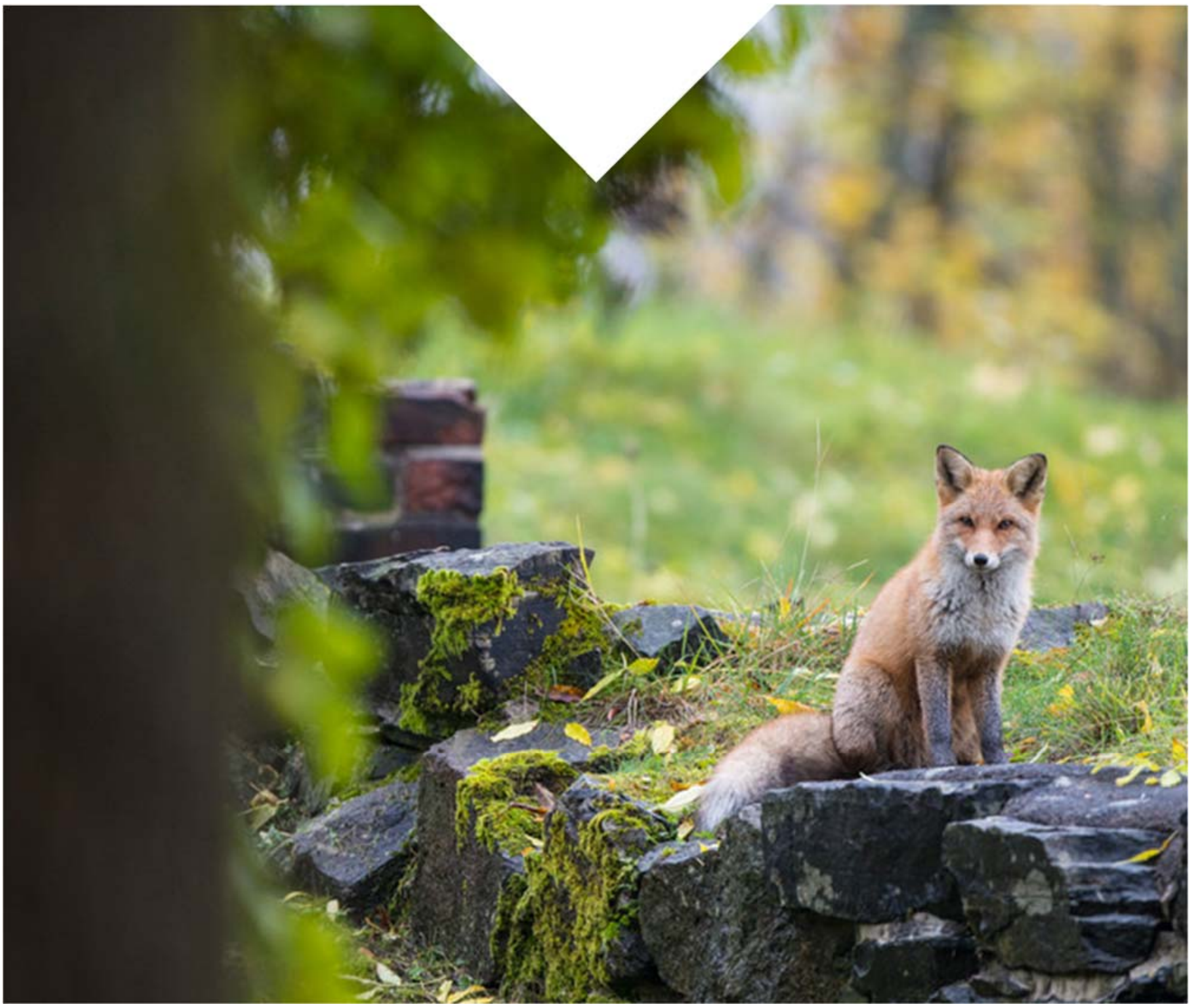
ENVIRONMENTAL MONITORING

M-752 | 2017

Environmental pollutants in the terrestrial and urban environment

2016



COLOPHON

Executive institution

NILU – Norwegian Institute for Air Research

Project manager for the contractor

Dorte Herzke (NILU)

Contact person in the Norwegian Environment Agency

Eivind Farmen

M-no

752

Year

2017

Pages

230

Contract number

[Contract number]

Publisher

NILU - Norwegian Institute for Air Research

The project is funded by

Norwegian Environmental Agency

Author(s)

Dorte Herzke (NILU), Torgeir Nygård (NINA), Eldbjørg S. Heimstad (NILU)

Title – Norwegian and English

Miljøgifter i terrestrisk og bynært miljø 2016
Environmental pollutants in the terrestrial and urban environment 2016

Summary – sammendrag

We analysed biological samples from the terrestrial and urban environment for various inorganic and organic contaminants in the Oslo area. A foodchain approach was used, in order to detect bioaccumulation of the different compounds. The species analysed were earthworms, fieldfare, sparrowhawk, brown rat, tawny owl and red fox. Air and soil samples were also included in the study to increase the understanding on sources and uptake of pollutants.

Biologiske prøver fra det urbane terrestriske miljøet i Oslo-området ble analysert for flere organiske og uorganiske miljøgifter. En næringskjede ble valgt for å undersøke bioakkumulering av de forskjellige stoffene. De utvalgte artene var meitemark, gråtost, spurvehauk, rotte, kattugle og rødrev. Luft og jordprøver ble også analysert for å øke forståelsen av kilder og opptak av miljøgifter.

4 emneord

POPs, PFAS, tungmetaller, nye miljøgifter

4 subject words

POPs, PFAS, heavy metals, emerging pollutants

Front page photo

Foto: Bård Bredesen, Naturarkivet

Summary

On behalf of the Norwegian Environment Agency, the Norwegian Institute for Air Research (NILU) in collaboration with Norwegian Institute for Nature Research (NINA) analysed biological samples from the terrestrial and urban environment for various inorganic and organic contaminants in 2016. The purpose of this report is to provide an updated assessment of pollution present within the terrestrial urban environment in Norway in order to evaluate potential environmental hazards caused by a densly populated urban area, and to provide information to ongoing regulatory work at both national and international level.

The project had the following key goals:

- Report concentrations of chosen environmental pollutants in several levels of the terrestrial food chain
- Evaluate the bioaccumulation potential of pollutants in a terrestrial food chain
- Evaluate the combined exposure and mixture risk assessment of pollutants in terrestrial animals
- Evaluate how land-living species are exposed to a variety of pollutants

This report presents the findings from the fourth year of the urban terrestrial programme. For the first time in the urban terrestrial programme, air samples were included in 2016.

A vast number of chemical parameters was analysed, in addition to the assement of bioaccumulation and combined risk for primary consumers and predators, resulting in a comprehensive overview of conventional and emerging pollutants including metals in a complex urban environment. A broad cocktail of pollutants, consisting both of persistent organic pollutants, organic phenolic pollutants, biocides, pesticides, UV compounds, emerging and conventional PFAS, siloxanes, chlorinated paraffines, organic phosphorous flame retardants and metals were measured.

The concentration of the various contaminant group in the investigated species was as follows (on a wet weight basis):

- Air : SumSiloxanes >> SumOPFRs >> SumCPs
- Soil : SumToxic metals >> SumCPs > SumPFAS
- Earthworms : SumToxic metals >SumPhenols > SumPFAS
- Fieldfare : SumPesticides > SumPFAS > SumToxic metals
- Sparrowhawk: SumPesticides > SumPCBs > SumToxic metals
- Tawny owl : SumPesticidess > SumPCBs > SumCPs
- Red fox : SumRodenticides > SumToxic metals > SumCPs
- Brown rat : SumToxic metals >> SumPFAS > SumPhenols

Contaminant data revealed larger differences both in levels and composition between the various locations for soil, earthworm and partly fieldfare than for birds of higher trophic levels. Of all the organisms and tissues measured in the study, sparrowhawk had the highest average concentration of the sum of all organic pollutants measured, followed by red fox, eathworms and tawny owl. Cyclic siloxanes, organic phosphorous flame retardants (OPFRs) and perfluorinated alkylic substances (PFAS) were first and foremost found in earthworms, and to a much lesser degree in species higher up the food chain. Phenols were found in highest concentrations in soil.

Metals; concentrations were highest in soil. Of the biological matrices analysed, worms and foxes contained the highest amounts of the toxic metals Hg, Cd, Pb and As. Fieldfare egg from one sampling site (Kjelsås) showed very high Pb concentration of 494 ng/g ww, more than 20 times higher than the other sites.

PCBs; data across all species and media revealed that sparrowhawk had the highest concentrations with SumPCB of 804 ng/g ww followed by tawny owl, fieldfare and red fox and (78, 26 and 20 ng/g ww). PCB 153 dominated in almost all sample types, with the exception of fox and fieldfare were PCB 180 dominated, and air where PCB 52 and 101 dominated.

PBDEs; similar to PCBs, sparrowhawk eggs had the highest contamination of PBDEs (SumPBDE 34.5 ng/g ww), followed by fieldfare and tawny owl with approximately 10-times lower concentrations (4.1 and 5.3 ng/g ww). Rat and fox liver showed comparable low concentrations with 1.8 and 1.5 ng/g ww followed by earthworm with 0.15 ng/g ww. While PBDE 209 dominated in soil, PBDE 47 and 99 dominated in the biological samples with the exception of tawny owl and rats, where the PBDE 153 was the most important one.

PFAS; the very high Sum PFAS concentration and the extreme PFOS concentration (955 ng/g ww) found in earthworms at Alnabru rise considerable concern for both the quality of the terrestrial ecosystem at that site, but also for the fresh- and groundwater system close by. Action should be taken to identify the identity and magnitude of the source. Sparrowhawk is the second most contaminated species with average SumPFAS of 147 ng/g ww, followed by fieldfare (134 ng/g ww).

S/MCCP; SCCPs were present in air, soil, fox, sparrowhawk and tawny owl samples, indicating an ubiquitous distribution in Oslo. MCCPs were only found sporadically, mostly in soil and worms.

Cyclic Siloxanes; besides elevated concentrations in air (average 2055 ng/sampler and highest in Slottsparken with 2893 ng/sampler), the highest concentrations in eggs of sparrowhawk (13.3 ng/g ww) was found followed by worms (13.2 ng/g ww) and tawny owl (5.5 ng/g ww). D5 was the dominating siloxane in all matrices observed.

OPFRs; were mostly found in earthworms (SumOPFR of 286 ng/g ww), compared to 1.3 ng/g ww in sparrowhawk, red fox (1.4 ng/g ww) and rat liver (4.6 ng/g).

Phenols; earthworms were the most prominent species for contamination with phenolic compounds, indicating a major uptake potential, mostly due to the contribution of bisphenol A, B and Z (average sum of 721 ng/g ww).

Pesticides; *p,p'*-DDE dominated amongt the pesticides (mean 1157 ng/g ww). Highest SumPesticide levels were also found sparrowhawk eggs, followed by fieldfare and tawny owl. Indications of shell thinning were found in sparrowhawk eggs, a known effect of DDE.

Biocides; Bromdiolone was the dominating of the ratpoisons. It was surprising to find that the levels of rat poisons were much higher in the liver of red fox (mean SumRodenticides 1635 ng/g ww) than in the rats (29.3 ng/g ww). Only bromdiolone and brodifacoum were detected.

The cumulative risk of contaminants for soil living organisms and predators was evaluated with a first tier conservative concentration addition (CA) approach using predicted no effect concentration for soil living organisms ($PNEC_{soil}$) and predators ($PNEC_{pred}$) as reference values. The RQmix-soil, describing the cumulative risk for soil-living organisms, ranged between 14 and 52, and was far above the threshold of 1 in all locations, indicating potential risk. The compounds contributing most to the risk quotient were first and foremost the metals, followed by PFOS and PCB7. The earthworms from the five sampled sites in Oslo area showed an RQmix-pred ranging between 6 and 43, indicating a risk for predators with earthworm as an important food item in all five locations. The compounds contributing most to the sum were cadmium, PFOS and PFOA. Fieldfare eggs showed an average RQmix-pred of 3.9 for secondary predators, mostly caused by PFOS, PFOA and HCB.

Sammendrag

På oppdrag fra Miljødirektoratet analyserte Norsk institutt for luftforskning (NILU) og Norsk institutt for naturforskning (NINA) en lang rekke uorganiske og organiske miljøgifter i dyrearter fra bynært og terrestrisk miljø. Formålet med studien var å gi en vurdering av forurensningssituasjonen i det terrestriske miljøet i bynære områder samt å se på samlet effekt av miljøgifter. Resultatene vil også kunne brukes i forbindelse med nasjonale og internasjonale reguleringer av stoffene.

Prosjektet hadde følgende delmål:

- Rapportere konsentrasjoner av de utvalgte miljøgifter på flere nivå av en terrestrisk næringskjede
- Vurdere bioakkumuleringspotensialet av forurensninger i en terrestrisk næringskjede
- Vurdere kombinert eksponering og risikovurdering av miljøgiftblandinger
- Vurdere hvordan terrestriske arter er utsatt for en rekke miljøgifter

Denne rapporten presenterer funnene fra det fjerde året av det urbane terrestriske programmet. For første gang i det terrestriske programmet ble også luftprøver inkludert i 2016.

Et stort antall kjemiske parametere ble analysert, i tillegg til beregning av bioakkumulering i en næringskjede og kumulativ risiko for jordlevende organismer og predatorer av meitemark og gråtrost. Resultatene har gitt en omfattende oversikt over både regulerte og mange andre nye kjemikalier som kan utøve risiko i et komplekst bymiljø. Et bredt spekter av forurensende stoffer som bestod av peristente organiske miljøgifter, fenoler, biocider, UV-forbindelser, nye og konvensjonelle PFAS, siloksaner, klorerte paraffiner, organiske fosforflammehemmere og metaller ble målt.

De mest dominerende miljøgiftgruppene i de ulike miljøprøvene var som følgende: (på våtvektbasis):

- Luft : SumSiloksaner >> SumOPFRs >> SumPCBs
- Jord : SumToksiske metaller >> SumCPs > SumPFAS
- Meitemark : SumToksiske metaller > SumFenoler > SumPFAS
- Gråtrost : SumPesticider > SumPFAS > SumToksiske metaller
- Spurvehauk : SumPesticider > SumPCBs > SumToksiske metaller
- Kattugle : SumPesticider > SumPCBs > SumCPs
- Rødrev : SumRodenticider > SumToksiske metaller > SumCPs
- Brunrotte : SumToksiske metaller >> SumPFAS > SumFenoler

Av alle organismer og vev målt i studien hadde spurvehauk den høyeste gjennomsnittlige sumkonsentrasjonen av alle organiske forurensninger, etterfulgt av rødrev, meitemark og kattugle. Sykliske siloksaner, organiske fosforflammehemmere (OPFR) og perfluorerte alkylstoffer (PFAS) ble først og fremst funnet i jord- og meitemark, og i langt mindre grad i arter høyere opp i næringskjeden. De høyeste fenolkonsentrasjonene ble funnet i jord.

Metaller; høyeste konsentrasjoner av metallene ble funnet i jord. Av alle biologiske prøver som ble analysert, ble de høyeste konsentrasjonene av de giftige metallene Hg, Cd, Pb og As

funnet i meitemark og rødrev. Gråtrost fra en av lokalitetene (Kjelsås) hadde veldig høy Pb-konsentrasjon på 494 ng/g vv, mer enn 20 ganger høyere enn de andre lokalitetene.
PCBer; av alle artene hadde spurvehauk de høyeste konsentrasjonene med SumPCB på 804 ng/g vv etterfulgt av kattugle, gråtrost og rødrev (78, 26 og 20 ng/g vv). PCB 153 dominerte i alle prøvetyper bortsett fra rødrev og gråtrost der PCB 180 dominerte, og luft der PCB 52 og 101 dominerte.
PBDEer; som for PCB, så hadde spurvehaukegg de høyeste sum konsentrasjonene av PBDE (SumPBDE 34.5 ng/g vv), etterfulgt av gråtrost og kattugle med ca. 10 ganger lavere konsentrasjoner (4.1 og 5.3 ng/g vv). Lever fra rotte og rødrev viste sammenlignbare lave konsentrasjoner med 1.8 og 1.5 ng/g vv etterfulgt av meitemark med 0.15 ng/g vv. Mens PBDE 209 dominerte i jord, så ble PBDE 47 og 99 funnet i høyeste konsentrasjoner i biologiske prøver med unntak av kattugle og rotte, hvor PBDE 153 dominerte.
PFAS; den høye sumkonsentrasjonen og ekstreme PFOS-konsentrasjonen (955 ng/g vv) som ble funnet i meitemark i Alnabru indikerer risiko for det terrestre miljøet i nærheten av Alnabru, men også helse- og miljørisiko knyttet til ferskvann. Videre undersøkelser bør foretas for å undersøke forurensingskilden samt nødvendige tiltak. Etter meitemark var spurvehauk den mest forurensede arten med gjennomsnittlig sumPFAS på 113 ng/g vv, etterfulgt av gråtrost, rotte og meitemark.
S/MCCP; SCCP var tilstede i luft-, jord-, rev-, spurvehauk- og kattugleprøver, noe som indikerer en utbredelse i bymiljøet i Oslo. MCCP ble bare funnet sporadisk, hovedsakelig i jord og meitemark.
Siloksaner; i tillegg til forhøyede konsentrasjoner i luften (gjennomsnittlig 2055 ng/sampler og maksimum i Slottsparken med 2893 ng/sampler) ble de høyeste konsentrasjonene funnet i spurvehauk (13.4 ng/g vv) etterfulgt av meitemark og kattugle (13.2 og 5.5 ng/g vv). D5 var den dominerende siloksanen i alle typer prøver.
OPFRs; ble først og fremst funnet i meitemark (SumOPFR of 25.4 ng/g vv), sammenlignet med 4.6 i rotter og 1.3 ng/g vv i spurveahauk.
Fenoler; meitemark hadde de høyeste fenolkonsentrasjonene, som for det meste skyldtes bisfenol A, B og Z (gjennomsnittlig sum 721 ng/g vv).
Pesticider; *p,p'*-DDE dominerte blant pesticidene. De klart høyeste pesticidnivåene ble funnet hos spurvehauk, dernest hos gråtrost og kattugle. Indikasjoner på skallfortynning ble funnet hos spurvehauk, en effekt av DDE.
Biocides; Bromdiolone var det dominerende av rottegiftene, og bare brodifacoum ble funnet I tillegg. Det var overraskende å finne at nivåene av rottegift var mye høyere i rødrev (gj.sn. SumRodenticides 1635 ng/g vv) enn i rotte (29.3 ng/g vv).

Bioakkumuleringspotensialet av miljøgifter i den terrestre næringskjeden jord- meitemark - gråtrost - spurvehauk ble evaluert. Kattugle, rev og rotter er også del av næringsnettet og indikatorer for urbane spesialister (kattugle) og opportunister (rev og rotter). Beregningene av den trofiske anrikningsfaktoren (trophic magnification factor, TMF) indikerte høy anrikning for PCB og PBDE mellom trofiske nivåer.

Den kumulative risikoen av miljøgifter for jordlevende organismer og rovdyr ble evaluert med en konservativ konsentrasjonsaddisjon (CA) tilnærming med bruk av PNECsoil og PNECpred som referanseverdier for hhv jordøkosystem og predatorer. RQmix-soil, som beskriver den kumulative risikoen for jordlevende organismer, varierte mellom 14 og 52, og derfor langt over terskelen på 1 som indikerer potensiell risiko. Forbindelsene som bidro mest til risikokvotienten var først og fremst metallene, etterfulgt av PFOS og PCB7. Meitemarkene fra de fem prøvelokalitetene i Oslo-området viste en RQmix-pred på mellom 6 og 43, noe som indikerte en risiko for dyr der meitemark utgjør en stor del av dietten. Forbindelsene som bidro mest til summen var kadmium, PFOS og PFOA. Gråtrostegg viste gjennomsnittlig RQmix-pred på 3.9 for rovdyr, hovedsakelig forårsaket av PFOS, PFOA og HCB.

Abbreviations

BFR	brominated flame retardants
CA	concentration addition
CI	confidence interval
dw	dry weight
EI	electron impact ionization
ESI	electrospray ionization
EAC	ecotoxicological assessment criteria
EQS	environmental quality standard
ww	wet weight
GC-HRMS	gas chromatography - high resolution mass spectrometry
GC-MS	gas chromatography - mass spectrometry
ICP MS	inductive coupled plasma - mass spectrometry
LC-MS	liquid chromatography - mass spectrometry
LOD	limit of detection
lw	lipid weight
MEC	measured environmental concentration
M-W U	Mann-Whitney *U* test
MCCP	medium-chain chlorinated paraffins
N	detected/measured samples
NCI	negative chemical ionization
NOEC	no observed effect concentration
NP-detector	nitrogen-phosphorous detector
PBDE	polybrominated diphenylethers
PCA	principal component analysis
PCB	polychlorinated biphenyls
PCI	positive chemical ionization
PEC	predicted environmental concentration
PFAS	perfluorinated alkylated substances
PNEC	predicted no effect concentration
$PNEC_{pred}$	predicted no effect concentration for predator
PSA	primary/secondary amine phase
SCCP	short-chain chlorinated paraffins
SSD	species sensitivity distribution
SIR	selective ion reaction
SPE	solid phase extraction
STU	sum toxic unit
TL	Trophic level
TMF	Trophic magnification factor
UHPLC	ultra high pressure liquid chromatography

Content

Attachments:

Appendix 1: Concentrations of pollutants in individual samples
Appendix 2: PNECsoil and PNECpred from various literature sources
Appendix 3: GPS locations for sampling locations

1. Introduction

1.1 Background and objectives

The main objective of this monitoring study was to investigate the concentrations of selected organic and inorganic pollutants and their bioaccumulation potential and possible adverse effects in species living in a terrestrial and urban ecosystem. The urban sites were chosen in or in the near vicinity of Oslo. The results from this study will feed into the evaluation of potential environmental hazard, and ongoing regulatory work at both national- and international level. The project had the following key goals:

- Report concentrations of chosen environmental pollutants in several trophic levels of the terrestrial food chain
- Evaluate the bioaccumulation potential of pollutants in the terrestrial food chain
- Evaluate the total exposure and predict the risk from mixture of pollutants in terrestrial animals
- Evaluate how land-living species are exposed to a variety of pollutants

1.2 Investigated samples

Sparrowhawk (*Accipiter nisus*).
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 & Bogan 1978, 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 cultured 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.

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, 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.

Small rodents

Small rodents are common mammals in Norway. They represent an important food source for owls and live in a grassy habitat. They are herbivores, feeding on grass and roots and other vegetation, occasionally on insects as well. Estimated trophic level: 1-2. Our sample was a mix of two species; bank vole (klatremus, *Myodes glareolus)* and wood mouse (småskogmus, *Apodemus sylvaticus)*.

Soil

Soil samples were taken from the surface layer (0-10 cm), combining three subsamples to one combined sample per location. The total organic carbon (TOC) was determined for each location to be used in bioconcentration estimations. The location for soil samples were the same locations as for the earthworm samplings to make direct comparisons possible.

Air

At three locations chosen for soil- and earthworm sampling (Alnabru, Slottsparken and Voksenkollen), air samples were collected. We used passive airsamplers consisting of PUF and XAD samplers over a period of three months (June to August 2016).

1.3 Investigated pollutants

In this study a total of 73 compounds were investigated. These included 11 metals, 7 PCBs, 16 PFAS, 14 PBDEs, three siloxanes (D4, D5 and D6), chlorinated paraffins, organic phosphorous compounds (OPFRs), UV compounds, biocides and phenolic compounds, together with the stable isotopes $\delta^{15}N$, $\delta^{13}C$ and $\delta^{34}S$. Some pesticides (DDT and breakdown products, HCB, chlordanes and Mirex) were analysed in the bird species. Thirty additional 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 1

Table 1: 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 substances (PFAS)		
Perfluorinated hexanoic acid	PFHxA	307-24-4
Perfluorinated heptanoic acid	PFHpA	375-85-9
Perfluorinated octanoic acid	PFOA	335-67-1
Perfluorinated nonanoic acid	PFNA	375-95-1
Perfluorinated decanoic acid	PFDcA	335-76-2
Perfluorinated undecanoic acid	PFUnA	2058-94-8
Perfluorinated dodecanoic acid	PFDoA	307-55-1
Perfluorinated tridecanoic acid	PFTriA	72629-94-8
Perfluorinated tetradecanoic acid	PFTeA	376-06-7
Perfluorinated butane sulphonate	PFBS	375-73-5
Perfluorinated pentane sulphonate	PFPS	2706-91-4
Perfluorinated hexane sulphonate	PFHxS	355-46-4
Perfluorinated heptane sulphonate	PFHpS	375-92-8
Perfluorinated octane sulphonate	PFOS	2795-39-3
Perfluorinated nonane sulphonate	PFNS	17202-41-4

Perfluorinated decane sulphonate	PFDcS	67906-42-7
6:2 Fluortelomersulphonate	6:2 FTS	27619-97-2
8:2 Fluortelomersulphonate	8:2 FTS	
New PFAS		
F53	F53	
F53B	F53B	
Monochlorinated PFOS	Cl-PFOS	
Monochlorinated PFOA	Cl-PFOA	
Polybrominated diphenylethers (PBDE) and other FRs		
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
Decabromodiphenylether 209	BDE-209	1163-19-5
Decabromodiphenyl ethane	DBDPE	84852-53
Dechlorane plus		13560-89-9
Dec-602		
Dec-603		
Dec-604		
Cyclic Siloxanes	D4	556-67-2
	D5	541-02-6
	D6	540-97-6
Chlorinated paraffins	SCCP (C10-C13)	85535-84-8
	MCCP (C14-C17)	85535-85-9
Phosphorous organic flame retardants (PFR):		
Tri(2-chloroethyl)phosphate	TCEP	115-96-8
Tri(1-chlor-2-propyl) phosphate	TCPP	13674-84-5
Tri(1,3-dichloro-2-propyl)phosphate	TDCPP	13674-87-8
Tri(2-butoxyethyl) phosphate	TBEP	78-51-3
2-etylhexyl-di-phenyl phosphate	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
UV compounds:		
Octocrylen		6197-30-4
Benzophenone-3		131-57-7
Ethylhexylmethoxycinnamate		5466-77-3
UV-327		3864-99-1
UV-328		25973-55-1
UV-329		3147-75-9
Biocids:		
Bromadiolon		28772-56-7
Phenols:		
Bisphenol A		80-05-7
Bisphenol S		80-09-1
Bisphenol F		1333-16-0
Hexafluorobisphenol A		1478-61-1
Bisphenol BP		1844-01-5

Bisphenol B	77-40-7
Bisphenol Z	843-55-0
Bisphenol AP	1571-75-1
Bisphenol E	2081-08-5
Bisphenol FL	3236-71-3
BIsphenol P	2167-51-3
Bisphenol M	13595-25-0
Bisphenol G	127-54-8
Bisphenol TMC	129188-99-4
Nonylphenol	104-40-5
Octylphenol	1806-26-4
Tetrabromobisphenol A	79-94-7
Pesticides:	
α-**HCH**	319-84-6
β-**HCH**	319-85-7
γ-**HCH**	58-89-9
HCB	118-74-1
Oxy-**Chlordane**	27304-13-8
Trans-**Chlordane**	5103-74-2
Cis-**Chlordane**	5103-71-9
Trans- **Nonachlor**	39765-80-5
Cis- **Nonachlor**	5103-73-1
Mirex	2385-85-5
o,p-**DDT**	789-02-6
p,p'-**DDT**	50-29-3
o,p-**DDE**	3424-82-6
p,p'-**DDE**	72-55-9

1.3.1 Metals including Hg

Mercury (Hg), Lead (Pb) and Cadmium (Cd) are metals that are toxic and have adverse effects on environment and health, even at very low concentrations. 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 three metals are considered as environmentally hazardous compounds (Latif et al. 2013). Arsenic (As) was also included in the group of toxic metals. 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.

1.3.2 Polychlorinated biphenyls (PCB)

Polychlorinated biphenyles (PCBs) have been used in a variety of industrial applications since the 1930s. PCBs 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 PCBs 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 results, PCBs are recognized as persistent organic pollutants and are regulated under the Stockholm Convention. They are widely distributed in the environment and can be found in air, water, sediments and biota. Most PCBs 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. PCBs can be metabolized in organisms and form metabolites causing hormonal disturbances. This study includes the group of PCBs found to be dominating most environmental samples, the non-dioxin like PCBs, the PCB7 group.

1.3.3 Polybrominated diphenylethers (PBDE)

Polybrominated diphenylethers (PBDEs) 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 decabromodiphenyl ether. These are all technical mixtures containing different PBDE congeners. Tetra-, penta-, hexa- and heptaBDE congeners were listed in the Stockholm Convention 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 and listed in the Stockholm Convention. 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 aggreement for including decaBDE in the Stockholm Convention as a persistent organic pollutant 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 PBDEs. 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 PBDEs, and most probably better waste handling, have resulted in a decrease of most BDEs, except BDE 209, the main component of commercial decaBDE, over time (AMAP 2009; Helgason et al. 2009). Spatial trends of PBDEs 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 hexaBDEs biomagnify in arctic food webs while results for the fully brominated PBDE congener, BDE 209 or decaBDE, are more ambiguous. Several lines of evidence show that also BDE-209 bioaccumulates, at least in some species. The equivocation in 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. 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).

1.3.4 Per- and polyfluorinated alkyl substances (PFAS)

Per- and polyfluorinated alkylated substances (PFASs) have been widely used in many industrial and commercial applications. The chemical and thermal stability of a perfluoroalkyl moiety, which is caused by the 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, PFASs 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; de Wit et al. 2012).Studies have revealed the potential for atmospheric long-range transport ofPFAS (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 listed in the Stockholm Convention and are recognized as persistent organic pollutants. 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[1] 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.

1.3.5 Cyclic siloxanes, (cVMS)

There are concerns about the properties and environmental fate of the three most common cyclic siloxanes 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 to stop emissions of these substances within 2020. In 2015 a proposal to restrict D4 and D5 in wash-off personal care products in EU was submitted under REACH, and will likely be adopted by the end of 2017.

1.3.6 Chlorinated paraffins (CPs)

CPs have been produced since the 1930s and the world production of chloroparaffins was 300,000 tonnes in 2009. Chloroparaffins 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 CPs, particularly at high chlorine contents,

---

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

relies on their ability to release hydrochloric acid at elevated temperatures, thereby inhibiting the radical reactions in flames (WHO, 1996).

CPs have been studied in the environment, but data from Scandinavia and the Arctic is limited (Bayen et al. 2006). In air collected at Bear Island (Norway), concentrations were 1.8 to 10.6 ng/m^3 (Borgen et al. 2003) while SCCPs have been detected in river water in a range of 15.7 to 59.6 ng/L in the St. Lawrence River, Canada (Moore et al., 2004) and < 0.1 to 1.7 µg/L in England and Wales (Nicholls et al., 2001). SCCP have been detected in surface sediments in Arctic lakes in Canada 1.6 to 257 ng/g (Tomy et al., 1997), and SCCPs and MCCPs 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). CPs have been detected in biota samples collected in Norway, SCCPs 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 SCCPs in the atmosphere (Borgen et al., 2003). Levels of MCCPs ranged from 276 to 563 ng/g ww in carp and 0.257 to 4.39 µg/g ww in trout from Lake Ontario. In Beluga whales collected between 1987 and 1991, SCCPs ranged from 1.78 to 80.0 µg/g ww in blubber and 0.545 to 20.9 µg/g ww in liver samples (Bennie et al. 2000). In fish livers collected from samples in the North and Baltic Seas, SCCPs and MCCPs ranged from 19 to 286 and <10 to 260 ng/g ww (Geiss et al. 2010; Reth et al. 2006). SCCP was included in the POPs Regulation (EC) 850/2004 by the amendment (EU) 2015/2030 in 2015. So far MCCPs are not globally regulated, however, SCCP has recently been included in the Stockholm Convention, and a global regulation will be effectuatated within November, 2019.

1.3.7 Organophosphorous flame retardants (OPFR)

The global use of phosphorous containing flame retardants in 2001 was 186000 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 PFR 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).

1.3.8 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 one of the main sources 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 (BPA) is an industrial chemical with high production volumes used in the production of polycarbonate plastics and epoxy resins. Due to its versatile use, BPA 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. These days two of the analogues – bisphenol S (BPS) and bisphenol F (BPF) have been mostly used as bisphenol A replacements. BPS 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). BPS is also used as a wash fastening agent in cleaning products, an electroplating solvent and constituent of phenolic resins (Clark, 2000). BPF 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 BPA by the polymer industry triggered its replacement with bisphenol S (BPS) in thermal paper and other products. Bisphenol F (BPF) and bisphenol B (BPB) can replace BPA 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 (BPAF) has broad application in the manufacture of phenolic resins or fluoroelastomers. Annual production is assumed to be in the range of 5 to 300 tons in the USA (Yang et al. 2014). Unfortunately, those new bisphenol compounds could have similar deleterious effects as BPA. Recent studies have indeed demonstrated possible estrogenic activity similar to that of BPA (Rosenmai et al. 2014).

1.3.9 UV compounds

Concern over our contribution to the loads of environmental contaminants originating from our use of personal care products is continuing to grow. Due to their continuous release via wastewater effluent, personal care products have been termed pseudo-persistent (Barceló & Petrovic, 2007) irrespective of their PBT characteristics. The increase in public awareness over the dangers of over-exposure to sunlight has lead in 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 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 form manufacture or use in Japan. Filter-feeding and sediment-dwelling organisms contained some of the high concentrations indicating sorption to particulates is a likely sink for some benzotraizole UV stabilizers. 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).

1.3.10 Biocides

Rodenticides are classed 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 1 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 anaerial application of ceral-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 anthropod 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.

1.3.11 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).

2. Methods

2.1 Sampling

The main objective of the project was to assess the pollution present in selected terrestrial urban environments in Norway, and to evaluate the combined risk of these pollutants and assess their bioaccumulation. A variety of locations were chosen for sampling of air, soil, worms and when possible fieldfare eggs, reflecting the different area uses in an urban setting: Alnabru, an idustrialised site; Slottsparken, an urban parks surrounded by traffic; Voksenkollen and Frognerseteren, popular skiing areas, also used for international competitions; Svartdalsparken, a semi-rural area. The different species included in the study were selected to represent different trophic levels, from primary consumers (earthworm) via secondary consumers (fieldfare) to a top predator (sparrowhawk). In addition, two omnivore generalists representing a truly urban environment, the red fox and the brown rat, were chosen. The tawny oml is also top predator, feeding primarily on small rodents. Sparrowhawk and tawny owl eggs were used in this study to give insights to how a terrestrial top predators within both urban and rural habitats is affected by pollution levels and their biomagnification potentials. An overview over the analysed species and samples is given in Table 2. All samples were sampled and handled according the guidelines given in OSPAR/ JAMP, 2009.

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

Sample type	No. of samples	Location	Date	Sampling strategy
Air	3	Oslo	2016	Passive air samples
Soil	5	Oslo	2016	Pool of individual samples
Earthworms (*Lumbricidae*)	5	Oslo	2016	Pool of individual samples
Fieldfare (*Turdus pilaris*)	10	Oslo	2016	Pool of 2 individual samples
Sparrowhawk (*Accipiter nisus*)	10	Oslo	2016	Fresh eggs
Brown rat (*Rattus norvegicus*)	10	Oslo	2016	Pool of 2 individual samples
Tawny owl (*Strix aluco*)	10	Ås, Vestby	2016	Fresh eggs
Red fox (*Vulpes vulpes*)	10	Oslo	2016	Individual liver samples
Small rodents (*Myotis glareolus* and *Apodemus sylvaticus*)()	1	Ås	2016	Pool of 10 samples

Air

Passive air samples were collected at three locations (Alnabru, Slottsparken and Voksenkollen), same spots as chosen for soil and worms.

Air Samplers were prepared and put out by NILU personnel. Air samples consisted of PUF and XAD materials to be able to gather a wide range of volatile pollutants. This is considered as the the most correct sampling strategy for non-regulated components (still in use) (Melymuk et al., 2016) and it gives the opportunity to compare the results with previous studies of semi volatile organic compounds in Norway and other Nordic countries (Sweden) and Europe. To cover as wide spectrum of volatile chemicals as possible, a set of "current state-of-art" passive air samplers with three different adsorbents were used: i) Polyurethane foam (PUF), ii) XAD adsorbent and iii) Tenax adsorbent. PUF is the most widely used passive sampler at the global level, both in indoor and outdoor environments, it is placed in a metal container that controls the absorption of chemicals and it is exposed during 8-12 weeks. PUF is a hydrophobic material having good capacity for hydrophobic components. It covers the largest part of volatile components in the gas phase, but it is also shown that it has the capacity to take up particles and thereby the less volatile particle-bound components - albeit with lower accuracy. XAD- and Tenax adsorbents are common samplers for outdoor use, it only takes up the gas phase, but have the capacity to capture volatile substances not accessible to PUFs, such as perfluorinated alkanes, siloxanes and other volatiles. Passive samplers provide semiquantitative levels that commonly are stated per sampler. These can be converted to air concentrations with the aid of a recording speed obtained from calibration studies. For the components of this study there are no calibration studies, and a general admission rate (0.5 to 1 m^3/day) were therefore used. 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.

	Placed out	Collected
Alnabru	14. juni	13. sept
Holmenkollen	14. juni	13. sept
Slottsparken	17. juni	16. sept

Soil

Soil samples were collected at five locations (Figure 1). The upper layer of 0-10 cm of soil was sampled. The different locations varied between forest soil (Voksenkollen, Frognerseteren), and urban soil characterized by little plant debris and artificial fertilisation (Slottsparken, Svartdalsparken) and potential industrial affected soil (Alnabru).

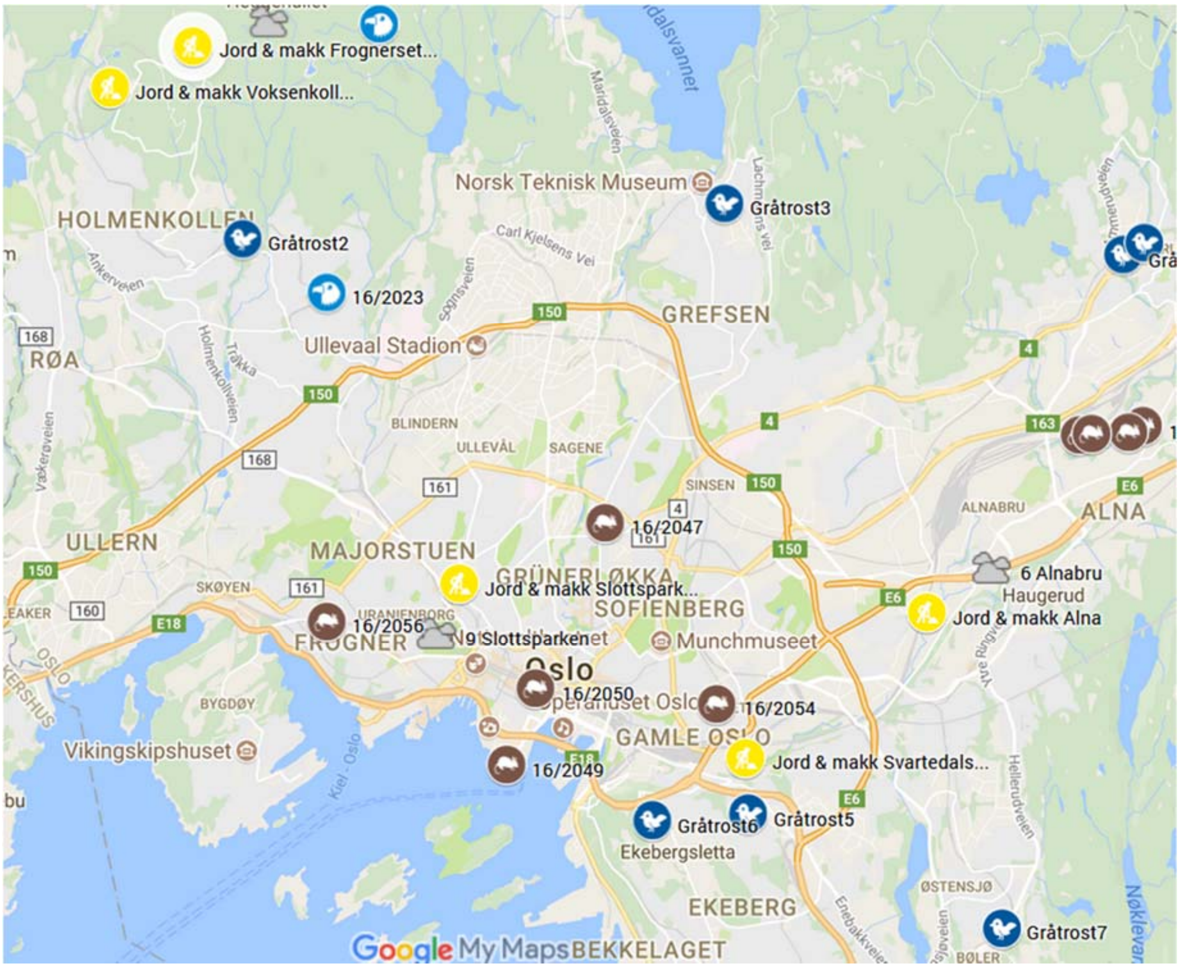


Figure 1: Locations for soil and earthworms (yellow circle) and air samples (grey) samples in Oslo area. Other samples shown on the figure are fieldfare (dark blue), sparrowhawk (blue) and rodents (brown).

Earthworms (*Lumbricidae*)

Earthworms were collected at the same five locations in Oslo as the soil samples to allow a direct comparison (Figure 1). All pooled samples consisted of up to 10 individuals. To purge their guts, earthworms were kept in plastic containers lined with moist paper sheets for three days before being frozen at -21°C.

Figure 2: Habitat (left) and soil profile (right) of the soil and worm sampling-site in Voksenkollen.

Fieldfare *(Turdus pilaris)*
Two fieldfare eggs were collected from each out of ten nests in the Oslo area, under permission from the Norwegian Environment Agency. The laying order of the eggs was not taken into account when collecting the eggs due to practical considerations as not to disturb 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 were 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).

Sparrowhawk *(Accipiter nisus)*
Sparrowhawk eggs were collected at different locations in the Oslo area (N=10). The exact location of the nests is known to the authors and the contractor, but will not be published here in order to protect the nesting sites. Nests were located early in the breeding season, and sampled in April-May just after eggs had been laid. The eggs were handled by the same method as the fieldfare eggs at NINA.

Tawny owl *(Strix aluco)*
Tawny owl eggs were collected 20th of April in Ås and Vestby district. The eggs were handled by the same method as the fieldfare eggs at NINA.

Brown rat *(Rattus norvegicus)* **and small rodents** (*Myotis glareolus* and *Apodemus sylvaticus*)
Rodents and rats were caught using clap-traps (no rat poison involved). Liver samples of two rats of the same sex and 10 voles consisting of an equal number of both sexes, were pooled together for analyses. The final sample number was 5 liver samples of female rats and 5 liver samples of male rats. The bodyweight of the female rats ranged between 148 g and 304 g and for male rats between 54 g and 384 g. Liver weights varied between 3.8 and 21.6 g. For the voles, the bodyweight varied between 10 and 31 g, with liverweights varying between 0.5 and 1.6 g.

Figure 3. Wood-mouse caugt in a clap-trap. Photo: Neri Horntvedt Thorsen.

Red fox *(Vulpes vulpes)*
Red foxes for the urban pollution measurements were collected in Oslo, (Amotkollene, Maridalen og Sørkedalen). The foxes were shot by local hunters on assignment from NINA. Dissection of their livers was carried out at the laboratories of NINA, applying the siloxane relevant precautions. The samples were wrapped in aluminium foil and thereafter put into sealed polyethylene bags before being frozen at – 21°C. Among the sampled foxes, we collected 6 males and 4 females. Their age was estimated to vary between 1 and 4 years. Their sex was determined by inspection of the gonads, while the age was determined by examining the incremental layer-structure in their teeth (Morris, 1972).

Quality assurance
NINA and NILU are certified to both ISO 9001 and 14001. In addition, the "Guidelines for field work in connection with environmental monitoring" were followed (JAMP; OSPAR). Moreover, special precautions were taken to prevent contamination of samples during field work. Sample collection manuals tested and adapted to special conditions so as 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.

2.2 Sample preparation and analysis

Preparation of bird eggs and measurement of eggshell thickness

Length (L) and breadth (B) of eggs were measured with a vernier calliper to the nearest 0.1 mm. The eggs were weighed before emptying (W_b). A hole was drilled at the equator, and the contents were transferred to a glass container and sealed with sheets of aluminium foil. The egg volume was calculated by using the formula

$$V = 0.51 * L * B^2$$

The dried eggshells were measured (length (mm), breadth (mm) and weight (W_s) (in mg)) 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). The data for shell thickness can be found in the Appendix.

The shell index was calculated according to following equation:

$$SI = W_s\ (mg)/L \times B.$$

Chemical analysis

Due to the differing physicochemical properties of the pollutants of interest, several sample preparations methods were applied. Lipophilic compounds as PBDEs and PCBs were analyzed together. PFAS and metals required a dedicated sample preparation each. Together three different sample preparation methods were applied.

PBDEs, CPs, DDTs, pesticides and PCBs. All biological samples were prepared in a similar manner. Briefly, 3-4 grams of sample were mixed and homogenized with a 20 fold amount of dry Na_2SO_4. The homogenate was extracted using a mixture of Acetone/ Cyclohexane (1/1 v/v). The organic extract was evaporated and treated 2-4 times with 3-4 mL of concentrated sulfuric acid to remove the lipids. Extracts were measured using GC/HRMS.

PFAS. Samples were extracted with acetonitrile and treated with emulsive clean-up prior to analyses with UPLC/MS/MS in ESI(-) mode.

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 220ºC 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. 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 spectormetry (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 vigirous mixing on a horitonal mixer for one hour. Resulting hexane phase was collected and analysed using CSR-LVI-GC/MS.

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 SFC-MS (super critical fluid chromatography – mass spectrometry). Rodenticides were separated on a C18 column with methanol (0.1% formic acid) as both the make-up and the mobile phase, using a gradient elution.

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 the 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 labeled internal standards for the BFRs (^{13}C DBDPE), PCBs (^{13}C PCBs) 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 10 samples, one standard reference material (SRM; NIST 1945 for PCBs and PBDEs and PERFOOD intercal 2012 for PFAS) and one blank sample was prepared. 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 preperation was performed within a clean cabinet (equipped with HEPA- and activated carbont filter) to avoid contamination from sources within the indoor environment and perform trace analysis of these compounds in matrices from pristine environment (Krogseth et al. 2013; 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. The data were used to calculate limits of quantification (average blank response + 3 times standard deviation of response). To ensure accuracy of measured results, a random sample from each matrix was selected for duplicate analysis. Field blanks were prepared for the sampling of samples 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 contamiantion. 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. All data are listed in the Appendix. The total organic content in soil was determined by Akvaplan-niva.

2.3 Biomagnification

Similar to the urban terrestrial study from 2015, (Herzke et al., 2016), 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, fieldfare = 3, sparrowhawk = 4.

For earthworms we modified the TL value by multiplying it with the ratio between the sample $\delta^{15}N_{\text{sample}}$ and the average $\delta^{15}N$ 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):

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

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

For further data assessment of the biomagnification, all sumPCB and sumPBDE data were lipid normalized. PFAS are not lipophilic compounds (Kelly, 2009), however we performed calculations for SumPFAS both on lipid weight basis and wet weight basis for comparisons. 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.

$\text{Log [compound]} = a + bTL$

$TMF = 10^b$

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

The here estimated TMFs have to 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 those only reflect the short term exposure rather than the long term one.

2.4 Statistical methods

Statistics were performed using SPSS statistics, ver. 24 (® 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 was made to substitute LOD with an expected concentration value (C_{exp}), using the total number of analyzed samples of same type (N_{tot}), and the number of samples with concentration levels above LOD (N_{above}):

$$C_{exp} = LOD^* \ N_{above}/N_{tot}.$$

In such cases, <LOD has been substituted with C_{exp}, and in the tables the number of detected (n) over measured samples (N) are given.

2.5 Mixture risk assessment

The method of summing up PEC/PNEC or MEC/PNEC ratios was used as a justifiable mixture risk approximation in order to estimate in a first tier approach whether there is a potential risk for an exposed ecosystem (Backhaus and Karlsson, 2014; Petersen et al, 2013; Backhaus and Faust 2012). In order to evaluate the risk for soil living organisms such as earthworm, the measured concentration (MEC) of the contaminants in pooled soil samples was compared to the PNEC for soil ecosystem for the specific contaminants. The potential mixture effects was assessed by summing up the MEC/PNECsoil ratios for each locations. For terrestrial predators feeding on lower trophic levels, the MEC values of earthworm and fieldfare eggs were compared to predicted no-effect concentration for oral intake ($PNEC_{pred}$). PNEC values were adopted from previously assessed and reported values (Andersen et al., 2012) and literature search, see Appendix 2. The single MEC/PNEC was calculated and summed up to assess if the sum exceeded 1 or not. The methodology was applied with the presumption that the available PNEC values were protective and assessed for the most sensitive species, in accordance to the guidelines for deriving PNEC values (ECHA, 2008).

3. Results

Of the 109 compounds that were analysed in all samples, 78 could be detected. In the chapters below, we mainly discuss the sum for each group of contaminants investigated. Single compounds/ congeners are only discussed in special cases. Detected concentrations are summarized in the tables below (means, medians, maximums and minimums) and individual data can be found in the Appendix. The number of cases (N/N) in all tables denotes the number of detectable/measured samples.

In general, the largest number of substances and the highest concentrations of halogenated organic pollutants were found in sparrowhawk eggs. PCB and PBDE levels were highest in sparrowhawk, while PFAS levels were high in both sparrowhawk, rats, fieldfare and earthworms. Toxic metals were found in highest concentrations in earthworm, brown rat and red fox. Siloxanes and SCCP were detected in all sample matrices, with highest concentrations of siloxanes found in earthworms and sparrowhawk, while chlorinated paraffins were highest in sparrowhawk eggs. Phenols were highest in earthworms and brown rat, while OPFRs were highest in earthworms.

3.1 PCBs

3.1.1 Air

For the first time in the urban terrestrial program, air was sampled in 2016 with passive air samples. Of the seven measured PCBs, all were found in all three air samples, with PCB 28, 52, 101 and 118 being the dominating congeners. Of the three sampled locations, Slottsparken showed the highest levels with sumPCB of 91.8 ng/ sampler, followed by Alnabru and Voksenkollen with respectively 6.8 and 2.5 ng/ sampler. After calculating concentrations respective to the estimated airmasses that passed through the sampler, the following sumPCB concentrations were achieved: 277 pg/m^3, 18 and 5 pg/m^3 for Slottsparken, Alnabru and Voksenkollen. For comparison, SumPCB (=SumPCB$_7$) data from the background air quality station at Birkenes in southern Norway showed concentrations of 4.5 pg/m^3 in 2014 and 2.5 pg/m^3 in 2015 (Bohlin-Nizzetto et al, 2015; Bohlin-Nizzetto et al, 2016). In our present study comparable levels to those detected at Birkenes was found at Voksenkollen. The air concentrations at Voksenkollen was 50-times lower than air from Slottsparken and 3-times lower than Alnabru.This indicates that the urban environment is a significant source to PCB concentrations in air.

3.1.2 Soil

SumPCB concentrations varied between 1.27 and 2.5 ng/g dw, with a median of 1.39 ng/g dw (Table 3). The highest sumPCB concentrations were measured in Slottsparken followed by Frognerseteren. According to the Norwegian guidelines on classification of environmental quality of soil (normverdi), 10 ng/g dw sumPCB$_7$ corresponds to a good environmental status (SFT 2009). None of the samples analysed in this study exceeded this threshold value.

Table 3: PCB concentrations in soil in ng/g dw. N: number of detected/ analysed samples.

	PCB28	PCB52	PCB101	PCB118	PCB138	PCB153	PCB180	SumPCB7
N	0/5	0/5	1/5	4/5	5/5	5/5	3/5	
Mean	<LOD	<LOD	0.09	0.20	0.59	0.72	0.18	1.78
Median	<LOD	<LOD	<LOD	0.20	0.53	0.66	0.22	1.39
Minimum	<LOD	<LOD	<LOD	<LOD	0.43	0.53	<LOD	1.27
Maximum	<LOD	<LOD	0.46	0.41	0.81	0.94	0.44	2.50

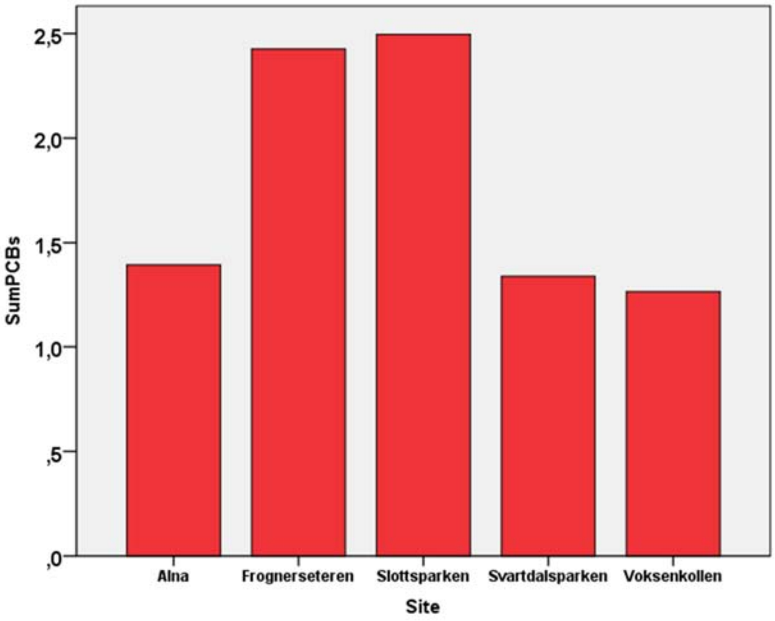


Figure 4: SumPCB concentrations (ng/g dw) in soil at the different sampling sites.

3.1.3 Earthworms

SumPCB concentrations in Earthworms ranged from 0.6 ng/g ww to 3.5 ng/g ww. The median sumPCB concentration was 2.27 ng/g ww, comparable with 2014 and 2015 data (1.11 and 1.16 ng/g ww). The detailed results are shown in Table 4. PCB 138 and 153 were the dominating PCBs measured.

Table 4 : PCB concentrations in earthworms in ng/g ww. N: number of detected/ analysed samples.

	PCB28	PCB52	PCB101	PCB118	PCB138	PCB153	PCB180	SumPCB7
N	0/5	0/5	4/5	4/5	5/5	5/5	5/5	
Mean	<LOD	<LOD	0.25	0.21	0.49	0.97	0.22	2.15
Median	<LOD	<LOD	0.17	0.17	0.46	1.26	0.20	2.27
Minimum	<LOD	<LOD	<LOD	<LOD	0.16	0.31	0.12	0.76
Maximum	<LOD	<LOD	0.73	0.35	0.78	1.46	0.46	3.33

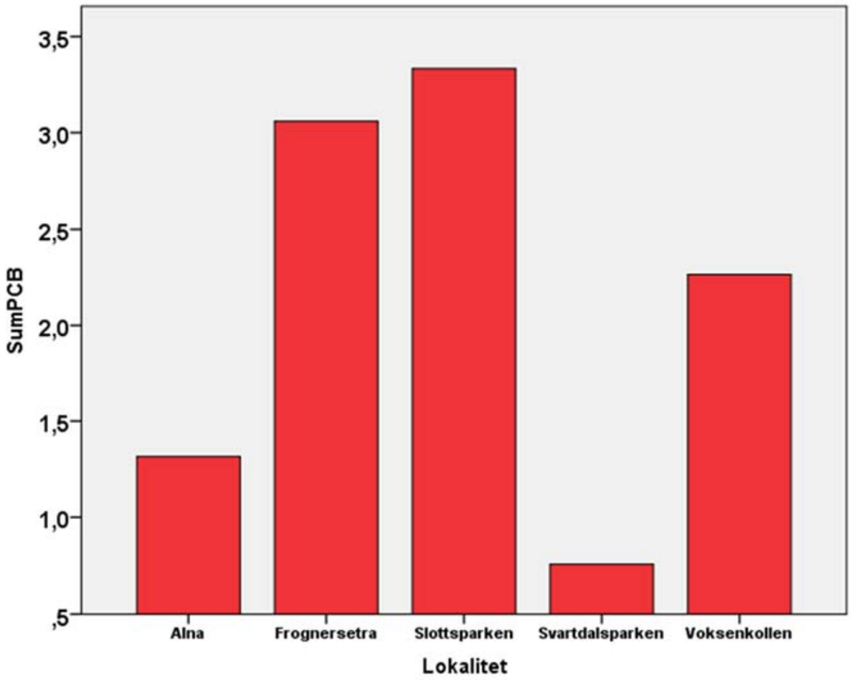


Figure 5: SumPCB concentrations in earthworms at the different sampling sites in ng/g ww.

3.1.4 Fieldfare

SumPCB concentrations varied between 9.7 and 76 ng/g ww, with a median of 17.9, which was similar to the median concentration of 18.7 ng/g ww reported in the 2015 (Herzke et al., 2016). A summary of values are given in Table 5. PCB 138, 153 and 180 dominate the PCB pattern (Figure 6). For improved interspecies comparability, lipid related concentrations are used (lw). Data for great tits (Parus major) were available and will be used for comparison purposes. In our study, 453 ng/g lw sumPCB were detected in the fieldfare eggs. This is about a tenth of that found in eggs of great tits in Belgium (average sumPCB$_{21}$ concentrations of 4110 ng/g lw) (Voorspoels et al., 2007), and almost similar to levels in fieldfare reported in our report from 2015 (427 ng/g lw sumPCB) (Herzke et al., 2015). In a second study, PCBs in eggs of great tits collected all over Europe were studied in 2009 (Van den Steen et al. 2009). This study included a Norwegian location as well, a suburban site close to Oslo. The PCB concentration of 22 congeners of nearly 1000 ng/g lw in the Norwegian loaction was twice as high as found in our present study. A more recent study on starling eggs (*Sturnus vulgaris*), sampled worldwide, showed less than 500 ng/g lw sumPCBs at the one included Norwegian rural location in Northern Trøndelag (Eens et al. 2013), similar to what was observed in our fieldfare eggs from 2016.

Table 5 : PCB congener concentrations in fieldfare eggs from 2016 in ng/g ww. N: number of detected/ analysed samples.

	PCB28	PCB52	PCB101	PCB118	PCB138	PCB153	PCB180	SumPCB7
N	3/10	10	10	10	10	10	10	
Mean	0.06	0.46	2.02	1.06	6.32	11.2	4.97	26.1
Median	<LOD	0.23	1.50	0.72	4.71	7.79	3.04	17.9
Minimum	<LOD	0.07	0.81	0.44	2.24	3.43	1.51	9.70
Maximum	0.47	1.19	4.64	2.82	17.5	33.1	16.7	76.0

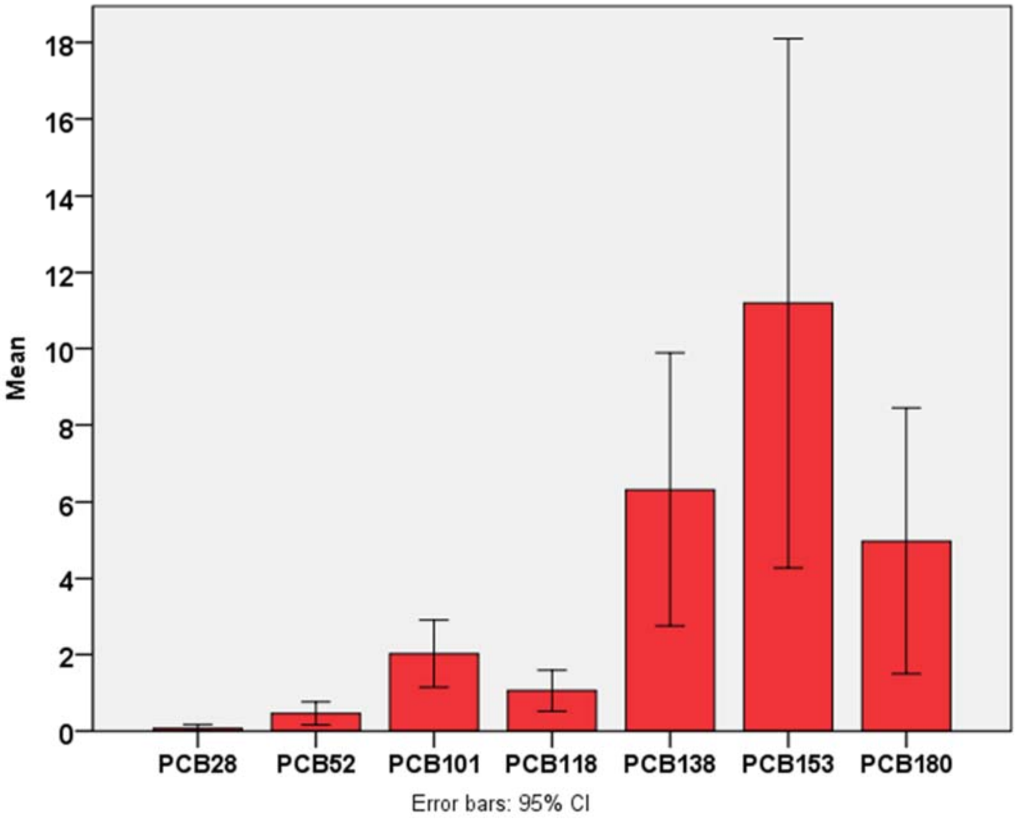


Figure 6: Mean concentrations of PCB congeners in fieldfare eggs (ng/g ww).

3.1.5 Sparrowhawk

Ten eggs were available for analysis, all from the Oslo area. The detailed results are shown in Table 6.

In Figure 7, the median PCB concentrations by sampling location and congeners are shown. Elevated PCB concentrations were found in a number of eggs, with a maximum concentration of sumPCB of more than 1700 ng/g ww (wet weight) in two samples. The locations of these two nests were more than 15 km apart, revealing high concentrationsof PCBs in the Oslo area. The median sumPCB concentration for Oslo was with 663 ng/g very close to the median found in 2015 (672 ng/g ww), which was slightly lower than in the previous year (750 ng/g ww). PCB 138 and 153 were the dominating PCB congeners. For comparison, the highest sumPCB contamination found in Norway in any bird of prey, was in peregrine falcon eggs from 1976 in Rogaland, with 110 000 ng/g ww (Nygård, 1983). During the 1970's, average PCB values of more than 23 000 ng/g ww were measured in sparrowhawks from Norway, making it one of the most contaminated species by environmental pollutants at that time, and with eggshells that were between 20 and 30 % thinner than normal (Nygård and Polder, 2012). However, pollutant concentrations have decreased considerably in Norwegian sparrowhawks since then. Findings from the period 2005-2010 showed an average value of 229 ng/g PCBs in sparrowhawk eggs (Nygård and Polder 2012). In the present material, an average of 663 ng/g ww PCBs was found, compared to 692 and 410 ng/g ww reported in 2015 and 2014 (Herzke et al., 2015, 2016). Its food choice, feeding on other birds (Hagen et al. 1952), makes it vulnerable to trophic magnification of pollutants, but due to variations in local prey species, one might expect large variations in pollutant levels. The evidence of non-declining concentrations from 2010 to now for traditional POPs like PCB in sparrowhawks, emphasize the need of continuous monitoring and for the identification of local urban sources. There are good reasons to believe that eggs can reflect the local ecosystem quite well, rather than the wintering grounds, as the eggs are formed in the body after reaching the breeding-grounds in the spring. That leads to the question whether we still have local PCB sources close to cities like Oslo, in addition to diffuse widespread pollution from multiple sources, or if previous accumulated PCBs in the mother bird has been transferred to the egg. An exposure by feeding on migrating birds coming from polluted wintering grounds is also a source which should be accounted for.

Table 6 : Concentrations of PCB congeners in sparrowhawk eggs in ng/g ww, N: number of detected/ analysed samples.

	PCB28	PCB52	PCB101	PCB118	PCB138	PCB153	PCB180	SumPCB7
N	10/10	10/10	10/10	10/10	10/10	10/10	10/10	
Mean	1.16	1.96	20.7	44.2	179	349	209	804
Median	0.65	1.29	18.2	48.8	144	311	148	663
Minimum	0.21	0.25	3.03	7.75	37.2	89	55	193
Maximum	4.73	6.14	44.0	83.9	468	720	522	1758

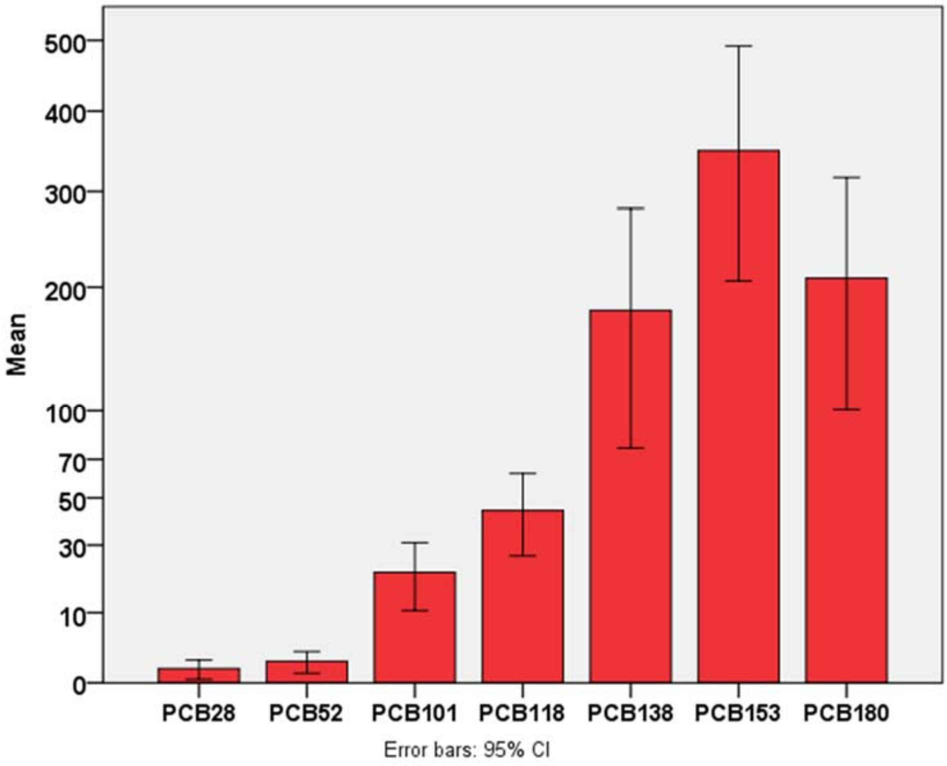


Figure 7: Mean concentrations of PCB congeners in eggs of sparrowhawk (ng/g ww).

3.1.6 Tawny owl

The median sumPCB concentration of 41.8 ng/g was higher than reported the previous year (26.4 ng/g ww) and clearly lower than for the sparrowhawk. PCB 153 and 180 dominated the PCB pattern, similar to the sparrowhawk. SumPCB concentrations varied between 14.8 and 133 ng/g ww. For comparison, Bustnes et al., (2011), found a four times higher median (193 ng/g ww) in tawny owl eggs collected 2009 in Trøndelag, Norway.

Table 7: Concentrations of PCB congeners in tawny owl eggs in ng/g ww. N: number of detected/analysed samples.

	PCB28	PCB52	PCB101	PCB118	PCB138	PCB153	PCB180	SumPCB7
N	10/10	1/10	8/10	10/10	10/10	10/10	10/10	
Mean	0.32	<LOD	0.30	3.08	9.09	22.0	13.1	47.9
Median	0.16	<LOD	0.21	2.28	7.18	18.2	11.6	41.8
Minimum	0.04	<LOD	<LOD	0.97	2.78	6.91	4.12	14.9
Maximum	1.34	0.05	0.73	9.16	24.5	65.9	35.6	133

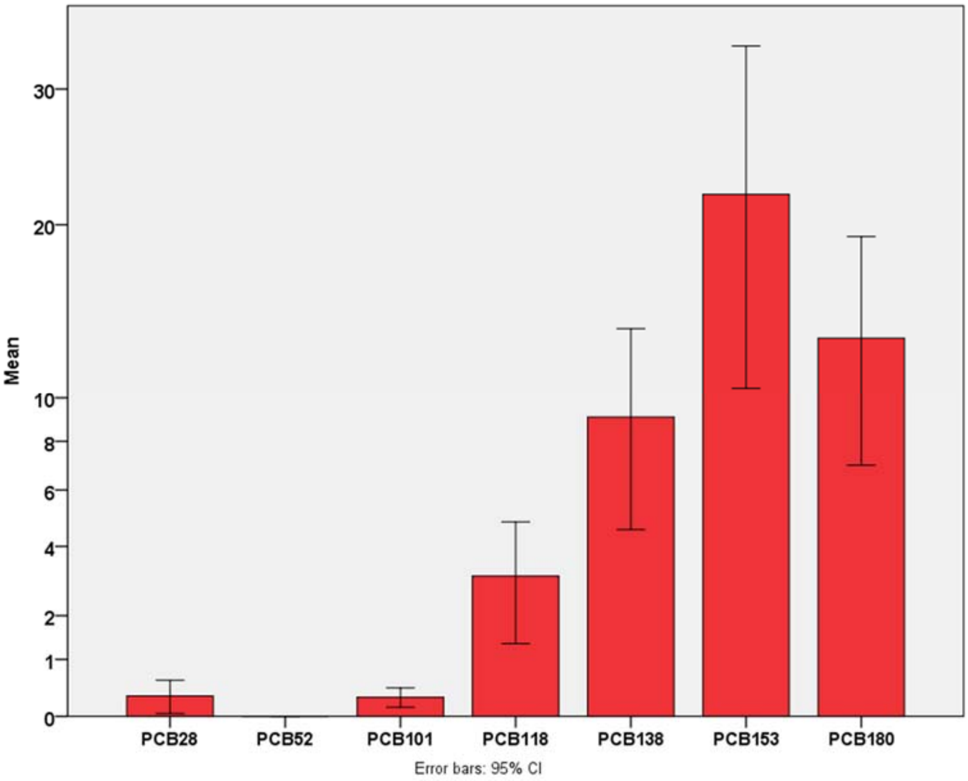


Figure 8: Mean PCB concentrations in tawny owl eggs (ng/g ww).

3.1.7 Brown Rats

PCBs were found in seven out of 10 rat samples. SumPCB varied between <LOD and 50.2 ng/g ww with PCB 153, 138 and 180 dominating the PCB pattern. The median of sumPCB dropped from a previous median of 11 ng/g ww in 2015, to 2.8 ng/g ww in 2016 (Herzke et al., 2016), mainly due to a larger number of non-detects in the 2016 samples compared to 2015.

Table 8: Concentrations of PCB congeners in brown rat livers in ng/g ww. N: number *of detected/analysed samples*.

	PCB28	PCB52	PCB101	PCB118	PCB138	PCB153	PCB180	SumPCB7
N	1/10	0/10	0/10	4/10	7/10	7/10	7/10	
Mean	<LOD	<LOD	<LOD	<LOD	2.59	3.32	2.88	9.12
Median	<LOD	<LOD	<LOD	0.05	0.80	1.06	0.62	2.78
Minimum	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.34
Maximum	0.30	<LOD	<LOD	1.37	14.4	19.9	14.2	50.2

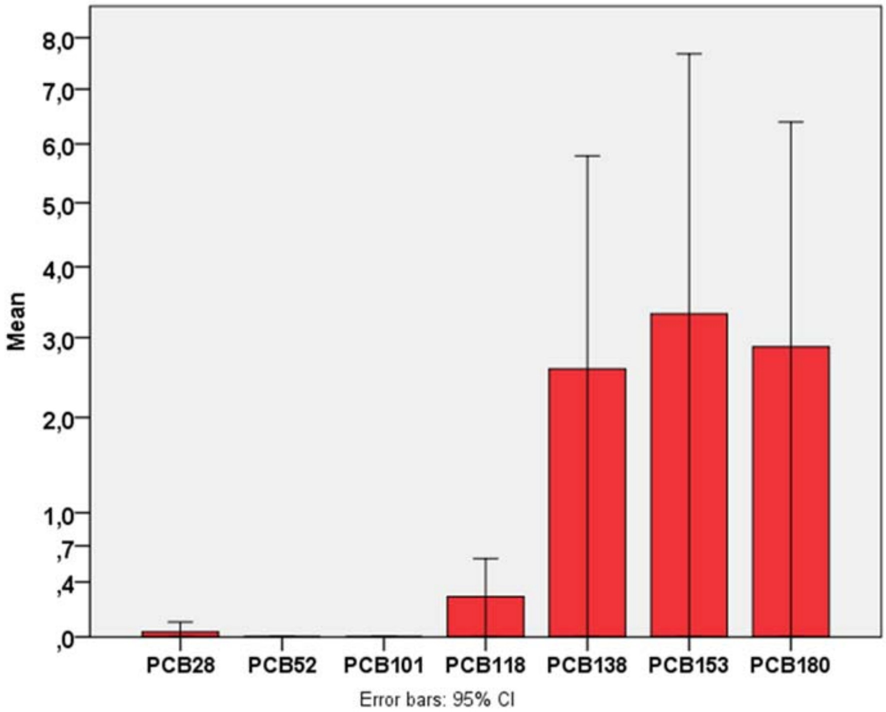


Figure 9: Mean PCB concentrations in rat livers (ng/g ww).

3.1.8 Red fox

In total, 10 livers of foxes all from the Oslo area, were analysed for PCBs.

PCB 153 and 180 were the dominant congeners (Figure 10). The observed sumPCB concentration ranged between 2.85 and 54 ng/g ww, with a median of 14.2 ng/g ww (compared to 6.8 ng/g ww in 2015 and 6.5 ng/g ww in 2014). A summary of values are given in (Table 9). 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 Andalusia in Southern Spain, ca 90 times higher than what we found in samples from the urban site in Oslo.

Table 9: PCB concentrations in red fox livers from the Oslo area in ng/g ww. N: number of detected/analysed samples.

	PCB28	PCB52	PCB101	PCB118	PCB138	PCB153	PCB180	SumPCB
N	0/10	0/10	0/10	5/10	9/10	10/10	10/10	
Mean	<LOD	<LOD	<LOD	0.21	1.31	5.91	12.9	20.3
Median	<LOD	<LOD	<LOD	0.09	0.39	3.11	10.7	14.2
Minimum	<LOD	<LOD	<LOD	<LOD	<LOD	0.91	1.74	2.91
Maximum	<LOD	<LOD	<LOD	1.12	7.90	22.3	27.0	54.0

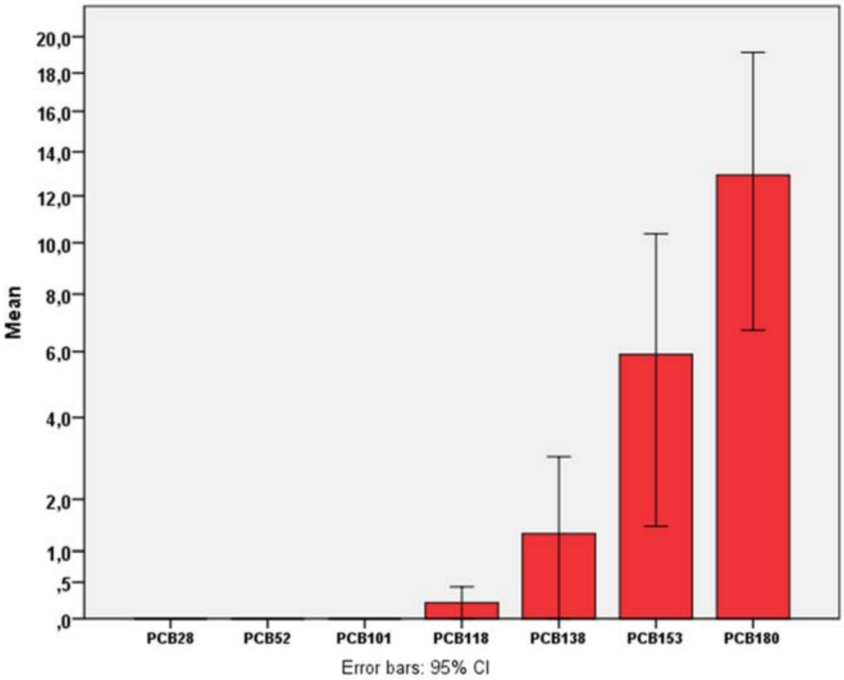


Figure 10: Mean PCB congener concentrations in fox livers in ng/g ww.

Andersen et al. reported in Arctic fox liver from Svalbard, Norway, a median sumPCB of 342 ng/g ww, more than twenty times higher than the urban foxes in this study, due to their marine diet (Andersen et al., 2015).

3.1.9 Small rodents

Small rodents were sampled the first time during this project. A pool of ten individual liver samples was analysed. No PCBs were detected in the rodent livers.

3.1.10 Summary of PCB results

PCB data across all species and media revealed that sparrowhawk had the highest concentrations with SumPCb of 804 ng/g ww followed by tawny owl, fieldfare and red fox and (78, 26 and 20 ng/g ww). PCB 153 dominated in most sample types, with the exception of fox where PCB 180 dominated, and air where PCB 52 and 101 dominated.

3.2 PBDEs and DBDPE

3.2.1 Air

Air data showed, as expected, the prevalence of the less brominated and more volatile PBDEs rather than the less volatile higher brominated ones. This was expected as passive air samplers (PAS) have been shown to have a good performance for compounds in the gas-phase (i.e. the volatile ones) while lower accuracy and reproducibility for compounds associated to particles in air (i.e. less volatile compounds). Some particle-associated compounds (e.g. BDE-209) are collected by the passive air sampler too, but the results should be considered as less certain due to uptake uncertainties in the sampler (which is not designed to sample particles, but gases).

SumPBDE levels varied from <LOD to 0.94 ng/sampler at Alnabru. For comparison, Hearn et al., reported in 2012 PBDEs sampled by PAS in Brisbane, Australia, averaging at 12.7 ng/sampler (0.4 – 16.4 ng/ sampler), more than 10-times higher than observed in Oslo. In Brisbane, PBDE 47, 99 and 209 were the dominating PBDEs, similar to our findings, also with 209 dominating the overall pattern. The more atmospherically mobile PBDE congeners PBDE 47 and PBDE 99 were mostly found in in the central urban area of Slottsparken and the industrialised location of Alnabru. The mostly particle bound PBDE 209 was found in up to 10-times higher concentrations (<LOD – 0.9 ng/ sampler). Besides the gas phase, PAS sample or ‘trap’ aerosols (and hence particle associated POPs) depending on the profile of the particle load at an air monitoring site. At Zeppelin, Svalbard, average concentrations of 0.4 pg/m^3 of PBDE 47 was found (Bohlin-Nizzetto et al 2016). For comparison, the concentrations in Oslo of 0.002 pg/m^3 PBDE 47 were much lower, however large fluctuations over the year were observed at Zeppelin (0.06 – 1.8 pg/m^3). At Birkenes the average concentration of PBDE 47 was at 0.12 pg/m^3 in the same period.

3.2.2 Soil

PBDEs were found in all soil samples collected. Nona-BDEs dominated in the soil, followed by PBDE 99 and 47. The highest sumPBDE concentrations were found at Alnabru and Frognerseteren (0.73 ng/g dw and 0.32 ng/g dw). No DBDPE was found. According to the Norwegian guidelines on classification of environmental quality of soil, 80 ng/g dw PBDE 99 and 2 ng/g dw PBDE 209 represent the threshold for clean soil (SFT, 2009). None of the samples analysed in this study exceeded this threshold value.

Table 10: PBDE in soil samples from Oslo in ng/g dw. N: number of detected/analysed samples.

	PBDE47	PBDE99	PBDE100	PBDE191	PBDE206	PBDE207	PBDE209	SumPBDE
N	2/5	3/5	3/5	1/5	2/5	2/5	0/5	5
Mean	0.011	0.029	0.005	0.01	0.02	0.011	<LOD	0.022
Median	<LOD	0.017	0.002	<LOD	<LOD	<LOD	<LOD	0.014
Minimum	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Maximum	0.032	0.052	0.017	0.035	0.051	0.042	<LOD	0.058

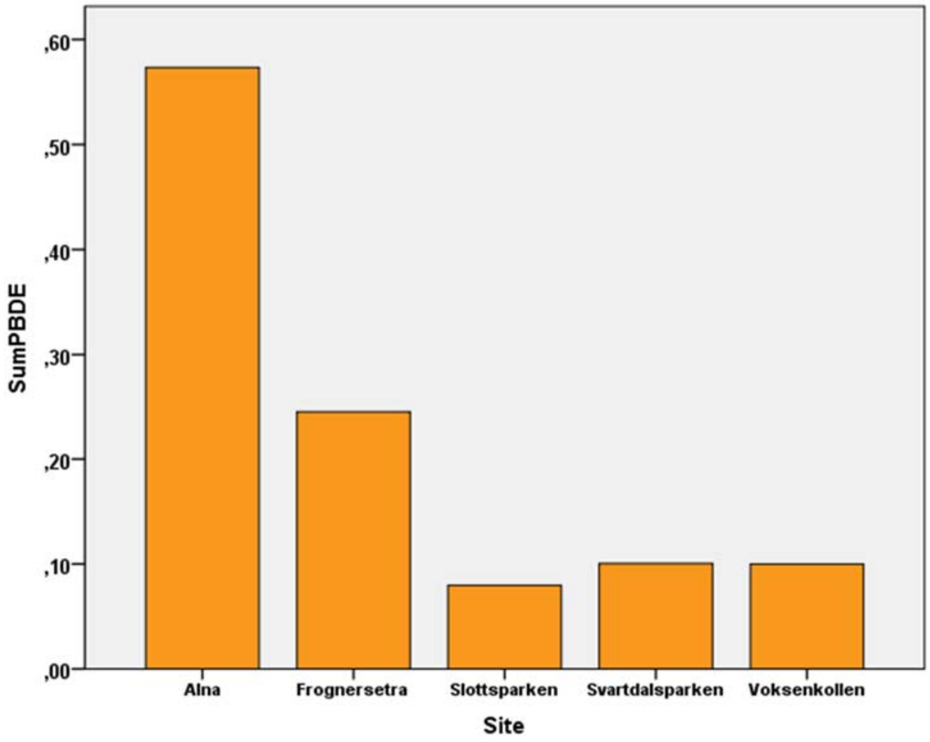


Figure 11: SumPBDEs in soil at the different sampling sites in ng/g dw.

3.2.3 Earthworms

In the five samples collected from different locations in Oslo, the sumPBDE concentration levels ranged from 0.06 ng/g to 0.11 ng/g ww. Similar to the 2015 samples, PBDE 47 and 99 were the dominating congeners. No PBDE 209 was detected in the earthworms. DBDPE on the other hand, was detected in the one sample from Alnabru showing 109 ng/g ww.

Table 11: Average values of detected individual congeners of PBDE and sum PBDEs in earthworms combined (ng/g ww). N: number of detected/analysed samples.

	PBDE47	PBDE99	PBDE100	SumPBDE	DBDPE
N	5/5	5/5	4/5		1/5
Mean	0.08	0.05	0.013	0.14	<LOD
Median	0.07	0.04	0.016	0.14	<LOD
Minimum	0.06	0.03	<LOD	0.11	<LOD
Maximum	0.11	0.06	0.02	0.17	109

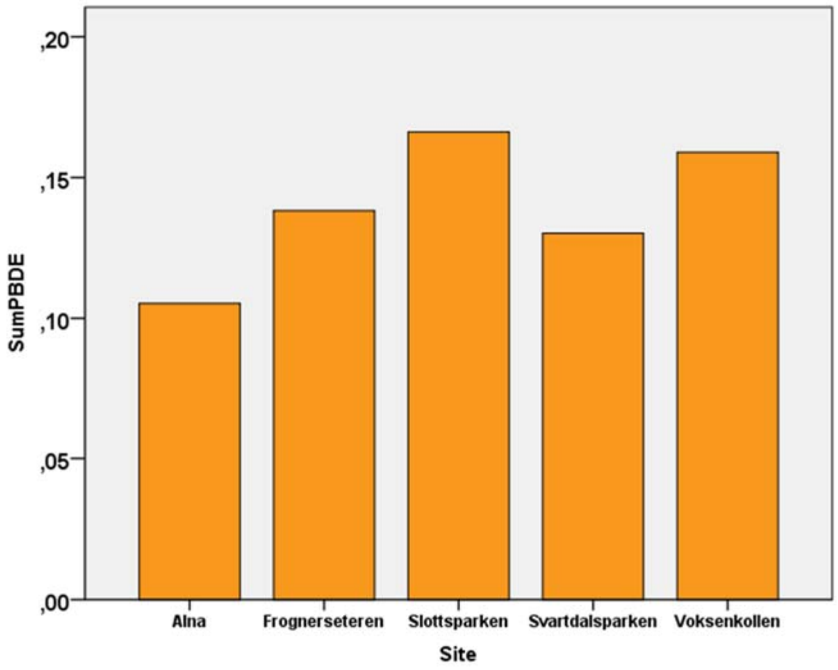


Figure 12: Sum PBDEs in earthworm at the different sampling sites in ng/g ww.

3.2.4 Fieldfare

The concentrations of the PBDEs detected were generally low (median sumPBDE 3.2 ng/g ww compared to 2.3 ng/g ww in 2015). PBDE 47 and 99 dominated the pattern (Figure 13). No PBDE 209 was detected in any of the fieldfare eggs. On average, sumPBDE concentrations in fieldfare eggs were almost 10 times lower than the sumPBDE concentrations found in sparrowhawk eggs. DBDPE was found in four locations, varying between 44 and 54 ng/g ww, in ca. five times higher than median sumPBDE.

Table 12: Values of individual congeners of PBDE and sum PBDEs in fieldfare eggs (ng/g ww). N: number of detected/analysed samples.

	PBDE47	PBDE99	PBDE100	PBDE153	PBDE154	PBDE196	PBDE202	PBDE207	Sum PBDE	DBDPE
N	10/10	10/10	10/10	10/10	10/10	7/10	6/10	9/10	10/10	4/10
Mean	1.07	1.55	0.67	0.37	0.29	0.03	0.04	0.05	4.16	30.0
Median	0.71	1.15	0.38	0.35	0.21	0.03	0.03	0.05	3.19	16.8
Minimum	0.29	0.42	0.17	0.09	0.07	<LOD	<LOD	<LOD	1.24	<LOD
Maximum	2.40	3.10	2.17	0.89	0.80	0.41	0.08	0.13	8.70	54.3

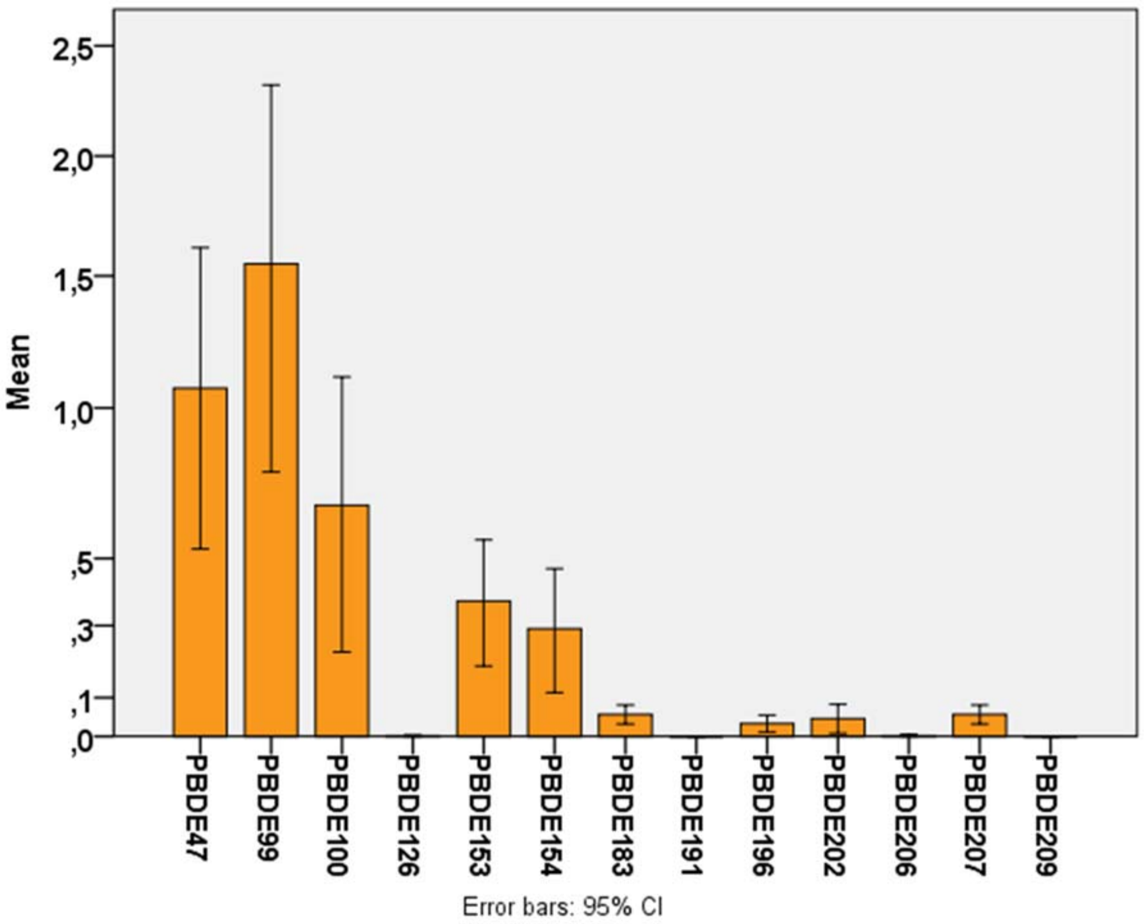


Figure 13: Mean PBDE concentrations in eggs of fieldfare in ng/g ww.

For improved interspecies comparability with data from literature, lipid related concentrations are used (lw). Data for great tits (Parus major) were available from a Belgian study and will be used for comparison purposes. The authors reported that PBDEs were found in eggs of great tits with levels averaging 220 ng/g lw. In our study 86 ng/g lw were found in fieldfare eggs, less than half of the Belgian levels. However, the monitoring results from fieldfare eggs reported from 2015 i.e. only one year earlier, were 143 ng/g lw, and much closer to the levels found in great tit eggs from Belgium. In a second study, PBDEs and PCBs in eggs of great tits collected all over Europe were studied in 2009 (Van den Steen et al. 2009). This study included a Norwegian location as well, a suburban site close to Oslo, showing PBDEs concentrations of 25 ng/g lw. Since the samples from that study were collected in 2006, changes over time in PBDE exposure as well as dietary differences can explain why lower levels were observed in the Van den Steen study. A more recent study on starling eggs (Sturnus vulgaris), sampled worldwide, with one Norwegian rural location in Nord Trøndelag, showed less than 50 ng/g lw sumPBDEs, (Eens et al. 2013), similar to the findings from this years monitoring and ten times lower than observed in our fieldfare eggs from 2015.

3.2.5 Sparrowhawk

As published in the reports in 2015 and 2016 (2014 and 2015-data), the dominating PBDE congener was PBDE 99, followed by PBDE 47 and PBDE 153 (Table 13). SumPBDE concentrations ranged from 10.8 to 62 ng/g ww, with a median of 33.5 ng/g ww i.e. on average ten times higher than in fieldfare which is lower in the food chain. PBDE 209 was detected in the majority of eggs, together with nona-PBDEs 206 and 207. Figure 14 shows the average PBDE concentration of the measured congeners. Lacking data for comparable raptor species nesting in urban sites we compared with eggs of the terrestrial passerine birds from the Pearl River Delta, South China, a highly industrialised area (Sun et al., 2014). In this study SumPBDE concentrations ranged between 6-14 ng/g ww, half of what we found in the sparrowhawk eggs in Oslo, indicating a relatively high PBDE exposure in birds from Oslo.

Table 13: PBDE congener values in sparrowhawk eggs in ng/g ww. N: number of detected/analysed samples.

	PBDE47	PBDE99	PBDE100	PBDE126	PBDE153	PBDE154	PBDE183	PBDE191	PBDE196	PBDE202	PBDE206	PBDE207	PBDE209	SumPBDE	DBDPE
N	10/10	10/10	10/10	10/10	10/10	10/10	10/10	2/10	2/10	9/10	2/10	9/10	6/10		3/10
Mean	7.30	12.6	4.36	0.02	4.82	1.85	1.52	0.01	0.50	0.43	<LOD	0.41	0.66	34.6	18.4
Median	6.25	12.4	4.53	0.02	5.19	1.93	1.52	<LOD	0.41	0.49	<LOD	0.12	0.78	33.5	<LOD
Minimum	2.74	1.31	1.04	0.01	1.21	0.83	0.08	<LOD	<LOD	<LOD	<LOD	0.12	<LOD	10.8	<LOD
Maximum	12.9	25.6	7.26	0.04	8.86	2.82	2.94	0.05	1.54	0.94	0.06	2.40	2.32	62.4	71.3

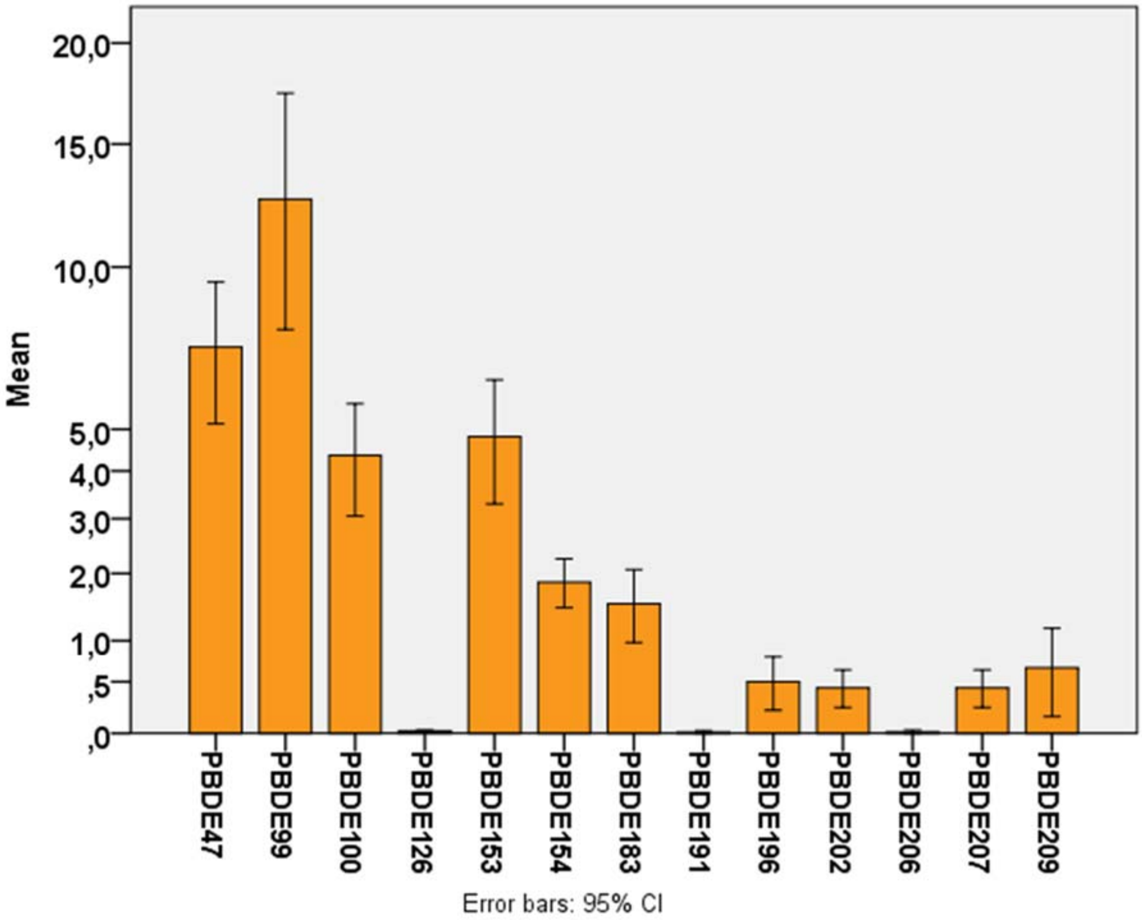


Figure 14: Mean concentrations of different PBDEs in eggs of sparrowhawk in ng/g ww.

DBDPE was only found in 3 of 10 samples. The concentrations for the three samples were 42.6, 69.7 and 71.3 ng/g ww. In the 2015 study, DBDPE was found in 9 of 10 sparrowhawk eggs. The concentrations varied then between <LOD and 155 ng/g ww, with a median concentration of 4.35 ng/g ww.

3.2.6 Tawny owl

With median sumPBDE concentrations of 4.1 ng/g ww, levels were slightly higher compared to those reported from 2015 (1.15 ng/g ww), clearly lower concentrations than for the sparrowhawk, but similar to that of the fieldfare. PBDE 47, 99 and 153 dominated the PBDE pattern, similar to the sparrowhawk. SumPBDE concentrations varied between 0.85 ng/g ww and 11.6 ng/g ww (median 4.1 ng/g ww). PBDE 207 was detected in 9 out of 10 tawny owl eggs, PBDE 209 only in three. For comparison, Bustnes et al, 2011, reported a comparable median of sumPBDE in tawny owl eggs collected in Trondheim (63.42 N, 10.23 E) in Sør-Trøndelag County, Central Norway in 2009. DBDPE was found in 6 of 10 samples, varying between 43.4 and 57.7 ng/g ww. Comparable DBDPE concentrations were found in eggs of the terrestrial passerine bird Light-vented bulbul (*Pycnonotus sinensis*) from the Pearl River Delta, South China, a highly industrialised area (Sun et al., 2014).

Table 14: Detected PBDEs in tawny owl egg from the Oslo area, ng/g ww. N: number of detected/analysed samples.

	PBDE47	PBDE99	PBDE100	PBDE153	PBDE154	PBDE183	PBDE196	PBDE202	PBDE206	PBDE207	PBDE209	Sum PBDE	DBDPE
N	10/10	10/10	10/10	10/10	9/10	10/10	7/10	7/10	2/10	9/10	3/10	10/10	6/10
Mean	0.92	1.57	0.49	1.39	0.19	0.15	0.35	0.03	0.07	0.03	0.35	5.01	40.3
Median	0.40	1.21	0.42	1.36	0.16	0.16	0.04	0.08	<LOD	0.09	<LOD	4.10	45.5
Minimum	0.13	0.19	0.04	0.19	0.01	0.03	<LOD	<LOD	<LOD	<LOD	<LOD	0.85	<LOD
Maximum	3.13	4.65	1.37	2.91	0.51	0.33	0.10	0.19	0.05	0.26	1.86	11.6	57.7

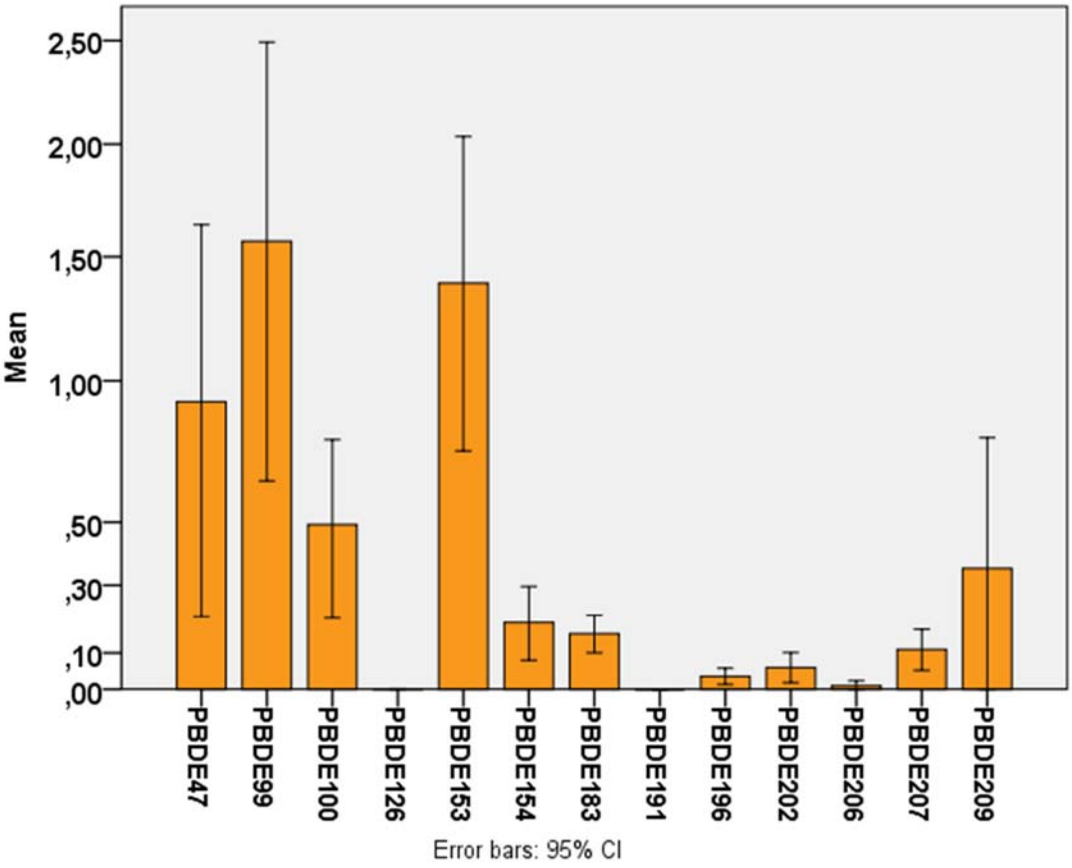


Figure 15: Mean concentrations of different PBDEs in eggs of tawny owl in ng/g ww.

3.2.7 Brown rat

PBDEs in brown rat livers displayed a large variation. SumPBDE concentrations varied between 0.4 ng/g and 4.5 ng/g. PBDE 209 (detection frequency 85%) dominated in most cases followed by PBDE 47 and 153, indicating a different exposure than that of the other observed species. Median sumPBDE concentration was 0.92 ng/g ww. DBDPE was found only in one rat liver (86 ng/g ww). Male rats tended to have higher SumPBDE levels than females (2.65 *vs* 0.75 ng/g), but the number of individuals were too small to test for significance.

Table 15: PBDE concentrations in liver of brown rat from Oslo in ng/g. N: number of detected/analysed samples.

	PBDE47	PBDE99	PBDE100	PBDE153	PBDE154	PBDE183	PBDE196	PBDE202	PBDE206	PBDE207	PBDE 209	SumPBDE	DBDPE
N	4/7	4/7	3/7	5/7	2/7	4/7	1/7	1/7	1/7	7/7	6/7	7/7	1/9
Mean	0.09	0.06	0.06	0.27	0.01	0.05	<LOD	<LOD	<LOD	0.13	1.07	1.78	<LOD
Median	0.02	0.02	<LOD	0.02	0.003	0.004	<LOD	<LOD	<LOD	0.11	0.61	0.92	<LOD
Minimum	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.03	<LOD	0.43	<LOD
Maximum	0.38	0.21	0.37	1.35	0.02	0.22	0.04	0.04	0.07	0.31	3.49	4.49	85.9

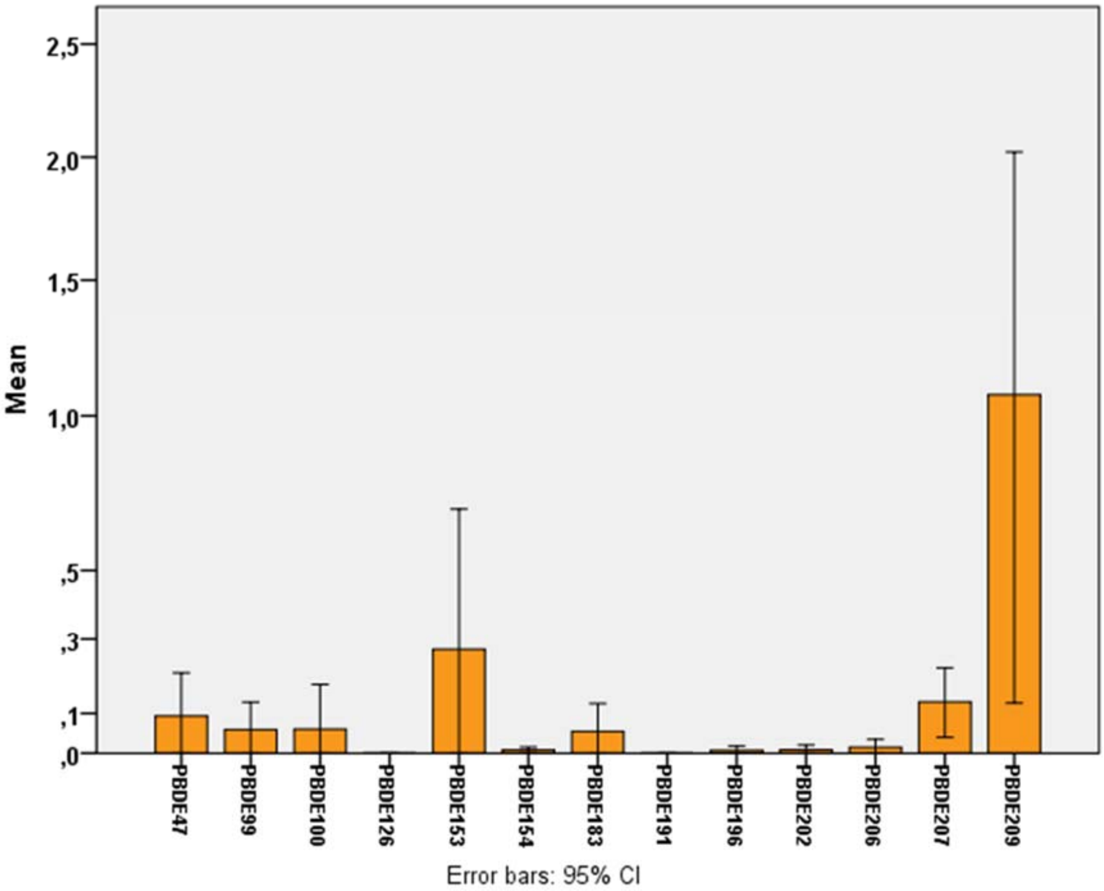


Figure 16: Mean concentrations of different PBDEs in rat livers (ng/g ww). Errorbars show the 95% confidence limits.

3.2.8 Red fox

In red fox, sumPBDE ranged from 0.31 to 3.5 ng/g ww. PBDE 209 was found in most of the samples, and dominated in the fox livers (Table 16, Figure 17). Levels in this study were comparable to the ones reported from 2015 with a median of sumPBDE of 0.31 ng/g ww compared to 0.53 ng/g ww in 2015. Andersen et al. reported PBDEs in Arctic fox liver from Svalbard, Norway, with comparable median PBDE 47 and 153 concentrations of 0.16 and 0.08 ng/g ww respectively (Andersen et al., 2015). There was no difference in levels between the sexes.

Table 16: Values of individual congeners of PBDE and sumPBDEs in red fox livers in the Oslo area 2016 in ng/g ww. N: number of detected/analysed samples.

	PBDE47	PBDE99	PBDE100	PBDE153	PBDE154	PBDE183	PBDE196	PBDE206	PBDE207	PBDE209	SumPBDE
N	6/9	5/9	4/9	9/9	3/9	2/9	5/9	6/9	9/9	7/9	
Mean	0.13	0.03	0.02	0.09	0.01	0.003	0.03	0.06	0.11	1.03	0.43
Median	0.06	0.02	0.01	0.09	0.01	0.001	0.02	0.46	0.05	1.24	0.31
Minimum	<LOD	<LOD	<LOD	0.02	<LOD	<LOD	<LOD	<LOD	0.02	<LOD	0.12
Maximum	0.31	0.08	0.09	0.17	0.03	0.02	0.095	0.16	0.47	3.1	3.47

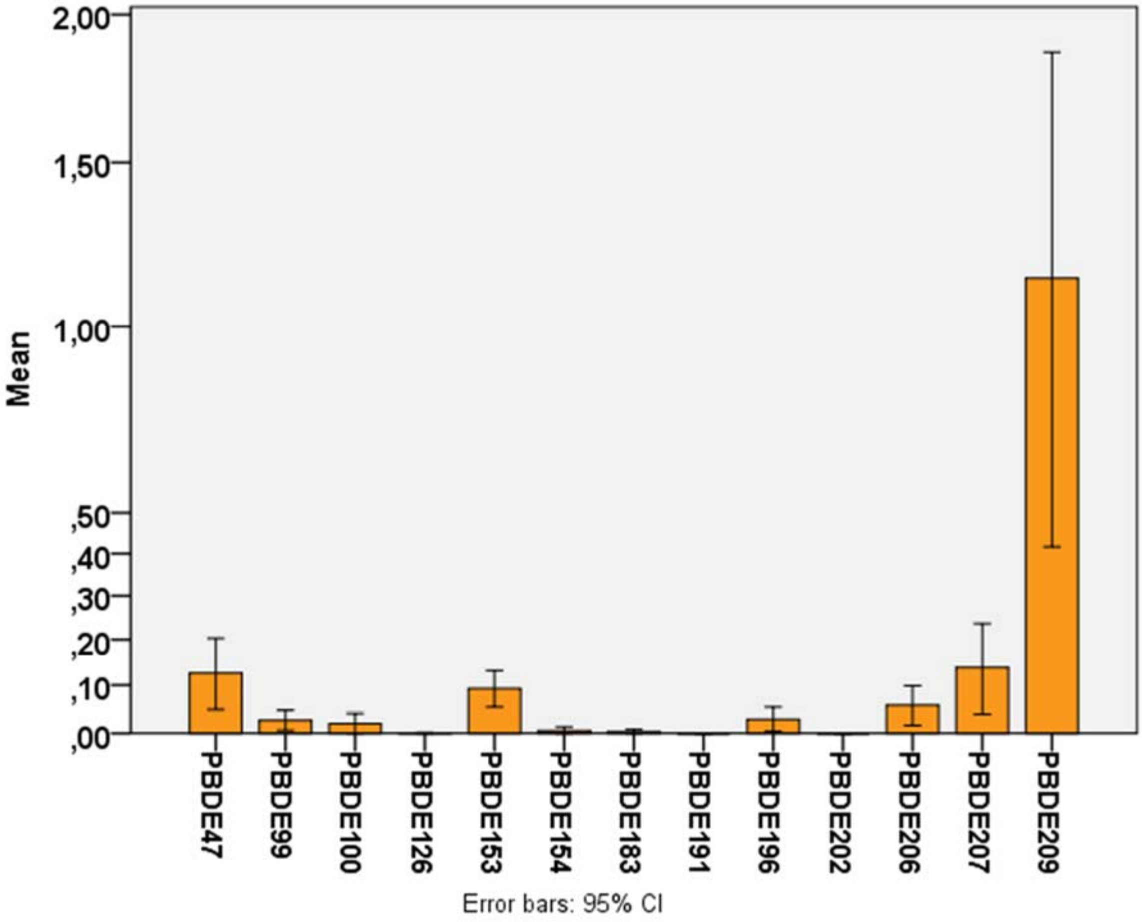


Figure 17: Mean concentrations of different PBDEs in red fox livers in Oslo (ng/g ww). Errorbars show the 95% confidence limits.

DBDPE was only found in one of the fox liver samples, with a concentration of 85.9 ng/g ww.

3.2.9 Small rodents

No PBDEs were found in rodent liver.

3.2.10 Summary PBDEs

Similar to PCBs, where sparrowhawk eggs had the highest levels of PBDE (mean SumPBDE 34 ng/g ww), followed by tawny owl and fieldfare with approximately 10-times lower concnetrations (5.3 and 4.1 ng/g ww). Rat liver and fox liver showed comparable low concentrations with 1.8 and 1.5 ng/g ww followed by earthworm with 0.14 ng/g ww. While PBDE 209 dominated in soil, liver from red fox and brown rat, PBDE 99 followed by PBDE 47 dominated in the other biological samples. Only in tawny owl, the levels of PBDE 153 was comparable to PBDE 99.

3.3 Per-and polyfluoroalkyl substances (PFASs)

3.3.1 Air

Ionic PFAS could be found at the three locations sampled for air (Alnabru, Slottsparken and Voksenkollen), possibly caused by fine dust settling in the sampler and/or due to degradation of volatile precursor PFAS. SumPFAS was dominated by PFOS and PFOA in all three samples, with considerable contribution of 6:2 FTS in Slottsparken. PFDcA was also found. SumPFAS ranged between 0.18 and 0.45 ng/ sampler, in the decreasing order Voksenkollen, Slottsparken and Alnabru. Ahrens et al. reported passive air data for ionic and neutral (volatile) PFAS in a suburban site in Toronto in 2011 (Ahrens et al., 2013). The most abundant PFAS class for the total air concentration were the FTOHs representing on average ~80% of the ΣPFASs, followed by PFCAs, opposite to our findings. A direct comparison of concetrations is difficult due to the different application of concentration units.

3.3.2 Soil

The five sampled locations showed both a varying PFAS composition as well as abundancy (Table 17, Figure 18). Of the measured PFAS, only PFDcS, PFDoA, PFTeA and 8:2 FTS were not found in soil. PFOS dominated the sumPFAS pattern in Alnabru, Frognerseteren and Voksenkollen, while PFOA dominated in the other locations. SumPFAS was highest at Alnabru and Frognerseteren (174 ng/g dw and 10.3 ng/g dw), clearly higher compared to last years highest contaminated stations Grorud and Voksenkollen I with 3.6 and 4.9 ng/g dw respectively. Local sources are probable sources for these two stations, while the other three sites seem to be more affected by long range transported/ background PFAS contamination. PFBS was present only at the Alnabru station. PFHxA was present in all stations except Svartdalsparken ranging between 0.11 and 1.1 ng/g dw. According to the Norwegian guidelines on classification of environmental quality of soil (normverdi), concentrations below 100 ng/g dw of PFOS represent the threshold for clean soil, (SFT 2009). The sample from Alnabru exceeded that threshold with 129 ng/g dw of PFOS. For comparison, Herzke et al., found up to 54 ng/g PFOS in soil at the local firestation in Tromsø (Herzke et al, 2014b). Also, Xiao et al. found PFOS varying between 0.2 and 28 ng/g dw in surface soil collected in the U.S. metropolitan area of Minneapolis, endangering the quality of the groundwater (Xiao, et al., 2015). The observed levels at Alnabru were comparable with or lower than those detected in soils receiving municipal biosolids (Illinois and Alabama, USA) (Csoil, PFOS < 410 ng/g) (Sepulvado et al., 2011; Washington et al., 2010), or near a PFAS manufacturing facility in China (Csoil,PFOS < 189 ng/g) (Wang et al., 2010). The contamination of soil by PFOS may adversely affect water resources and endanger the health of the surrounding ecosystem and human populations and is recommended to be followed up further.

Table 17: PFAS in soil of the Oslo collection sites in ng/g dw. N: number of detected/analysed samples.

	PFBS	PFPS	PFHxS	PFOS	PFNS	PFHxA	PFHpA	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	Sum PFAS
N	1/5	1/5	1/5	5/5	1/5	4/5	3/5	5/5	3/5	3/5	1/5	0/5	1/5	
Mean	0.01	0.04	0.75	33.0	<LOD	0.43	0.29	1.36	0.46	0.71	0.025	<LOD	<LOD	38.4
Median	<LOD	<LOD	<LOD	1.58	<LOD	0.36	0.09	0.76	0.18	0.76	<LOD	<LOD	<LOD	5.26
Minimum	<LOD	<LOD	<LOD	0.13	<LOD	<LOD	<LOD	0.103	<LOD	<LOD	<LOD	<LOD	<LOD	0.98
Maximum	0.07	0.19	3.76	162	0.56	1.09	0.91	3.33	1.68	1.59	0.12	<LOD	0.54	174

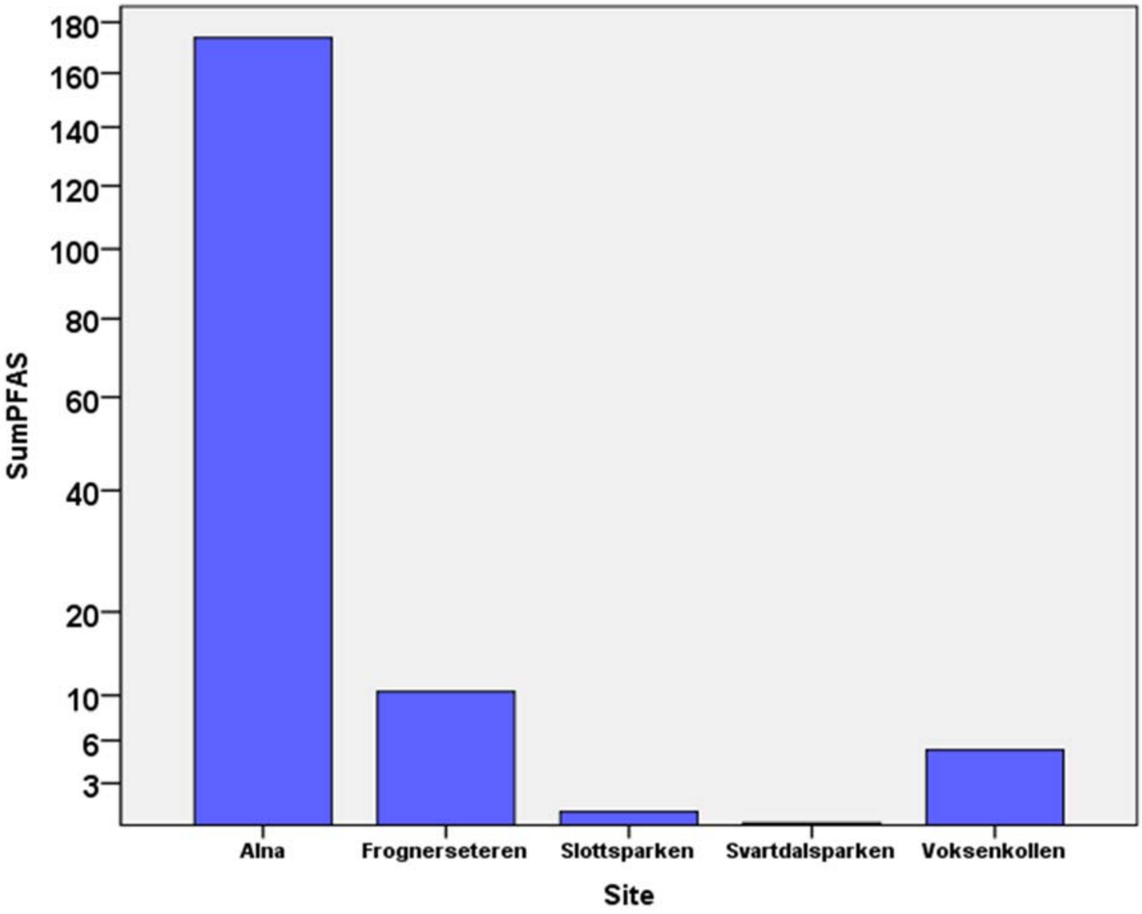


Figure 18: SumPFAS in soil at the different sampling sites in Oslo in ng/g dw.

3.3.3 Earthworms

As shown in Table 18, PFASs were present in every sample. The sumPFAS concentrations ranged from 12.9 ng/g ww to 1164 ng/g ww (compared to last years 5.3 to 157 ng/g ww), with a median value of 50.1 ng/g ww. Again earthworms from both sites close to the Homenkollen ski area (Voksenkollen and Frognerseteren) were clearly elevated in sumPFAS compared with the other sites (180 and 50 ng/g ww). However, the concentration found in worms from Alnabru were more than 5 times higher than these two elevated locations (1164 ng/g ww).

PFOS was dominating in all locations, except for worms from Voksenkollen, were the 6:2 FTS was most abundand. In general, variations within the sampling location are considerable, confirming the need of sampling several subsamples in one location as done in this study. At Alnabru and Voksenkollen high levels of 6:2 FTS (50.6 and 115 ng/g ww respectively) were found, indicating spill of new generation AFFF or skiwaxes or other applications. PFHxS was detected in three out of five locations. Both skiing areas, Voksenkollen and Frognerseteren, showed higher levels of longchained PFCAs than the industrialised station Alnabru, indicating a different source. On the other hand, all five sites show even-numbered PFCAs dominating over the odd-numbered PFCA pattern. In contrast to soil, PFTrA and PFTeA were found in the majority of worm samples, illustrating the bioavailability of these compounds. Rich et al. reported in 2015 that BSAFs and BAFs increased with increasing chain length for PFCAs and decreased with increasing chain length for the PFSAs, being in agreement with our findings (Rich et al., 2015).

When comparing soil and worm PFAS concentrations, both the site at Alnabru, Voksenkollen and Frognerseteren showed a high sumPFAS in both soil and worms. However, it is known that PFAS retention in soil as well as bioavalability is governed by the carbon chain length of the respective PFAS as well as the composition of the soil. Very sandy soil will retain PFAS to a much lesser extent than very humic soils due to increased water drainage and limited active sites in sand. With increasing carbon chain length, water solubility decreases and surface activity increases, causing a strong soil retention of longchained PFAS and an efficient drainage by water of the short chained PFAS. Wen et al. reported bioaccumulation factors (BAFs) of PFOS and PFOA ranging between 1.54-4.12 for soil and 0.52-1.34 g for worm. PFOS and PFOA concentrations exhibited positive influence and organic matter contents showed the negative influence on the accumulation of PFOS and PFOA in earthworms, indicating that sandy soils support the bioavailability of PFOS and PFOA into earthworms. Soil pH and clay contents played a relatively unimportant role in PFOS and PFOA bioavailability (Wen et al., 2015).

Table 18: PFAS concentrations in earthworm from Oslo in ng/g ww. N: number of detected/analysed samples.

	PFBS	PFPS	PFHxS	PFOS	PFNS	PFHxA	PFHpA	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA	Sum PFAS
N	1/5	1/5	3/5	5/5	1/5	5/5	0/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	
Mean	0.8	1.83	8.86	223	<LOD	3.28	<LOD	3.39	0.69	2.08	1.33	3.59	1.25	1.35	288
Median	0.02	0.02	1.33	26.8	<LOD	2.06	<LOD	2.49	0.56	2.58	1.26	0.83	1.09	0.69	50.1
Minimum	<LOD	<LOD	<LOD	7.88	<LOD	0.21	<LOD	0.93	0.17	0.27	0.399	0.55	0.38	0.44	12.9
Maximum	3.91	9.07	40.5	1032	1.25	11.7	<LOD	6.41	1.43	3.85	2.15	11.8	2.11	3.11	1164

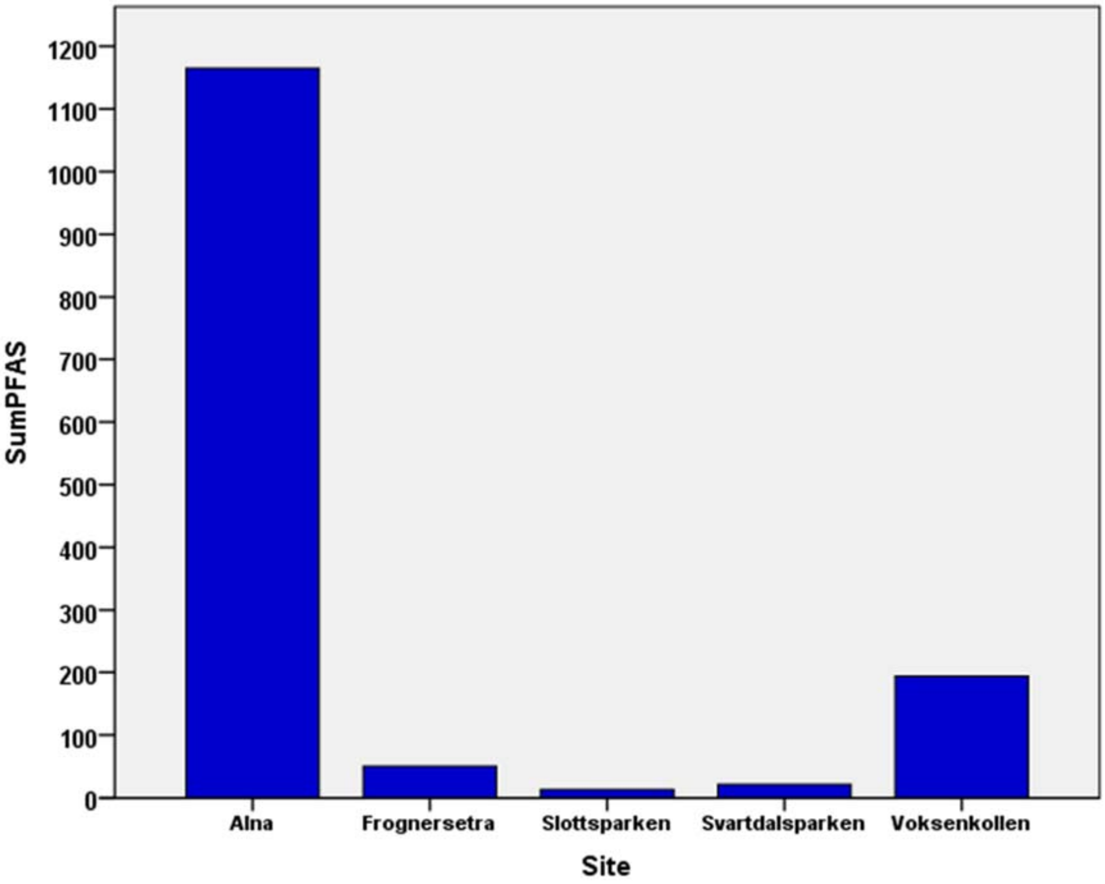


Figure 19: SumPFAS in earthworms at the different sampling sites in ng/g ww.

3.3.4 Fieldfare

PFAS were detected in all fieldfare eggs (Table 19). PFOS dominated in all eggs in contrast to earlier findings for the reference site, sampled in 2014 (Herzke et al., 2015). SumPFAS concentrations ranged from 19.3 ng/g ww to 755 ng/g ww at one site from Grønmo. This site has also earlier shown elevated levels at 87.1 ng/g ww. Grønmo, is a former municipal landfill. It was the main landfill for Oslo from 1969 til 2007. At the site there is currently a collection station for reusable items and a compost facility for garden waste (*Figure 20*). Both the collection station and the former landfill are possible sources to PFAS. The sample with the second highest sumPFAS concetrations (119 ng/g ww) was collected in Midtstua, which also is known for it's ski jumping and cross country facilities close by (also close to the Voksenkollen site). PFBS and PFHxS were only sporadically found.

Table 19: PFAS in eggs of fieldfare in ng/g ww. N: number *of detected/analysed samples*.

	PFHxS	PFHPS	PFOS	PFNS	PFDcS	PFHxA	PFHpA	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA	SumPFAS
N	9/10	10/10	10/10	1/10	7/10	1/10	8/10	10/10	10/10	10/10	10/10	10/10	10/10	9/10	
Mean	0.59	1.2	99.6	0.03	1.23	0.01	0.05	1.00	0.95	3.19	3.95	8.64	5.94	5.39	134
Median	0.38	0.39	31.5	0.01	0.14	<LOD	0.03	0.56	0.83	2.63	3.34	6.65	5.87	4.178	69.4
Minimum	<LOD	0.05	8.8	<LOD	<LOD	<LOD	<LOD	0.22	0.19	0.65	1.51	1.35	1.63	<LOD	19.5
Maximum	2.69	7.90	666	0.21	5.45	0.09	0.23	3.06	2.10	10.5	8.71	19.8	11.9	15.9	755

Figure 20: Illustration of nest location relative to a waste recycling site

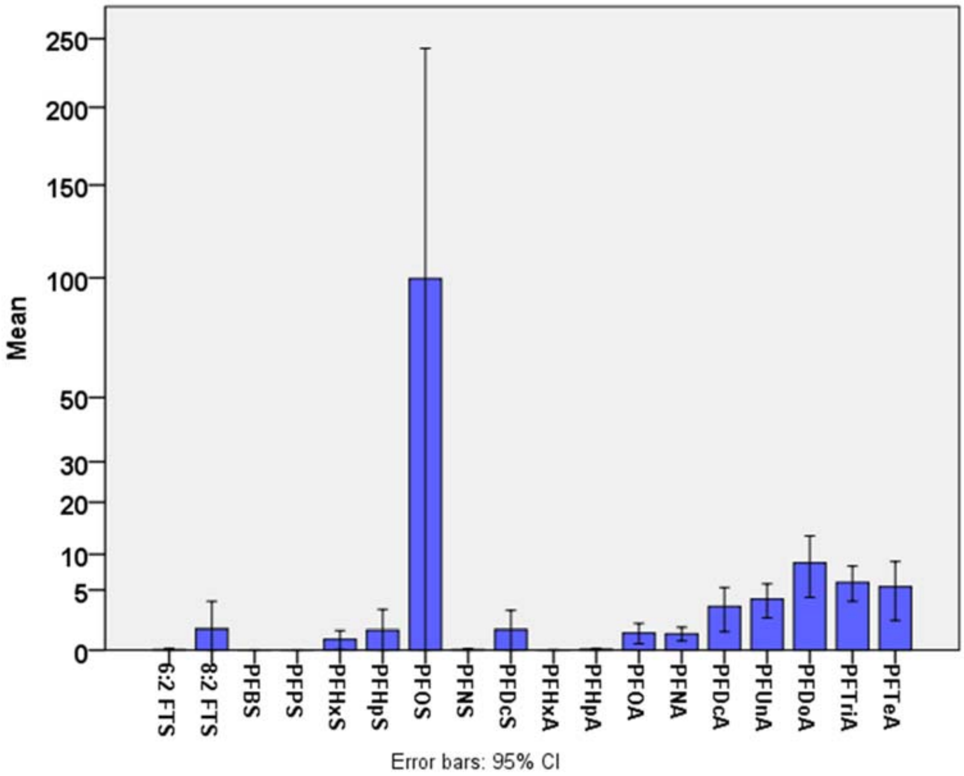


Figure 21: Mean PFAS concentrations in ng/g ww in fieldfare eggs

3.3.5 Sparrowhawk

The highest sumPFAS concentration of 383 ng/g ww was found in one egg from Ås (Table 20). PFOS was the dominating PFAS ranging between 11 to 262 ng/g ww (average 108 ng/g ww). Other important PFAS were in decreasing order: PFTrA, PFDoA, PFTeA, PFUnA. Other PFAS were detected in minor concentrations in all eggs; 8:2 FTS, PFDcA, PFNA, PFOA, PFHpS. PFHxS, PFDcS, and PFHpA were found with a high detection rate too. The median concentration of sumPFAS in this study was 148 ng/g ww, compared to 14 ng/g ww reported for the 2015 monitoring data (Herzke et al., 2016). There is limited information with respect to PFAS concentrations in eggs from sparrowhawk. For comparison, in a study from 2012, common kestrel eggs were analysed with respect to PFASs (Nygård and Polder, 2012). They were collected in the time period 2005-2010 with reported sum concentrations on the average of 4.5 ng/g ww, but the common kestrel mainly preys on rodents, placing it lower in the food chain than sparrowhawks. A more comparable species is the Merlin, which preys on small birds, and which had 67 ng/g PFAS during the same period.

Table 20: Detected PFAS congener concentrations in sparrowhawk eggs in ng/g ww. N: number of detected/measured samples.

	PFHxS	PFHPS	PFOS	PFNS	PFDcS	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA	SumPFAS
N	9/10	10/10	10/10	2/10	9/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	
Mean	0.88	1.50	108	0.01	0.95	2.18	1.63	3.39	5.64	10.3	10.5	8.98	155
Median	0.69	0.94	105	<LOD	0.78	1.21	1.69	3.10	5.32	9.94	10.5	10.3	148
Minimum	<LOD	0.08	11.0	<LOD	<LOD	0.59	0.488	1.38	1.50	2.13	2.27	2.87	23.0
Maximum	1.61	3.95	292	0.07	1.82	5.16	3.77	7.45	14.0	23.9	21.3	12.8	383

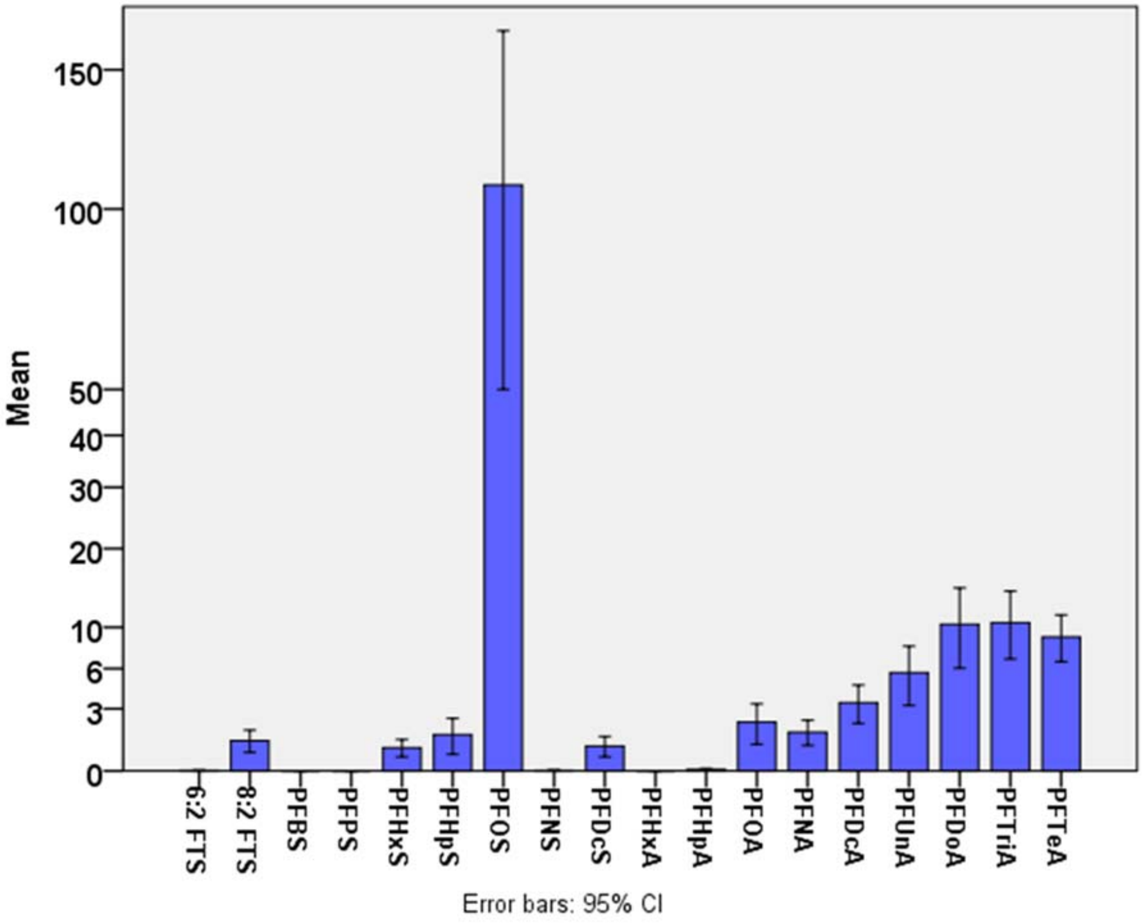


Figure 22: Mean PFAS concentrations in ng/g ww in eggs of sparrowhawk.

In three pools consisting of 3 eggs each, we also analysed for new emerging PFAS, as F53, F53B, monochlorinated PFOS and PFOA. None of these new PFAS were detected.

3.3.6 Tawny owl

SumPFAS concentrations in tawny owl eggs varied between 3.4 and 65.5 ng/g ww, with two extreme samples with sum concentrations higher than 50 (Table 21). However, on average sumPFAS concentrations in tawny owl are with 24.7 ng/g ww about five times lower than sparrowhawk eggs (113 ng/g ww). Similar to the findings from sparrowhawk eggs, PFOS dominated in all samples with levels ranging between 2 and 50 ng/g ww (median 12.1 ng/ g ww). For comparison with a rural location, Bustnes et al. reported a median of 9 ng/g ww in tawny owl eggs collected in Trondheim in Sør-Trøndelag County, Central Norway in 2008 (Bustnes et al., 2013). Besides PFOA, we also detected PFNA – PFTeA in all egg samples, with PFDoA, PFTrA and PFUnA dominating the PFCA pattern.

Table 21: PFAS in eggs of tawny owl in the Oslo district in ng/g ww. N: number of detected/measured samples

	PFHxS	PFHpS	PFOS	PFDcS	PFHxA	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA	SumPFAS
N	1/10	3/10	10/10	5/10	1/10	2/10	10/10	10/10	10/10	10/10	10/10	10/10	
Mean	0.18	0.03	18.3	0.35	0.01	0.02	0.19	0.81	1.09	1.04	1.19	0.59	24.7
Median	<LOD	<LOD	12.2	0.045	<LOD	<LOD	0.14	0.67	1.00	0.79	0.95	0.39	16.7
Minimum	<LOD	<LOD	1.89	<LOD	<LOD	<LOD	0.06	0.19	0.32	0.01	0.37	0.19	3.41
Maximum	1.76	0.15	49.8	1.41	0.07	0.10	0.36	2.02	2.41	3.09	3.45	2.29	65.5

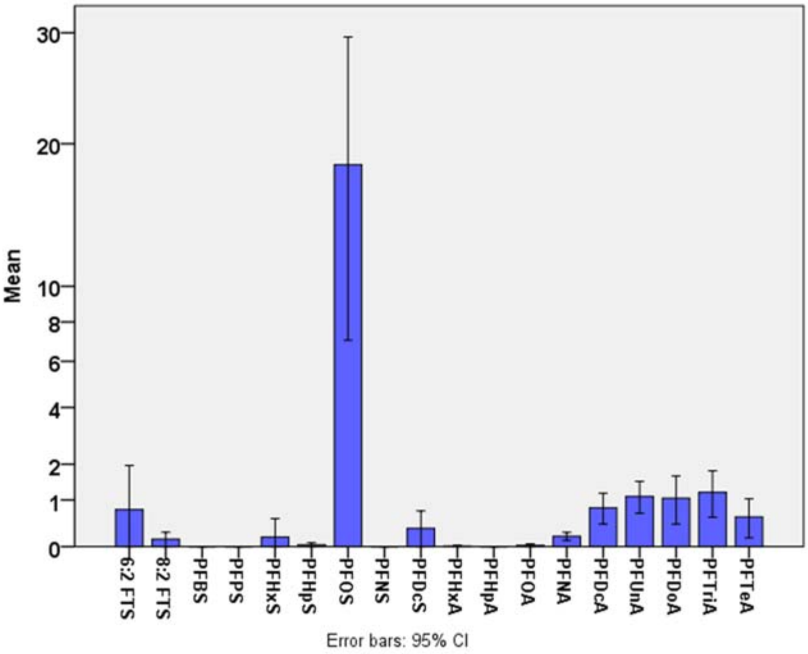


Figure 23: Mean PFAS concentrations in ng/g ww in eggs of tawny owl

3.3.7 Brown rat

As seen for other pollutants, PFAS in rats varied considerably between individuals (Table 22). SumPFAS ranged between 12 and 281 ng/ ww, with PFOS being the dominating contributor in all samples. In comparison, in the 2015 monitoring campaign PFAS levels ranging between 3.1 and 72 ng/g ww were detected (Herzke et al., 2016). The highest PFOS concentrations measured in this year's montoring were 188 ng/g and 151 ng/g ww in rats, with no direct exposure explanation. High PFCA concentrations could be found in a number of rats as well, with a varying pattern.

Table 22: PFAS in liver of brown rat, Oslo, in ng/g. N: number of detected/measured samples.

	PFHpS	PFOS	PFNS	PFDcS	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA	SumPFAS
N	4/10	10/10	4/10	1/10	9/10	10/10	10/10	10/10	6/10	10/10	10/10	
Mean	0.52	61.9	0.27	0.92	2.08	3.26	4.93	3.21	9.68	3.04	3.95	96.5
Median	<LOD	36.9	<LOD	<LOD	0.95	1.62	3.38	1.65	4.46	0.89	1.20	57.2
Minimum	<LOD	6.78	<LOD	<LOD	<LOD	0.28	<LOD	0.8	<LOD	0.43	0.51	11.9
Maximum	2.81	188	1.40	9.22	10.1	9.18	14.6	9.82	44.7	14.1	18.5	281

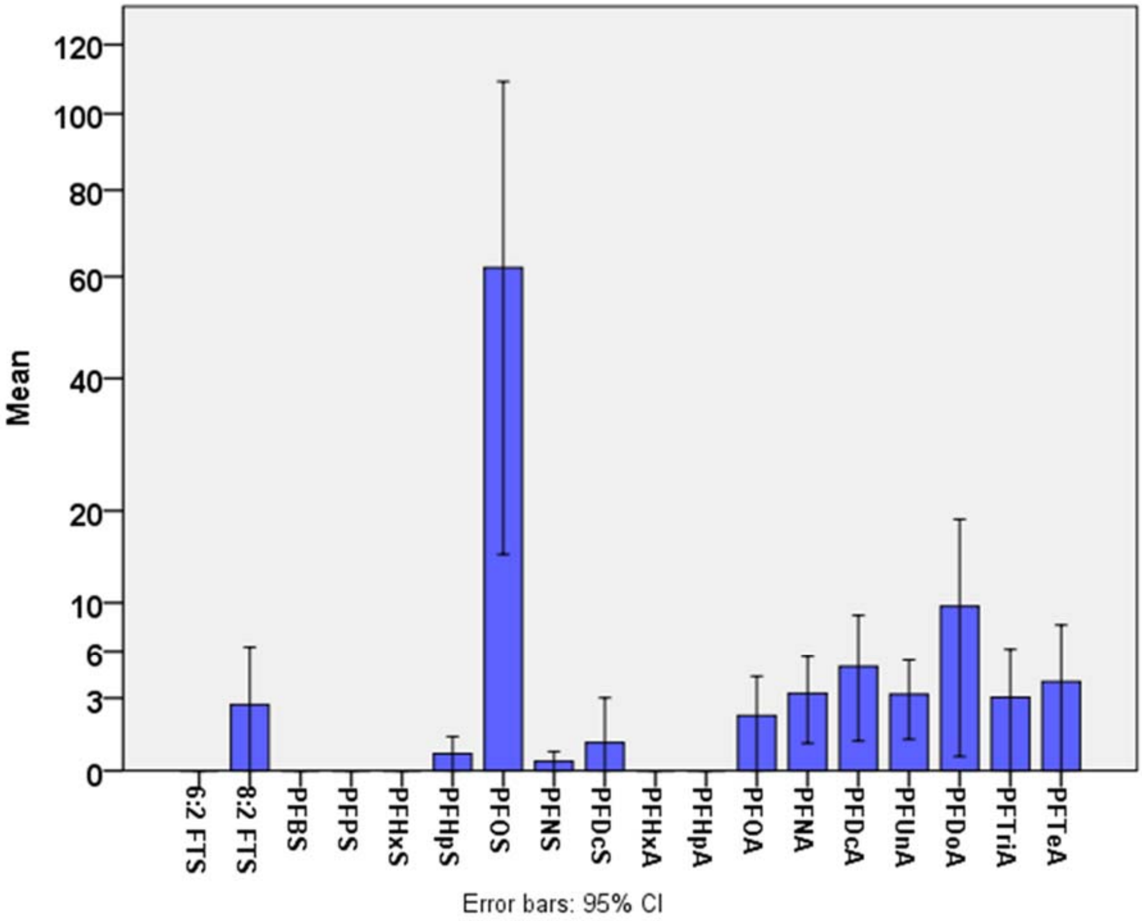


Figure 24: Mean concentrations (ng/g ww) of PFAS in Brown rat livers. Errorbars show the 95% confidence limits.

In three pools consisting of 3 livers each, we also analysed for new emerging PFAS, as F53, F53B, monochlorinated PFOS and PFOA. None of these new PFAS were detected.

3.3.8 Red fox

PFAS could be detected in all fox liver samples (Table 23, Figure 25). SumPFAS concentrations were comparable to the reported data in 2015, ranging from 4.6 to 37.1 ng/g ww compared to 2.26 to 43.5 ng/g ww in 2015 (Herzke et al., 2016). Linear PFOS was the dominating PFAS in all samples, followed by PFUnA and PFDcA (Table 23). For comparison, in polar fox liver from Svalbard, PFOS concentrations ranging between 10 and 220 ng/g ww were found, a result that has been / can be explained by the partly marine diet of polar foxes (Aas et al., 2014).

Table 23: Concentrations of detected PFAS compounds in red fox livers in ng/g ww. N: number of detected/measured samples.

	PFHxS	PFHpS	PFOS	PFOA	PFNA	PFDcA	PFUnA	PFDoA	PFTriA	PFTeA	**SumPFAS**
N	9/10	9/10	10/10	10/10	10/10	10/10	10/10	8/10	9/10	6/10	
Mean	0.32	0.15	14.8	0.40	1.33	1.64	1.78	0.85	0.71	0.17	23.2
Median	0.32	0.12	15.3	0.41	1.25	1.83	1.95	0.79	0.52	0.09	23.6
Minimum	<LOD	<LOD	2.73	0.22	0.44	0.55	0.28	<LOD	<LOD	<LOD	4.62
Maximum	0.52	0.42	27.9	0.67	2.53	2.29	3.12	1.73	1.597	0.63	37.1

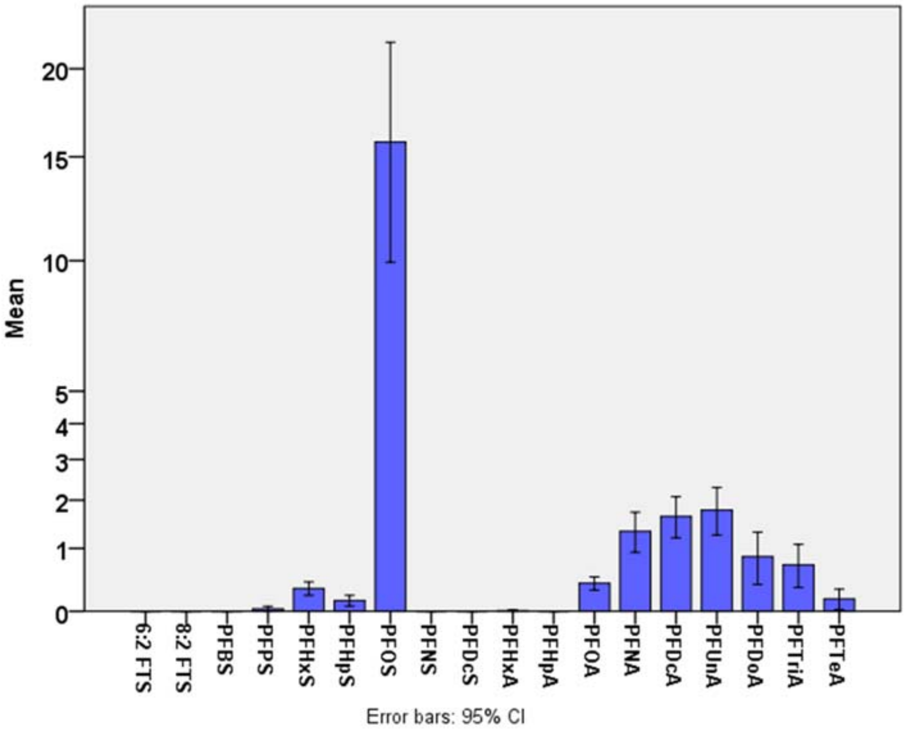


Figure 25: Mean concentrations in ng/g ww of detected PFAS compounds in the analysed fox livers.

3.3.9 Small rodents

In one pool consisting of 10 livers of small rodents, we also analysed for old and new emerging PFAS, as F53, F53B, monochlorinated PFOS and PFOA. None of these new PFAS were detected. Of the conventional PFAS, PFOS was dominating the PFAS pattern with 5.5 ng/g ww followed by PFTrA and PFUnA (2.3 and 1.9 ng/g ww). SumPFAS amounted to 13.1 ng/g ww, about 5 times lower than observed in rats (57 ng/g ww) and half of what was found in fox liver (23.6 ng/g ww).

3.3.10 Summary PFAS

The extreme PFOS concentrations found in soil and worms at Alnabru raise considerable concern about both the quality of the terretrial ecosystem at that site, but also for the freshwater- and grooundwater system close by. Action has to be taken to identify the magnitute of the source. Also skiing areas still show elevated levels in soil and earthworms. Sparrowhawk is the most contaminated species with a mean of 147 ng/g ww (median 112 ng/g), followed by fieldfare, rat and earthworms (excluding Alnabru). The results indicate a moderate biomagnification of PFAS through food-chains.

3.4 Metals

3.4.1 Soil

Metals have a very high abundancy in soils in general and in urban soils in particular. Zink and chromium were the dominating metals in all soils, except for Frognersteren, were lead was of similar abundancy (Table 24), similar to last years findings (Herzke et al., 2016). The sumToxicMetals concentrations ranged from 20 500 ng/g dw in Svartdalparken to 120 000 ng/g dw in Frognerseteren. The following order of SumToxic Metal concentrations was found: Svartdals parken < Alnabru < Voksenkollen < Slottsparken < Frognerseteren. This was somewhat unxpected, as Alnabru was believed to be the most contaminated site in this respect.

Silver and mercury were found only at low concentrations of less than 400 ng/g g dw. However, in this years study, cadmium showed elevated levels in three locations with concentration of 575, 1692 and 2712 ng/g dw in Alnabru, Frognerseteren and Voksenkollen (4911 and 1735 ng/g dw in 2015 at Frognerseteren and Voksenkollen) (Herzke et al., 2016). Besides cadmium, also high concentrations of chromium, lead and arsenic were found in a number of the locations together with one finding of high nickel levels in Slottsparken. Pb varies between the sites, with highest concentrations found in Frognersætra (105 000 ng/g dw) and lowest in Svartdalsparken (15 000 ng/g dw).

According to the Norwegian guidelines on classification of environmental quality of soil (normverdi), 8000 ng/g dw of As, 60 000 ng/g dw of Pb, 1500 ng/g dw of Cd, 1000 ng/g dw of Hg, 100000 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 for clean soil (SFT, 2009).

These thresholds were exceeded for

- Pb in Frognersætra (105 434 ng/g dw)
- Cr, all locations except Frognersætra and Svartdalsparken exceeded the threshold
- As, all locations except Frognersætra and Svartdalsparken exceeded the threshold
- Ni, Slottsparken exceeded the threshold
- Zn, all locations exceeded the threshold
- Cd, Fognersætra and Voksenkollen exceeded the threshold

For comparison, Luo et al, reported a median of 25 000 ng/g dw for Pb and 13 000 ng/g dw for Cr in urban park surface soils of Xiamen City, China (Luo, et al., 2012), which is considerable lower than what was found in Oslo. The authors calculated a bioaccumulation factor (BAF) of 49% for lead and and 10% for chrome, indicating potential for lead to enter the terrestrial foodchain. In Torino, Italy, soil concentrations of 288 000 ng/g dw for Cr and 1 405 000 ng/g dw for Pb were reported, all considerably higher than in Oslo soils (Madrid, 2008). In soil in parks from Bristol, UK, average concentrations of 22 000 ng/g As, 180 000 ng/g dw of Pb, 500 ng/g dw of Cd, 40 000 ng/g dw of Cu, 250 000 ng/g Zn, 20 000 ng/g dw of Cr and 25 000 ng/g dw of Ni was found (Giusti, 2011). For comparison, in Oslo, As and Pb are lower, Cd is higher at Voksenkollen and Frognersætra, Cu is comparable, Zn is higher in Alnabru and Voksenkollen, Cr and Ni are higher in all locations except Frognersætra. With 450 000 inhabitants Bristol is of comparable size as Oslo, also both coastal cities.

Table 24: Metals soil from Oslo, in ng/g dw. N: number of detected/analysed samples.

	Hg	Ag	Cd	Pb	Cu	Zn	Cr	Ni	As
N	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5
Mean	149	246	1100	49572	41502	302052	58706	34494	8086
Median	129	122	575	37954	43052	167252	67307	33510	9107
Minimum	165	122	230	15118	21494	102829	16057	9139	4680
Maximum	317	332	2712	105434	59153	813261	93413	52744	11200

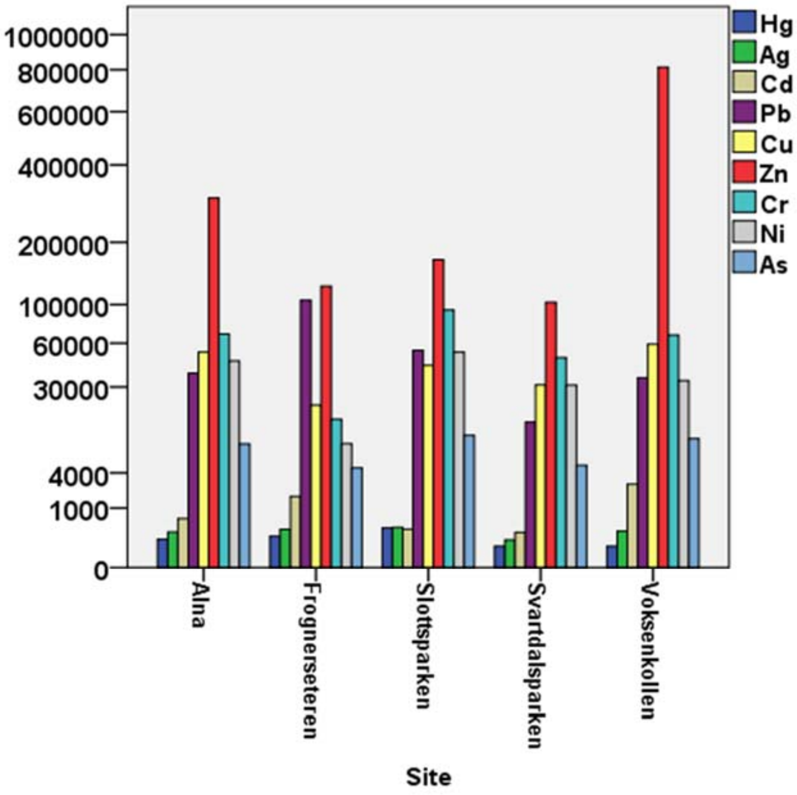


Figure 26: Metal concentrations in soil samples at the different sites in Oslo in ng/g dw.

3.4.2 Earthworm

Zink was the dominating metal, followed by copper, chrome, lead and cadmium.
However, as Zn has important physiological functions in all organisms, the concentrations cannot be interpreted as toxic. High levels of lead found in earthworms prove the bioavailability of lead in urban soil. The soil-worm relationships of the metals measured varied between $r^2 = 0.32$ for nickel and 0.96 for cadmium, showing a varying uptake potential into worms. Kumar et al. observed that copper and cadmium were toxic for worms at 1 500 000 ng/g and 100 000 ng/g in soil respectively, concentrations not reached in our study. Cadmium is the most toxic metal to earthworms, followed by copper (Kumar et al. 2008).

Table 25: Metals in pooled earthworms from Oslo, in ng/g ww.

	Hg	Ag	Cd	Pb	Cu	Zn	Cr	Ni	As
N	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5
Mean	280	34	2057	1519	2886	170278	2245	1219	684
Median	101	20	938	1156	2494	161140	1408	884	640
Minimum	29	9	576	369	1911	97225	492	332	483
Maximum	1101	76	5523	3528	4972	246145	4699	2271	1017

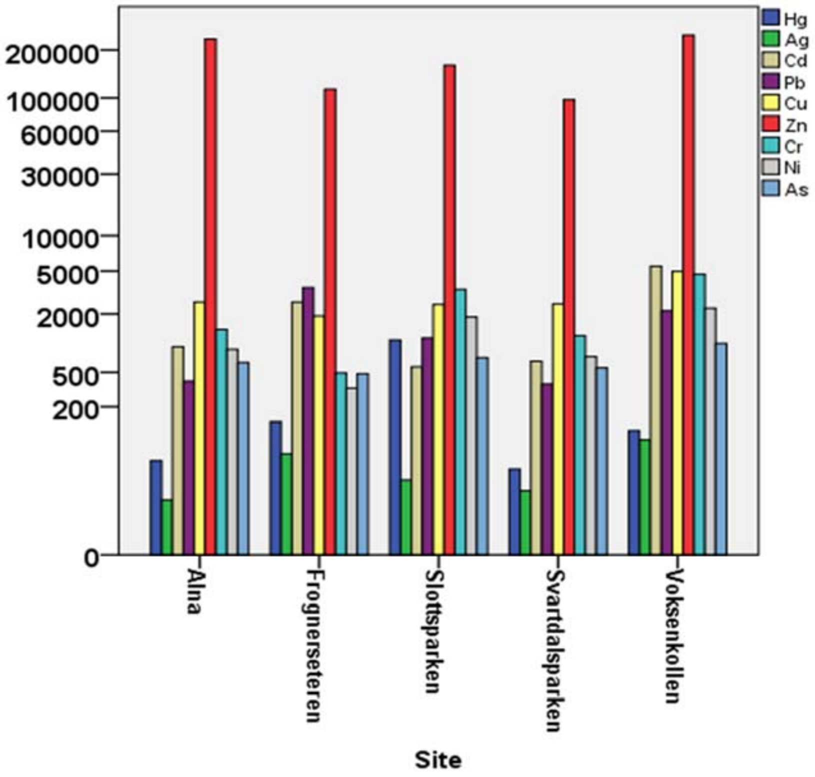


Figure 27: Metal concentrations in earthworms at the different sampling-sites in Oslo in ng/g ww.

When comparing the different urban locations where earthworm were collected, the highest sumToxicMetal concentration was found in Frognerseteren (59 350 ng/g ww) followed by Slottsparken (34 770 ng/g ww), Voksenkollen (28 560 ng/g WW), Alnabru (24 890 ng/g ww) and Svartdalsparken (11 050 ng/g ww).

Cd varies the most between the sites, with highest concentrations found in Voksenkollen (4117 ng/g ww) and lowest in Slottsparken with 434 ng/g ww. Pb was the major contibutor to the toxic metals, and was highest in Frognerseteren (54 480 ng/g ww), and lowest in Svartdalsparken (7 740 ng/g ww).

Latif et al., 2013 found Pb and Cd concentrations in three different earthworm species varying between 200 – 600 ng/g for lead and 200 and 350 ng/g Cd, which is much lower than found in the samples in Oslo. Possible harmful effects caused by the concentration of certain metals may be difficult to assess, as this seems to be species- and site specific (Lock and Janssen 2001). Even so, Zn concentrations in the earthworm species E. fetida, has been found to be physiologically regulated to a relatively constant concentration of 100 000-200 000 ng/g independent of Zn concentration in the surrounding soil (Lock and Janssen 2001). Other authors report findings of higher body burdens, even at fairly low contaminated sites (Lukkari 2004; Kennette et al. 2002).

3.4.3 Fieldfare

For the first time, fieldfare eggs from Oslo were available for metal determination (Table 26).

As also shown in the worms, Zn and Cu dominate the metal pattern. However, Zn and Cu are physiologically regulated and supposed to have little toxicological impact (Lukkari et al. 2004). Of the toxic metals investigated, lead, mercury and arsenic were the most abundant ones (average of 58.5, 8.9 and 2.9 ng/g ww respectively). Tsipoura et al., reported on metal concentrations in three species of passerine birds breeding in New Jersey, US (Tsipoura et al., 2008). Metal concentrations in eggs of 38, 120 and 48 ng/g respectively were reported for lead, chrome and mercury besides 6 ng/g for arsenic and 0,3 ng/g for cadmium in the red-winged blackbird (*Agelaius phoeniceus*) a passerine bird, feeding on seeds, insects and worms. In birds, Pb levels as low as 400 ng/g can cause negative effects on behavior, thermoregulation, and locomotion. The average levels of PB in the present study for eggs were amore than seven times lower than these levels (58 ng/g ww). One egg showed with 494 ng/g ww an exceptionally elevated level, crossing the effect-level mentioned above. That egg was collected close to the Kjelsåsmyra artificial turf (kunstgress bane), which also contained elevated concentrations of bisphenol A (300 ng/g ww) and *p,p'*-DDE (280 ng/g ww).

Table 26: Metals in fieldfare eggs in ng/g ww. N: number *of detected/analysed samples.*

	Hg	Ag	Cd	Pb	Cu	Zn	Cr	Ni	As
N	10/10	10/10	3/10	10/10	10/10	10/10	10/10	10/10	9/10
Mean	8.98	0.60	0.15	58.5	441	7697	22.5	10.8	2.89
Median	7.59	0.59	<LOD	12.1	398	7942	10.3	6.55	1.67
Minimum	4.67	0.32	<LOD	4.04	275	5108	4.98	3.60	<LOD
Maximum	16.2	0.94	0.49	494	746	10552	135	47.2	6.30

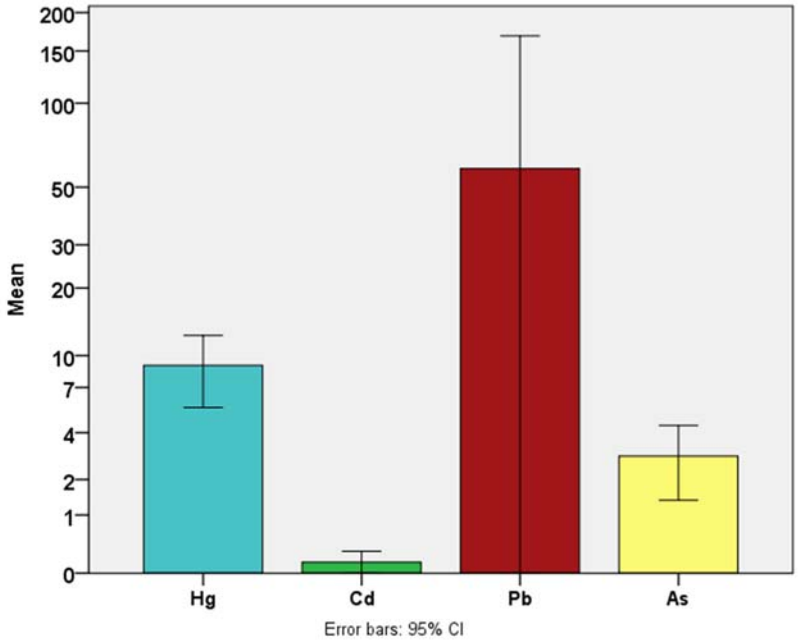


Figure 28: Mean concentations of toxic metals in fieldfare eggs in ng/g ww.

3.4.4 Sparrowhawk

Zn, Cu and Hg dominated in the sparrowhawk eggs (Table 27). The concentration of Zn found in sparrowhawk eggs were in the range of what was found in Audouins's gull *Larus audouinii* (Morera 1997), and Cory's shearwater *Calonectris diomedea* (Renzoni et al.1986). Cu concentrations found were in agreement with results obtained for *Larus audouinii* (Morera 1997). Since Cu and Zn are physiologically regulated in birds (Richards and Steele 1987), mostly total Hg, Pb, Cd and As can prove toxic at concentrations that can be found in the environment (Depledge et al. 1998). Ag was not detected in any of the analysed egg samples. Pb, Ni, Cd and As were only found at low concentrations of <70 ng/g ww. Cr and Hg were found with an average of 131 and 133 ng/g ww in all eggs, more than 10-times higher than in the fieldfare.

Table 27: The concentrations of the detected metals in the sparrowhawk eggs (ng/g ww). N: number of detected/measured samples.

	Hg	Ag	Cd	Pb	Cu	Zn	Cr	Ni	As
N	10/10	0/10	0/10	10/10	10/10	10/10	10/10	10/10	5/10
Mean	134	<LOD	<LOD	7.5	559	7970	131	68.3	2.0
Median	139	<LOD	<LOD	6.2	562	7788	40.1	21.3	1.0
Minimum	58.2	<LOD	<LOD	2.4	343	5923	3.6	4.3	<LOD
Maximum	223	<LOD	<LOD	16.8	711	9944	433	252	4.9

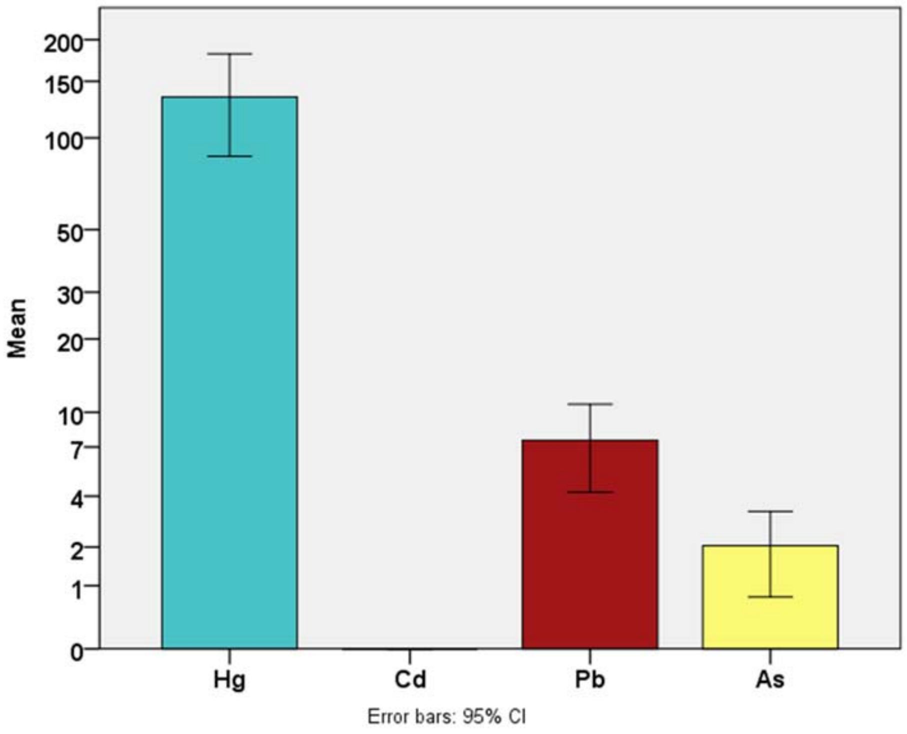


Figure 29: The mean concentration of toxic metals in the sparrowhawk eggs at the different sites in ng/g ww.

Pb and Hg are neurotoxins that cause cognitive and behavior deficits as well as decreased survival, growth, learning, and metabolism (Carvalho et al., 2008, Khadeim, 2015). As mentioned also above, in birds, Pb levels as low as 400 ng/g can cause negative effects on behavior, thermoregulation, and locomotion. The highest levels in the present study for sparrowhawk eggs were more than 50 times lower than these levels (7.5 ng/g ww). For Hg, levels of 1.5 ng/g egg of *Gallus domesticus* showed induced motor impairments, which correlated to histological damage and alterations in the cerebellar GSH system's development. The MeHg dose (1 µg/egg; 15 ng/g egg) increased the basal activity of the cerebellar antioxidant system in chicks (Carvalho et al., 2008). As shown in 2014, almost all Hg found in sparrowhawk eggs was in the form of MeHg (Herzke et al., 2015). The Hg concentrations found in all sparrowhawk eggs are well above these effect thresholds, indicating a harmful impact of Hg on sparrowhawks. As reported in the 2014 data, MeHg concentrations in a rural reference site showed significantly higher levels, indicating other than urban specific exposure (Herzke et al., 2015). Metals in eggs reflect those in the maternal blood and organs during egg formation (Evers et al. 2005), with the exception of several toxic metals that are not effectively transferred to eggs, such as Cd and Pb (Furness, 1996 and Spahn and Sherry, 1999). As, Hg, and Pb belong to the non-essential metals whilst Cu and Zn belong to the essential metals. Cu, Zn and Cd have been shown to significantly bioconcentrate from soils to invertebrates, but to biodilute from invertebrates to birds (Hargreaves et al., 2011). Cu, Zn and Fe are essential macro elements with many important biological functions, and body concentrations are usually well-regulated. Sparrowhawk eggs collected in a period between 2005 and 2010 have been reported to have a Hg concentration of 175 ng/g ww (Nygård and Polder, 2012). This is similar to the 148 ng/g ww (median) detected in sparrowhawk eggs in the Oslo area in our study. However, the low sample sizes precludes any comparison over time. For Hg, concentrations of 500 ng/g to 2000 ng/g in eggs are sufficient to reduce egg viability, hatchability, embryo survival and chick survival in nonmarine birds

(Thompson 1996; Mierzykowski, 2005). Embryo deformities may occur in bird eggs containing about 1000 ng Hg/g, with sensitive embryos experiencing mortality with mercury levels as low as 740 ng/g (Heinz and Hoffman 2003). Mercury sensitivity varies among bird species (Fimreite 1971, Barr 1986) and within clutches (Heinz and Hoffman 2003). An often used reproductive effect threshold level for mercury in bird eggs is 800 ng/g (Heinz 1979, Henny et al. 2002), while other investigators and ecological risk assessors may use 500 ng Hg/g as an ecological effect screening benchmark value of (RAIS 2004). In the case of the sparrowhawk from this study, the found median concentration of 148 ng/g ww as well as the maximum concentration found of 196 ng/g ww are well below these thresholds. The other toxic metals, Cd, Pb and As, were detected in very low levels; <LOD, 7.5 and 2.0 ng/g ww, respectively.

3.4.5 Tawny owl

Cu was, with a median of 827 ng/g ww, the second most important metal found after zinc (Table 28). Cr showed also high concentrations with an median of 155 ng/g ww, with one extreme finding of 1474 ng/g ww. All other metals were only present in very low concentrations (median Hg was 8.2 ng/g, for Pb 2.2, Ag 0.4, Cd <LOD, Ni 49 and As 0.4 ng/g ww). Elevated Ni concentrations were found in one egg from Kjøvangen, with 540 ng/g ww. All eggs were above the reported concentration for induced motor impairments of 1.5 ng/g ww Hg and four eggs were above the effect Hg concentration for the increased basal activity of the cerebellar antioxidant system of 15 ng/ww (Carvalho et al., 2008). Otherwise only little data on toxicological thresholds for wild birds exists, even less on terrestrial species.

Table 28: Metal concentrations in tawny owl eggs in ng/g ww; N: number of detected/analysed samples.

	Hg	Ag	Cd	Pb	Cu	Zn	Cr	Ni	As
N	10/10	5/10	0/10	10/10	10/10	10/10	10/10	10/10	4/10
Mean	11.3	0.68	<LOD	2.0	827	13358	147	72.4	2.98
Median	8.2	0.19	<LOD	1.7	285	13914	168	10.8	<LOD
Minimum	5.0	0.19	<LOD	1.0	285	7242	20.3	10.8	<LOD
Maximum	24.5	2.67	<LOD	3.6	1252	18105	1474	539	12.4

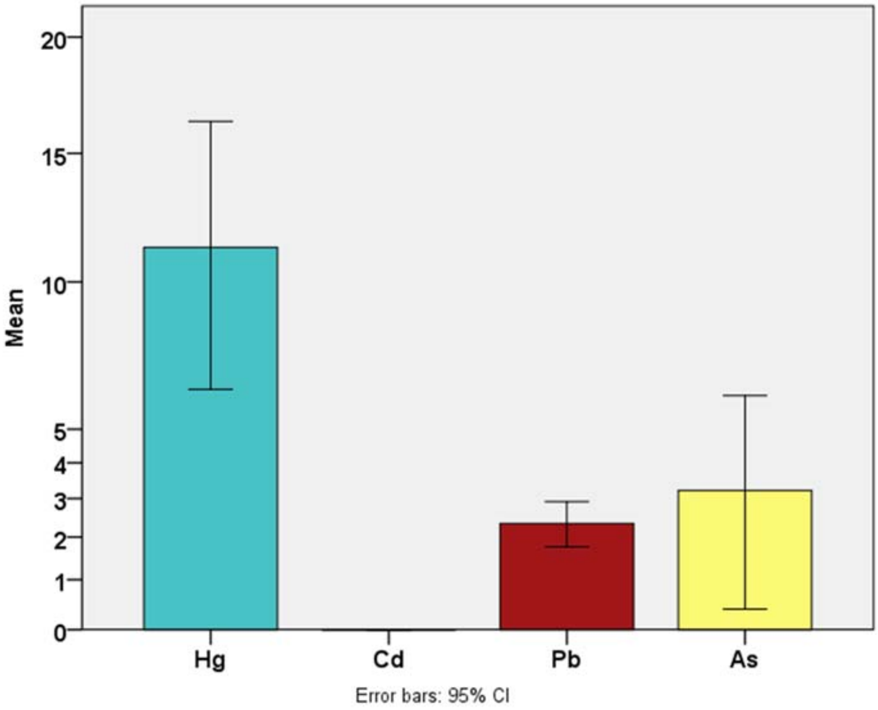


Figure 30: Toxic metal levels in eggs of tawny owl in the Oslo area (ng/g ww).

3.4.6 Brown Rat and small rodents

Metals in rat liver were mostly represented by high levels of Zn (average of 27 450 ng/g ww) followed by Cu and Cr (average of 4256 and 1297 ng/g respectively). Of the toxic metals, rats showed, with an average of 1743 ng/g ww, the highest levels of As in all observed species, with the extreme of 9717 ng/g ww in one sample from Stovner around a conglomerate of stores, schools and a riding centre. The same sample did also contain elevated levels of Cd, Cr and Ni. Pb played a minor metal in rats, with two exceptions of concentrations higher than 600 ng/g (659 and 913 ng/g ww).

Table 29: Metal concentrations in brown rat livers from Oslo (ng/g ww). N: number of detected/measured samples.

	Hg	Ag	Cd	Pb	Cu	Zn	Cr	Ni	As
N	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10
Mean	5.2	1.4	56.9	192	4256	27450	1297	629	1743
Median	2.4	0.6	18.5	46	4150	24773	1224	585	327
Minimum	0.4	0.6	6.6	28	2840	19342	456	219	327
Maximum	24.0	4.2	394	913	6026	49137	2422	1175	9717

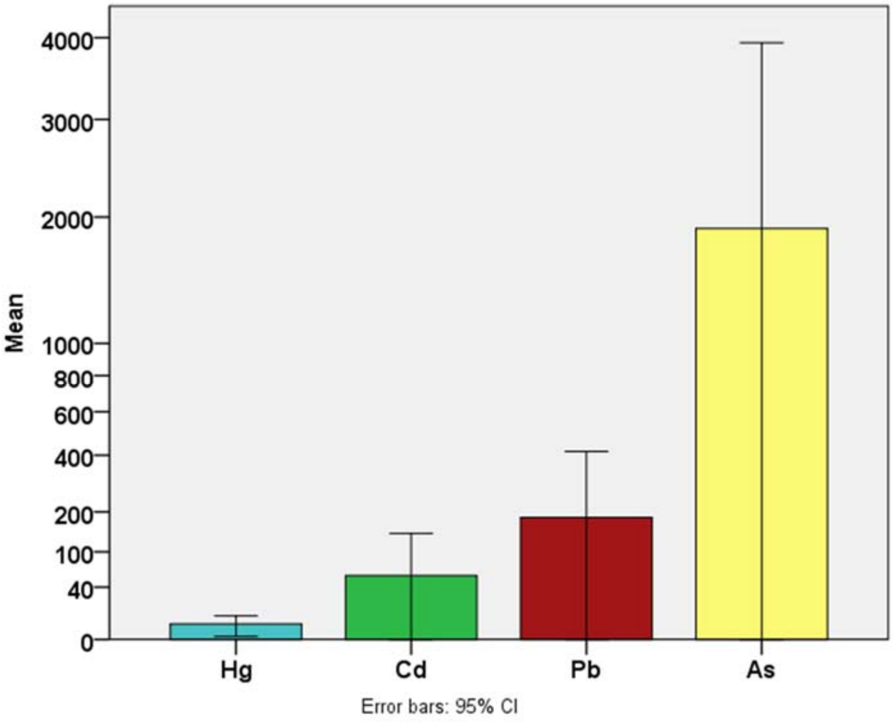


Figure 31: Toxic metals in brown rat livers at different sites in Oslo (ng/g ww).

The field vole exhibited very similar metal concentration to rats. The only exception was As which was with 11 ng/g ww about 70-times lower than in the rat livers, indicating an elevated exposure for rats, but not for voles.

3.4.7 Red fox

Zn was the dominating metal detected in fox liver, with average concentrations of 37 943 ng/g, followed by Cu with 10 351 ng/g ww. Of the other elements determined, Hg, Cr, Ni and Cd were found in average concentrations above 100 ng/g ww. One fox liver contained 1571 ng/g lead, exceeding the 1000 ng/g threshold for clinical lead poisoning.

Table 30: Concentrations of metals in livers of red fox from Oslo in ng/g ww. N: number of detected/ measured samples.

	Hg	Ag	Cd	Pb	Cu	Zn	Cr	Ni	As
N	10/10	10/10	10/10	10/10	10/10	10/10	10/10	7/10	4/10
Mean	178	2.2	238	283	10351	37943	367	150	27.2
Median	30	1.8	210	86	9682	39501	286	101	0.4
Minimum	30	0.3	73	29	4553	24345	65	<LOD	<LOD
Maximum	1269	4.5	505	1571	16112	45835	968	450	233

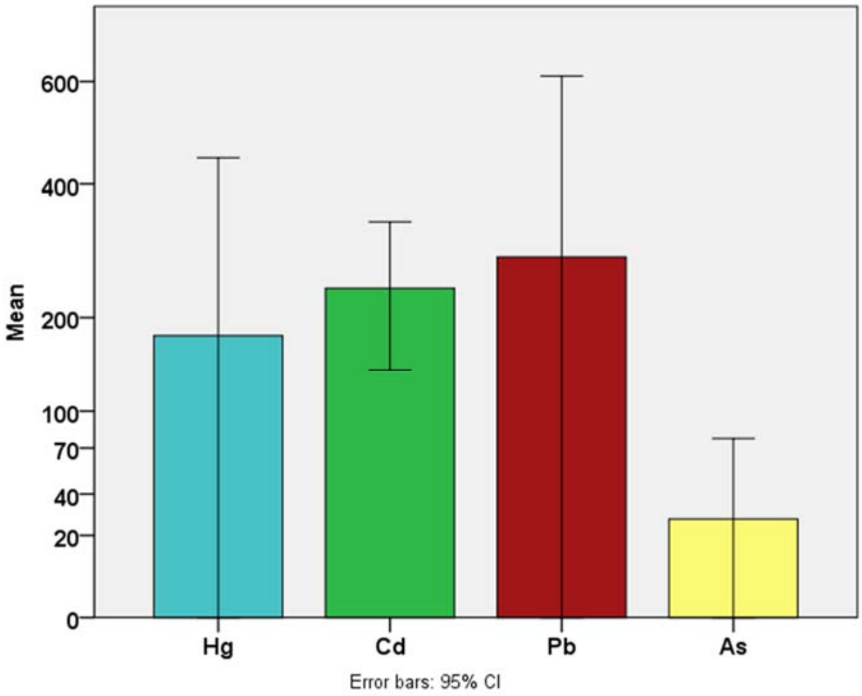


Figure 32: Mean concentrations of toxic metals in red fox liver (ng/g ww).

It is unclear if the high levels found in this individual is attributed to the use of lead ammunition. However, one possible explanation is that lead ammunition used to kill the animal has contaminated the liver sample, another explanation is that the animal ingested lead ammunition along with prey, prior hurt by lead ammunition.

Dip et al. (2001) reported that liver of suburban and rural foxes contained the highest Cd concentrations, whereas urban foxes contained the highest Pb levels within the municipality of Zurich (Switzerland). In the liver of urban foxes, Cd levels of 94 ng/g were found (Dip et al., 2001), half of our findings of an average of 210 ng/g ww. Copper was slightly lower in Oslo, compared to Zurich with 9681 ng/ g compared to 16 000 ng/g found in Zurich. Also zinc and lead showed comparable median values to those of Zurich, both cities being of similar size in terms of inhabitants.

3.4.8 Summary metals

Toxic metals concentrations were highest in soil. Of the biologiacal matrices analysed, earthworms, brown rats and foxes contained the highest amounts. The levels in earthworms are most certainly caused by the feeding technique of the worms, eating their way through the soil. Fieldfare egg from one sampling site (Kjelsås) showed very high Pb concentration of 494 ng/g ww, more than 20 times higher than at the other sites.There are reasons for concern of the high levels of mercury in sparrowhawk eggs. The high levels in fox livers may also be of concern, and may be related to its opportunistic feeding on carrion shot by lead bullets.

3.5 Chlorinated paraffin's (CPs)

3.5.1 Air

For the first time CPs were measured in air at three locations in Oslo. SCCPs were detected in 10 to 100 times higher concentrations than MCCPs in all three locations. Between the locations sampled, Alnabru showed more than 10-times higher CP concentrations than the other two sites. Levels ranged from 33 to 730 ng/sampler for SCCP and 1.4 to 7.3 ng/ sampler for MCCP. For comparison, Wang et al found in the Pearl River Delta of South China average SCCP and MCCP concentrations of 5200 and 4100 ng/sampler for passive air samples (Wang et al., 2013). On the basis of published sampling rates for SCCPs from PUFs (4.2 m^3 /d), the SCCP air levels ranged between 0.09 and 1.9 ng/m^3 air. This is about two-times lower than 0.95 to 26.5 ng/m^3 in winter and 50-times lower than the 2.01 to 106 ng/m^3 observed in summer in in the Pearl River Delta of South China (Wang et al. 2013). To compare with Europe, Barber et al. 2007 measured in Lancaster, UK, SCCPs and MCCPs in the range of 220−9100 and 560−2900 ng/sampler in a 12 week sampling period. At the Zeppelin station on Svalbard, Norwegian Arctic, average concentrations of 0.42 and 0.13 ng/m^3 were measured in 2015 (Norwegian Environment Agency 2016).

3.5.2 Soil

SCCPs could be detected in all soil samples. MCCPs were present in all samples with the exception of Voksenkollen. SCCP concentrations ranged between 69 and 237 ng/g dw and MCCP varied between <LOD and 3.6 ng/g dw with an median SumCP of 122 ng/g dw. The highest sumCP concentration was found in Svartdalsparken closely followed by Alnabru (237 and 201 ng/g ww). The average concentrations for SCCP in soil was 142 ng/g dw and for MCCP was 1.7 ng/g dw, almost 100-times lower.

For comparison, Wang et al found average SCCP and MCCP concentrations of 18.3 and 59.3 ng/g for soil samples in the Pearl River Delta in South China, (Wang et al., 2013). This is more than 10-times lower and 30-times higher than the SCCP and MCCP levels detected in our study. However, the same authors also point out the large spatial variation found for CP in soils. Additionally, Wang et al., 2014 reported higher SCCP concentrations in soil from Shanghai, China, compared to MCCPs (median of 15.7 ng/g SCCPs and 7.98 ng/g MCCP). Our data for MCCPs are also similar to levels reported in humus (7–199 ng /g , mean 40 ng /g) in the Alps from five countries (Austria, Germany, Italy, Slovenia, and Switzerland) (Iozza et al., 2009).

Table 31: Chlorinated paraffins found in soil samples in Oslo (ng/g dw). N: number of detected/analysed samples.

	SCCP	MCCP
N	5/5	4/5
Mean	142	1.8
Median	121	1.4
Minimum	69.0	<LOD
Maximum	237	3.6

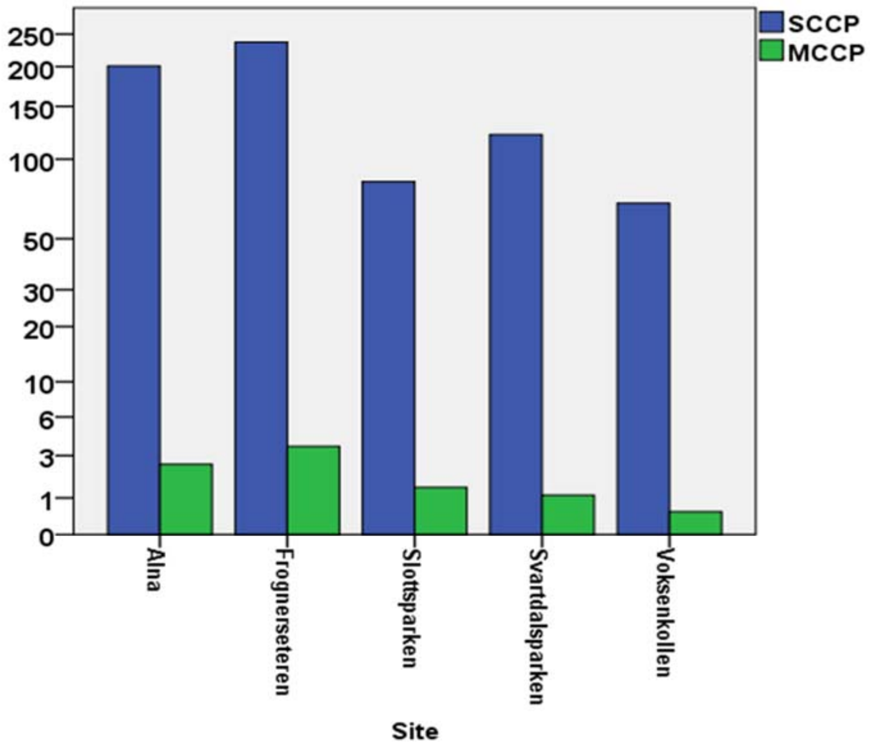


Figure 33: Concentrations of chlorinated paraffins in soil at the different sampling sites in Oslo (ng/g dw).

3.5.3 Earthworms

Both SCCPs and MCCPs were found in earthworms from Oslo. Concentrations varied for SCCP between 28 and 33 ng/g ww and for MCCP between 1.2 and 12.6 ng/g ww. Concentrations in worms from Alnabru and Frognerseteren did not reflect the elevated SCCP levels found in soil, indicating a low biomagnification potential in earthworms. Svartdalsparken showed the highest concentrations of chlorinated paraffins with 43.6 ng/g ww sumCPs.

Table 32: Chlorinated paraffins found in earthworms in Oslo (ng/g ww). N: number of detected/analysed samples.

	SCCP	MCCP
N	5/5	5/5
Mean	30.0	5.3
Median	30.0	4.8
Minimum	28.0	1.2
Maximum	33.0	12.6

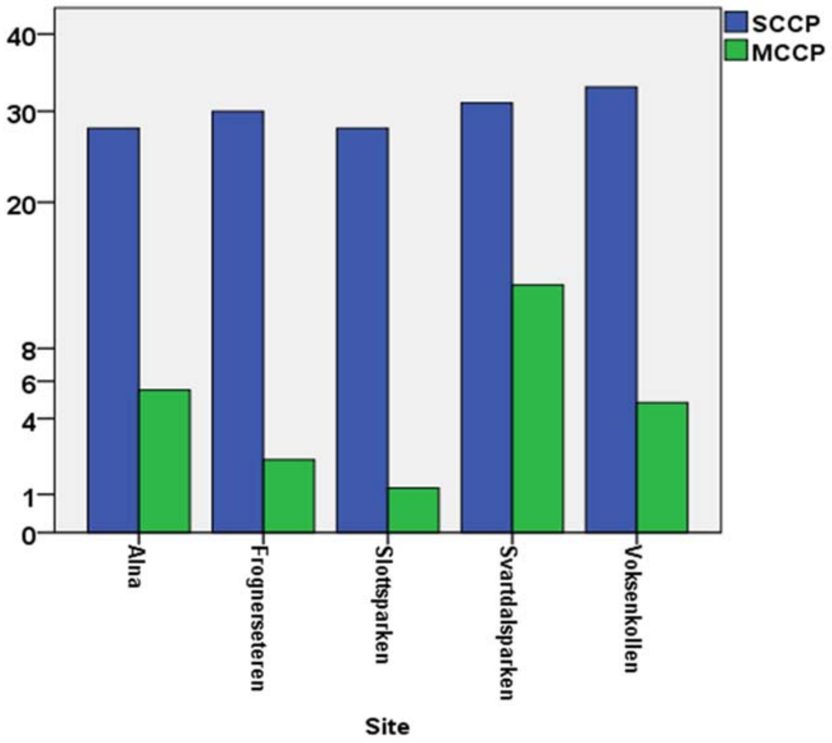


Figure 34: Chlorinated paraffins in earthworms at the different sampling-sites in Oslo (ng/g ww).

Nicholls et al. (2001) investigated the presence of SCCPs and MCCPs in farm soils in the UK and found that they were below detection limits (< 100 ng/g ww); however, CPs were present in earthworms living in the associated soils (<100–1700 ng/g ww), the leves were considerably higher than what was found in Oslo. Thomson (2001) investigated the effects of MCCPs on the survival, growth and reproduction of the earthworm. The most sensitive toxicity value for reproduction for earthworms in soil is the chronic (28-day) lowest observed effect concentration (LOEC) of 383 000 ng/ g dw, which was clearly above the highest soil samples reported here. This indicates that the present level of CPs in soil in Oslo likely poses no significant ecological risk for soil organisms in the area.

3.5.4 Fieldfare

Very little SCCPs and MCCPs were found in fieldfare eggs. In general SCCP concentrations were higher than MCCP (median SCCP 8 ng/g ww and MCCP 0.3 ng/g ww). Little information is available on CPs in bird eggs. In an earlier report by NILU on CPs in seabird eggs, similar concentrations to those reported in this study were found (Huber et al.,2015)

Table 33: Chlorinated paraffins found in eggs of fieldfare in Oslo (ng/g ww). N: number of detected/analysed samples.

	SCCP	MCCP
N	4/10	4/10
Mean	17.5	0.7
Median	8.0	0.3
Minimum	<LOD	<LOD
Maximum	52.0	2.6

3.5.5 Sparrowhawk

SCCPs and MCCPs were found in all except one sparrowhawk egg, ranging between <LOD and 318 ng/g ww for SCCP and <LOD and 0.5 ng/g ww for MCCP. The medians were 51 ng/g ww for SCCP and <LOD for MCCP, different to the medians of 12.7 and 3.3 ng/g reported in 2015 (Herzke et al., 2016). SCCPs was in general more abundant than the MCCPs. S/MCCP data for herring gull eggs from Oslo reported by the Norwegian Environment Agency in 2014, were in the same order of magnitude (Norwegian Environment Agency, 2015).

Table 34: Chlorinated paraffins in sparrowhawk eggs (ng/g ww). N: number of detected/analysed samples.

	SCCP	MCCP
N	9/10	1/10
Mean	81.6	0.10
Median	51.0	<LOD
Minimum	<LOD	<LOD
Maximum	318	0.50

3.5.6 Tawny owl

S/MCCPs were found in all tawny owl eggs, with SCCP dominating. Lower SCCP and MCCP median concentrations compared to the sparrowhawk could be found (36.5 and <LOD ng/g ww).

Table 35: Chlorinated paraffins in tawny owl eggs (ng/g ww). N: number of detected/analysed samples.

	SCCP	MCCP
N	10/10	1/10
Mean	35.1	0.12
Median	36.5	0.05
Minimum	25.0	0.05
Maximum	45.0	0.70

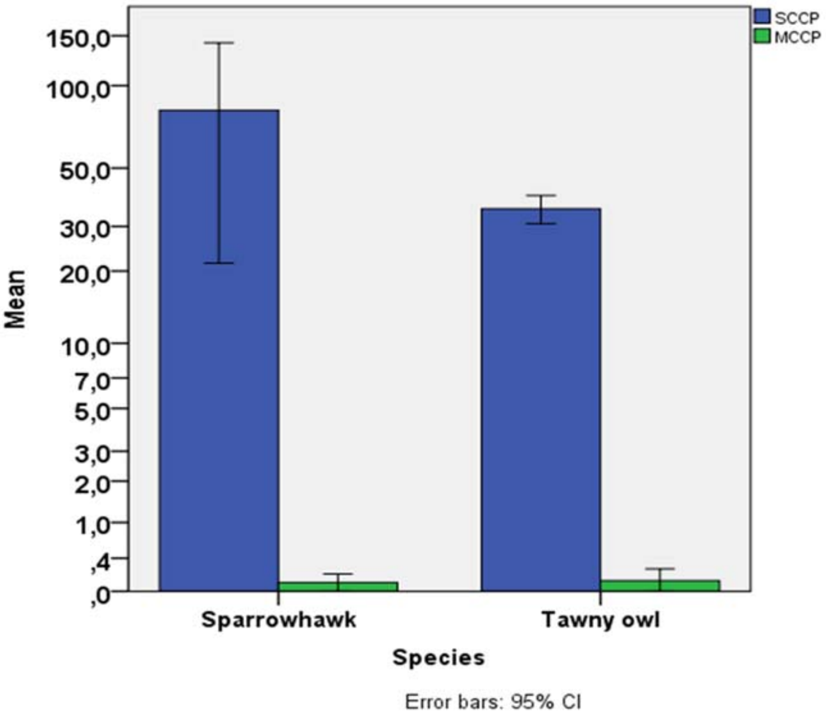


Figure 35: Mean concentrations of chlorinated paraffins in sparrowhawk and tawny owl eggs (ng/g ww).

3.5.7 Brown Rats

S- and MCCPs were only occasionally found in rat liver (in four of ten samples with maximum concentrations of 160 ng/g ww at Karl Johans gate).

Table 36: Chlorinated paraffins in rat livers (ng/g ww). N: number of detected/analysed samples.

	SCCP	MCCP
N	4/10	9/10
Mean	27.7	8.8
Median	8.0	1.7
Minimum	<LOD	<LOD
Maximum	160.0	70.0

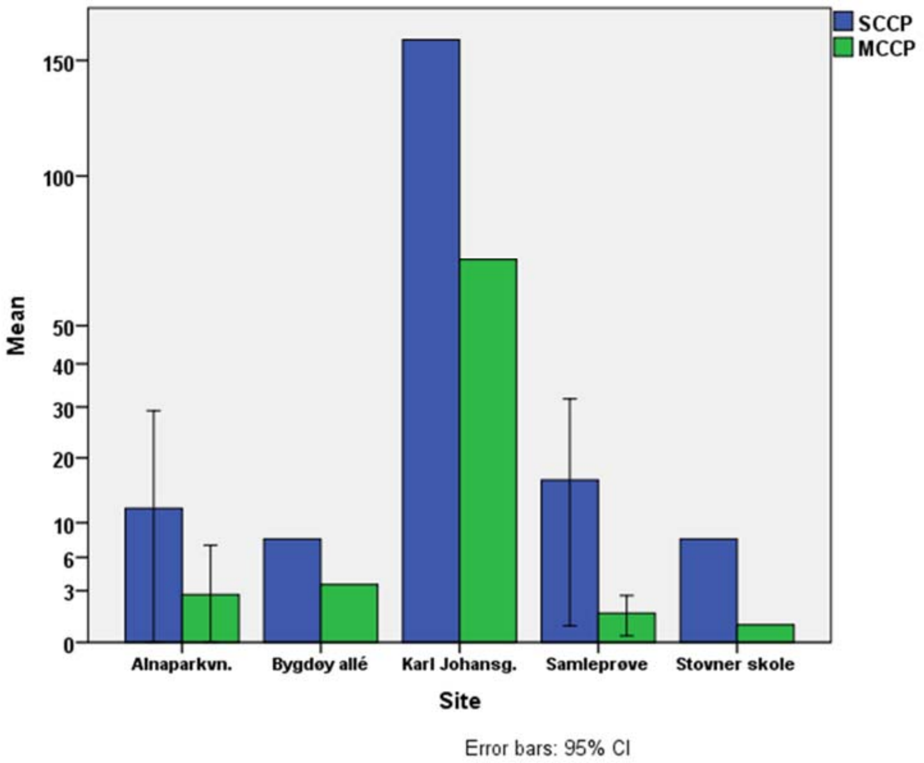


Figure 36: Mean concentrations of chlorinated paraffins in rat livers (ng/g ww) collected at different sites in Oslo.

3.5.8 Red fox

In fox liver, mostly SCCP could be detected, ranging between 18 and 44 ng/g ww. MCCPs were present in 50% of all samples, ranging between <LOD and 3.8 ng/g ww.

Table 37: Chlorinated paraffins in red fox livers (ng/g ww). N: number of detected/analysed samples.

	SCCP	MCCP
N	9/10	5/10
Mean	32.1	1.24
Median	32.0	0.63
Minimum	<LOD	<LOD
Maximum	44.0	3.80

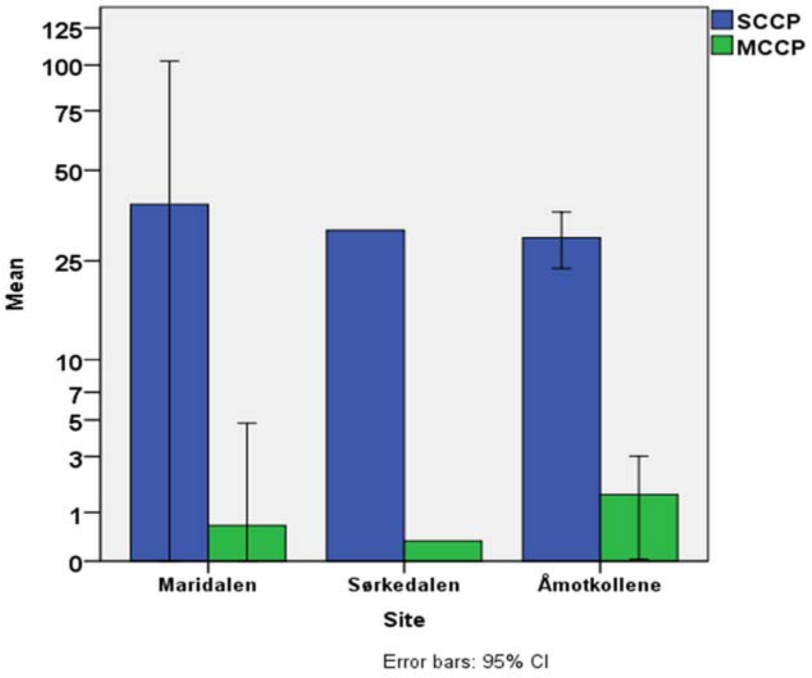


Figure 37: Mean concentrations of chlorinated paraffins in red fox livers (ng/g ww) at the different collecting-sites in Oslo.

3.5.9 Small rodents

No S/MCCPs could be detected in field voles.

3.5.10 Summary S/MCCPs

SCCPs were present in all air, soil, fox, sparrowhawk and tawny owl samples, indicating an ubiquitous distribution in Oslo. MCCPs were only found sporadically, mostly in earthworms and soil

3.6 Cyclic Siloxanes

The three cyclic volatile methylsiloxanes, octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5), and dodecamethylcyclohexasiloxane (D6), have been found to accumulate in biota (Warner et al. 2010; Kierkegaard et al. 2011; Kierkegaard et al. 2013). They do however bioaccumulate to large varying degrees depending on the chemical and organism studied. The European Community Regulation on Registration, Evaluation, Authorization and Restriction of chemicals (REACH) classified D4 and D5 as very bioaccumulative, in contrast to D6.

3.6.1 Air

All three siloxanes could be detected in all three locations in Oslo. D5 dominated in all three locations, ranging between 418 and 2893 ng/ sampler (corresponding to 2 and 13 ng/m^3). The highest SumSiloxane concentration was found at Slottsparken with 4095 ng/ sampler. Genualdi et al., reported in 2011 in a global review, D5 concentrations ranging between 0.3 (Barrow, Alaska) and 280 ng/m^3 in Paris (Genualdi et al., 2011). The authors suggest that elevated concentrations of D4 on the West coast of North America and at high elevation sites suggest these sites are influenced by trans-Pacific transport, while D5 and D6 have elevated concentrations in urban areas, which is most likely due to personal care product use. At Zeppelin, Norwegian Arctic, D5 was measured in the summer of 2015 at 1.8 ng/m^3. For comparison, our data translate to 1.9, 5.0 and 13.0 ng/m^3 at Voksenkollen, Alnabru and Slottsparken respectively. D6 shows the opposite picture, with a maximum of 1.2 ng/m^3 observed at Slottsparken compared to 1.75 ng/m3 observed at Zeppelin during the summer 2015 (Bohlin-Nizzetto et al 2016).

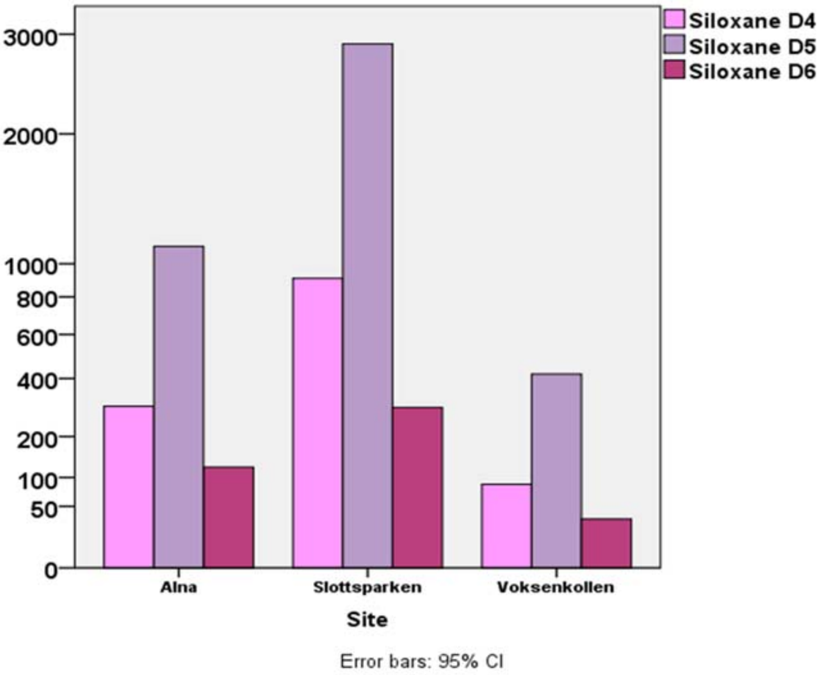


Figure 38: Siloxanes in air at the different sampling sites in Oslo (ng/sampler).

3.6.2 Soil

Of the three different cyclic siloxanes, D5 above LOD was only found in soil from Frognersætra with 13.2 ng/g ww. This is comparable to finding in 2015 of 18.6 ng/g dw D5 in Svartdalsparken. D4 and D6 were not detected in soil.

3.6.3 Earthworms

All three siloxanes measured could be detected in the earthworm samples from Oslo. The highest concentrations was found in the earthworm sample from Voksenkollen (3.1, 16.3 and 17.6 ng/g ww for D4, D5 and D6 respectively) followed by Frognersætra and Slottsparken.

Table 38: Cyclic syloxanes in earthworm in ng/g ww. *N: number of detected/analysed samples.*

	Siloxane D4	Siloxane D5	Siloxane D6
N	1/5	4/5	5/5
Mean	<LOD	6.45	5.79
Median	<LOD	6.37	3.49
Minimum	<LOD	<LOD	1.2
Maximum	3.10	16.33	17.6

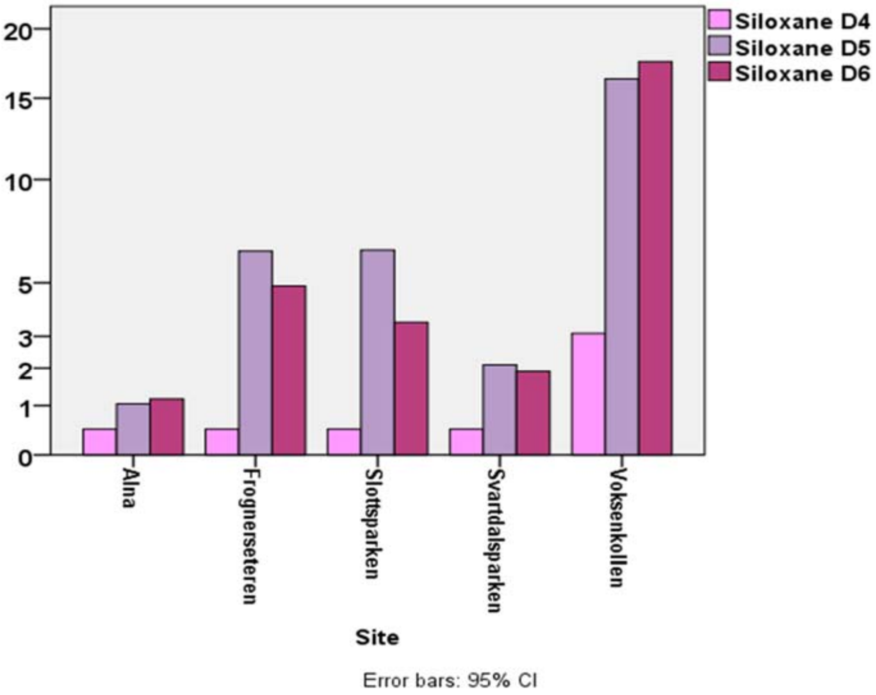


Figure 39: Siloxanes in earthworms at the different sampling-sites in Oslo (ng/g ww). Note that Concentrations for D4 represent the LOD, see chapter 2.4

3.6.4 Fieldfare

Regarding siloxanes in fieldfare, D4 was below or just above LOQ for all samples. D5 had the highest concentrations (<LOQ – 11.2 ng/g ww). One egg contained concentrations comparable to some of the sparrowhawk eggs, whereas the other samples had much lower concentrations. D6 was mostly found in low concentrations, close or below to the limit of quantification.

Table 39: Cyclic syloxanes in fieldfare in ng/g ww. *N: number of detected/analysed samples.*

	Siloxane D4	Siloxane D5	Siloxane D6
N	0/8	6/8	5/8
Mean	<LOD	2.84	0.93
Median	<LOD	1.29	0.88
Minimum	<LOD	<LOD	<LOD
Maximum	<LOD	11.2	2.28

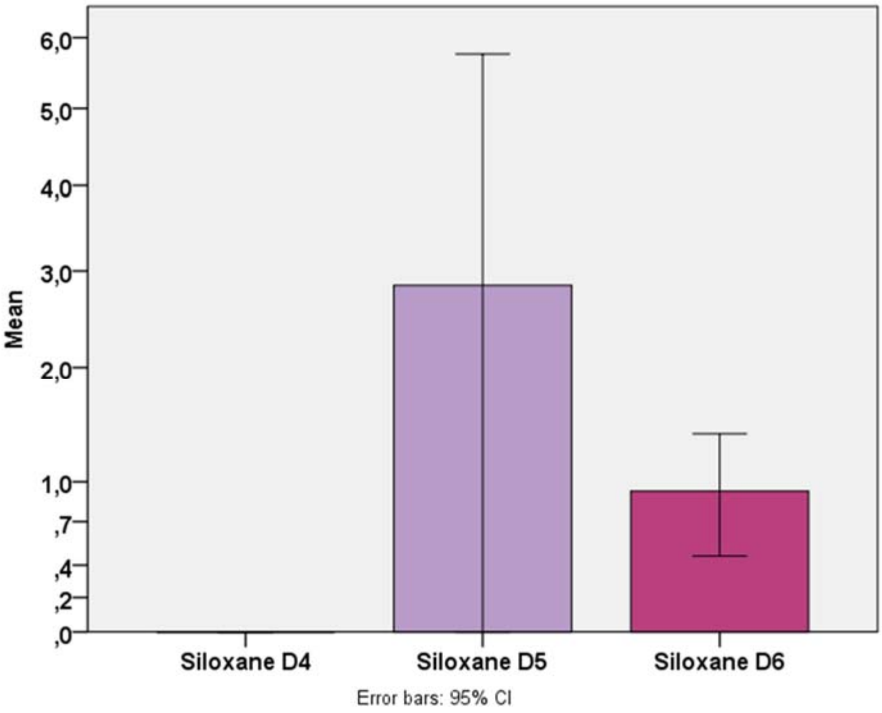


Figure 40: Mean siloxanes in fieldfare eggs at the different sampling-sites in Oslo (ng/g ww).

3.6.5 Sparrowhawk

In sparrowhawk, D5 was found at higher concentrations than D6 and D4. D5 concentrations ranged from 3.3 to 23.4 ng/g ww, an order of magnitude higher than D4 and D6. But the concentrations are still much lower than for Herring gull eggs from Oslo 2015, were the highest concentration of D5 was more than 1000 ng/g ww. Glaucous gull eggs from Svalbard showed D4 and D5 concentrations varying between <LOD and 5.8 for D4 and 3.1 and 40 ng/g ww for D5 in 2016, comparable to the sparrowhawk in our study (Lucia et al., 2016).

Table 40: Cyclic syloxanes in sparrowhawk in ng/g ww. *N: number of detected/analysed samples.*

	Siloxane D4	Siloxane D5	Siloxane D6
N	4/10	10/10	10/10
Mean	1.2	9.7	2.4
Median	1.2	7.5	2.5
Minimum	<LOD	3.3	1.8
Maximum	1.5	23.4	3.2

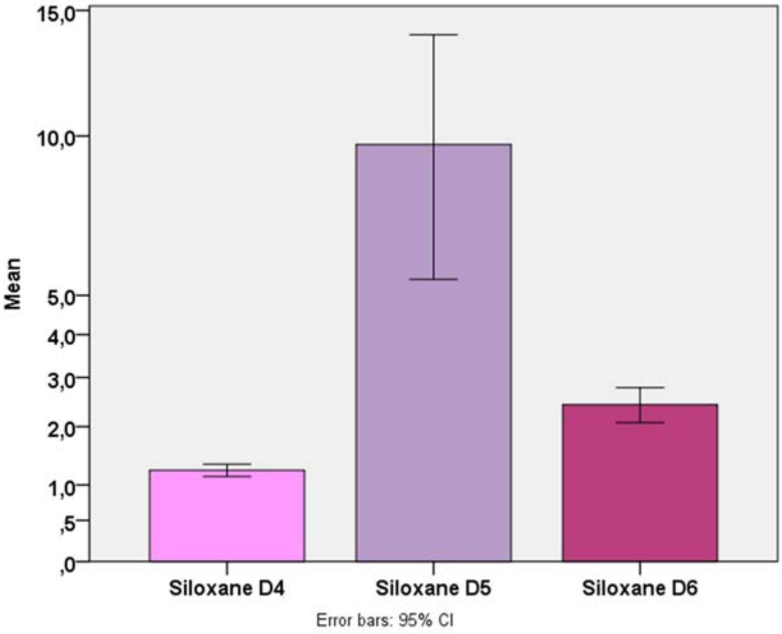


Figure 41: Mean concentrations of siloxanes in sparrowhawk eggs (ng/g ww).

3.6.6 Tawny owl

D4 was not detected in any of the tawny owl eggs. D5 and D6 were detected in 9 out of 10 eggs. D5 levels are higher than D6, comparable with findings in sparrowhawk eggs (median of 1.6 and 1.3 ng/g ww respectively). One egg contained the maximum concentration of 23.5 ng/g ww of D5, whereas D6 was relatively low for all detected samples.

In 2015, D5 showed a median of 3.1 ng/g ww, comparable with findings in sparrowhawk eggs, but lower than herring gull eggs. Due to high detection limits, D5 was only quantifiable in 5 out of 10 samples in 2015. One egg contained the maximum concentration of 27.7 ng/g ww of D4 and 7.4 ng/g ww of D5 (Herzke, et al., 2016).

Table 41: Cyclic siloxanes in tawny owl in ng/g ww. *N: number of detected/analysed samples.*

	Siloxane D4	Siloxane D5	Siloxane D6
N	0/10	9/10	10/10
Mean	<LOD	4.13	1.36
Median	<LOD	1.56	1.31
Minimum	<LOD	<LOD	0.97
Maximum	<LOD	23.5	1.75

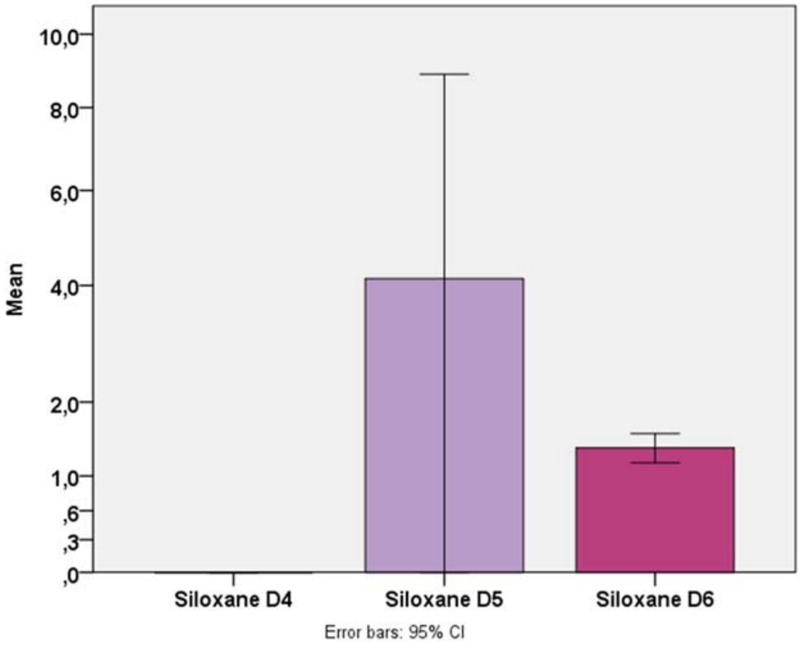


Figure 42: Mean concentrations of siloxanes in tawny owl eggs (ng/g ww).

3.6.7 Brown Rats and small rodents

The siloxane analysis in rat and rodent livers were affected by high blank levels and thus high detection limits. D4 and D5 could be detected only in a few rat liver samples, and D6 was in all cases below the limit of quantification. The maximum levels were lower than in 2015, especially for D4 and D6 (2015 values: Median D4 15.9 ng/g, and D5 15.8 ng/g, D6 ranged between <LOD and 33 ng/g) (Herzke et al., 2016).

The one pooled small rodent liver sample analyzed had D4, D5 and D6 values of 8.6, 10.0 and 14.0 ng/g ww, somewhat higher concentrations compared to the rat liver samples.

Table 42: Cyclic siloxanes in in brown rat in ng/g ww. *N: number of detected/analysed samples.*

	Siloxane D4	Siloxane D5	Siloxane D6
N	4/10	2/10	0/10
Mean	3.47	4.27	<LOD
Median	<LOD	<LOD	<LOD
Minimum	<LOD	<LOD	<LOD
Maximum	7.79	22.5	<LOD

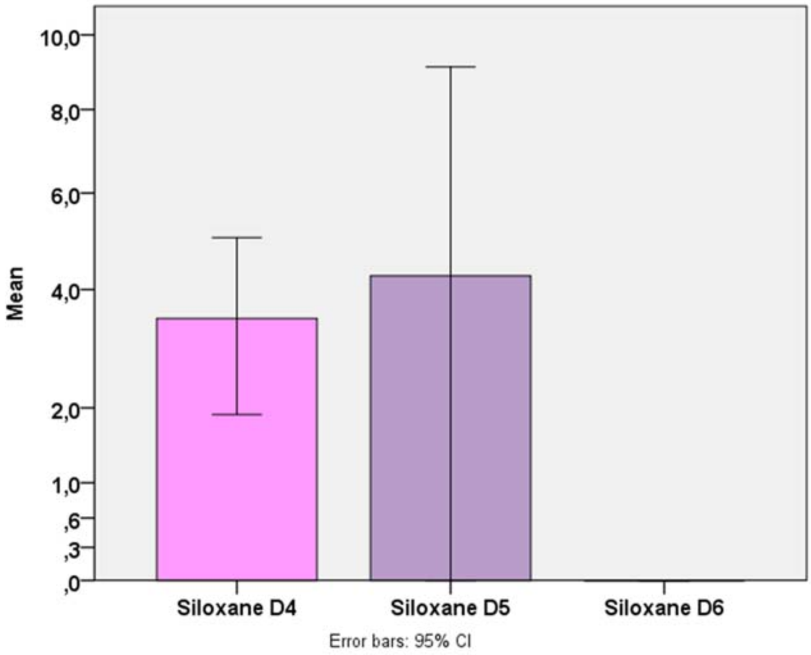


Figure 43: Mean concentrations of siloxanes in livers of brown rat in ng/g ww.

3.6.8 Red fox

Cyclic siloxanes were present in only few fox liver samples with quite low concentrations. D4 was not found in any of the samples. The highest concentrations found were 1.6 and 3.2 ng/g ww for D5 and D6. The measured concentrations were much lower than in 2015 (median of 8.9, 10.2 and 8.6 ng/g ww for D4, D5 and D6 respectively) (Herzke et al., 2016).

Table 43: Siloxanes in red fox in ng/g ww. *N: number of detected/analysed samples.*

	Siloxane D4	Siloxane D5	Siloxane D6
N	0/10	1/10	2/10
Mean	<LOD	0.30	0.72
Median	<LOD	<LOD	<LOD
Minimum	<LOD	<LOD	<LOD
Maximum	<LOD	1.62	3.23

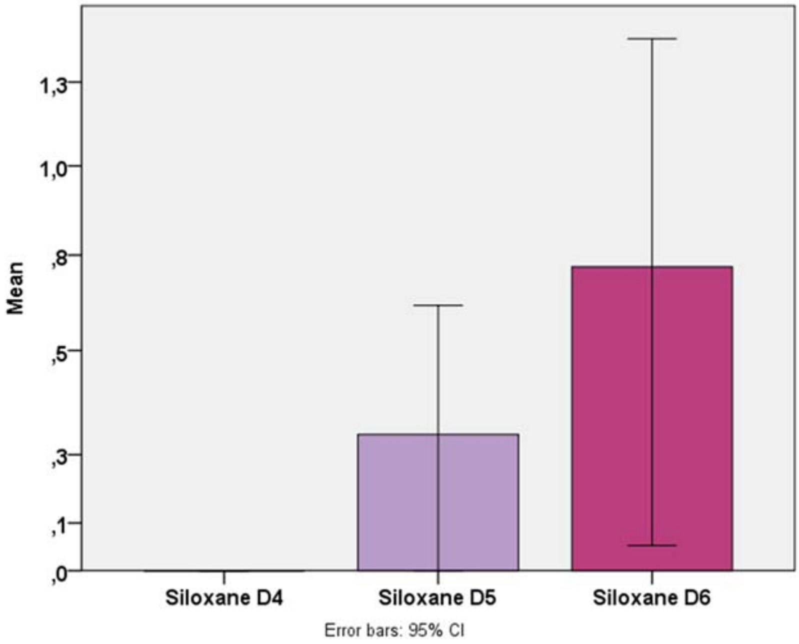


Figure 44: Mean concentrations of siloxanes in liver of red fox in ng/g ww.

3.6.9 Summary siloxanes

Besides elevated concentrations in air (average 1533 ng/sampler, highest in Slottsparken with 2893 ng/sampler), we detected the highest sumCP concentrations in eggs of sparrowhawk (11.3 ng/g lw) followed by worms and twany owl (9.9 and 3.1 ng/g lw). Except from red fox liver, D5 was the dominating siloxane in all matrices.

3.7 Organic phosphorous flame retardants and Dechlorane

3.7.1 Air

OPFRs were measured in air for the first time within this project and we detected a number of OPFRs in all three locations. SumOPFR were ranging between 103 and 625 ng/ sampler, dominated mostly by EHDP (2-Etylhexyldiphenylphosphate). In Slottsparken also an elevated concentration for TCPP was found (376 ng/ sampler). The highest SumOPFR concentrations were found at Slottsparken, followed by Alnabru and Voksenkollen. Other important OPFRs found were TCEP, TnBP and TEHP. Little air data on OPFR exists, however, for comparison, Cao et al., found TCIPP, TCEP and TPHP in road dust of one composite road dust sample sampled from main roads of Beijing, China in 2012 (Cao et al., 2014). So far, mostly OPFR in indoor air of buildings and cars have been reported, both are a potential source for outdoor air.

Table 44: OPFR in air samples from Oslos in ng/ sampler. *N: number of detected/analysed samples.*

	TEP	TCEP	TPrP	TCPP	TiBP	BdPhP	TPP
N	1/3	3/3	0/3	2/3	2/3	0/3	2/3
Mean	4.53	15.8	<LOD	166	21.7	<LOD	9.43
Median	0.10	7.40	<LOD	93.1	24.9	<LOD	7.30
Minimum	<LOD	4.30	<LOD	<LOD	<LOD	<LOD	<LOD
Maximum	13.4	35.6	<LOD	376	40.2	<LOD	17.4

	DBPhP	TnBP	TDCPP	TBEP	TCP	EDHP	TEHP	Sum OPFR
N	3/3	3/3	0/3	3/3	3/3	3/3	3/3	
Mean	0.97	12.0	<LOD	6.13	2.60	75.0	23.0	336
Median	0.80	13.3	<LOD	5.20	2.20	91.5	20.3	280
Minimum	0.68	4.20	<LOD	4.10	1.30	39.1	19.9	103
Maximum	1.43	18.6	<LOD	9.10	4.30	94.5	28.9	625

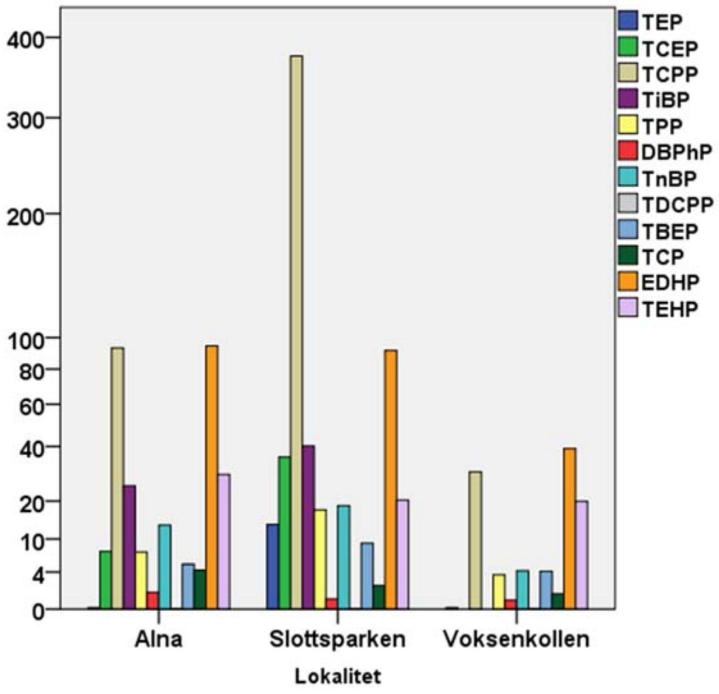


Figure 45: OPFR in air samples from Oslo in ng/ sampler.

3.7.2 Soil

For OPFR analyses we prepared a single pooled sample representing all five locations from Oslo.

Only TEP, TCPP, TnBP, TDCPP, TCP and EDHP could be found. TCPP was found at 4.2 ng/g dw, followed by 1.9 ng/g dw of TCP and minor amounts of the other OPFRs. SumOPFR was 8.57 ng/g dw. For comparison, in 2015 SumOPFR concentrations, ranging between 5 and 325 ng/g dw, were found in Oslo (Herzke et al., 2016).

3.7.3 Earthworms

We prepared one pooled sample representing all five locations from Oslo.

TEP, TCEP, TCPP, TiBP, TPP, TnBP, TBEP, EHDP and TEHP were all found in this pool, resulting in a SumOPFR of 25.4 ng/g ww. The dominating OPFR was TCPP with 12 ng/g ww followed by TnBP and TiBP with 7.65 and 2.21 ng/g ww respectively.

In the previous study from 2015, TPP, TCP, EHDP and TEHP were found in most worms, but at low concentrations < 1.5 ng/g ww (Herzke et al., 2016). The dominating OPFR in earthworms then was TBP with concentrations ranging between <LOD and 3.2 ng/g ww.

3.7.4 Fieldfare

No OPFR analyses were carried out.

3.7.5 Sparrowhawk

For OPFR analyses three pooled samples, each consisting of three eggs, were prepared.

With SumOPFR concentrations ranging between <LOD and 3.12 ng/g ww, overall OPFR concentrations were rather low with TBEP being the most abundant one (<LOD – 3 ng/g ww).

In sparrowhawk, also dechlorane and its congeners (dechlorane 602, 603, 604, plus syn, plus anti) were analysed. With the exception of dechlorane 604, all dechloranes were detected above LOD in the three pools. Dechlorane 602 and 603 were most abundant, followed by plus syn and plus anti. SumDechlorane varied between 1.82 and 8.0 ng/g. For comparison, Guerra et al., reported SumDechlorane concentration ranging from 0.015 to 10 ng/g ww in peregrine falcon eggs from Spain, the same order of magnitudeas in the sparrowhawk eggs reported in the present study.

Table 45: Dechlorane in sparrowhawk eggs in ng/g ww. *N: number of detected/analysed samples.*

	Dechlorane 602	Dechlorane 603	Dechlorane 604	Dechlorane PlusSyn	Dechlorane Plus	SumDechloranes
N	3/3	3/3	0/3	3/3	3/3	3
Mean	2.45	0.75	<LOD	0.18	0.45	4.03
Median	0.72	0.79	<LOD	0.16	0.52	2.28
Minimum	0.50	0.49	<LOD	0.11	0.22	1.82
Maximum	6.13	0.97	<LOD	0.27	0.59	7.98

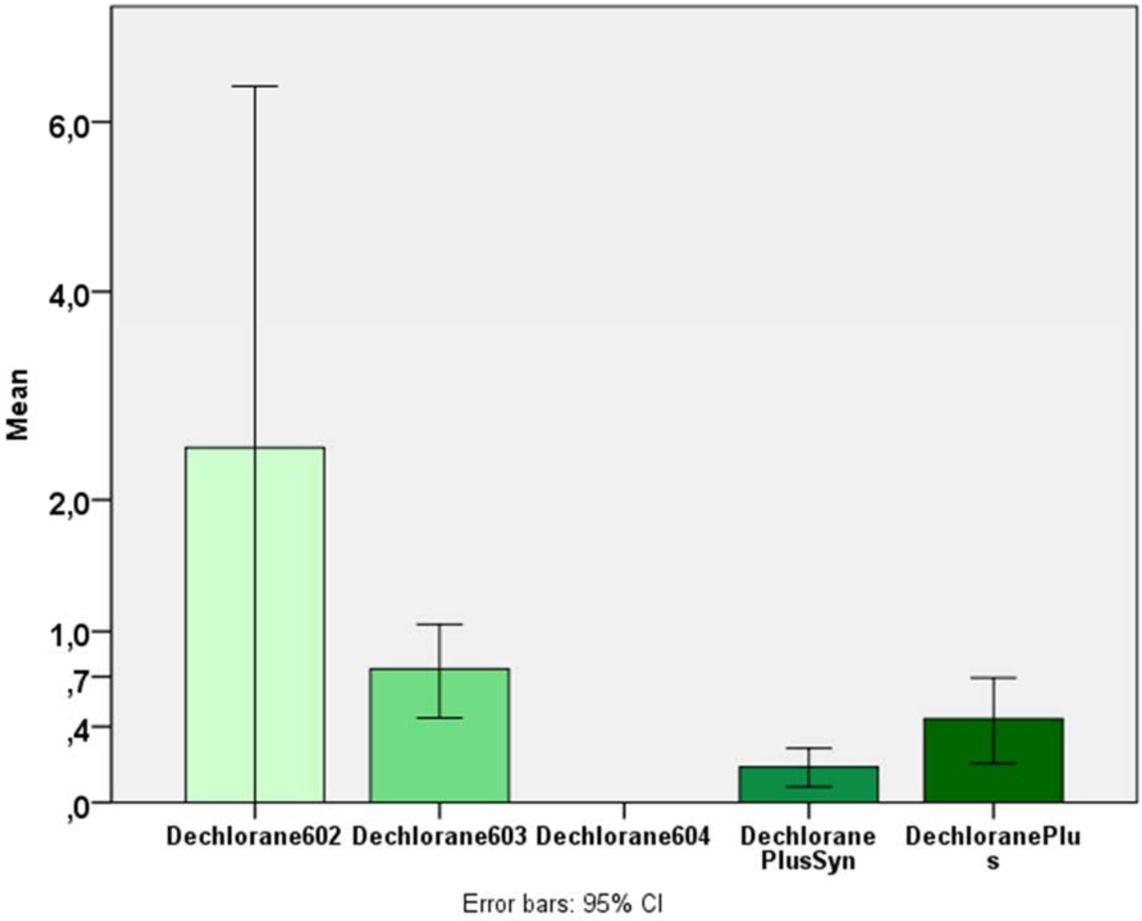


Figure 46: Mean concentrations of dechloranes in pooled eggs samples of sparrowhawk, in ng/g ww.

3.7.6 Tawny owl

Similar to sparrowhawk, three pools each consisting of three eggs were prepared.
TBEP was the only OPFR found in detectable amounts ranging from 0.15 to 1.37 ng/g ww.

3.7.7 Brown Rats and small rodents

Also for rat liver, three pools consisting of three individuals were prepared prior analyses. In rats, only limited concentrations were found with TBEP and TCPP the dominating ones. SumOPFR varied between 1.7 and 6.9 ng/g ww.

In the small rodents SumOPFR reached 2.09 ng/g ww, with TiBP and TCPP contributing the most (1.24 and 0.61 ng/g ww).

3.7.8 Red fox

Within this year's campaign, only TCPP was detected in pooled fox livers (0.23 - 3.92 ng/g). For comparison, in 2015, EDHP, TBEP, TCPP and TPP were the most frequently detected OPFRs in fox liver ranging from 0.3 to 3.3 ng/g. SumOPFR ranged in 2015 between 0.7 and 9.5 ng/g ww (Herzke et al., 2016).

3.7.9 Summary OPFRs

OPFRs were either not detectable, or were found in very low levels at the higher trophic levels in biota. However, in earthworms appreciable levels were found (SumOPFR of 898 ng/g lw), compared to about 10 ng/g lw in sparrowhawk, tawny owl and rat liver. Based on our findings, the trophic magnification potential of these compounds seems to be low.

3.8 Phenolic compounds

Due to the sporadic detection of phenolic compounds, results are discussed in the text and not all compounds are shown in the tables and figures. Detailed information regarding concentrations of the various phenolic compounds can be found in the Appendix. Phenolic componds were not analysed in air samples.

3.8.1 Soil

The greatest contribution to the overall load of phenolic compounds can be attributed to 4,4’-bisphenol F, 2,4-bisphenol F, bisphenol A and bisphenol B. Bisphenol A dominated in all locations (10.4 – 30.0 ng/g dw). SumPhenols ranged from <LOD in Voksenkollen to 43.2 ng/g dw in Alnabru. Due to contamination of the solvent used during sample clean up, no octyl- and nonylphenols were above LOD. In experiments, reported in literature, involving spiking compounds into soil samples, degradation half lives of 1–17 days for 4-nonylphenol (Topp and Starratt, 2000 and Roberts et al., 2006), approximately 5 days for 4-t-octylphenol (Ying and Kookana, 2005), 1–7 days for bisphenol A (Ying and Kookana, 2005 and Xu et al., 2009) were reported, pointing to a relatively short residence time in soil after single emissions. However, if emissions are of a rather continuous nature, as for example for diffuse urban sources, these half-lives can cause an increase in soil over time. Important sources of phenolic compounds in soil are for example emissions from degradation products of surfactants, UV stabilisers and plasticisers of plastic materials. It has been indicated that the most important source for octylphenol in Sweden was the possible abrasion from car tires with a yearly emission of about 800 kg to surface waters and 8000 kg to land in Sweden, although with high uncertainty in the calculations (COHIBA, 2012).

Table 46: Phenolic compounds in soil in ng/g dw. N: *number of detected/analysed samples.*

	4,4'-bisphenol F	2,4'-bisphenol F	Bisphenol A	Bisphenol B	Bisphenol G	SumPhenols
N	4/5	4/5	4/5	4/5	1/5	
Mean	4.34	4.97	13.7	2.21	0.64	26.3
Median	4.20	4.88	13.4	1.37	0.20	29.6
Minimum	<LOD	<LOD	<LOD	<LOD	<LOD	3.40
Maximum	8.73	9.74	30.0	5.96	2.41	43.2

3.8.2 Earthworms

In this study a number of bisphenols could be found, with bisphenol Z, B, G, A, and AP as the most abundant bisphenols found in earthworms at all locations, in descending order. Bisphenol Z was with 564 ng/g ww in Frognersætra, the highest detected bisphenol analysed. Detected sumPhenol concentrations ranged between 192vand 1099 ng/g ww, slightly lower than observed in 2015, maybe due to the change of some sites (varying between 5600 and 9800 ng/g ww), indicating biomagnification from the soil (Herzke et al., 2016).

Table 47: Phenolic compounds in earthworm in ng/g ww. N: number of detected/analysed samples.

	Bisphenol S	2,4'-bisphenol F	Bisphenol E	Bisphenol A	Bisphenol B	Bisphenol AP
N	5/5	1/5	2/5	5/5	5/5	2/5
Mean	3.08	3.53	18.4	57.0	222	33.7
Median	2.61	0.2	0.4	45.4	209	0.4
Minimum	2.01	<LOD	<LOD	27.3	163	<LOD
Maximum	6.01	16.9	58.5	125	306	96.8

	Bisphenol Z	Bisphenol FL	Bisphenol M	Bisphenol G	Bisphenol TMC	sumPhenols
N	5/5	5/5	2/5	2/5	3/5	
Mean	222	22.6	3.96	157	23.9	723
Median	133	23.6	0.4	0.4	29.7	869
Minimum	50.5	8.20	<LOD	<LOD	<LOD	192
Maximum	564	37.4	16.1	460	50.8	1099

3.8.3 Fieldfare

Phenolic compounds were found sporadically in eggs of fieldfare. 2,4-bisphenol F was the most abundant phenol, with a detection frequency of 60% (<LOD – 2.92 ng/g). Bisphenol A was only found in one egg, but at an elevated level of 299 ng/g ww. SumPhenols ranged from <LOD to 300 ng/g ww (median of 1.8 ng/g ww). Results indicate that phenols are not prone to be accumulated from earthworms to fieldfare (eggs), or they might have been biotransformed in the bird.

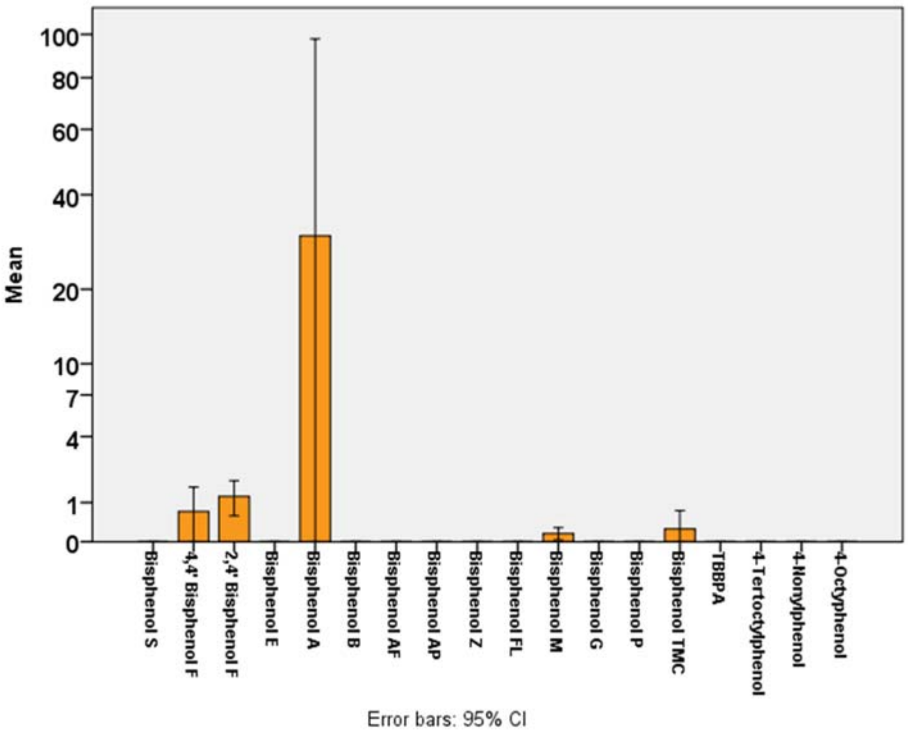


Figure 47: Mean concentrations of bisphenols in eggs of fieldfare in ng/g ww.

3.8.4 Sparrowhawk

Phenolic compounds were only sporadically found. Of the analysed phenols, Bisphenol S, F and TBBP A were detected in the samples. SumPhenol concentrations ranged from <LOD to 2.7 ng/g ww. For comparison, Herzke et al. reported in 2005 lower TBBPA concentrations, varying between lower than the quantification limit and 0.013 ng/ g ww, in a limited number of eggs from four different birds of prey species (Herzke et al., 2005). Additionally, Lucia et al. reported in 2016, BPA and BP and BP S in eggs of kittiwake and glaucous gull from Svalbard (all higher than in the here reported species) (Lucia, 2016). Our findings further emphasize the apparent low bioaccumulation properties of these compounds.

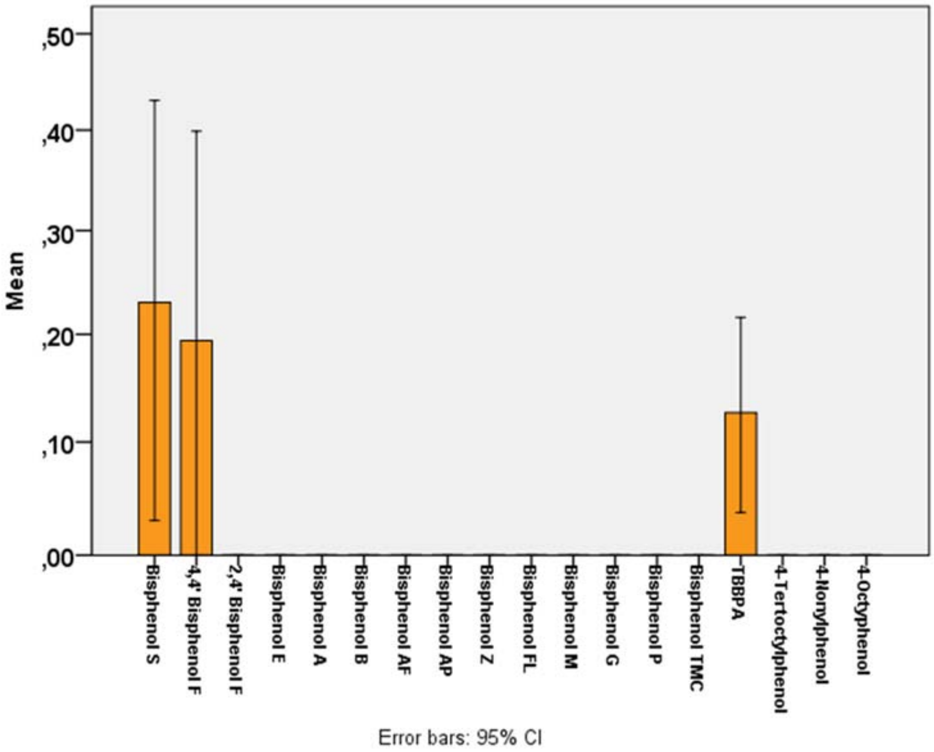


Figure 48: Mean concentrations of phenolic compounds in sparrowhawk eggs, ng/g ww.

3.8.5 Tawny owl

Phenolic compounds were not abundant in the tawny owl eggs, but, 2,4-bisphenol F were detected. Little is known about toxicological effects of phenolic compounds in birds. However, Halldin et al., 2005, showed that bisphenol A (BPA) had oestrogen-like effects in bird embryos, causing malformations of the oviducts in Japanese quail (Coturnix japonica) and feminisation of the left testis in chicken (Gallus domesticus). In their study, neither BPA (200 µg/g egg) nor TBBPA (15 µg/g egg) caused any significant oestrogen-like effects on the variables studied, although effects on the female oviducts after BPA exposure were indicated. 4-Tertoctylphenol showed some very high values that were considered aberrant outliers due to analytical problems, and are therefore omitted.

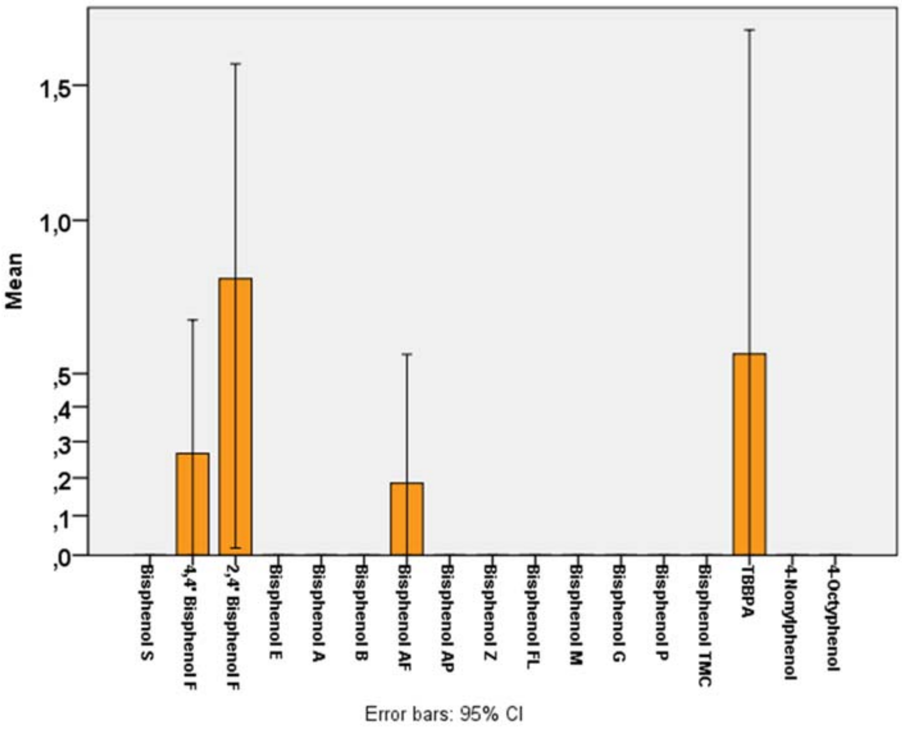


Figure 49: Mean concentrations of phenolic compounds in tawny owl eggs, ng/g ww.

3.8.6 Red fox and brown rats

Only 4,4'- and 2,4-bisphenol F were found at detectable levels in the liver of red fox (<LOD to 3.3 ng/g ww).

In rats, only Bisphenol B and Bisphenol AF were detected, with concentrations varying from 0.22 to 487 ng/g w in their livers, with Bisphenol B having the highest concentrations.

3.8.7 Summary phenols

The highest levels of phenols were found in earthworms, usually ten times higher than in other sample types. Also in brown rats and in fieldfare relatively high levels were found, possibly reflecting their use of of earthworms as part of their diet. In red fox and sparrowhawk, only minor concentrations were detected. Earthworms are the most prominent species for contamination with phenolic compounds, indicating biomagnification potential from the soil, mostly due to the contribution of bisphenol A, B, Z and G (median of 868 ng/g ww). However, biomagnification further up in the food-chain seems not to occur.

3.9 UV compounds

Due to the sporadic detection of UV compounds, results are discussed in the text below without further illustration by figures and tables. Detailed information regarding concentrations can be found in the Appendix.

3.9.1 Soil

All soil samples had values below detection limits (< 5ng/g dw)

3.9.2 Earthworms

All samples had values below detection limits (< 3 ng/g ww)

3.9.3 Fieldfare

UV compounds were not analysed for in the fieldfare egg samples.

3.9.4 Sparrowhawk

All egg samples had values below detection limits (< 3 ng/g ww)

3.9.5 Tawny owl

All egg samples had values below detection limits (< 3 ng/g ww)

3.9.6 Red fox

All liver samples had values below detection limits (< 3 ng/g ww)

3.9.7 Brown rats and small rodent

All liver samples had values below detection limits (< 30 ng/g ww)

3.10 Biocides

Biocides were only analysed for in red fox, rats and rodents i.e. species that were more likely to be exposed to these substances via their diet. They were not analysed for in soil, earthworms, fieldfare, sparrowhawk and tawny owl. Due to the sporadic detection of biocides, results are discussed in the text below without further illustration by figures and tables. Information regarding concentrations can be found in the Appendix.

3.10.1 Red fox

Four biocides were selected for analyses in fox liver samples (Bromodiolone, Brodifacoum, Flocumafen and Difenacoum). Bromodiolone and brodifacoum were found in all samples varying between 12 and 3883 ng/g ww and 69 and 1072 ng/g ww, respectively. Bromadiolone persists very long in the liver, up to 270 days. Brodifacoum is a highly lethal 4-hydroxycoumarin vitamin K antagonist anticoagulant poison, showing a half life of 120 days in dogs and 156 hours in rats. In recent years, it has become one of the world's most widely used pesticides. It is typically used as a rodenticide, but is also toxic to all mammal species. Besides LD 50 values no literature data on tissue concentrations could be found for comparison and assessment of harmful effects. Flocumafen and Difenacoum were not detected.

3.10.2 Brown rats and small rodents

In rats, of the four biocides analysed, only bromodiolone was found in brown rats occasionally. The concentrations ranged between <LOD and 161 ng/g ww. No biocides were detected in the small rodents.

3.10.3 Summary biocides

It was surprising to find that 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 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.

3.11 Pesticides

In the following we present the results for pesticides for sparrowhawk, tawny owl and fieldfare, the only groups analysed. The pesticides DDTs, HCB, chlordanes and mirex are grouped together in the SumPest value.

Table 48: Pesticides in eggs of sparrowhawk (ng/g ww). N: number of detected/analysed samples.

	HCB	Mirex	opDDE	ppDDE	opDDD	ppDDD	opDDT	ppDDT	Trans-chlord.	Cis-chlord.	Oxychlordane	Trans-nonachl	Cis-nonachlor	SumPesticides
N	10 /10	10 /10	0 /10	10 /10	10 /10	10 /10	3 /10	10 10	2 /10	6 /10	10 /10	10 /10	10 /10	
Mean	13.5	2.2	<LOD	1157	0.04	10.7	0.04	10.3	0.06	0.44	17.5	25.6	5.74	1243
Median	10.3	2.2	<LOD	1041	0.03	7.76	<LOD	9.20	<LOD	0.22	12.4	20.0	4.38	1122
Min.	5.44	0.53	<LOD	615	0.01	3.39	<LOD	2.63	<LOD	<LOD	6.13	4.73	0.72	653
Max.	28.9	3.62	<LOD	2400	0.16	23.0	0.14	24.0	0.41	2.20	38.6	79.6	16.9	2560

Pesticides, especially *p,p'*-DDE are still a dominating pollutants in sparrowhawk egg, despite the fact that DDT has been banned for general use in Norway since 1972 (Table 48). One suspects long-range transport to be the main factor behind this, either via air, precipitation and ocean currents. Equally important may be the fact that this species also feeds on migrating prey, i.e. small birds, especially passerines, which may have spent their winter Europe or Africa (Haftorn, 1971), thus being able to carry pollutants in their bodies from areas more polluted than ours. However, it eggs are probably primarily formed in its body after the return to Norway from it winter quarters in south-western Europe, since it is energetically costly to migrate with a body burden of eggs that may weigh up to half of its own mass (Haftorn, 1971). Relatively low concentrations of HCB, Mirex and chlordanes were found relative to *p,p'*-DDE (*Figure 50*).

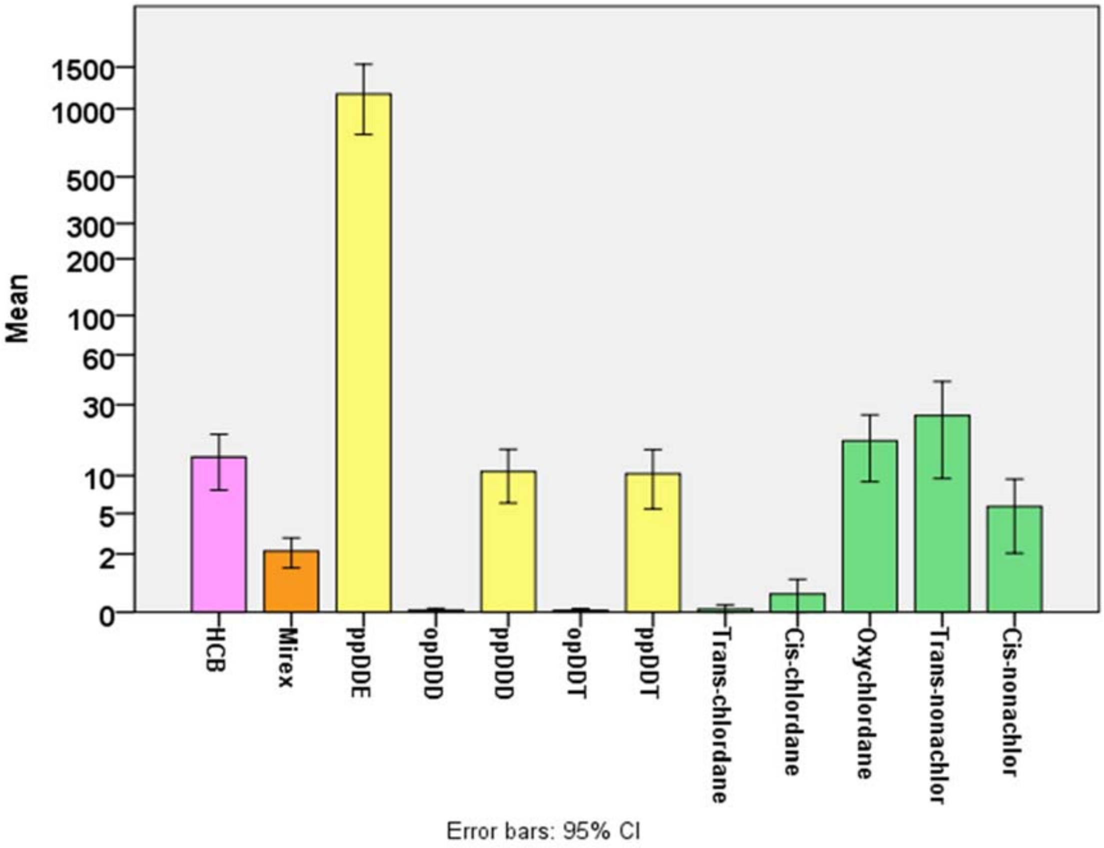


Figure 50. Mean of Pesticides in eggs of sparrowhawk (ng/g ww).

Table 49: Pesticides in eggs of tawny owl (ng/g ww). N: number of detected/analysed samples.

	HCB	Mirex	opDDE	ppDDE	opDDD	ppDDD	opDDT	ppDDT	Trans-chlord.	Cis-chlord.	Oxychlordane	Trans-nonachl	Cis-nonachlor	SumPesticides
N	10/ 10	5/ 10	0/10	10/ 10	1/ 10	10/ 10	0/ 10	10/10	0/10	0/10	10/ 10	9/10	10/ 10	
Mean	1.56	0.09	<LOD	74.0	<LOD	0.43	<LOD	0.25	<LOD	<LOD	1.84	0.37	0.08	78.7
Median	1.31	0.03	<LOD	46.8	<LOD	0.25	<LOD	0.14	<LOD	<LOD	1.44	0.29	0.06	49.9
Min.	0.82	<LOD	<LOD	14.0	<LOD	0.13	<LOD	0.04	<LOD	<LOD	0.33	<LOD	0.01	17.7
Max.	4.31	0.41	<LOD	172	0.02	1.41	<LOD	1.07	<LOD	<LOD	7.02	1.29	0.35	187

Levels of pesticides in tawny owl egg were about one order of magnitude lower than those of the sparrowhawk

Table 49: Pesticides in eggs of tawny owl (ng/g ww). This probably reflects the feeding habits of the tawny owl, being a predator mostly on rodents (Hagen, 1952), which are one trophic level below passerine birds.

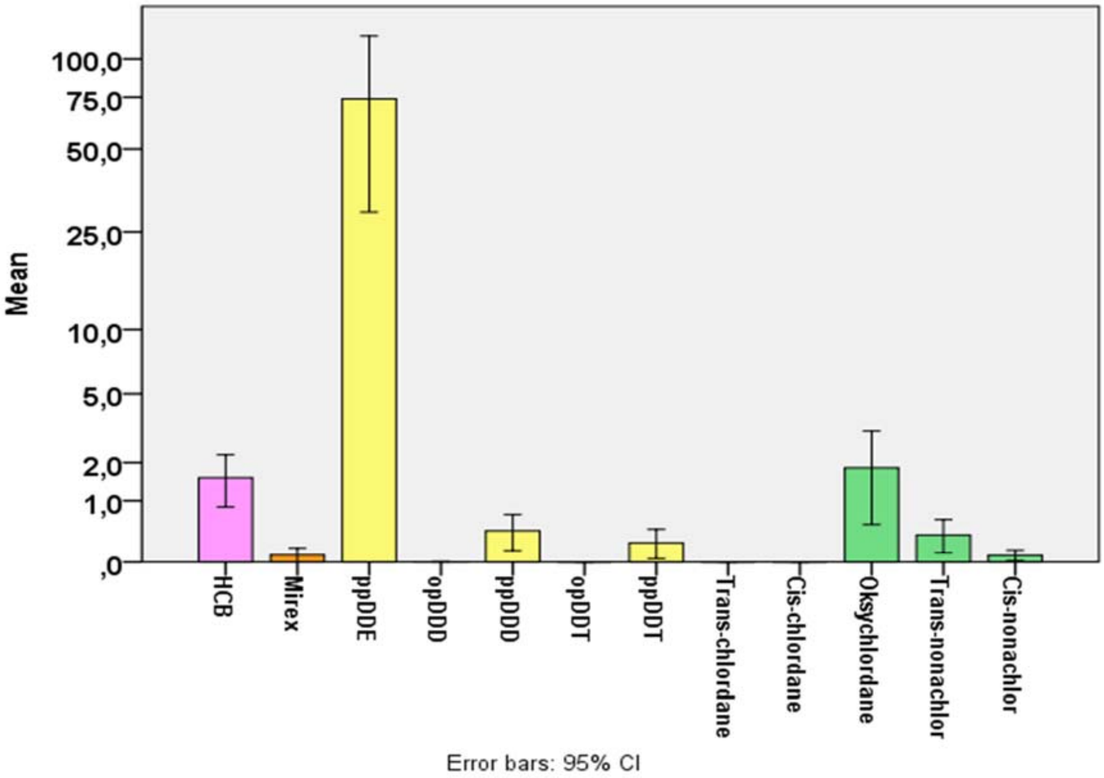


Figure 51: Pesticides in eggs of tawny owl (ng/g ww).

Table 50: Pesticides in fieldfare eggs. N: number of detected/analysed samples.

	HCB	Mirex	opDDE	ppDDE	opDDD	ppDDD	opDDT	ppDDT	Trans-chlord.	Cis-chlord.	Oxychlordane	Trans-nonachl	Cis-nonachlor	SumPesticides
N	9/9	9/9	0/10	9/9	0/9	8/9	0/9	9/9	0/10	2/9	9/9	9/9	5/10	
Mean	3.65	0.07	<LOD	132	<LOD	0.37	<LOD	8.99	<LOD	0.18	1.60	3.49	0.60	151
Median	3.68	0.07	<LOD	20.1	<LOD	0.09	<LOD	1.98	<LOD	<LOD	0.58	1.14	0.20	27
Min.	1.73	0.03	<LOD	6.11	<LOD	<LOD	<LOD	0.17	<LOD	<LOD	0.14	0.25	<LOD	10.7
Max.	6.56	0.09	<LOD	644	<LOD	1.34	<LOD	44.1	<LOD	1.45	5.94	17.70	3.54	702

The pesticide levels in fieldfare eggs were intermediate between tawny owl and sparrowhawks (Figure 52). This was somewhat surprising, but can possibly be explained by the fact that the fieldfare preys on a wide variety of food items from berries to earthworms and insects, and the fact that is a migratory species, and thus being able to ingest polluted food items on its wintering grounds. In this context it is interesting to see that it has relatively high concentrations of un-degraded DDT in its eggs, indicating relatively recent use. DDT was banned in Norway in 1972.

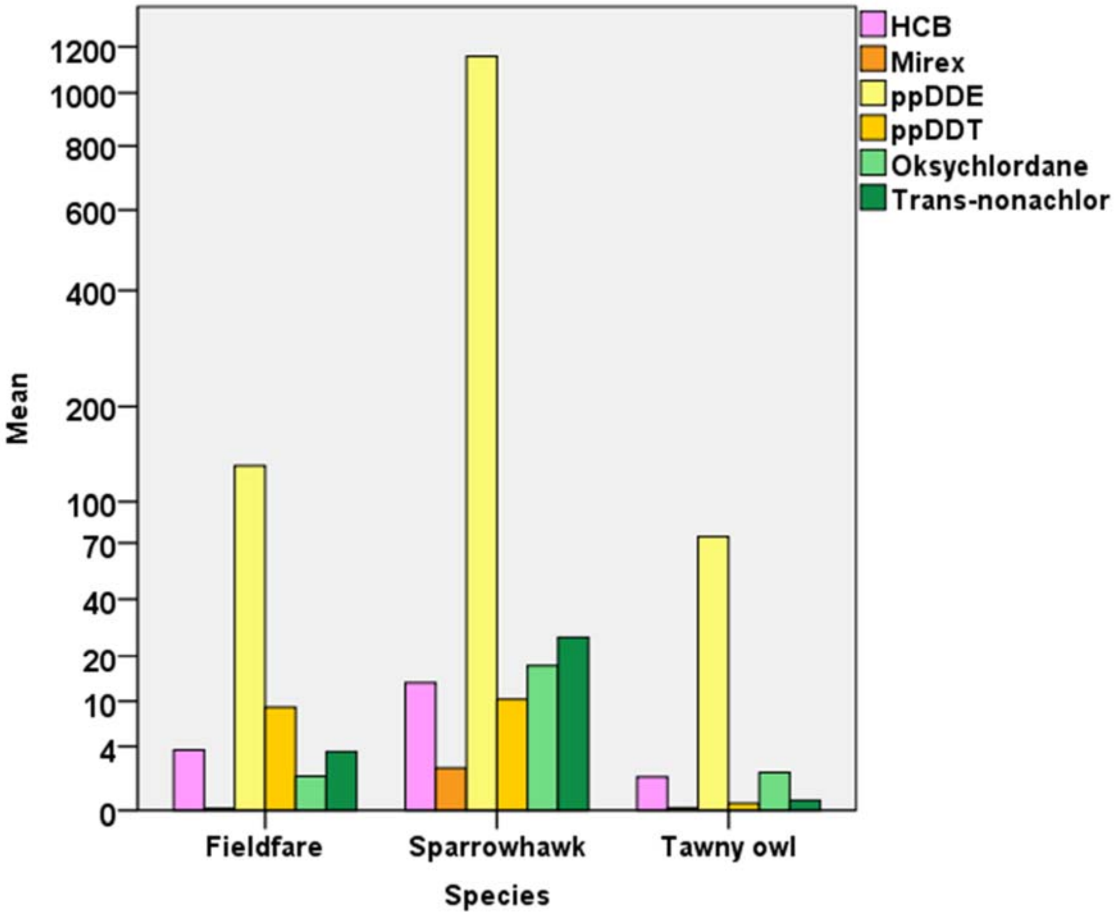


Figure 52: The dominant pesticides in fieldfare, tawny owl and sparrowhawk egg.

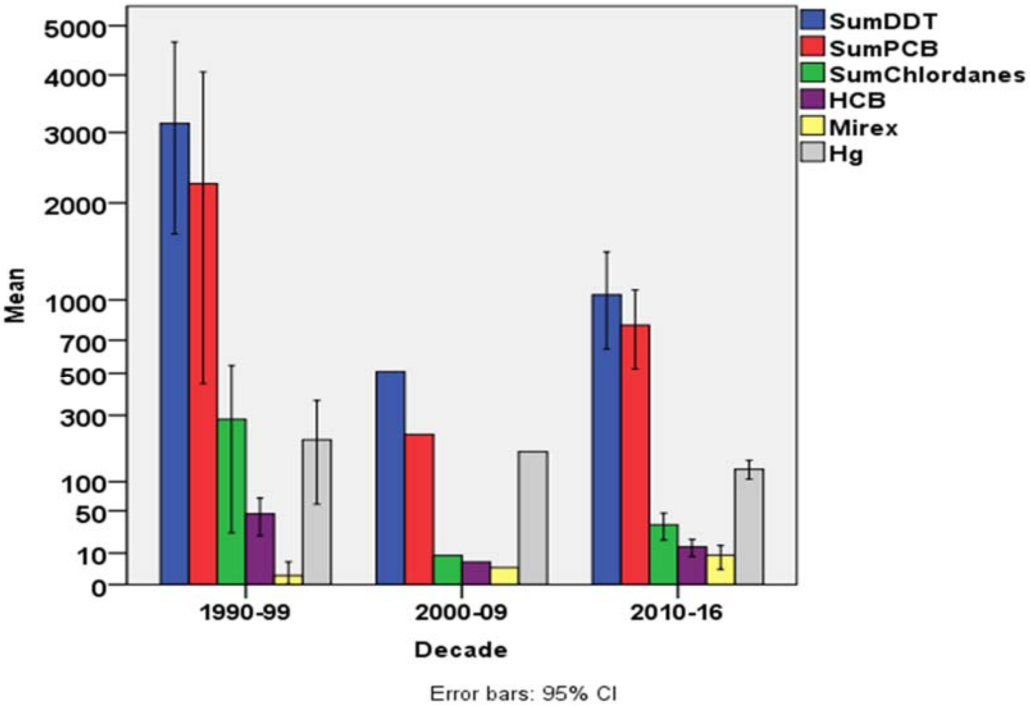


Figure 53: Mean of pesticides in sparrowhawk eggs 1990-2016 (ng/g ww).

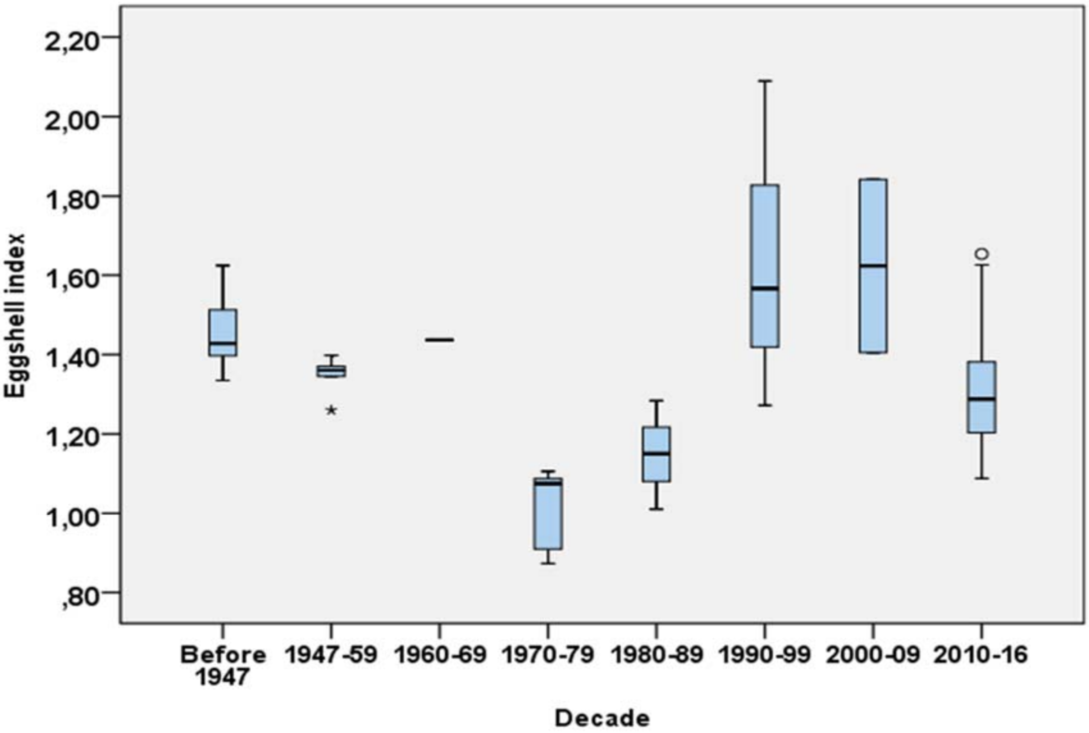


Figure 54: Eggshell index of sparrowhawk eggs by decade.

Compared to the eggshell index levels of eggs prior to 1947 (the year normally chosen as dividing the pre- and post-DDT era, the eggshell index was significantly lowered in the 2015-16 eggs compared to the pre-DDT period (Figure 54) The reference index before 1947 is 1.453, while the index for 2015-17 is 1.328 (- 8.7 %). The difference is significant (ANOVA, F = 12.69, P = 0.001. The sparrowhawk has been one of the species most affected by shell thinning on a European level (Ratcliffe, 1970, Newton and Bogan, 1978), and also in Norway (Nygård and Polder, 2012)

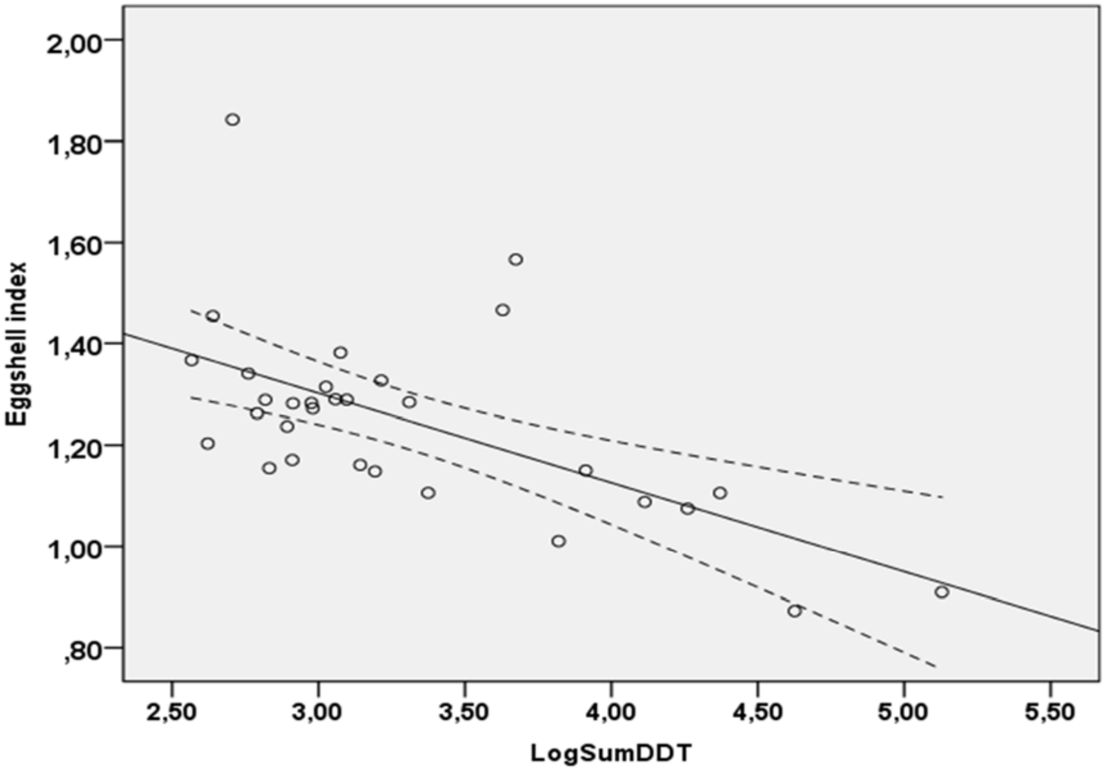


Figure 55 : The relation between sum DDT in eggs and eggshell index in sparrowhawk eggs. The graph contains all egg data of sparrowhawks from Norway as shown in Figure 54.

There was a significant relationship between the eggshell index and the levels of sumDDTs in the eggs (Spearman corr., R^2= 0.3, P=0.002). This is in line with what has been shown in numerous species around the world (Lindén et al., 1984, Nygård, 1983, Elliot et al., 1988, Odsjö and Sondell, 1982, Ohlendorf et al., 1978, Newton and Bogan, 1974).

3.11.1 Summary pesticides

P,p'-DDE still dominates among the pesticides, despite the fact that is more than 40 years since it was banned for most uses in Norway. A study in Vietnam showed that the half-life in soil of SumDDT was 6.7 years, but is may be much longer in temperate and cold climates, since the breakdown rate is very temperature-dependent (Toan et al., 2009) The sparrowhawk had the highest levels of most pesticides, which fits with is its role a top avian predator. The fieldfare was intermediated compared to the sparrowhawk and the tawny owl. The levels of HCH, Mirex and chlordanes were generally low. Compared to reference eggs collected before the DDT era (before 1947), there is still some eggshell thinning in the sparrowhawk eggs (ca. 9 %), and there is a significant correlation between degree of shell thinning (as measured by the eggshell index) and sumDDT concentration in the eggs. The shell thinning agent is the breakdown product *p,p'*-DDE (Lundholm, 1997), the dominating form of DDT present in the eggs.

3.12 Discussion and interspecies comparison including herring gull

In the following chapter we will assess the overall exposure of all measured pollutants in the species investigated in this study. The main aim is to compare the contribution of the investigated pollutant groups per species to be able to identify the main contributors to contamination and potential risk. In addition, we will assess the relationship between pollutant groups to better understand exposure routes and bioaccumulation rates. Interspecies comparison will be discussed as well, improving the understanding of uptake and accumulation of pollutants in urban terrestrial environments. Also, a comparison with data on herring gull eggs collected in Oslo in 2016, contributed by the project "Environmental Contaminants in an Urban Fjord, 2016" is presented (Ruus, 2017).

Mostly sum parameters of the investigated pollutants will be discussed, information for single compounds can be found in the chapters above. Of the analysed metals, mainly the metals Hg, Pb, Cd and As are known to be toxic at concentrations that can be found in the environments and are therefore included in the combined exposure assessment. The prediction of risk based on predicted no effect concentrations (PNEC) of the individual contaminants and in combination, can be found in chapter 4.

Note that pesticides including DDTs were only measured in the birds' eggs, and will not be discussed in details below, but is discussed in Chapter 3.11. Individual data can be found in the Annex 1.

Air

When comparing concentrations, emerging pollutants like siloxanes, and OPFRs dominate the overall pattern in respect to concentrations. The very volatile siloxanes constitute more than 90% of the measured contaminants, indicating the existence of a number of point sources/emissions caused by human activities in Oslo. However, the observed maximum sumSiloxane concentrations of 17.9 ng/m^3 (4095 ng/ sampler) seem to be higher, but are difficult to compare with the annual mean concentrations observed at Svalbard, Zeppelin (4 ng/m^3) since different sampling methods were applied at the two sites (passive air sampling was used in Oslo and active sampling methods were applied at Svalbard).

Figure 56 shows the dominating airmasses during the observed time period of air sampling (92 days from June to August 2016). As the figure illustrates, airmasses were arriving mainly from the west, transporting airborne pollutants from these regions to the Oslo area. The main continental source regions identified were the U.K and Denmark.

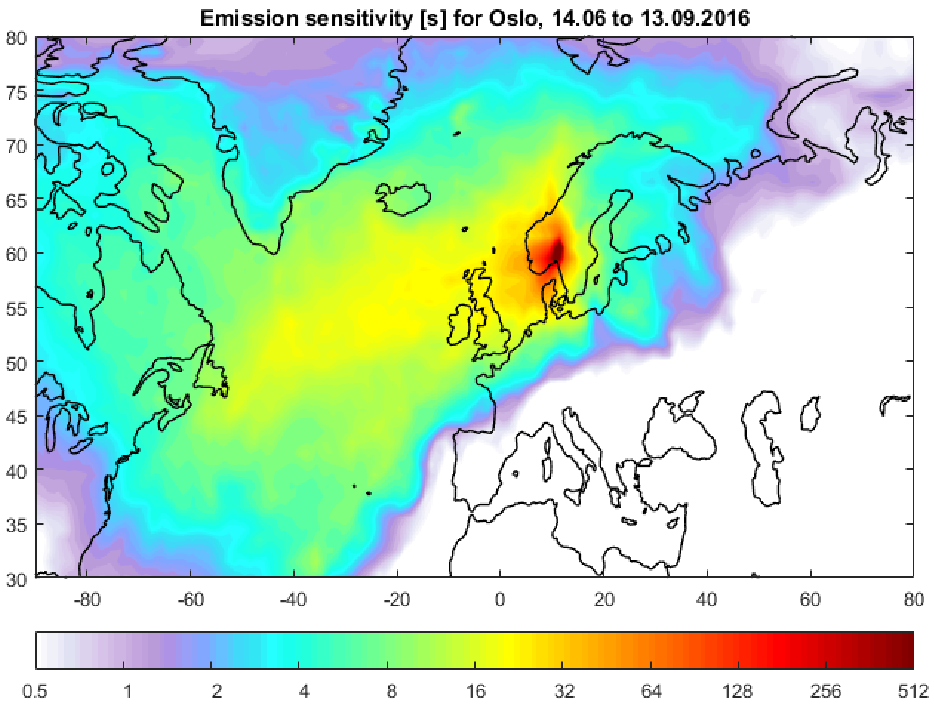


Figure 56: Source of dominating airmasses in the time period of 14.06. to 13.09.2016

However, the dominating compounds observed in air consist of D5, OPFRs and CPs, all closely related to urban point sources. More sampling sites would be needed to improve the understanding of the contribution of long-range transport versus point source pollution.

Soil

In soil, the main contributors to the overall pollution are besides metals (where Pb was the major toxic metal), chlorinated paraffins and PFAS. PCBs and PBDEs play only a small role of the overall contamination. The high levels of SumPFAS in soil from Alnabru (175 ng/g dw) are concerning and more than 10-times higher compared to the other locations related to skiing activities. Similar high levels of CPs compared to PFAS were found in soil from Alnabru and the Holmenkollen area.

Inter-species comparisons

In general, direct comparison of the pollutant concentrations found in the investigated species is difficult, since different tissue types were sampled. As a result, only general conclusions can be drawn. There are major differences between the concentrations and patterns of accumulation of organic pollutants and metals between the species involved in this study (see below). Levels of organic pollutants, especially PCBs, are much higher in the top predators (eggs of sparrowhawk) than in the other species. On the other hand, metals were much higher in earthworms than in any other species. PFAS, which primarily binds to proteins, behaves differently in biota compared to the "classic" organic pollutants such as PCBs, however some PFAS have been shown to bioaccumulate similar to PCBs.

When comparing the average sum concentrations of the analysed pollutants in the seven observed species, interesting species related differences can be observed (Figure 57).

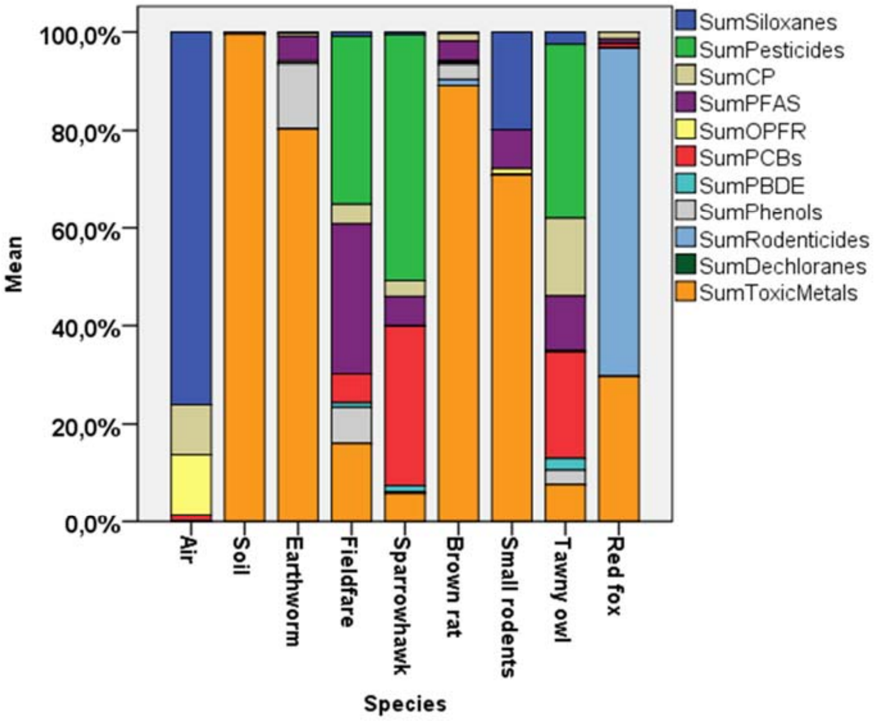


Figure 57: Relative contribution in % of major pollutants to the observed species calculated on a ww basis (dw for soil and per sample for air).

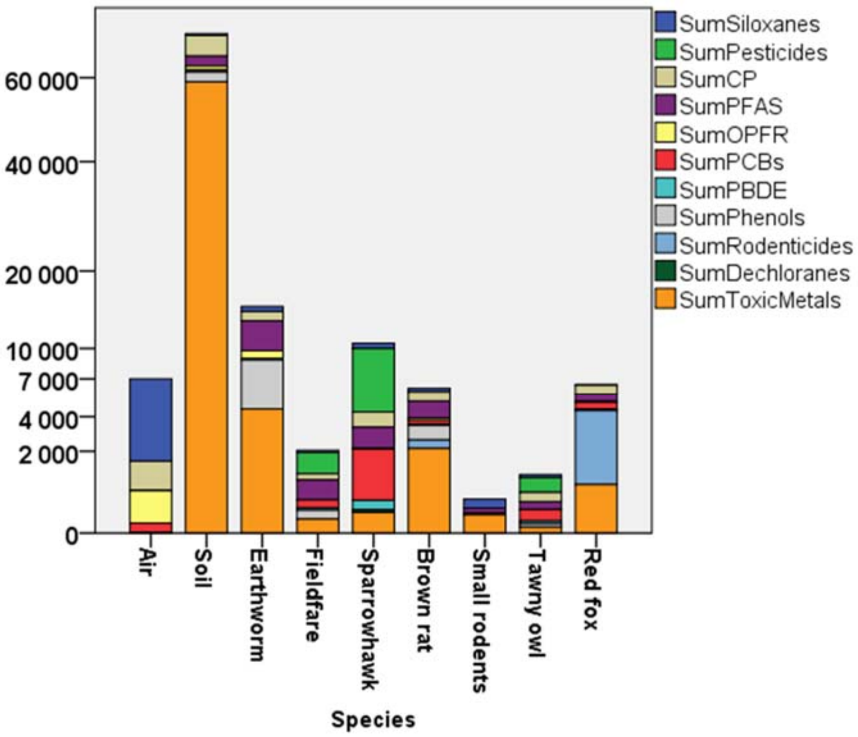


Figure 58: Major pollutant groups in the observed species calculated on a ww basis (dw for soil).

Figure 57 and Figure 58 show the contribution of all organic pollutant groups, with sparrowhawk showing up to more than 20 times higher PCB concentrations than the other species observed on a ww basis. In tawny owl, red fox, fieldfare and brown rat, on the other hand, sumPCB concentrations are not as dominating. PBDEs contributed generall less than 5% to the overall contamination load. DDTs were still major contributors to the pollutant load in sparrowhawk, fieldfare and tawny owl.

In terms of quantity, PFAS were present in most of the investigated sample types. Distinct interspecies differences were found (Figure 59). PFOS is the overall dominating compound. PFTDoA, PFTriA and PFTeA contribute more higher up in the food-chains (fieldfare, sparrowhawk and tawny owl), but also in rodents. The reduced relative contribution up from soil and earthworms indicate that the alkylated PFASs are more prone to bioaccumulation than PFOS.

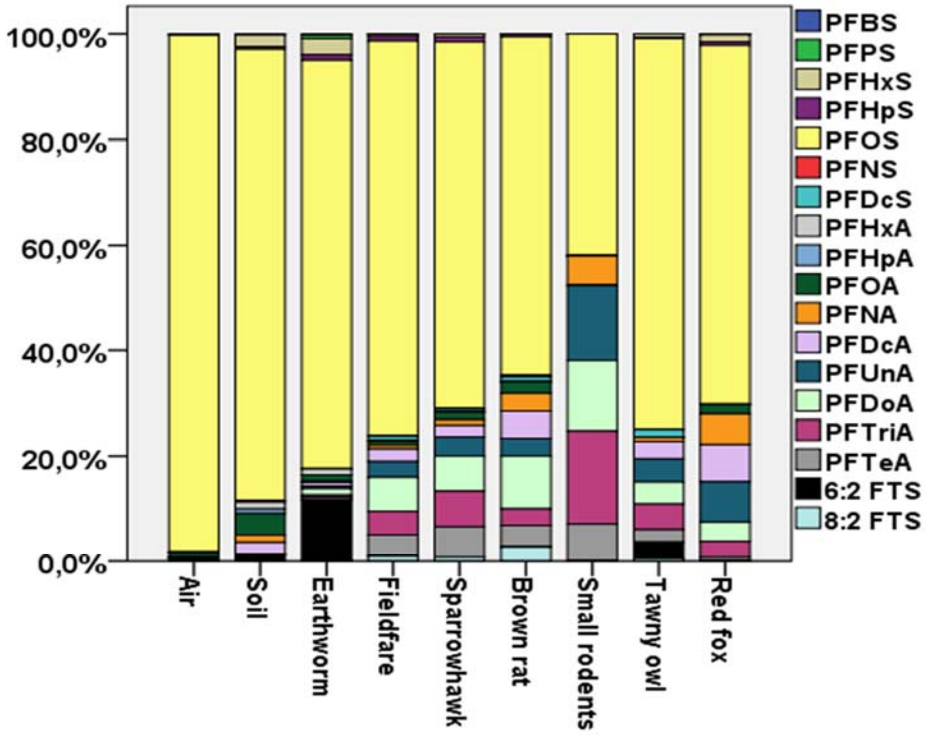


Figure 59: Average relative PFAS distribution in the observed species calculated on a ww basis (dw for soil).

When comparing average concentrations on a wet weight basis, earthworms were the species with the highest SumPFAS concentrations, mostly due to the pointsource at Alnabru (*Figure 60*).

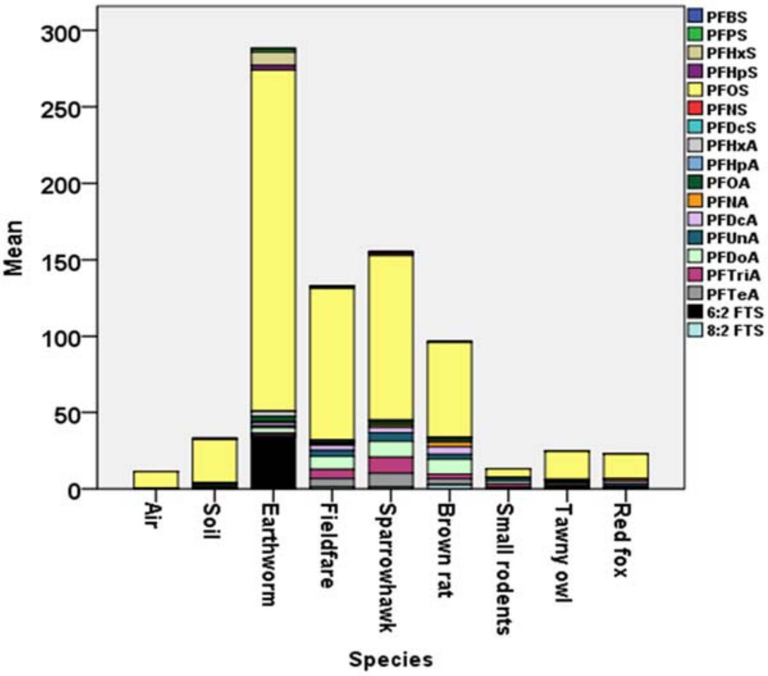


Figure 60: Average PFAS distribution in the observed species calculated on a ww basis (dw for soil).

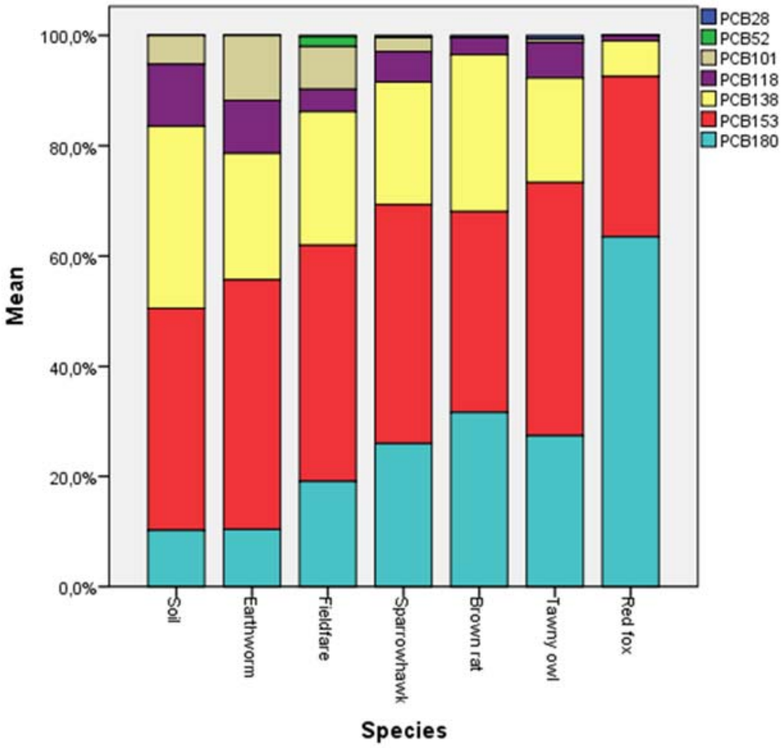


Figure 61: Relative mean contributions of the analyzed congeners of PCBs in the different sample types.

As seen in Figure 61 there is a shift from low- chlorinated PCBs tog high-chlorinated PCBs up through the food-chains. The especially high prevalence of PCB 180 in rats and foxes may be caused by different species and the different matrixes used; livers in the mammals and eggs of the birds. Enzymatic processes in the livers may play a role here as well as differences in transfer efficiencies of low- and high chlorinated PCBs together with differences in bioaccumulation potential.

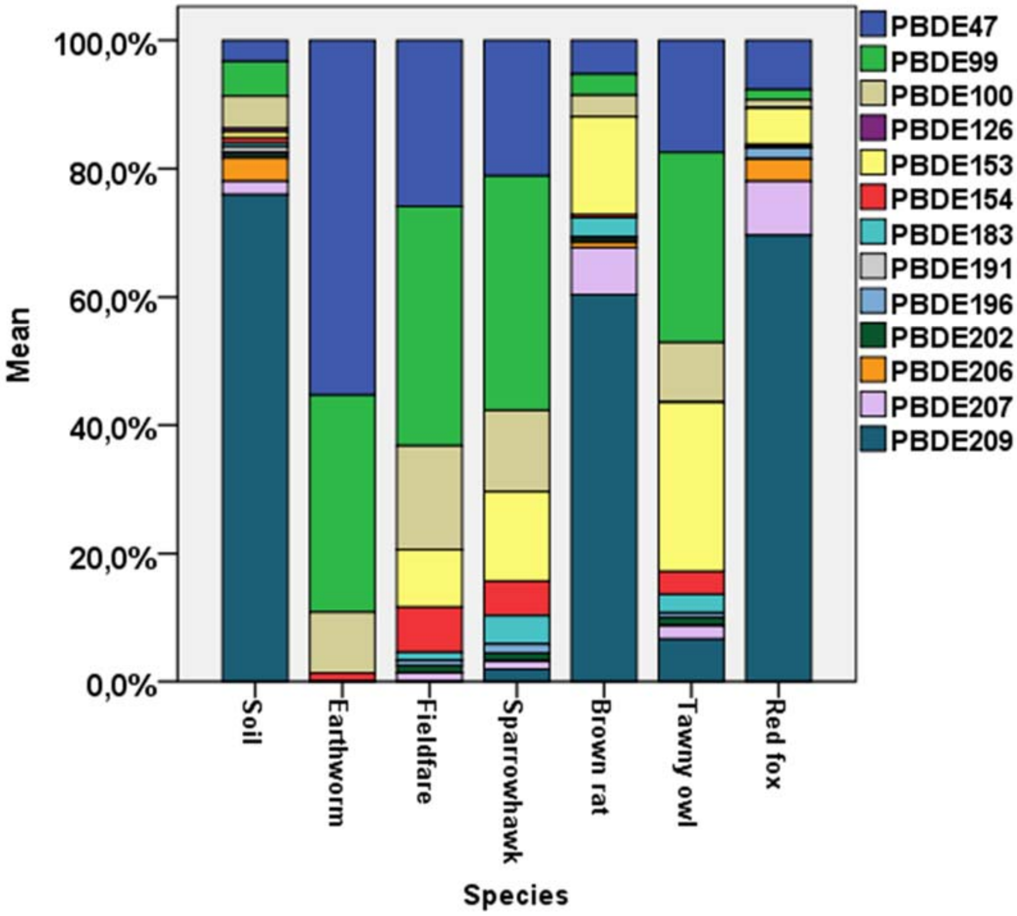


Figure 62: Relative mean contributions of the analyzed congeners of PBDEs in the different sample types.

The relative distribution of the various brominated PBDEs reveals similarities to those of PCBs, but with some peculiarities. PBDE209 is dominating in soil, but not in earthworms. But, it is again dominating in the mammals (rats and foxes). The route of exposure here needs to be explored. In bird eggs, there is a tendency for the higher brominated PBDEs going from lower to higher trophic levels (Figure 62). The low-brominated PBDEs dominate in earthworms.

Comparison with Herring gull eggs

Oslo was the main sampling location of the two parallel-running projects “Environmental Contaminants in an Urban Fjord, 2016” and the here presented project on “Environmental pollutants in the terrestrial and urban environment, 2016”, enabling a direct comparison of the marine and terrestrial environment impacted by the city of Oslo. Of the chemicals analysed and detected in both projects, PCBs, PBDEs, DDTs, DBDPE, cyclic siloxanes, PFAS and metals are the most suitable compound groups to include for comparison. Also, we selected sparrowhawk eggs for direct comparison to herring gull due to the closeness of both species in the urban foodweb of Oslo as Figure 63 illustrates. As established by the Urban Fjord project (Ruus et al., 2016, 2017), herring gull does not reside on the top of the marine food chain in the Oslo fjord, but rather feeds on terrestrial prey as well as waste.

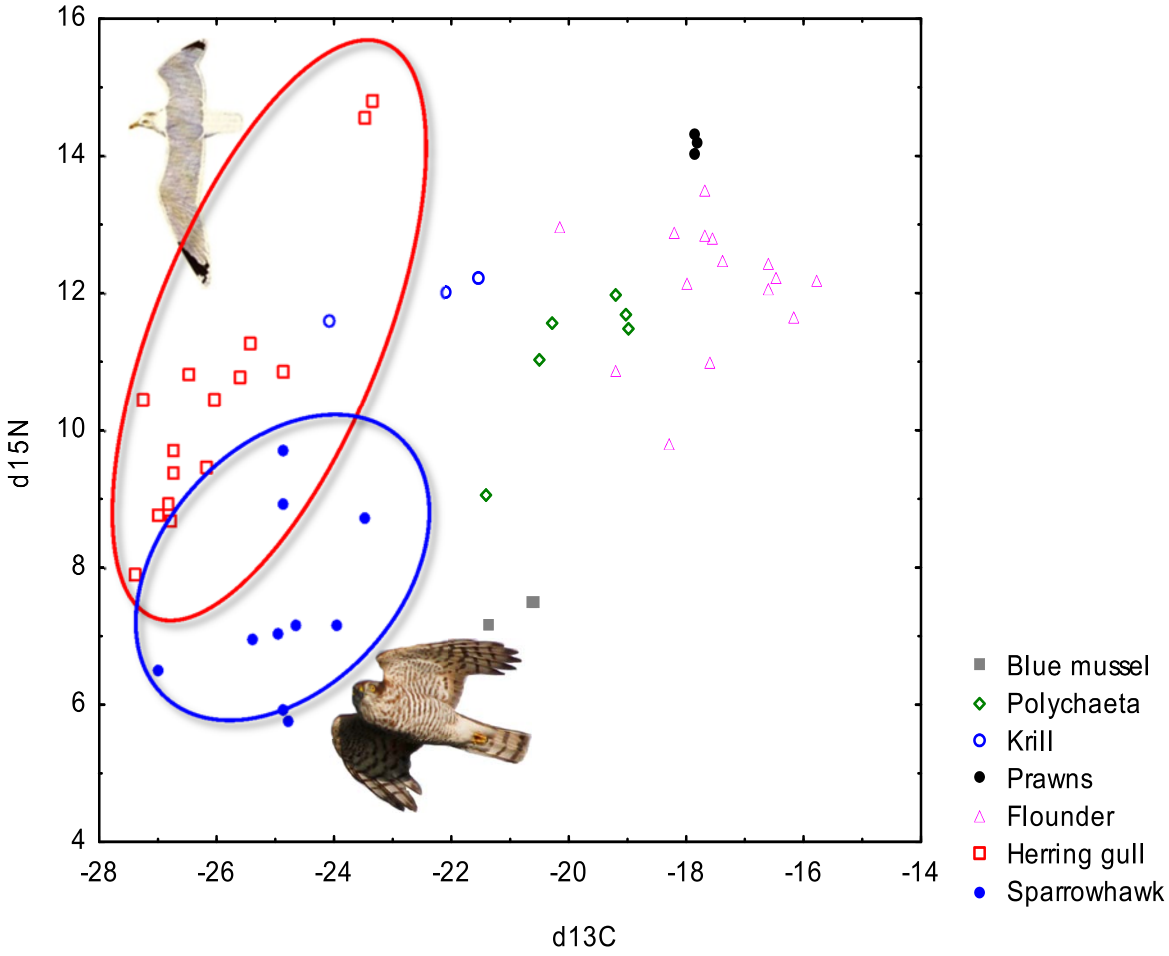


Figure 63: δ^{13}C vs δ^{15}N in herring gull and sparrowhawk eggs sampled in 2015 compared to marine organisms from the Inner Oslofjord (Norway). Figure by A. Ruus, NIVA

In Figure 64 we illustrate the close similarity of the stable isotope signature of earthworms, sparrowhawk and herring gulls, indicating a similar feeding habit. The signals for fieldfare are overlapping the signature of the worms.

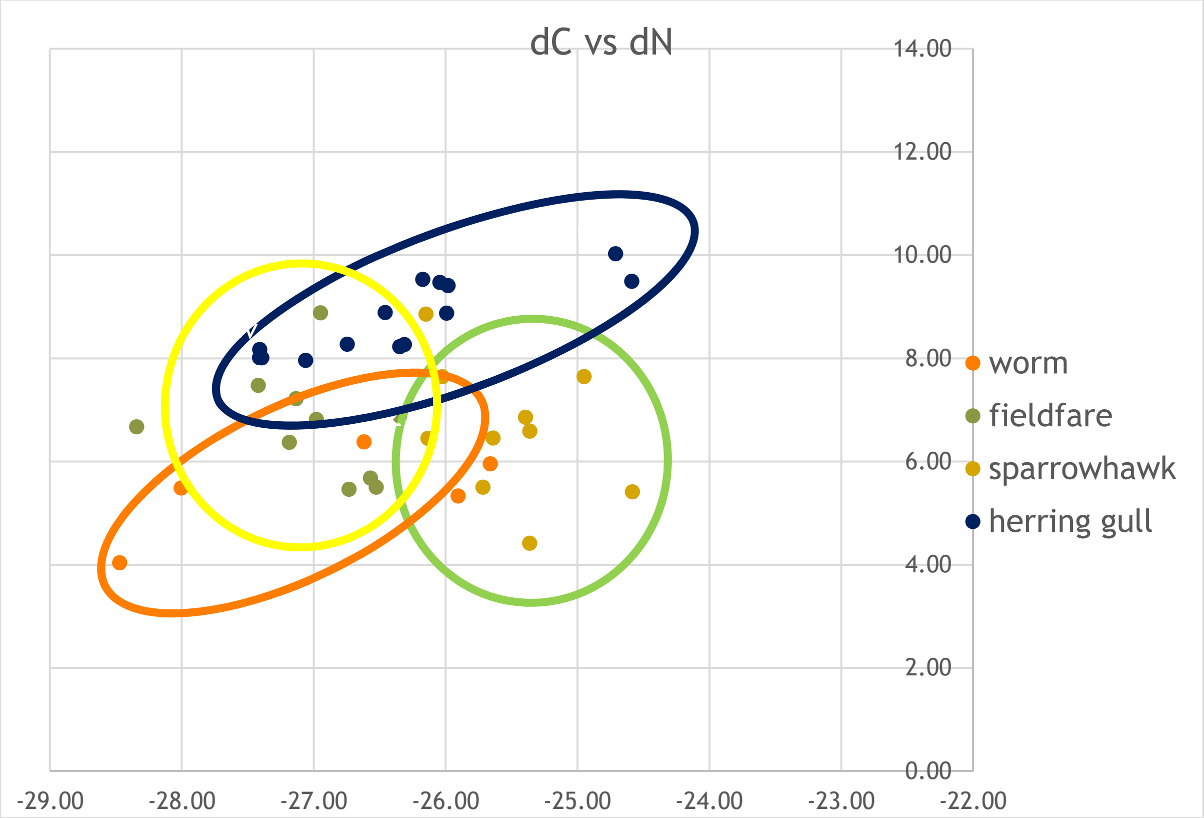


Figure 64: Comparison of stable isotope relationship in earthworms, eggs of sparrow hawk and herring gull

The lipid content (9 %) in herring gull egg is almost twice as high as the sparrowhawk egg with 4.8 %. However, when comparing the lipophilic pollutants measured in both species, almost all were considerably higher in sparrowhawk eggs compared to the herring gull on a lipid weight basis (Figure 65).

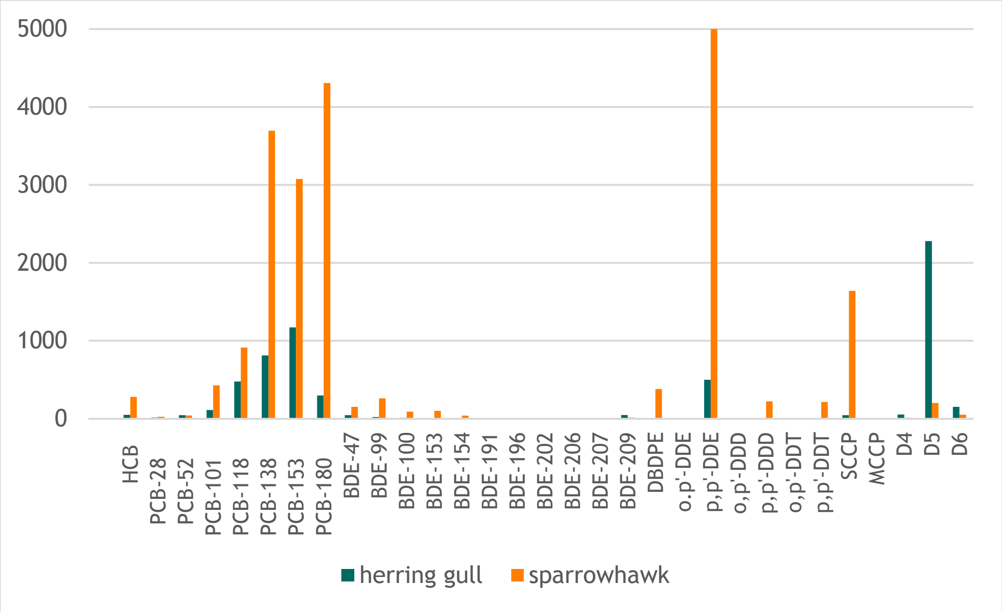


Figure 65: Comparison of lipophilic compounds in eggs of herring gull and sparrowhawks in ng/g lw; p,p'-DDE sparrowhawk = 23905 ng/g lw

PBDE 206 and 209 and the cyclic siloxanes D4, D5 and D6 were the only compounds with higher concentrations in the herring gull eggs on a lipid base. The large difference in concentration load between the species is most probably caused by the choice of prey as well as migration pattern. The sparrowhawk feeds mainly on birds of small to medium size. Most of the population migrates to south-western Europe during winter.

The herring gull feeds on a varied diet, consisting mostly of fish and crustaceans as well as being an opportunistic and omnivore scavenger. As discussed above, according to the SI signature that seems not to be the case for the gulls sampled in Oslo. The herring gulls are mostly permanent residents, with some migrating to the south, but the degree of migration in the here investigated gulls is not known. The large 48-fold difference of the *p,p'*-DDE concentration may be caused by the sparrowhawk feeding on migrating birds as well being a migratory bird itself. The compounds with higher concentrations in the herring gull eggs than the sparrowhawk are mostly related to the gulls feeding on waste from electric and electronic equipment (WEEEs) and building materials such as the PBDEs and personal care products (PCPPs) such as the siloxanes.

Moving on to PFAS, a similar picture can be found, with elevated concentrations found in sparrowhawk eggs, but with a similar PFAS pattern, again indicating an feeding choice of the herring gull in an urban setting (Figure 66). The concentration pattern found for metals showed a large difference for all metals, again mostly all being more abundant in sparrowhawk eggs.

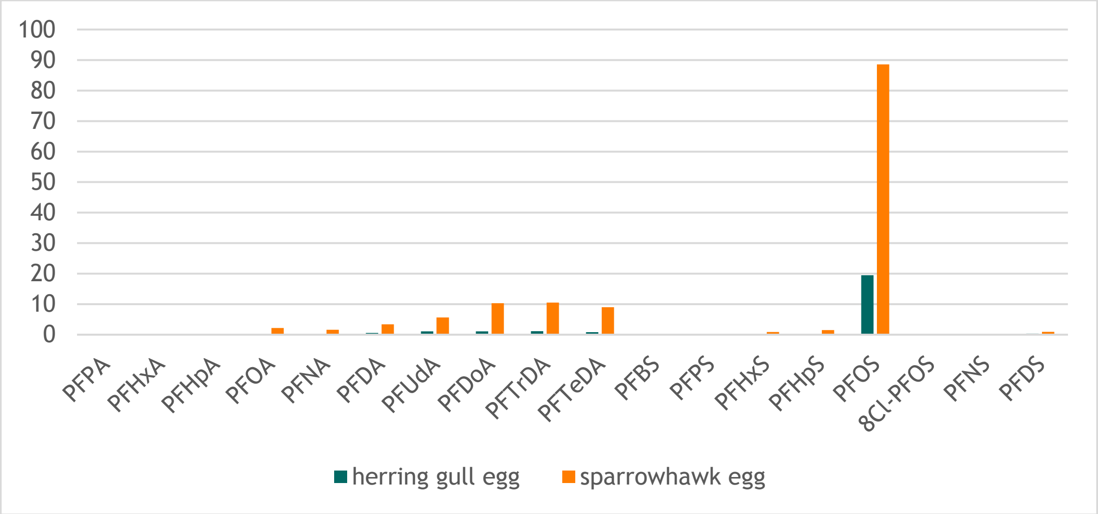


Figure 66: Comparison of average PFAS concentrations in eggs of herring gull and sparrowhawks from Oslo; ng/g ww

3.13 Bioaccumulation and biomagnification

As part of the sampling campaign, 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. In addition, stable isotopes were determined as supporting parameters on all biological samples within this study. Using this information, trophic magnification factors (TMFs) were estimated to determine the bioaccumulation potential of a chemical within the food web.

TMFs are increasingly used to quantify biomagnification and represent the average diet-to-consumer transfer of a chemical through food webs. They have been suggested as a reliable tool for bioaccumulation assessment of chemicals that have been in commerce long enough to be quantitatively measured in environmental samples. TMFs differ from biomagnification factors, which apply to individual species and 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.

3.13.1 Results from stable nitrogen and carbon isotope analyses

$\delta^{15}N$ values can be used to estimate the relative trophic positions of an organism. 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 51: $\delta^{15}N$ in the different sample types from the Oslo area.

Species	N	Mean	Median	Minimum	Maximum
Soil	5	2.14	3.07	-2.76	5.59
Earthworm	5	5.43	5.49	4.04	6.38
Fieldfare	10	6.71	6.74	5.46	8.88
Sparrowhawk	10	6.58	6.52	4.42	8.86
Brown rat	10	7.77	7.62	6.37	9.98
Small rodents	1	6.01	6.01	6.01	6.01
Tawny owl	10	7.12	7.13	3.90	9.47
Red fox	10	8.38	8.49	7.01	9.45

According to the measured $\delta^{15}N$ data, the organisms included in this monitoring cover different trophic levels. Earthworms showed the lowest $\delta^{15}N$ which is consistent with the fact that it holds the lowest tropic position among the different organisms/species in this study, while rats and red foxes were at the highest. Sparrowhawks, tawny owls and fieldfares were closely together in between.

Figure 67 shows the $\delta^{15}N$ signature of the four investigated species. Differences between soil and earthworms to the other species are quite considerable, with moderate $\delta^{15}N$enrichment occurs further up the food web.

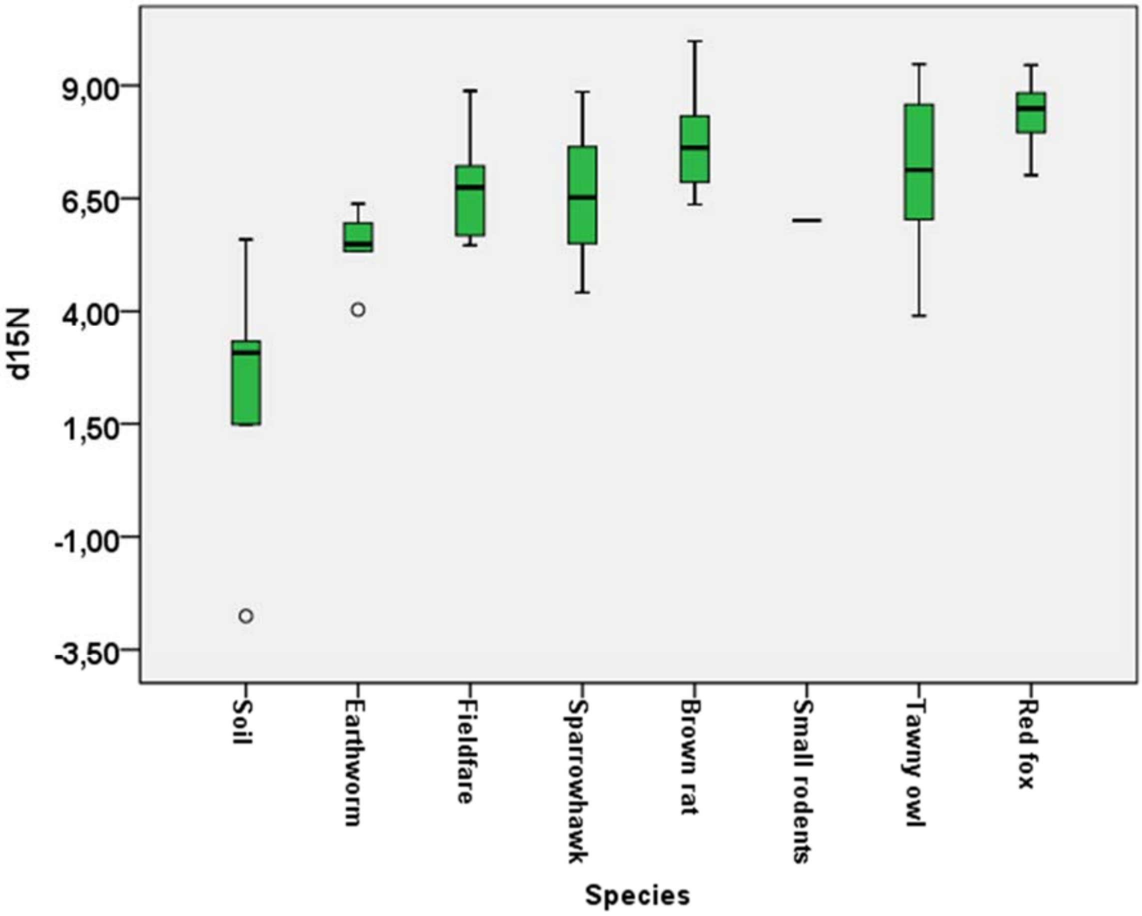


Figure 67: Mean δ^{15}N concentrations in all species analysed (‰).

Nitrogen in the protein of consumers is generally enriched in δ^{15}N by 3–5‰ relative to prey nitrogen (i.e. δ^{15}N = 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 study, the brown rat and the red fox were characterized by the highest δ^{15}N concentrations (mean of 7.7 and 8.4 respectively), followed by tawny owl (7.1), fieldfare (6.7), sparrowhawk (6.6) and earthworms (5.4). Small rodents showed with 6.0 a low position in the food chain. Soil showed an average δ^{15}N of 2.1. In the literature δ^{15}N were reported for polar fox, varying between 10 and 12 ‰ (Andersen et al., 2015). Similar to the 2015 and 2016 data, the finding that the sparrowhawk had relatively low levels of δ^{15}N was quite surprising, and may indicate that the fractionation rate in this species or its prey species is different than expected, but it might more likely be caused by the fact that the prey of the sparrowhawk is almost dominated by terrestrial prey (Hagen, 1952). Also similar to the 2015 findings, the fieldfare is considered to be a secondary consumer, feeding on insects and earthworms. Since some insect species can be carnivorous also, they might reside on an equally high TL as the prey of sparrowhawk and thus causing similarly high δ^{15}N concentrations in fieldfare compared to sparrowhawks. Still, these findings were surprising, and deserve further study of their respective prey items. Tillberg et al., found for example a difference in δ^{15}N of 6.0

‰ among some ant colonies suggesting that estimates of trophic position in a single species can span up to two trophic levels (Tillberg et al., 2006).

δ^{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 δ^{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 analyzed for the different species in the study (eggs, liver, whole individuals). Different tissues may have different δ^{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).

The differences in δ^{13}C concentrations found in sparrowhawk eggs ranged between -26.2 to -24.6 (Table 51, Figure 68), but with a mean of -25.5. For comparison with the marine food chain, a range of δ^{13}C concentrations between different gull species of -17 to -25 has been reported previously (Gebbink and Letcher 2012; Gebbink et al. 2011). Tawny owl eggs showed the lowest δ^{13}C of all biota samples (-28.8), indicating a δ^{13}C depleted food source such as rodents (-28.3). Herring gull eggs sampled in Oslo in 2014, showed a median δ^{13}C of -26.4, indicating a terrestrial prey source similar to the fieldfare from this study (median -27.0).

Red fox and brown rat as well as earthworms showed similar concentrations, averaging at -25.9, -25.9 and -26.9 ‰ respectively Figure 68), indicating that all selected species are part of a similar food chain, feeding on terrestrial food items.

Table 52: δ^{13}C levels in the different sample types.

Species	N	Mean	Median	Minimum	Maximum
Soil	5	-28.60	-28.11	-29.92	-27.69
Earthworm	5	-26.93	-26.62	-28.47	-25.66
Fieldfare	10	-27.02	-26.96	-28.34	-26.35
Sparrowhawk	10	-25.53	-25.52	-26.15	-24.58
Brown rat	10	-25.85	-25.49	-27.61	-24.04
Small rodents	1	-28.27	-28.27	-28.27	-28.27
Tawny owl	10	-28.83	-28.84	-30.77	-27.75
Red fox	10	-25.85	-25.76	-26.56	-25.38

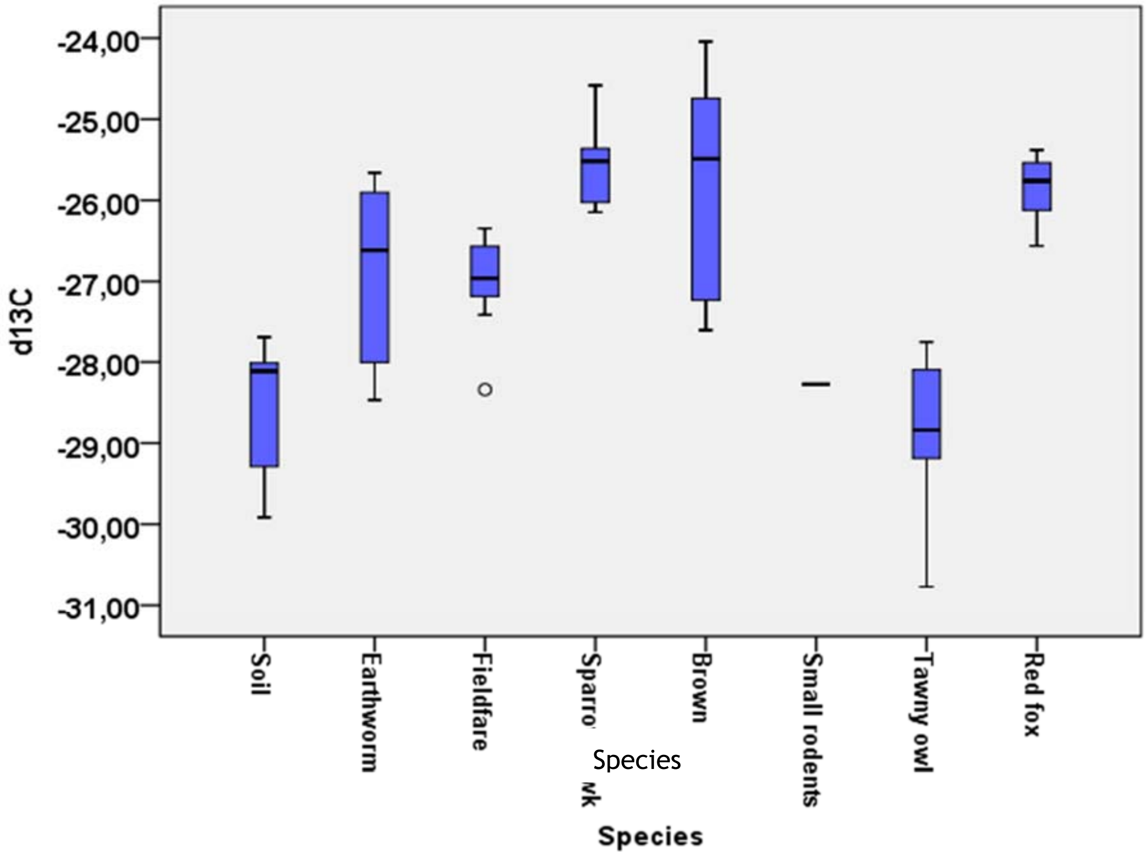


Figure 68: Boxplot of mean δ^{13} C concentrations in the different species analysed.

δ^{34}S values provide information regarding the foraging ecology of certain species. Marine sulfate generally has higher δ^{34}S values than terrestrial materials or waters (Michener and Schell 1994) and sulfur isotope analyses have been used extensively in wetlands and fisheries studies to determine the amount of marine derived nutrients in estuarine systems (Hesslein et al. 1991; Kwak and Zedler 1997; MacAvoy et al. 2000). Using this method, Lott et al., managed to develop four foraging groups of raptors: Coastal bird-eaters (CB), coastal generalists (CG), inland bird-eaters (IB), and inland generalists (IG) (Lott et al., 2003).

Figure 69 illustrates the four foraging groups from Lott et al., 2003. Sparrowhawk would belong to the bird eater category, tawny owls belong to the generalist's category and fieldfare to the inland generalists. The investigated mammals are in the same range as the sparrowhawk.

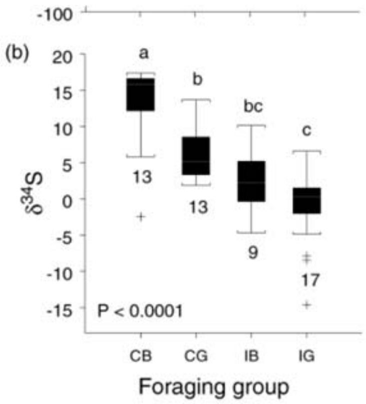


Fig. 2 Box plot showing the central 50% (*boxes*) and range (*lines*) of **a** $\delta D_{f\text{-}p}$ and **b** $\delta^{34}S$ for four foraging groups of raptors: coastal bird-eaters (*CB*), coastal generalists (*CG*), inland bird-eaters (*IB*), and inland generalists (*IG*). Letters above boxes indicate group membership and numbers below boxes indicate sample size. + An outlier value

Figure 69: Boxplot illustrating $\delta^{34}S$ relationships in respect to foraging strategies in raptors, taken from (Lott et al., 2003).

Table 53: δ34S levels in the different sample types.

Species	N	Mean	Median	Minimum	Maximum
Earthworm	5	0.84	2.80	-6.13	5.12
Fieldfare	10	5.00	5.49	.87	6.91
Sparrowhawk	10	7.44	7.69	6.08	8.48
Brown rat	10	7.09	6.73	5.73	8.94
Small rodents	1	6.04	6.04	6.04	6.04
Tawny owl	10	6.67	6.59	5.36	8.37
Red fox	10	6.51	6.23	5.93	8.64

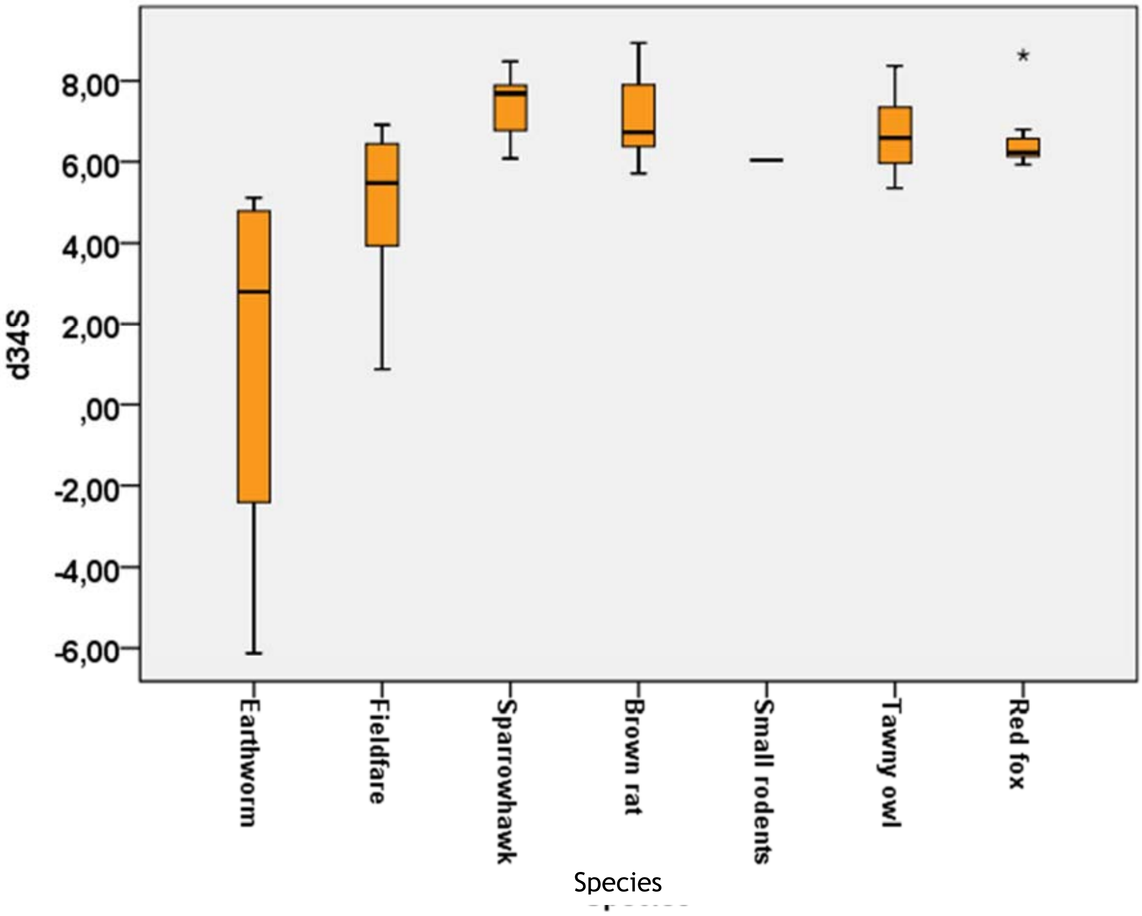


Figure 70: δ^{34} S data measured in the urban terrestrial environment in the Oslo area.

However, according to the δ^{34} S data acquired in this study, no clear grouping into foraging classes of the here observed birds of prey, sparrowhawk and tawny owl, can be found (overlapping of data). Fieldfare as a terrestrial omnivore (seeds, berries earthworms and insects), on the other hand, shows a distinction to the other bird species, overlapping earthworm data, as opposite to tawny owl and sparrowhawk, which are clearly distinguished from the earthworm data. δ^{34} S levels are not enriched in the foodchain and stay stable within the same location, allowing comparison of foraging habits.

When relating all samples against δ^{13}C and δ^{15}N, the following graph is achieved, showing differences between tawny owl, sparrowhawks and fieldfare with some overlap, spanning more than one trophic level but without any distinct clustering of the species, indicating a more complex food web rather than a food chain (Figure 71). The species rather distinguish themselves along the δ^{13}C isotope than the δ^{15}N isotope, spanning from -31 to -24, with sparrowhawk, rats and foxes showing the highest δ^{13}C values, possibly die to the semi-coastal nature of their habitat. The omnivores, rat and fox are also overlapping with sparrowhawk, complicating the relationships. In general, little stable isotope data exist from terrestrial food chains similar to the one sampled here. The variation in δ^{13}C values in earthworm is difficult to explain, as we know little about the diet of earthworms, except that they feed on organic matter in the soil where they live. The difference may depend on the local origin and parent organisms of this organic matter, and on different species of earthworms involved, but this is only open to speculations. The range of values was least for the fieldfare. Foxes and sparrowhawk showed a large spread of values. This is probably caused by the fact these species feed on a wide range of species and food items.

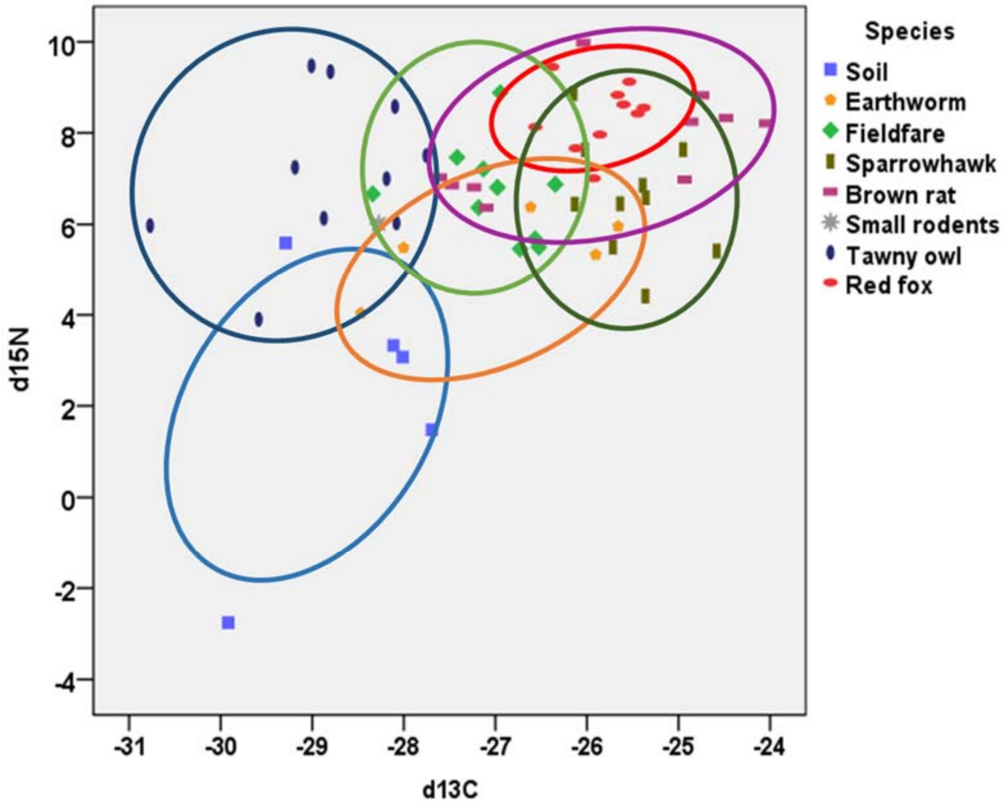
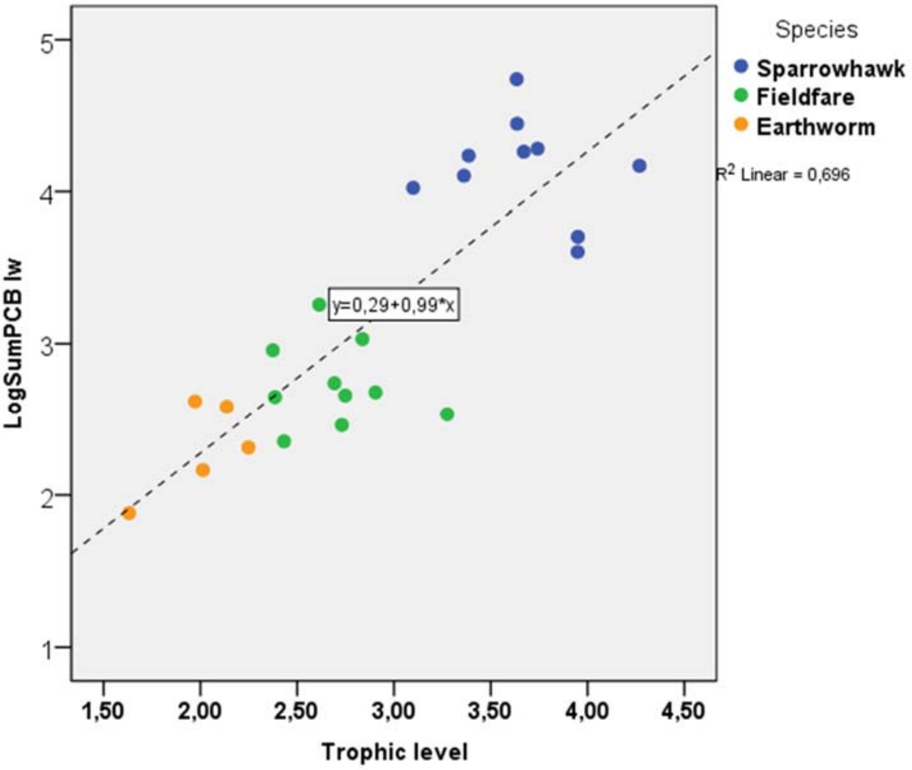
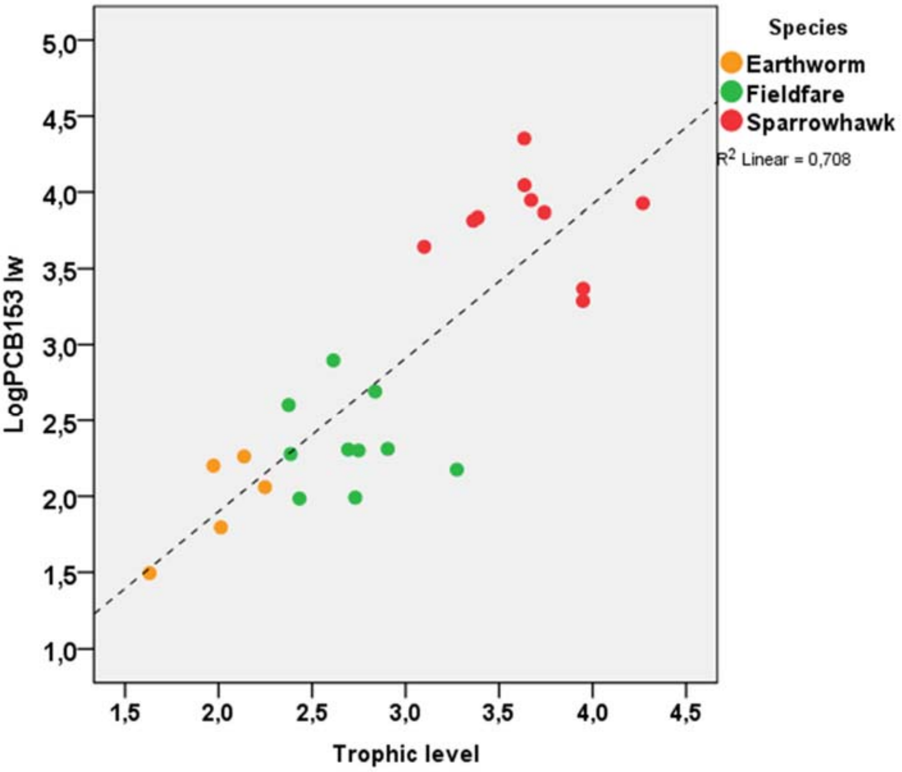


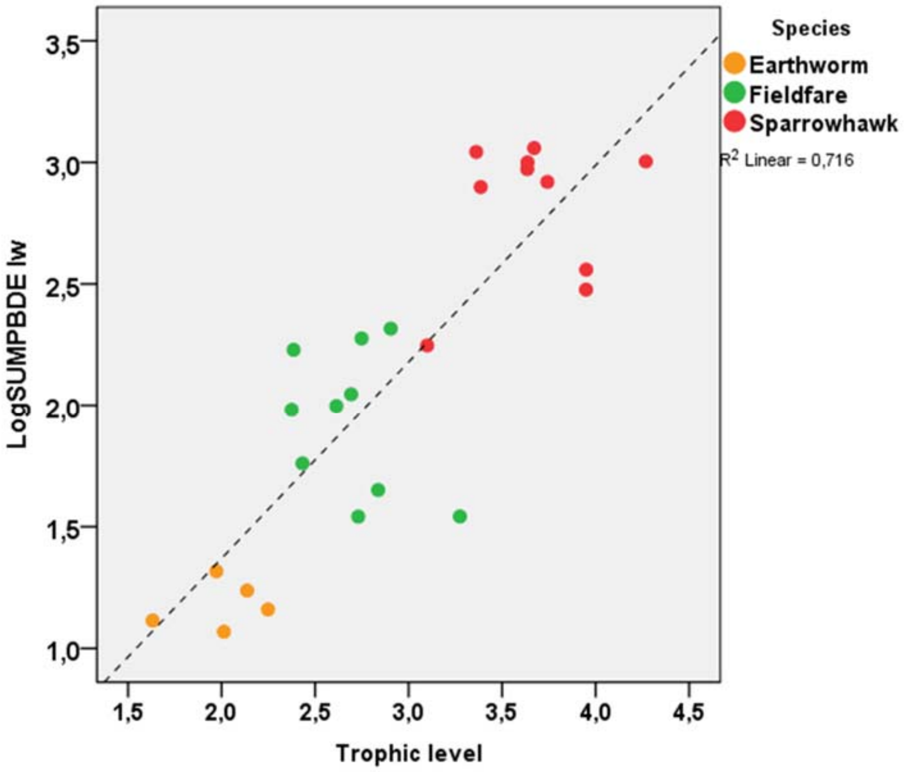
Figure 71: Relationship between the dietary descriptors δ^{15}N and δ^{13}C in biota from urban terrestrial environments.

3.13.2 Estimation of biomagnification by calculation of TMF values

The selected species in this study represent species from the 2nd trophic level (earthworms), 2nd to 3rd (fieldfare) and the 3rd and 4th trophic level (tawny owl, brown rat, red fox and sparrowhawk). To assess the biomagnification of each chemical we correlated the lipid-corrected (except for the case of PFOS) log concentrations of the different pollutants in the different species of the food web with δ^{15}N, i.e. information on the relative trophic position of the organisms (Figure 72). Within the frame of this study, the foodchain earthworm – fieldfare – sparrowhawk was included, enabling the estimation of the TMF.


Species
Sparrowhawk
Fieldfare
Earthworm
R² Linear = 0,696
y=0,29+0,99*x
LogSumPCB lw
1
2
3
4
5
1,50
2,00
2,50
3,00
3,50
4,00
4,50
Trophic level


Species
Earthworm
Fieldfare
Sparrowhawk
R² Linear = 0,708
LogPCB153 lw
1,0
1,5
2,0
2,5
3,0
3,5
4,0
4,5
5,0
1,5
2,0
2,5
3,0
3,5
4,0
4,5
Trophic level



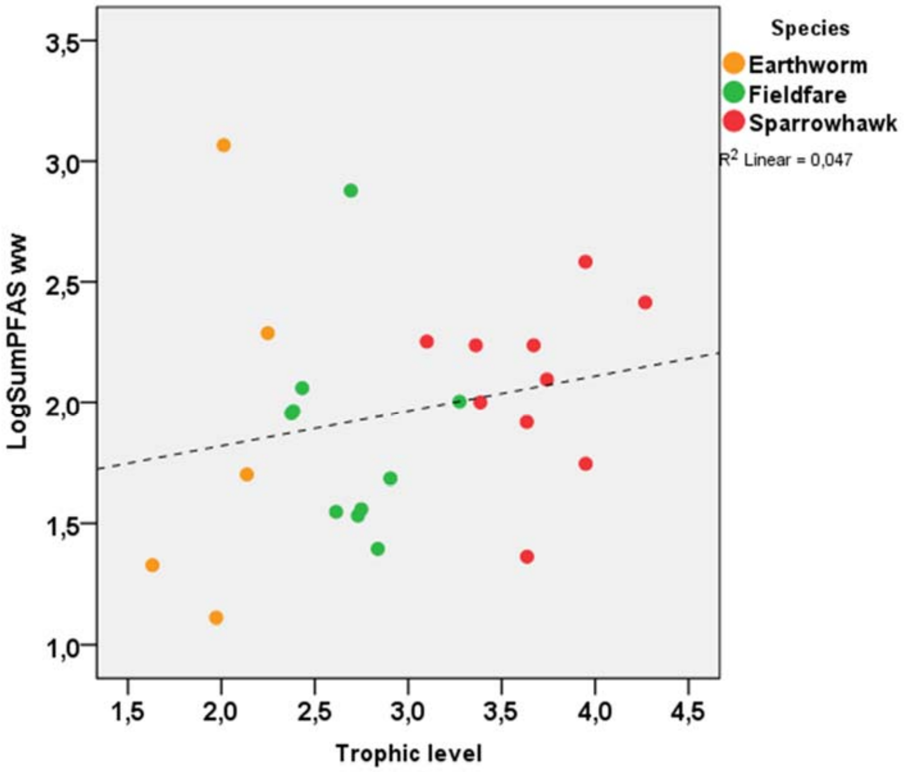


Figure 72: Relationship between trophic level and log SumPCBs, PCB153, sumPBDE, and SumPFOS, concentrations in ng/g lw or ww.

The red fox, brown rat and tawny owl were omitted from the calculations, as they do not belong to the studied food-chain, due to their omnivore diet. We obtained the following TMFs for Oslo, based on lipid concentrations and on a wet weight basis for PFOS, using the equation Log [compound] = a + *b*TL, and TMF = 10^b:

PCB 153: 5.1
SumPCB: 9.8
SumPBDEs: 5.2
SumPFAS (ww): 1.1

TMFs >1 indicate biomagnification of these compounds in the terrestrial foodchain. In respect to these criteria, PCBs and PBDEs bioaccumulate strongly in the observed food-chain. PFAS show a very moderate biomagnification across trophic levels in the studied foodchain

For comparison, the following TMFs were found for a reference location and in Oslo (Herzke et al., 2015; 2016), showing approximate the same levels of biomagnification.

	Remote; Herzke et al. 2015	Oslo; Herzke et al. 2016
SumPCBs:	10.2	11.5
SumPBDEs:	6.0	6.3
SumPFAS	1.4	1.3 (PFOS)

4. Prediction of combined risk for soil living organisms and predators

In the natural environment, living organisms are not only exposed to one single pollutant, but to a variety of different contaminants. The exposure to the mixture of chemicals is first and foremost through food (prey), but also from water and the environment they live in. Component-based approaches are suitable methods for evaluating risk of mixtures when exposure data (i.e. concentrations) in addition to toxicity endpoints or similar toxicity reference values exist for the individual chemical components. (Altenburger et al., 2014).

Within the European REACH regulation on chemicals, guidance exists on how to quantitatively assess the effects of a substance on the environment by determining the concentration of the substance below which adverse effects are not expected to occur in the environment. This concentration is known as Predicted No-Effect Concentrations (PNECs) (ECHA, 2008). A PNEC is obtained through the application of an assessment factor to ecotoxicological endpoints (EC50 or NOECs) using organisms with different sensitivities for any type of chemical. The size of the assessment factor depends on duration of the test (acute or chronic), the number of trophic concentrations tested and the general uncertainties in predicting ecosystem effects from laboratory data. In order to derive risk of contaminants for soil living organisms, such as plants, microorganisms and earthworm, $PNEC_{soil}$ should be determined (Andersen et al., 2012). The evaluation of risk for soil living organisms is performed by comparing predicted or measured concentrations in soil with the derived $PNEC_{soil}$. To avoid risk for terrestrial soil ecosystem the measured environmental concentration (MEC) should not exceed the PNEC level for the specific substance.

Risk of contaminants to organisms higher up the food chain has to consider and include bioaccumulative properties of the contaminants, which is a highly relevant property of several organic pollutants. Biomagnification is defined as accumulation and transfer of chemicals via the food chain, resulting in an increase of the internal concentration in organisms at higher levels in the trophic chain. Secondary poisoning is a concern for toxic effects in the higher members of the food chain of the terrestrial environment, which result from ingestion of organisms from lower trophic levels that contain accumulated substances. In order to estimate risk for wildlife and predators due to oral intake from lower trophic levels of bioaccumulative contaminants, $PNEC_{oral}$ should be determined (Mayfield et al., 2014). $PNEC_{oral}$ values represent dietary predicted no effect concentrations, below which food concentrations are not expected to pose a risk to birds or mammals (ECHA 2008). Results from long-term laboratory studies are strongly preferred, such as NOECs for mortality, reproduction or growth. If a chronic NOEC for both birds and mammals is available, the lower of the resulting PNECs may be used as the secondary poisoning assessment to represent all predatory organisms (ECHA, 2008). To avoid risk for wildlife, the PEC or MEC in feed should not exceed the $PNEC_{oral}$ levels for the specific chemical or chemical group; i.e. the MEC/PNEC ratio, the risk quotient (RQ) should not exceed 1.

The component-based method of summing up PEC/PNEC or MEC/PNEC ratios (i.e. risk quotient, RQ) has been recommended as a justifiable mixture risk approximation (Backhaus and Faust 2012; Kortenkamp et al., 2014) in order to estimate in a first tier whether there is a potential risk for an exposed ecosystem; i.e. if the sum of MEC/PNEC exceed 1. This approach has been used in the present study in order to evaluate the risk for combined effects for soil ecosystem through the use of PNEC_{soil} and PNEC_{pred} (=PNEC_{oral}) for predators where earthworm, fieldfare eggs/chick could be a substantial part of the diet. PNEC_{soil} and PNEC_{pred} were adopted from a previous Norwegian study (Andersen et al. 2012), from selected EU risk assessment reports, Environment Agency risk evaluation reports (EA RER) and European Chemicals Agency (ECHA). The PNEC values from Andersen et al. 2012, and risk assessment reports by EU and EA were considered as first choice references compared to other sources. A list of available PNEC values is given in Appendix 2. The chosen PNECsoil and PNECoral values used in the calculations are shown in black font color in Appendix 2. However, a large number of compounds measured in this study does not have PNEC data available and cannot be assessed. This was the case for instance PCB7 group and DDT/DDE for secondary poisoning. The contribution of these compounds to the overall risk is therefore not possible to calculate, even if it might be considerable.

4.1 Prediction of risk for soil living organisms

The detected levels (MEC) of the contaminants in soil from the various Oslo areas are shown in Table 54 with respective PNEC_{soil} values (from Appendix 2). The single $\text{MEC}/\text{PNEC}_{soil}$ (RQsoil) values (Table 55) characterize the risk for each chemical and the $\sum\text{MEC}/\text{PNEC}_{soil}$ (RQmix-soil) were calculated in order to predict mixture effects by the concentration addition approach. In the case of unavailable PNEC values per dry weight (dw), wet weight (ww) PNEC values were used together with MEC in ww. See Appendix 2 for PNECsoil values.

Table 54: Measured concentrations (MEC) of pooled soil samples from Alnabru, Slottsparken, Voksenkollen, Frognerseteren and Svartdalsparken. All concentrations are given as ng/g dw, except for OctaBDE, DecaBDE, SCCP, MCCP since PNECsoil is given in ng/g ww.

MEC	Alnabru	Slotts-parken	Voksen-kollen	Frogner-seteren	Svartdals-parken	PNEC_{soil}	PNEC_{soil} wet weight
PFOS	126	0.39	1.58	3.36	0.127	373	
PFOA	2.31	0.28	0.76	3.34	0.10	160	
SumPCB7	1.39	2.49	1.26	2.43	1.34	10	
PentaBDE	0.094	0.048	0.037	0.067	0.041	380	
OctaBDE	0.11	0.01	0.00	0.02	0.01		20900
DecaBDE	0.046	0.001	0.012	0.011	0.004		9800
BPA	30	13.4	10.6	10.4	13.7	3200	
SCCP	76.4	35.7	8.97	102	15.7		1760
MCCP	0.95	0.182	<LOD	43.8	0.143		10600
Cr	68243	93413	67307	16057	48510	62000	
Ni	46119	52744	33510	9139	30960	50000	
Cu	52695	43053	59153	21494	31113	89600	
Zn	302403	167252	813262	124511	102829	26000	
Cd	575	293	2712	1692	230	1150	

Pb	37954	54171	35182	105434	15118	166000	
Hg	129	317	82	167	31	300	
Ag	237	332	250	288	122	1400	
As	9107	11201	10385	4680	5057	700	

Organophosphates compounds were only analyzed for in a pooled soil sample across all sites where TnBP (0.8 ng/g dw) and TCP (1.9 ng/g dw) were above LOQ. The $\text{PNEC}_{\text{soil}}$ value of TCP of 0.0027 mg/kg dw is very low compared to the other organophosphates. For the pooled soil sample the RQsoil value for TnBP is very low and do not pose any potential risk. However TCP revealed a $\text{PNEC}_{\text{soil}}$ value of 0.70. The contribution of the pooled soil sample is not part of the table and the risk evaluation for the respective sites below.

Table 55: RQsoil (MEC/PNECsoil) values of contaminants for soil samples from Alnabru, Slottsparken, Voksenkollen, Frognerseteren and Svartdalsparken. Values > 1 in bold

RQsoil	Alnabru	Slottsparken	Voksenkollen	Frognerseteren	Svartdalsparken
PFOS	0.34	1E-03	4E-03	9E-03	3E-04
PFOA	0.01	2E-03	5E-03	2E-02	6E-04
SumPCB7	0.14	0.25	0.13	0.24	0.13
PentaBDE	2.5E-04	1.3E-04	9.7E-05	1.8E-04	1.1E-04
OctaBDE	5.4E-06	2.7E-07	1.4E-07	1.0E-06	2.7E-07
DecaBDE	4.7E-07	1.1E-08	1.3E-07	1.1E-07	4.2E-08
BPA	0.01	4.2E-03	0.003	3.3E-03	4.3E-03
SCCP	0.04	0.02	0.01	0.06	0.01
MCCP	9.0E-05	1.7E-05	-	4.1E-03	1.3E-05
Cr	**1.10**	**1.51**	**1.09**	0.26	0.78
Ni	0.92	1.05	0.67	0.18	0.62
Cu	0.59	0.48	0.66	0.24	0.35
Zn	**11.63**	**6.43**	**31.28**	**4.79**	**3.95**
Cd	0.50	0.25	**2.36**	**1.47**	0.20
Pb	0.23	0.33	0.21	0.64	0.09
Hg	0.43	**1.06**	0.27	0.56	0.10
Ag	0.17	0.24	0.18	0.21	0.09
As	**13.01**	**16.00**	**14.84**	**6.69**	**7.22**

After considering all RQsoil data together, the risk caused by the mixture of contaminants in soil ecosystem at the various sites can be estimated. The sum of the respective RQ, SumRQmix-soil is summarised below:

	Alnabru	Slotts-parken	Voksen-kollen	Frogner-seteren	Svartdals-parken
RQmix-soil	29	28	52	15	14

All sites show RQmix-soil above 1. The compounds contributing most to the sum were mainly the metals, PFOS and PCB7. Among the metals, Zn shows the highest risk quotients. Of the organic pollutants, PFOS and PCB7 are among the most contributing pollutants, but all are below 1. The RQmix-soil of the organic compounds alone was highest at Alnabru (0.54) followed by Frognerseteren, Slottsparken, Voksenkollen and Svartdalsparken (0.34, 0.28, 0.15, 0.15 respectively), mostly caused by PCB7.

Zn has an important physiological function in all organisms, and it is uncertain if the high concentration in soil is of high risk to soil living organisms. The Norwegian normative value for soil has been set to 200 mg/kg and Alnabru and Voksenkollen exceeded this concentration. However, in accordance to the available PNEC value used and the ECHA PNECsoil value of 35.6 mg/kg soil dw, the MEC/PNEC$_{soil}$ for Zn is above 1 at all sites, indicating reason for concern for soil living species such as earthworm. Other toxic metals also cause MEC/PNEC$_{soil}$ > 1 in several sites.

The sum of risk quotients for metals as a group is above 1 for all sites, also if Zn is not included mostly due to As, Cd and Cr.

4.2 Earthworm as prey

Detected concentrations of the various contaminants in pooled earthworm samples from the various locations are listed below in Table 56 together with PNECpred values. The risk for oral intake of earthworm for predators of single compounds was evaluated by the calculation of MEC/PNECpred (RQpred), Table 57. Potential risk from mixture of contaminants were assessed by summing up the single RQpred values (RQmix-pred). Species feeding on earthworms are a broad range of birds as well as small mammals (voles), which can consume up to 50 worms per day. See Appendix 2 for PNEC$_{pred}$ values.

Table 56: Measured concentrations (MEC) of pooled earthworm samples from Alnabru, Slottsparken, Voksenkollen, Frognerseteren and Svartdalsparken. All concentrations are given as ng/g ww. PNECpred (ng/g ww) represents dietary predicted no effect concentrations for predators where earthworm is a substantial part of diet.

MEC	Alnabru	Slotts-parken	Voksen-kollen	Frogner-seteren	Svartdals-parken	$PNEC_{pred}$
BPA	27.3	47.13	45.44	125.12	40.19	2670
PFOS	955	5.0	33.5	21.9	8.63	37
PFOA	2.5	0.93	5.8	6.4	1.3	
PCB153	0.561	1.27	1.26	1.46	0.312	670
PentaBDE	0.097	0.166	0.159	0.138	0.130	1000
D4			3.1			1700
D5		6.4	16.3	6.4	2.1	13000
D6	1.2	3.5	17.6	4.9	1.9	66700
SCCP	28	28	33	30	31	5500
MCCP	5.5	1.2	4.8	2.2	12.6	10000
Ni	884	1867	2271	332	740	8500
Cd	938	576	5523	2589	661	160
Pb	398	1156	2145	3528	369	3600
Hg	39	1101	101	131	31.6	400

The concentrations of metals are more or less in accordance with 2014 and 2015 data from the Oslo area. Since Cu and Zn are physiologically regulated in birds (Richards and Steele 1987), mostly Hg, Pb, Cd and As can prove toxic at concentrations that can be found in the environment (Depledge et al. 1998).

Organophosphates compounds were only analyzed for in a pooled earthworm sample across sites where TCPP and TnBP revealed highest concentration of 12 ng/g ww and 7.7 ng/g ww, respectively. However, calculation of RQ_{pred} for the orgaonaphosphates compounds with available $PNEC_{pred}$ values (Appendix 2) revealed negligible risks.

Table 57: Single RQpred values of contaminants in earthworm from Alnabru, Slottsparken, Voksenkollen, Frognerseteren and Svartdalsparken. Predicted combined risk is given as Sum RQmix-pred for each site.

RQpred	Alnabru	Slottsparken	Voksenkollen	Frognerseteren	Svartdalsparken
BPA	0.01	0.02	0.02	0.05	0.02
PFOS	**26**	0.14	**0.91**	0.59	0.23
PFOA	**2.8**	**1.0**	**6.4**	**7.1**	**1.4**
PCB153	8.4E-04	1.9E-03	1.9E-03	2.2E-03	4.7E-04
PentaBDE	9.7E-05	1.7E-04	1.6E-04	1.4E-04	1.3E-04
D4			1.8E-03		
D5		4.9E-04	1.3E-03	4.9E-04	1.6E-04
D6	1.7E-05	5.2E-05	2.6E-04	7.3E-05	2.8E-05
BPA		0.02	0.02	0.05	0.02
SCCP	5.1E-03	5.1E-03	6.0E-03	5.5E-03	5.6E-03
MCCP	5.5E-04	1.2E-04	4.8E-04	2.2E-04	1.3E-03
Ni	0.10	**0.22**	**0.27**	0.04	0.09
Cd	**5.86**	**3.60**	**34.52**	**16.18**	**4.13**
Pb	0.11	0.32	0.60	**0.98**	0.10
Hg	0.10	**2.75**	0.25	0.33	0.08

After considering all $\mathrm{RQ}_{\mathrm{pred}}$ data together, the risk caused by the mixture of contaminants for organisms feeding on earthworms can be estimated for the various sites. The sum of the respective RQ, $\mathrm{SumRQ}_{\mathrm{mix\text{-}pred}}$ is summarised below.

	Alnabru	Slottsparken	Voksenkollen	Frognerseteren	Svartdalsparken
RQmix-pred	**35**	**8**	**43**	**25**	**6**

All sites show $\mathrm{RQ}_{\mathrm{mix\text{-}pred}}$ above 1. The compounds contributing most to the sum were mainly cadmium, PFOS and PFOA. Of the organic pollutants, PFOS and PFOA are among the most contributing pollutants mostly above 1. The $\mathrm{RQ}_{\mathrm{mix\text{-}pred}}$ of the organic compounds alone was > 1 in all five locations, and highest at Alnabru (29) followed by Frognerseteren, Voksenkollen, Svartdalsparken and Slottsparken, (7.7, 7.3, 1.6, 1.1), mostly caused by PFOS at Alnabru and PFOA at the other locations.

Very few data exist for BPA in terrestrial animals. A recent review on BPA (Corrales et al, 2015) stated that the only terrestrial organisms for which field BPA accumulation data are available, is for the earthworm (*Eisenia fetida*). BPA in the referred study was measured in tissue from adult earthworms collected from sewage percolating beds and domestic gardens (Markman et al, 2007) and the levels (< 5 ng/g ww) were much lower than concentrations found in earthworm from Oslo area, the present study .

4.3 Fieldfare as prey

The risk assessment for predators ($RQ_{mix\text{-}pred}$) with fieldfare as an important prey was done using eggs as a substitute for chicks. Normal prey of the sparrowhawk would be fieldfare chicks (and adults), however fieldfare chicks were not sampled in this study.

Cadmium as evaluated with the highest risk for predators of earthworm in this year as well as last year's study, was only detected at low concentrations in the fieldfare samples. BPA with a rather high concentration in earthworm, and high risk ratio for predators of earthworm, was only found in one of the fieldfare samples, but at high levels. We therefore cannot rule out that BPA might pose a potential risk for fieldfare if BPA bioaccumulates. PFOS and PFOA were found to constitute a potential risk for predators of earthworm at some sampling locations, and PFOS was detected as one of the main pollutants in the fieldfare samples.

Table 58: Measured concentrations (MEC) in fieldfare egg samples from Maridalsvatnet (16/1998), Midstua (16/1999), Kjelsås (16/2000), Grorud (16/2001), Kvernerparken (16/2002), Ekebergsletta (16/2003), Bøler (16/2004), Skullerud (16/2005), Grønmo (16/2006), Grorud (16/2007). All concentrations are given as ng/g ww. PNECpred (ng/g ww) represents dietary predicted no effect concentrations for predators where fieldfare (egg) is a substantial part of diet.

MEC	Maridalsv	Midstua	Kjelsås	Grorud	Kvernerp.	Ekebergsl	Bøler	Skullerud	Grønmo	Grorud	$PNEC_{pred}$
PFOS	19.8	59.7	62.9	33.5	8.8	60.3	25.8	22.4	**601**	16.4	37
PFOA	0.5	0.9	1.7	0.6	0.2	2.0	0.5	0.4	3.1	0.2	0.9
PCB153	7.2	4.2	9.9	8.0	24.1	4.9	7.6	33.1	9.5	3.4	670
PentaBDE	5.7	1.9	7.0	1.7	1.7	0.9	6.6	2.4	4.1	1.0	1000
OctaBDE	1.2	0.6	1.8	0.2	0.5	0.3	1.2	1.9	1.2	0.3	6700
BPA	3.1	2.8	299	3.1	3.6	3.7	2.2	2.4	3.0	3.4	2670
HCB	4.7	1.7	5.2	2.5	2.2	6.6	3.9	4.0	2.2	3.5	16.7
D4							1.2	1.2			1700
D5	5.0	1.0			1.2	1.4	1.4	11.2			13000
D6					1.2	3.5	17.6	4.9	1.9		66700
SCCP			27	52					27	21	5500
MCCP	1.0	1.0			2.6					0.4	10000
Ni	47	3	6	6	8	5	13	7	7	5	8500
Cd	0.5	0.5			0.4						160
Pb	12.5	9.0	494	6.2	14.8	12.3	11.8	5.8	14.5	4.0	3600
Hg	10.5	15.7	9.0	4.1	12.7	7.0	8.8	8.0	16.2	11.4	400

As Table 59 shows, PFOS and PFOA revealed high risk quotient close and above 1, indicating risk to organisms feeding on fieldfare eggs and chicks. The extreme high BPA concentration found in one egg (299 ng/g ww) causes only a RQ of 0.11, three times lower than the RQ from HCB in this particular sample. In general is HCB the most relevant POP of the here estimated compounds, causing a RQ ranging from 0.1 to 0.39, more than ten times higher than PCB 153. In general, for a secondary predator preying on fieldfare, toxic metals only play a minor role in the overall RQ$_{mix}$ value.

Table 59: **Single RQpred** values of contaminants in fieldfare eggs. Predicted combined risk is given as Sum RQmix-pred for each site.

RQ Fieldfare	Maridalsv.	Midstua	Kjelsås	Grorud	Kvernerp.	Ekebergsl.	Bøler	Skullerud	Grønmo	Grorud
PFOS	**0.53**	**1.61**	**1.70**	**0.90**	0.24	**1.63**	**0.70**	**0.60**	**16.3**	0.44
PFOA	**0.55**	**1.02**	**1.86**	**0.65**	0.24	**2.17**	**0.61**	0.41	**3.40**	0.25
PCB153	1E-02	6E-03	1E-02	1E-02	4E-02	7E-03	1E-02	5E-02	1E-02	5E-03
PentaBDE	5.7E-03	1.9E-03	7.0E-03	1.7E-03	1.7E-03	8.7E-04	6.6E-03	2.4E-03	4.1E-03	9.7E-04
OctaBDE	1.9E-04	9.0E-05	2.6E-04	3.5E-05	8.0E-05	5.1E-05	1.7E-04	2.8E-04	1.7E-04	4.4E-05
BPA	1.2E-03	1.1E-03	0.11	1.2E-03	1.3E-03	1.4E-03	8.2E-04	9.0E-04	1.1E-03	1.3E-03
HCB	0.28	0.10	0.31	0.15	0.13	0.39	0.23	0.24	0.13	0.21
D4							7.1E-04	7.1E-04		
D5	3.8E-04	8.0E-05			9.1E-05	1.1E-04	1.1E-04	8.6E-04		
D6	7.1E-05				7.0E-05	7.3E-05	6.6E-05	1.8E-04		
SCCP			4.9E-03	9.5E-03					4.9E-03	3.8E-03
MCCP	1.0E-04	1.0E-04			2.6E-04					4.0E-05
Ni	6E-03	3E-04	7E-04	7E-04	1E-03	6E-04	1E-03	9E-04	9E-04	6E-04
Cd	3.1E-03	3.1E-03			2.7E-03					
Pb	3.5E-03	2.5E-03	1.4E-01	1.7E-03	4.1E-03	3.4E-03	3.3E-03	1.6E-03	4.0E-03	1.1E-03
Hg	0.026	0.039	0.022	0.010	0.032	0.017	0.022	0.020	0.040	0.028

Prediction of risk from mixture of contaminants in fieldfare as prey for the various individuals, given as sum of the respective RQ, RQ$_{mix\text{-}pred2}$:

Fieldfare	Maridalsv.	Midstua	Kjelsås	Grorud	Kvernerp.	Ekebergsl.	Bøler	Skullerud	Grønmo	Grorud
RQ$_{mix\text{-}pred2}$	**1.5**	**2.8**	**4.2**	**1.8**	**0.7**	**4.3**	**1.6**	**1.4**	**19.9**	**0.9**

RQ$_{mix\text{-}pred}$ for predators of fieldfare as substantial part of diet was above 1 in 80% of all cases, with one extreme individual showing an RQ$_{mix\text{-}pred}$ of almost 20 due to extreme PFOS concentrations. PFOS, PFOA and HCB contribute the most to the sum of the risk ratios for predators of fieldfare egg/chicks. Fieldfare chicks may be part of the diet of sparrowhawks and other birds of prey as well as mammals (cats, foxes). **The mean $RQ_{mix\text{-}pred2}$ was 3.9 with a median of 1.7, indicating potential risk for fieldfare preying species**. As our results revealed, metals are found in lower amounts in bird eggs compared to whole earthworm samples. Previous studies have also revealed that metals are found in higher concentrations in eggshell compared to egg contents (Mora et al. 2003; Zhou et al 2005). The risk for predators of fieldfare using egg content may therefore be underestimated with respect to metals if the predator eat juvenile bird or adult bird which has been feeding mainly on earthworm.

Unfortunately, we were not able to find PNECpred for DDT or the persistent metabolite DDE, which may have contributed to the risk evaluation for predators of earthworm and fieldfare. This might be due to the fact that DDT is metabolised fast to the more toxic DDE, and any feeding experiments will not be able to distinguish which compound is causing which effect.

The authors want to emphasize that the PNECpred values are meant to protect the most sensitive predators as part of the soil ecosystem and therefore the same PNECpred value are used for oral intake of earthworm as for intake of fieldfare (eggs); i.e. the same $PNEC_{pred}$ values are used to evaluate risk of mixtures for primary and secondary predators such as fieldfare and sparrowhawk, respectively.

We will also make a remark that the PNEC values (soil and for oral intake) used for this monitoring programme might change in the future, as a result of new experimental data and more thorough assessments. It is notable that we found a very low PNECpred value for PFOA, much lower than for PFOS, having a large impact on the RQmix results. This value is from a recently published paper in 2016 and not from risk assessment reports produced by EU or EEA.

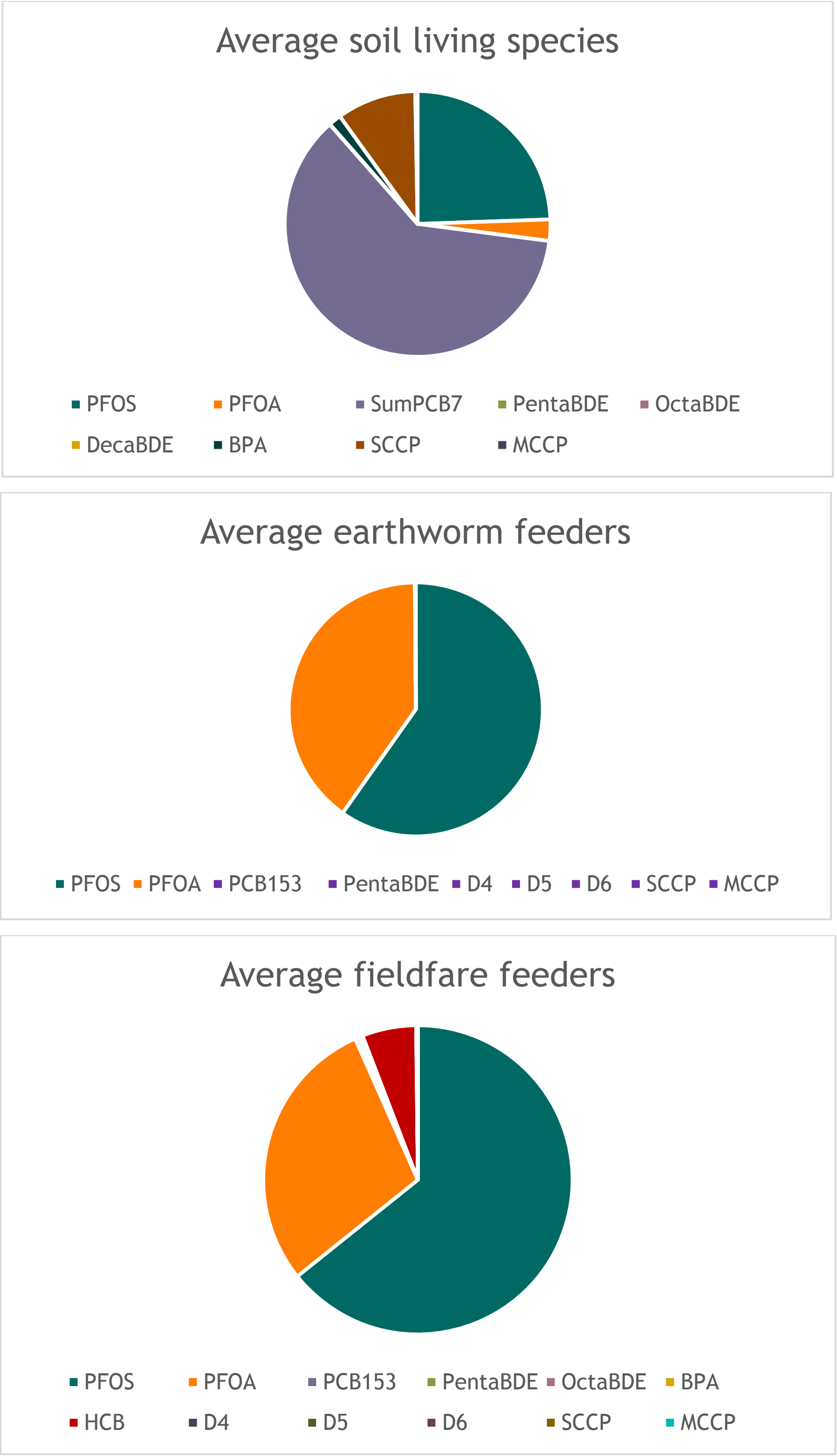


Figure 73: Comparison of the relative RQmix contribution for organisms living in soil, feeding on worms and feeding on fieldfare

When comparing the relative influence of organic pollutants on the overall risk to the consuming organism (Figure 73), it seems that PFOS and PFOA increase in their impact on the overall risk with increasing trophic level, while PCBs and CPs impact on the risk to the consumer diminishes due to relatively low concentrations observed in the predating organisms.

5. Conclusions and Recommendations

The concentration of the various contaminant group in the investigated species was as follows (on a wet weight basis):

- Air : SumSiloxanes >> SumOPFRs >> SumCPs
- Soil : SumToxic metals >> SumCPs > SumPFAS
- Earthworms : SumToxic metals >SumPhenols > SumPFAS
- Fieldfare : SumPesticides > SumPFAS > SumToxic metals
- Sparrowhawk: SumPesticides > SumPCBs > SumToxic metals
- Tawny owl : SumPesticides > SumPCBs > SumCPs
- Red fox : Sum Rodenticides > SumToxic metals > SumCPs
- Brown rat : SumToxic metals >> SumPFAS > SumPhenols

Of all the organisms and tissues measured in the study, earthworms showed the highest average concentration of organic pollutants measured, followed by sparrowhawk and tawny owl. This is comparable to last year's findings. When only focusing on the toxic metals mercury, cadmium, lead and arsenic, soil was the most contaminated compartment followed by worm and rats.

An estimation of the trophic magnification was carried out for the foodchain:

soil - earthworm - fieldfare - sparrowhawk

In order to assess the bioaccumulation potential, trophic magnification factors (TMF) were calculated. The TMF calculations indicated trophic biomagnification for PCBs, PBDEs, and PFOS in decreasing order. These calculations should be extend to cover more compounds.

The cumulative risk of contaminants for soil living organisms and predators was evaluated with a first tier conservative concentration addition (CA) approach using predicted no effect concentration for soil living organisms ($PNEC_{soil}$) and predators ($PNEC_{pred}$) as reference values. The RQmix-soil, describing the cumulative risk for soil-living organisms, ranged between 14 and 52, and was far above the threshold of 1 in all locations, indicating potential risk. The compounds contributing most to the risk quotient were first and foremost the metals, followed by PFOS and PCB7. The earthworms from the five sampled sites in Oslo area showed an RQmix-pred ranging between 6 and 43, indicating a risk for predators with earthworm as an important food item in all five locations. The compounds contributing most to the sum were cadmium, PFOS and PFOA. Fieldfare eggs showed an average RQmix-pred of 3.9 for secondary predators, mostly caused by PFOS, PFOA and HCB.

A successful campaign for collecting sparrowhawk egg was conducted in 2014, 2015, and 2016. It shows high levels of pollutants, and shows eggshell thinning compared to pre-DDT levels. We recommend to carry on using this species as a true trophic level 4 reperesentative for long-term studies.

For the first time, air samples were added to the campaign, enabling the assessment of sources to the urban environment in comparison with long-range transported pollutant loads. Since PFAS and phenolic compounds play an important role in the overall urban contamination situation, new emerging PFAS as well as phenols are recommended to be included in the analytical portfolio. Sampling is recommended to occur in a short time period, at the same location, and similar types of sample matrix should be collected. We also recommend to increase the sites for airsampling to allow a more detailed assessment of local versus long-range transported compounds. Further we suggest the addition of the discontinued airport Fornebu and local firefighting stations in Oslo as additional potential pointsources for PFAS. We also need to closer examine the reasons of the elevated PFOS findings at Alnabru and Grorud as well as the high siloxane findings at Slottsparken.

The following findings should have particular attention and should also be followed up in future campaigns:

- Alnabru is an industrialised site, showing a different pollution pattern and markedly higher levels of PFAS (PFOS, PFHxS and PFBS) and DBDPE in earthworm compared to the other locations sampled
- Biomagnification through trophic levels of chlorinated and brominated pollutants is prominent
- DBBPE concentrations was six times higher than SumPBDE in tawny owl, opposite to all other species
- OPFR in air was measured for the first time in Oslo, and more sampling stations should be established
- S/MCCPs and cyclic siloxanes play an important role as air pollutants in Oslo
- Earthworms ingest pollutants directly from the soil, making pollutants bioavailable
- Fieldfare eggs act as an important matrix to detect pollution hotspots on local/regional scale (as the Oslo city region) due to their fast adaption to their habitat
- RQmix is mostly affected by toxic metals and single organic pollutants.

By keeping and building on this monitoring scheme, we can expect to follow the trends in time of pollutant levels in biota in the Oslo region, and identify hotspots where mitigation and management measures can be implemented.

6. Acknowledgements

We are grateful for all help from many participants in the project and a special thanks goes to:

Erik Framstad, Nina Eide, Aniko Hildebrand, Norwegian Institute for Nature Research (NINA), prepared the samples before analysis. Tawny owl eggs collected by by Fredrik Gustavsen og Neri Horntvedt Thorsen, (NMBU). The nests were located in nest boxes installed by Arnkjell Johansen, Vestby, who is a local contact for Statens naturoppsyn (SNO). Eric Roualet (Oslo), collected sparrowhawk eggs.

Ingar Johansen (IFE), responsible for stable isotope analysis.

Arntraut Götsch, Linda Hanssen, Silje Winnem, Vladimir Nikiforov, Mikael Harju, Nicholas Warner, Silja Sletten, Pawel Rostkowski, Anders Borgen, Hilde T. Uggerud, Anne Karine Halse, Norwegian Institute for Air Research (NILU) did the chemical analyses.

7. References

Aas, C.B., Fuglei, E., Herzke, D., Yoccoz, N.G., Routti, H. (2014) Effect of body condition on tissue distribution of perfluoroalkyl substances (PFASs) in Arctic fox (Vulpes lagopus). *Environ. Sci. Technol., 48,* 11654-11661.

Ahrens, L., Shoeib, M., Del Vento, S., Codling, G., & Halsall, C. (2011). Polyfluoroalkyl compounds in the Canadian Arctic atmosphere. *Environmental Chemistry*, 8(4), 399-406.

Ahrens, L., Harner, T., Shoeib, M., Koblizkova, M., & Reiner, E. J. (2013). Characterization of two passive air samplers for per-and polyfluoroalkyl substances. Environmental science & technology, 47(24), 14024-14033.

Altenburger, R., Arrhenius, Å., Backhaus, T., Coors, A., Faust, M., Zitzkat, D. (2014) Ecotoxicological combined effects from chemical mixtures. Part 1: Relevance and adequate consideration in environmental risk assessment of plant protection products and biocides. Dessau-Roßlau, Umweltbundesamt (Texte, 92/2013). URL: http://www.umweltbundesamt.de/publikationen/ecotoxicological-combined-effects-from-chemical [Accessed 15 October 2014].

AMAP (2009) Arctic pollution 2009. Oslo, Arctic Monitoring and Assessment Programme.

AMAP Assessment 2015: Temporal Trends in Persistent Organic Pollutants in the Arctic. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. vi+71pp

Andersen, S., Gudbrandsen, M., Haugstad, K., Hartnik, T. (2012) Some environmentally harmful substances in sewage sludge - occurrence and environmental risk. Oslo, Norwegian Climate and Pollution Agency (TA-3005/2012). (In Norwegian).

Andersen, M.S., Fuglie, E., Konig, M., Lipasti, I., Pedersen, A.O., Polder, A., Yoccoz, N. G., Routti, H. (2015) Levels and temporal trends of persistent organic pollutants (POPs) in arctic foxes (Vulpes lagopus) from Svalbard in relation to dietary habits and food availability. *Sci. Total Environ., 511*, 112-122.

Aston, L. S., & Seiber, J. N. (1996). Methods for the comparative analysis of organophosphate residues in four compartments of needles of Pinus ponderosa. Journal of agricultural and food chemistry, 44(9), 2728-2735.

Backhaus, T., Faust, M. (2012) Predictive environmental risk assessment of chemical mixtures: A conceptual framework. *Environ. Sci. Technol., 46*, 2564-2573.

Backhaus, T., Karlsson, M. (2014) Screening concentration mixture risk assessment of pharmaceuticals in STP effluents. *Water Res., 49,* 157-165.

Bakken, V., Runde, O., Tjørve, E. (2006) Norsk ringmerkingsatlas. Stavanger, Stavanger museum.

Barber, J.L., Berger, U., Chaemfa, C., Huber, S., Jahnke, A., Temme, C., Jones, K.C. (2007) Analysis of per- and polyfluorinated alkyl substances in air samples from Northwest Europe. *J. Environ. Monit., 9*, 530-541.

Barceló, D., & Petrovic, M. (2007). Pharmaceuticals and personal care products (PPCPs) in the environment. Analytical and bioanalytical chemistry, 387(4), 1141-1142.

Barr JF (1986) Population dynamics of the common loon (Gavia immer) associated with mercury-contaminated waters in northwestern Ontario. Occ. Paper 56, Can. Wildl. Serv., Ottawa, ON, Canada

Bayen, S., Obbard, J.P., Thomas, G.O. (2006) Chlorinated paraffins: A review of analysis and environmental occurrence. *Environ. Int., 32,* 915-929.

Beach S.A., Newsted J.L., Coady K., Giesy J.P. (2006) Ecotoxicological evaluation of perfluorooctanesulfonate (PFOS). *Rev. Environ. Contam. Toxicol., 186*, 133–174.

Bennie, D.T., Sullivan, C.A., Maguire, R.J. (2000) Occurrence of chlorinated paraffins in beluga whales (Delphinapterus leucas) from the St. Lawrence River and rainbow trout (Oncorhynchus mykiss) and carp (Cyprinus carpio) from Lake Ontario. *Water Qual. Res. J. Can., 35,* 263-281.

Bennington, A. (1971) The decline of the sparrowhawk Accipiter nisus in Northern Ireland. *Irish Nat. J., 17*, 85-88.

Bohlin-Nizzetto, P.B., Aas, W., Warner, N. (2015) Monitoring of environmental contaminants in air and precipitation, annual report 2014. Kjeller, NILU (Miljødirektoratet rapport, M-368/2015) (NILU OR, 19/2015)

Bohlin-Nizzetto, P. B; Aas, W. (2016). Monitoring of environmental contaminants in air and precipitation, annual report 2015 (Norwegian Environment Agency report, M-579/2016) (NILU report, 14/2016). Kjeller: NILU.

Bollmann, U. E., Möller, A., Xie, Z., Ebinghaus, R., & Einax, J. W. (2012). Occurrence and fate of organophosphorus flame retardants and plasticizers in coastal and marine surface waters. Water research, 46(2), 531-538.

Borgen, A.R., Schlabach, M., Mariussen, E. (2003) Screening of chlorinated paraffins in Norway. *Organohalogen Compd., 60,* 331–334.

Borgå, K., Kidd, K.A., Muir, D.C.G., Berglund, O., Conder, J.M., Gobas, F.A.P.C., Kucklick, J., Malm, O., Powell, D.E. (2012) Trophic magnification factors: Considerations of ecology, ecosystems, and study design. *Integrated Environ. Assess. Manag.*, *8*, 64-84.

Buck, R. C., Franklin, J., Berger, U., Conder, J. M., Cousins, I. T., De Voogt, P., ... & van Leeuwen, S. P. (2011). Perfluoroalkyl and polyfluoroalkyl substances in the environment: terminology, classification, and origins. Integrated environmental assessment and management, 7(4), 513-541.

Burgers, J., Opdam, P., Müskens, G., de Ruiter, E. (1986) Residue levels of DDE in eggs of Dutch Sparrowhawks Accipiter nisus Following the ban on DDT. *Environ. Pollut. Ser. B., 11,* 29-40.

Bustnes, J.O.,Yoccoz N.G., Bangjord, G., Herzke, D., Ahrens, L. and Skaare J.U. (2011) Impacts of Climate and Feeding Conditions on the Annual Accumulation (1986–2009) of Persistent

Organic Pollutants in a Terrestrial Raptor. Environ Sci & Techn 45 (17), 7542-7547. DOI: 10.1021/es201786x

Bustnes, J.O., Bardsen, B.J., Herzke, D., Johnsen, T.V., Eulaers, I., Ballesteros, M., Hanssen, S.A., Covaci, A., Jaspers, V.L.B., Eens, M., Sonne, C., Halley, D., Moum, T., Nost, T.H., Erikstad, K.E., Ims, R.A. (2013) Plasma concentrations of organohalogenated pollutants in predatory bird nestlings: Associations to growth rate and dietary tracers. *Environ. Toxicol. Chem., 32*, 2520-2527.

Butt, C.M., Berger, U., Bossi, R., Tomy, G.T. (2010) Levels and trends of poly- and perfluorinated compounds in the arctic environment. *Sci. Total Environ., 408*, 2936-2965.

Bühler, U., Norheim, U. (1981) The mercury content in feathers of the Sparrowhawk Accipiter nisus in Norway. *Fauna Norv. Ser. C, Cinclus, 5*, 43-46.

Cao, Z., Xu, F., Covaci, A., Wu, M., Wang, H., Yu, G., ... & Wang, X. (2014). Distribution patterns of brominated, chlorinated, and phosphorus flame retardants with particle size in indoor and outdoor dust and implications for human exposure. Environmental science & technology, 48(15), 8839-8846.

Carvalho, M. C., Nazari, E. M., Farina, M., & Muller, Y. M. (2008) Behavioral, morphological, and biochemical changes after in ovo exposure to methylmercury in chicks. *Toxicol. Sci., 106,* 180-185.

Christen, V., Zucchi, S., & Fent, K. (2011). Effects of the UV-filter 2-ethyl-hexyl-4-trimethoxycinnamate (EHMC) on expression of genes involved in hormonal pathways in fathead minnows (Pimephales promelas) and link to vitellogenin induction and histology. Aquatic toxicology, 102(3), 167-176.

Clark, E. (2000) Sulfolane and Sulfones. In: *Kirk-Othmer Encyclopedia of Chemical Technology*. John Wiley and Sons.

Ciccioli, P., Cecinato, A., Brancaleoni, E., Montagnoli, M., & Allegrini, I. (1994) Chemical composition of particulate organic matter (POM) collected at Terra Nova Bay in Antarctica. *Int. J. Environ. Aanal. Chem., 55,* 47-59.

COHIBA (2012) Summary report SWEDEN - Work package 4: Identification of sources and estimation of inputs/impacts on the Baltic Sea. URL: http://www.cohiba-project.net/publications/en_GB/publications/_files/87106105533662778/default/WP4_National_Summary_Report_Sweden_FINALrevised.pdf

Companioni-Damas, E. Y., Santos, F. J., & Galceran, M. T. (2012). Analysis of linear and cyclic methylsiloxanes in water by headspace-solid phase microextraction and gas chromatography-mass spectrometry. Talanta, 89, 63-69.

Connell, D.W., Miller, G.J. (1984) Chemistry and ecotoxicology of pollution. New York, John Wiley & Sons.

Cooke, A.S. (1979) Changes in egg shell characteristics of the Sparrowhawk Accipiter nisus and Peregrine Falco peregrinus associated with exposure to environmantal pollutanrs during recent decades. *J. Zool. Lond., 187,* 245-263.

Corrales, J., Kristofco, L.A., Steele, W.B., Yates, B.S., Breed, C.S., Williams, E.S., Brooks, B.W. (2015) Global Assessment of Bisphenol A in the Environment: Review and Analysis of Its Occurrence and Bioaccumulation. *Dose-Response, 13,* 1559325815598308. doi:10.1177/1559325815598308.

Darnerud, P.O. (2003) Toxic effects of brominated flame retardants in man and in wildlife. *Environ. Int., 29,* 841-853.

DeNiro, M.J., Epstein, S. (1978) Influence of diet on the distribution of carbon isotopes in animals. *Geochim. Cosmochim. Acta, 42,* 495-506.

Depledge, M.H., Weeks, J.M., Bjerregaard, P. (1998) Heavy metals. In: *Handbook of ecotoxicology*. Ed. by: Calow, P. Oxford, Blackwell Publishing. pp. 543-569.

de Wit, C.A., Herzke, D., Vorkamp, K. (2010) Brominated flame retardants in the Arctic environment - trends and new candidates. *Sci. Total Environ., 408*, 2885-2918.

Dip, R., Stieger, C., Deplazes, P., Hegglin, D., Muller, U., Dafflon, O., Koch, H., Naegeli, H. (2001) Comparison of heavy metal concentrations in tissues of red foxes from adjacent urban, suburban, and rural areas. *Arch. Environ. Contam. Toxicol., 40,* 551-556.

Doucett, R.R., Hooper, W., Power, G. (1999) Identification of anadromous and nonanadromous adult brook trout and their progeny in the Tabusintac River, New Brunswick, by means of multiple-stable-isotope analysis. *Trans. Am. Fish. Soc., 128,* 278-288.

Eason, C. T., Murphy, E. C., Wright, G. R., & Spurr, E. B. (2002) Assessment of risks of brodifacoum to non-target birds and mammals in New Zealand. *Ecotoxicol., 11,* 35-48.

ECHA (2008) Guidance on information requirements and chemical safety assessment. Chapter R.10: Characterisation of dose (concentration)-response for environment. Helsinki, European Chemicals Agency. URL: http://echa.europa.eu/web/guest/guidance-documents/guidance-on-information-requirements-and-chemical-safety-assessment [Accessed 15 October 2014].

Eens, M., Jaspers, V.L.B., Van den Steen, E., Bateson, M., Carere, C., Clergeau, P., Costantini, D., Dolenec, Z., Elliott, J.E., Flux, J., Gwinner, H., Halbrook, R.S., Heeb, P., Mazgajski, T.D., Moksnes, A., Polo, V., Soler, J.J., Sinclair, R., Veiga, J.P., Williams, T.D., Covaci, A., Pinxten, R. (2013) Can starling eggs be useful as a biomonitoring tool to study organohalogenated contaminants on a worldwide scale? *Environ. Int., 51*, 141-149.

Ehrhardt, M., Bouchertall, F., & Hopf, H. P. (1982) Aromatic ketones concentrated from Baltic Sea water. *Mar. Chem., 11,* 449-461.

Elmeros, M., Topping, C.J., Christensn, T.K., Bossi, R. (2015) Spredning af anti-koagulante rodenticider med mus og eksponeringsrisiko for rovdyr. København, Miljøstyrelsen (Bekæmpelsesmiddelforskning, nr. 159).

Evers, D.C., Clair, T.A. (2005) Mercury in northeastern North America: A synthesis of existing databases. *Ecotoxicology, 14*, 7-14.

Fent, K., Zenker, A., & Rapp, M. (2010) Widespread occurrence of estrogenic UV-filters in aquatic ecosystems in Switzerland. *Environ. Pollut., 158,* 1817-1824.

Fent, K., Kunz, P. Y., & Gomez, E. (2008). UV filters in the aquatic environment induce hormonal effects and affect fertility and reproduction in fish. CHIMIA International Journal for Chemistry, 62(5), 368-375.Fromme, H., Küchler, T., Otto, T., Pilz, K., Müller, J., & Wenzel, A. (2002) Occurrence of phthalates and bisphenol A and F in the environment. *Water Res., 36,* 1429-1438.

Fiege, H., Voges, H.-W., Hamamoto, T., Umemura, S., Iwata, T., Miki, H., Fujita, Y., Buysch, H.-J., Garbe, D. & Paulus, W. (2000) Phenol Derivatives. In: *Ullmann's Encyclopedia of Industrial Chemistry*. Wiley-VCH Verlag.

Fimreite, N., Holsworth, W.N., Keith, J., Pearce, P.A., Gruchy, I.M. (1971) Mercury in Fish and Fish-eating Birds near Sites of Industrial Contamination in Canada. *The Canadian field-naturalist, 85,* 211-220.

Fromme, H., Küchler, T., Otto, T., Pilz, K., Müller, J., & Wenzel, A. (2002). Occurrence of phthalates and bisphenol A and F in the environment. Water research, 36(6), 1429-1438.

Frøslie, A., Holt, G., Norheim , G. (1986) Mercury and persistent chlorinated hydrocarbons in owls Strigiformes and birds of prey Falconiformes collected in Norway during the period 1965-1983. *Environ. Pollut. Ser. B, 11*, 91-108.

Furness, R.W. (1996) Cadmium in birds. In: *Environmental Contaminants in Wildlife, Interpreting Tissue Concentrations*. Ed. by: Beyer, W.N., Heinz, G.H., Redmon-Norwood, A.W. Boca Raton, Lewis Pub (SETAC special publication series). pp. 389-404.

Gai, N., Pan, J., Tang, H., Chen, S., Chen, D.Z., Zhu, X.H., Lu, G.H., Yang, Y.L. (2014) Organochlorine pesticides and polychlorinated biphenyls in surface soils from Ruoergai high altitude prairie, east edge of Qinghai-Tibet Plateau. *Sci. Total Environ., 478*, 90-97.

Gebbink, W.A., Letcher, R.J. (2012) Comparative tissue and body compartment accumulation and maternal transfer to eggs of perfluoroalkyl sulfonates and carboxylates in Great Lakes herring gulls. *Environ. Pollut., 162,* 40-47.

Gebbink, W.A., Letcher, R.J., Hebert, C.E., Weseloh, D.V.C. (2011) Twenty years of temporal change in perfluoroalkyl sulfonate and carboxylate contaminants in herring gull eggs from the Laurentian Great Lakes. *J. Environ. Monit., 13*, 3365-3372.

Geiss, S., Einax, J.W., Scott, S.P. (2010) Determination of the sum of short chain polychlorinated n-alkanes with a chlorine content of between 49 and 67% in water by GC-ECNI-MS and quantification by multiple linear regression. *Clean - Soil Air Water, 38,* 57-76.

Genualdi, S., Harner, T., Cheng, Y., MacLeod, M., Hansen, K. M., van Egmond, R., ... & Lee, S. C. (2011). Global distribution of linear and cyclic volatile methyl siloxanes in air. Environmental science & technology, 45(8), 3349-3354.

Giusti, L. (2011). Heavy metals in urban soils of Bristol (UK). Initial screening for contaminated land. *Journal of Soils and Sediments*, *11*(8), 1385-1398.

Guerra, P., Fernie, K., Jiménez, B., Pacepavicius, G., Shen, L., Reiner, E., ... & Alaee, M. (2011). Dechlorane Plus and related compounds in peregrine falcon (Falco peregrinus) eggs from Canada and Spain. Environmental science & technology, 45(4), 1284-1290.

Haftorn, S. (1971) Norges fugler. Oslo, Universitetsforlaget.

Hagen, Y. (1952) Rovfuglene og viltpleien. Oslo, Universitetsforlaget.

Hagenaars, A., Knapen, D., Meyer, J., van der Ven, K., De Coen, W. (2008) Toxicity evaluation of perfluorooctane sulfonate (PFOS) in common carp (Cyprinus carpio): A systems biology approach. *Comp. Biochem. Physiol. Mol. Integr. Physiol., 150*, S43.

Halldin, K. (2005). Impact of endocrine disrupting chemicals on reproduction in Japanese quail. Domestic animal endocrinology, 29(2), 420-429.

Hallanger, I.G., Warner, N.A., Ruus, A., Evenset, A., Christensen, G., Herzke, D., Gabrielsen, G.W., Borgå, K. (2011) Seasonality in contaminant accumulation in Arctic marine pelagic food webs using trophic magnification factor as a measure of bioaccumulation. *Environ. Toxicol. Chem., 30*, 1026–1035.

Hallanger, I.G., Sagerup, K., Evenset, A., Kovacs, K.M., Leonards, P., Fuglei, E., Routti, H., Aars, J., Strom, H., Lydersen, C., Gabrielsen, G.W. (2015) Organophosphorous flame retardants in biota from Svalbard, Norway. *Mar. Pollut. Bull., 101*, 442-447.

Halldorsson, T.I., Rytter, D., Haug, L.S., Bech, B.H., Danielsen, I., Becher, G., Henriksen, T.B., Olsen, S.F. (2012) Prenatal exposure to perfluorooctanoate and risk of overweight at 20 years of age: A prospective cohort study. *Environ. Health Perspect., 120*, 668-673.

Hargreaves, A.L., Whiteside, D.P., Gilchrist, G. (2011) Concentrations of 17 elements, including mercury, in the tissues, food and abiotic environment of Arctic shorebirds. *Sci. Total Environ., 409*, 3757-3770.

Hearn, L. K., Kennedy, K., Hawker, D. W., Toms, L. M. L., Alberts, V., & Mueller, J. F. (2012). Spatial mapping of city-wide PBDE levels using an exponential decay model. Journal of Environmental Monitoring, 14(2), 643-650.

Heikens, A., Peijnenburg, W.J.G.M., Hendriks, A.J. (2001) Bioaccumulation of heavy metals in terrestrial invertebrates. *Environ. Pollut., 113*, 385-393.

Heinz, G. H. (1979). Methylmercury: reproductive and behavioral effects on three generations of mallard ducks. *The Journal of Wildlife Management*, 394-401.

Heinz, G. H., & Hoffman, D. J. (2003). Embryotoxic thresholds of mercury: estimates from individual mallard eggs. *Archives of Environmental Contamination and Toxicology, 44*(2), 0257-0264.

Helgason, L.B., Polder, A., Føreid, S., Bæk, K., Lie, E., Gabrielsen, G.W., Barrett, R.T., Skaare, J.U. (2009) Levels and temporal trends (1983-2003) of polybrominated diphenyl ethers

(PBDEs) and hexabromocyclododecane (HBCD) in seabird eggs from Northern Norway. *Environ. Toxicol. Chem., 28,* 1096-1103.

Henny, C. J., Hill, E. F., Hoffman, D. J., Spalding, M. G., & Grove, R. A. (2002). Nineteenth century mercury: hazard to wading birds and cormorants of the Carson River, Nevada. Ecotoxicology, 11(4), 213-231.

Hermanson, M. H., Isaksson, E., Teixeira, C., Muir, D. C., Compher, K. M., Li, Y. F., Igarashi, M. & Kamiyama, K. (2005). Current-use and legacy pesticide history in the Austfonna ice cap, Svalbard, Norway. *Environ. Sci. Technol., 39,* 8163-8169.

Herzke, D., Berger, U., Kallenborn, R., Nygård, T., & Vetter, W. (2005) Brominated flame retardants and other organobromines in Norwegian predatory bird eggs. *Chemosphere*, *61*, 441-449.

Herzke, D.; Vestergen, R., Wang, T. (2014b) Perfluorinated Acids (PFAAs) emitted by pointsources into the Norwegian Environment- Two Case Studies: public airports and a small town; SETAC proceedings, SETAC Europe 2014

Herzke, D., Nygård, T., Heimstad, E.S., Uggerud, H. (2015) Environmental pollutants in the terrestrial and urban environment, 2014. Kjeller, NILU. (Norwegian Environment Agency report, M-354|2015. (NILU OR, 24/2015).

Herzke, D., Nygård, T., Heimstad, E.S., Uggerud, H. (2016) Environmental pollutants in the terrestrial and urban environment, 2015. Kjeller, NILU. (Norwegian Environment Agency report M-570|2016.(NILU report 27/2016)

Hesslein, R. H., Capel, M. J., Fox, D. E., & Hallard, K. A. (1991) Stable isotopes of sulfur, carbon, and nitrogen as indicators of trophic level and fish migration in the lower Mackenzie River basin, Canada. Canadian *J. Fish. Aquat. Sci., 48,* 2258-2265.

Hobson, K.A., Sealy, S.G. (1991) Marine protein contributions to the diet of northern saw-whet owls on the Queen Charlotte Islands: A stable-isotope approach. *The Auk, 108,* 437-440.

Holt, G., Sakshaug, J. (1968) Organochlorine insecticide residues in wild birds in Norway 1965-1967. *Nord. Vet. Met. 20,* 685-695.

Huber, S., Warner, N. A., Nygård, T., Remberger, M., Harju, M., Uggerud, H. T., .& Hanssen, L. (2015) A broad cocktail of environmental pollutants found in eggs of three seabird species from remote colonies in Norway. *Environ. Toxicol. Chem., 34,* 1296-1308.

Hui, D. (2012) Food web: concept and applications. *Nature Educ. Knowl., 3,* 6.

Iozza, S., Schmid, P., & Oehme, M. (2009) Development of a comprehensive analytical method for the determination of chlorinated paraffins in spruce needles applied in passive air sampling. *Environ. Pollut., 157,* 3218-3224.

Jahnke, A., Ahrens, L., Ebinghaus, R., Temme, C. (2007) Urban versus remote air concentrations of fluorotelomer alcohols and other polyfluorinated alkyl substances in Germany. *Environ. Sci. Technol., 41*, 745-752.

Kannan, K., Tao, L., Sinclair, E., Pastva, S.D., Jude, D.J., Giesy, J.P. (2005) Perfluorinated compounds in aquatic organisms at various trophic levels in a Great Lakes food chain. *Arch. Environ. Contam. Toxicol., 48*, 559-566.

Kelly, B.C., Ikonomou, M.G., Blair, J.D., Surridge, B., Hoover, D., Grace, R., Gobas, F.A.P.C. (2009) Perfluoroalkyl contaminants in an Arctic marine food web: Trophic magnification and wildlife exposure. *Environ. Sci. Technol., 43*, 4037-4043.

KEMI (2013) Hazardous chemicals in textiles – report of a government assignment. Bromma, Swedish Chemical Agency (Report, 3/13).

Kennette, D., Hendershot, W., Tomlin, A., Sauve, S. (2002) Uptake of trace metals by the earthworm Lumbricus terrestris L. in urban contaminated soils. *Appl. Soil Ecol., 19*, 191-198.

Kidd, K.A., Schindler, D.W., Hesslein, R.H., Muir, D.C.G. (1995) Correlation between stable nitrogen isotope ratios and concentrations of organochlorines in biota from a fresh-water food-web. *Sci. Tot. Environ., 160-61*, 381-390.

Kierkegaard, A., van Egmond, R., & McLachlan, M. S. (2011). Cyclic volatile methylsiloxane bioaccumulation in flounder and ragworm in the Humber Estuary. Environmental science & technology, 45(14), 5936-5942.

Kierkegaard, A., Bignert, A., & McLachlan, M. S. (2013). Cyclic volatile methylsiloxanes in fish from the Baltic Sea. Chemosphere, 93(5), 774-778.

Klaassen, C.D. ed. (2008) Casarett and Doull's toxicology: The basic science of poisons. 7th ed. New York, McGraw-Hill.

Kortenkamp, A., Martin, O., Evans, R., Faust, M., Backhaus, T. (2014) Risk of combination effects between decabromodiphenyl ether and other polybrominated diphenyl ethers. Oslo, Norwegian Environment Agency (Report, M-223/2014).

Krogseth, I.S., Kierkegaard, A., McLachlan, M.S., Breivik, K., Hansen, K.M., Schlabach, M. (2013) Occurrence and seasonality of cyclic volatile methyl siloxanes in Arctic air. *Environ. Sci. Technol., 47*, 502–50.

Kumar, S., Sharma, V., Bhoyar, R. V., Bhattacharyya, J. K., & Chakrabarti, T. (2008). Effect of heavy metals on earthworm activities during vermicomposting of municipal solid waste. Water Environment Research, 80(2), 154-161.

Kunz, P. Y., & Fent, K. (2006) Multiple hormonal activities of UV filters and comparison of in vivo and in vitro estrogenic activity of ethyl-4-aminobenzoate in fish. *Aquat. Toxicol. 79,* 305-324.

Kwak, T. J., & Zedler, J. B. (1997) Food web analysis of southern California coastal wetlands using multiple stable isotopes. *Oecologia, 110,* 262-277.

Laakso S., Suomalainen K. & Koivisto S. (2010) Literature Review on Residues of Anticoagulant Rodenticides in Non-Target Animals. Copenhagen, Nordic Council of Ministers (TemaNord 2010:541).

Langford, K. H., Reid, M. J., Fjeld, E., Øxnevad, S., & Thomas, K. V. (2015). Environmental occurrence and risk of organic UV filters and stabilizers in multiple matrices in Norway. *Environ. Int., 80,* 1-7.

Langford, K. H., Reid, M., & Thomas, K. V. (2013) The occurrence of second generation anticoagulant rodenticides in non-target raptor species in Norway. *Sci. Total Environ.,* 450, 205-208.

Langford, K. H., & Thomas, K. V. (2008) Inputs of chemicals from recreational activities into the Norwegian coastal zone. *J. Environ. Monit., 10,* 894-898.

Latif, R., Malek, M., Mirmonsef, H. (2013) Cadmium and lead accumulation in three endogeic earthworm species. *Bull. Environ. Contam. Toxicol., 90,* 456-459.

Law, R.J., Covaci, A., Harrad, S., Herzke, D., Abdallah, M.A.E., Femie, K., Toms, L.M.L., Takigami, H. (2014) Levels and trends of PBDEs and HBCDs in the global environment: Status at the end of 2012. *Environ. Int., 65,* 147-158.

Lee, S., Kim, S., Park, J., Kim, H.-J., Jae Lee, J., Choi, G., Choi, S., Kim, S., Young Kim, S., Choi, K., Kim, S., & Moon, H.-B. (2015) Synthetic musk compounds and benzotriazole ultraviolet stabilizers in breast milk: Occurrence, time–course variation and infant health risk. *Environ. Res., 140,* 466-473.

Liao, C., Liu, F. & Kannan, K. (2012) Bisphenol s, a new bisphenol analogue, in paper products and currency bills and its association with bisphenol a residues. *Environ. Sci. Technol., 46,* 6515-22.

Lindén, H., Nygård, T. & Wikman, M. 1984. On the eggshell thickness and reproduction of the Peregrine Falcon Falco peregrinus in Finland. *Orn. Fenn., 61,* 116-120.

Lock, K., Janssen, C.R. (2001) Zinc and cadmium body burdens in terrestrial oligochaetes: Use and significance in environmental risk assessment. *Environ. Toxicol. Chem., 20,* 2067-2072.

Lott, C. A., Meehan, T. D., & Heath, J. A. (2003) Estimating the latitudinal origins of migratory birds using hydrogen and sulfur stable isotopes in feathers: influence of marine prey base. *Oecologia, 134,* 505-510.

Loyo-Rosales, J. E., Rice, C. P., & Torrents, A. (2007) Fate of octyl-and nonylphenol ethoxylates and some carboxylated derivatives in three American wastewater treatment plants. *Environ. Sci. Technol., 41,* 6815-6821.

Lukkari, T., Taasvitsainen, M., Väisänen, A., Haimi, J. (2004) Effects of heavy metals on earthworms along contamination gradients in organic rich soils. *Ecotoxicol. Environ. Saf., 59,* 340-348.

Lundholm, C. E. (1997). DDE-induced eggshell thinning in birds: effects of p, p′-DDE on the calcium and prostaglandin metabolism of the eggshell gland. Comparative Biochemistry and Physiology Part C: Pharmacology, Toxicology and Endocrinology, 118(2), 113-128.

Luo, X. S., Ding, J., Xu, B., Wang, Y. J., Li, H. B., & Yu, S. (2012). Incorporating bioaccessibility into human health risk assessments of heavy metals in urban park soils. *Science of the Total Environment*, *424*, 88-96.

Lucia, M., Gabrielsen, G. W., Herzke, D., & Christensen, G. (2016). Screening of UV chemicals, bisphenols and siloxanes in the Arctic. Norsk POlarinstitutt M-number:M-598|2016

MacAvoy, S. E., Macko, S. A., McIninch, S. P., & Garman, G. C. (2000) Marine nutrient contributions to freshwater apex predators. *Oecologia, 122,* 568-573.

Macdonald, D.W. (1983) Predation on earthworms by terrestrial vertebrates. In: *Earthworm ecology. From Darwin to vermiculture*. Ed. by: Satchell, J.E. London, Chapman and Hall. pp. 393-414.

Marklund, A., Andersson, B., P. Haglund, P. (2005) Organophosphorus flame retardants and plasticizers in air from various indoor environments. *J. Environ. Monit., 7,* 814–819

Markman, S., Guschina, I.A., Barnsley, S., Buchanan, K.L., Pascoe, D., Müller, C.T. (2007) Endocrine disrupting chemicals accumulate in earthworms exposed to sewage effluent. *Chemosphere, 70,* 119–125

Mateo, R., Milian, J., Rodriguez-Estival, J., Camarero, P. R., Palomares, F., Ortiz-Santaliestra, M. E. (2012) Levels of organochlorine pesticides and polychlorinated biphenyls in the critically endangered Iberian lynx and other sympatric carnivores in Spain. *Chemosphere, 86*, 691-700.

Mayfield D.B., Johnson M.S., Burris J.A., Fairbrother A. (2014) Furthering the development of predictive toxicity reference values for the development of soil cleanup values. *Integr. Environ. Assess. Manag., 10,* 358–371.

Melymuk, L., Bohlin-Nizzetto, P., Prokeš, R., Kukučka, P., & Klánová, J. (2016). Sampling artifacts in active air sampling of semivolatile organic contaminants: Comparing theoretical and measured artifacts and evaluating implications for monitoring networks. Environmental Pollution, 217, 97-106

Michener, R.H. & Schell, D.M. (1994) Stable isotopes as tracers in marine aquatic food webs. In: *Stable Isotopes in Ecology and Environmental Science*. Ed. by: Lajtha, K. and Michener, R.H. Oxford, U.K., Blackwell Scientific. pp. 138-157.

Mierzykowski, S. E., Welch, L. J., Goodale, W., Evers, D. C., Hall, C. S., Kress, S. W., & Allen, R. B. (2005). Mercury in bird eggs from coastal Maine. USFWS Special Project Report FY05-MEFO-1-EC, Old Town, ME.

Möller, R. Sturm, Z. Xie, M. Cai, J. He, R.Ebinghaus. (2012). Organophosphorus flame retardants and plasticizers in airborne particles over the Northern Pacific and Indian Ocean toward the Polar regions: evidence for global occurrence. Environ Sci Technol, 46, 3127-3134

Moore, S., Vromet, L., Rondeau, B. (2004) Comparison of metastable atom bombardment and electron capture negative ionization for the analysis of polychloroalkanes. *Chemosphere, 54,* 453–459.

Mora, M. A. (2003). Heavy metals and metalloids in egg contents and eggshells of passerine birds from Arizona. Environmental Pollution, 125(3), 393-400

Morera, M., Sanpera, C., Crespo, S., Jover, L. and Ruiz, X. (1997) Inter- and intraclutch variability in heavy metals and selenium levels in Audiouin's Gull eggs from the Ebro Delta, Spain. *Arch. Environ. Contam. Toxicol., 33,* 71-75.

Morris, P.A. (1972) A review of mammalian age determination methods. *Mamm. Rev., 2,* 69-104.

A. Möller, R. Sturm, Z. Xie, M. Cai, J. He, R.Ebinghaus. (2012). Organophosphorus flame retardants and plasticizers in airborne particles over the Northern Pacific and Indian Ocean toward the Polar regions: evidence for global occurrence. Environ Sci Technol, 46, 3127-3134

Nakata, H., Murata, S., Shinohara, R., Filatreau, J., Isobe, T., Takahashi, S., & Tanabe, S. (2009) Occurrence and concentrations of persistent personal care products, organic UV filters, in the marine environment. In: *Interdisciplinary Studies on Environmental Chemistry—Environmental Research in Asia for Establishing a Scientist's Network*. Ed. by: Obayashi, T. Tokyo, Terrapub., 239-246.

Newsted, J.L., Jones, P.D., Coady, K., Giesy, J.P. (2005) Avian toxicity reference values for perfluorooctane sulfonate. *Environ. Sci. Technol., 39,* 9357-9362.

Newton, I., Bogan, J.A., Rothery, P. (1986) Trends and effects of organochlorine compounds in sparrowhawk eggs. *J. Anim. Ecology., 23,* 461-478.

Newton, I. & Bogan, J.A. (1974) Organochlorine residues, eggshell thinning and hatching success in British sparrow-hawks. *Nature, 249,* 582-583.

Newton, I., Bogan, J.A. & Haas, M.B. (1989) Organochlorines and mercury in the eggs of British Peregrines Falco peregrinus. *Ibis, 131,* 355-376.

Nicholls, C.R., Allchin, C.R., Law, R.J. (2001) Levels of short and medium chain lengthpolychlorinated n-alkanes in environmental samples from selected industrial areas in England and Wales. *Environ. Pollut., 113,* 415-430.

Nygard, I. (2014) Geokjemisk kartlegging av metaller i jord i Hamar by. Master oppgave, NTNU. URL: http://hdl.handle.net/11250/248014

Nygård, T. (1983) Pesticide residues and eggshell thinning in eggs of peregrines in Norway. *Ornis Scand., 14,* 161–166.

Nygård, T., Herzke, D., Polder, A. (2006) Environmental pollutants in eggs of birds of prey in Norway. Trends in time, and new compounds. Trondheim, Norwegian Institute for Nature Research (NINA Rapport, 213). (In Norwegian).

Nygård, T., Polder, A. (2012) Pollutants in raptor eggs in Norway. Current state and time-trends. Trondheim, Norwegian Institute for Nature Research. (NINA Rapport, 834). (In Norwegian).

Odsjö,T and Sondell, J. (1982) Eggshell thinning, and DDT, PCB and mercury in eggs of Osprey (Pandion haliaetus (L.)) and their relations to breeding success. . In: ODSJÖ, T. (ed.) Eggshell thickness and levels of DDT, PCB and mercury in eggs of Osprey [Pandion haliaetus (L.)] and

Marsh harrier [Circus aerigonusus] (L.)] in relation to their breeding success and population status in Sweden. Stockholm: Ph. D. Thesis. Department of Zoology, University of Stockholm.

Ogilvie, S. C., Pierce, R. J., Wright, G. R. G., Booth, L. H., & Eason, C. T. (1997) Brodifacoum residue analysis in water, soil, invertebrates, and birds after rat eradication on Lady Alice Island. *New Zeal. J. Ecol., 21,* 195-197.

Ohlendorf, H. M., Klaas, E. E., & Kaiser, T. E. (1978). Organochlorine residues and eggshell thinning in wood storks and anhingas. Wildl. Bull., 90, 608-618.

OSPAR (2009) JAMP Guidelines for Monitoring Contaminants in Biota. London, OSPAR Commission (Ref. no. 1992-2).

Petersen, K., Stenrød, M., Tollefsen, K.E. (2013) Initial environmental risk assessment of combined effects of plant protection products in six different areas in Norway. Oslo, Norwegian Institute for Water Research (NIVA Report, 6588-2013).

Peterson, B.J., Fry, B. (1987) Stable isotopes in ecosystem studies. *Annu. Rev. Ecol. Systemat., 18,* 293-320.

Post, D.M. (2002) Using stable isotopes to estimate trophic position: models, methods, and assumptions. *Ecology, 83,* 703–718.

Preuss, T. G., Gehrhardt, J., Schirmer, K., Coors, A., Rubach, M., Russ, A., Jones, P.D., Giesy, J.P. & Ratte, H. T. (2006). Nonylphenol isomers differ in estrogenic activity. *Environ. Sci. Technol., 40,* 5147-5153.

Ratcliffe, D.A. (1960) Broken eggs in the nests of sparrowhawk and golden eagle. *Br. Birds, 53,* 128-130.

Ratcliffe, D.A. (1970) Changes attributable to pesticides in egg breaking frequency and eggshell thickness in some British birds. *J. Appl. Ecol., 7,* 67-115.

Regnery, J. and Püttmann,W. (2009) Organophosphorus flame retardants and plasticizers in rain and snow from Middle Germany. *Clean-Soil Air Water, 37,* 334–342.

Regnery, J. and Püttmann, W. (2010) Seasonal fluctuations of organophosphate concentrations in precipitation and storm water runoff. *Chemosphere, 78,* 958–964.

Renzoni, A., Focardi, S., Fossi, C., Leonzio, C., Mayol, J. (1986) Comparison between concentrations of mercury and other contaminants in eggs and tissues of Cory's shearwater Calonectris diomedea collected on Atlantic and Mediterranean islands. *Environ. Pollut., 40,* 17-35.

Reth, M., Ciric, A., Christensen, G.N., Heimstad, E.S., Oehme, M. (2006) Short-and medium-chain chlorinated paraffins in biota from the European Arctic – Differences in homologue group patterns. *Sci.Total Environ., 367,* 252–260

Rich, C. D., Blaine, A. C., Hundal, L., & Higgins, C. P. (2015) Bioaccumulation of perfluoroalkyl acids by earthworms (Eisenia fetida) exposed to contaminated soils. *Environ. Sci. Technol., 49,* 881-888.

Richards, M.P., Steele, N.C. (1987) Trace elements metabolism in the developing avian embryo: A review. *J. Exp. Zool. Supp., 1*, 39-51.

Roberts, P., Roberts, J. P., & Jones, D. L. (2006). Behaviour of the endocrine disrupting chemical nonylphenol in soil: assessing the risk associated with spreading contaminated waste to land. Soil Biology and Biochemistry, 38(7), 1812-1822.

Rosenmai, A.K., Dybdahl, M., Pedersen, M., Alice van Vugt-Lussenburg, B.M., Wedebye, E.B., Taxvig, C. & Vinggaard, A.M. (2014) Are structural analogues to bisphenol a safe alternatives? *Toxicol. Sci., 139*, 35-47.

Rungby, J. (1990) An experimental-study on silver in the nervous-system and on aspects of its general cellular toxicity. *Dan. Med. Bull., 37*, 442-449.

Ruus, A., Bæk, K., Petersen, K., Allan, I., Beylich, B., Schlabach, M., Warner, N., Helberg, M. (2016) Environmental Contaminants in an Urban Fjord, 2015, Norsk institutt for vannforskning. (Norwegian Environment Agency report) ISBN 978-82-577-6808-9. M 601.

Ruus, A., Bæk, K., Petersen, K., Allan, I., Beylich, B., Schlabach, M., Warner, N., Helberg, M. (2017) Environmental Contaminants in an Urban Fjord, 2016, Norsk institutt for vannforskning. (Norwegian Environment Agency report) In prep.

Sakkas, V. A., Giokas, D. L., Lambropoulou, D. A., & Albanis, T. A. (2003) Aqueous photolysis of the sunscreen agent octyl-dimethyl-p-aminobenzoic acid: formation of disinfection byproducts in chlorinated swimming pool water. *J. Chrom., 1016,* 211-222.

Sepulvado, J. G., Blaine, A. C., Hundal, L. S., & Higgins, C. P. (2011). Occurrence and fate of perfluorochemicals in soil following the land application of municipal biosolids. Environmental science & technology, 45(19), 8106-8112.

SFT (2009) Norwegian Pollution Control Authority 2009. Helsebaserte tilstandsklasser for forurenset grunn. Veileder. Report TA-2553/2009. pp. 30

Spahn, S.A., Sherry, T.W. (1999) Cadmium and lead exposure associated with reduced growth rates, poorer fledging success of little blue heron chicks (Egretta caerulea) in south Louisiana wetlands. *Arch. Environ. Contam. Toxicol., 37*, 377-384.

Sparham, C., Van Egmond, R., O'Connor, S., Hastie, C., Whelan, M., Kanda, R., & Franklin, O. (2008) Determination of decamethylcyclopentasiloxane in river water and final effluent by headspace gas chromatography/mass spectrometry. *J. Chrom., 1212,* 124-129.

Sparham, C., Van Egmond, R., Hastie, C., O'Connor, S., Gore, D., & Chowdhury, N. (2011). Determination of decamethylcyclopentasiloxane in river and estuarine sediments in the UK. Journal of Chromatography A, 1218(6), 817-823.

Stock, N.L., Furdui, V.I., Muir, D.C.G., Mabury, S.A. (2007) Perfluoroalkyl contaminants in the canadian arctic: Evidence of atmospheric transport and local contamination. *Environ. Sci. Technol., 41*, 3529-3536.

Stone, W. B., Okoniewski, J. C., & Stedelin, J. R. (2003) Anticoagulant rodenticides and raptors: recent findings from New York, 1998–2001. *Bull. Environ. Contam. Toxicol.*, *70,* 0034-0040.

Sun, Y. X., Xu, X. R., Hao, Q., Luo, X. J., Ruan, W., Zhang, Z. W., ... & Mai, B. X. (2014). Species-specific accumulation of halogenated flame retardants in eggs of terrestrial birds from an ecological station in the Pearl River Delta, South China. Chemosphere, 95, 442-447.

Taniyasu, S., Senthilkumar, K., Yamazaki, E., Yeung, L.W.Y., Guruge, K.S., Kannan, K., Yamashita, N. (2013) Perfluoroalkyl substances in the blood of wild rats and mice from 47 prefectures in Japan: Use of samples from nationwide specimen bank. *Arch. Environ. Contam. Toxicol., 65*, 149-170.

Thomas, K., Schlabach, M., Langford, K., Fjeld, E., Øxnevad, S., Rundberget, T., Bæk, K., Rostkowski, P., Harju, M. (2014) Screening program 2013. New bisphenols, organic peroxides, fluorinated siloxanes, organic UV filters and selected PBT substances. Oslo, Norwegian Environment Agency (Miljødirektoratet rapport, M-176/2014) (NIVA rapport, 6696-2014) (NILU OR 26/2014).

Thompson, D. R. (1996). Mercury in birds and terrestrial mammals. Environmental Contaminants in Wildlife: Interpreting Tissues Concentrations. Lewis Publishers, Boca Raton, Florida, 341-356.

Thomson, R.S., Hutchings, M.J., Gillings, E., (2001) Medium chain chlorinated paraffin (52% chlorinated, C14-17): Effects in soil on the survival, growth and reproduction of the earthworm, Eisenia fetida. AstraZeneca Confidential Report BL7115/B.

Tillberg, C.V., McCarthy, D.P., Dolezal, A.G., Suarez, A.V. (2006) Measuring the trophic ecology of ants using stable isotopes. *Insectes Sociaux, 53*, 65-69.

Toan, V. D., Thao, V. D., Walder, J., & Ha, C. T. (2009). Residue, temporal trend and half-life time of selected organochlorine pesticides (OCPs) in surface soils from Bacninh, Vietnam. Bulletin of environmental contamination and toxicology, 82(4), 516-521.

Tomy, G.T., Stern, G.A., Muir, D.C.G., Fisk, A.T., Cymbalisty, D., Westmore, J.B. (1997) Quantifying C10–C13 polychloroalkanes in environmental samples by high resolution gas chromatography/electron capture negative ion mass spectrometry. *Anal. Chem., 69*, 2762–2771.

Topp, E., & Starratt, A. (2000). Rapid mineralization of the endocrine-disrupting chemical 4-nonylphenol in soil. Environmental toxicology and chemistry, 19(2), 313-318.

Trier, X., Granby, K., Christensen, J.H. (2011) Polyfluorinated surfactants (PFS) in paper and board coatings for food packaging. *Environ. Sci. Pollut. Res., 18*, 1108-1120.

Tsipoura, N., Burger, J., Feltes, R., Yacabucci, J., Mizrahi, D., Jeitner, C., & Gochfeld, M. (2008). Metal concentrations in three species of passerine birds breeding in the Hackensack Meadowlands of New Jersey. Environmental research, 107(2), 218-228.

Tsui, M. M., Leung, H. W., Lam, P. K., & Murphy, M. B. (2014) Seasonal occurrence, removal efficiencies and preliminary risk assessment of multiple classes of organic UV filters in wastewater treatment plants. *Water Res., 53,* 58-67.

Van den Steen, E., Pinxten, R., Jaspers, V.L.B., Covaci, A., Barba, E., Carere, C., Cichon, M., Dubiec, A., Eeva, T., Heeb, P., Kempenaers, B., Lifjeld, J.T., Lubjuhn, T., Mand, R., Massa, B., Nilsson, J.A., Norte, A.C., Orell, M., Podzemny, P., Sanz, J.J., Senar, J.C., Soler, J.J., Sorace, A., Torok, J., Visser, M.E., Winkel, W., Eens, M. (2009) Brominated flame retardants and organochlorines in the European environment using great tit eggs as a biomonitoring tool. *Environ. Int., 35*, 310-317.

Vandenbroucke, V., Bousquet-Melou, A., De Backer, P., & Croubels, S. (2008) Pharmacokinetics of eight anticoagulant rodenticides in mice after single oral administration. *J. Vet. Pharmacol. Therapeut., 31,* 437-445.

VKM (2009) Risk assessment of contaminants in sewage sludge applied on Norwegian soils. Opinion of the Panel on Contaminants in the Norwegian Scientific Committee for Food Safety (VKM). URL: http://www.vkm.no/dav/2ae7f1b4e3.pdf

Voorspoels, S., Covaci, A., Jaspers, V.L.B., Neels, H., Schepens, P. (2007) Biomagnification of PBDEs in three small terrestrial food chains. *Environ. Sci. Technol., 41*, 411-416.

Wang, Y., Fu, J., Wang, T., Liang, Y., Pan, Y., Cai, Y., & Jiang, G. (2010). Distribution of perfluorooctane sulfonate and other perfluorochemicals in the ambient environment around a manufacturing facility in China. Environmental science & technology, 44(21), 8062-8067.

Wang, D. G., Norwood, W., Alaee, M., Byer, J. D., & Brimble, S. (2013). Review of recent advances in research on the toxicity, detection, occurrence and fate of cyclic volatile methyl siloxanes in the environment. Chemosphere, 93(5), 711-725.

Wang, X. T., Wang, X. K., Zhang, Y., Chen, L., Sun, Y. F., Li, M., & Wu, M. H. (2014) Short-and medium-chain chlorinated paraffins in urban soils of Shanghai: spatial distribution, homologue group patterns and ecological risk assessment. *Sci. Total Environ., 490,* 144-152.

Warner, N.A., Evenset, A., Christensen, G., Gabrielsen, G.W., Borgå, K., Leknes, H. (2010) Volatile siloxanes in the European Arctic: sources and spatial distribution. *Environ. Sci. Technol., 44,* 7705-7710.

Warner, N.A., Kozerski, G., Durham, J., Koerner, M., Reinhard, G., Campbell, R., McNett, D.A. (2013) Positive vs. false detection: A comparison of analytical methods and performance for analysis of cyclic volatile methylsiloxanes (cVMS) in remote environmental matrices. *Chemosphere, 93*, 749-756.

Washington, J. W., Yoo, H., Ellington, J. J., Jenkins, T. M., & Libelo, E. L. (2010). Concentrations, distribution, and persistence of perfluoroalkylates in sludge-applied soils near Decatur, Alabama, USA. *Environmental science & technology*, *44*(22), 8390-8396.

Wen, B., Zhang, H., Li, L., Hu, X., Liu, Y., Shan, X. Q., & Zhang, S. (2015). Bioavailability of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) in biosolids-amended soils to earthworms (Eisenia fetida). *Chemosphere*, *118*, 361-366.

WHO (1996) Chlorinated Paraffins. Geneva, World Health Organization (Environmental Health Criteria, 181).

Whitworth, K.W., Haug, L.S., Baird, D.D., Becher, G., Hoppin, J.A., Skjaerven, R., Thomsen, C., Eggesbo, M., Travlos, G., Wilson, R., Cupul-Uicab, L.A., Brantsaeter, A.L., Longnecker, M.P. (2012) Perfluorinated compounds in relation to birth weight in the Norwegian mother and child cohort study. *Am. J. Epidemiol., 175*, 1209-1216.

Xiao, F., Simcik, M. F., Halbach, T. R., & Gulliver, J. S. (2015). Perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) in soils and groundwater of a US metropolitan area: migration and implications for human exposure. Water research, 72, 64-74.

Xu, J., Wu, L., & Chang, A. C. (2009). Degradation and adsorption of selected pharmaceuticals and personal care products (PPCPs) in agricultural soils. Chemosphere, 77(10), 1299-1305.

Yunjia Y., Libin L., Jing Z., Yi Y., Yongning W., Bing S. (2014) Simultaneous determination of seven bisphenols in environmental water and solid samples by liquid chromatography–electrospray tandem mass spectrometry. *Journal of Chromatography A, 1328*, 26-34

Ying, G. G., & Kookana, R. S. (2005). Sorption and degradation of estrogen-like-endocrine disrupting chemicals in soil. Environmental Toxicology and Chemistry, 24(10), 2640-2645.

Zar, J.H. (1984) Biostatistical analysis. Englewood Cliffs, NJ, Prentice-Hall.

Zhou, L., Li, J., Yin, H., Chang, W., Wang, X., Liu, Q., ... & Yan, R. (2005). Enrichment characteristics of heavy metals in heron eggs. Ying yong sheng tai xue bao= The journal of applied ecology/Zhongguo sheng tai xue xue hui, Zhongguo ke xue yuan Shenyang ying yong sheng tai yan jiu suo zhu ban, 16(10), 1932-1937.

Appendix 1

Concentrations of pollutants in individual samples

PCB, PBDE, CPs

NILU sample ID:		16/1983	16/1984	16/1985	16/1986	16/1987	16/1988	16/1989	16/1990	16/1991
Location		Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:		Air	Air	Air	Soil	Soil	Soil	Soil	Soil	Soil pooled
Concentration units:		ng/PUF	ng/PUF	ng/PUF	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g ww
Compound name:										
PCB	28	2,15	10,6	0,377	<LOD	<LOD	<LOD	<LOD	<LOD	-
PCB	52	2,13	26,4	0,554	<LOD	<LOD	<LOD	<LOD	<LOD	-
PCB	101	1,11	26,2	0,401	<LOD	0,46	<LOD	<LOD	<LOD	-
PCB	118	1,73	4,868	1,81	0,20	0,41	<LOD	0,24	0,16	-
PCB	138	0,217	7,43	0,091	0,53	0,75	0,43	0,81	0,43	-
PCB	153	0,456	14,3	0,199	0,66	0,88	0,59	0,94	0,53	-
PCB	180	0,054	1,99	0,026	<LOD	<LOD	0,25	0,44	0,22	-
PBDE	47	0,063	0,065	<LOD	0,032	<LOD	<LOD	<LOD	0,208	-
PBDE	99	0,032	0,033	<LOD	0,045	<LOD	<LOD	0,247	0,105	-
PBDE	100	<LOD	<LOD	<LOD	0,017	<LOD	<LOD	0,052	0,300	-
PBDE	126	<LOD	<LOD	<LOD	0,035	<LOD	<LOD	<LOD	0,005	-
PBDE	153	<LOD	<LOD	<LOD	0,051	<LOD	<LOD	<LOD	0,020	-
PBDE	154	<LOD	<LOD	<LOD	0,042	<LOD	<LOD	<LOD	0,016	-
PBDE	183	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,028	0,014	-
PBDE	191	<LOD	<LOD	<LOD	0,058	<LOD	<LOD	<LOD	<LOD	-
PBDE	196	<LOD	<LOD	<LOD	0,032	<LOD	<LOD	<LOD	<LOD	-
PBDE	202	<LOD	<LOD	<LOD	0,038	<LOD	<LOD	<LOD	<LOD	-
PBDE	206	<LOD	<LOD	<LOD	0,224	<LOD	<LOD	<LOD	0,041	-
PBDE	207	<LOD	<LOD	<LOD	0,120	<LOD	<LOD	<LOD	0,032	-
PBDE	209	0,847	0,792	<LOD	3,720	<LOD	<LOD	1,810	0,342	-

DBDPE	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-
SCCP	730	53	33	201,00	83,00	69,00	237,00	121,00	-
MCCP	7,3	5,4	<LOD	2,50	1,40	<LOD	3,60	1,10	-

<LOD Less than Limit of Quantification

PCB, PBDE, CPs

NILU sample ID:		16/1992	16/1993	16/1994	16/1995	16/1996	16/1997
Location		Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:		Earthworm	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm
Concentration units:		ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:							
PCB	28	<LOD	<LOD	<LOD	<LOD	<LOD	-
PCB	52	<LOD	0,136	<LOD	<LOD	<LOD	-
PCB	101	0,165	0,733	0,168	0,122	<LOD	-
PCB	118	0,168	0,351	0,169	0,251	<LOD	-
PCB	138	0,301	0,777	0,46	0,762	0,175	-
PCB	153	0,561	1,27	1,26	1,46	0,312	-
PCB	180	0,10	0,20	0,21	0,46	0,07	-
PBDE	47	0,0626	0,107	0,0796	0,0686	0,0693	-
PBDE	99	0,0347	0,0444	0,0606	0,052	0,0449	-
PBDE	100	<LOD	0,0148	0,0188	0,0176	0,016	-
PBDE	126	<LOD	<LOD	<LOD	<LOD	<LOD	-
PBDE	153	<LOD	<LOD	<LOD	<LOD	<LOD	-
PBDE	154	0,00885	<LOD	<LOD	<LOD	<LOD	-
PBDE	183	<LOD	<LOD	<LOD	<LOD	<LOD	-
PBDE	191	<LOD	<LOD	<LOD	<LOD	<LOD	-
PBDE	196	<LOD	<LOD	<LOD	<LOD	<LOD	-
PBDE	202	<LOD	<LOD	<LOD	<LOD	<LOD	-
PBDE	206	<LOD	<LOD	<LOD	<LOD	<LOD	-
PBDE	207	<LOD	<LOD	<LOD	<LOD	<LOD	-
PBDE	209	<LOD	<LOD	<LOD	<LOD	<LOD	-

DBDPE	109	<LOD	<LOD	<LOD	<LOD	-
SCCP	28,00	28,00	33,00	30,00	31,00	-
MCCP	5,50	1,20	4,80	2,20	12,60	-

<LOD Less than Limit of Quantification

PCB, PBDE, CPs

NILU sample ID:		16/1998	16/1999	16/2000	16/2001	16/2002	16/2003	16/2004	16/2005	16/2006	16/2007
Location		Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:		Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg
Concentration units:		ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:											
PCB	28	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,05	0,04	0,47
PCB	52	0,18	0,139	0,252	0,2	0,574	0,0672	0,176	1,19	0,651	1,17
PCB	101	1,43	0,962	2,22	1,49	3,25	1,05	1,5	4,64	2,88	0,805
PCB	118	0,591	0,436	1,16	0,743	1,79	0,561	0,688	2,82	1,25	0,52
PCB	138	3,94	2,35	6,48	4,74	12,9	2,89	4,67	17,5	5,48	2,24
PCB	153	7,2	4,15	9,85	8,01	24,1	4,94	7,57	33,1	9,53	3,43
PCB	180	3,02	1,65	3,15	2,91	10	1,77	3,05	16,7	5,96	1,51
PBDE	47	1,770	0,552	1,900	0,683	0,49	0,288	2,400	0,746	1,540	0,340
PBDE	99	2,880	1,030	2,940	0,711	0,77	0,415	3,100	1,260	1,930	0,444
PBDE	100	1,020	0,347	2,170	0,287	0,41	0,168	1,090	0,345	0,657	0,187
PBDE	126	<LOD	0,006	<LOD	<LOD	<LOD	<LOD	0,005	0,005	<LOD	<LOD
PBDE	153	0,476	0,253	0,894	0,100	0,26	0,093	0,450	0,580	0,518	0,093
PBDE	154	0,343	0,156	0,796	0,074	0,14	0,084	0,358	0,626	0,260	0,074
PBDE	183	0,139	0,064	0,080	0,033	0,09	0,056	0,116	0,405	0,232	0,040
PBDE	191	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
PBDE	196	0,070	0,022	<LOD	<LOD	<LOD	0,030	0,032	0,077	0,072	0,023
PBDE	202	0,093	0,046	<LOD	<LOD	<LOD	<LOD	0,118	0,137	0,031	0,027
PBDE	206	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
PBDE	207	0,126	0,059	<LOD	0,028	0,06	0,080	0,079	0,044	0,047	0,038
PBDE	209	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

DBDPE	53,1	<LOD	<LOD	48,3	<LOD	<LOD	54,3	43,6	<LOD	<LOD
SCCP	<LOD	<LOD	27,00	52,00	<LOD	<LOD	<LOD	<LOD	27,00	21,00
MCCP	1,00	1,00	<LOD	<LOD	2,60	<LOD	<LOD	<LOD	<LOD	0,40

<LOD Less than Limit of Quantification

PCB, PBDE, CPs

NILU sample ID:		16/2008	16/2009	16/2010	16/2011	16/2012	16/2013	16/2014	16/2015	16/2016	16/2017	16/2018	16/2019	16/2020
Location		Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:		Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver pooled sample	Red fox liver pooled sample	Red fox liver pooled sample
Concentration units:		ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:														
PCB	28	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PCB	52	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PCB	101	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PCB	118	0,3	<LOD	<LOD	<LOD	<LOD	<LOD	0,167	0,115	0,12	1,12	-	-	-
PCB	138	2,5	0,396	0,201	0,461	<LOD	0,4	0,3	0,6	0,17	7,90	-	-	-
PCB	153	11	6,62	0,908	5,75	1,61	2,9	2,1	3,3	2,8	22	-	-	-
PCB	180	21	27	1,74	19,2	4,03	7	5	7	14	23	-	-	-
PBDE	47	0,175	0,052	0,060	<LOD	-	0,229	<LOD	0,201	<LOD	0,316	-	-	-
PBDE	99	0,024	<LOD	0,016	<LOD	-	0,058	<LOD	0,0868	<LOD	0,033	-	-	-
PBDE	100	0,035	<LOD	<LOD	<LOD	-	0,015	<LOD	0,0164	<LOD	0,092	-	-	-
PBDE	126	<LOD	<LOD	<LOD	<LOD	-	<LOD	<LOD	<LOD	<LOD	0,005	-	-	-
PBDE	153	0,172	0,126	0,040	0,087	-	0,132	0,021	0,079	0,033	0,142	-	-	-
PBDE	154	0,010	<LOD	<LOD	<LOD	-	<LOD	<LOD	0,009	<LOD	0,032	-	-	-
PBDE	183	0,014	<LOD	<LOD	<LOD	-	<LOD	<LOD	<LOD	<LOD	0,016	-	-	-
PBDE	191	<LOD	<LOD	<LOD	<LOD	-	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PBDE	196	0,035	0,095	<LOD	<LOD	-	0,063	0,023	<LOD	<LOD	0,043	-	-	-
PBDE	202	<LOD	<LOD	<LOD	<LOD	-	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PBDE	206	0,106	<LOD	0,107	0,161	-	0,046	<LOD	<LOD	0,046	0,051	-	-	-
PBDE	207	0,114	0,044	0,207	0,120	-	0,068	0,048	0,475	0,076	0,088	-	-	-

PBDE	209	1,58	<LOD	2,080	3,100	<LOD	0,609	0,790	<LOD	1,240	0,885	-	-	-
DBDPE		<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
SCCP		44,00	32,00	35,00	41,00	-	27,00	27,00	31,00	34,00	32,00	-	-	-
MCCP		1,00	<LOD	3,90	<LOD	-	3,80	1,00	0,90	<LOD	<LOD	-	-	-

<LOD Less than Limit of Quantification

PCB, PBDE, CPs

NILU sample ID:		16/2021	16/2022	16/2023	16/2024	16/2025	16/2026	16/2027	16/2028	16/2029	16/2030	16/2031	16/2032	16/2033
Location		Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:		Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg
Concentration units:		ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:														
PCB	28	0,66	0,95	1,81	0,64	0,65	4,73	0,45	1,17	0,21	0,37	-	-	-
PCB	52	1,41	6,14	3,80	1,17	1,72	2,31	0,89	1,08	0,25	0,80	-	-	-
PCB	101	14	40,7	32,2	44	17,6	26,6	6,15	18,9	3,03	3,81	-	-	-
PCB	118	57	56,1	68,3	83,9	29,5	66,9	17,5	41,6	7,75	13,4	-	-	-
PCB	138	171	125	163	468	116	420	59,1	172	37,2	56,5	-	-	-
PCB	153	348	273	258	720	363	688	209	372	88,8	169	-	-	-
PCB	180	285	153	143	440	106	522	113	161	55,4	107	-	-	-
PBDE	47	8,980	5,580	6,560	5,940	9,710	12,900	5,650	10,600	2,740	4,330	-	-	-
PBDE	99	14,000	1,310	10,700	10,800	17,400	25,600	14,200	18,300	5,010	9,010	-	-	-
PBDE	100	5,540	1,040	3,480	4,370	6,660	4,930	4,680	7,260	2,370	3,270	-	-	-
PBDE	126	0,029	0,006	0,012	0,024	0,024	0,016	0,043	0,030	0,012	0,014	-	-	-
PBDE	153	5,840	1,210	3,690	4,710	4,940	8,860	6,030	5,670	1,780	5,430	-	-	-
PBDE	154	2,220	1,520	1,250	1,780	2,100	2,290	2,080	2,820	0,827	1,660	-	-	-
PBDE	183	1,530	0,082	2,220	1,490	1,650	2,940	1,350	1,850	0,579	1,510	-	-	-
PBDE	191	0,053	<LOD	<LOD	<LOD	<LOD	0,046	<LOD	<LOD	<LOD	<LOD	-	-	-
PBDE	196	0,656	<LOD	0,718	0,367	0,456	1,540	0,344	0,495	0,124	0,293	-	-	-
PBDE	202	0,725	<LOD	0,309	0,369	0,267	0,434	0,769	0,944	0,187	0,319	-	-	-
PBDE	206	<LOD	<LOD	<LOD	<LOD	<LOD	0,052	<LOD	<LOD	<LOD	0,063	-	-	-
PBDE	207	0,738	<LOD	0,528	0,197	0,279	2,400	0,193	0,443	0,077	0,224	-	-	-
PBDE	209	0,702	<LOD	0,768	<LOD	<LOD	2,320	0,782	0,775	<LOD	1,250	-	-	-

DBDPE	<LOD	<LOD	<LOD	<LOD	<LOD	71,3	42,6	<LOD	<LOD	69,7	-	-	-
SCCP	53,00	63,00	318,00	98,00	49,00	102,00	35,00	36,00	<LOD	40,00	-	-	-
MCCP	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,50	<LOD	<LOD	<LOD	-	-	-

<LOD Less than Limit of Quantification

PCB, PBDE, CPs

NILU sample ID:		16/2034	16/2035	16/2036	16/2037	16/2038	16/2039	16/2040	16/2041	16/2042	16/2043	16/2044	16/2045	16/2046
Location		Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:		Towny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg pooled sample	Tawny owl egg pooled sample	Tawny owl egg pooled sample
Concentration units:		ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:														
PCB	28	0,30	0,16	0,17	0,13	0,27	0,65	0,05	1,34	0,07	0,04	-	-	-
PCB	52	<LOD	<LOD	<LOD	0,05	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PCB	101	0,656	0,401	0,188	0,305	0,216	0,733	0,196	<LOD	0,121	<LOD	-	-	-
PCB	118	5,79	2,16	2,98	1,63	2,3	9,16	2,26	0,967	2,61	0,967	-	-	-
PCB	138	24,5	7,3	10,3	5,31	7,05	16,1	7,41	3,45	6,71	2,78	-	-	-
PCB	153	65,9	21	30	14,4	18,1	17,5	20,4	7,75	18,4	6,91	-	-	-
PCB	180	35,6	11	17,9	10,5	13,6	8,52	12,2	4,99	12,6	4,12	-	-	-
PBDE	47	0,686	0,377	1,100	0,331	2,47	0,132	0,422	3,13	0,39	0,18	-	-	-
PBDE	99	1,600	0,922	2,470	0,722	2,48	0,191	1,190	4,65	1,23	0,20	-	-	-
PBDE	100	0,848	0,441	0,268	0,078	0,82	0,038	0,562	1,37	0,40	0,10	-	-	-
PBDE	126	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,004	<LOD	<LOD	-	-	-
PBDE	153	2,050	0,648	2,420	0,734	2,91	0,264	1,160	1,55	1,97	0,19	-	-	-
PBDE	154	0,333	0,149	0,262	0,097	0,24	0,029	0,220	0,508	<LOD	0,03	-	-	-
PBDE	183	0,331	0,164	0,172	0,093	0,20	0,105	0,164	0,128	0,16	0,03	-	-	-
PBDE	191	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PBDE	196	0,102	0,044	0,033	<LOD	0,04	0,023	0,056	0,054	<LOD	<LOD	-	-	-
PBDE	202	0,190	0,086	0,077	<LOD	0,11	0,026	0,064	<LOD	0,04	<LOD	-	-	-
PBDE	206	0,049	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,045	<LOD	<LOD	-	-	-
PBDE	207	0,133	0,045	0,065	0,089	0,17	0,048	0,061	0,224	0,26	<LOD	-	-	-

PBDE	209	0,69	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,972	1,860	<LOD	-	-	-
DBDPE		47,6	<LOD	<LOD	57,7	53,3	<LOD	49,3	<LOD	43,4	50,4	-	-	-
SCCP		33,00	36,00	41,00	39,00	38,00	30,00	45,00	37,00	27,00	25,00	-	-	-
MCCP		<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,70	<LOD	<LOD	-	-	-

<LOD Less than Limit of Quantification

PCB, PBDE, CPs

NILU sample ID:		16/2047	16/2048	16/2049	16/2050	16/2051	16/2052	16/2053	16/2054	16/2055	16/2056	16/2057	16/2058	16/2059	16/2060
Location		Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:		Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver pooled	Brown rat liver pooled	Brown rat liver pooled	Brown rat liver pooled
Concentration units:		ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:															
PCB	28	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,30	<LOD	-	-	-	<LOD
PCB	52	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
PCB	101	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
PCB	118	<LOD	<LOD	0,44	0,21	<LOD	<LOD	<LOD	<LOD	1,37	0,57	-	-	-	<LOD
PCB	138	0,35	<LOD	5,28	0,86	<LOD	<LOD	0,75	0,99	14,40	3,06	-	-	-	<LOD
PCB	153	0,45	<LOD	5,76	1,06	<LOD	<LOD	1,39	1,06	19,90	3,30	-	-	-	<LOD
PCB	180	0,30	<LOD	9,62	0,61	<LOD	<LOD	0,63	1,19	14,20	1,92	-	-	-	<LOD
PBDE	47	0,08	0,04	-	-	<LOD	<LOD	<LOD	0,12	0,38	-	-	-	-	<LOD
PBDE	99	0,02	0,02	-	-	<LOD	<LOD	<LOD	0,15	0,21	-	-	-	-	<LOD
PBDE	100	0,02	<LOD	-	-	<LOD	<LOD	<LOD	0,02	0,37	-	-	-	-	<LOD
PBDE	126	<LOD	<LOD	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	-	<LOD
PBDE	153	0,20	0,02	-	-	<LOD	<LOD	0,02	0,29	1,35	-	-	-	-	<LOD
PBDE	154	<LOD	<LOD	-	-	<LOD	<LOD	<LOD	0,02	0,02	-	-	-	-	<LOD
PBDE	183	0,11	0,01	-	-	<LOD	<LOD	<LOD	0,03	0,22	-	-	-	-	<LOD
PBDE	191	<LOD	<LOD	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	-	<LOD
PBDE	196	<LOD	<LOD	-	-	<LOD	<LOD	<LOD	<LOD	0,04	-	-	-	-	<LOD
PBDE	202	<LOD	<LOD	-	-	<LOD	<LOD	<LOD	<LOD	0,04	-	-	-	-	<LOD
PBDE	206	<LOD	<LOD	-	-	<LOD	<LOD	<LOD	0,07	<LOD	-	-	-	-	<LOD
PBDE	207	0,07	0,12	-	-	0,04	0,11	0,03	0,31	0,24	-	-	-	-	<LOD

PBDE 209	0,609	0,453	-	-	<LOD	0,76	0,574	3,49	1,29	-	-	-	-	<LOD
DBDPE	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	85,9	<LOD	<LOD	-	-	-	<LOD
SCCP	22,00	<LOD	<LOD	160,00	<LOD	20,00	<LOD	27,00	<LOD	<LOD	-	-	-	<LOD
MCCP	<LOD	1,10	1,40	70,00	2,00	4,80	<LOD	2,50	1,30	3,50	-	-	-	<LOD

<LOD Less than Limit of Quantification

PFAS

NILU sample ID:	16/1983	16/1984	16/1985	16/1986	16/1987	16/1988	16/1989	16/1990	16/1991
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Air	Air	Air	Soil	Soil	Soil	Soil	Soil	Soil pooled
Concentration units:	ng/PUF	ng/PUF	ng/PUF	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g ww
Compound name:									
PFBS	0,06	<LOD	<LOD	0,07	<LOD	<LOD	<LOD	<LOD	-
PFPS	<LOD	<LOD	<LOD	0,19	<LOD	<LOD	<LOD	<LOD	-
PFHxS	<LOD	<LOD	<LOD	3,76	<LOD	<LOD	<LOD	<LOD	-
PFHpS	0,02	<LOD	<LOD	0,72	<LOD	<LOD	<LOD	<LOD	-
brPFOS	0,01	0,01	<LOD	36,85	<LOD	<LOD	<LOD	<LOD	-
PFOS	0,21	0,08	0,02	125,53	0,39	1,58	3,36	0,13	-
PFNS	<LOD	<LOD	<LOD	0,56	<LOD	<LOD	<LOD	<LOD	-
PFDcS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-
PFHxA	<LOD	<LOD	0,05	1,09	0,11	0,60	0,36	<LOD	-
PFHpA	0,02	<LOD	<LOD	0,91	0,09	0,47	<LOD	<LOD	-
PFOA	0,06	0,08	0,09	2,31	0,28	0,76	3,34	0,10	-
PFNA	0,02	<LOD	<LOD	0,43	<LOD	0,18	1,68	<LOD	-
PFDcA	0,05	0,04	0,04	1,19	<LOD	0,76	1,59	<LOD	-
PFUnA	<LOD	<LOD	<LOD	0,13	<LOD	<LOD	<LOD	<LOD	-
PFDoA	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-
PFTriA	<LOD	<LOD	<LOD	<LOD	0,54	<LOD	<LOD	<LOD	-
PFTeA	<LOD	0,01	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-
6:2FTS	<LOD	0,19	0,02	0,07	<LOD	0,89	<LOD	0,69	-
8:2 FTS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-

<LOD Less than Limit of Quantification

PFAS

NILU sample ID:		16/1992	16/1993	16/1994	16/1995	16/1996	16/1997
Location		Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:		Earthworm	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm
Concentration units:		ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:							
PFBS		3,91	<LOD	<LOD	<LOD	<LOD	-
PFPS		9,07	<LOD	<LOD	<LOD	<LOD	-
PFHxS		40,46	1,33	2,37	<LOD	<LOD	-
PFHpS		14,28	<LOD	<LOD	<LOD	<LOD	-
brPFOS		77,35	<LOD	1,26	1,01	0,52	-
PFOS		955,31	5,01	33,50	21,87	8,63	-
PFNS		1,25	<LOD	<LOD	<LOD	<LOD	-
PFDcS		<LOD	<LOD	<LOD	<LOD	<LOD	-
PFHxA		2,13	0,21	11,68	2,06	0,31	-
PFHpA		<LOD	<LOD	<LOD	<LOD	<LOD	-
PFOA		2,50	0,93	5,80	6,41	1,30	3,61
PFNA		0,56	0,18	0,79	1,43	0,53	0,73
PFDcA		3,09	0,27	3,85	2,58	0,60	1,82
PFUnA		1,26	0,40	2,16	2,03	0,79	1,34
PFDoA	183	0,55	0,65	11,81	4,14	0,83	4,36
PFTriA	191	0,61	0,38	2,11	2,06	1,10	1,41
PFTeA	196	0,69	0,45	3,11	2,08	0,44	1,52
6:2FTS	202	50,57	<LOD	115,33	<LOD	<LOD	28,83
8:2 FTS	206	1,04	0,07	1,05	0,24	0,31	0,41

<LOD Less than Limit of Quantification

PFAS

NILU sample ID:	16/1998	16/1999	16/2000	16/2001	16/2002	16/2003	16/2004	16/2005	16/2006	16/2007
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:										
PFBS	<LOD	<LOD	0,06	<LOD	<LOD	<LOD	<LOD	<LOD	0,02	<LOD
PFPS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,05	<LOD
PFHxS	0,38	0,61	0,51	0,14	0,11	1,04	0,37	0,11	2,70	<LOD
PFHpS	0,25	0,66	0,97	0,29	0,05	1,03	0,46	0,32	7,91	0,05
brPFOS	2,35	5,28	7,46	1,42	<LOD	8,49	2,88	2,72	64,78	1,75
PFOS	19,75	59,70	62,93	33,48	8,81	60,28	25,80	22,37	601,21	16,38
PFNS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,21	<LOD
PFDcS	0,11	0,67	<LOD	5,45	<LOD	0,16	0,13	<LOD	5,36	0,29
PFHxA	<LOD	<LOD	<LOD	<LOD	0,09	<LOD	<LOD	<LOD	<LOD	<LOD
PFHpA	0,04	0,04	0,05	0,02	<LOD	0,03	0,04	<LOD	0,24	0,02
PFOA	0,49	0,92	1,67	0,59	0,22	1,95	0,55	0,37	3,06	0,22
PFNA	0,40	1,34	1,45	0,51	1,15	1,44	0,41	0,51	2,11	0,19
PFDcA	0,65	5,31	3,32	3,32	2,17	3,09	0,90	1,57	10,50	1,14
PFUnA	1,89	7,77	4,87	2,98	3,70	4,23	1,51	2,28	8,71	1,57
PFDoA	3,17	14,54	9,42	16,43	1,35	8,10	5,19	3,91	19,85	4,49
PFTriA	5,60	11,87	4,83	8,38	1,63	6,16	6,14	2,34	8,81	3,67
PFTeA	3,29	10,03	1,55	15,90	<LOD	5,07	5,17	1,33	8,57	3,02
6:2FTS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,02	<LOD	0,29	<LOD
8:2 FTS	0,06	0,24	0,26	0,17	<LOD	0,72	0,25	<LOD	10,97	<LOD

<LOD Less than Limit of Quantification

PFAS

NILU sample ID:	16/2008	16/2009	16/2010	16/2011	16/2012	16/2013	16/2014	16/2015	16/2016	16/2017	16/2018	16/2019	16/2020
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver pooled sample	Red fox liver pooled sample	Red fox liver pooled sample
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
PFBS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFPS	<LOD	<LOD	<LOD	0,11	0,11	0,09	<LOD	<LOD	<LOD	<LOD	-	-	-
PFHxS	0,36	<LOD	0,49	0,30	0,42	0,22	0,52	0,35	0,29	0,29	-	-	-
PFHpS	0,42	<LOD	0,12	0,16	0,06	0,11	0,17	0,20	0,11	0,11	-	-	-
brPFOS	<LOD	<LOD	<LOD	4,77	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFOS	16,70	2,73	16,65	22,26	6,91	4,96	14,87	27,95	14,78	15,78	-	-	-
PFNS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFDcS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFHxA	<LOD	<LOD	<LOD	<LOD	0,06	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFHpA	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFOA	0,43	0,22	0,47	0,48	0,35	0,67	0,39	0,55	0,23	0,23	-	-	-
PFNA	1,71	0,44	1,72	1,52	0,87	0,83	1,32	2,53	1,18	1,18	-	-	-
PFDcA	1,71	0,55	2,13	1,95	1,12	0,78	1,43	2,29	2,21	2,21	-	-	-
PFUnA	1,79	0,28	3,12	2,18	1,86	1,01	2,05	1,40	2,04	2,04	-	-	-
PFDoA	0,88	0,19	0,80	1,67	0,73	<LOD	0,77	<LOD	1,73	1,73	-	-	-
PFTriA	0,56	0,11	1,60	1,40	0,97	0,36	1,10	<LOD	0,49	0,49	-	-	-
PFTeA	0,63	0,09	0,24	0,30	0,34	<LOD	0,09	<LOD	<LOD	<LOD	-	-	-
6:2FTS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
8:2 FTS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-

<LOD Less than Limit of Quantification

PFAS

NILU sample ID:	16/2021	16/2022	16/2023	16/2024	16/2025	16/2026	16/2027	16/2028	16/2029	16/2030	16/2031	16/2032	16/2033
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
PFBS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFPS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFHxS	0,58	0,49	0,51	0,80	1,58	<LOD	1,37	1,37	0,53	1,61	-	-	-
PFHpS	0,50	0,85	0,46	1,04	3,95	0,09	2,83	2,83	0,57	1,93	-	-	-
brPFOS	6,68	7,66	2,80	9,18	23,88	2,47	15,14	15,14	3,83	30,21	-	-	-
PFOS	50,61	57,41	27,53	42,72	169,17	11,07	117,69	117,69	30,15	261,96	-	-	-
PFNS	<LOD	0,08	<LOD	<LOD	0,05	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFDcS	0,74	0,59	1,21	<LOD	0,82	0,24	1,82	1,82	1,77	0,50	-	-	-
PFHxA	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFHpA	<LOD	0,12	<LOD	<LOD	0,11	<LOD	0,10	0,10	<LOD	<LOD	-	-	-
PFOA	1,12	1,09	1,01	1,30	5,16	0,59	3,85	3,85	0,69	3,20	-	-	-
PFNA	1,84	1,34	0,83	1,55	2,18	0,49	1,86	1,86	0,64	3,77	-	-	-
PFDcA	3,23	2,99	1,94	2,55	5,11	1,41	3,93	3,93	1,39	7,46	-	-	-
PFUnA	5,52	7,62	2,83	5,11	6,87	1,50	5,32	5,32	2,36	14,04	-	-	-
PFDoA	8,41	14,45	6,48	6,80	13,47	2,14	11,48	11,48	4,44	23,97	-	-	-
PFTriA	11,81	13,68	6,41	10,55	13,26	2,27	10,59	10,59	4,59	21,32	-	-	-
PFTeA	10,28	12,82	8,86	7,66	11,98	2,88	10,46	10,46	3,14	11,31	-	-	-
6:2FTS	<LOD	0,05	<LOD	<LOD	0,05	0,03	<LOD	<LOD	<LOD	<LOD	-	-	-
8:2 FTS	2,65	0,37	1,52	0,80	2,05	0,31	1,28	1,28	0,38	1,46	-	-	-

<LOD Less than Limit of Quantification

PFAS

NILU sample ID:	16/2034	16/2035	16/2036	16/2037	16/2038	16/2039	16/2040	16/2041	16/2042	16/2043	16/2044	16/2045	16/2046
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg pooled sample	Tawny owl egg pooled sample	Tawny owl egg pooled sample
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
PFBS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFPS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFHxS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	1,76	<LOD	-	-	-
PFHpS	0,07	<LOD	<LOD	<LOD	0,09	<LOD	<LOD	<LOD	0,15	<LOD	-	-	-
brPFOS	5,24	<LOD	2,87	<LOD	4,98	6,21	3,26	1,15	5,76	<LOD	-	-	-
PFOS	44,62	5,05	8,10	1,90	18,54	17,09	10,13	6,94	36,24	5,16	-	-	-
PFNS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFDcS	1,42	0,09	<LOD	<LOD	0,54	<LOD	0,13	<LOD	1,29	<LOD	-	-	-
PFHxA	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,07	<LOD	<LOD	<LOD	-	-	-
PFHpA	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
PFOA	0,10	<LOD	<LOD	<LOD	<LOD	0,10	<LOD	<LOD	<LOD	<LOD	-	-	-
PFNA	0,33	0,11	0,14	0,06	0,33	0,25	0,14	0,11	0,36	0,08	-	-	-
PFDcA	2,03	0,47	0,56	0,20	1,10	1,10	0,79	0,49	0,98	0,36	-	-	-
PFUnA	2,41	1,06	0,79	0,32	1,28	1,45	0,94	0,75	1,35	0,51	-	-	-
PFDoA	3,10	0,85	0,65	0,36	1,11	1,58	0,73	<LOD	1,58	0,47	-	-	-
PFTriA	3,46	1,34	0,69	0,37	0,78	1,63	1,12	0,75	1,20	0,63	-	-	-
PFTeA	2,29	0,58	0,30	0,20	0,21	0,84	0,45	0,49	0,34	0,24	-	-	-
6:2FTS	<LOD	5,55	1,45	<LOD	0,17	0,43	<LOD	0,04	<LOD	<LOD	-	-	-
8:2 FTS	0,47	<LOD	<LOD	<LOD	0,54	0,06	0,10	0,03	0,14	<LOD	-	-	-

<LOD Less than Limit of Quantification

PFAS

NILU

NILU sample ID:	16/2047	16/2048	16/2049	16/2050	16/2051	16/2052	16/2053	16/2054	16/2055	16/2056	16/2057	16/2058	16/2059	16/2060
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver pooled	Brown rat liver pooled	Brown rat liver pooled	Brown rat liver pooled
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:														
PFBS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
PFPS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
PFHxS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
PFHpS	<LOD	<LOD	<LOD	<LOD	<LOD	0,93	0,57	0,91	<LOD	2,81	-	-	-	<LOD
brPFOS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
PFOS	27,68	12,41	46,24	48,03	9,36	6,78	115,28	151,09	14,00	188,74	-	-	-	5,49
PFNS	<LOD	<LOD	<LOD	1,40	0,39	<LOD	<LOD	0,47	<LOD	0,46	-	-	-	<LOD
PFDcS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	9,22	-	-	-	<LOD
PFHxA	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
PFHpA	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
PFOA	3,00	0,18	3,02	0,39	<LOD	0,13	0,18	1,53	2,32	10,14	-	-	-	<LOD
PFNA	3,80	0,72	5,26	0,99	0,75	0,28	1,10	9,19	2,15	8,40	-	-	-	0,75
PFDcA	2,33	<LOD	4,45	8,29	<LOD	<LOD	6,93	14,64	<LOD	12,70	-	-	-	<LOD
PFUnA	1,72	1,12	3,46	1,59	0,89	0,84	5,26	9,83	1,11	6,31	-	-	-	1,87
PFDoA	4,04	4,15	6,33	4,79	3,05	2,04	9,23	44,78	3,18	15,25	-	-	-	1,74
PFTriA	0,95	0,80	1,37	0,49	0,57	0,43	5,24	14,14	0,83	5,60	-	-	-	2,31
PFTeA	1,15	1,94	0,76	0,89	0,94	0,52	4,79	18,58	1,27	8,68	-	-	-	0,93
6:2FTS	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
8:2 FTS	<LOD	<LOD	4,85	2,97	<LOD	<LOD	<LOD	16,45	<LOD	2,16	-	-	-	<LOD

<LOD Less than Limit of Quantification

Metals

NILU sample ID:	16/1983	16/1984	16/1985	16/1986	16/1987	16/1988	16/1989	16/1990	16/1991
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Air	Air	Air	Soil	Soil	Soil	Soil	Soil	Soil pooled sample
Concentration units:	ng/PUF	ng/PUF	ng/PUF	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g ww
Compound name:									
52 Cr	-	-	-	68243	93413	67307	16057	48510	-
60 Ni	-	-	-	46119	52744	33510	9139	30960	-
63 Cu	-	-	-	52695	43053	59153	21494	31113	-
66 Zn	-	-	-	302403	167252	813262	124511	102829	-
75 As	-	-	-	9107	11201	10385	4680	5057	-
107 Ag	-	-	-	237	332	250	288	122	-
111 Cd	-	-	-	575	293	2712	1692	230	-
208 Pb	-	-	-	37954	54171	35182	105434	15118	-
202 Hg	-	-	-	129	317	82	167	31	-

<LOD Less than Limit of Quantification

Metals

NILU sample ID:	16/1992	16/1993	16/1994	16/1995	16/1996	16/1997
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:						
52 Cr	1407,5	3403,0	4698,8	491,6	1222,3	-
60 Ni	884	1867	2271	332	740	-
63 Cu	2587	2465	4972	1911	2494	-
66 Zn	233111	161140	246145	113770	97225	-
75 As	640	720	1017	483	561	-
107 Ag	9	20	76	49	13	-
111 Cd	938	576	5523	2589	661	-
208 Pb	398	1156	2145	3528	369	-
202 Hg	39	1101	101	131	32	-

<LOD Less than Limit of Quantification

Metals

NILU sample ID:	16/1998	16/1999	16/2000	16/2001	16/2002	16/2003	16/2004	16/2005	16/2006	16/2007
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:										
52 Cr	135,1	5,0	10,8	9,9	11,6	12,6	13,7	9,9	8,3	7,9
60 Ni	47,16	2,51	5,65	5,87	8,15	4,75	12,72	7,34	7,23	5,37
63 Cu	288,9	290,6	344,9	275,7	430,1	366,0	609,1	483,9	580,0	745,9
66 Zn	5659,3	7049,3	5140,5	5108,1	8673,3	8835,6	9928,7	8810,9	10552,3	7212,3
75 As	4,44	4,67	6,30	1,70	1,26	1,32	<LOD	1,64	5,62	1,02
107 Ag	0,9	0,59	0,91	0,20	0,13	0,57	0,71	0,40	0,59	0,70
111 Cd	0,49	0,49	<LOD	<LOD	0,44	<LOD	<LOD	<LOD	<LOD	<LOD
208 Pb	12,5	9,0	494,4	6,2	14,8	12,3	11,8	5,8	14,5	4,0
202 Hg	10,5	15,7	9,0	4,1	12,7	7,0	8,8	8,0	16,2	11,4

<LOD Less than Limit of Quantification

Metals

NILU sample ID:	16/2008	16/2009	16/2010	16/2011	16/2012	16/2013	16/2014	16/2015	16/2016	16/2017	16/2018	16/2019	16/2020
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox pooled sample	Red fox pooled sample	Red fox pooled sample
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
52 Cr	371	968	112	711	114	245	113	65	327	646	-	-	-
60 Ni	183	450	56	313	<LOD	87	<LOD	<LOD	115	286	-	-	-
63 Cu	5423	16112	9701	15220	13626	10834	9601	8774	9663	4553	-	-	-
66 Zn	24345	42430	36914	39450	39552	45835	32643	40613	40179	37466	-	-	-
75 As	<LOD	<LOD	11	9	16	<LOD	<LOD	<LOD	<LOD	233	-	-	-
107 Ag	0,26	1,87	1,59	4,16	2,34	1,63	3,54	1,52	0,35	4,48	-	-	-
111 Cd	151	73	123	505	229	462	133	279	237	192	-	-	-
208 Pb	1571	38	77	485	44	352	29	95	100	37	-	-	-
202 Hg	272	1269	38	263	96	161	133	147	77	100	-	-	-

<LOD Less than Limit of Quantification

Metals

NILU

NILU sample ID:	16/2021	16/2022	16/2023	16/2024	16/2025	16/2026	16/2027	16/2028	16/2029	16/2030	16/2031	16/2032	16/2033
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
52 Cr	22,8	16,6	13,0	308,7	176,7	32,8	47,3	258,6	433,1	3,4	-	-	-
60 Ni	24,4	6,4	4,3	144,0	87,6	18,3	11,7	124,1	251,9	10,0	-	-	-
63 Cu	503,3	711,4	512,9	473,5	640,4	343,1	630,2	663,8	611,5	498,9	-	-	-
66 Zn	6994,9	7836,8	7739,4	7609,9	9347,4	6296,1	9168,8	9943,6	8843,4	5923,2	-	-	-
75 As	1,5	<LOD	<LOD	<LOD	<LOD	3,9	3,8	3,8	<LOD	4,9	-	-	-
107 Ag	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
111 Cd	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
208 Pb	12,3	5,6	9,5	16,8	3,1	2,4	3,1	6,7	4,3	11,5	-	-	-
202 Hg	87,2	58,9	66,9	223,4	199,4	32,8	95,2	186,7	182,7	194,5	-	-	-

<LOD Less than Limit of Quantification

Metals

NILU sample ID:	16/2034	16/2035	16/2036	16/2037	16/2038	16/2039	16/2040	16/2041	16/2042	16/2043	16/2044	16/2045	16/2046
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg pooled sample	Tawny owl egg pooled sample	Tawny owl egg pooled sample
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
52 Cr	1473,88	287,20	100,37	141,89	168,50	20,31	1297,89	21,33	22,40	314,95	-	-	-
60 Ni	97,40	93,64	48,71	34,84	48,53	14,02	539,53	18,63	15,73	49,20	-	-	-
63 Cu	853,76	811,93	785,25	788,62	993,29	672,30	1251,75	707,25	842,25	995,02	-	-	-
66 Zn	8147,00	16907,02	12642,18	15896,22	15652,45	7817,45	15029,67	11159,29	12798,84	18105,31	-	-	-
75 As	<LOD	6,51	<LOD	5,64	5,28	<LOD	12,37	<LOD	<LOD	<LOD	-	-	-
107 Ag	0,87	<LOD	<LOD	1,93	2,67	<LOD	<LOD	0,68	<LOD	0,72	-	-	-
111 Cd	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
208 Pb	2,29	3,44	3,56	2,08	2,11	1,11	1,22	1,90	2,66	3,02	-	-	-
202 Hg	11,35	18,15	8,34	15,65	18,09	11,35	11,12	9,67	24,48	7,66	-	-	-

<LOD Less than Limit of Quantification

Metals

NILU sample ID:	16/2047	16/2048	16/2049	16/2050	16/2051	16/2052	16/2053	16/2054	16/2055	16/2056	16/2057	16/2058	16/2059	16/2060
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver pooled	Brown rat liver pooled	Brown rat liver pooled	Brown rat liver pooled
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:														
52 Cr	586	1981	209	890	1353	1510	2223	1095	239	2422	-	-	-	380
60 Ni	282	965	100	304	647	794	1175	524	120	1162	-	-	-	206
63 Cu	3195	5195	3746	4739	3654	4554	5019	6026	2984	3589	-	-	-	5152
66 Zn	23454	49137	26843	33745	25157	24389	27630	23838	19343	20988	-	-	-	27302
75 As	980	516	829	395	490	610	9717	2330	654	2440	-	-	-	11
107 Ag	2,54	0,45	0,30	1,55	0,61	0,59	4,21	3,33	0,18	0,86	-	-	-	1,52
111 Cd	6,6	22,6	14,5	29,3	18,7	18,2	394,0	39,1	17,6	8,0	-	-	-	68
208 Pb	63	17	74	913	10	14	13	659	6	72	-	-	-	38
202 Hg	3,81	0,73	5,08	0,73	0,91	0,60	23,96	5,42	0,42	10,78	-	-	-	6,41

<LOD Less than Limit of Quantification

DDTs and pesticides

NILU sample ID:	16/1998	16/1999	16/2000	16/2001	16/2002	16/2003	16/2004	16/2005	16/2006	16/2007
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:										
trans-Chlordane	0,0519	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
cis-Chlordane	1,45	0,113	<LOD	<LOD	<LOD	<LOD	0,0865	<LOD	<LOD	<LOD
Oxy-chlordane	5,4	0,631	0,747	0,486	0,522	0,411	1,28	5,94	0,43	0,146
Heptachlor	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
trans-Nonachlor	17,7	1,25	1,34	0,319	0,376	0,26	1,75	10,6	1,02	0,249
cis-Nonachlor	3,54	0,221	0,242	<LOD	<LOD	<LOD	0,373	1,28	0,188	<LOD
HCB	4,74	1,73	5,22	2,54	2,16	6,56	3,86	4,03	2,19	3,49
Mirex	0,0809	0,0658	0,0794	0,09	0,0752	0,0465	0,0747	0,0691	0,0453	0,0339
o.p'-DDE	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
p,p'-DDE	644	13,8	280	258	14,7	7,85	25,6	54,0	14,6	6,11
o,p'-DDD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
p,p'-DDD	1,34	0,08	0,53	1,32	0,06	<LOD	0,07	0,10	0,14	0,07
o,p'-DDT	0,10	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
p,p'-DDT	23,2	1,85	13,8	44,1	1,01	0,17	0,99	2,10	2,14	0,57

<LOD Less than Limit of Quantification

DDTs and pesticides

NILU sample ID:	16/2021	16/2022	16/2023	16/2024	16/2025	16/2026	16/2027	16/2028	16/2029	16/2030	16/2031	16/2032	16/2033
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
trans-Chlordane	<LOD	0,405	<LOD	<LOD	<LOD	0,179	<LOD	<LOD	<LOD	<LOD	-	-	-
cis-Chlordane	0,408	2,2	<LOD	0,37	0,724	0,443	<LOD	<LOD	<LOD	0,0763	-	-	-
Oxy-chlordane	28,4	14,2	6,13	19	38,6	8,7	6,89	34,8	7,2	10,6	-	-	-
Heptachlor	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
trans-Nonachlor	79,6	30,3	8,78	20,3	36	19,7	6,15	44,1	4,73	6,44	-	-	-
cis-Nonachlor	16,9	6,58	1,92	3,81	6,03	4,95	1,58	13,2	0,717	1,67	-	-	-
HCB	7,91	9,04	12,5	28,9	27,7	6,48	9,95	16,8	5,44	10,7	-	-	-
Mirex	1,78	1,03	0,533	2,66	3,39	1,14	2,74	3,56	1,05	3,62	-	-	-
o.p'-DDE	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
p,p'-DDE	1 310	720	777	1 260	2 400	697	881	1 200	615	1 710	-	-	-
o,p'-DDD	0,03	<LOD	0,16	0,07	0,07	<LOD	<LOD	<LOD	0,02	0,04	-	-	-
p,p'-DDD	15,4	5,81	19,9	11,6	23,0	3,39	5,31	8,33	7,04	7,19	-	-	-
o,p'-DDT	<LOD	<LOD	0,14	0,06	0,13	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
p,p'-DDT	13,7	4,94	16,0	15,9	24,0	2,83	2,63	7,09	11,3	4,94	-	-	-

<LOD Less than Limit of Quantification

DDTs and pesticides

NILU sample ID:	16/2034	16/2035	16/2036	16/2037	16/2038	16/2039	16/2040	16/2041	16/2042	16/2043	16/2044	16/2045	16/2046
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg samlepr	Tawny owl egg samlepr	Tawny owl egg samlepr
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
trans-Chlordane	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
cis-Chlordane	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
Oxy-chlordane	7,02	1,11	1,96	1,45	1,54	0,62	1,43	0,33	1	1,95	-	-	-
Heptachlor	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
trans-Nonachlor	1,29	0,33	0,25	0,25	<LOD	0,56	0,36	0,05	0,06	0,49	-	-	-
cis-Nonachlor	0,349	0,07	0,007	0,05	0,07	0,02	0,05	0,02	0,06	0,12	-	-	-
HCB	4,31	1,79	1,44	1,28	1,32	1,15	1,33	0,82	1,29	0,87	-	-	-
Mirex	0,407	0,12	0,08	<LOD	<LOD	<LOD	0,19	0,04	<LOD	<LOD	-	-	-
o.p'-DDE	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
p,p'-DDE	172	168	154	44,4	41,0	15,1	58,5	23,9	49,1	14,0	-	-	-
o,p'-DDD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,02	<LOD	<LOD	<LOD	-	-	-
p,p'-DDD	1,41	0,94	0,26	0,13	0,16	0,24	0,34	0,24	0,43	0,17	-	-	-
o,p'-DDT	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
p,p'-DDT	0,15	1,07	0,11	0,07	0,11	0,30	0,12	0,28	0,26	0,04	-	-	-

<LOD Less than Limit of Quantification

OPFR

NILU sample ID:	16/1992	16/1993	16/1994	16/1995	16/1996	16/1997
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:						
TEP	-	-	-	-	-	1,13
TCEP	-	-	-	-	-	0,91
TPrP	-	-	-	-	-	<LOD
TCPP	-	-	-	-	-	11,99
TiBP	-	-	-	-	-	2,21
BdPhP	-	-	-	-	-	<LOD
TPP	-	-	-	-	-	0,20
DBPhP	-	-	-	-	-	<LOD
TnBP	-	-	-	-	-	7,65
TDCPP	-	-	-	-	-	<LOD
TBEP	-	-	-	-	-	0,66
TCP	-	-	-	-	-	<LOD
EHDP	-	-	-	-	-	0,27
TEHP	-	-	-	-	-	0,40

<LOD Less than Limit of Quantification

OPFR

NILU sample ID:	16/1998	16/1999	16/2000	16/2001	16/2002	16/2003	16/2004	16/2005	16/2006	16/2007
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:										
TEP	-	-	-	-	-	-	-	-	-	-
TCEP	-	-	-	-	-	-	-	-	-	-
TPrP	-	-	-	-	-	-	-	-	-	-
TCPP	-	-	-	-	-	-	-	-	-	-
TiBP	-	-	-	-	-	-	-	-	-	-
BdPhP	-	-	-	-	-	-	-	-	-	-
TPP	-	-	-	-	-	-	-	-	-	-
DBPhP	-	-	-	-	-	-	-	-	-	-
TnBP	-	-	-	-	-	-	-	-	-	-
TDCPP	-	-	-	-	-	-	-	-	-	-
TBEP	-	-	-	-	-	-	-	-	-	-
TCP	-	-	-	-	-	-	-	-	-	-
EHDP	-	-	-	-	-	-	-	-	-	-

<LOD Less than Limit of Quantification

OPFR

NILU sample ID:	16/2008	16/2009	16/2010	16/2011	16/2012	16/2013	16/2014	16/2015	16/2016	16/2017	16/2018	16/2019	16/2020
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver pooled sample	Red fox liver pooled sample	Red fox liver pooled sample
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
TEP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TCEP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TPrP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TCPP	-	-	-	-	-	-	-	-	-	-	<LOD	3,92	<LOD
TiBP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
BdPhP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TPP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
DBPhP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TnBP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TDCPP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TBEP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TCP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
EHDP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TEHP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD

<LOD Less than Limit of Quantification

OPFR

NILU sample ID:	16/2021	16/2022	16/2023	16/2024	16/2025	16/2026	16/2027	16/2028	16/2029	16/2030	16/2031	16/2032	16/2033
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
TEP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TCEP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TPrP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TCPP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TiBP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
BdPhP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TPP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
DBPhP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TnBP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TDCPP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TBEP	-	-	-	-	-	-	-	-	-	-	0,60	<LOD	3,00
TCP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
EHDP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TEHP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	0,13

<LOD Less than Limit of Quantification

OPFR

NILU sample ID:	16/2034	16/2035	16/2036	16/2037	16/2038	16/2039	16/2040	16/2041	16/2042	16/2043	16/2044	16/2045	16/2046
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg pooled sample	Tawny owl egg pooled sample	Tawny owl egg pooled sample
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
TEP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TCEP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TPrP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TCPP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TiBP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
BdPhP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TPP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
DBPhP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TnBP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TDCPP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TBEP	-	-	-	-	-	-	-	-	-	-	1,37	0,40	<LOD
TCP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
EHDP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
TEHP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD

<LOD Less than Limit of Quantification

OPFR

NILU sample ID:	16/2047	16/2048	16/2049	16/2050	16/2051	16/2052	16/2053	16/2054	16/2055	16/2056	16/2057	16/2058	16/2059	16/2060
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver pooled	Brown rat liver pooled	Brown rat liver pooled	Brown rat liver pooled
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:														
TEP	-	-	-	-	-	-	-	-	-	-	<LOD	0,48	<LOD	0,09
TCEP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD
TPrP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD
TCPP	-	-	-	-	-	-	-	-	-	-	3,83	0,58	0,27	0,61
TiBP	-	-	-	-	-	-	-	-	-	-	0,53	2,14	<LOD	1,24
BdPhP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD
TPP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD
DBPhP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD
TnBP	-	-	-	-	-	-	-	-	-	-	0,08	0,14	0,06	0,14
TDCPP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	0,47	<LOD
TBEP	-	-	-	-	-	-	-	-	-	-	0,27	3,42	0,56	<LOD
TCP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD
EHDP	-	-	-	-	-	-	-	-	-	-	0,16	0,16	<LOD	<LOD
TEHP	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD

<LOD Less than Limit of Quantification

Cyclic siloxanes

NILU sample ID:	16/1983	16/1984	16/1985	16/1986	16/1987	16/1988	16/1989	16/1990	16/1991
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Air	Air	Air	Soil	Soil	Soil	Soil	Soil	Soil pooled
Concentration units:	ng/PUF	ng/PUF	ng/PUF	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g ww
Compound name:									
D4	296	910	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-
D5	1115	2893	418	<LOD	<LOD	<LOD	13,2	<LOD	-
D6	122	292	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-

<LOD Less than Limit of Quantification

Cyclic siloxanes

NILU sample ID:	16/1992	16/1993	16/1994	16/1995	16/1996	16/1997
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:						
D4	<LOD	<LOD	3,1	<LOD	<LOD	-
D5	<LOD	6,4	16,3	6,4	2,1	-
D6	1,2	3,5	17,6	4,9	1,9	-

<LOD Less than Limit of Quantification

Cyclic siloxanes

NILU sample ID:	16/1998	16/1999	16/2000	16/2001	16/2002	16/2003	16/2004	16/2005	16/2006	16/2007
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:										
D4	<LOD	<LOD	lost	<LOD	<LOD	<LOD	1,2	1,2	<LOD	<LOD
D5	5,0	1,0	lost	<LOD	1,2	1,4	1,4	11,2	<LOD	<LOD
D6	0,9	<LOD	lost	<LOD	0,9	0,9	0,9	2,3	<LOD	<LOD

<LOD Less than Limit of Quantification

Cyclic siloxanes

NILU sample ID:	16/2008	16/2009	16/2010	16/2011	16/2012	16/2013	16/2014	16/2015	16/2016	16/2017	16/2018	16/2019	16/2020
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver samlepr.	Red fox liver samlepr.	Red fox liver samlepr.
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
D4	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
D5	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	1,6	<LOD	<LOD	-	-	-
D6	<LOD	<LOD	1,6	<LOD	<LOD	<LOD	<LOD	3,2	<LOD	<LOD	-	-	-

<LOD Less than Limit of Quantification

Cyclic siloxanes

NILU sample ID:	16/2021	16/2022	16/2023	16/2024	16/2025	16/2026	16/2027	16/2028	16/2029	16/2030	16/2031	16/2032	16/2033
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:												-	
D4	1,5	1,3	1,3	1,1	1,1	1,0	1,2	1,4	1,2	1,2	-	-	-
D5	5,8	4,6	6,6	3,3	13,2	6,1	9,4	23,4	16,0	8,5	-	-	-
D6	1,9	1,8	2,5	1,9	3,0	1,9	2,9	3,2	2,7	2,5	-	-	-

<LOD Less than Limit of Quantification

Cyclic siloxanes

NILU sample ID:	16/2034	16/2035	16/2036	16/2037	16/2038	16/2039	16/2040	16/2041	16/2042	16/2043	16/2044	16/2045	16/2046
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg samlepr	Tawny owl egg samlepr	Tawny owl egg samlepr
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
D4	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
D5	3,6	<LOD	1,6	1,3	23,5	1,8	1,4	1,5	4,0	1,5	-	-	-
D6	1,1	1,1	1,2	1,0	1,7	1,7	1,2	1,5	1,4	1,6	-	-	-

<LOD Less than Limit of Quantification

Cyclic siloxanes

NILU sample ID:	16/2047	16/2048	16/2049	16/2050	16/2051	16/2052	16/2053	16/2054	16/2055	16/2056	16/2057	16/2058	16/2059	16/2060
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver pooled	Brown rat liver pooled	Brown rat liver pooled	field vole liver pooled
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:														
D4	7,8	4,7	<LOD	<LOD	<LOD	<LOD	<LOD	5,5	<LOD	5,4	-	-	-	8,6
D5	22,5	<LOD	<LOD	8,4	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	10,0
D6	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	14,0

<LOD Less than Limit of Quantification

Stabile isotopes & Lipid %

NILU sample ID:	16/1983	16/1984	16/1985	16/1986	16/1987	16/1988	16/1989	16/1990	16/1991
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Air	Air	Air	Soil	Soil	Soil	Soil	Soil	Soil pooled
Concentration units:	ng/PUF	ng/PUF	ng/PUF	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g ww
Compound name:									
$d^{13}C_{VPDB}$	-	-	-	-29,29	-28,01	-28,11	-27,69	-29,92	-
$d^{15}N_{AIR}$	-	-	-	5,59	3,07	3,33	1,49	-2,76	-
$d^{34}S_{CDT}$	-	-	-	-	-	-	-	-	-
fett%	-	-	-	-	-	-	-	-	-

<LOD Less than Limit of Quantification

Stabile isotopes & Lipid %

NILU sample ID:	16/1992	16/1993	16/1994	16/1995	16/1996	16/1997
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:						
$d^{13}C_{VPDB}$	-28,00	-25,90	-26,62	-25,66	-28,47	-
$d^{15}N_{AIR}$	5,49	5,33	6,38	5,96	4,04	-
$d^{34}S_{CDT}$	-2,40	2,80	5,12	4,79	-6,13	-
fett%	1	1	1	1	1	-

<LOD Less than Limit of Quantification

Stabile isotopes & Lipid %

NILU sample ID:	16/1998	16/1999	16/2000	16/2001	16/2002	16/2003	16/2004	16/2005	16/2006	16/2007
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:										
$d^{13}C_{VPDB}$	-26,35	-26,57	-26,53	-26,73	-27,13	-26,95	-27,42	-27,18	-28,34	-26,98
$d^{15}N_{AIR}$	6,88	5,68	5,50	5,46	7,22	8,88	7,47	6,37	6,67	6,81
$d^{34}S_{CDT}$	6,62	6,91	6,06	4,91	0,87	6,38	4,54	6,44	3,94	3,29
fett%	4	4	5	2	5	3	4	4	5	4

<LOD Less than Limit of Quantification

Stabile isotopes & Lipid %

NILU sample ID:	16/2008	16/2009	16/2010	16/2011	16/2012	16/2013	16/2014	16/2015	16/2016	16/2017	16/2018	16/2019	16/2020
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver samlepr.	Red fox liver samlepr.	Red fox liver samlepr.
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
$d^{13}C_{VPDB}$	-25,45	-26,38	-25,60	-26,12	-25,86	-25,38	-25,66	-25,54	-25,93	-26,56	-	-	-
$d^{15}N_{AIR}$	8,42	9,45	8,62	7,67	7,96	8,55	8,83	9,12	7,01	8,13	-	-	-
$d^{34}S_{CDT}$	6,15	6,23	6,79	6,10	5,93	6,22	6,13	6,57	6,34	8,64	-	-	-
fett%	4,1	2,3	1,8	2,9	2,5	1,3	1,2	2,2	1,6	6,8	-	-	-

<LOD Less than Limit of Quantification

Stabile isotopes, lipid % and eggshell parameters

NILU sample ID:	16/2021	16/2022	16/2023	16/2024	16/2025	16/2026	16/2027	16/2028	16/2029	16/2030	16/2031	16/2032	16/2033
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
d^{13}C$_{VPDB}$	-25,71	-25,36	-25,39	-26,13	-26,15	-25,64	-24,58	-25,36	-24,95	-26,02	-	-	-
d^{15}N$_{AIR}$	5,50	4,42	6,86	6,45	8,86	6,45	5,41	6,59	7,65	7,64	-	-	-
d^{34}S$_{CDT}$	7,63	7,75	6,08	7,75	6,78	6,56	7,89	7,44	8,00	8,48	-	-	-
fett%	5,1	6,2	3,5	3,2	4,3	6,2	3,2	4,2	3,8	8,7	-	-	-
Shell thickness with membrane	263,8			270		263,8	270	267,5	265	266,3			
Shell thickness without membrane	228,8		211,3										
Eggshell index	1,29	1,15	1,17	1,38	1,11	1,29	1,28	1,29	1,26	1,28			

<LOD Less than Limit of Quantification

Stabile isotopes, lipid % and eggshell parameters

NILU sample ID:	16/2034	16/2035	16/2036	16/2037	16/2038	16/2039	16/2040	16/2041	16/2042	16/2043	16/2044	16/2045	16/2046
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg samlepr	Tawny owl egg samlepr	Tawny owl egg samlepr
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
$d^{13}C_{VPDB}$	-28,10	-28,80	-29,58	-28,87	-27,75	-28,19	-30,77	-28,08	-29,01	-29,19	-	-	-
$d^{15}N_{AIR}$	8,58	9,35	3,90	6,13	7,51	7,01	5,97	6,03	9,47	7,26	-	-	-
$d^{34}S_{CDT}$	6,21	5,96	8,37	5,36	7,02	6,68	6,49	7,48	7,35	5,78	-	-	-
fett%	6,1	4,6	7,7	5,9	6,7	4,8	5,6	4	7,50	5,2	-	-	-
Shell thickness with membrane	308,8		286,3	267,5	268,8	265		288,8		270			
Shell thickness without membrane					242,5		200						
Eggshell index	1,50	1,38	1,34	1,39	1,37	1,40	1,27	1,47	1,44	1,33			

<LOD Less than Limit of Quantification

Stabile isotopes & Lipid %

NILU sample ID:	16/2047	16/2048	16/2049	16/2050	16/2051	16/2052	16/2053	16/2054	16/2055	16/2056	16/2057	16/2058	16/2059	16/2060
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver pooled	Brown rat liver pooled	Brown rat liver pooled	field vole lever pooled
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:														
$d^{13}C_{VPDB}$	-24,48	-27,23	-24,86	-26,04	-27,61	-27,47	-24,04	-24,93	-27,10	-24,74	-	-	-	-28,27
$d^{15}N_{AIR}$	8,32	6,82	8,24	9,98	7,04	6,86	8,20	6,99	6,37	8,83	-	-	-	6,01
$d^{34}S_{CDT}$	7,59	8,17	8,94	7,90	6,79	6,20	6,67	5,73	6,37	6,55	-	-	-	6,04
fett%	6,42	5,64	4,82	4,80	4,66	4,40	4,22	3,76	3,62	3,22	-	-	-	-

<LOD Less than Limit of Quantification

UV and biocides

NILU sample ID:	16/1983	16/1984	16/1985	16/1986	16/1987	16/1988	16/1989	16/1990	16/1991
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Air	Air	Air	Soil	Soil	Soil	Soil	Soil	Soil pooled
Concentration units:	ng/PUF	ng/PUF	ng/PUF	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g ww
Compound name:									
BP3	-	-	-	-	-	-	-	-	<LOD
EHMC	-	-	-	-	-	-	-	-	<LOD
UV-329	-	-	-	-	-	-	-	-	<LOD
OC	-	-	-	-	-	-	-	-	<LOD
UV-328	-	-	-	-	-	-	-	-	<LOD
UV-327	-	-	-	-	-	-	-	-	<LOD
Bromodiolone	-	-	-	-	-	-	-	-	-
Brodifacoum	-	-	-	-	-	-	-	-	-
Flocumafen	-	-	-	-	-	-	-	-	-
Difenacoum	-	-	-	-	-	-	-	-	-

<LOD Less than Limit of Quantification

UV and biocides

NILU sample ID:	16/1992	16/1993	16/1994	16/1995	16/1996	16/1997
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:						
BP3	-	-	-	-	-	<LOD
EHMC	-	-	-	-	-	<LOD
UV-329	-	-	-	-	-	<LOD
OC	-	-	-	-	-	<LOD
UV-328	-	-	-	-	-	<LOD
UV-327	-	-	-	-	-	<LOD
Bromodiolone	-	-	-	-	-	-
Brodifacoum	-	-	-	-	-	-
Flocumafen	-	-	-	-	-	-
Difenacoum	-	-	-	-	-	-
	-	-	-	-	-	-

<LOD Less than Limit of Quantification

UV and biocides

NILU sample ID:	16/2008	16/2009	16/2010	16/2011	16/2012	16/2013	16/2014	16/2015	16/2016	16/2017	16/2018	16/2019	16/2020
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver pooled sample	Red fox liver pooled sample	Red fox liver pooled sample
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
BP3	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
EHMC	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
UV-329	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
OC	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
UV-328	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
UV-327	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
Bromodiolone	118	38,0	367	12,0	1 579	996	3 883	2 324	1 640	724	-	-	-
Brodifacoum	310	341	259	69,0	465	314	238	1 069	1 072	530	-	-	-
Flocumafen	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
Difenacoum	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-

<LOD Less than Limit of Quantification

UV and biocides

NILU sample ID:	16/2021	16/2022	16/2023	16/2024	16/2025	16/2026	16/2027	16/2028	16/2029	16/2030	16/2031	16/2032	16/2033
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
BP3	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
EHMC	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
UV-329	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
OC	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
UV-328	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
UV-327	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
Bromodiolone	-	-	-	-	-	-	-	-	-	-	-	-	-
Brodifacoum	-	-	-	-	-	-	-	-	-	-	-	-	-
Flocumafen	-	-	-	-	-	-	-	-	-	-	-	-	-
Difenacoum	-	-	-	-	-	-	-	-	-	-	-	-	-

<LOD Less than Limit of Quantification

UV and biocides

NILU sample ID:	16/2034	16/2035	16/2036	16/2037	16/2038	16/2039	16/2040	16/2041	16/2042	16/2043	16/2044	16/2045	16/2046
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg samlepr	Tawny owl egg samlepr	Tawny owl egg samlepr
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
BP3	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
EHMC	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
UV-329	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
OC	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
UV-328	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
UV-327	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD
Bromodiolone	-	-	-	-	-	-	-	-	-	-	-	-	-
Brodifacoum	-	-	-	-	-	-	-	-	-	-	-	-	-
Flocumafen	-	-	-	-	-	-	-	-	-	-	-	-	-
Difenacoum	-	-	-	-	-	-	-	-	-	-	-	-	-

<LOD Less than Limit of Quantification

UV and biocides

NILU sample ID:	16/2047	16/2048	16/2049	16/2050	16/2051	16/2052	16/2053	16/2054	16/2055	16/2056	16/2057	16/2058	16/2059	16/2060
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver pooled	Brown rat liver pooled	Brown rat liver pooled	field vole lever pooled
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:														
BP3	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD
EHMC	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD
UV-329	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD
OC	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD
UV-328	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD
UV-327	-	-	-	-	-	-	-	-	-	-	<LOD	<LOD	<LOD	<LOD
Bromodiolone	<LOD	<LOD	56	161	<LOD	<LOD	51	14	<LOD	<LOD	-	-	-	<LOD
Brodifacoum	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
Flocumafen	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
Difenacoum	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD

<LOD Less than Limit of Quantification

Phenolic compounds incl. TBBPA

NILU sample ID:	16/1983	16/1984	16/1985	16/1986	16/1987	16/1988	16/1989	16/1990	16/1991
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Air	Air	Air	Soil	Soil	Soil	Soil	Soil	Soil pooled
Concentration units:	ng/PUF	ng/PUF	ng/PUF	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g dw	ng/g ww
Compound name:									
bisphenol S	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-
4,4-bisphenol F	-	-	-	4,20	4,57	<LOD	3,42	8,73	-
2,4-bisphenol F	-	-	-	4,98	4,88	<LOD	4,43	9,74	-
Bisphenol E (+60)	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-
bisphenol A	-	-	-	30,0	13,4	<LOD	10,4	13,7	-
bisphenol B	-	-	-	1,61	5,96	<LOD	1,37	1,33	-
bisphenol AF	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-
bsiphenol AP	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-
bisphenol Z	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-
bisphenol FL	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-
bisphenol BP	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-
bisphenol M	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-
bisphenol G	-	-	-	2,41	<LOD	<LOD	<LOD	<LOD	-
bisphenol P	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-
bisphenol TMC	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-
TBBPA	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-
4-octylphenol	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-
4-nonylphenol	-	-	-	<LOD	<LOD	<LOD	<LOD	<LOD	-

<LOD Less than Limit of Quantification

Phenolic compounds incl. TBBPA

NILU sample ID:	16/1992	16/1993	16/1994	16/1995	16/1996	16/1997
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm	Earthworm
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:						
bisphenol S	2,64	2,014	2,141	6,013	2,614	-
4,4-bisphenol F	<LOD	<LOD	<LOD	<LOD	<LOD	-
2,4-bisphenol F	16,87	<LOD	<LOD	<LOD	<LOD	-
Bisphenol E (+60)	58,50	<LOD	<LOD	<LOD	32,390	-
bisphenol A	27,32	47,126	45,438	125,117	40,190	-
bisphenol B	<LOD	188	306	231	163	-
bisphenol AF	<LOD	<LOD	<LOD	<LOD	<LOD	-
bsiphenol AP	<LOD	<LOD	<LOD	96,8	70,5	-
bisphenol Z	50,5	132,9	129,3	564,1	233,0	-
bisphenol FL	34	8,2	9,6	23,6	37,4	-
bisphenol BP	<LOD	<LOD	<LOD	<LOD	<LOD	-
bisphenol M	<LOD	<LOD	2,5	<LOD	16,1	-
bisphenol G	<LOD	460,0	<LOD	<LOD	322,6	-
bisphenol P	<LOD	<LOD	<LOD	<LOD	<LOD	-
bisphenol TMC	<LOD	29,7	<LOD	50,7	38,3	-
						-
TBBPA	<LOD	<LOD	<LOD	<LOD	<LOD	-
						-
4-octylphenol	<LOD	<LOD	<LOD	<LOD	<LOD	

4-nonylphenol	<LOD	<LOD	<LOD	<LOD	<LOD

<LOD Less than Limit of Quantification

Phenolic compounds incl. TBBPA

NILU sample ID:	16/1998	16/1999	16/2000	16/2001	16/2002	16/2003	16/2004	16/2005	16/2006	16/2007
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg	Fieldfare egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:										
bisphenol S	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
4,4-bisphenol F	<LOD	<LOD	<LOD	<LOD	2,40	<LOD	3,26	<LOD	<LOD	<LOD
2,4-bisphenol F	1,17	1,22	1,10	<LOD	2,36	1,06	2,92	<LOD	<LOD	<LOD
Bisphenol E (+60)	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
bisphenol A	<LOD	<LOD	299	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
bisphenol B	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
bisphenol AF	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
bsiphenol AP	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
bisphenol Z	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
bisphenol FL	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
bisphenol BP	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
bisphenol M	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,53	0,26	0,48
bisphenol G	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
bisphenol P	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
bisphenol TMC	<LOD	<LOD	<LOD	<LOD	2,19	<LOD	<LOD	<LOD	<LOD	<LOD
TBBPA	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

4-octylphenol	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
4-nonylphenol	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

<LOD Less than Limit of Quantification

Phenolic compounds incl. TBBPA

NILU sample ID:	16/2008	16/2009	16/2010	16/2011	16/2012	16/2013	16/2014	16/2015	16/2016	16/2017	16/2018	16/2019	16/2020
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver	Red fox liver samlepr.	Red fox liver samlepr.	Red fox liver samlepr.
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
bisphenol S	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
4,4-bisphenol F	<LOD	<LOD	1,52	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
2,4-bisphenol F	<LOD	<LOD	3,34	<LOD	2,97	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
Bisphenol E (+60)	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol A	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol B	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol AF	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bsiphenol AP	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol Z	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol FL	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol BP	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol M	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol G	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol P	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol TMC	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
TBBPA	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
4-octylphenol	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-

4-nonylphenol	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-

<LOD Less than Limit of Quantification

Phenolic compounds incl. TBBPA

NILU sample ID:	16/2021	16/2022	16/2023	16/2024	16/2025	16/2026	16/2027	16/2028	16/2029	16/2030	16/2031	16/2032	16/2033
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg	Sparrowhawk egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
bisphenol S	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,89	0,56	<LOD	0,40	-	-	-
4,4-bisphenol F	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	1,04	-	-	-
2,4-bisphenol F	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
Bisphenol E (+60)	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol A	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol B	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol AF	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bsiphenol AP	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol Z	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol FL	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol BP	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol M	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol G	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol P	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol TMC	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
TBBPA	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0,34	0,40	<LOD	<LOD	-	-	-
4-octylphenol	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-

4-nonylphenol	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-

<LOD Less than Limit of Quantification

Phenolic compounds incl. TBBPA

NILU sample ID:	16/2034	16/2035	16/2036	16/2037	16/2038	16/2039	16/2040	16/2041	16/2042	16/2043	16/2044	16/2045	16/2046
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg	Tawny owl egg samlepr	Tawny owl egg samlepr	Tawny owl egg samlepr
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
bisphenol S	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
4,4-bisphenol F	<LOD	<LOD	<LOD	<LOD	2,28	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
2,4-bisphenol F	<LOD	<LOD	<LOD	4,46	1,67	<LOD	<LOD	<LOD	<LOD	1,23	-	-	-
Bisphenol E (+60)	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol A	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol B	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol AF	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bsiphenol AP	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol Z	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol FL	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol BP	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol M	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol G	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol P	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
bisphenol TMC	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
TBBPA	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-
4-octylphenol	<LOD	-	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-

4-nonylphenol	<LOD	-	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-

<LOD Less than Limit of Quantification

Phenolic compounds incl. TBBPA

NILU sample ID:	16/2047	16/2048	16/2049	16/2050	16/2051	16/2052	16/2053	16/2054	16/2055	16/2056	16/2057	16/2058	16/2059	16/2060
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver	Brown rat liver pooled	Brown rat liver pooled	Brown rat liver pooled	field vole lever pooled
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:														
bisphenol S	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
4,4-bisphenol F	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
2,4-bisphenol F	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
Bisphenol E (+60)	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
bisphenol A	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
bisphenol B	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	486,9	<LOD	<LOD	-	-	-	9,10
bisphenol AF	2,07	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	12,99	<LOD	<LOD	-	-	-	<LOD
bsiphenol AP	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
bisphenol Z	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
bisphenol FL	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
bisphenol BP	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
bisphenol M	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
bisphenol G	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
bisphenol P	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
bisphenol TMC	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
TBBPA	6,42	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD
4-octylphenol	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	-	-	-	<LOD

4-nonylphenol	<LOD	<LOD	<LOD	7,65	<LOD	0,31	<LOD	0,44	1,27	<LOD	-	-	-	<LOD

<LOD Less than Limit of Quantification

Dechlorane

NILU sample ID:	16/2021	16/2022	16/2023	16/2024	16/2025	16/2026	16/2027	16/2028	16/2029	16/2030	16/2031	16/2032	16/2033
Location	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo	Oslo
Sample type:	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg	Sparrow-hawk egg
Concentration units:	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww	ng/g ww
Compound name:													
Dechlorane 602	-	-	-	-	-	-	-	-	-	-	0,72	6,13	0,50
Dechlorane 603	-	-	-	-	-	-	-	-	-	-	0,49	0,97	0,79
Dechlorane 604	-	-	-	-	-	-	-	-	-	-	<0,2	<0,2	<0,2
Dechlorane plus syn	-	-	-	-	-	-	-	-	-	-	0,27	0,16	0,11
Dechlorane plus anti	-	-	-	-	-	-	-	-	-	-	0,59	0,52	0,22

<LOD Less than Limit of Quantification

Appendix 2

PNECSoil and PNECpred values from various literature sources

PNEC values

PNEC values for Soil ecosystem with references. Most data adopted from Andersen et al 2012, EU risk assessment reports (EU RAR), Environment Agency risk evaluation reports (EA ERAR) and European Chemicals Agency, http://echa.europe.eu. Entries with font coloured in grey are not used in the calculations.

Compound	PNEC$_{Soil}$	Unit	Reference	Safety factor	Endpoint
BPA	3.2	mg/kg dw	EU RAR BPA	10	Calculated from PNECaquatic -D. magna
TBBPA	0.012	mg/kg dw	EU draft RAR TBBPA	10	Earthworm reproduction
PentaBDE	0.38	mg/kg dw	TA-2625	50	
OctaBDE	20.9	mg/kg ww	EU RAR 2003	50	Phytotoxicity
DecaBDE	98	mg/kg ww	EU RAR 2002	50	
HexBDE	1.2	mg/kg ww	EU RAR 2003	50	Phytotoxicity
TriBDE	20.9	mg/kg ww	Using Octa BDE value	50	Phytotoxicity
TetraBDE	20.9	mg/kg ww	Using Octa BDE value*	50	Phytotoxicity
HeptaBDE	20.9	mg/kg ww	Using Octa BDE value	50	Phytotoxicity
NonaBDE	20.9	mg/kg ww	Using Octa BDE value	50	Phytotoxicity
Cyclic siloxane (D4)	0.16	mg/kg ww	EA ERA 2009 Octamethylcyclotetra-siloxane		PNEC for water, equilibrium partitioning method
Cyclic siloxane (D4)	0.15	mg/kg dw	European Chemicals Agency,		partition coefficient
Cyclic siloxane (D5)	4.8	mg/kg ww	EA ERA 2009 Decamethylcyclo-pentasiloxane		PNEC for water, equilibrium partitioning method
Cyclic siloxane (D5)	3.77	mg/kg dw	European Chemicals Agency	100	
Nonylphenols	0.3	mg/kg dw	European Chemicals Bureau, 2002	10	Earthworm reproduction
Octylphenols	0.0067	mg/kg dw	Environmental Agency (UK) 2005	10	Calculated from PNECaquatic-mysid M. bahia
4-tert-octylphenol	0.0059	*mg/kg ww*	EA RER 2005 4-tert-octylphenol	Large uncertainty	PNEC surface water and equilibrium partitioning
4-tert-octylphenol	2.3	mg/kg dw	European Chemicals Agency,	10	
MCCP	11.9	mg/kg dw	European Chemicals Agency,	10	
SCCP	5.95	mg/kg dw	European Chemicals Agency,	20	
MCCP	10.6	mg/kg ww	EU RAR addendum 2007	**10**	Earthworm reproduction
SCCP	1.76	mg/kg ww	EU RAR addendum 2008	**0**	LogKow estimation- no safety factor
PFOA	0.16	mg/kg dw	TA-2444/2008	100	Worm reproductivity
PFOS	0.373	mg/kg dw	pfos.uk.risk.eval.report.2004	1000	Worm toxicity
SumPCB$_7$	0.01	mg/kg dw	Aquateam rapport nr 06-039	50	Calculated from aquatic data
TCEP	0.386	mg/kg dw	EURAS, 2009	50	Folsomia candida 28 d exposure
TCPP	1.7	mg/kg dw	EU RAR TCPP	10	Spiring Lactuca sativa
TDCP/TDCPP	0.33	mg/kg dw	EU RAR 2008	10	57d NOEC reproduction toxicity E.foetida

TBEP	0.81	mg/kg dw	TA-2784	EqP	Calculated
EHDPP	0.302	mg/kg ww	Environmental Agency (UK), 2009	10	Estimated from aquatic data
TCP	0.0027	mg/kg dw	EU-RER	10	Spiring Lactuca sativa
TBP/TnBP	5.3	mg/kg dw	TA-2784	EqP	Based on LogKow
TBP/TnBP	0.64	mg/kg dw	ECHA-Registration dossier		
TIBP	0.64	mg/kg dw	TA-2784	EqP	Based on LogKow
Cd	1.15	mg/kg dw	European chemicals Bureau, 2007	2	*SSD: species sensitivity distribution*
Cd	0.9	mg/kg dw	European Chemicals Agency,		
Cr	62	mg/kg dw	European chemicals Bureau, 2005	3	Estimated from aquatic data
Cu	89.6	mg/kg dw	European chemicals Bureau, 2008	2	SSD
Cu	65	mg/kg dw	European Chemicals Agency		
Hg	0.3	mg/kg dw	Euro-chlor, Voluntary risk assessment, Mercury, 2004	1000	Background value Soil
Hg	0.022	mg/kg dw	European Chemicals Agency,		
Ni	50	mg/kg dw	VKM report 2009	2	SSD
Pb	166	mg/kg dw	EURAS, 2008	2	SSD
Pb	147-212	mg/kg dw	European Chemicals Agency,		
Zn	26	mg/kg dw	VROM, 2008	2	SSD
Zn	35.6	mg/kg dw	European Chemicals Agency,		
As	0.7	mg/kg dw	Reimann et al. (2017)[2]		

---

[2] Reimann et al. (2017). GEMAS: Establishing geochemical background and threshold for 53 chemical elements in European agricultural soil. Applied Geochemistry

PNEC$_{pred}$ values (mg/kg in food) for secondary poisoning with references. Most data adopted from Andersen et al 2012, EU risk assessment reports (EU RAR), Environment Agency risk evaluation reports (EA ERAR) and European Chemicals Agency, http://echa.europe.eu. Entries with font coloured in grey are not used in the calculations.

Compound	PNEC$_{pred}$ mg/kg	Reference	Safety factor	Endpoint
BPA	2.67	EU RAR BPA add	30	Three generation feeding study of rats
TBBPA	667	(mammalian) EU RAR TBBPA	30	2-generation rat reproduction study
PentaBDE	1	EU Risk assessment-Diphenyl Ether, Pentabromo derivative Final Report, August 2000	10	30 day oral rat study-liver effects
OctaBDE	6.7	EU Risk assessment-Diphenyl Ether, Octabromo derivative Final Report, August 2003	10	Rabbit phetotoxicity
DecaBDE	833	DecaBDE, EA-ENvRA-2009	30	Rat, two years carcinogenicity study
PFOS	0.067	Brooke et al. 2004 http://www.environment-agency.gov.uk/	30	Rat liver effects, chronic study NOEC 2mg/kg
PFOS	0.017	Brooke et al. 2004	30	Rat liver effects, chronic study Lowest no effect 0.5 ppm
PFOS	0.037	RIVM 2010 http://www.rivm.nl/dsresource?objectid=rivmp:15878&type=org&disposition=inline&ns_nc=1	90	NOAEL of 0.1 mg/kgbw/d for maternal weight gain from a teratogenicity study
PFOS	0.33	Newsted et al 2007, in Appendix 3, RIVM 2010	30	21 weeks, bodyweight, reproduction, NOEC, northern bobwhite quail
PFOA	0.9E-03	Valsecchia et al 2016 doi:10.1016/j.jhazmat.2016.04.055	90	Developmental abnormalities in mice
HCB	0.0167	Science Dossier http://www.eurochlor.org/media/90477/sd16-hcbaquaticra-final.pdf	30	NOEC mink 0.5 mg/kg
Cyclic Siloxane (D4)	1.7	EA ERAR 2009 Octamethylcyclotetra-siloxane	300	Rat liver effects
Cyclic Siloxane (D4)	41	Source: European Chemicals Agency, http://echa.europa.eu/	90	
Cyclic Siloxane (D5)	13	EA ERAR 2009 Decamethylcyclopenta-Siloxane,	30	Repeated exposure, liver effects

Compound	$PNEC_{pred}$ mg/kg	Reference	Safety factor	Endpoint
Cyclic Siloxane (D5)	16	Source: European Chemicals Agency, http://echa.europa.eu/	90	
Cyclic Siloxane (D6)	66.7	Source: European Chemicals Agency, http://echa.europa.eu/	300	
Cyclic Siloxane (D6)	50-100	EA ERAR 2009	300	Reproduction NOAEL rat
Nonylphenols	10	EU RAR nonylphenol	10	Rat multi-generation study, reproduction effect
Octylphenols	10	Environmental Agency (UK) 2005	30	Rat, two-generation study, systemic and postnatal toxicity
4-tert-octylphenol	10	EA RER 2005 4-tert-octylphenol	30	
4-tert-octylphenol	2.36	Source: European Chemicals Agency, http://echa.europa.eu/	30	
MCCP	10	EU RAR addendum 2007	30	Rat, 90 days study, kidney effects
SCCP	5.5	EU RAR addendum 2008	30	Reproduction effects on wild duck
TDCP	3.3	EU RAR 2008	30	Two-years carcinogenicity rat study
EHDPP	1.1	Environmental Agency (UK) 2009	90	Rat 90 d oral exposure
TCP	1.7	EA RER 2009 (1330-78-5)	30	Two-years reproduction mouse study
TCPP	11.6	EU RAR TCPP 2008	90	Rat, 13 weeks study, liver effects
PCB153	0.67	TemaNord 2011: 506. ISBN 978-92.893-2194-5 Using Sludge on Arable Land (Table 7)	20	RIVM (1995) Risk assessment of bioaccumulation in the food webs of two marine AMOEBE species: common tern and harbor seal. RIVM Report 719102040.
Cd	0.16	EU RAR	10	Based on 4 studies with birds and 5 studies with mammals
Hg	0.4	2009, Munoz et al.	10	NOEC 4 mg/kg food for Coturnis c. Japonica.
Ni	8.5	EU RAR Ni 2008	10	Wild duck, tremor effects observed in chickens at day 28
Pb	3.6	Lead Water Framework Directive EQS dossier 2011	15	SSD

$PNEC_{pred}$ not found for PCB7

EU RAR: EU Risk Assessment report

EA RER: Environmental Agency Risk Evaluation Report

Appendix 3

GPS locations for sampling locations

GPS locations for sampling locations

Location	UTM-zone	East Coordinates	North Coordinates
Air			
16/1983	32V	59,90853	10,82415
16/1984	32V	59,91703	10,72428
16/1985	32V	59,97938	10,66817
Soil			
16/1987	32V	59,91423	10,82915
16/1988	32V	59,91703	10,72428
16/1989	32V	59,97938	10,66817
16/1990	32V	59,9771	10,68045
16/1991	32V	59,90422	10,79267
Earthworm			
16/1992	32V	59,91423	10,82915
16/1993	32V	59,91703	10,72428
16/1994	32V	59,97938	10,66817
16/1995	32V	59,9771	10,68045
16/1996	32V	59,90422	10,79267
Red fox			
16/2008	32V	86,13695	31,59972
16/2009	32V	60,01002	10,7765
16/2010	32V	60,01002	10,7765
16/2011	32V	60,01002	10,7765
16/2012	32V	60,01002	10,7765
16/2013	32V	60,01002	10,7765
16/2014	32V	60,01002	10,7765
16/2015	32V	60,01002	10,7765
16/2016	32V	60,01002	10,7765
16/2017	32V	60,0365	10,59467
Brown rat			
16/2048	32V	60,56597	11,45952
16/2049	32V	60,54978	11,09392
16/2050	32V	60,51937	11,2447
16/2051	32V	60,56597	11,45952
16/2052	32V	60,56597	11,45952
16/2053	32V	60,5936	11,54495
16/2054	32V	60,53407	11,26518
16/2055	32V	60,56597	11,45952
16/2056	32V	60,5317	11,16922
Fieldfare			
16/1998	32V	59,99467	10,75348
16/1999	32V	59,96078	10,68315
16/2000	32V	59,9647	10,78805
16/2001	32V	59,95905	10,87445
16/2002	32V	59,90427	10,7917
16/2003	32V	59,89743	10,7722
16/2004	32V	59,8857	10,84808
16/2005	32V	59,87123	10,83672
16/2006	32V	59,83785	10,8508
16/2007	32V	59,96022	10,87525
Tawny owl and Sparrowhawk	Confidential for species protection	Confidential for species protection	Confidential for species protection

Norwegian Environment Agency
Telephone: +47 73 58 05 00 | Fax: +47 73 58 05 01
E-mail: post@miljodir.no
Web: www.environmentagency.no
Postal address: Postboks 5672 Sluppen, N-7485 Trondheim
Visiting address Trondheim: Brattørkaia 15, 7010 Trondheim
Visiting address Oslo: Grensesvingen 7, 0661 Oslo

The Norwegian Environment Agency is working for a clean and diverse environment. Our primary tasks are to reduce greenhouse gas emissions, manage Norwegian nature, and prevent pollution.

We are a government agency under the Ministry of Climate and Environment and have 700 employees at our two offices in Trondheim and Oslo and at the Norwegian Nature Inspectorate's more than sixty local offices.

We implement and give advice on the development of climate and environmental policy. We are professionally independent. This means that we act independently in the individual cases that we decide and when we communicate knowledge and information or give advice.

Our principal functions include collating and communicating environmental information, exercising regulatory authority, supervising and guiding regional and local government level, giving professional and technical advice, and participating in international environmental activities.