	<0.14	<1.91
20/1466	Earthworm	0.13	0.04	0.03	0.00	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	<0.03	<0.37
20/1467	Earthworm	0.03	<0.01	0.01	0.00	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	<0.03	<0.37
20/1468	Earthworm	0.04	0.03	0.01	0.00	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	<0.03	<0.37
20/1469	Earthworm	0.08	0.11	0.05	<0.01	<0.03	<0.02	<0.02	<0.03	<0.05	<0.06	<0.06	<0.05	<0.17
20/1470	Earthworm	<0.03	0.02	0.01	0.01	0.01	0.01	0.01	<0.01	<0.01	0.03	<0.04	<0.03	<0.37
20/1471	Fieldfare egg	0.28	0.27	0.13	<0.01	<0.07	<0.04	<0.03	<0.04	<0.07	<0.08	<0.09	<0.07	<0.37
20/1472	Fieldfare egg	0.17	0.25	0.10	0.00	0.05	0.03	0.02	<0.01	<0.01	<0.02	<0.04	<0.03	<0.37

NILU-Sample number:	Sample type:	BDE-47	BDE-99	BDE-100	BDE-126	BDE-153	BDE-154	BDE-175/183	BDE -191	BDE 196	BDE-202	BDE-206	BDE-207	BDE-209
20/1473	Fieldfare egg	0.83	2.14	0.74	<0.01	0.52	0.23	0.13	<0.09	<0.04	<0.05	<0.09	0.18	0.73
20/1474	Fieldfare egg	0.15	0.18	0.06	0.00	0.04	0.02	0.02	<0.01	<0.01	<0.02	<0.04	<0.03	<0.37
20/1475	Fieldfare egg	3.76	9.39	5.34	0.02	1.48	1.71	0.27	<0.01	0.13	0.38	<0.04	0.19	<0.37
20/1476	Fieldfare egg	0.42	0.32	0.09	0.01	0.11	0.06	0.05	<0.01	0.02	0.02	<0.04	0.03	<0.37
20/1477	Fieldfare egg	1.42	2.05	0.85	0.00	0.32	0.28	0.09	<0.01	0.07	0.36	<0.04	0.05	<0.37
20/1478	Fieldfare egg	0.95	1.50	0.99	0.10	0.23	0.25	0.03	<0.01	0.01	0.02	<0.04	<0.03	<0.37
20/1481	Red fox liver	<0.03	<0.01	0.01	<0.004	0.05	<0.01	<0.01	<0.01	<0.01	<0.02	0.07	0.09	1.12
20/1482	Red fox liver	<0.03	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	<0.03	0.62
20/1483	Red fox liver	0.03	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	<0.03	<0.37
20/1484	Red fox liver	<0.03	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.03	<0.04	<0.03	<0.37
20/1485	Red fox liver	<0.03	<0.01	<0.01	<0.01	0.02	<0.01	0.01	<0.01	<0.01	<0.02	0.06	0.05	0.70
20/1486	Red fox liver	<0.03	<0.01	<0.01	<0.01	0.65	<0.01	0.35	<0.01	0.24	0.03	0.19	0.18	3.81
20/1487	Red fox liver	<0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	<0.03	<0.37
20/1488	Red fox liver	0.04	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	<0.03	<0.37
20/1489	Red fox liver	<0.03	<0.01	<0.01	<0.01	0.14	<0.01	0.02	<0.01	<0.01	0.04	0.09	0.16	2.60
20/1490	Red fox liver	0.04	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.03	<0.04	0.03	0.43
20/1501	Tawny owl egg	1.72	4.60	1.45	0.05	1.56	0.32	0.11	<0.01	0.03	0.04	<0.04	<0.03	<0.37

NILU-Sample number:	Sample type:	BDE-47	BDE-99	BDE-100	BDE-126	BDE-153	BDE-154	BDE-175/183	BDE -191	BDE 196	BDE-202	BDE-206	BDE-207	BDE-209
20/1502	Tawny owl egg	0.28	0.28	0.11	<0.02	0.30	<0.07	<0.05	<0.07	<0.10	<0.12	<0.17	<0.14	0.62
20/1503	Tawny owl egg	0.39	0.53	0.35	<0.01	0.79	0.10	0.07	<0.04	<0.08	<0.10	<0.06	<0.05	<0.37
20/1504	Tawny owl egg	0.17	0.16	0.04	<0.003	0.19	0.02	0.02	<0.01	0.02	<0.02	<0.04	<0.03	<0.37
20/1505	Tawny owl egg	0.19	0.65	0.05	<0.01	2.57	0.07	0.05	<0.01	<0.01	<0.02	<0.04	<0.03	<0.37
20/1506	Tawny owl egg	0.20	0.11	0.04	<0.02	0.21	0.02	0.04	<0.01	<0.01	0.03	<0.04	<0.03	<0.37
20/1507	Tawny owl egg	0.09	0.20	0.08	<0.01	0.33	0.05	0.11	0.01	0.04	0.05	<0.04	0.05	<0.37
20/1508	Tawny owl egg	0.06	0.12	0.05	<0.003	0.29	0.03	0.03	<0.01	<0.01	0.03	<0.04	<0.03	<0.37
20/1509	Tawny owl egg	0.18	0.20	0.17	<0.004	0.65	0.03	0.03	<0.01	0.02	<0.02	<0.04	<0.03	<0.37
20/1510	Tawny owl egg	0.12	0.13	0.07	<0.003	0.17	0.03	0.05	<0.01	0.02	0.02	<0.04	<0.03	<0.37
20/1491	Rat liver	*<0.03*	<0.01	<0.01	<0.003	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	0.09	0.94	20.80
20/1492	Rat liver	<0.03	<0.01	<0.01	<0.003	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	0.06	<0.37
20/1493	Rat liver	<0.03	<0.01	<0.01	<0.003	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	0.05	0.66
20/1494	Rat liver	<0.03	<0.01	<0.01	<0.003	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	0.04	0.43
20/1495	Rat liver	<0.03	<0.01	<0.01	<0.003	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	0.17	0.65
20/1496	Rat liver	<0.03	<0.01	<0.01	<0.003	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	0.11	0.76

NILU-Sample number:	Sample type:	BDE-47	BDE-99	BDE-100	BDE-126	BDE-153	BDE-154	BDE-175/183	BDE -191	BDE 196	BDE-202	BDE-206	BDE-207	BDE-209
20/1497	Rat liver	<0.03	<0.01	<0.01	<0.003	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.04	0.10	<0.37
20/1498	Rat liver	0.06	0.02	0.02	0.003	0.02	<0.01	0.01	<0.01	<0.01	<0.02	<0.04	0.05	0.50
20/1499	Rat liver	<0.03	0.01	0.01	0.005	0.02	<0.01	0.02	<0.01	<0.01	0.02	<0.04	0.05	0.37
20/1500	Rat liver	<0.03	<0.01	<0.01	<0.003	<0.01	<0.01	0.01	<0.01	<0.02	<0.02	<0.04	0.05	<0.37

PFSA (perfluorosulfonates)

NILU-Sample number:	Sample type:	PFBS	PFPS	PFHxS	PFHpS	brPFOS	PFOS	PFNS	PFDcS
20/1946	Air	<0.27	<0.27	5.30	3.27	<5.00	6.58	<0.79	<5.36
20/1950	Air	<0.27	<0.27	5.07	9.49	<5.00	4.78	<0.79	<5.36
20/1947	Air	<0.27	<0.27	5.90	<2.53	<5.00	<2.82	6.49	<5.36
20/1948	Air	<0.27	<0.27	4.56	6.08	<5.00	<1.20	<0.79	<5.36
20/1949	Air	<0.27	<0.27	5.44	<1.13	5.64	<2.89	<0.79	<5.36
20/1461	Soil	<0.030	<0.030	<0.175	<0.171	<0.629	0.566	<0.030	<0.524
20/1462	Soil	<0.080	<0.081	<0.468	<0.458	<1.684	2.919	0.138	<1.403
20/1463	Soil	<0.032	<0.032	<0.186	<0.182	<0.669	1.008	<0.032	<0.558
20/1464	Soil	<0.033	<0.033	<0.191	<0.187	<0.687	1.326	<0.033	<0.572
20/1465	Soil	<0.034	<0.034	<0.199	<0.195	<0.715	0.327	<0.034	<0.596
20/1466	Earthworm	<0.025	<0.025	3.253	<0.142	<0.522	9.942	<0.025	<0.435
20/1467	Earthworm	<0.025	<0.025	<0.145	<0.142	<0.522	3.530	<0.025	<0.435
20/1468	Earthworm	<0.025	<0.025	3.553	<0.142	<0.522	22.420	<0.025	<0.435
20/1469	Earthworm	<0.025	<0.025	2.250	<0.142	<0.522	10.022	<0.025	<0.435
20/1470	Earthworm	<0.025	<0.025	2.707	<0.142	<0.522	4.175	<0.025	<0.435
20/1471	Fieldfare egg	<0.039	<0.025	0.875	1.183	15.2	231	0.506	27.5
20/1472	Fieldfare egg	<0.039	<0.025	0.534	0.309	2.576	14.8	0.033	0.476
20/1473	Fieldfare egg	<0.039	<0.025	1.288	0.617	5.935	89.1	0.127	5.999
20/1474	Fieldfare egg	<0.039	<0.025	0.265	0.121	1.219	10.2	0.071	1.152
20/1475	Fieldfare egg	<0.039	<0.025	0.222	0.229	1.336	18.6	0.134	1.968

NILU-Sample number:	Sample type:	PFBS	PFPS	PFHxS	PFHpS	brPFOS	PFOS	PFNS	PFDcS
20/1476	Fieldfare egg	<0.039	<0.025	0.244	0.241	1.712	22.228	0.065	7.648
20/1477	Fieldfare egg	<0.039	<0.025	0.243	0.182	1.687	12.734	0.041	0.447
20/1478	Fieldfare egg	<0.039	<0.025	0.279	0.351	3.083	27.296	0.042	0.817
20/1481	Red fox liver	<0.039	<0.025	0.245	<0.119	<0.336	4.985	<0.026	<0.347
20/1482	Red fox liver	<0.039	<0.025	0.161	<0.119	<0.336	5.000	<0.026	<0.347
20/1483	Red fox liver	<0.039	<0.025	0.205	<0.119	<0.336	10.84	0.033	<0.347
20/1484	Red fox liver	<0.039	<0.025	<0.113	<0.119	<0.336	9.212	<0.026	<0.347
20/1485	Red fox liver	<0.039	<0.025	0.124	<0.119	<0.336	7.217	0.027	<0.347
20/1486	Red fox liver	<0.039	<0.025	0.427	0.168	4.190	7.070	0.034	<0.347
20/1487	Red fox liver	<0.039	<0.025	0.173	<0.119	<0.336	2.261	<0.026	<0.347
20/1488	Red fox liver	<0.039	<0.025	0.367	0.198	<0.336	5.490	0.036	<0.347
20/1489	Red fox liver	<0.039	<0.025	2.070	0.426	<0.336	50.29	0.091	0.843
20/1490	Red fox liver	<0.039	<0.025	0.315	0.111	<0.336	7.713	0.040	<0.347
20/1501	Tawny owl egg	<0.039	<0.025	1.041	0.125	1.724	5.734	0.036	<0.347
20/1502	Tawny owl egg	<0.039	<0.025	<0.113	<0.119	1.446	9.786	0.049	3.938
20/1503	Tawny owl egg	<0.039	<0.025	<0.113	<0.119	1.908	7.587	<0.026	0.411
20/1504	Tawny owl egg	<0.039	<0.025	0.136	<0.119	1.712	6.165	<0.026	3.011
20/1505	Tawny owl egg	<0.039	<0.025	0.138	0.140	2.803	7.432	<0.026	0.402
20/1506	Tawny owl egg	<0.039	<0.025	0.326	0.158	5.632	21.357	0.042	0.441
20/1507	Tawny owl egg	<0.039	<0.025	<0.113	<0.119	1.382	4.415	<0.026	0.444
20/1508	Tawny owl egg	<0.039	<0.025	<0.113	<0.119	0.572	2.456	0.038	<0.347
20/1509	Tawny owl egg	<0.039	<0.025	0.140	<0.119	1.575	5.538	<0.026	1.061

NILU-Sample number:	Sample type:	PFBS	PFPS	PFHxS	PFHpS	brPFOS	PFOS	PFNS	PFDcS
20/1510	Tawny owl egg	<0.039	<0.025	<0.113	<0.119	1.859	5.833	0.055	0.964
20/1491	Rat liver	<0.039	<0.025	0.319	<0.119	<0.336	2.948	0.118	<0.347
20/1492	Rat liver	<0.039	<0.025	<0.113	<0.119	<0.336	1.334	<0.026	<0.347
20/1493	Rat liver	<0.039	<0.025	0.249	<0.119	<0.336	2.201	0.122	<0.347
20/1494	Rat liver	<0.039	<0.025	0.268	<0.119	<0.336	1.980	0.095	<0.347
20/1495	Rat liver	<0.039	<0.025	0.121	<0.119	<0.336	2.444	0.038	<0.347
20/1496	Rat liver	<0.039	<0.025	0.246	<0.119	<0.336	2.290	0.036	<0.347
20/1497	Rat liver	<0.039	<0.025	0.167	<0.119	0.728	1.425	<0.026	<0.347
20/1498	Rat liver	<0.039	<0.025	0.650	<0.119	<0.336	4.935	0.111	0.924
20/1499	Rat liver	<0.039	<0.025	0.406	<0.119	1.237	4.496	0.090	9.758
20/1500	Rat liver	<0.039	<0.025	0.301	<0.119	0.807	4.848	0.035	<0.347

PFCA (perfluorocarboxylates)

NILU-Sample number:	Sample type:	PFBA	PFPA	PFHxA	PFHpA	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA	PFHxDA	PFOcDA
20/1946	Air	<0.27	<0.27	<0.11	<0.27	<0.93	<1.80	<0.27	<0.27	<0.30	<0.38	<0.38	<0.38	<0.38
20/1950	Air	<0.27	<0.27	<0.11	<0.27	<0.93	<0.99	<0.27	<0.27	<0.30	1.12	<0.38	3.82	<0.38
20/1947	Air	<0.27	<0.27	<0.11	<0.27	<0.93	<1.15	<0.27	1.46	<0.30	<0.38	<0.35	<0.38	3.31
20/1948	Air	<0.27	<0.27	<0.11	<0.27	<0.93	<0.67	<0.27	<0.35	<1.10	1.31	<0.38	<0.38	<0.38
20/1949	Air	<0.27	<0.27	11.66	<0.27	6.93	<0.92	<0.27	<0.27	<0.30	1.37	<0.98	1.13	<0.38
20/1461	Soil	0.478	0.096	0.133	0.122	0.415	<0.030	0.116	0.060	0.076	<0.100	<0.116	<0.243	<0.563
20/1462	Soil	2.427	<0.081	0.264	0.437	1.415	0.797	0.475	0.368	<0.065	<0.268	<0.310	<0.652	<1.506
20/1463	Soil	<0.064	<0.032	<0.062	<0.032	0.250	<0.032	0.033	<0.017	<0.026	<0.106	<0.123	0.259	<0.599
20/1464	Soil	0.826	0.143	0.170	0.150	0.385	0.248	0.096	0.053	0.055	<0.109	<0.126	<0.266	<0.614
20/1465	Soil	0.368	0.073	0.067	0.106	0.283	<0.034	0.060	0.065	<0.027	<0.114	<0.132	<0.277	<0.640
20/1466	Earthworm	4.086	1.041	<0.048	3.174	3.312	1.250	0.938	0.793	2.307	2.277	5.528	1.384	0.317
20/1467	Earthworm	<0.050	4.071	<0.048	0.350	0.402	0.454	0.680	0.833	1.045	0.975	1.192	0.216	0.198
20/1468	Earthworm	<0.050	3.466	<0.048	0.430	0.595	0.205	0.230	0.210	0.508	0.620	1.240	0.238	0.176
20/1469	Earthworm	<0.050	<0.025	<0.048	0.284	0.251	0.169	0.135	0.216	0.662	1.050	1.661	0.322	0.559
20/1470	Earthworm	<0.050	<0.025	<0.048	0.522	0.392	0.295	0.276	0.483	0.626	0.983	1.043	0.274	0.200
20/1471	Fieldfare egg	<0.100	<0.050	<0.020	0.060	1.197	1.369	5.746	4.734	13.22	6.955	8.819	0.438	<0.373
20/1472	Fieldfare egg	<0.100	<0.050	<0.020	0.046	0.472	0.575	0.961	1.466	3.59	4.476	3.796	0.253	<0.373
20/1473	Fieldfare egg	<0.100	<0.050	<0.020	0.079	0.886	1.356	5.687	4.303	17.48	11.713	13.87	0.499	<0.373
20/1474	Fieldfare egg	<0.100	6.031	<0.020	0.055	0.553	0.732	1.065	1.195	3.199	3.349	3.414	0.278	<0.373
20/1475	Fieldfare egg	<0.100	<0.050	<0.020	0.047	0.289	0.927	1.865	2.005	5.818	5.577	9.708	0.933	0.548

NILU-Sample number:	Sample type:	PFBA	PFPA	PFHxA	PFHpA	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA	PFHxDA	PFOcDA
20/1476	Fieldfare egg	<0.100	<0.050	<0.020	0.058	0.476	0.654	1.369	2.202	8.198	9.123	12.29	0.763	<0.373
20/1477	Fieldfare egg	<0.100	<0.050	<0.020	0.028	0.638	1.099	1.551	2.042	4.549	4.371	5.436	0.299	<0.373
20/1478	Fieldfare egg	<0.100	<0.050	<0.020	0.036	0.962	2.131	3.130	3.447	6.163	6.045	7.127	0.332	<0.373
20/1481	Red fox liver	<0.100	<0.050	<0.020	0.081	0.210	0.878	0.640	0.588	0.294	0.366	0.197	<0.147	0.137
20/1482	Red fox liver	<0.100	<0.050	<0.020	<0.025	0.219	0.549	0.298	0.244	0.151	0.080	0.060	<0.147	<0.373
20/1483	Red fox liver	<0.100	<0.050	<0.020	<0.025	0.162	1.234	1.280	1.455	0.715	0.956	0.518	<0.147	<0.373
20/1484	Red fox liver	<0.100	<0.050	<0.020	<0.025	0.135	0.636	0.732	0.408	0.265	0.234	0.155	<0.147	<0.373
20/1485	Red fox liver	<0.100	<0.050	<0.020	<0.025	0.091	0.817	0.783	0.500	0.256	0.259	0.128	<0.147	<0.373
20/1486	Red fox liver	<0.100	<0.050	<0.020	<0.025	0.413	1.591	0.767	0.579	0.313	0.288	0.220	<0.147	<0.373
20/1487	Red fox liver	<0.100	<0.050	<0.020	<0.025	0.127	0.454	0.289	0.203	0.107	0.097	0.058	<0.147	<0.373
20/1488	Red fox liver	<0.100	<0.050	0.180	0.129	0.459	1.048	0.609	0.829	0.683	0.841	0.402	<0.147	<0.373
20/1489	Red fox liver	<0.100	<0.050	<0.020	<0.025	0.641	3.257	4.765	4.062	3.232	2.330	2.149	0.183	<0.373
20/1490	Red fox liver	6.478	<0.050	0.222	<0.025	0.173	0.794	0.630	0.573	0.357	0.258	0.187	<0.147	<0.373
20/1501	Tawny owl egg	<0.100	<0.050	<0.020	<0.025	<0.021	0.137	0.387	1.070	1.736	2.479	1.963	<0.147	<0.373
20/1502	Tawny owl egg	<0.100	0.249	<0.020	<0.025	0.067	0.200	0.864	1.229	2.673	1.678	3.943	<0.147	<0.373
20/1503	Tawny owl egg	<0.100	0.442	<0.020	<0.025	0.040	0.290	0.734	0.736	0.875	1.006	0.713	<0.147	<0.373
20/1504	Tawny owl egg	<0.100	<0.050	<0.020	0.026	0.070	0.186	0.521	0.668	1.385	1.034	2.171	<0.147	<0.373
20/1505	Tawny owl egg	<0.100	<0.050	<0.020	<0.025	0.054	0.197	0.427	0.652	0.990	1.063	0.619	<0.147	<0.373
20/1506	Tawny owl egg	<0.100	<0.050	<0.020	<0.025	<0.021	0.135	0.449	1.164	1.234	1.863	0.970	<0.147	<0.373
20/1507	Tawny owl egg	<0.100	<0.050	<0.020	<0.025	0.082	0.148	0.354	0.557	0.996	1.335	1.109	<0.147	<0.373
20/1508	Tawny owl egg	<0.100	<0.050	<0.020	<0.025	0.060	0.087	0.209	0.377	0.731	0.860	0.583	<0.147	<0.373
20/1509	Tawny owl egg	<0.100	<0.050	<0.020	<0.025	<0.021	0.154	0.366	0.633	0.739	1.294	0.780	<0.147	<0.373

NILU-Sample number:	Sample type:	PFBA	PFPA	PFHxA	PFHpA	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA	PFHxDA	PFOcDA
20/1510	Tawny owl egg	<0.100	<0.050	<0.020	<0.025	0.049	0.180	0.543	1.054	1.529	1.919	1.170	<0.147	<0.373
20/1491	Rat liver	<0.100	1.371	0.026	<0.025	<0.021	<0.075	0.577	1.035	0.515	0.927	0.238	<0.147	<0.373
20/1492	Rat liver	<0.100	<0.050	<0.020	<0.025	0.158	0.313	0.320	0.193	0.197	0.136	0.078	<0.147	<0.373
20/1493	Rat liver	<0.100	2.346	<0.020	<0.025	<0.021	<0.075	0.233	0.550	0.258	0.497	0.206	<0.147	<0.373
20/1494	Rat liver	<0.100	1.321	<0.020	<0.025	<0.021	<0.075	0.524	0.526	0.401	0.563	0.142	<0.147	<0.373
20/1495	Rat liver	<0.100	0.826	<0.020	<0.025	<0.021	<0.075	0.542	0.523	0.481	0.506	0.363	<0.147	<0.373
20/1496	Rat liver	<0.100	0.323	<0.020	<0.025	<0.021	<0.075	0.523	0.365	0.434	0.483	0.235	<0.147	<0.373
20/1497	Rat liver	<0.100	<0.050	<0.020	<0.025	0.279	0.311	0.545	0.263	0.310	0.141	0.146	<0.147	<0.373
20/1498	Rat liver	<0.100	1.833	<0.020	<0.025	<0.021	<0.075	0.521	0.397	0.329	0.286	0.107	<0.147	<0.373
20/1499	Rat liver	<0.100	1.913	<0.020	<0.025	<0.021	<0.075	0.439	0.260	0.240	0.163	0.111	<0.147	<0.373
20/1500	Rat liver	<0.100	1.500	<0.020	<0.025	<0.021	<0.075	0.294	0.286	0.242	0.195	0.099	<0.147	<0.373

nPFAS

NILU-Sample number:	Sample type:	PFOSA	meFOSA	etFOSA	meFOSEA	meFOSE	etFOSE	6:2 FTOH	8:2 FTOH	10:2 FTOH	12:2 FTOH
20/1946	Air	3.27	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
20/1950	Air	9.49	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
20/1947	Air	<2.53	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
20/1948	Air	6.08	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
20/1949	Air	<1.13	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
20/1461	Soil	<0.121	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1462	Soil	<0.327	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1463	Soil	<0.128	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1464	Soil	0.229	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1465	Soil	<0.138	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1466	Earthworm	<0.100	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
20/1467	Earthworm	0.133	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
20/1468	Earthworm	0.251	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
20/1469	Earthworm	0.183	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
20/1470	Earthworm	0.193	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
20/1471	Fieldfare egg	0.417	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1472	Fieldfare egg	0.072	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1473	Fieldfare egg	0.302	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1474	Fieldfare egg	0.184	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2

NILU-Sample number:	Sample type:	PFOSA	meFOSA	etFOSA	meFOSEA	meFOSE	etFOSE	6:2 FTOH	8:2 FTOH	10:2 FTOH	12:2 FTOH
20/1475	Fieldfare egg	0.240	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1476	Fieldfare egg	0.116	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1477	Fieldfare egg	0.134	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1478	Fieldfare egg	0.145	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1481	Red fox liver	0.067	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1482	Red fox liver	<0.025	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1483	Red fox liver	0.240	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1484	Red fox liver	0.077	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1485	Red fox liver	<0.025	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1486	Red fox liver	0.104	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1487	Red fox liver	0.094	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1488	Red fox liver	0.559	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1489	Red fox liver	1.009	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1490	Red fox liver	0.115	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1501	Tawny owl egg	<0.025	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1502	Tawny owl egg	0.095	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1503	Tawny owl egg	0.045	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1504	Tawny owl egg	0.117	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1505	Tawny owl egg	0.143	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1506	Tawny owl egg	0.229	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1507	Tawny owl egg	<0.025	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2

NILU-Sample number:	Sample type:	PFOSA	meFOSA	etFOSA	meFOSEA	meFOSE	etFOSE	6:2 FTOH	8:2 FTOH	10:2 FTOH	12:2 FTOH
20/1508	Tawny owl egg	<0.025	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1509	Tawny owl egg	0.056	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1510	Tawny owl egg	0.061	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1491	Rat liver	0.047	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1492	Rat liver	<0.025	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1493	Rat liver	<0.025	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1494	Rat liver	0.048	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1495	Rat liver	0.050	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1496	Rat liver	<0.025	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1497	Rat liver	0.043	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1498	Rat liver	0.079	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1499	Rat liver	0.090	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2
20/1500	Rat liver	0.073	<0.3	<0.3	<5	<5	<5	<2	<2	<2	<2

Fluorotelomer sulfonates (New PFAS)

NILU-Sample number:	Sample type:	4:2 FTS	6:2 FTS	8:2 FTS	10:2 FTS
20/1946	Air	<0.27	<0.27	<0.27	n.a.
20/1950	Air	<0.27	<0.27	<0.27	n.a.
20/1947	Air	<0.27	<0.27	<0.27	n.a.
20/1948	Air	<0.27	<0.27	<0.27	n.a.
20/1949	Air	<0.27	<0.27	<0.27	n.a.
20/1461	Soil	<0.031	<0.077	<0.061	<0.3
20/1462	Soil	<0.084	<0.206	<0.165	<0.3
20/1463	Soil	<0.033	<0.082	<0.065	<0.3
20/1464	Soil	<0.034	<0.084	<0.067	<0.3
20/1465	Soil	<0.036	<0.088	<0.070	<0.3
20/1466	Earthworm	<0.026	0.076	0.695	n.a.
20/1467	Earthworm	<0.026	<0.064	<0.027	n.a.
20/1468	Earthworm	<0.026	<0.064	0.235	n.a.
20/1469	Earthworm	<0.026	0.227	0.133	n.a.
20/1470	Earthworm	<0.026	0.094	0.139	n.a.
20/1471	Fieldfare egg	<0.019	<0.023	0.586	2.5
20/1472	Fieldfare egg	<0.019	0.029	0.340	0.3
20/1473	Fieldfare egg	<0.019	0.565	55.05	30.3
20/1474	Fieldfare egg	<0.019	0.070	1.42	1.0
20/1475	Fieldfare egg	<0.019	0.802	19.25	5.6

NILU-Sample number:	Sample type:	4:2 FTS	6:2 FTS	8:2 FTS	10:2 FTS
20/1476	Fieldfare egg	<0.019	0.032	0.335	0.5
20/1477	Fieldfare egg	<0.019	<0.023	0.212	0.9
20/1478	Fieldfare egg	<0.019	<0.023	0.298	0.7
20/1481	Red fox liver	<0.019	<0.023	<0.027	<0.3
20/1482	Red fox liver	<0.019	<0.023	<0.027	<0.3
20/1483	Red fox liver	<0.019	<0.023	0.076	<0.3
20/1484	Red fox liver	<0.019	<0.023	<0.027	<0.3
20/1485	Red fox liver	<0.019	<0.023	0.025	<0.3
20/1486	Red fox liver	<0.019	<0.023	<0.027	<0.3
20/1487	Red fox liver	<0.019	<0.023	<0.027	<0.3
20/1488	Red fox liver	<0.019	<0.023	0.029	<0.3
20/1489	Red fox liver	<0.019	<0.023	0.090	<0.3
20/1490	Red fox liver	<0.019	<0.023	0.066	<0.3
20/1502	Tawny owl egg	<0.019	<0.023	0.104	0.5
20/1503	Tawny owl egg	<0.019	<0.023	0.175	0.4
20/1504	Tawny owl egg	<0.019	<0.023	0.104	<0.3
20/1505	Tawny owl egg	<0.019	<0.023	0.138	<0.3
20/1506	Tawny owl egg	<0.019	<0.023	0.132	<0.3
20/1507	Tawny owl egg	<0.019	<0.023	0.066	<0.3
20/1508	Tawny owl egg	<0.019	<0.023	0.041	<0.3
20/1509	Tawny owl egg	<0.019	<0.023	0.067	<0.3

NILU-Sample number:	Sample type:	4:2 FTS	6:2 FTS	8:2 FTS	10:2 FTS
20/1510	Tawny owl egg	<0.019	<0.023	0.033	<0.3
20/1491	Rat liver	<0.019	<0.023	0.037	<0.3
20/1492	Rat liver	<0.019	0.143	0.665	0.4
20/1493	Rat liver	<0.019	<0.023	<0.027	<0.3
20/1494	Rat liver	<0.019	<0.023	<0.027	<0.3
20/1495	Rat liver	<0.019	<0.023	0.028	<0.3
20/1496	Rat liver	<0.019	<0.023	<0.027	<0.3
20/1497	Rat liver	<0.019	0.053	0.597	<0.3
20/1498	Rat liver	<0.019	<0.023	0.168	0.6
20/1499	Rat liver	<0.019	<0.023	0.068	<0.3
20/1500	Rat liver	<0.019	<0.023	<0.027	<0.3

Chlorinated paraffins (CP)

NILU-Sample number:	Sample type:	SCCP	MCCP
20/1946	Air	9958	<2400
20/1950	Air	<1541	<644
20/1947	Air	3920	<2592
20/1948	Air	4844	<2065
20/1949	Air	<2148	<872
20/1461	Soil	<2.2	<5.9
20/1462	Soil	101	<5.6
20/1463	Soil	18	<6.0
20/1464	Soil	<1.5	<3.9
20/1465	Soil	<1.8	<4.7
20/1466	Earthworm	5.5	<10.0
20/1467	Earthworm	<8.0	<20.0
20/1468	Earthworm	<8.0	<20.0
20/1469	Earthworm	<8.0	<20.0
20/1470	Earthworm	<4.0	<10.0
20/1471	Fieldfare egg	<8.0	28
20/1472	Fieldfare egg	8.9	21
20/1473	Fieldfare egg	4.7	57
20/1474	Fieldfare egg	<8.0	53
20/1475	Fieldfare egg	6.9	132

NILU- Sample number:	Sample type:	SCCP	MCCP
20/1476	Fieldfare egg	12	38
20/1477	Fieldfare egg	32	31
20/1478	Fieldfare egg	9.2	28
20/1481	Red fox liver	4.8	14
20/1482	Red fox liver	10	19
20/1483	Red fox liver	6.4	<10.0
20/1484	Red fox liver	7.9	12
20/1485	Red fox liver	4.5	<10.0
20/1486	Red fox liver	8.2	13
20/1487	Red fox liver	<4.0	<10.0
20/1488	Red fox liver	4.3	15
20/1489	Red fox liver	130	<10.0
20/1490	Red fox liver	<4.0	<10.0
20/1501	Tawny owl egg	10.0	17.0
20/1502	Tawny owl egg	6.4	11.0
20/1503	Tawny owl egg	5.9	26.0
20/1504	Tawny owl egg	6.7	14.0
20/1505	Tawny owl egg	<4.0	11.0
20/1506	Tawny owl egg	8.8	<10.0
20/1507	Tawny owl egg	<4.0	<10.0
20/1508	Tawny owl egg	<4.0	<10.0
20/1509	Tawny owl egg	<4.0	<10.0

NILU- Sample number:	Sample type:	SCCP	MCCP
20/1510	Tawny owl egg	4.8	<10.0
20/1491	Rat liver	<4.0	12
20/1492	Rat liver	<4.0	<10.0
20/1493	Rat liver	<4.0	17
20/1494	Rat liver	<4.0	26
20/1495	Rat liver	<4.0	<10.0
20/1496	Rat liver	<4.0	<10.0
20/1497	Rat liver	<4.0	<10.0
20/1498	Rat liver	<4.0	66
20/1499	Rat liver	<4.0	22
20/1500	Rat liver	<4.0	30

Cyclic siloxanes (cVMS)

NILU- Sample number:	Sample type:	D4	D5	D6
20/1946	Air	7967	33808	3210
20/1950	Air	8202	4677	458
20/1947	Air	2515	4871	459
20/1948	Air	6233	15494	2085
20/1949	Air	22273	57661	3866
20/1461	Soil	1.31	0.99	0.81
20/1462	Soil	1.34	1.10	0.83
20/1463	Soil	0.86	0.73	0.58
20/1464	Soil	0.76	0.66	0.45
20/1465	Soil	0.99	0.76	0.47
20/1466	Earthworm	3.54	1.75	1.18
20/1467	Earthworm	4.37	1.64	1.01
20/1468	Earthworm	3.91	1.55	1.00
20/1469	Earthworm	4.17	1.57	1.01
20/1470	Earthworm	4.30	1.70	1.23
20/1471	Fieldfare egg	38.36	19.69	11.87
20/1472	Fieldfare egg	15.82	8.39	5.52
20/1473	Fieldfare egg	21.80	26.61	8.08
20/1474	Fieldfare egg	3.38	3.86	1.91
20/1475	Fieldfare egg	13.13	9.76	5.05

NILU- Sample number:	Sample type:	D4	D5	D6
20/1476	Fieldfare egg	17.48	9.83	5.89
20/1477	Fieldfare egg	2.45	4.72	2.32
20/1478	Fieldfare egg	16.68	9.10	5.98
20/1481	Red fox liver	4.29	2.12	1.13
20/1482	Red fox liver	8.11	3.76	2.29
20/1483	Red fox liver	2.49	0.78	0.44
20/1484	Red fox liver	10.46	5.37	3.71
20/1485	Red fox liver	9.98	5.07	3.23
20/1486	Red fox liver	5.18	2.68	1.69
20/1487	Red fox liver	9.52	4.75	3.08
20/1488	Red fox liver	5.90	3.24	1.73
20/1489	Red fox liver	5.84	3.17	2.04
20/1490	Red fox liver	11.32	5.34	3.06
20/1501	Tawny owl egg	2.86	1.14	0.93
20/1502	Tawny owl egg	2.95	4.67	0.92
20/1503	Tawny owl egg	4.59	1.87	1.17
20/1504	Tawny owl egg	3.85	1.48	<0.43
20/1505	Tawny owl egg	4.19	1.94	<0.69
20/1506	Tawny owl egg	5.11	2.15	0.86
20/1507	Tawny owl egg	6.35	2.78	1.66
20/1508	Tawny owl egg	3.73	1.63	<0.8
20/1509	Tawny owl egg	6.38	3.11	1.96

NILU- Sample number:	Sample type:	D4	D5	D6
20/1510	Tawny owl egg	3.79	2.35	0.91
20/1491	Rat liver	27.7	14.7	4.12
20/1492	Rat liver	14.3	12.4	1.89
20/1493	Rat liver	64.5	38.0	8.09
20/1494	Rat liver	55.1	15.1	3.12
20/1495	Rat liver	12.1	31.3	4.21
20/1496	Rat liver	44.4	535	5.43
20/1497	Rat liver	9.10	14.5	1.58
20/1498	Rat liver	11.4	38.6	27.8
20/1499	Rat liver	12.6	80.3	30.7
20/1500	Rat liver	15.1	74.9	29.8

OPFR

NILU-Sample number:	Sample type:	TCEP	TPrP	TCPP	TiBP	TPP	TnBP	DBPhP	BdPhP	TDCPP	TBEP	TCP	EHDP	TXP	TIPPP	TEHP
20/1946	Air	285	<120	3124	282	171	127	<8.70	<8.70	<96.7	<266	27.4	<780	<32.6	<21.7	424
20/1950	Air	<120	<120	<503	<174	<120	<61	<8.70	<8.70	<96.7	<266	<7.6	<780	<32.6	<21.7	<75.0
20/1947	Air	<120	<120	<503	<174	<120	<61	<8.70	<8.70	<96.7	<266	57.2	<780	<32.6	<21.7	75.8
20/1948	Air	191	<120	2862	<174	213	133	<8.70	<8.70	<96.7	<266	774	<780	<32.6	59.6	85.3
20/1949	Air	426	<120	1628	377	216	354	<8.70	<8.70	<96.7	266.3	38.0	<780	<32.6	<21.7	<75.0
20/1511	Soil	<0.3	<0.3	6.0	<0.3	<0.6	<0.3	<0.3	<0.3	<1	<0.3	6.56	<0.8	<0.8	<0.8	1.62
20/1512	Earthworm	<0.4	<0.1	3.94	1.53	0.42	2.09	<0.1	<0.1	<0.2	<0.1	0.33	<0.2	<0.2	<0.1	<0.2

NewBrom

NILU Sample number:	Sample type:	ATE (TBPAE)	a-TBECH	b-TBECH	g/d-TBECH	BATE	PBT	PBEB	PBBZ	HBB	DPTE	EHTBB	BTBPE	TBPH (BEH /TBP)	DBDPE
20/1946	Air	<0.1	21.5	11.4	0.6	<0.1	2.2	0.2	3.2	<1.1	0.3	0.3	<0.3	1.2	<154.3
20/1950	Air	<0.1	2.8	1.4	<0.4	<0.1	0.4	<0.2	<2.6	<1.1	<0.1	<0.1	<0.3	<0.8	<154.3
20/1947	Air	<0.1	<1.1	<0.8	<0.4	<0.1	<0.4	<0.2	<2.6	<1.1	0.1	<0.1	<0.3	<0.8	<154.3
20/1948	Air	<0.1	3.5	1.7	<0.4	<0.1	1.0	0.6	<2.6	<1.1	0.2	<0.2	1.4	<0.8	<154.3
20/1949	Air	<0.1	2.8	1.3	<0.4	0.2	11.5	<0.2	2.8	4.8	0.7	1.0	<0.3	<0.8	<154.3
20/1461	Soil	<0.034	<0.310	<0.222	<0.126	<0.040	<0.110	<0.045	<0.751	<0.305	<0.026	<0.042	<0.096	<0.217	<44.5
20/1462	Soil	<0.036	<0.319	<0.229	<0.130	<0.041	<0.113	<0.046	<0.775	<0.314	<0.027	<0.044	<0.099	<0.224	<45.9
20/1463	Soil	<0.036	<0.319	<0.229	<0.130	<0.041	<0.113	<0.046	<0.775	<0.314	<0.027	<0.044	<0.099	<0.224	<45.9
20/1464	Soil	<0.036	<0.319	<0.229	<0.130	<0.041	<0.113	<0.046	<0.775	<0.314	<0.027	<0.044	<0.099	<0.224	<45.9
20/1465	Soil	<0.036	<0.319	<0.229	<0.130	<0.041	<0.113	<0.046	<0.775	<0.314	<0.027	<0.044	<0.099	<0.224	<45.9
20/1466	Earthworm	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	0.018	<0.240	<0.097	0.015	<0.049	<0.031	<0.170	<14.200
20/1467	Earthworm	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.033	<0.031	<0.106	<14.200
20/1468	Earthworm	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.025	<0.031	<0.189	<14.200
20/1469	Earthworm	<0.051	<0.429	<0.316	<0.406	<0.025	<0.070	<0.029	<0.481	<0.195	<0.043	<0.125	<0.062	<0.546	<28.400
20/1470	Earthworm	<0.011	<0.099	<0.071	<0.040	0.017	<0.035	0.015	<0.240	<0.097	<0.008	<0.021	<0.031	<0.097	<14.20
20/1471	Fieldfare egg	<0.051	<0.587	<0.433	<0.556	<0.055	<0.035	0.015	<0.240	<0.097	<0.036	<0.256	<0.079	<0.898	<14.2
20/1472	Fieldfare egg	<0.022	<0.198	<0.142	<0.081	<0.026	<0.070	<0.029	<0.481	<0.195	<0.017	<0.202	<0.062	<0.749	<28.4
20/1473	Fieldfare egg	<0.040	<0.394	<0.291	<0.373	<0.021	<0.035	<0.014	<0.240	<0.097	<0.026	<0.228	<0.050	<0.616	<14.2
20/1474	Fieldfare egg	<0.022	<0.240	<0.169	<0.081	<0.025	<0.070	<0.029	<0.481	<0.195	<0.016	<0.034	<0.062	<0.139	<28.4

NILU Sample number:	Sample type:	ATE (TBPAE)	a-TBECH	b-TBECH	g/d-TBECH	BATE	PBT	PBEB	PBBZ	HBB	DPTE	EHTBB	BTBPE	TBPH (BEH /TBP)	DBDPE
20/1475	Fieldfare egg	<0.012	<0.113	<0.079	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.047	<0.031	<0.073	<14.2
20/1476	Fieldfare egg	<0.011	<0.106	<0.074	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.077	<0.031	<0.092	<14.2
20/1477	Fieldfare egg	<0.022	<0.211	<0.148	<0.081	<0.025	<0.070	<0.029	<0.481	<0.195	<0.016	<0.118	<0.062	<0.139	<28.4
20/1478	Fieldfare egg	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.014	<0.031	<0.069	<14.2
20/1481	Red fox liver	<0.022	<0.198	<0.142	<0.081	<0.025	<0.070	<0.029	<0.481	<0.195	<0.016	<0.520	<0.062	<0.325	<28.40
20/1482	Red fox liver	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.204	<0.031	<0.079	<14.20
20/1483	Red fox liver	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.094	0.038	<0.069	<14.20
20/1484	Red fox liver	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	0.010	<0.114	<0.031	<0.069	<14.20
20/1485	Red fox liver	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.170	<0.031	<0.069	<14.20
20/1486	Red fox liver	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.093	<0.031	<0.069	<14.20
20/1487	Red fox liver	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.062	<0.031	<0.069	<14.20
20/1488	Red fox liver	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.009	<0.305	<0.031	<0.363	<14.20
20/1489	Red fox liver	<0.015	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.139	<0.031	<0.119	<14.20
20/1490	Red fox liver	<0.014	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.071	<0.031	<0.090	<14.20
20/1501	Tawny owl egg	<0.011	<0.099	<0.071	<0.040	0.019	<0.035	0.025	<0.240	<0.097	0.016	<0.039	0.044	<0.069	<14.20
20/1502	Tawny owl egg	<0.011	<0.099	<0.071	<0.040	0.013	<0.035	0.019	<0.240	<0.097	0.013	<0.482	0.032	<0.069	<14.20
20/1503	Tawny owl egg	<0.066	<0.485	<0.358	<0.459	<0.031	<0.035	0.029	<0.240	0.117	0.065	<0.231	<0.070	<0.815	<14.20
20/1504	Tawny owl egg	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.032	<0.031	<0.069	<14.20

NILU Sample number:	Sample type:	ATE (TBPAE)	a-TBECH	b-TBECH	g/d-TBECH	BATE	PBT	PBEB	PBBZ	HBB	DPTE	EHTBB	BTBPE	TBPH (BEH /TBP)	DBDPE
20/1505	Tawny owl egg	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.056	<0.031	<0.069	<14.20
20/1506	Tawny owl egg	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.077	<0.031	<0.069	<14.20
20/1507	Tawny owl egg	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.022	<0.031	<0.069	<14.20
20/1508	Tawny owl egg	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.022	<0.031	<0.069	<14.20
20/1509	Tawny owl egg	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.018	<0.031	<0.069	<14.20
20/1510	Tawny owl egg	<0.011	<0.099	<0.071	<0.040	<0.013	<0.035	<0.014	<0.240	<0.097	<0.008	<0.014	<0.031	<0.069	<14.20
20/1491	Rat liver	<0.02	<0.13	<0.09	<0.08	<0.02	<0.04	<0.01	<0.24	<0.10	<0.01	<0.09	<0.03	<0.12	<14.20
20/1492	Rat liver	<0.03	<0.12	<0.09	<0.08	<0.02	<0.04	<0.01	<0.24	<0.10	<0.01	<0.07	<0.03	<0.139	<14.20
20/1493	Rat liver	<0.03	<0.22	<0.16	<0.14	<0.02	<0.04	<0.01	<0.24	<0.10	<0.01	<0.13	<0.03	<0.294	<14.20
20/1494	Rat liver	<0.01	<0.10	<0.07	<0.05	<0.01	<0.04	<0.01	<0.24	<0.10	<0.01	<0.06	<0.03	<0.096	<14.20
20/1495	Rat liver	<0.03	<0.14	<0.10	<0.09	<0.01	<0.04	<0.01	<0.24	<0.10	<0.01	<0.06	<0.03	<0.163	<14.20
20/1496	Rat liver	<0.01	<0.10	<0.07	<0.06	<0.01	<0.04	<0.01	<0.24	<0.10	<0.01	<0.07	<0.03	<0.165	<14.20
20/1497	Rat liver	<0.01	<0.10	<0.07	<0.04	<0.01	<0.04	<0.01	<0.24	<0.10	<0.01	<0.06	<0.03	<0.174	<14.20
20/1498	Rat liver	<0.01	<0.10	<0.07	<0.04	<0.01	<0.04	<0.01	<0.24	<0.10	<0.01	<0.05	<0.03	<0.069	<14.20
20/1499	Rat liver	<0.01	<0.10	<0.07	<0.04	<0.01	<0.04	<0.01	<0.24	<0.10	0	<0.04	<0.03	<0.091	<14.20
20/1500	Rat liver	<0.01	<0.10	<0.07	<0.04	<0.01	<0.04	<0.01	<0.24	<0.10	<0.01	<0.10	<0.03	<0.646	<14.20

Phenols

NILU-Sample number:	Sample type:	Bis-A	2,4-bis-A	Bis-S	2,4-bis-S	4.4-bis-F	2,4-bis-F	2,2-bis-F	TBBPA	4-t-octylphenol	4-n-octylphenol	4-n-nonylphenol
20/1461	Soil	<11.6	<1.61	<22.4	<0.595	<5.74	<10.5	<0.57	<32.1	<36.5	<11.3	<36.9
20/1462	Soil	<11.6	<1.61	<22.4	<0.714	<5.74	<10.5	<0.57	<5.63	<8.54	<5.62	<11.1
20/1463	Soil	<11.6	<1.65	<22.4	<0.624	<5.74	<10.5	<0.57	<13.2	<24.4	<7.56	<15.9
20/1464	Soil	<11.6	<1.95	<22.4	<0.618	<5.74	<10.5	<0.6	<14.6	<30	<9.29	<19
20/1465	Soil	<11.6	<1.54	<22.4	<0.595	<5.74	<10.5	<0.57	<12.8	<30.3	<9.4	<16.5
20/1471	Fieldfare egg	<11.6	<1.4	<22.4	<0.595	<5.74	<10.5	<0.57	<4.93	<1.39	<5.62	<7.7
20/1472	Fieldfare egg	<10.60	<<1.27	<<20.30	<<0.54	<<5.22	<<9.56	<<0.52	<<4.48	<1.26	<5.11	<7
20/1473	Fieldfare egg	<11.6	<1.4	<22.4	<0.595	<5.74	<10.5	<0.57	<4.93	<1.83	<5.62	<7.7
20/1474	Fieldfare egg	<11.6	<1.4	<22.4	<0.595	<5.74	<10.5	<0.57	<4.93	<1.13	<5.62	<7.7
20/1475	Fieldfare egg	<11.6	<1.4	<22.4	<0.595	6.28	12	<0.57	<4.93	<2.37	<5.62	<7.7
20/1476	Fieldfare egg	<11.6	<1.4	<22.4	<0.595	<5.74	<10.5	<0.57	<4.93	<1.36	<5.62	<7.7
20/1477	Fieldfare egg	<10.6	<1.27	<20.3	<0.541	<5.22	<9.56	<0.518	<4.48	<1.68	<5.11	<7
20/1478	Fieldfare egg	<11.6	<1.4	<22.4	<0.595	11.4	13.3	<0.57	<4.93	<2.6	<5.62	<7.7

NILU-Sample number:	Sample type:	Bis-A	2,4-bis-A	Bis-S	2,4-bis-S	4.4-bis-F	2,4-bis-F	2,2-bis-F	TBBPA	4-t-octylphenol	4-n-octylphenol	4-n-nonylphenol
20/1481	Red fox liver	<10.6	<2.64	<20.3	<0.645	<5.22	<9.56	<0.808	<1.78	<4.22	<5.11	<12.3
20/1482	Red fox liver	<10.6	<2.89	<20.3	<0.686	<5.22	<9.56	<0.796	<6.32	<3.84	<5.11	<7
20/1483	Red fox liver	<10.6	<2.89	<20.3	<0.571	<5.22	<9.56	<1.08	<7.55	<5.12	<5.11	<7
20/1484	Red fox liver	<10.6	<2.57	<20.3	<0.6	<5.22	<9.56	<0.675	<5.28	<3.04	<5.11	N.A.
20/1485	Red fox liver	34.1	<2.77	<22.4	<0.628	<5.74	<10.5	<0.783	<7.26	<4.05	<5.62	<7.7
20/1486	Red fox liver	<11.6	<4.5	<22.4	<0.633	<5.74	<10.5	<1.64	<24.2	<10.1	<8.1	<13.1
20/1487	Red fox liver	<10.6	<2.6	<20.3	<0.541	<5.22	<9.56	<0.608	<4.55	<2.86	<5.11	<50
20/1488	Red fox liver	<10.6	<2.81	<20.3	<0.593	<5.57	<9.56	<0.786	<5.05	<2.91	<5.11	N.A.
20/1489	Red fox liver	<10.6	<2.61	<20.3	<0.594	<5.22	<9.56	<0.72	<5.68	<3.54	<5.11	<21.5
20/1490	Red fox liver	<11.6	<3.29	<22.4	<0.678	<5.74	<10.5	<0.85	<6.1	<3.45	<5.62	N.A.
20/1501	Tawny owl egg	<11.6	<1.4	<22.4	<0.595	<5.74	<10.5	<0.57	<4.93	<1.3	<5.62	<7.7
20/1502	Tawny owl egg	<11.6	<1.4	<22.4	<0.595	<5.74	<10.5	<0.57	<4.93	<0.986	<5.62	<7.7

NILU-Sample number:	Sample type:	Bis-A	2,4-bis-A	Bis-S	2,4-bis-S	4.4-bis-F	2,4-bis-F	2,2-bis-F	TBBPA	4-t-octylphenol	4-n-octylphenol	4-n-nonylphenol
20/1503	Tawny owl egg	<11.6	<1.4	<22.4	<0.595	<5.74	<10.5	<0.57	<4.93	<1.01	<5.62	<7.7
20/1504	Tawny owl egg	<11.6	<1.4	<22.4	<0.595	<5.74	<10.5	<0.57	<4.93	<1.08	<5.62	<7.7
20/1505	Tawny owl egg	<10.6	<1.27	<20.3	<0.541	<5.22	<9.56	<0.518	<4.48	<0.944	<5.11	<7
20/1506	Tawny owl egg	<11.6	<1.4	<22.4	<0.595	12.5	17.7	1.26	<4.93	<2.06	<5.62	<7.7
20/1507	Tawny owl egg	<11.6	<1.4	<22.4	<0.595	6.13	<10.5	<0.57	<4.93	<2	<5.62	<7.7
20/1508	Tawny owl egg	<11.6	<1.4	<22.4	<0.595	<5.74	<10.5	<0.57	<4.93	<1.19	<5.62	<7.7
20/1509	Tawny owl egg	<10.6	<1.27	<20.3	<0.541	<5.22	<9.56	<0.518	<4.48	<0.985	<5.11	<7
20/1510	Tawny owl egg	<10.6	<1.27	<20.3	<0.541	<5.22	<9.56	<0.518	<4.48	<0.76	<5.11	<7
20/1516	Rat liver	0.11	25.7	<1.51	<20.3	<0.541	<5.22	<9.56	<0.518	<5.42	<2.77	<5.11
20/1517	Rat liver	0.1	33.4	<1.85	<22.4	<0.595	<5.74	<10.5	<0.57	<6.4	<3.01	<5.62
20/1518	Rat liver	0.1	11.9	<1.64	<22.4	<0.595	<5.74	<10.5	<0.57	<4.93	<2.93	<5.62

UV compounds

NILU Sample number:	Sample type:	BP3	EHMC-Z	ODPABA	EHMC-E	UV-320	UV-326	UV-329	UV-328	UV-327	OC
20/1511	Soil	<0.400	<0.030	<0.050	<0.100	<0.070	0.14	<0.200	2.4	0.16	1.3
20/1513	Red fox liver	<0.400	<0.030	<0.050	<0.100	<0.070	0.064	<0.200	0.078	<0.030	<1.0
20/1514	Red fox liver	<0.300	<0.030	<0.050	<0.100	<0.070	0.062	<0.200	<0.070	<0.030	<1.0
20/1515	Red fox liver	<0.300	<0.030	<0.050	<0.100	<0.070	<0.060	<0.200	0.18	<0.030	<1.0
20/1519	Tawny owl egg	<0.400	<0.100	<0.050	<0.100	<0.070	<0.060	<0.200	0.23	0.038	<1.0
20/1520	Tawny owl egg	<0.400	<0.100	<0.100	<0.200	<0.070	0.13	<0.200	0.071	0.055	<1.0
20/1521	Tawny owl egg	<0.400	<0.100	<0.100	<0.100	<0.070	0.11	<0.200	<0.070	0.15	<1.0
20/1516	Rat liver	<0.300	<0.030	<0.040	<0.100	<0.050	0.29	<0.200	1.4	0.064	<1.0
20/1517	Rat liver	<0.300	<0.030	<0.040	<0.100	<0.050	0.19	<0.200	0.091	0.080	<1.0
20/1518	Rat liver	<0.300	<0.030	<0.040	<0.100	<0.050	0.35	<0.200	0.27	<0.030	<1.0

Biocides

NILU-Sample number:	Sample type:	Bromadiolone	cis-Broda-ficoum	trans-Broda-ficoum	trans-flocumafen	cis-Flocu-mafen	cis-difena-coum	trans-difena-coum	trans-difethia-lone	cis-difethia-lone
20/1481	Red fox liver	173	112	77.5	<0.2	<0.2	5.86	1.26	<0.2	<0.2
20/1482	Red fox liver	677	37.7	20.9	<0.2	<0.2	1.67	<0.2	<0.2	<0.2
20/1483	Red fox liver	111	197	49.1	<0.2	<0.2	0.55	0.51	<0.2	<0.2
20/1484	Red fox liver	382	146	65.9	<0.2	<0.2	6.36	0.59	<0.2	<0.2
20/1485	Red fox liver	17.9	0.95	1.19	<0.2	<0.2	34	22.8	<0.2	<0.2
20/1486	Red fox liver	147	56.9	23.5	<0.2	<0.2	3.77	0.92	<0.2	<0.2
20/1487	Red fox liver	47.9	72.4	86.5	<0.2	<0.2	9.68	2.66	<0.2	<0.2
20/1488	Red fox liver	315	37.2	13.8	<0.2	<0.2	1.92	<0.2	<0.2	<0.2
20/1489	Red fox liver	1090	71.9	57.7	<0.2	<0.2	1.44	2.16	<0.2	<0.2
20/1490	Red fox liver	57.9	0.98	0.85	<0.2	<0.2	0.78	0.44	<0.2	<0.2
20/1491	Rat liver	20.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
20/1492	Rat liver	0.85	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
20/1493	Rat liver	58.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
20/1494	Rat liver	60.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
20/1495	Rat liver	1.95	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
20/1496	Rat liver	9.13	0.62	0.95	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
20/1497	Rat liver	1.62	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
20/1498	Rat liver	33.6	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
20/1499	Rat liver	65.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
20/1500	Rat liver	41.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

NILU – Norwegian Institute for Air Research

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