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Environmental pollutants in the terrestrial and urban environment 2024

MILBY 2024

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Environmental pollutants in the terrestrial and urban environment 2024

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Short summary (English)
Samples from the urban terrestrial environment in the Oslo area were analysed for metals and a large number of organic environmental pollutants. The selected sample types that were analysed were soil, earthworm, fieldfare and sparrowhawk eggs, liver samples of brown rat, red fox and badger and blood serum from dog. Biomagnification potential was estimated based on detected data for relevant predator-prey pairs.

Short summary (Norwegian)
Prøver fra det urbane terrestriske miljøet i Oslo-området ble analysert for metaller og et stort antall av kjente og nye organiske miljøgifter. De utvalgte prøvetypene som ble analysert var jord, meitemark, egg fra gråtrost og spurvehauk, lever fra brunrotte, rødrev og grevling og serum fra hund. Biomagnifiseringspotensial ble estimert basert på detekterbare data for relevante rov- og byttedyrpar.

Keywords
Urban terrestrial monitoring, POPs, PFAS, Metals, Bioaccumulation

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Contents

Abbreviations

BAF	bioaccumulation factor
BMF	biomagnification factor
BSAF	biota soil accumulation factor
CI	confidence interval
CRM	certified reference material
Dw	dry weight
EI	electron impact ionization
ESI	electrospray ionization
GC-MS	gas chromatography – mass spectrometry
GC-HRMS	gas chromatography – high resolution mass spectrometry
GPC	gel permeation chromatography
ICP MS	inductive coupled plasma – mass spectrometry
LC-MS	liquid chromatography – mass spectrometry
LOD	limit of detection
LOEL	lowest observed effect level
Lw	lipid weight
MDL	method detection limit
MEC	measured environmental concentration
M-W U	Mann–Whitney *U* test
n	number of analysed samples
n.a.	not analysed
NCI	negative chemical ionization
NOEC	no observed effect concentration
NOAEL	no observed adverse effect level
NOEL	no observed effect level
NP-detector	nitrogen-phosphorous detector
PCA	principal component analysis
PCI	positive chemical ionization
PEC	predicted environmental concentration
PNEC	predicted no effect concentration
PSA	primary/secondary amine phase
QSbiota	specific quality standard for concentration in prey biota tissue protective of secondary poisoning in predators;
SIR	selective ion reaction
SPE	solid phase extraction
SSD	species sensitivity distribution
TL	trophic level
TMF	trophic magnification factor
TOC	total organic carbon content
UHPLC	ultra high pressure liquid chromatography
Ww	wet weight

Environmental pollutants in the terrestrial and urban environment 2024

Summary

The MILBY project in the year 2024 covered sampling and analysis of soil, earthworm, fieldfare egg, brown rat liver, sparrowhawk egg, and liver from red fox and badger in the Oslo area. In addition, one pooled sample of blood serum from dogs was analysed for selected pollutant classes. The results from the year 2024 are generally comparable to the findings from previous years in this program period (2021-2025). In total, 167 single compounds, stable isotopes, lipid content in biota, and TOC in soil were analysed, in addition to PFAS TOP assay of dog serum. The detection frequencies in the various sample types were highest for contaminant classes, such as metals, PCBs, cyclic siloxanes, CPs, and PFAS.

Sparrowhawk egg, red fox liver, and badger liver were analysed for the first time in this program period. For the large PFAS group, the median PFOS concentrations were highest in badger liver, and the highest maximum concentrations were detected in bird eggs, followed by badger liver. Badger liver also had the highest concentrations of the compound, 7:3 FTCA, and together with sparrowhawk eggs, some of the highest concentrations of long chain carboxylates. PFOS and PFOA concentrations exceeded PNECoral (QSbiota) for secondary poisoning of predators in many samples of the species.

Brown rat samples have, over the years, proven to be a matrix that mirrors the signal of urban pollution with high concentrations of some contaminant groups, like PFAS, CPs, and siloxanes. As in previous years, for the group CPs, concentration of MCCP and LCCP were highest in brown rat liver (based on both wet weight and lipid weight) when comparing across species. The isomer or congener patterns of LCCP were comparable for rat liver, sparrowhawk eggs, and badger liver, and exhibited different patterns compared to the rest of the samples. For MCPP, the pattern for rat liver was different compared to the other sample types with detected concentrations. For the UV compounds and the phenols in the species, the maximum concentrations of UV-328 and bisphenol A (BPA) were also highest in rat liver.

Cyclic siloxanes were ubiquitous in the samples from Oslo, where rat liver and bird eggs had the highest levels. D5 in the rat liver samples was much lower in 2024 compared to previous years. OPFR had highest detection frequences in soil and earthworm samples. TEP dominated in earthworm, rat liver and bird eggs, and a relatively high concentration of EHDP was detected in one of the two red fox liver samples. The UV compounds UV-327 and UV-328 were important compounds in rat liver, whereas homosalate was present in earthworm and fieldfare egg. The rodenticide bromadiolone had the highest concentrations in badger and red fox liver samples. For the group dechloranes, syn- and anti-DP dominated in most sample types. Among the analysed phenols, BPA and 4-tert-octyphenol were the prevailing compounds in most matrices.

The PCB concentrations on a lipid weight basis were highest in sparrowhawk eggs, as was also observed in the previous program period. The Pb level of one pooled red fox liver was very high and exceeded a proposed toxicity threshold of 10 mg/kg. In addition, the Cd concentration in earthworms, liver samples of red fox and badger, and As in two rat liver samples exceeded PNECoral value for predators. The concentration of As in all soil samples exceeded the PNECsoil value for soil living organisms. The phthalate

compounds DEHP and DiNP dominated in the soil sample, whereas only DEP was detected in dog serum. The compound classes BFR and musk were only sparsely detected and in relatively low concentrations.

4-tert octylphenol (50 ng/g ww) and PFAS compounds were detected in the one pooled dog serum sample, but many of the selected pollutants were below detection or blank levels. The concentrations with the use of PFAS TOP assay were comparable to results of target analysis in dog serum. However for the compounds PFBA, PFPeA and PFBS the concentrations increased after the TOP assay.

Bioaccumulation calculation from soil to earthworm and biomagnification from earthworm to fieldfare egg (BMF) were for some compounds in agreement with other studies and revealed bioaccumulation from soil to earthworm for some OPFR, several PFAS compounds, cyclic siloxanes, Syn-DP and 4-tert-oktylphenol. BMF calculations indicated magnification of PCBs, UV-328 and several PFAS compounds.

Sammendrag

MILBY-prosjektet i 2024 omfattet prøvetaking og analyse av jord, meitemark, gråtrostegg, brunrottelever, spurvehaukegg, lever fra rødrev og grevling i Oslo-området. I tillegg ble en samleprøve av blodserum fra hund analysert for utvalgte miljøgiftklasser. Resultatene fra året 2024 er generelt sammenlignbare med funnene fra tidligere år i denne programperioden (2021-2025). Totalt ble 167 enkeltforbindelser, stabile isotoper, lipidinnhold i biota og TOC i jord analysert i tillegg til PFAS TOP-analyse av hundeserum. Deteksjonsfrekvensene i de ulike prøvene var høyest for forurensningsklasser som metaller, PCBer, sykliske siloksaner, CPer og PFAS.

Spurvehaukegg, rødrevlever og grevlinglever ble analysert for første gang i denne programperioden. For den store PFAS-gruppen var mediankonsentrasjonen av PFOS høyest i grevlinglever, og de høyeste maksimumskonsentrasjonene ble påvist i fugleegg etterfulgt av grevlinglever. Grevlinglever hadde også de høyeste konsentrasjonene av forbindelsen 7:3 FTCA, og sammen med spurvehaukegg også noen av de høyeste konsentrasjonene av langkjedede karboksylater. PFOS- og PFOA-konsentrasjonene oversteg PNECoral (QSbiota) for sekundær forgiftning av rovdyr i mange prøver av artene.

Prøver fra rotter har gjennom årene vist seg å være en art som gjenspeiler signalet fra urban forurensning med høye konsentrasjoner av enkelte forurensningsgrupper som PFAS, CPer og siloksaner. Som i tidligere år var konsentrasjonen av MCCP og LCCP høyest i brunrotte-lever (basert på både våtvekt og lipidvekt) når man sammenlignet mellom artene. Isomer- eller kongenermønstrene for LCCP var sammenlignbare for rottelever, spurvehaukegg og grevlinglever, og med et annet mønster sammenlignet med resten av prøvene. For MCPP var mønsteret for rottelever annerledes enn for de andre prøvene med påviste konsentrasjoner. For UV stoffene og fenoler, var de høyeste konsentrasjonene av UV-328 og bisfenol A (BPA) funnet i rottelever.

Sykliske siloksaner var allestedsnærværende i prøvene fra Oslo, der rottelever og fugleegg hadde de høyeste nivåene, og D5 i rotteleverprøvene var mye lavere i år 2024 sammenlignet med tidligere år. OPFR forbindelsene hadde høyest deteksjonsfrekvens i jord- og meitemarkprøver. TEP dominerte i meitemark, rottelever og fugleegg, og en relativt høy konsentrasjon av EHDP ble påvist i en av de to prøvene av rødrevlever. UV-forbindelsene UV-327 og UV-328 var viktige forbindelser i rottelever, og homosalat i meitemark og gråtrostegg. Rodenticidet bromadiolon hadde de høyeste konsentrasjonene i leverprøver fra grevling og rødrev. For gruppen dekloraner dominerte syn- og anti-DP i de fleste prøvetypene. Blant de analyserte fenolene var BPA og 4-tert-oktyfenol de dominerende forbindelsene i flest prøver.

PCB konsentrasjonene på lipidvekt var høyest i spurvehaukegg, som også var observert i forrige programperiode. Pb-nivået i én samleprøve av rødrevlever var svært høyt og overskred den foreslåtte toksisitetsgrensen på 10 mg/kg, og Cd-konsentrasjonen i meitemark, leverprøver av rødrev og grevling, samt As i to leverprøver av rotte, overskred PNECoral-verdien for rovdyr. Konsentrasjonen av As i alle jordprøver overskred PNEC-jord for jordlevende organismer. Ftalatforbindelsene DEHP og DiNP dominerte i jordprøvene, og kun DEP ble påvist i hundeserum. BFRer og muskforbindelsene hadde lav deteksjonsfrekvens og i relativt lave konsentrasjoner.

4-tert-oktylfenol (50 ng/g vv) og PFAS-forbindelser ble detektert i samleprøven av serum fra hund, men mange av de utvalgte miljøgiftene var under deteksjons- eller blanknivå. Konsentrasjonene ved bruk av PFAS TOP assay var sammenlignbare med resultatene fra target-analyse i hundeserum, men konsentrasjonene for PFBA, PFPeA og PFBS økte etter TOP assay.

Beregning av bioakkumulering fra jord til meitemark og biomagnifisering fra meitemark til gråtrostegg (BMF) var sammenlignbare med andre studier og viste akkumulering fra jord til meitemark for noen OPFR, flere PFAS-forbindelser, sykliske siloksaner, Syn-DP og 4-tert-oktylfenol. BMF-beregninger indikerte magnifisering av PCBer, UV-328 og flere PFAS-forbindelser.

1 Background

Terrestrial ecosystems cover soil, plants, and food chains of organisms that live and grow on land. The main objective of this monitoring program Environmental pollutants in the terrestrial and urban environment “MILBY” is to assess the occurrence and bioaccumulation potential of certain environmental pollutants in a terrestrial urban ecosystem, and potential sources of pollution.

The monitoring is conducted in Oslo, the capital of Norway, and Norway’s largest city. The sampling design with various locations for sample collection aims to reflect the general exposure of wildlife to pollution in an urban region. The program is not specifically designed as a monitoring program with the objective to produce temporal trend studies, or to assess and discuss pollutant differences across the various areas of the city.

The program is led by NILU in collaboration with The Norwegian Institute for Nature Research (NINA), The Norwegian Institute for Water Research (NIVA), and the Institute for Energy Technology (IFE). MILBY, together with the monitoring programs: “Environmental pollutants in an urban fjord” that monitors environmental pollutants in the inner Oslofjord; MILFERSK, which monitors pollutants in Mjøsa; and “Atmospheric contaminants” that monitors contaminants in urban air in Oslo and remote areas, seek to assess the presence and environmental uptake of environmental pollutants from sources in an urban environment.

Key goals of the programme:

- Report concentrations of selected environmental pollutants at different trophic levels of a terrestrial food web in an urban area.
- Estimate bioaccumulation and biomagnification potential of the different pollutants in food chains.
- Contribute with information about potential sources of pollutants for terrestrial organisms.

A broad range of environmental pollutants, consisting of metals, polychlorinated biphenyls (PCBs), brominated flame retardants (BFRs), organic phenolic pollutants, ultraviolet (UV) stabilizing substances, per- and polyfluoroalkyl substances (PFAS), siloxanes, chlorinated paraffins (CPs), organic phosphorous flame retardants (OPFRs), dechloranes and selected biocides were measured in the following sample types:

- five pooled samples of soil from five locations, year 2024
- five pooled samples of earthworm from five locations, year 2024
- five pooled samples of fieldfare egg from five locations, year 2024
- five pooled samples of brown rat liver from five locations, year 2024
- three pooled egg samples of sparrowhawk from three locations across years
- two pooled liver sample of red fox liver from two locations across years
- two pooled liver sample of badger liver from two locations across years
- one pooled sample of serum from 38 dogs

A description of the various species, pollutants, and how the samples were handled and prepared, is provided in the Material and Methods, Appendix 1, as are the chemical analyses and the quality assurance measures taken.

Due to the different physicochemical properties of the pollutants of interest, several different sample preparations methods were applied. Lipophilic compounds, such as PCB, BFR, and CP, were analysed together. PFAS, metals, phenols, siloxanes, UV compounds, phthalates, and selected biocides each required dedicated sample preparation.

NILU id and GPS coordinates of the samples are given in Appendix 1, chapter 4.2.

2 Plan for sampling and analysis in 2024

An overview of the analysed species and sample types is given in Table 1, and locations are given in Figure 1 and Table 2. All samples were collected and handled according to the guidelines given in the Coordinated Environmental Monitoring Program, CEMP, of the OSPAR commission[1]. The type of samples and collection procedures for 2024 are described in Appendix 1. Analytical endpoints in the various samples are shown in Table 3.

The sampling sites at Alna and Alnabru are located in an area with industrial activity and are close to one of Oslo's main highways, where Alnaparken is a park along Alnaelva in the Grorud valley. Ammerud and Hølaløkka comprise Grorud valley with the Alna river and are partly recreational areas with parks. The sampling site in Svartdalsparken near Alnaelva is at a former landfill, which has been converted and restored to a recreational area. Various urban locations were relevant for the collection and sampling of brown rats.

2.1 Sampling plan in 2024

Table 1: Type of samples, sampling strategy showing whether and how samples where pooled before analysis, number of samples analysed and locations, (Coordinates can be found in Appendix 1, 4.2). Locations correspond to those shown in Figure 1.

Sample type	Sampling strategy	No. of samples	Locations	Year
Soil	Approx. 3 subsamples were pooled together to one sample per location	5	Alna, Alnaparken, Ammerud, Hølaløkka, Svartdalen	2024
Earthworms *Lumbricidae*	Approx. 60-70 individuals per location	5	Alna, Alnaparken, Ammerud, Hølaløkka, Svartdalen	2024
Fieldfare *Turdus pilaris*	Pool of 2 eggs from 5 nests/locations	5	Alna, Alnaparken, Ammerud, Hølaløkka, Svartdalen	2024
Brown rat liver *Rattus norvegicus*	Pool of 2-3 individual livers, preferentially same gender from various places in the city centre	5	Oslo city	2024
Dog *Canis lupus familiaris*	Pool of 38 individual serum samples from dogs	1	Bergen	2024
Sparrowhawk *Accipiter nisus*	Pooled of egg samples across years for three locations	3	Oslo area	2021-2023
Red fox *Vulpes vulpes*	Pooled of liver samples across years for two locations	2	Oslo area	2021-2023
Badger *Meles meles*	Pooled of liver samples across years for two locations	2	Oslo area	2021-2023

[1] https://www.ospar.org/documents?d=32414

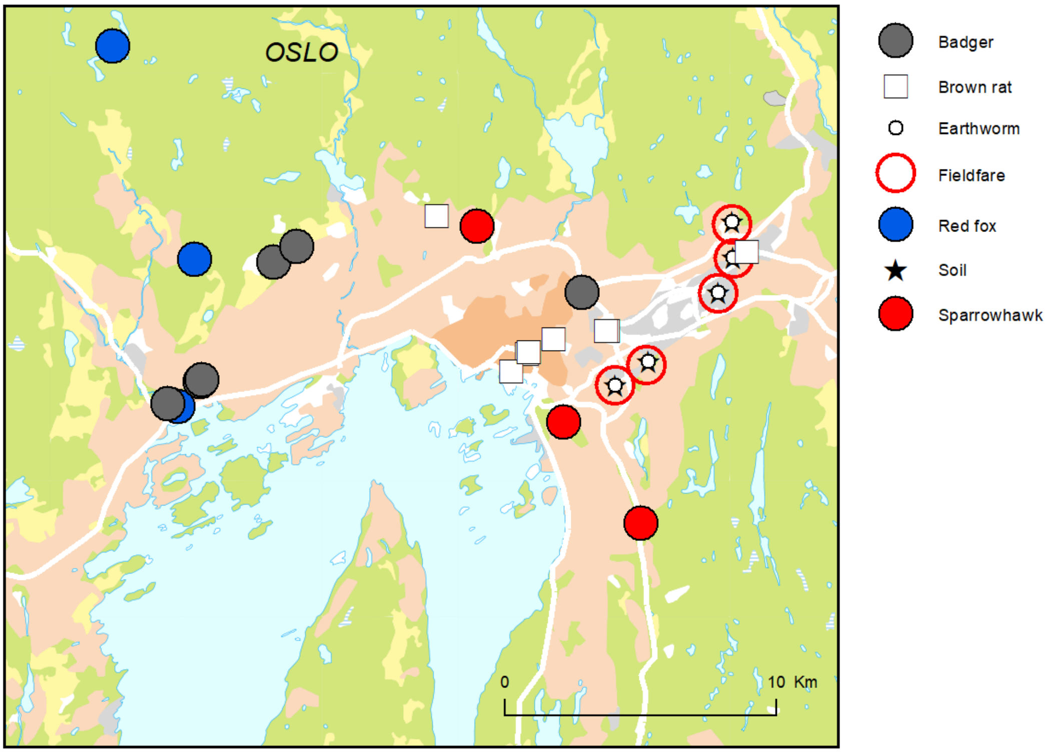


Figure 1: Locations of samples analysed in 2024. See below for the corresponding table of sample types and locations, and Appendix 1 for coordinates of the sites. Fieldfare and sparrowhawk refer to eggs. Note that some samples were pooled together across locations (see Table 1), and note that more samples were collected but not analysed in 2024, and these are not shown here.

Table 2: Locations of all samples collected and analysed in 2024 in the Oslo area. Locations are shown in the map in Figure 1. See Appendix 1, chapter 4.2 for coordinates of the samples.

Area	Sampling sites	Soil	Earth-worm	Fieldfare Egg	Brown rat	Sparrow-hawk egg	Red fox	Badger
Oslo	Alna	X	X	X				
Oslo	Alnaparken	X	X	X				
Oslo	Ammerud	X	X	X				
Oslo	Hølaløkka	X	X	X				
Oslo	Svartdalen	X	X	X				
Oslo	Torggata				X			
Oslo	Eikenga				X			
Oslo	Frognerseterv.				X			
Oslo	Sofienberggt.				X			
Oslo	Kongens gt.				X			
Oslo	Bekkestenv.				X			
Oslo	Torggt.				X			
Oslo	Gråkammen					X		
Oslo	Skullerud					X		
Oslo	Ekeberg					X		
Oslo	Hellerudmyra						X	
Bærum	Bærum						X	X
Oslo	Oslo centroid#							X

#unknown locations, Oslo centroid (Sinsenkrysset) is used.

2.2 Pollutants and other analytical endpoints in 2024 matrices

The various contaminant classes and other analytical endpoints are given in Table 3. Phthalates were only analysed in the soil samples and biocides were analysed in sparrowhawk eggs and liver samples from brown rat, red fox and badger. The detection rates of the analytical endpoints are given in *Table 4.*

Table 3: Type of matrices and analytical endpoints in 2024.

Contaminant classes and parameters	Soil	Earthworm	Fieldfare egg	Brown rat liver	Sparrowhawk egg	Red fox liver	Badger liver	Dog serum
Metals	X	X	X	X	X	X	X	
PCBs	X	X	X	X	X	X	X	
PFCA	X	X	X	X	X	X	X	X
PFAS	X	X	X	X	X	X	X	X
New PFAS	X	X	X	X	X	X	X	X
TOPA								X
Other BFRs	X	X	X	X	X	X	X	
Dechloranes	X	X	X	X	X	X	X	X
Siloxanes	X	X	X	X	X	X	X	
CPs	X	X	X	X	X	X	X	X
OPFRs	X	X	X	X	X	X	X	X
UV-comp.	X	X	X	X	X	X	X	X
Bisphenols/phenols	X	X	X	X	X	X	X	X
Musk comp.	X	X	X	X	X	X	X	
Biocides				X	X	X	X	
Phthalates	X							X
Antioxidants								X
Stable isotope $\delta^{15}N$	X	X	X	X	X	X	X	
Stable isotope $\delta^{13}C$	X	X	X	X	X	X	X	
Lipid content	X	X	X	X	X	X	X	
TOC & pH	X							

3 Key findings

A list of the selected environmental pollutants with abbreviations and CAS no. can be found in Appendix 1, Table 24. In addition, Appendix 1 gives background information on the sampling strategies, compound classes, analytical and statistical methods.

In total, 167 environmental pollutants from 16 pollutant groups were analysed. In addition, other important parameters, such as $\delta^{13}C$ and $\delta^{15}N$ isotopes, lipid content in biological samples, dry matter, pH, and TOC in soil were analysed.

In the chapters below, tables with median, minimum, and maximum concentrations are given for each component where the number of samples was two or more. For dog only one concentration is available for most compound classes, except for the PFAS where there were two samples due to both target and TOP assay analyses. All concentrations in the tables are given as ng/g except for the metals where concentrations are given as mg/kg. All concentrations in biota are given on a wet weight (ww) basis whereas soil concentrations are given on a dry weight (dw) basis.

Table 4 shows the detection frequencies for the components in the different sample types. Environmental pollutants not analysed in the samples, are denoted "n.a.". The number of samples, denoted "n=" , are given above each sample type in the table. As can be seen, metals were detected in almost all of the samples, which was also the case for the PCBs, followed by cyclic siloxanes, PFAS and LCCPs.

Only the key findings are given in this chapter with an emphasis on results of non legacy contaminant groups, groups which have recently been regulated or banned, and for contaminant groups where only a few compounds are regulated.

Most box plots have been created with Online Graph Maker ·Plotly Chart Studio and the JMP program (JMP version 18.2.0) without outliers. In some of the figures, the R program[2] has been used for creating box plots where the boxes stretch from the first to third quartile and the horizontal line representing the measurement median. The whiskers extend to 1.5 times the interquartile range, and the points reveal outliers (extreme values).

Appendix 2, Results give the full overview.

[2] R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Table 4: Detection frequency (%) of components in various sample types. n.a.: not analysed. The colour scale is from navy blue (100 % detection) through lighter blue to white (0%, not detected).

		n=5	n=5	n=5	n=5	n=1	n=3	n=2	n=2
Compound group	**Abbreviation**	**Soil**	**Earthworm**	**Fieldfare egg**	**Rat liver**	**Dog (Serum)**	**Sparrow-hawk egg**	**Red fox liver**	**Badger liver**
Metals	Cr	100	100	100	100	n.a.	100	100	100
Metals	Ni	100	100	100	40	n.a.	67	50	100
Metals	Cu	100	100	100	100	n.a.	100	100	100
Metals	Zn	100	100	100	100	n.a.	100	100	100
Metals	As	100	100	100	100	n.a.	100	100	100
Metals	Ag	100	100	100	100	n.a.	100	100	100
Metals	Cd	100	100	100	100	n.a.	100	100	100
Metals	Sn	100	40	100	40	n.a.	100	50	0
Metals	Sb	100	100	0	100	n.a.	33	100	100
Metals	Gd	100	100	0	60	n.a.	0	100	100
Metals	Pb	100	100	100	100	n.a.	100	100	100
Metals	Hg	100	100	100	100	n.a.	100	100	100
PCBs	CB28	20	100	100	80	n.a.	100	0	50
PCBs	CB52	40	100	100	40	n.a.	100	50	0
PCBs	CB101	100	100	100	100	n.a.	100	100	50
PCBs	CB118	100	100	100	100	n.a.	100	100	100
PCBs	CB138	100	100	100	100	n.a.	100	100	100
PCBs	CB153	100	100	100	100	n.a.	100	100	100
PCBs	CB180	100	100	100	100	n.a.	100	100	100
other BFRs	α-HBCD	40	40	100	60	n.a.	100	0	0
other BFRs	β-HBCD	20	0	0	0	n.a.	0	0	0
other BFRs	γ-HBCD	0	0	0	0	n.a.	0	0	0
other BFRs	ATE	0	20	20	60	n.a.	0	50	0
other BFRs	α-TBECH	0	0	0	20	n.a.	0	0	0
other BFRs	β-TBECH	0	0	0	20	n.a.	0	0	0
other BFRs	γ/δ–TBECH	0	20	0	40	n.a.	0	0	0
other BFRs	BATE	0	20	40	60	n.a.	0	0	0
other BFRs	PBT	0	20	20	60	n.a.	0	0	0
other BFRs	PBEB	0	20	20	60	n.a.	0	0	0
other BFRs	PBBZ	0	20	0	40	n.a.	0	0	0
other BFRs	PTBX	20	20	20	40	n.a.	33	0	0
other BFRs	HBB	0	20	0	60	n.a.	0	0	0
other BFRs	DPTE	0	20	20	60	n.a.	0	0	0
other BFRs	EHTBB	0	20	0	60	n.a.	0	0	0
other BFRs	BTBPE	0	0	0	0	n.a.	0	0	0
other BFRs	TBPH	0	0	0	0	n.a.	0	0	0
other BFRs	DBDPE	40	0	0	0	n.a.	0	0	0
CPs	SCCP	0	0	0	0	0	33	0	0
CPs	MCCP	20	60	80	80	0	33	0	0
CPs	LCCP	100	60	100	100	0	100	100	50
Siloxanes	D4	60	100	100	100	n.a.	100	100	100
Siloxanes	D5	60	100	100	100	n.a.	100	100	100
Siloxanes	D6	60	80	100	100	n.a.	100	100	100
Siloxanes	L3	0	0	0	0	n.a.	0	0	0
Siloxanes	L4	0	0	0	0	n.a.	0	0	0
Siloxanes	L5	0	0	0	0	n.a.	0	0	0
Siloxanes	M3T (Ph)	0	0	0	0	n.a.	0	0	0
UV compounds	OC	0	0	20	0	0	0	0	0
UV compounds	BP3	0	100	20	20	0	0	0	50
UV compounds	EHMC	0	0	20	20	0	0	0	0
UV compounds	UV-327	20	0	60	60	0	100	0	0
UV compounds	UV-328	60	80	80	80	0	100	50	0
UV compounds	UV-329	0	0	0	0	0	0	0	0
UV compounds	Homosalate	0	40	0	0	100	0	0	0

Compound group	Abbreviation	Soil n=5	Earthworm n=5	Fieldfare egg n=5	Rat liver n=5	Dog (Serum) n=1	Sparrow-hawk egg n=3	Red fox liver n=2	Badger liver n=2
OPFRs	TCEP	80	0	0	0	0	0	0	0
OPFRs	TCPP	100	100	100	100	100	100	100	100
OPFRs	TDCPP	0	0	0	0	0	0	0	0
OPFRs	TBEP	100	60	40	40	0	33	50	50
OPFRs	EHDP	60	0	0	0	0	0	50	0
OPFRs	TCP	80	0	0	0	0	0	0	0
OPFRs	TBP	60	100	0	0	100	0	0	50
OPFRs	TIBP	60	100	40	0	0	0	0	50
OPFRs	TEP	60	20	40	40	0	67	0	0
OPFRs	TPRP	0	0	0	0	0	0	0	0
OPFRs	BdPhP	0	0	0	0	0	0	0	0
OPFRs	TPP	80	20	0	0	0	33	50	50
OPFRs	DBPhP	0	0	0	0	0	0	0	0
OPFRs	TXP	80	0	0	0	0	0	0	0
OPFRs	TIPPP	0	0	0	0	0	0	0	0
OPFRs	TTBPP	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
OPFRs	TEHP	100	60	0	20	0	0	0	0
Dechloranes	DBALD	0	0	0	0	0	0	0	0
Dechloranes	Dec-602	0	0	60	0	0	100	0	50
Dechloranes	Dec-603	0	0	60	0	0	100	0	0
Dechloranes	Dec-604	0	0	0	0	0	0	0	0
Dechloranes	Dec-601	0	0	0	0	0	0	0	0
Dechloranes	syn-DP	60	60	20	60	0	100	0	0
Dechloranes	anti-DP	60	60	40	80	0	100	0	0
Musk compounds	HHCB	0	0	0	0	n.a.	0	0	0
Musk compounds	TONA	0	60	0	40	n.a.	33	0	0
Musk compounds	TRAS	0	100	0	0	n.a.	0	0	0
Musk compounds	PANT	0	0	0	0	n.a.	0	0	0
Musk compounds	KELE	0	0	0	0	n.a.	0	0	0
Musk compounds	MCKETON	0	20	0	0	n.a.	0	0	0
Musk compounds	OTNE	0	0	0	0	n.a.	0	0	0
Biocides	BRDIOL	n.a.	n.a.	n.a.	100	n.a.	0	100	100
Biocides	BRDIFA	n.a.	n.a.	n.a.	0	n.a.	0	100	100
Biocides	FLOCO	n.a.	n.a.	n.a.	0	n.a.	0	0	0
Biocides	DIFEN	n.a.	n.a.	n.a.	100	n.a.	0	100	100
Biocides	DIFET	n.a.	n.a.	n.a.	0	n.a.	0	0	0
Biocides	PERM	n.a.	n.a.	n.a.	20	0	33	50	50
Phthalates	DEHP	100	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Phthalates	SDPHP_DIDP	0	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Phthalates	DINP	40	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Phthalates	DIBP	40	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Phthalates	DBPH	40	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Phthalates	DEP	0	n.a.	n.a.	n.a.	100	n.a.	n.a.	n.a.
Phthalates	BBP	80	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Phthalates	DCHP	40	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Phthalates	DNHP	0	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Phthalates	DNOP	20	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Phthalates	DNNP	20	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Phthalates	DDPT	0	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Phenols	TBBPA	0	0	n.a.	0	0	33	0	0
Phenols	BPA	80	0	n.a.	0	0	0	0	0
Phenols	BPA24	0	0	n.a.	0	0	0	0	0
Phenols	BPS24	0	0	n.a.	0	0	67	0	0
Phenols	BPF	40	0	n.a.	0	0	33	0	0
Phenols	BPF24	20	0	n.a.	0	0	33	0	0
Phenols	BPG	0	0	n.a.	0	0	0	0	0
Phenols	BPFL	0	0	n.a.	0	0	0	0	0
Phenols	BPAP	0	0	n.a.	0	0	0	0	0
Phenols	BPZ	0	0	n.a.	0	0	0	0	0
Phenols	BPE	0	0	n.a.	0	0	0	0	0
Phenols	BPB	0	0	n.a.	0	0	0	0	0
Phenols	BPM	0	0	n.a.	0	0	0	0	0
Phenols	MB1	0	0	n.a.	0	0	0	0	0
Phenols	NOPHE4	0	0	n.a.	0	0	0	0	0
Phenols	OCPHE4N	0	0	n.a.	0	0	0	0	0
Phenols	OCPHEpt	80	67	n.a.	100	100	33	0	50

Table 4 cont: Detection frequency (%) of components in various sample types. n.a.: not analysed. The colour scale is from navy blue (100 % detection) through lighter blue to white (0%, not detected).

Compound group	Abbreviation	Soil n=5	Earthworm n=5	Fieldfare egg n=5	Rat liver n=5	Dog (Serum) n=1	Sparrow-hawk egg n=3	Red fox liver n=2	Badger liver n=2
PFCAs	TFA	100	0	0	40	0	0	0	0
PFCAs	PFPrA	0	0	0	0	0	0	0	0
PFCAs	PFBA	0	100	0	0	100	0	0	0
PFCAs	PFPA	60	100	40	0	0	0	0	0
PFCAs	PFHXA	60	20	20	0	0	0	0	0
PFCAs	PFHPA	60	0	20	0	0	0	0	
PFCAs	PFOA	100	100	100	40	100	100	100	50
PFCAs	PFNA	100	100	100	60	100	100	100	100
PFCAs	PFDA	60	100	100	100	100	100	100	100
PFCAs	PFUnDA	40	0	0	0	100	100	0	0
PFCAs	PFDoDA	40	100	100	100	0	100	100	100
PFCAs	PFTrDA	0	20	20	20	0	67	0	0
PFCAs	PFTeDA	0	40	40	0	0	100	0	0
PFCAs	PFHxDA	0	40	40	0	100	100	0	100
PFCAs	PFOcDA	0	0	0	0	0	0	0	0
PFSAs	PFETS	0	0	0	0	0	0	0	0
PFSAs	PFPRS	0	0	0	0	0	0	0	0
PFSAs	PFBS	0	80	0	0	100	0	0	100
PFSAs	PFPS	0	20	0	0	0	0	0	100
PFSAs	PFHXS	0	40	100	20	100	100	100	100
PFSAs	PFHPS	0	100	100	60	100	100	100	100
PFSAs	PFOS	100	100	100	100	100	100	100	100
PFSAs	brPFOS	100	100	100	100	100	100	100	100
PFSAs	PFNS	0	0	40	20	0	33	0	100
PFSAs	PFDS	0	100	100	100	0	100	50	100
PFSAs	PFUNS	0	0	40	0	0	67	0	0
PFSAs	PFDOS	0	40	80	0	0	67	0	0
PFSAs	PFTRS	0	0	40	0	0	0	0	0
new PFAS	7:3 FTCA	0	40	100	100	100	100	100	100
new PFAS	4:2 FTS	0	0	0	0	0	0	0	0
new PFAS	6:2 FTS	0	20	100	40	0	0	0	100
new PFAS	8:2 FTS	0	40	80	80	0	100	0	100
new PFAS	10:2 FTS	0	20	60	20	0	33	0	100
new PFAS	12:2 FTS	0	0	0	0	0	0	0	0
new PFAS	PFECHS	0	0	20	0	0	33	0	0
Antioxidants	Isobutyl-4-Hydroxybenzoate	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Antioxidants	Butyl-4-Hydroxybenzoate	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Antioxidants	Butylated Hydroxyanisole BHA	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Antioxidants	4-(4-isopropoxyphenylsulfonyl)phenol	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Antioxidants	3-tert-butyl-4-hydroxyanisole	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Antioxidants	4-tert-butyl-phenol	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Antioxidants	Ethyl-4-Hydroxybenzoate	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Antioxidants	Methyl-4-Hydroxybenzoate	n.a.	n.a.	n.a.	n.a.	100	n.a.	n.a.	n.a.
Antioxidants	Benzyl-4-Hydroxybenzoate	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.
Antioxidants	Propyl-4-Hydroxybenzoate	n.a.	n.a.	n.a.	n.a.	100	n.a.	n.a.	n.a.
Antioxidants	Isopropyl-4-Hydroxbenzoate	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.	n.a.

3.1 PFAS

The PFAS group consists of numerous per- and polyfluorinated compounds. We have chosen to separate this large class of compounds into three subgroups dependent on functional groups and properties: The perfluorinated sulfonates (PFSA), the perfluorinated carboxylates (PFCA), and the relatively new fluorotelomer sulfonates (newPFAS) with the compounds 4:2 FTS, 6:2 FTS, 8:2 FTS, 10:2 FTS, 12:2 FTS and 7:3 FTCA. In this chapter and in summary, SumPFAS is the sum of all sub-groups. SumPFOS is the sum of the branched and linear PFOS.

PFAS could be detected in all samples and PFOS was the dominating compound.

It is known that longer-chain PFAS degrades to trifluoro acetic acid (TFA) in the environment, for example via oxidation by OH radicals in the atmosphere (Garavagno et al., 2024). Current research suggests that the water soluble TFA and other short-chain PFAS do not bioaccumulate in food chains, but a number of studies reported that direct uptake from the atmosphere can contribute to high levels of TFA in terrestrial plant leaves, and some terrestrial plants have been found to bioaccumulate TFA (Garavagno et al., 2024). The LOD for TFA was higher this year than previous years and only detected above LOD in the five soil samples and two of the rat liver samples.

Compound 7:3 FTCA was detected in many of the samples, and highest amount in the badger liver samples. 7:3 FTCA is known to be an intermediate degradation product of other compounds and has been shown to bioaccumulate, and higher concentration has been detected in liver compared to muscle samples which is likely related to protein binding in liver (Xie et al., 2020). The compounds 8:2 FTS and 10:2 FTS were highest in fieldfare egg.

Highest PFOS concentrations were detected in fieldfare eggs, rat and badger liver. Several samples exceeded the PNECoral of 37 ng/g ww (see Appendix) and QSbiota of 33 ng/g ww for secondary poisoning of predators for PFOS, set by the European Commission (Ankley et al., 2021).

Several samples also exceeded the low QSbiota value for PFOA of 0.9 ng/g for secondary poisoning of predators set by Valsecchi et al., 2017 (Ankley et al., 2021). Highest concentration of PFOA was detected in badger liver samples.

The TOP assay was used on the pooled blood serum sample of dog in addition to the target analysis. The median (min-max) values in the tables are calculated on the basis of both results, therefore n=2 for dog. TOP assay concentrations were in agreement with concentrations using target analysis which indicated that not many precursor of PFAS were present in the pooled dog serum sample. Largest change after use of TOP assay was found for PFBA and PFBS, as revealed by the min-max range in the tables. TOP assay was applied in year 2022 of several samples of fieldfare egg, rat liver and Spanish slug. The concentration of targeted PFAS after the samples have been processed through TOP assay had increased for both PFCA and PFSA, which indicated that several precursors of PFCA and PFSA were present in the samples. For some of the samples the sumPFAS concentrations were nearly doubled after use of TOP assay. TOP assay is therefore a useful tool to investigate the total load of extractable PFAS in the samples.

Table 5: PFCA concentrations (median, min-max) in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). <LOD/2 values were used in the calculations. PFCA compounds with known PNEC values are marked with orange background colour. Concentrations exceeding PNEC or other thresholds are shown with orange background colour.

	Soil n=5	Earthworm n=5	FF egg n=5	BR liver n=5	Dog serum n=2*	SH egg n=3	RF liver n=2	EB liver n=2
TFA	2.94 1.14-4.72	<2	<2	2 <2- 7.46	<2	<2	<2	<2
PFPrA	<0.3	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
PFBA	<0.06	0.88 0.23 - 1.74	<0.05	<0.05	0.23 0.03 - 0.44	<0.05	<0.05	<0.05
PFPA	0.18 <0.06 - 0.55	0.88 0.11- 2.32	0.05 <0.05- 0.18	<0.05	0.10 <0.05- 0.16	<0.05	<0.05	<0.05
PFHxA	0.19 <0.06- 0.35	0.050 <0.05 - 1.48	0.05 <0.05 - 0.11	<0.05	<0.05	<0.05	<0.05	<0.05
PFHpA	0.22 <0.06 - 0.31	<0.04	0.04 <0.04- 0.44	<0.038	0.06 <0.04- 0.08	<0.04	<0.04	0.081 <0.04 - 0.13
PFOA	0.46 0.18- 0.79	1.64 0.70 - 3.40	0.70 0.20 - 2.73	0.03 <0.03- 3.78	1.11 1.10 - 1.12	1.41 1.40 - 3.27	0.57 0.17- 0.98	10.7 8.60 - 12.7
PFNA	0.20 0.12 - 0.367	1.37 0.18 - 1.98	1.37 0.68 - 2.89	5.37 <0.03- 9.47	1.24 1.22 - 1.26	2.87 1.41 - 3.14	1.84 1.47 - 2.21	18.6 17.1 - 20.1
PFDA	0.18 <0.06- 0.45	0.81 0.45 - 1.98	3.56 1.03 - 8.53	3.68 1.02 - 33.9	0.40 0.37 - 0.44	5.42 1.99 - 85.2	2.19 1.57 - 2.82	19.4 14.2 - 24.7
PFUnDA	0.11 <0.06 - 0.27	<0.04	4.75 <0.04 - 8.32	<0.04	0.50 0.46 - 0.53	7.43 2.13 - 16.7	<0.04	<0.04
PFDoDA	0.13 <0.06 - 0.21	1.35 0.95 - 3.26	9.76 3.50 - 43.2	1.41 1.11 - 34.1	<0.05	18.7 3.96 - 71.6	1.07 0.97 - 1.17	16.7 8.66 - 24.8
PFTrDA	<0.10	0.05 <0.05 - 1.29	0.05 <0.05 - 23.7	0.05 <0.05 - 18.4	<0.05	13.0 <0.05 - 13.5	<0.05	<0.05
PFTeDA	<0.06	0.05 <0.05 - 0.49	1.08 <0.05 - 12.9	<0.05	<0.05	5.36 1.23 - 6.12	<0.05	<0.05
PFHxDA	<0.06	0.05 <0.05- 0.86	1.80 0.50 - 4.05	<0.05	0.93 0.88 - 0.98	1.57 0.48 - 1.83	<0.05	1.73 1.10 - 2.37
PFOcDA	<0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

**n=2 for Targeted and TOPA analysis*

Table 6: PFSA concentrations in Soil, Earthworm EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text. PFSA compounds with known PNEC values are marked with orange background colour. Concentrations exceeding PNEC or other thresholds are shown with orange background colour.

	Soil n=5	Earthworm n=5	FF egg n=5	BR liver n=5	Dog n=2*	SH egg n=3	RF liver n=2	EB liver n=2
PFEtS	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PFPrS	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PFBS	<0.05	0.45 <0.03- 3.35	<0.03	<0.03	1.98 0.85 - 3.12	<0.03	<0.03	0.25 0.14 - 0.36
PFPS	<0.05	0.03 <0.03- 0.98	<0.03	<0.03	<0.03	<0.03	<0.03	0.14 0.07 - 0.21
PFHxS	<0.05	0.03 <0.03 - 1.49	0.25 0.15 - 5.04	0.03 <0.03- 0.99	1.54 1.54 - 1.54	0.49 0.31 - 0.82	0.57 0.29 - 0.85	2.37 1.33 - 3.42
PFHpS	<0.05	0.56 0.24 - 3.38	0.40 0.20 - 2.21	0.11 <0.03 - 1.80	0.22 0.18 - 0.26	0.55 0.46 - 1.19	0.31 0.18- 0.44	2.28 2.01 - 2.54
brPFOS	0.14 0.03 - 0.31	0.32 0.24 - 1.87	1.52 0.56 - 12.5	4.68 0.47 - 51.4	2.74 2.43 - 3.06	2.29 1.88 - 10.1	2.10 1.27 - 2.93	14.5 10.1 - 19.0
SumPFOS	1.16 0.67 - 3.25	12.9 7.63 - 40.7	44.5 17.2 - 379	22.3 4.50 - 256	9.74 9.46 - 10.0	30.3 26.4 - 117	43.5 31.2 - 55.9	185 134 - 236
PFNS	<0.05	<0.05	0.05 <0.05 - 0.57	0.05 <0.05 0.32	<0.05	0.05 <0.05- 0.28	<0.05	0.21 0.12 - 0.30
PFDS	<0.05	0.49 0.41 - 1.35	4.88 0.44 - 19.8	0.57 0.54 - 35.9	<0.05	2.13 0.43 - 5.63	0.30 <0.05- 0.56	3.67 1.51 - 5.82
PFUnS	<0.05	<0.05	0.05 <0.05- 0.44	<0.05	<0.05	0.05 <0.05- 0.16	<0.05	<0.05
PFDoS	<0.05	0.05 <0.05- 0.29	0.42 <0.05 - 2.27	<0.05	<0.05	0.25 <0.05- 0.44	<0.05	<0.05
PFTrS	<0.05	<0.05	0.05 <0.05-0.13	<0.05	<0.05	<0.05	<0.05	<0.05

**n=2 for Targeted and TOPA analysis*

Table 7: newPFAS concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text. Compounds with known PNEC values are marked with orange background colour. Concentrations exceeding PNEC or other thresholds are shown with orange background colour.

	Soil n=5	Earthworm n=5	Fieldfare egg n=5	Brown rat liver n=5	Dog serum n=2	Sparrowhawk egg n=3	Red fox liver n=2	Badger liver n=2
4:2 FTS	<0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
6:2 FTS	<0.06	0.05 <0.05 - 0.35	0.25 0.08 - 7.07	0.05 <0.05- 2.22	<0.05	<0.05	<0.05	0.60 0.30- 0.90
8:2 FTS	<0.06	0.05 <0.05- 3.10	3.51 <0.05- 140	0.40 <0.05- 27.3	<0.05	0.41 0.38 - 1.07	<0.05	5.82 1.85 - 9.80
10:2 FTS	<0.06	0.05 <0.05-2.54	3.30 <0.5-58.8	0.5 <0.5-4.02	<0.5	0.5 <0.5-1.98	<0.5	6.06 4.30-7.81
12:2 FTS	<0.06	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
7:3 FTCA	<0.06	0.05 <0.05 - 2.17	0.68 0.26 - 12.1	1.39 0.60 - 18.0	0.11 <0.05- 0.16	0.76 0.19 - 1.06	2.49 1.16 - 3.82	27.9 10.0 - 45.8
PFECHS	<0.1	<0.1	0.1 <0.1-0.2	<0.1	<0.1	0.1 <0.1-0.29	<0.1	<0.1

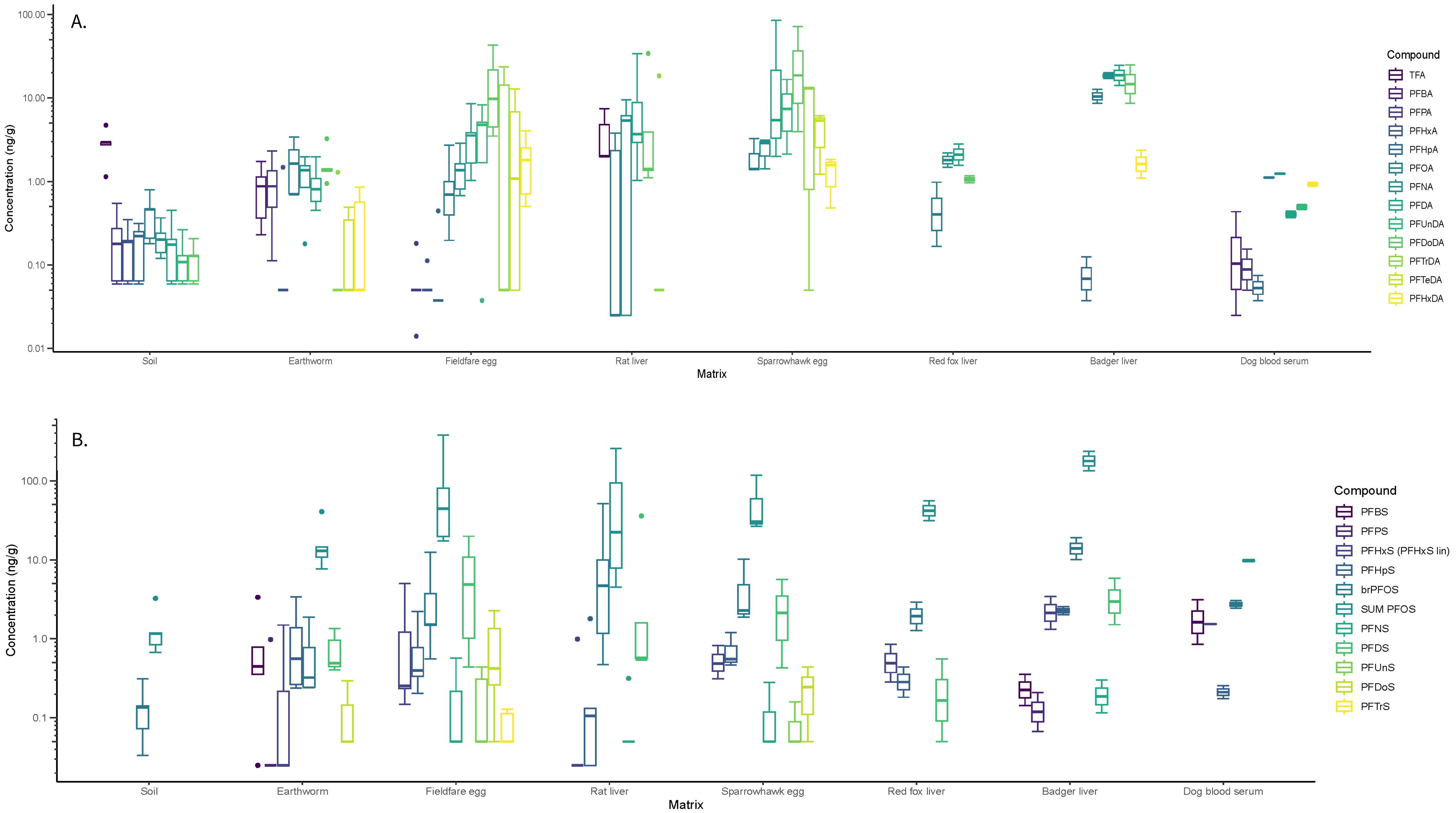


Figure 2: Box plot of PFCA (A.) and PFSA (B.) components in the various matrices. Concentrations below LOD are included as ½ LOD.

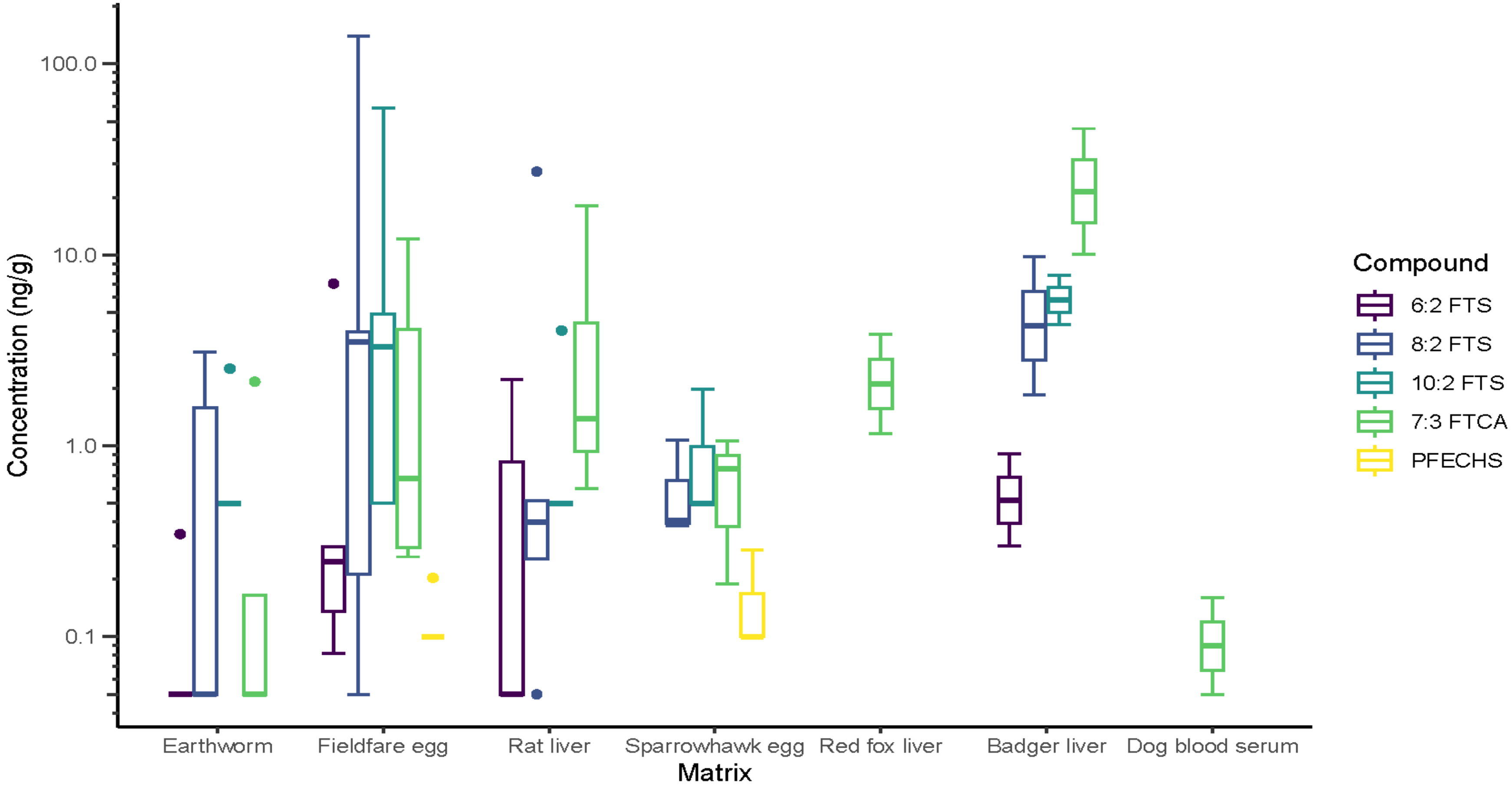


Figure 3 : Box plot of NewPFAS components in the various matrices. Concentrations below LOD are included as ½ LOD.

3.2 Chlorinated paraffins, CPs

Chlorinated paraffins include short-chain (C10-C13), medium-chain (C14-C17), and long-chain (C18-C28) chlorinated paraffins (SCCPs, MCCPs, and LCCPs, respectively). LCCP were detected in many samples, SCCP concentrations were below LOD, and MCCP were detected in some of the samples, see Table 8.

As observed in past years' results in this program, rat liver sample had some of the highest detected concentrations of both LCCPs and MCCPs, both on wet and lipid weight basis. Highest concentration of LCCPs in brown rat liver was 3190 ng/g ww (79080 ng/g lw) and the average concentration in rat liver was 739 ng/g ww (32122 ng/g lw). We have not been able to compare this level to other studies of liver from mammals living in urban areas. However, in a study of samples collected between 2006 to 2017 from Sweden, Denmark, and the Baltic Sea, the terrestrial species had, in general, higher concentrations than marine species (Yuan et al., 2019). The LCCP concentrations were highest in peregrine falcon muscle samples, up to 1200 ng/g lw (Yuan et al., 2019). For the CPs investigated in wildlife from paddy fields in the Yangtze River delta in China, the average and min-max concentrations of LCCPs in 6 muscle samples of peregrine falcon were 690 ng/g lw (530-10000 ng/g lw) (Du et al., 2018).

Occurrence data for LCCPs in German coastal, terrestrial, and freshwater ecosystems revealed LCCP concentrations ranging from <MDL to 140 ng/g lw for deer liver samples collected in 2018 (Yuan et al., 2022).

The CP levels in the blood serum of dog were below the levels detected in the Blank serum vial, i.e. empty sample vial used for blood serum.

None of the samples in the Oslo area exceeded the PNECoral values of 5500 ng/g food for the SCCPs or 10 000 ng/g food (wet weight) for the MCCPs and LCCPs. The LCCP concentration in all soil samples were below the PNECsoil of 4.64 g/kg soil dw[3].

Table 8: CP concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text.

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	Dog n=1	SH egg n=3	RF liver n=2	EB liver n=2
SCCPs	<12.8	<6.40	<6.40	<7.68	<10.5	6.40 <6.40 - 14.0	<12.8	<12.8
MCCPs	17.6 <17.6 - 87.0	30.0 <8.80 - 34.1	25.0 <8.80 - 33.0	78 <8.80 - 219	<46.5	8.80 <8.80 - 24.0	<17.5	<17.5
LCCPs	48.8 20.9 - 380	3.20 <0.40 - 16.1	17.9 10.2 - 47.7	739 7.53 - 3190	<10.5	165 69.4 - 194	15.1 4.15 - 26.1	2.26 <0.80 - 3.72

[3] https://echa.europa.eu/brief-profile/-/briefprofile/100.058.300

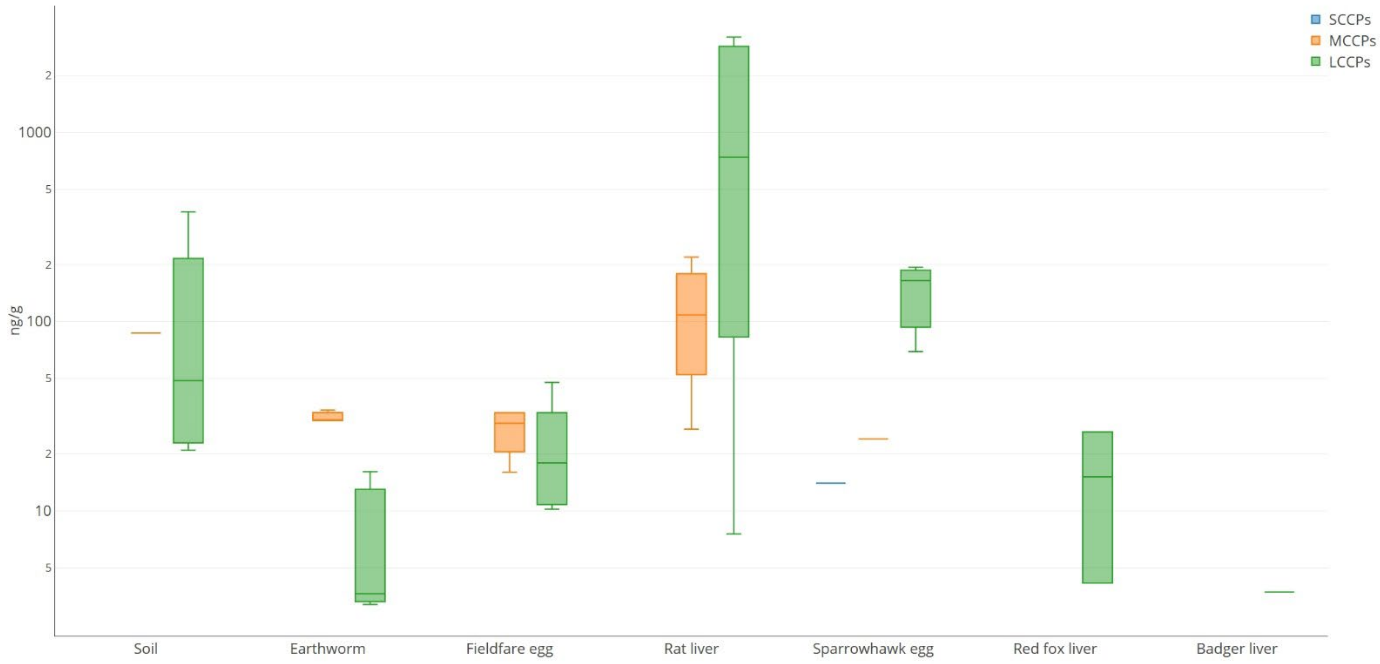


Figure 4: Box plots of detected concentrations of SCCPs, MCCPs and LCCPs in the samples.

The fractional contribution of each isomer/congener group was investigated and calculated from the total detected concentrations of SCCPs, MCCPs, and LCCPs, respectively. The various isomer groups and congeners most likely have different physical-chemical properties important for occurrence, fate, bioaccumulation and toxicity (Yuan et al., 2022). The patterns can be compared across species, and may give insight into which isomers or congener groups are most likely to bioaccumulate and biomagnify at various trophic levels. Also different sources like products and area of use or production may result in different isomer pattern (Yuan et al., 2022). In addition, consistent patterns or fingerprints between terrestrial animals and marine sediments might be indicative of atmospheric deposition of CPs to both water and terrestrial ecosystem (Yuan et al, 2019).

SCCPs were only detected in one pooled sparrowhawk egg where the isomer group with 12 carbon atoms dominated; C12Cl9 with highest concentration followed by C12Cl8, C12Cl10 and C13Cl8.

For MCCPs, the isomer groups C14Cl6 and C14Cl7, were dominating groups in earthworm, fieldfare eggs and sparrowhawk eggs. This agrees with results from previous years in MILBY. The C14 isomer classes of MCCPs were also dominating in the Scandinavian study of Yuan et al., 2019.

For the one sample of soil with detected concentrations, C14Cl6 also dominated as in the biota samples, followed by C15Cl6 and C14Cl9. For brown rat liver the isomer groups containing 16 and 17 carbon atoms dominated. See overview of the most dominating isomer groups of MCCPs below:

Soil :	C14Cl6> C15Cl6>C14Cl9> C16Cl7> C16Cl8
EW:	C14Cl6> C14Cl7> C15Cl6> C15Cl7
FF egg:	C14Cl6> C14Cl7> C15Cl6> C15Cl7
SH egg:	C14Cl6 >C14Cl7> C14Cl5
BR liver:	C16Cl8> C16Cl7> C17Cl9> C16Cl9

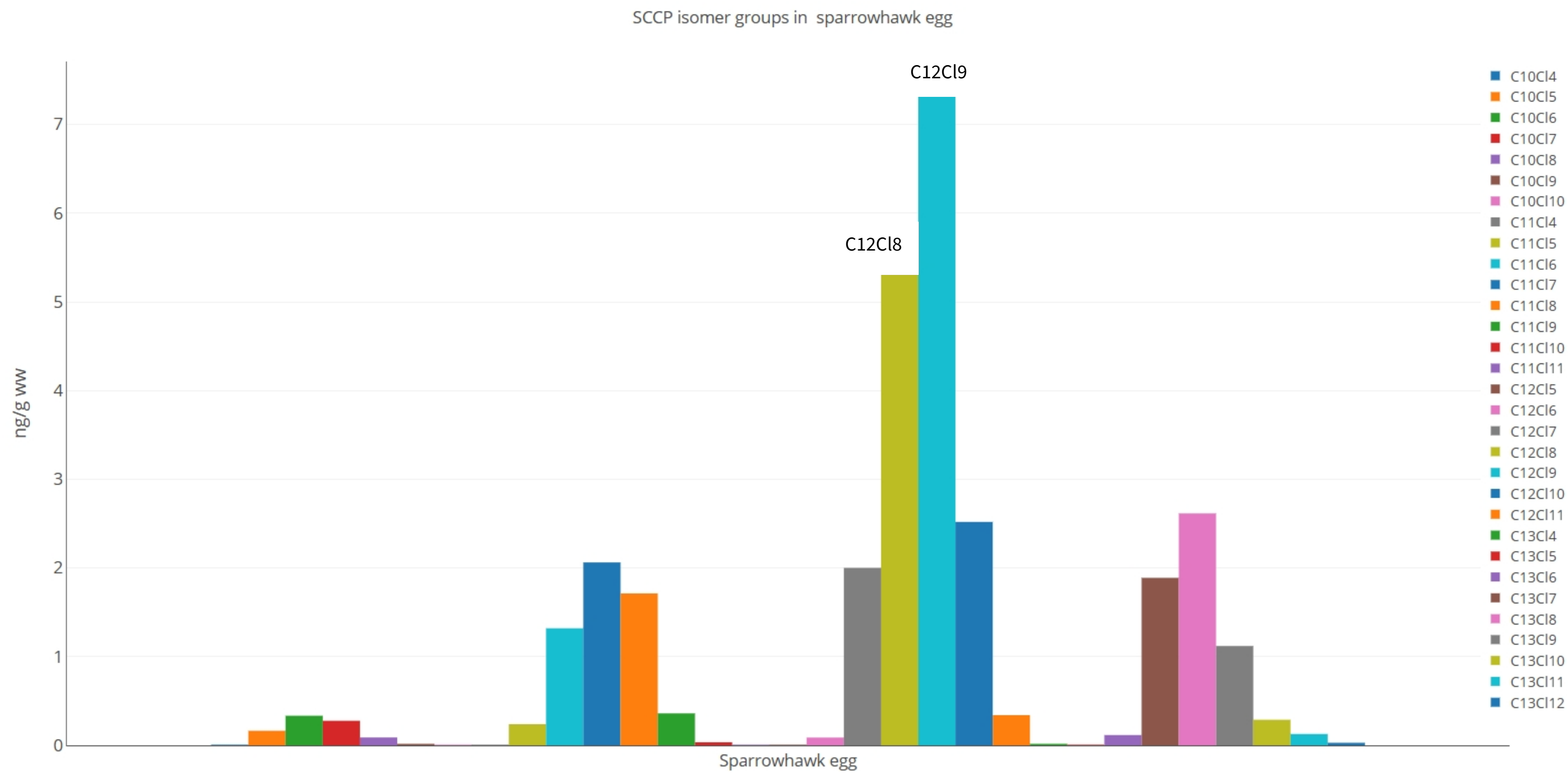


Figure 5: Patterns of SCCP isomers in detected concentrations of one sparrowhawk (SH) egg.

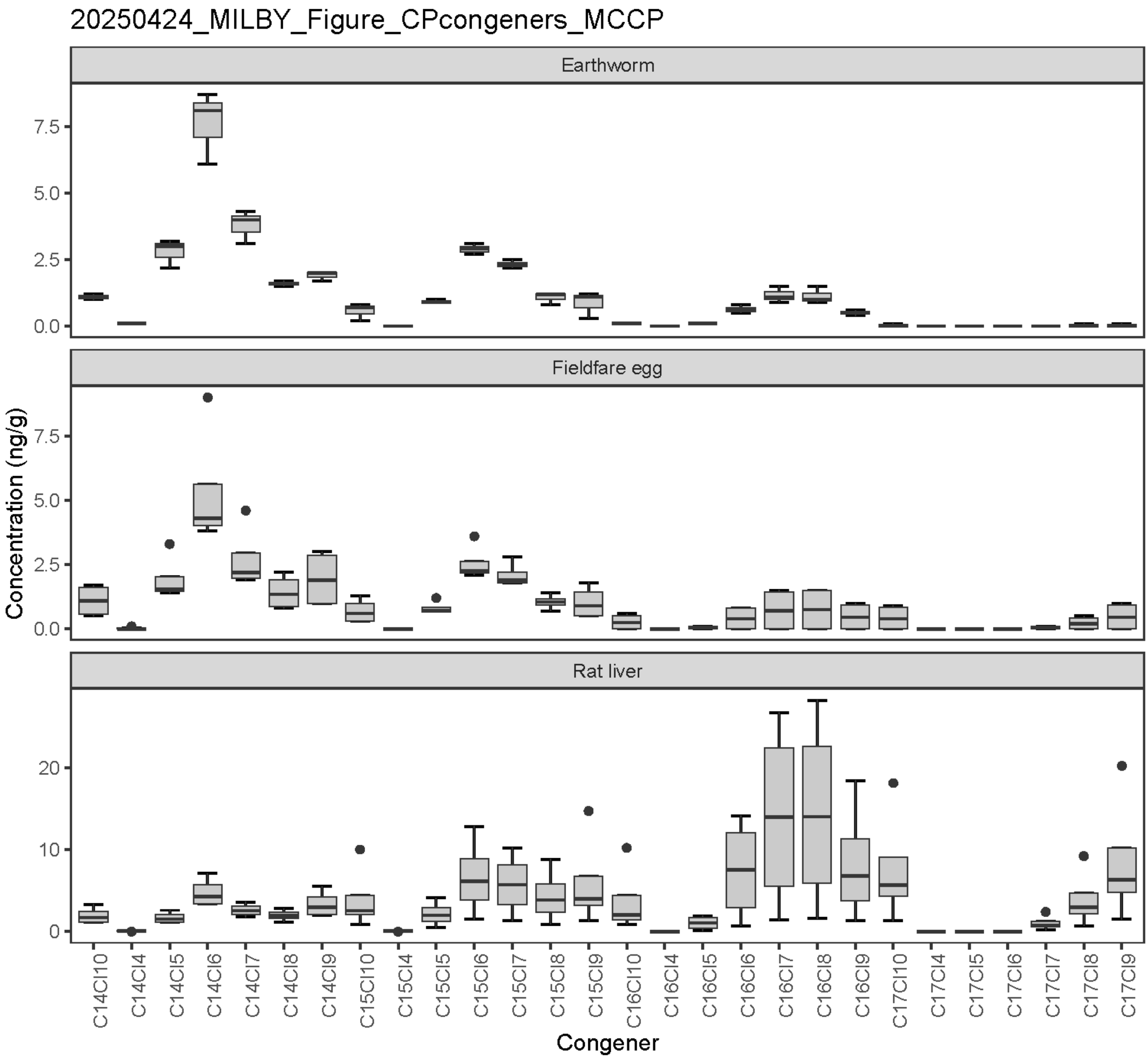


Figure 6: Box plots with the program R showing patterns of MCCP isomers in matrices with 5 samples. The whiskers extend to 1.5 times the interquartile range, and the points reveal outliers (extreme values).

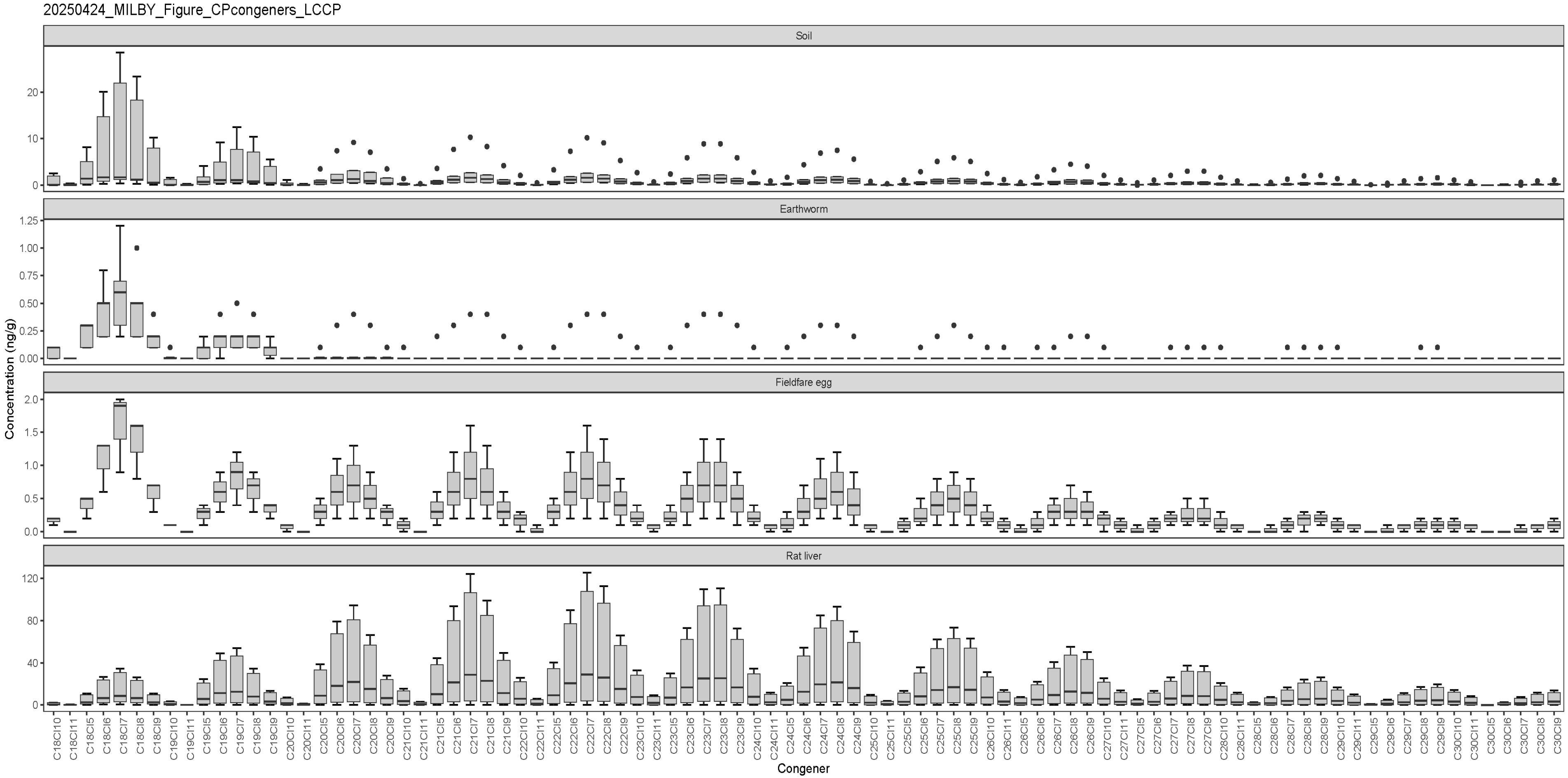


Figure 7: Box plots with the program R showing patterns of of LCCP isomers in matrices with 5 samples. The whiskers extend to 1.5 times the interquartile range, and the points reveal outliers (extreme values).

For LCCPs many isomer groups were detected in most matrices, especially in the rat liver as also observed last year.

The most dominating isomer groups based on average values in the samples with detected concentrations are listed below. The pattern for dominating LCCP isomer groups was similar for soil, earthworm and fieldfare eggs, and red fox liver. The pattern for sparrowhawk eggs was comparable to the isomer pattern in badger and brown rat liver. LCCP isomer pattern with dominating C22-C26 isomer groups were observed in peregrine falcon muscle samples in the Scandinavian study of Yuan et al., 2019.

Soil	C18Cl7> C18Cl8> C18Cl6> C19Cl7
Earthworm	C18Cl7 >C18Cl8> C18Cl6 > C19Cl7
Fieldfare egg	C18Cl7 >C18Cl8> C18Cl6> C19Cl7
Sparrowhawk egg	C22Cl7~ C21Cl7>C22Cl8~C23Cl8~C23Cl7
Red fox liver	C18Cl7 >C18Cl8> C18Cl6> C22Cl7
Badger liver	C22Cl7~ C21Cl7> C22Cl8~ C23Cl7
Brown rat liver	C22Cl7~ C21Cl7> C22Cl8>C23Cl8~C23Cl7

3.3 Siloxanes

The cyclic siloxanes, D4, D5 and D6 were detected in all the samples analysed (Table 9).

The median concentrations on a wet and lipid weight basis were highest in brown rat liver, but the maximum level of D5 was much lower than in year 2021 (53 ng/g ww), 2022 (148 ng/g ww) and 2023 (104 ng/g ww), and lower than detected in bird eggs. Linear siloxanes and M3TPH were not detected in any sample.

None of the biological samples exceeded the available PNEC values for secondary poisoning available at the ECHA chemical information web site[4] (see also Appendix 1).

Table 9: Siloxane concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text.

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	Dog serum n=1	SH egg n=3	Red fox liver n=2	Badger liver n=2
D4	0.24 <0.06 - 1.55	0.72 0.53 - 1.06	0.86 0.40 - 1.36	1.10 0.71 - 13.2	n.a.	0.19 0.15 - 0.23	0.32 0.31 - 0.33	0.59 0.28 - 0.89
D5	0.37 <0.08 - 3.41	0.97 0.45 - 1.02	2.16 1.35 - 7.95	3.89 1.05 - 4.47	n.a.	3.79 1.81 - 9.40	0.74 0.69- 0.79	1.00 0.56 - 1.45
D6	0.68 <0.21 - 5.05)	0.86 <0.21 - 0.97	1.41 1.22 - 2.12	1.68 1.13 - 4.32	n.a.	1.54 1.35 - 2.09	0.91 0.70 - 1.13	1.57 0.71 - 2.44
L3	<0.129	<0.0476	<0.0914	<0.0241	n.a.	<0.015	<0.012	<0.051
L4	<0.128	<0.235	<0.404	<0.0721	n.a.	<0.035	<0.0392	<0.112
L5	<0.687	<0.647	<0.739	<0.485	n.a.	<0.111	<0.240	<0.396
M3TPH	<0.0681	<0.0345	<0.0655	<0.284	n.a.	<0.0787	<0.140	<0.285

[4] https://echa.europa.eu/da/search-for-chemicals

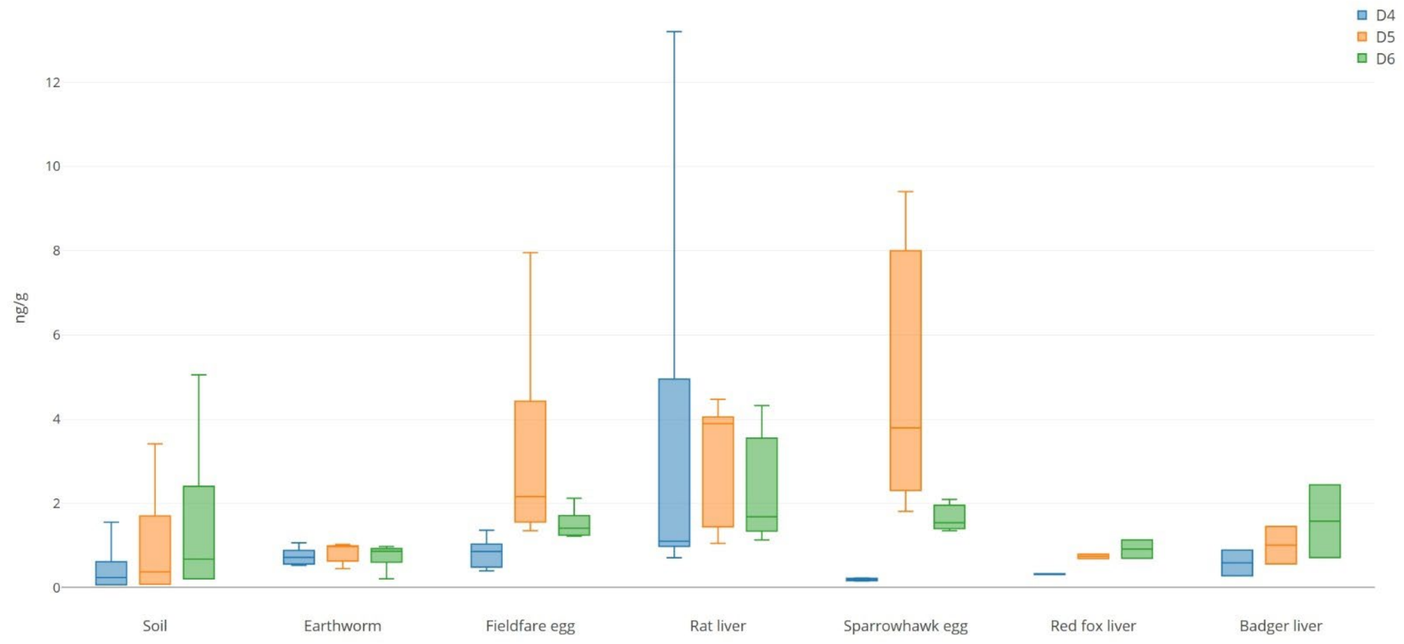


Figure 8: Box plot created with Chart studio of detected siloxane compounds. Concentrations below LOD are included as ½ LOD

3.4 Organophosphorus flame retardants, OPFR

OPFR compounds had highest detection frequencies in soil and earthworm samples. TCPP were detected in all the analysed samples, which agrees with the previous years' data in the MILBY program, but higher concentrations of TEP were detected in some of the samples. TEP did not exceed PNECsoil of 640 ng/g dw in soil [5], and TCPP did not exceed known PNECsoil (1.3-1.7 mg/kg soil dw) or PNECoral (11600 g/kg food) in biota[6].

Table 10: OPFR concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver and European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text.

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	Dog n=1	SH egg n=3	RF liver n=2	EB liver n=2
TCEP	0.24 <0.05 - 0.84	<0.50	<0.50	<0.50	<0.05	<0.50	<0.50	<0.50
TCPP	5.71 0.48 - 16.4	13.5 8.32 - 25.9	0.92 0.31 - 1.69	1.36 0.70- 4.56	0.68	0.82 0.78 - 1.05	2.26 1.93 - 2.59	2.70 0.85 - 4.55
TDCPP	<0.15	<0.25	<0.25	<0.25	<0.10	<0.25	<0.25	<0.25
TBEP	0.58 0.39 - 13.1	0.28 <0.10 -0.76	0.10 <0.10 - 0.43	0.10 <0.10 - 0.35	<0.05	0.10 <0.10 - 0.30	0.18 <0.10 - 0.26	0.24 <0.10 - 0.37
EHDP	0.25 <0.05 - 2.19	<0.25	<0.25	<0.25	<1.30	<0.25	10.8 <0.25- 21.4	<0.25
TCP	1.24 <0.05 - 6.03	<0.25	<0.25	<0.25	<0.05	<0.25	<0.25	<0.25
TBP	0.15 <0.05 - 0.54	3.47 2.92 - 9.53	<0.10	<0.10	0.2	<0.10	<0.10	0.44 <0.10 - 0.79
TIBP	0.15 <0.05 - 0.33	4.81 3.19 - 5.38	0.10 <0.10 - 0.47	<0.10	<0.05	<0.10	<0.10	0.34 <0.10- 0.57
TEP	2.80 <1.20 - 3.51	2.50 <2.50 - 19.9	2.50 <2.50 - 14.8	2.50 <2.50 - 20.4	<0.65	12.2 <2.50 - 29.1	<2.50	<2.50
TPRP	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
BdPhP	<0.05	<0.10	<0.10	<0.10	<0.05	<0.10	<0.10	<0.10
TPP	0.35 <0.05 - 2.70	0.10 <0.10 - 0.27	<0.10	<0.10	<0.05	0.10 <0.10 - 14.1	0.24 <0.10 - 0.38	0.36 <0.10 - 0.63
DBPhP	<0.05	<0.10	<0.10	<0.10	<0.05	<0.10	<0.10	<0.10
TXP	0.43 <0.05- 0.94	<0.50	<0.50	<0.50	<0.05	<0.50	<0.50	<0.50
TIPPP	<0.05	<0.10	<0.10	<0.10	<0.05	<0.10	<0.10	<0.10
TTBPP	n.a.	n.a.	n.a.	n.a.	<0.05	n.a.	n.a.	n.a.
TEHP	1.96 0.85 - 12.3	0.13 <0.05 - 1.40	<0.05	0.05 <0.05- 0.12	<0.10	<0.050	<0.05	<0.05

[5] Brief Profile - ECHA
[6] https://echa.europa.eu/brief-profile/-/briefprofile/100.033.766

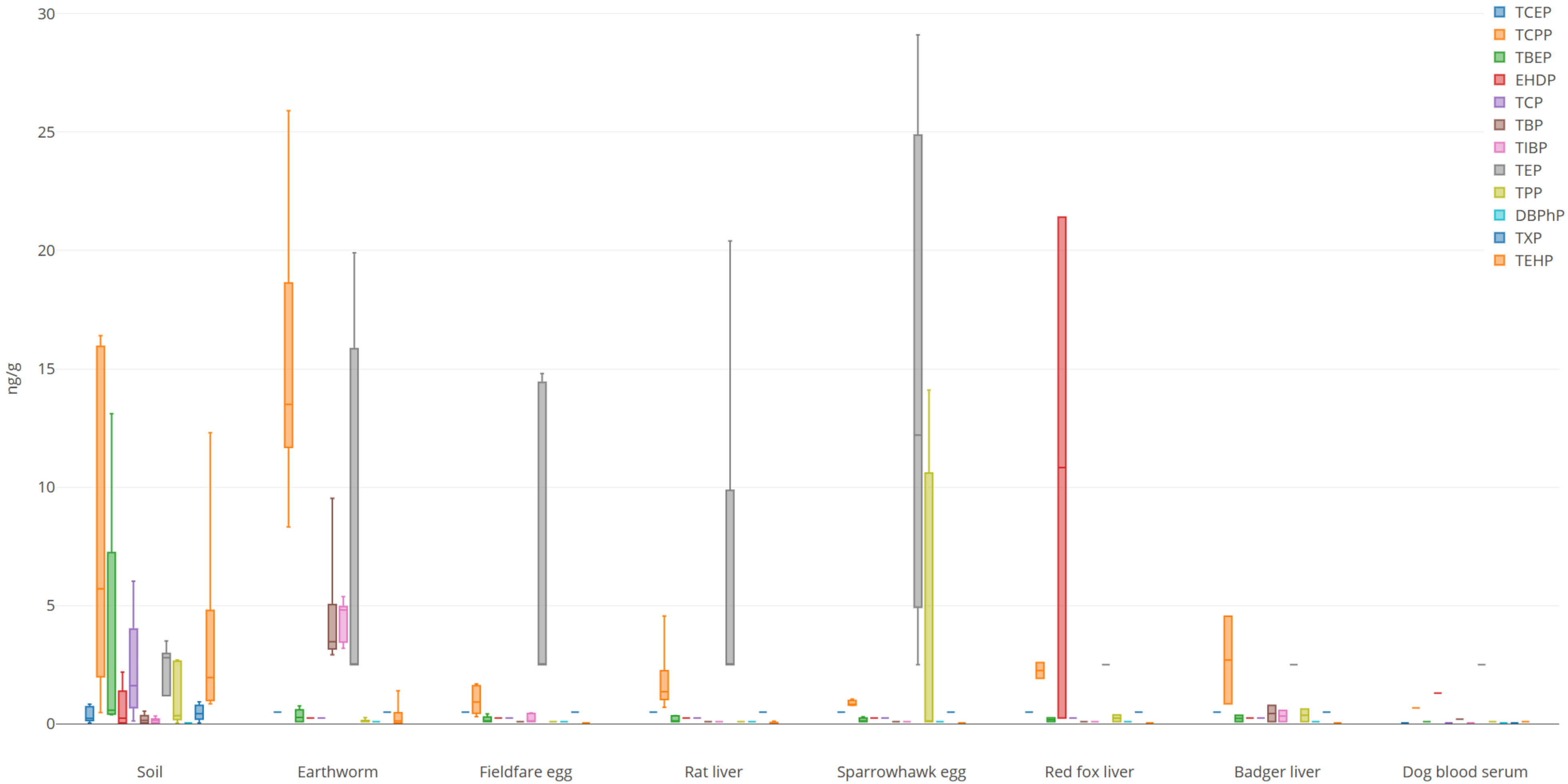


Figure 9: Box plot of OPFR compounds. LOD/2 values are included. Compounds not detected in any samples are excluded.

3.5 UV compounds

Highest detection frequences of UV compounds were found in fieldfare eggs and brown rat liver. UV-328 was the compound detected in all the various matrices, except badger liver samples. Homosalate was detected in earthworm, fieldfare eggs and in the one pooled blood serum sample from dogs.

Table 11: UV compound concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text.

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	Dog n=1	SH egg n=3	RF liver n=2	EB liver n=2
OC	<5.00	<3.00	3.00 <3.00 - 9.00	<3.00	<5.00	<3.00	<3.00	<3.00
BP3	<4.00	0.70 0.50 -1.40	0.15 <0.15- 1.40	0.15 <0.15 -0.70	<4.00	<0.15	<0.15	0.32 <0.15 - 0.50
EHMC	<0.50	<0.30	0.30 <0.30-1.70	0.30 <0.30 - 0.80	<0.500	<0.30	<0.30	<0.30
UV-327	0.05 <0.05-0.90	<0.05	0.30 0.10 - 1.70	0.20 <0.05 - 7.90	0.7	0.80 0.60- 0.90	<0.05	<0.05
UV-328	0.90 <0.15 -2.60	0.10 <0.05 -0.20	0.60 0.20 -2.00	0.30 <0.05- 14.4	0.7	2.10 1.40 - 2.70	0.12 <0.05 -0.20	<0.05
UV-329	<1.00	<0.20	<0.20	<0.20	<1.00	<0.20	<0.20	<0.20
Homosalate	<2.00	2.65 <2.65 -6.50	2.65 <2.65 - 5.80	<2.65	6.00	<2.65	<2.65	<2.65

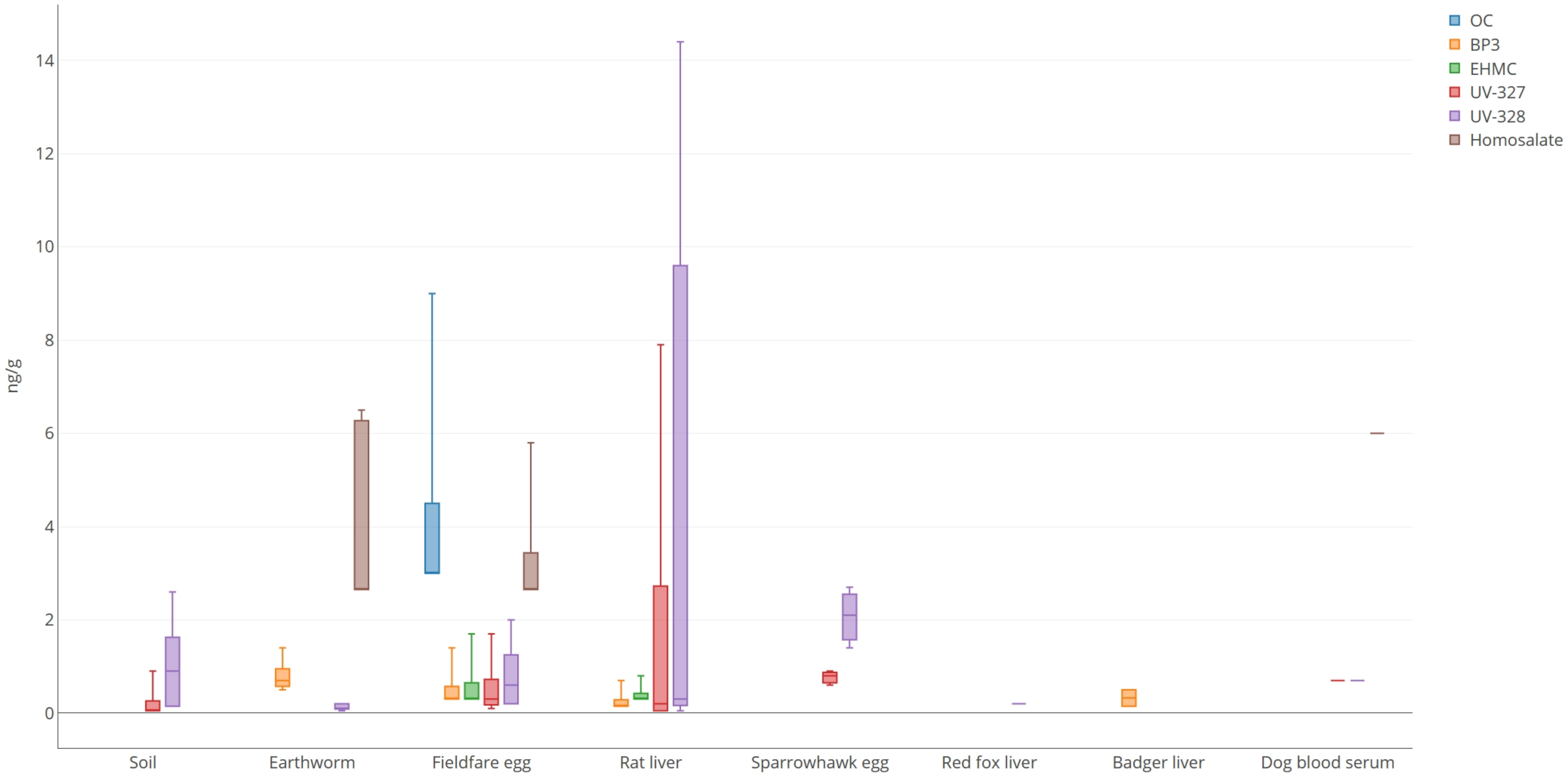


Figure 10: Box plot for UV protecting compounds in samples. ½ LOD is included for cases where compound is detected in at least one sample in each matrix.

3.6 Bisphenols and alkylphenols

In general, bisphenols and alkylphenols are sensitive to matrix effects, and especially in biological samples. Over the years in MILBY, this has been a known challenge for analysis of these components, which can give low recovery or interfering components in the chromatogram, thereby higher uncertainty in the data. Bisphenols and phenols were not analysed in fieldfare eggs this year due to the lack of sufficient sample amount.

The phenolic compounds with highest detection frequencies were Bisphenol A (BPA), 4-tert-octylphenol and Bisphenol F (BPF). Most of the other phenolic compounds were below LOD or near LOD. The results are more or less in agreement with previous years' result.

Table 12: Concentrations of phenols in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver and European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text.

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	Dog n=1	SH egg n=3	RF liver n=2	EB liver n=2
TBBPA	<0.95	<1.78	n.a.	<2.36	<2.25	2.38 <2.22 - 4.76	<2.38	<2.22
BPA	3.70 <1.00 - 14.9	<2.35	n.a.	6.18 <2.47 - 15.0	<2.40	<2.43	<2.54	<2.37
BPA24	<0.25	<0.60	n.a.	<0.60	<0.60	<0.593	<0.62	<0.58
BPS24	<0.07	<0.10	n.a.	0.10 <0.11 - 0.50	<0.10	0.20 <0.11- 0.46	<0.11	<0.10
BPF	0.30 <0.30 - 3.75	<0.70	n.a.	0.90 <0.72- 2.60	<0.70	0.73 <0.73 - 1.42	<0.73	<0.68
BPF24	0.70 <0.69 - 5.20	<1.60	n.a.	<1.62	<1.60	1.70 <1.59 - 16.9	<1.70	3.18 <1.62 - 4.73
BPG	<0.62	<1.25	n.a.	<1.33	<1.30	<1.29	<1.34	<1.25
BPFL	<0.36	<0.85	n.a.	<0.88	<0.85	<0.88	<0.91	<0.85
BPAP	<0.22	<0.45	n.a.	<0.50	<0.45	<0.62	<0.46	<0.45
BPZ	<0.55	<1.20	n.a.	<1.33	<1.30	<1.31	<1.37	<1.27
BPE	<0.19	<0.77	n.a.	<0.46	<0.45	<0.44	<0.46	<0.43
BPB	<0.20	<0.90	n.a.	<0.50	<0.50	<0.48	<0.50	<0.47
BPM	<0.10	<0.26	n.a.	<0.25	<0.25	<0.23	<0.24	<0.23
MB1	<0.49	<1.15	n.a.	<1.18	<1.15	<1.16	<1.22	<1.13
NOPHE4	<0.20	<0.38	n.a.	<0.50	<0.50	<0.51	<0.53	<0.49
OCPHE4N	<0.51	<1.15	n.a.	<1.24	<1.25	<1.23	<1.28	<1.20
OCPHEpt	1.35 <0.60 - 2.09	4.90 <1.50 - 7.35	n.a.	6.10 5.70 - 13.0	50.5	1.50 <1.39 - 7.38	<1.28	3.03 <1.42 - 4.64

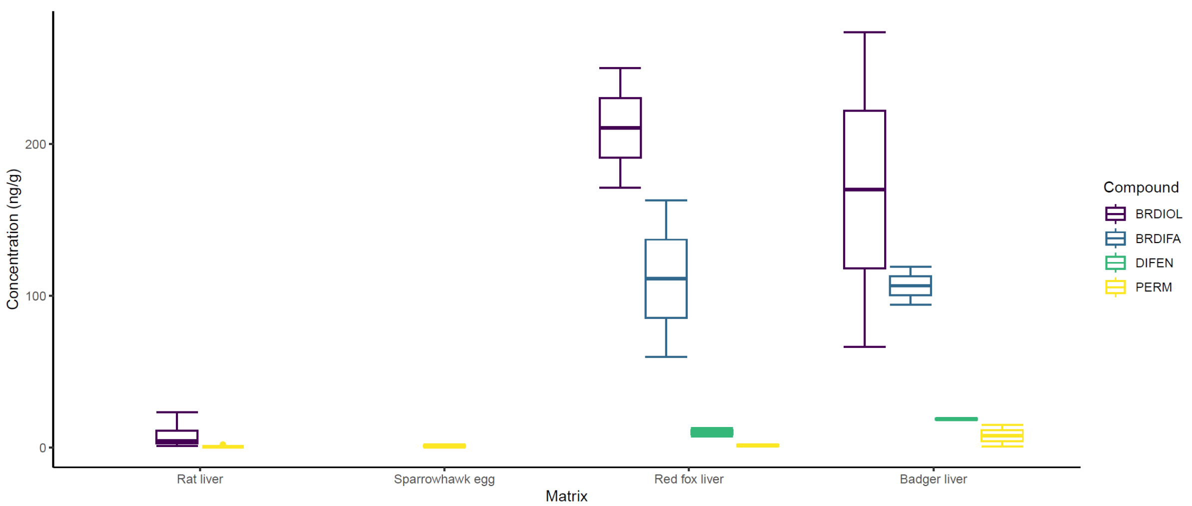
3.7 Biocides (rodenticides)

Selected biocides (rodenticides) were analysed in sparrowhawk eggs and in the liver samples of brown rat, red fox and badger. Permethrin was also analyzed in dog serum.

BRDIL, BRDIFA and DIFEN were detected in all the four liver samples of red fox and badger. BRDIOL dominated in the liver samples where highest concentrations were detected in badger and red fox liver samples on both wet weight (274 and 250 ng/g ww, respectively) and lipid weight basis. BRDIFA had second highest concentration in the liver samples of red fox and badger. The Oral LD50 for BRDIFA is about 0.4 mg/kg bw for male rat and mice.[7] The levels of BRDIOL and also other rodenticides have shown high variability from sample to sample over the years. The levels are in general lower this year for red fox and badger liver than previous program period, and the concentrations in rat liver were comparable to results from previous years.

Table 13: Biocide concentrations in sparrowhawk eggs and in the liver samples of brown rat, red fox and badger, and dog serum. All concentrations are given in ng/g ww. Concentrations below LOD are given as < LOD/2 values and are displayed in grey text.

	BR liver n=5	SH egg n=3	Red fox liver n=2	Badger liver n=2	Dog serum n=1
Bromadiolone (BRDIOL)	4.40 1.10 - 23.2	<0.50	211 171 - 250	170 66.2 - 274	n.a
Brodifacoum (BRDIFA)	<0.50	<0.50	111 59.6 - 163	107 94.2 - 119	n.a
Flocumafen (FLOCO)	<0.50	<0.50	<0.50	<0.50	n.a
Difenacoum (DIFEN)	<0.50	<0.50	10.0 7.30 - 12.8	18.8 18.1 - 19.4	n.a
Difethialone (DIFET)	<0.50	<0.50	<0.50	<0.50	n.a
Permethrin (PERM)	0.65 <0.65 - 2.00	0.65 <0.65 - 2.00	1.32 <0.65 - 2.00	7.82 <0.65 - 15.0	<1.5



[7] https://echa.europa.eu/documents/10162/581b315d-16e6-c4b4-85c1-9e68de106b6d

Figure 11: Box plot of biocides in rat liver, sparrowhawk egg, red fox liver and badger liver. Concentrations below LOD are included as ½ LOD. Compounds where all concentrations were below LOD are not included.

3.8 Phthalates in soil and dog serum

Phthalates were analysed in the five soil samples and the one pooled dog serum sample. As previous years, DEHP and DiNP dominated in the soil samples. The median values of these two compounds in 2024 are comparable to median concentrations of 2023 and 2022, but the maximum concentrations were higher in 2024. In the one pooled blood serum sample of dog, only DEP was detected. For comparison, hazard for secondary poisoning in predators (PNECoral) of DEP is 33 mg/kg food[8].

The concentration of DEHP was well below the PNECsoil value of 13 mg/g dw, and DnBP is also below the PNECsoil value of 50 ng/g dw (ECHA chemical information, see Appendix).

Table 14: Concentrations of phthalate compounds soil and dog serum samples. Concentrations are given in ng/g ww for dog serum and ng/g dw for soil. Concentrations below LOD are given as <LOD/2 values and are displayed in grey text.

	Soil n=5	Dog serum n=1
DEHP Di(2-ethylhexyl)phthalate	57.3 13.8 - 380	<6.90
SDPHP_DIDP Sum (DPHP+ Diisodecyl phthalate (DIDP))	<100	<100
DiNP Diisononyl phthalate	25.0 <25.0 - 324	<25.0
DiBP Diisobutyl phthalate	1.40 <1.40 - 9.14	<1.10
DnBP Dibutyl phthalate	2.60 <2.60 - 9.62	<0.25
DEP Diethyl phthalate	<8.20	4.34
BBP Butyl benzyl phthalate	6.84 <0.50 - 7.34	<0.30
DCHP Dicyclohexyl phthalate	1.00 <1.00 - 9.60	<0.30
DNHP Dihexyl phthalate	<0.50	<0.30
DNOP Di-n-octyl phthalate	0.50 <0.50 - 19.8	<0.50
DNNP Dinonyl phthalate	1.50 <1.50 - 15.0	<0.35
DDPT 1,2-Benzenedicarboxylic acid, 1,2-diundecyl ester, branched and linear	<100	<100

[8] Brief Profile - ECHA

3.9 Antioxidants in dog serum

Some antioxidant compounds were chosen to be analysed in the one pooled sample of dog serum. Many of these compounds belong to the compound group parabens. Several compounds were below LOD or below the levels detected in the empty vial used to sample the blood serum (Blank serum vial).

Table 15: Seleceted antioxidants in the pooled dog serum sample. All concentrations are given in ng/g ww.

		Dog serum n=1 ng/g ww
Isobutyl-4-Hydroxybenzoate	IBHB	<0.012
Butyl-4-Hydroxybenzoate	BUPAR	<0.011
Butylated Hydroxyanisole	BHA	<0.120
4-(4-isopropoxyphenylsulfonyl)phenol	4IPPSP	<0.015
3-tert-butyl-4-hydroxyanisole	3BHA	<2.50
4-tert-butyl-phenol	BUPHE4T	<16
Ethyl-4-Hydroxybenzoate	EPA	<0.035
Methyl-4-Hydroxybenzoate	MPA	0.24
Benzyl-4-Hydroxybenzoate	B4HB	<0.015
Propyl-4-Hydroxybenzoate	PPA	0.16
Isopropyl-4-Hydroxbenzoate	IPPA	<0.015

3.10 Dominating pollutant groups in the species

The dominant pollutant groups within each sample type were evaluated with respect to their summed concentration. Concentrations below LOD were not included in the summed average concentrations. Metals with high detection frequencies were also the pollutant class with the highest concentrations in most of the samples and are excluded from the comparison of pollutant classes below.

Table 16: Dominating organic pollutant groups in the various samples based on average summed concentrations on a wet weight basis for biota and dry weight basis for soil.

Matrix*	Dominating organic pollutant groups in various matrices (wet weight).
Soil	Phthalates> CPs> OPFRs
Earthworm	CPs> OPFRs> PFSA
Fieldfare egg	PFSA >newPFAS> CPs
Rat liver	CPs>> PFSA>PFCA
Dog serum	Phenols> PFSA> UV comp.
Sparrowhawk egg	PCBs> CPs> PFCA
Red fox liver	Biocides>PFSA >PCBs
Badger liver	Biocides>PFSA >PFCA

* *Phthalates were only analysed in soil, biocides only analysed in liver samples and sparrowhawk eggs, antioxidants only in dog serum. Only 4-t-octylphenol as part of phenols was detected in dog serum.*

The figure below compares the percentage distributions of the organic pollutant groups in the various sample types on a wet weight basis for all samples except dry weight for soil.

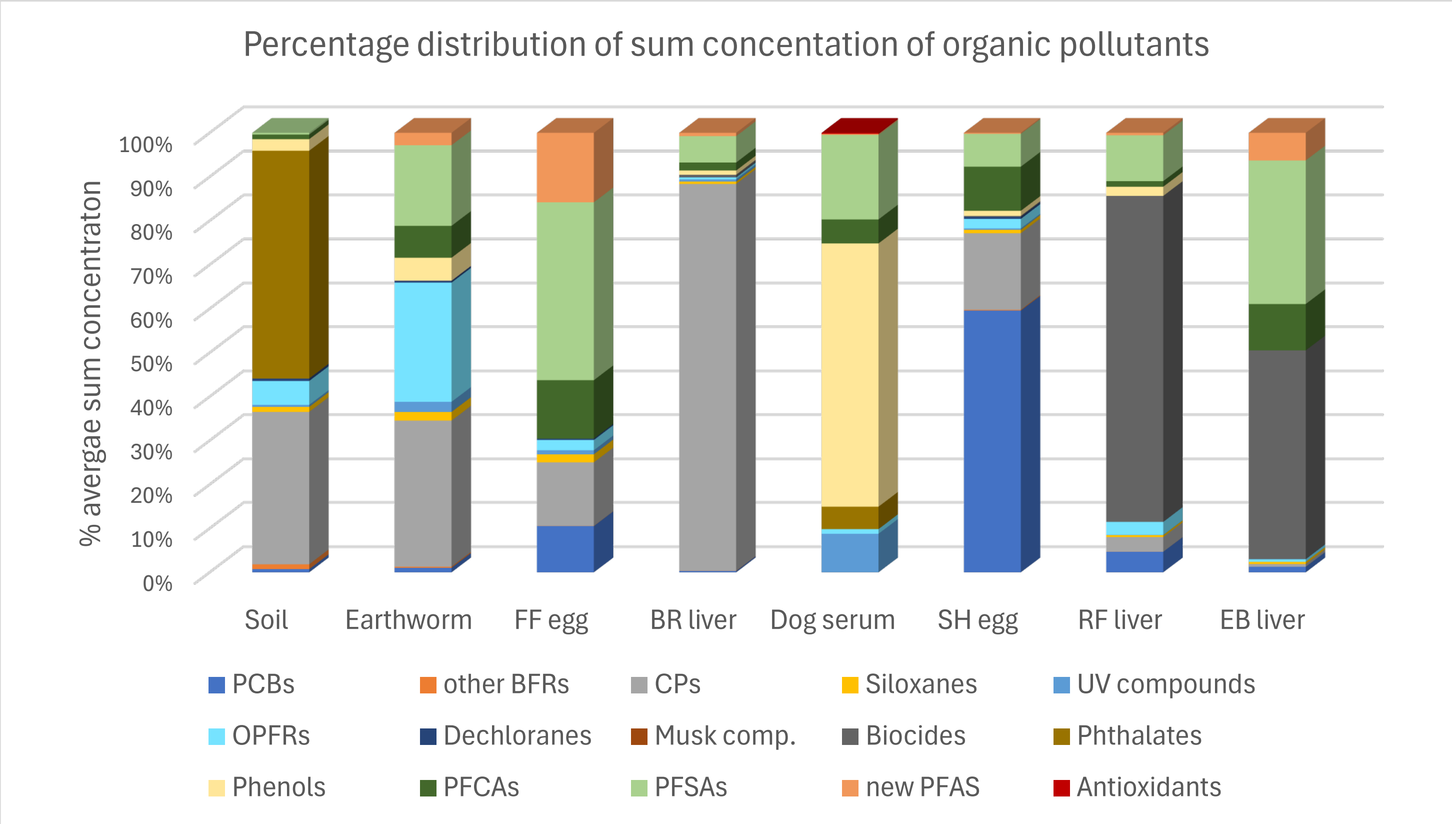


Figure 12: Percentage distributions of average summed concentrations of organic compond classes in various matrices: Soil, earthworm, fieldfare (FF) egg, brown rat (BR) liver, Dog serum, sparrowhawk (SH) egg, red fox (RF) liver and European badger (EB) liver. Phthalates were only analysed in the soil , antioxidant only in dog serum, biocides only in SH egg, RF and EB liver. Concentrations below LOD were not included in the summed average concentrations.

3.11 Trophic relationships

Figure 13 shows the relationship between the samples with stable isotope data by δ^{15}N (y-axis) as a function of δ^{13}C (x-axis).

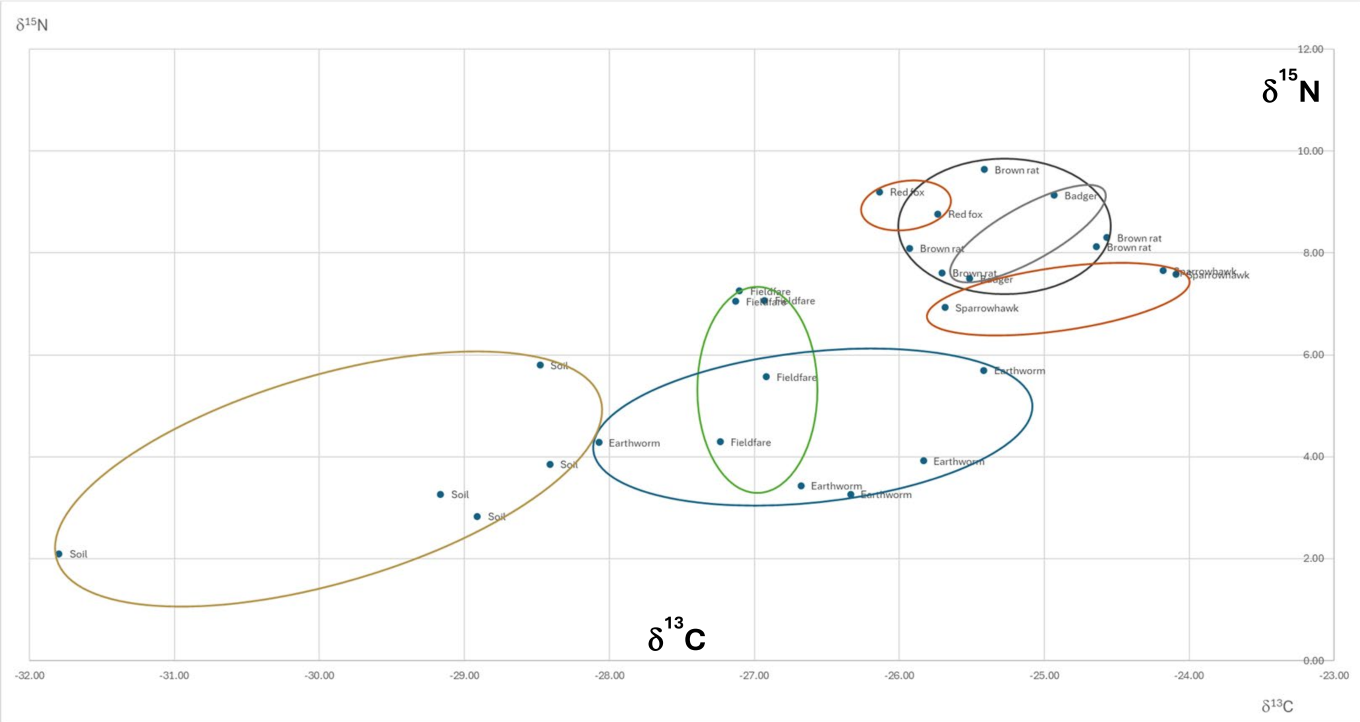


Figure 13: Relationship between the dietary descriptors, δ^{15}N (y-axis) and δ^{13}C (x-axis), in soil and biota samples from urban terrestrial environment in Oslo, 2024; soil, earthworm (EW), brown rat liver (BR liver) , fieldfare egg (FF egg), sparrowhawk (SH) egg, red fox (RF) liver and European badger (EB) liver.

Soil revealed lower δ^{13}C values than earthworm, but comparable δ^{15}N values. As can be seen from the plot, the five soil and earthworm samples encompassed a larger area than the other samples, and soil and earthworms from most of the same locations had comparable δ^{15}N, i.e. trophic position (see Figure 36 in Appendix 2). This might be explained by differences in soil properties at the various locations which are in a large extent mirrored in the earthworm samples. Total organic content (TOC) in soil varied from 3.4 to 6.0 % across locations where Ammerud (lower left corner) had lowest TOC value and Svartdalen had the highest TOC (Figure 36 in Appendix 2). Fieldfare prey on earthworm and the δ^{13}C values of the two species are overlapping, but δ^{15}N values of most fieldfare egg samples were higher than earthworm, pointing to a higher trophic level than earthworm and enrichment of δ^{15}N. The three sparrowhawk egg samples had a slightly higher average δ^{15}N value than fieldfare, and the isotopic niches had no overlap, and this can be explained by a small sample size of the species and other factors.

If fieldfare was the main prey of the sparrowhawks we would expect a larger gap in δ^{15}N values (see Heimstad et al., 2024a; Fremlin et al., 2020). Liver samples of brown rat, red fox and badger had higher δ^{15}N values than the other samples, indicating higher trophic levels.

Trophic magnification factors based on all species were not calculated in 2024 because many of the present organisms were not necessarily linked by diet (Kidd et al., 2019) by at least 3 trophic levels (Borgå et al, 2012, Kidd et al, 2019). Earthworms are known to be a major diet of fieldfare and fieldfare are known to be one of several preys of sparrowhawk. The average $\delta^{15}N$ difference between fieldfare eggs and earthworm was 2.13 ‰, while the $\delta^{15}N$ gap between sparrowhawk egg and fieldfare was only 1.13 ‰. It should be noted that only three pooled samples of sparrowhawk were analysed, and not from the same locations as the fieldfare eggs. As a general rule, a 2 to 4‰ enrichment in $\delta^{15}N$ from diet is expected, and in a Canadian terrestrial food web including birds an average value of 2.88 ‰ was determined and used (Fremlin et al, 2020). Due to the low $\delta^{15}N$ gap between sparrowhawk egg and fieldfare egg this indicated that the three species were not necessarily connected through a true prey predator relationship with three trophic levels, see Heimstad et al. 2024a for more details. Instead, we chose to assess if bioaccumulation from soil to biota and biomagnification factors from prey to predators could be calculated.

3.12 Bioaccumulation and biomagnification

Biota soil accumulation factor (BSAF) was calculated where contaminant data was detected for soil and earthworm (EW) in year 2024. BMF was calculated for the most relevant prey-predator pair, such as earthworm-fieldfare egg. See Appendix 2 for additional BMF calculations for potential prey-predator pairs.

Only earthworm (EW) has whole body concentrations. Egg concentrations were used for fieldfare (FF) and BMF should be interpreted as approximated biomagnification potential although egg levels of contaminants are known to reflect the contamination of the egg-laying female (Bianchini et al., 2022; Jouanneau et al., 2021; Cifuentes et al, 2003), and in a study of great tits, organochlorine egg concentrations were found to be similar to concentrations in adipose tissue of adult great tits (Dauwe et al., 2006).

Soil and earthworm were sampled in the same locations and fieldfare eggs nearby. The BSAF and BMF for these matrices per location are available in The Appendix 2, 5.17. The BSAF and BMF values revealed high variability across locations.

In the tables below, average concentrations across locations for soil, earthworm and fieldfare are used in the calculations. Cases with only one detected concentration were not included in the calculations. Highest BSAF value was observed for the organophosphorus compounds TCPP, TBP, TIBP, TEP and 4-tert-octylphenol (OCPHEpt) which was not reflected in the BMF values (Table 17). PCB congeners dominated the BMF values. For PFAS compounds, highest BAF and BMF values were in general observed for PFOS and for the long chain acids.

Table 17: BSAF and tentative BMF on a lipid weight (lw) basis for detected concentrations. Average concentrations per matrix are used in the calculations and only detected concentrations are used.

Compounds	BSAF(EW_{lw}/$Soil_{TOC}$)	BMF($FFegg_{lw}$/EW_{lw})
PCB-28	-	0.1
PCB-52	3.4	1.5
PCB-101	2.7	2.8
PCB-118	1.7	2.7
PCB-138	1.7	5.8
PCB-153	2.7	6.1
PCB-180	1.6	7.3
TCPP	11	0.03
TBEP	0.47	0.26
TBP	78	-
TIBP	114	0.03
TEP	36.5	-
TEHP	0.65	-
a-HBCD	0.3	0.1
D4	5.9	0.4
D5	2.8	0.7
D6	2.0	0.5
LCCP	0.3	0.7
MCCP	-	0.4
Syn-DP	2.4	-
Anti-DP	1.0	-
UV-328	0.5	2.1
OCPHEpt	19.8	-

For comparison to our BMF($FFegg_{lw}$/EW_{lw}), TMF values of D4, D5 and D6 in a terrestrial avian food web were shown to be near 1 or lower (Fremlin et al., 2021), and slightly higher than our BMF values. In the same terrestrial avian study, TMF of PCB153 was 5.6 compared to our result of 6.1 for BMF($FFegg_{lw}$/EW_{lw}).

PFAS compounds

The BAF and BMF calculations in the present study were first and foremost done on a dry weight basis for soil and wet weight basis for biota since PFAS are known to be protein associated compounds, and the lack of protein content in the samples. We used the term BAF for accumulation from soil to primary consumer earthworm on a wet weight basis, and BSAF for soil concentrations normalised to organic content.

Table 18: a) BAF values and b) BMF values for PFAS with detected concentrations on a wet weight basis. Average concentrations per matrix are used in the calcultions. The results for BMF in our study is compared to two terrestrial studies with earthworm and birds.

a)

Compounds	BAF($EW_{ww}/Soil_{dw}$)	BSAF($EW_{ww}/Soil_{TOC}$)
PFOA	4.2	0.2
PFNA	5.5	0.3
PFDA	3.5	0.2
PFDoDA	10.8	0.5
PFTeDA	-	
PFHxDA	-	
PFHpS	-	
PFOS	12.2	0.6
PFDS	-	
PFDoS	-	
8:2FTS	-	
7:3 FTCA	-	

b)

Compounds	BMF($FFegg_{ww}/EW_{ww}$)	TMF (Heimstad et al 2024a)	TMFp (protein normalised conc.) (Fremlin et al. 2023)
PFOA	0.6	0.7	1.3
PFNA	1.2	1.6	2.8
PFDA	3.8	2.0	3.3
PFDoDA	9.9	2.5	2.6
PFTeDA	16.6	1.9	2.0
PFHxDA	2.7	1.2	1.0
PFHpS	0.7		
PFOS	6.2	1.7	5.4
PFDS	10.1		3.3
PFDoS	4.9		
8:2FTS	15.8	1.8	
7:3 FTCA	3.0		

For comparison, a review of bioaccumulation in earthworm from soil reported large variability of BAF values (wet weight in earthworm divided by dry weight in soil) of PFOS and other PFAS compounds (Burkhard et al., 2023). One field study marked with high quality in Burkhardt et al. 2023 reported average BAF values of PFOS of 17, PFOA of 45, PFDA of 5.6 and PFDoDa of 1.2.

TMF calculations, which can be interpreted as diet-weighted average biomagnification factor (BMF) across the food web, were compared with our 2024 results. Protein normalized concentrations in a Canadian terrestrial food web revealed a TMF value of 5.4 for PFOS, 3.3 for PFDS, 1.3 for PFOA, 2.8 for PFNA, 3.3 for PFDA and 2.6 for PFDoDa (Fremlin et al., 2023). Heimstad et al., 2024a with a food chain approach (earthworm-fieldfare egg- sparrowhawk egg) reported lower TMF for PFOS (1.7), but in agreement with Fremlin et al., 2023, especially for some of the long chain carboxylates, and to reveal which compounds most susceptible for biomagnification with TMF >1, see Table 19b.

The general conclusion is that these bioaccumulation calculations, first and foremost, can indicate which compounds are more likely than others to bioaccumulate when BSAF (or BAF) and BMF are well above 1. For an overview of the bioaccumulation and biomagnification potential of PFAS based on data from previous programs periods (2013 to 2020), see Heimstad et al., 2024a.

3.13 Recommendations

The third program period (2021-2025) of the urban terrestrial monitoring program included several new species, new substances within some of the contaminant classes, and some new contaminant groups.

Investigating environmental pollutant at different trophic levels from soil to earthworm, bird eggs for species preying on earthworm and to higher trophic levels with predators such as sparrowhawk, brown rat, red fox and badger, has given us valuable insight of pollution levels in a terrestrial urban environment, and should be continued.

We recommend continuing sampling of bird egg as an invasive and effective sampling method, also since levels of bird eggs (preferentially the first laid eggs) resemble the levels in mother bird. Based on the results of contaminant load, brown rat is a species that seems to reflect the urban pollution signal and should be included in the future studies. The contact with the company Anticimex A.S. has been a success and an effective method for collecting rat samples. Also, the established contact with wildlife managers, hunters in Oslo have given the opportunity to receive red fox and badger as important predators in the urban environment. It is a good solution to sample and collect red fox and badger prior to the year of the chemical analysis since many of the samples have first and foremost been available late in the calendar year.

Some of the organisms collected this year were connected through diet in a prey-predator relationships. e.g. fieldfare-earthworm, sparrowhawk-fieldfare, badger-earthworm. One challenge in terrestrial ecosystems is that the food webs are very diverse, and each predator will rely on many different types of prey. Fieldfare-earthworm has been very good for calculating BMF, as we can assume that earthworms are important prey for fieldfares and they have been collected at the same locations. We recommend to keep this predator–prey pair for BMF calculations. The other pairs could be improved by collecting both the predator and the prey samples from the same locations. This requires more effort in the field, and most likely collecting the predator first and then specifically sample prey close to the same location. This will be possible for sparrowhawk- fieldfare, badger- earthworm and/or slug, and roe deer -rowan (previous years), but most likely not for red fox- roe deer.

For TMF calculations, it is recommended to have organisms related by diet through the food web, with approximately similar numbers of samples at lower and higher trophic levels, and covering at least three trophic levels. We have used earthworm- fieldfare- sparrowhawk for TMF calculations in the former program period. For the purpose of TMF, we suggest to improve this by collecting all the samples from the same locations. This could be done by collecting sparrowhawk eggs first, and then collect fieldfare and earthworm in the same location. This could be done in addition to the regular sampling locations (From Svartdalsparken, along Alna to Ammerud/Grorudalen, i.e. the most industrialized and urban area) for earthworm and fieldfare, in order to both maintain consistency for monitoring. It could also be further improved by collecting eggs from one or more potential prey species for sparrowhawk.

Location is important for prediction of biomagnification and also to pinpoint to possible pollution sources. Soil, earthworm and bird eggs are therefore important matrices, and collection of bird eggs are a highly standardized method and very comparable between studies. For comparison to other published studies, and link pollution level to physiological data, it is recommended to analyse individual samples of mammals and bird eggs. For temporal studies and trend analysis, it is recommended to select the same species, locations and preferentially the same analytical methods.

Due to the increase of compound groups for analysis there is a challenge to collect and gain sufficient amount of sample material for some species (especially fieldfare eggs) if all compound classes should be analysed in the same individual sample. One way to solve this is to collect more eggs from the same nests or from more nests. The former will provide a stronger impact on birds' reproductive success while the latter will involve more field effort. A good alternative is to divide analysis of compound classes across the samples of the same species when possible. In addition, sufficient amount of the sample for analysis prevent high limit of detection.

3.14 Acknowledgements

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Ida Ward Myran (NINA) and Kristine Roaldsnes Ulvund (NINA), prepared the egg and liver samples before analysis. Lisa Åsgård, Carl Christian Holm, Gjøran Stenberg, Morten Olsen, , Sveinn Are Hanssen (NINA), Nina Eide (NINA), Neri Horntvedt Thorsen (NINA) collected samples in the field or organized sample collection.

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The Dietary Protein Research Group at Haukeland University Hospital, for providing the project with 37 single samples of dog serum.

IFE:

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NIVA:

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NILU, sample preparation and chemical analyses;

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4 Appendix 1: Material & Methods

4.1 Sampling and matrices

4.1.1 Soil and earthworms

Soil and earthworm samples were collected at the same five locations as in year 2022 (Table 19). The upper layer of 0-30 cm of soil was sampled and at three locations at each site, combining the three subsamples to one pooled sample per location. In cases where the site was connected to a transition between forest and open field, samples were taken in the forest, in the field, and in between. For earthworms, pooled samples at each site consisted of 30-50 individuals. To purge their guts, earthworms were kept in aluminium covered plastic containers, and lined with moist paper sheets for three days before being frozen at -20°C.

Table 19: Sampling information for soil and earthworm sampling.

Location for soil and earthworms	Date	Soil depth	Site description
Svartdalen	10.08.2024	15 cm	Clearing in a deciduous forest (sandy soil, stones and clay)
Alna	10.08.2024	10 cm	Deciduous forest (compact sand)
Alnaparken	10.08.2024	15 cm	Deciduous forest (hard soil, mineral particles)
Hølaløkka	10.08.2024	15 cm	Deciduous forest near park and track(sandy soil)
Ammerud	10.08.2024	15 cm	Deciduous forest, near track and park area

4.1.2 *Fieldfare eggs*

Two fieldfare eggs were collected on the 4th of May 2024 from each of five nest locations at Svartdalen, Alna, Alnaparken, Hølaløkka and Ammerud; with permission from the Norwegian Environment Agency. The laying order of the eggs was not taken into account when collecting the eggs to avoid disturbing the nest more than necessary. The eggs were kept individually in polyethylene bags in a refrigerator (+4°C), before being shipped by express mail to NINA for measurements and emptying. Both the two eggs per location were pooled together to form one sample. When emptying, the whole content of the two eggs was removed from the shell, homogenized and stored in a clean glass before storage at – 20°C. The weight of the eggs varied from 4.1 to 7.7 grams.

Table 20: Locations and information of fieldfare eggs

Location fieldfare eggs	Date	Year	Content
Svartdalen	May 4	2024	Egg yolk, not developed
Svartdalen	May 4	2024	Egg yolk, not developed
Alna	May 4	2024	Egg yolk, not developed
Alna	May 4	2024	Egg yolk, not developed
Alnaparken	May 4	2024	Egg yolk, not developed
Alnaparken	May 4	2024	Egg yolk, not developed
Hølaløkka	May 4	2024	Embryo, developed
Hølaløkka	May 4	2024	Embryo, developed
Ammerud	May 4	2024	Egg yolk, not developed
Ammerud	May 4	2024	Egg yolk, not developed

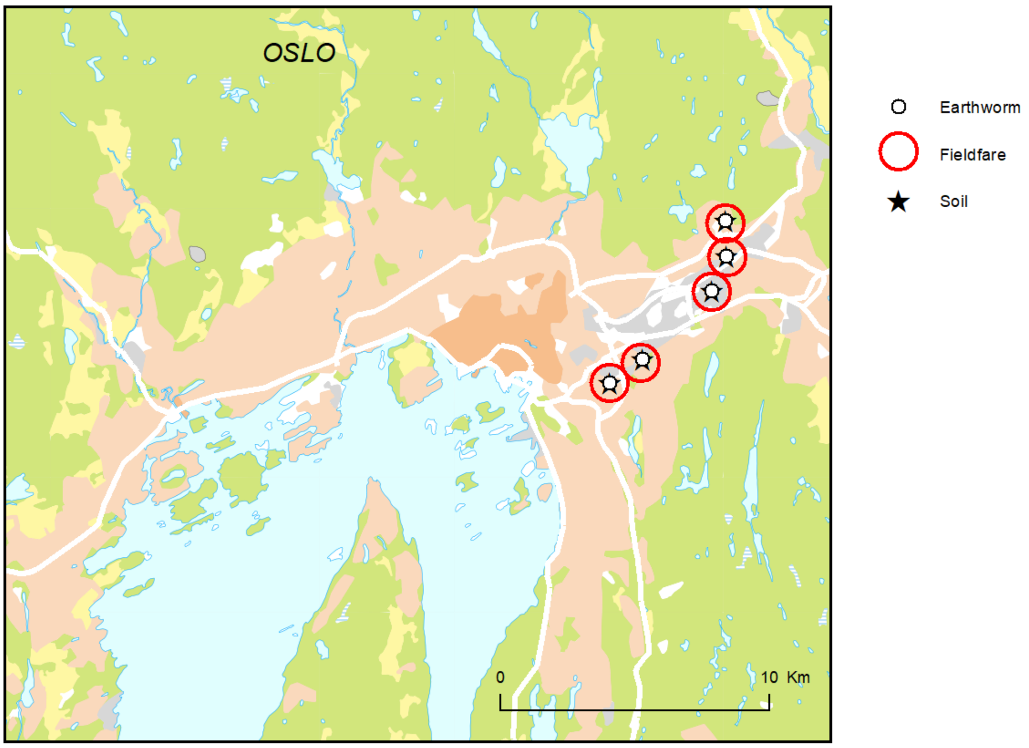

Figure 14: Locations along the Groruddalen for soil, earthworm and fiedlfare eggs

4.1.3 Brown rat

Eleven rats were caught during 2023 and 2024 aiming at using clap-traps without rat poison, see Table below. All rat samples were delivered to NINA by the pest control company Anticimex AS in Oslo. The bodyweight of the eleven rats varied between 148 g and 402 g. The rats were placed in the freezer as fast as possible on the day of collection and stored at -20°C before being shipped by express mail to NINA for measurements and dissection. The rat livers were sent frozen packed in aluminium foil in zip locked bags by express mail to NILU for analyses.

Table 21: Information on the rat samples.

NILU id		Locations	Sampling date	Sex	Body weight	Liver weight
24/2314	Brown rat	Torggata 16, Oslo (F)	06.11.2023	female	156	6.44
	Brown rat	Eikenga 19. 0579 Oslo (F)	18.02.2024	female	366	17.08
24/2315	Brown rat	Eikenga 19. 0579 Oslo. (M)	18.02.2024	male	340	11.64
	Brown rat	Eikenga 7. 0579 Oslo (M)	21.02.2024	male	320	11.86
	Brown rat	Frognerseterveien Oslo (F)	06.04.2024	female	148	4.98
24/2316	Brown rat	Sofienbergg.37, Oslo(M)	23.08.2023	male	384	11.96
	Brown rat	Unknown address (M)	21.12.2023	male	402	18.32
24/2317	Brown rat	Kongensgate 7, Oslo (F)	21.04.2023	female	192	13.32
	Brown rat	Bekkestenveien 27A, Oslo (F)	04.04.2024	female	268	18.28
24/2318	Brown rat	Torggata 24, Oslo (F)	27.07.2023	female	370	21.8
	Brown rat	Torggata 24, Oslo (F)	27.07.2023	female	270	16.52

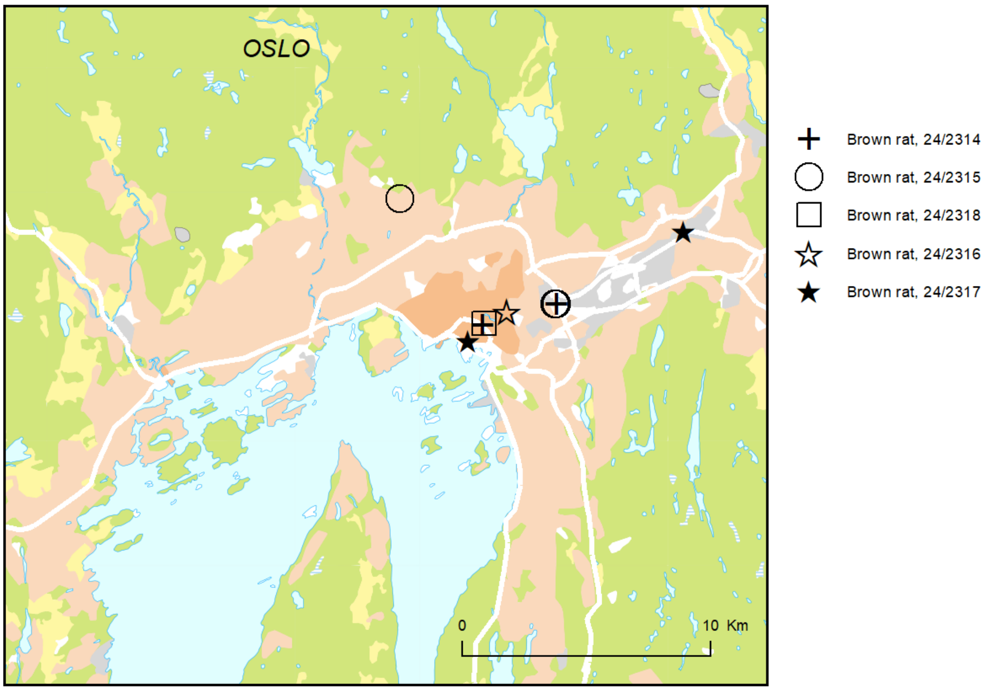

Figure 15: Locations of the pooled rat samples

4.1.4 Dog samples

Dog serum samples were generously provided by the Dietary Protein Research Group at Haukeland University Hospital. These samples were originally collected for a study investigating the health impacts of dietary marine protein in dogs (manuscript submitted). The samples utilized in our research are surplus baseline samples from this primary study. All participating dogs were healthy domestic pets from the large breeds Golden Retriever and Labrador. For one month prior to the baseline sampling, the dogs were provided Virbac veterinary dog food as their daily feed, and the dogs were fasting prior to blood sampling. The samples were collected during March to May in the year 2023. 38 individual serum samples were pooled together to create one sample for all the chemical analysis. Since only one sample, a lab blank or an empty blank vial for serum sampling was included in addition to a control sample in the analysis.

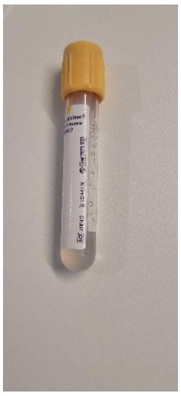

Figure 16: Serum Blank Vial used to separate red blood cells from plasma

4.1.5 Sparrowhawk, Red fox and European badger

Pooled samples across years for each sample type of sparrowhawk eggs, red fox liver and badger livers were analysed. It was aimed at making pooled samples for the same sex and same area when possible, resulting in three pooled samples of sparrowhawk eggs, two pooled samples of red fox liver and badger livers.

Table 22: Pooled samples of sparrowhawk egg, red fox liver and badger liver across years

NILU id	Type of matrix	Area	Sampling years	No. of individual samples included in the pooled samples
24/1829	Sparrowhawk eggs	Ekeberg	2022 and 2023	2
24/1830	Sparrowhawk eggs	Skullerud	2021, 2022, 2023	3
24/1831	Sparrowhawk eggs	Gråkammen	2021, 2022, 2023	3
24/1832	Red fox liver	Hellerudmyra	2022 and 2023	6
24/1833	Red fox liver	Bærum	2021 and 2023	3
24/1834	Badger liver	Bærum/Sandvika	2021 and 2023	4
24/1835	Badger liver	Oslo	2021 and 2022	5

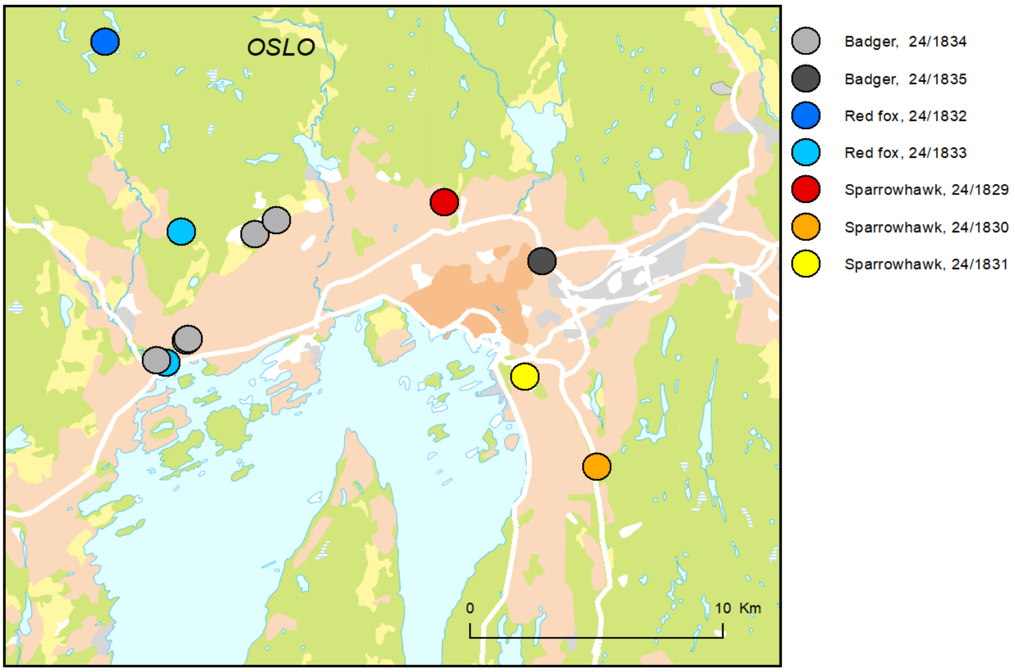

Figure 17: Locations of sparrowhawk eggs, red fox and badger for the pooled samples across years

4.2 GPS coordinates for sampling locations in 2024.

Table 23: NILU id for the various sample types and GPS coordinates in EU89- Geographic, degree (Lat/Lon) in decimal degrees for sampling locations in 2024

NILU ID	Sample	Location	Latitude	Longitude
24/2297	Soil	Alna	59.9161	10.8312
24/2298	Soil	Alnaparken	59.9403	10.8739
24/2299	Soil	Ammerud	59.9638	10.8806
24/2300	Soil	Hølaløkka	59.9521	10.8823
24/2301	Soil	Svartdalen	59.9074	10.8105
24/2302	Earthworm	Alna	59.9161	10.8312
24/2303	Earthworm	Alnaparken	59.9403	10.8739
24/2304	Earthworm	Ammerud	59.9638	10.8806
24/2305	Earthworm	Hølaløkka	59.9521	10.8823
24/2306	Earthworm	Svartdalen	59.9074	10.8105
24/2309	Fieldfare egg	Alna	59.9147	10.8299
24/2310	Fieldfare egg	Alnaparken	59.9399	10.8741
24/2311	Fieldfare egg	Ammerud	59.963	10.8802
24/2312	Fieldfare egg	Hølaløkka	59.9517	10.883
24/2313	Fieldfare egg	Svartdalen	59.9074	10.8105
24/2314	Brown rat	Torggata 16, Oslo (F)*	59.9159	10.751
	Brown rat	Eikenga 19. 0579 Oslo (F)	59.9252	10.80319
24/2315	Brown rat	Eikenga 19. 0579 Oslo. (M)	59.9252	10.80319
	Brown rat	Eikenga 7. 0579 Oslo (M)	59.9251	10.80233
	Brown rat	Frognerseterveien Oslo (F)	59.9594	10.68615
24/2316	Brown rat	Sofienbergg.37, Oslo(M)	59.92132	10.76773
	Brown rat	Unknown address (M)		
24/2317	Brown rat	Kongensgate 7, Oslo (F)	59.91001	10.74149
	Brown rat	Bekkestenveien 27A, Oslo (F)	59.9543	10.89142
24/2318	Brown rat	Torggata 24, Oslo (F)	59.91656	10.75224
	Brown rat	Torggata 24, Oslo (F)	59.91656	10.75224
24/1829	Sparrowhawk egg	Gråkammen	n.a.	n.a.
24/1830	Sparrowhawk egg	Skullerud	n.a.	n.a.
24/1831	Sparrowhawk egg	Ekeberg	n.a.	n.a.
24/1832	Red fox liver	Hellerudmyra	60.00834	10.46559
	Red fox liver	Bærum	59.89124	10.52472
24/1833	Red fox liver	Bærum	59.89124	10.52472
	Red fox liver	Bærum	59.94003	10.52918
	Badger liver	Bærum/Sandvika	59.94094	10.58123
	Badger liver	Bærum/Sandvika	59.89977	10.5379
24/1834	Badger liver	Bærum/Sandvika	59.89192	10.51805
	Badger liver	Bærum/Sandvika	59.90037	10.53934
	Badger liver	Bærum/Sandvika	59.94659	10.59542
24/1835	Badger liver	Oslo centroid (Sinsenkrysset)	59.93756	10.78459

**(F) denotes female and (M) male for rat samples. Coordinates for sparrowhawk are not given due to protected species.*

4.3 Investigated environmental pollutants

In this study a total of 167 environmental pollutants were investigated. These included metals, seven PCBs, PFAS, other BFRs, siloxanes, chlorinated paraffins (SCCPs, MCCPs, and LCCPs), organic phosphorous compounds (OPFRs), UV compounds, dechloranes, phenols, musk compounds, phthalates (soil), antioxidants (dog serum) and biocides (sparrowhawk eggs and liver samples). In addition, the stable isotopes $\delta^{15}N$ and $\delta^{13}C$ were measured in all samples except dog serum. An overview of the analysed compounds is given in Table 24. Note that n-PFAS compounds were not analysed in year 2025.

Table 24: Overview of the analysed compounds

Compounds	Abbreviation	CAS
Metals		
Chromium	Cr	7440-47-3
Nickel	Ni	7440-02-0
Copper	Cu	7440-50-8
Zink	Zn	7440-66-6
Arsenic	As	7440-38-2
Silver	Ag	7440-22-4
Cadmium	Cd	7440-43-9
Lead	Pb	7439-92-1
Mercury	Hg	7439-97-6
Gadolinium	Gd	7440-54-2
Antimony	Sb	7440-36-0
Tin	Sn	7440-31-5
Polychlorinated biphenyls (PCBs)		
2,4,4'-Trichlorobiphenyl	PCB-28	7012-37-5
2,2',5,5'-Tetrachlorobiphenyl	PCB-52	35693-99-3
2,2',4,5,5'-Pentachlorobiphenyl	PCB-101	37680-73-2
2,3',4,4',5-Pentachlorobiphenyl	PCB-118	31508-00-6
2,2',3,4,4',5'-Hexachlorobiphenyl	PCB-138	35065-28-2
2,2',4,4',5,5'-Hexachlorobiphenyl	PCB-153	35065-27-1
2,2',3,4,4',5,5'-Heptachlorobiphenyl	PCB-180	35065-29-3
Per- and polyfluorinated alkyl substances (PFAS)		
PFCA (perfluorinated carboxylate acids)		
Trifluoro acetic acid	TFA	76-05-1
Perfluoro propanoic acid	PFPrA	422-64-0
Perfluorinated butanoic acid	PFBA	375-22-4
Perfluorinated pentanoic acid	PFPA	2706-90-3
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	PFDA	335-76-2
Perfluorinated undecanoic acid	PFUnDA	2058-94-8
Perfluorinated dodecanoic acid	PFDoDA	307-55-1
Perfluorinated tridecanoic acid	PFTrDA	72629-94-8
Perfluorinated tetradecanoic acid	PFTeDA	376-06-7
Perfluorinated hexadecanoic acid	PFHxDA	67905-19-5
Perfluorinated octadecanoic acid	PFOcDA	16517-11-6

Compounds	Abbreviation	CAS
PFSA (Perfluorinated sulfonates)		
Perfluoro ethanoic sulphonate	PFEtS	354-88-1
Perfluoro propanoic sulphonate	PFPrS	423-41-6
Perfluorinated butane sulfonate	PFBS	375-73-5
Perfluorinated pentane sulfonate	PFPS	2706-91-4
Perfluorinated hexane sulfonate	PFHxS	355-46-4
Perfluorinated heptane sulfonate	PFHpS	375-92-8
Perfluorinated octane sulfonate (linear)	PFOS	1763-23-1
Perfluorinated octane sulfonate (branched)	brPFOS	n/a
Perfluorinated octane sulfonate (linear+branched)	sumPFOS	
Perfluorinated nonane sulfonate	PFNS	68259-12-1
Perfluorinated decane sulfonate	PFDS	335-77-3
Perfluoroundecane sulfonate	PFUnS	749786-16-1
Perfluorododecane sulfonate	PFDoS	79780-39-5
Perfluorotridecane sulfonate	PFTrS	791563-89-8
Perfluorotetradecane sulfonate	PFTS	1379460-39-5
Perfluorotetradecane sulfonate	PFTS	1379460-39-5
nPFAS (polyfluorinated neutral compounds)		
Perfluorooctane sulfonamide	FOSA	754-91-6
N-(methyl)nonafluorobutanesulfonamide	N-MeFBSA	68298-12-4
N-ethyl-perfluorobutane-1-sulfonamide	N-EtFBSA	40630-67-9
Perfluorobutylsulphonamide	PFBSA	30334-69-1
N-Methyl perfluorooctane sulphonamide	meFOSA	31506-32-8
N-Ethyl perfluorooctane sulfonamide	etFOSA	4151-50-2
N-Methylperfluorooctanesulfonamidoethyl acrylate	meFOSEA	25268-77-3
N-Methyl perfluorooctane sulfonamidoethanol	meFOSE	24448-09-7
N-Ethyl perfluorooctane sulfonamidoethanol	etFOSE	1691-99-2
Perfluorooctane sulfonamidoacetic acid	FOSAA	2806-24-8
N-Methylperfluoro-1-octanesulfonamidoacetic Acid	meFOSAA	2355-31-9
N-Ethyl perfluorooctanesulfonamidoacetic acid	etFOSAA	2991-50-6
newPFAS		
4:2 Fluorotelomersulfonate	4:2 FTS	757124-72-4
6:2 Fluorotelomersulfonate	6:2 FTS	27619-97-2
8:2 Fluorotelomersulfonate	8:2 FTS	39108-34-4
10:2 Fluorotelomersulfonate	10:2 FTS	120226-60-0
12:2 Fluorotelomersulfonate	12:2 FTS	149246-64-0
Cyclohexanesulfonic acid, decafluoro(pentafluoroethyl)	PFECHS	646-83-3
7:3 Fluortelomercarboxylate	7:3 FTCA	812-70-4
BFRs		
Decabromodiphenyl ethane	DBDPE	84852-53-9
2,4,6-tribromophenyl ether	ATE (TBP-AE)	3278-89-5
α-1,2-Dibromo-4-(1,2-di-bromo-ethyl)cyclohexane	α-TBECH	1232836-49-5, 3322-93-8
β-1,2-Dibromo-4-(1,2-di-bromo-ethyl)cyclohexane	β-TBECH	1232836-49-5, 3322-93-8
γ/δ- 1,2-Dibromo-4-(1,2-di-bromo-ethyl)cyclohexane	γ/δ-TBECH	
2-bromoallyl 2,4,6-tribromophenyl ether	BATE	99717-56-3
1,2,3,4,5 Pentabromobenzene	PBBZ	608-90-2

Compounds	Abbreviation	CAS
tetrabromo-p-xylene	PTBX	23488-38-2
Pentabromotoluene	PBT	87-83-2
Pentabromoethylbenzene	PBEB	85-22-3
Hexabromobenzene	HBB	87-82-1
2,3-dibromopropyl 2,4,6-tribromophenyl ether	DPTE	35109-60-5
2-Ethylhexyl 2,3,4,5-tetrabromobenzoate	EHTBB	183658-27-7
1,2-Bis(2,4,6-tribromophenoxy)ethane	BTBPE	37853-59-1
Bis(2-ethylhexyl) tetrabromophthalate	TBPH (BEH/TBP)	26040-51-7
α-Hexabromocyclododecane	α-HBCD	134237-50-6
β-Hexabromocyclododecane	β-HBCD	134237-51-7
γ-Hexabromocyclododecane	γ-HBCD	134237-52-8
Dechloranes and dibromo-aldrin		
Dechlorane plus syn	syn-DP	135821-03-3
Dechlorane plus anti	anti-DP	135821-74-8
Dechlorane 601	Dec-601	3560-90-2
Dechlorane 602	Dec-602	31107-44-5
Dechlorane 603	Dec-603	13560-92-4
Dechlorane 604	Dec-604	34571-16-9
Dibromoaldrin	DBALD	20389-65-5
Cyclic volatile methyl siloxanes		
D4 - octamethylcyclotetrasiloxane	D4	556-67-2
D5 - decamethylcyclopentasiloxane	D5	541-02-6
D6 - dodecamethylcyclohexasiloxane	D6	540-97-6
Tris(trimethylsiloxy)phenylsilane	M3TPH	2116-84-9
Octamethyltrisiloxane	L3	107-51-7
Decamethyltetrasiloxane	L4	141-62-8
Dodecamethylpentasiloxane	L5	141-63-9
Chlorinated paraffins (CP)		
Short-chain chlorinated paraffins (C10-C13)	SCCP	85535-84-8
Medium-chain chlorinated paraffins (C14-C17)	MCCP	85535-85-9
Long-chain chlorinated paraffins (C18-C30)	LCCP	85535-86-0
Organophosphorous flame retardants (OPFRs)		
Tri(2-chloroethyl)phosphate	TCEP	115-96-8
Tris(2-chloroisopropyl) phosphate	TCPP/TCIPP	13674-84-5
Tris(1,3-dichloro-2-propyl)phosphate	TDCPP/TDCIPP	13674-87-8
Tris(2-butoxyethyl) phosphate	TBEP/TBOEP	78-51-3
2-etylhexyldiphenyl phosphate	EHDP/EHDPP	1241-94-7
Tricresyl phosphate	TCP	1330-78-5
Tri-n-butylphosphate	TBP/ TnBP	126-73-8
Tri-iso-butylphosphate	TiBP	126-71-6
Triethyl phosphate	TEP	78-40-0
Tripropyl phosphate	TPrP/TPP	513-08-6
Butyl diphenyl phosphate	BdPhP	2752-95-6
Triphenyl phosphate	TPP/TPhP	115-86-6
Dibutylphenyl phosphate	DBPhP	2528-36-1
Trixylylphosphate	TXP	25155-23-1
Tris(4-isopropylphenyl)phosphate	TIPPP/T4IPP	26967-76-0

Compounds	Abbreviation	CAS
Tris(4-Tert-butylphenyl)phosphate	TTBPP	78-33-1
Tris(2-ethylhexyl)phosphate	TEHP	78-42-2
UV compounds		
Octocrylene	OC	6197-30-4
Benzophenone-3	BP3	131-57-7
Ethylhexylmethoxycinnamate	EHMC	5466-77-3
2-(5-Chloro-2H-benzotriazol-2-yl)-4,6-di-tert-butylphenol	UV-327	3864-99-1
2-(2H-Benzotriazol-2-yl)-4,6-di-tert-pentylphenol	UV-328	25973-55-1
Octrizole	UV-329	3147-75-9
Homomenthyl salicylate	Homosalate	118-56-9
Phenols		
Tetrabromobisphenol A	TBBPA	79-94-7
4,4 Bisphenol A	BPA	80-05-7
2,4 Bisphenol A	BPA24	837-08-1
2,4 Bisphenol S	BPS24	5397-34-2
4,4 Bisphenol F	BPF	620-92-8
2,4 Bisphenol F	BPF24	2467-03-0
Bisphenol G	BPG	127-54-8
Bisphenol FL	BPFL	3236-71-3
Bisphenol AP	BPAP	1571-75-1
Bisphenol Z	BPZ	843-55-0
Bisphenol E	BPE	2081-08-5
Bisphenol B	BPB	77-40-7
Bisphenol M	BPM	13595-25-0
AO-MB1	MB1	118-82-1
4-Dodecylphenol	DDPHE4	104-43-8
4-n-Nonylphenol	NOPHE4	104-40-5
4-n-Octylphenol	OCPHE4N	1806-26-4
4-t-Octylphenol	OCPHEpt	140-66-9
Biocides (rodenticides)		
Bromadiolon	BRDIOL	28772-56-7
Brodifacoum	BRDIFA	56073-10-0
Flocumafen	FLOCO	90035-08-8
Difenacoum	DIFEN	56073-07-5
Difethialone	DIFET	104653-34-1
Permethrin	PERM	52645-53-1
Phthalates		
Di (2-ethylhexyl)phthalate	DEHP	117-81-7
Di(2-propylheptyl) + Di-isodecyl phthalate	SDPHP_DIDP	53306-54-0 +68515-49-1
Di-isononyl phthalate	DiNP	28553-12-0
Di-isobutyl phthalate	DiBP	84-69-5
Di-n-butyl phthalate	DnBP	84-74-2
Diethyl phthalate	DEP	84-66-2
Butyl benzyl phthalate	BBP	85-68-7
Dicyclohexyl phthalate	DCHP	84-61-7
Dihexyl phthalate	DNHP	84-75-3

Compounds	Abbreviation	CAS
Di-n-octyl phthalate	DNOP	117-84-0
Dinonyl phthalate	DNNP	84-76-4
1,2-Benzenedicarboxylic acid, 1,2-diundecyl ester, branched and linear	DDPT	85507-79-5
Musk compounds		
Galaxolide	HHCB	1222-05-5
Tonalide (AKHT)	TONA	21145-77-7
Traesolide	TRAS	68140-48-7
Phantolide	PANT	15323-35-0
Celestolide	KELE	13171-00-1
Acetyl cedrene	MCKETON	32388-55-9
Iso-E-super	OTNE	54464-57-2
Antioxidants		
Isobutyl-4-Hydroxybenzoate (Isobutylparaben)	IBHB	4247-02-3
Butyl-4-Hydroxybenzoate(Butylparaben)	BUPAR	94-26-8
Butylated Hydroxyanisole	BHA	25013-16-5
4-(4-isopropoxyphenylsulfonyl)phenol	4IPPSP	95235-30-6
3-tert-butyl-4-hydroxyanisole	3BHA	121-00-6
4-tert-butyl-phenol	BUPHE4T	98-54-4
Ethyl-4-Hydroxybenzoate (Ethyl paraban)	EPA	120-47-8
Methyl-4-Hydroxybenzoate (Methyl paraben)	MPA	99-76-3
Benzyl-4-Hydroxybenzoate (Benzyl paraben)	B4HB	94-18-8
Propyl-4-Hydroxybenzoate (Propyl paraben)	PPA	94-13-3
Isopropyl-4-Hydroxbenzoate (Isopropyl paraben)	IPPA	4191-73-5

4.4 PNEC values

Table 25: PNEC values for Soil ecosystem, with references. Most data adopted from Andersen et al 2012[9], 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 second priority due to assumed lower reliability.

Compound	$PNEC_{Soil}$	Unit in soil	Reference	Safety factor	Comment
BPA (4,4 Bis-A)	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	
LCCP	4.64	g/kg dw	ECHA Chemical information (Scientific Properties)		https://echa.europa.eu/brief-profile/-/briefprofile/100.058.300
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
TFA	4.7	ng/g dw	ECHA Chemical information (Scientific Properties)		Secondary poisoning: No potential for bioaccumulation (1)
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

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

Compound	$PNEC_{Soil}$	Unit in soil	Reference	Safety factor	Comment
TCPP	1.7	mg/kg dw	EU RAR TCPP	10	Spiring Lactuca sativa
TCPP	1.33-1.7	mg/kg dw	Echa Chemical Information		
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
TCP	1.01	mg/kg dw	ECHA Chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.239.100
TBP/TnBP	5.3	mg/kg dw	TA-2784	EqP	Based on LogKow
TBP/TnBP	640- 2830	µg/kg dw	ECHA Chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.004.365
TBP/TiBP	420	µg/kg dw	ECHA Chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.004.363
TEP	640	µg/kg dw	ECHA Chemical information		
TIBP	0.64	mg/kg dw	TA-2784	EqP	Based on LogKow
TPP/TPhP	28.2	µg/kg dw			https://echa.europa.eu/brief-profile/-/briefprofile/100.003.739
TXP	11.7	mg/kg dw			https://echa.europa.eu/brief-profile/-/briefprofile/100.042.419
TEHP	3.7	mg/kg dw			https://echa.europa.eu/brief-profile/-/briefprofile/100.001.015
DEHP	13	mg/kg dw	ECHA Chemical information (Scientific Properties)		https://echa.europa.eu/brief-profile/-/briefprofile/100.003.829
DiNP	30	mg/kg dw	ECHA Chemical information (Scientific Properties)		No potential for bioaccumulation
DPHP	26.5	mg/kg dw	ECHA Chemical information (Scientific Properties)		No potential for bioaccumulation
DnBP	50	ng/g dw	ECHA Chemical information (Scientific Properties)		https://echa.europa.eu/brief-profile/-/briefprofile/100.001.416
DiBP	23.1	ng/g dw	ECHA Chemical information (Scientific Properties)		No potential for bioaccumulation
DEP	137	µg/kg dw	ECHA Chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.001.409
BBP	1.57	mg/kg dw	ECHA Chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.001.475
DCHP	310	µg/kg dw	ECHA Chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.001.405
DDPT	109	µg/kg dw	ECHA Chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.079.428
HHCB	1.5	mg/kg dw	ECHA Chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.013.588

Compound	$PNEC_{Soil}$	Unit in soil	Reference	Safety factor	Comment
MCKETON	4.87	mg/kg dw	ECHA Chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.046.367
UV-328 (25973-55-1)	90	mg/kg dw	ECHA Chemical information (Scientific Properties		
UV-329 (3147-75-9)	10	mg/kg dw	ECHA Chemical information (Scientific Properties		No potential to cause toxic effects if accumulated (in higher organisms) via the food chain
OC (6197-30-4)	1.25	mg/kg dw	ECHA Chemical information (Scientific Properties		No potential to cause toxic effects if accumulated (in higher organisms) via the food chain
Homosalate	54.11	mg/kg dw	ECHA Chemical information (Scientific Properties		No potential to cause toxic effects if accumulated (in higher organisms) via the food chain
BP3 (131-57-7)	13	**ng/g dw**	ECHA Chemical information (Scientific Properties		Additional info: No potential for bioaccumulation
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	2.9	mg/kg dw	ECHA Chemical Information https://echa.europa.eu/brief-profile/-/briefprofile/100.028.316		

Table 26:PNEC$_{oral}$ 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 have second priority.

Compound	PNEC$_{oral}$ mg/kg food	Reference	Safety factor	Comment
PCBs	0.001	INERIS: Annex VII PNEC values and hazard information for candidate substances, 2009. *Uncertainty to the value since not based on EU Risk Assessment report*		based on TDI of 0.02 µg/kg bw/day for total PCBs via diet (WHO, 2003 & ATSDR, 2000) and TDI of 0.01 µg/kgbw/day for total PCBs, via diet (RIVM, 2001)
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.
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/kg bw/d for maternal weight gain from a teratogenicity study
PFOS	0.033	European Commission. 2011. Perfluorooctane sulfonate. PFOS Environmental Quality Standard (EQS) dossier. Brussels, Belgium.		QSbiota (secondary poisoning: predators)
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

Compound	$PNEC_{oral}$ mg/kg food	Reference	Safety factor	Comment
DEHP	3.3	ECHA Chemical Information		
DnBP	1.33	ECHA Chemical Information		https://echa.europa.eu/brief-profile/-/briefprofile/100.001.416
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	https://echa.europa.eu/brief-profile/-/briefprofile/100.008.307
Cyclic Siloxane (D5)	13	EA ERAR 2009 Decamethylcyclopenta-Siloxane,	30	Repeated exposure, liver effects
Cyclic Siloxane (D5)	16	Source: European Chemicals Agency, http://echa.europa.eu/	90	https://echa.europa.eu/brief-profile/-/briefprofile/100.007.969
Cyclic Siloxane (D6)	66.7	Source: European Chemicals Agency, http://echa.europa.eu/	300	https://echa.europa.eu/brief-profile/-/briefprofile/100.007.967
Cyclic Siloxane (D6)	50-100	EA ERAR 2009	300	Reproduction NOAEL rat
Linear siloxane L3	1.7	ECHA chemical Information		https://echa.europa.eu/brief-profile/-/briefprofile/100.003.181
Linear siloxane L4	1.7	ECHA chemical Information		https://echa.europa.eu/brief-profile/-/briefprofile/100.004.993
Linear siloxane L5	No effect	ECHA chemical Information		https://echa.europa.eu/brief-profile/-/briefprofile/100.004.994
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	
LCCP	10	ECHA chemical Information		https://echa.europa.eu/brief-profile/-/briefprofile/100.058.300
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
TDCPP 13674-87-8	3.3	EU RAR 2008	30	Two-years carcinogenicity rat study
TBEP 78-51-3	4.44	ECHA chemical Information		https://echa.europa.eu/brief-profile/-/briefprofile/100.001.021
EHDPP	1.1	Environmental Agency (UK) 2009	90	Rat 90 d oral exposure
EHDP	1.62	ECHA chemical Information		https://echa.europa.eu/brief-profile/-/briefprofile/100.013.625

Compound	PNEC$_{oral}$ mg/kg food	Reference	Safety factor	Comment
TCP	1.7	EA RER 2009 (1330-78-5)	30	Two-years reproduction mouse study
TCP	0.65	ECHA chemical Information		https://echa.europa.eu/brief-profile/-/briefprofile/100.239.100
TCPP	11.6	EU RAR TCPP 2008	90	Rat, 13 weeks study, liver effects
TPP/TPhP	16.7	ECHA chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.003.739
DEHP	3.3	ECHA chemical information (scientific information)		https://echa.europa.eu/brief-profile/-/briefprofile/100.003.829
DnBP	1.33	ECHA chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.001.416
DEP	33	ECHA chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.001.409
BBP	100	ECHA chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.001.475
DCHP	133 g/kg food	ECHA chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.001.405
DDPT	20.7	ECHA chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.079.428
HHCB	20.4	ECHA chemical information		https://echa.europa.eu/brief-profile/-/briefprofile/100.013.588
UV-328	13.2	ECHA chemical information (scientific information)		
Cd	0.16	EU RAR	10	Based on 4 studies with birds and 5 studies with mammals
Hg and inorganic compounds	0.02	INERIS: Annex VII PNEC values and hazard information for candidate substances, 2009.	10	CIRCA data sheet, Dir. 2008/105/EC NOEC: 0.22 mg/kg_food Rhesus monkey, 1 year, growth
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
As	1	ECHA chemical information https://echa.europa.eu/brief-profile/-/briefprofile/100.028.316		
Bromadiolone	0.00019-0.00044	Directive 98/8/EC concerning the placing of biocidal products on the market 2010, Bromadiolone	90	NOAEL (mammals)
Permethrin	0.22	INERIS: Annex VII PNEC values and hazard information for candidate substances, 2009.	90	

EU RAR: EU Risk Assessment report

EA RER: Environmental Agency Risk Evaluation Report

4.5 Biomagnification

Field-derived trophic magnification factors (TMF) can be useful to evaluate bioaccumulation, when diet is the major route of exposure. TMF is a measure of biomagnification of a chemical within the food web and represents the average diet-to-consumer transfer of a chemical through food webs. TMF differs 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 (TL) of organisms in the food web. The trophic level can be determined from stable N isotope ratios, $\delta^{15}N$ (Borgå et al. 2012). The general scientific consensus is that chemicals are considered bioaccumulative if they exhibit a TMF > 1.

The recommended TL equation for determining the trophic magnification factor for application under the European Union Water Framework Directive (Kidd et al., 2019), which has also been used for a terrestrial food chain (Huang et al. 2022), is as follows:

$$TL\ (consumer) = 2.0 + (\delta^{15}N_{consumer} - \delta^{15}N_{baseline})/3.4$$

where TL (consumer) is the TL of the organism/consumer, and $\delta^{15}N_{consumer}$ and $\delta^{15}N_{baseline}$ are the $\delta^{15}N$ data for an organism and the baseline species, respectively, 2.0 is the assumed TL of the baseline species. 3.4 is a recommended isotopic (trophic) enrichment factor which, in principle, may vary from limnic to terrestrial food webs. A value of 3.4‰ per TL step has been recommended for constructing food webs without a priori knowledge of Δ15N or the ecology of the system (Kidd et al., 2019).

Kidd et al., 2019 recommended that the TMF study ideally includes species and individual organisms that range over at least 3 TLs to achieve the objective of quantifying biomagnification potential of a chemical.

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.

$$\text{Log [compound]} = a + b\,TL$$

$$TMF = 10^b$$

Bioaccumulation and biomagnification factors, BSAF and BAF

Field based bioaccumulation factors (BAF) or biota-soil accumulation factors (BSAF) can be used to evaluate potential bioaccumulation from soil to soil living species, such as earthworms.

For hydrophobic compounds, such as PCBs, BFRs, siloxanes, and UV compounds, the BSAF is normally calculated with concentrations normalized with respect to total organic content (TOC) in soil and lipid normalized concentrations in biota.

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

BMF for hydrophobic compounds are calculated as lipid normalized concentrations in consumer (predator) divided by lipid normalized concentrations in diet (prey). This is normally done for whole body concentrations or muscle concentrations. For PFAS, wet weight concentrations or protein normalised concentrations are most relevant to use for BMF calculations (Savoca and Pace, 2021).

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

PFAS compounds

Some previous studies have revealed correlations between the soil organic content and PFAS concentrations, and BSAF (or BAF) has in some cases been calculated with wet weight pollutant concentrations in earthworms divided by the soil concentrations normalized to TOC (Rich et al. 2015; Conder et al. 2020). The BAF calculations in the present study were done on a dry weight basis for concentrations of pollutants in soil and wet weight basis for concentrations in earthworm.

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

BMF was also calculated on a wet weight basis for fieldfare (FF), as the predator, and earthworm (EW), as the prey.

BMF= C_{FF} (ng/g ww) / C_{EW} (ng/g ww)

4.6 Analytical procedure

4.6.1 Sample preparation and quality assurance

In order to get sufficient material for analysis of the various chemical classes in each sample type, samples were pooled together for earthworms, fieldfare eggs, and brown rat liver samples. Pooled earthworm samples per site consisted of as many individuals as possible.. Samples of fieldfare eggs consisted of two eggs from the same nest in order to get sufficient material for all of the analyses. Samples of the brown rat liver consisted of one to three individual liver samples in order to get sufficient material for analysis..

All of the work related to sample homogenisation was performed in clean cabinet or clean room. In addition, a clean cabinet/clean room was used for sample extraction and clean-up for several compound classes, including siloxanes, phthalates, and OPFRs.

A short description of sample preparation, extraction, and analytical methods are given in the QA/QC tables, and a more detailed description can be found in the report from the previous program period (Heimstad et al., 2021).

4.7 QA/QC

In Table 27 there is a short method description, including LOQ, and an assessment and categorization of the uncertainty for every individual compound analysed. The uncertainty is divided in three groups from 1 to 3.

Group 1 includes the compounds with the highest certainty. For the compounds in this group, the method is well established, both at NILU and NIVA, and internationally. This means that the quality of the analysis has been proven with intercalibration studies and quality parameters are good. Most of these analyses are accredited according to ISO 17025.

Group 2 includes the compounds with medium certainty. The internal control parameters in the lab are good, the method is fit for purpose, but the quality cannot, or has not been proven within intercalibration studies. These groups also include parameters that have been tested in intercalibration studies, but the results within the studies show that the uncertainty of this analysis is still high (typically more than 50%).

Group 3 includes the compounds with the highest uncertainty. This could be due to unsatisfactory recovery data, method not fit for purpose, high variability in blanks, or similar. There will be comments on all of these parameters.

Table 27: Quality of analytical procedures for the various parameter groups and single parameters, including LOD or LOQ, and uncertainty category

Parameter group	Name of parameter	Cas nr	Blank	LOD range mg/kg	LOQ range mg/kg	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
Metals	Hg	7439-97-6	Method blanks following sample series. LOD/LOQ based on calculation of 3 and 10 stddev respectively	0.0001-0.0002	0.0002-0.0004	In-house accredited method. Microwave assisted decomposition with HNO3. Digestate split and one aliquot stabilized with HCl for subsequent determination of total-Hg. Analysis by ICP-MS (Agilent 7700x). CRM digested and analysed in every run	1	
	Cr	7440-47-3		0.0002-0.0003	0.0007-0.001		1	
	Ni	7440-02-0		0.0002-0.0003	0.0007-0.001		1	
	Cu	7440-50-8		0.003-0.005	0.01-0.02		1	
	Zn	7440-66-6		0.5-0.8	2-3		1	
	As	7440-38-2		0.0001-0.0002	0.0004-0.0006		1	
	Ag	7440-22-4		0.0005-0.0008	0.002-0.003		1	
	Cd	7440-43-9		0.00002-0.00004	0.0008-0.0001		1	
	Sb	7440-36-0		0.0007-0.0001	0.0002-0.0004		1	
	Sn	7440-31-5		0.0005-0.0009	0.002-0.003		2	Not accredited
	Gd	7440-54-2		0.000006-0.00001	0.00002-0.00003		2	Not accredited
	Pb	7439-92-1		0.0005-0.0008	0.002-0.003		1	

Parameter group	Name of parameter	Cas nr	Blank	LOD range ng/g	LOQ range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
PCBs	PCB 28	7012-37-5	Method blanks following sample series. LOD/LOQ based on calculation of 3 and 10 stddev respectively	0.01-0.03	0.03-0.09	In-house, accredited method. Internal standard addition, extraction, GPC and/or H_2SO_4 cleanup followed by adsorption chromatography. Analysis was performed on a GC/HRMS (autospec)	1	Y
	PCB 52	35693-99-3		0.01-0.03	0.03-0.09		1	Y
	PCB 101	37680-73-2		0.02-0.04	0.05-0.1		1	Y
	PCB 118	31508-00-6		0.01-0.02	0.03-0.05		1	Y
	PCB 138	35065-28-2		0.02-0.03	0.05-0.07		1	Y
	PCB 153	35065-27-1		0.04-0.04	0.08-0.09		1	Y
	PCB 180	35065-29-3		0.01-0.02	0.03-0.06		1	Y

Parameter group	Name of parameter	Cas nr	Blank	LOD range ng/g	LOQ range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
CPs	SCCPs	85535-84-8	Method blanks following sample series. SCCPs, MCCPs and LCCPs results are corrected for blanks. Blanks are subtracted on congener group level prior to deconvolution. LOD/LOQ based on calculation of 3 and 10 stddev respectively	9.6-25.6		In-house method. Internal standard addition, extraction, GPC and/or H_2SO_4 cleanup followed by adsorption chromatography. GC-qToF 7200 in ECNI	3	^{13}C-hexachloro-decane
	MCCPs	85535-85-9		13-35			3	
	LCCPs	85535-86-0		0.8-1.6		In-house method. Internal standard addition, extraction, GPC and/or H2SO4 cleanup followed by adsorption chromatography. Agilent LC-qToF 6546	3	

Parameter group	Name of parameter	Cas nr	Blank	LOD range ng/g	LOQ range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
BFRs	ATE (TBP-AE)	3278-89-5	Method blanks following sample series. LOD/LOQ based on calculation of 3 and 10 stddev respectively	0.02-0.04	0.06-0.1	In-house method. Internal standard addition, extraction, GPC and/or H_2SO_4 cleanup followed by adsorption chromatography. GC/HRMS (autspec)	2	N
	α-TBECH	1232836-48-4		0.25-0.18	0.83-0.47		2	N
	β-TBECH	1232836-49-5		0.07-0.14	0.17-0.35		2	N
	g/d-TBECH			0.07-0.08	0.10-0.20		2	N
	BATE	99717-56-3		0.05-0.09	0.13-0.26		2	N
	PBT	87-83-2		0.06-0.11	0.15-0.30		2	N
	PBEB	85-22-3		0.05-0.10	0.13-0.26		2	N
	PBBZ	608-90- 2		0.06-0.13	0.17-0.34		2	y
	HBB	87-82-1		0.08-0.16	0.21-0.42		2	y
	DPTE	35109-60-5		0.04-0.08	0.10-0.21		2	N
	EHTBB	183658-27-7		0.10-0.11	0.30-0.32		2	y
	BTBPE	37853-59-1		0.09-0.18	0.25-0.50		2	y
	TBPH (BEH /TBP)	26040-51-7		0.15-0.30	0.15-0.85		2	N
	DBDPE	84852-53-9		1.8-3.7	5.1-10		2	y

Parameter group	Name of parameter	Cas nr	Blank	LOD range ng/g	LOQ range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
Dechloranes	Dibromoaldrin	20389-65-5	Method blanks following sample series. LOD/LOQ based on calculation of 3 and 10 stddev respectively	0.41-0.83	1.0-2.0	In-house method. Internal standard addition, extraction, GPC and/or H_2SO_4 cleanup followed by adsorption chromatography. GCGC-qToF 7200 in ECNI	2	N
	Dechlorane 602	31107-44-5		0.06-0.12	0.15-0.30		2	y
	Dechlorane 603	13560-92-4		0.08-0.15	0.19-0.38		2	N
	Dechlorane 604	34571-16-9		1.9-3.8	5-10		2	N
	Dechlorane 601	13560-90-2		0.10-0.20	0.25-0.51		2	N
	Dechlorane plus syn	135821-03-3		0.16-0.32	0.40-0.80		2	Y
	Dechlorane plus anti	135821-74-8		0.20-0.38	0.49-0.98		2	N

Parameter group	Name of parameter	Cas nr	Blank	LOD range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
PFAS, soil	TFA [1)]	76-05-1	One blank pr batch. LOD calculated from average blanks + 3 x stdevs. If no peak present noise in the chromatogram was used as a proxy.	< 4	The weighed soil sample was added 1 ml of MilliQ water and ^{13}C internal standard. Precisely 1 ml of 200 mM NaOH in methanol is added. Let stand and soak for 30 min. Add exactly 100 µl 2M HCl in methanol plus 9 ml methanol. The sample was vortex-mixed before treated three times for 10 min in ultrasonic bath with vortex in between, followed by centrifugation. The supernatant is up-concentrated and cleaned up with suspensive EnviCarb treatment under acidic conditions. After addition of the RSTD, samples are ready for LC/MS measurements. With each sample batch a blank and a reference material sample must be run (for more than 20 samples one each 20th samples).	2	N
	PFPrA	422-64-0		< 0.5		2	N
	PFBA	375-22-4		0.50-1.0		2	Y
	PFPA	2706-90-3		0.15-1.0		2	Y
	PFHxA	307-24-4		0.05-0.15		1	Y
	PFHpA	375-85-9		0.05-0.15		1	Y
	PFOA	335-67-1		0.05-0.15		1	Y
	PFNA	375-95-1		0.05-0.15		1	Y
	PFDA	335-76-2		0.05-0.15		1	Y
	PFUnDA	2058-94-8		0.05-0.15		1	Y
	PFDoDA	307-55-1		0.05-0.15		1	Y
	PFTrDA	72629-94-8		0.15-0.50		1	N
	PFTeDA	376-06-7		0.05-0.15		1	Y
	PFHxDA	67905-19-5		0.15-0.50		1	N
	PFOcDA	16517-11-6		0.15-0.50		2	N
	PFEtS	354-88-1		< 1		2	N
	PFPrS	423-41-6		< 1		2	N
	PFBS	375-73-5		0.02-0.10		1	Y
	PFPS	2706-91-4		0.02-0.10		2	N
	PFHxS	355-46-4		0.02-0.10		1	Y
	PFHpS	375-92-8		0.02-0.10		1	N

Parameter group	Name of parameter	Cas nr	Blank	LOD range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
	PFOS	1763-23-1		0.02-0.10		1	Y
	brPFOS	-		0.02-0.10		1	N
	PFNS	68259-12-1		0.05-0.15		2	N
	PFDcS	335-77-3		0.05-0.15		2	N
	PFUnS	749786-16-1		0.05-0.15		2	N
	PFDoS	79780-39-5		0.05-0.15		2	N
	PFTrS	791563-89-8		0.05-0.15		2	N
	PFTS*	1379460-39-5		0.50-1.0		3	N
	7:3 FTCA	812-70-4		0.05-0.15		2	N
	4:2 FTS	757124-72-4		0.10-0.50		2	N
	6:2 FTS	27619-97-2		0.10-0.50		2	Y
	8:2 FTS	39108-34-4		0.10-0.50		2	N
	10:2 FTS	120226-60-0		0.10-0.50		2	Y
	12:2 FTS *	149246-64-0		0.50-1.0		3	N

Parameter group	Name of parameter	Cas nr	Blank	LOD range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
	PFECHS	646-83-3		0.10-0.50		2	N

[1)] High LOD due to instrument background

*	PFTS	No single standard available for these compounds. Retention time and MS settings based on similar isomers and literature references
	12:2 FTS	

Parameter group	Name of parameter	Cas nr	Blank	LOD range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
PFAS, biota/vegetation	TFA [1)]	76-05-1	One blank pr batch. LOD calculated from average blanks + 3 x stdevs. If no peak present noice in the chromatogram was used as a proxy.	< 4	1-2 g of biota was homogenized and added internal standard before extraction with methanol followed by vortexing and sonication for 30min. After centrifugation the supernatant was up-concentrated and cleaned up with suspensive EnviCarb treatment under acidic conditions. After addition of the RSTD, samples are ready for LC/MS measurements. With each sample batch a blank and a reference material sample must be run (for more than 20 samples one each 20th samples).	2	Y
	PFPrA	422-64-0		< 0 8		2	Y
	PFBA	375-22-4		0.50-1.0		2	Y
	PFPA	2706-90-3		0.15-1.0		2	Y
	PFHxA	307-24-4		0.05-0.15		1	Y
	PFHpA	375-85-9		0.05-0.15		1	Y
	PFOA	335-67-1		0.05-0.15		1	Y
	PFNA	375-95-1		0.05-0.15		1	Y
	PFDA	335-76-2		0.05-0.15		1	Y
	PFUnDA	2058-94-8		0.05-0.15		1	Y
	PFDoDA	307-55-1		0.05-0.15		1	Y
	PFTrDA	72629-94-8		0.15-0.50		1	N
	PFTeDA	376-06-7		0.05-0.15		1	Y
	PFHxDA	67905-19-5		0.15-0.50		1	N
	PFOcDA	16517-11-6		0.15-0.50		2	N
	PFEtS	354-88-1		< 1		2	N
	PFPrS	423-41-6		< 1		2	N
	PFBS	375-73-5		0.02-0.10		1	Y
	PFPS	2706-91-4		0.02-0.10		2	N
	PFHxS	355-46-4		0.02-0.10		1	Y
	PFHpS	375-92-8		0.02-0.10		1	N
	PFOS	1763-23-1		0.02-0.10		1	Y

Parameter group	Name of parameter	Cas nr	Blank	LOD range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
	brPFOS	-		0.02-0.10		1	N
	PFNS	68259-12-1		0.05-0.15		2	N
	PFDcS	335-77-3		0.05-0.15		2	N
	PFUnS	749786-16-1		0.05-0.15		2	N
	PFDoS	79780-39-5		0.05-0.15		2	N
	PFTrS	791563-89-8		0.05-0.15		2	N
	PFTS *	1379460-39-5		0.50-1.0		3	N
	7:3 FTCA	812-70-4		0.05-0.15		2	N
	4:2 FTS	757124-72-4		0.10-0.50		2	N
	6:2 FTS	27619-97-2		0.10-0.50		2	Y
	8:2 FTS	39108-34-4		0.10-0.50		2	N
	10:2 FTS	120226-60-0		0.10-0.50		2	Y
	12:2 FTS *	149246-64-0		0.50-1.0		3	N
	PFECHS	646-83-3		0.10-0.50		2	N

[1)] High LOD due to instrument background

*	PFTS 12:2 FTS	No single standard available for these compounds. Retention time and MS settings based on similar isomers and literature references

Parameter gruppe	Name parameter	Cas nr	Blank subtraction and determination of LOQ	LOQ range, µg/kg	Method	Uncertainty category	Stable isotope labeled (SIL) analogue	Comment
Siloxanes, biota/soil/ vegetation	D4	556-67-2	Three blanks pr batch. Blank substraction for each batch based on the blank average. LOQ calculated from 10 x stdev. from blanks	0.4-2.0	Internal standard added to 1-2 g of sample, followed by addition of acetonitrile and hexane. Ultrasonic bath and shaking before centrifugation. No further cleanup. Recovery standard added to a sub sample before analysis on GC/MSD. A detailed description can be found in previous MILBY reports.	2-3	Y	There is no reference material available for siloxanes and we rely on spiking and/or repeated measurements to assess the uncertainty. Since there is no clean-up of the extracts, for some samples there could be samples material present in the extract that could affect the background and LOQ.
	D5	541-02-6		0.5-2.0		2-3	y	
	D6 e	540-97-6		0.8-1.8		2-3	y	
	M3TPH	2116-84-9		0.1-1.0		3	N	
	L3	107-51-7	For linear siloxsanes there are no blank subtraction since these compounds are not present in our blanks. Instead, the LOD/LOQ calculations are based on noise in the chromatogram and calculated by the software.	0.5-3	For linear siloxanes we calculate the concentration with the response related to the ^{13}C cyclic siloxane closes in retention time.	3	N	
	L4	141-62-8		0.5-3		3	N	
	L5	141-63-9		0.5-3		3	N	

Parameter group	Name of parameter	Cas nr	Blank subtraction and determination of LOQ	LOQ range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
OPFRs, soil	TCEP	115-96-8	Three blanks pr batch. Blank subtraction for each batch based on the blank average. LOD and LOQ calculated from 3 x stdev and 10 x stdev. from blanks	5-10	2-5 g of soil was dried overnight and 2 g of dry material and deuterated internal standard was added and was taken for extraction with acetone using vortex and sonication for 10 min done three times. Cleanup of samples was done on a multilayer silica, evaporated and transferred to analytical glass. Recovery standard added and analysis on LC-MSMS.	2	Y
	TCPP	13674-84-5		2-3		2	Y
	TDCPP	13674-87-8		1-2		2	Y
	TBOEP/TBEP	78-51-3		2-3		2	N
	EHDP	1241-94-7		1-2		2	N
	TCP	1330-78-5		1-2		2	N
	TnBP	126-73-8		2-3		2	Y
	TiBP	126-71-6		1-2		2	N
	TEP	78-40-0		1-2		2	Y
	TPP	115-86-6		1-2		2	Y
	BdPhP	2752-95-6		1-2		2	N
	DBPhP	2528-36-1		1-2		2	N
	TXP	25155-23-1		1-2		2	N
	TIPPP	26967-76-0		1-2		2	Y
	TEHP	78-42-2		1-2		2	Y
	TTBPP	78-33-1		n.a.		3	N

Comments: TEP is generally lost during evaporation

Parameter group	Name of parameter	Cas nr	Blank subtraction and determination of LOQ	LOQ range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
OPFRs, biota	TCEP	115-96-8	Three blanks pr batch. Blank subtraction for each batch based on the blank average. LOD and LOQ calculated from 3 x stdev and 10 x stdev. from blanks	5-10	1-2 g of biota was added Na2SO4 and added deuterated internal standard and was taken for extraction with acetone/cyclohexane using vortex and sonication for 10 min done three times. Cleanup of samples was done on a multilayer silica, evaporated and transferred to analytical glass. Recovery standard added and analysis on LC-MSMS	2	Y
	TCPP	13674-84-5		2-3		2	Y
	TDCPP	13674-87-8		1-2		2	Y
	TBOEP/TBEP	78-51-3		2-3		2	N
	EHDP	1241-94-7		1-2		2	N
	TCP	1330-78-5		1-2		2	N
	TnBP	126-73-8		2-3		2	Y
	TiBP	126-71-6		1-2		2	N
	TEP	78-40-0		1-2		2	Y
	TPP	115-86-6		1-2		2	Y
	BdPhP	2752-95-6		1-2		2	N
	DBPhP	2528-36-1		1-2		2	Y
	TXP	25155-23-1		1-2		2	N
	TIPPP	26967-76-0		1-2		2	N
	TEHP	78-42-2		1-2		2	Y
	TTBPP	78-33-1		n.a.		3	N

Comment: TEP is generally lost during evaporation

Parameter group	Name parameter	Abbreviation	Cas nr	Blank	LOD range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
Musk, soil / biota	Traseolide	TRAS	68140-48-7	Sediment/Biota: One laboratory blank with Na2SO4 was prepared alongside each batch of ~6 samples. For all samples, LODs were calculated by 3xSD of the associated laboratory blanks. Where compounds were not present in the laboratory blanks, calibration standard peaks with signal:noise ratios of ~3:1 were converted to a sample concentration using the average blank volume/mass.	0.59	Soil/Biota: 1 g sample was mixed with Na2SO4, extracted via sonication with 2x 10 mL of acetone:hexane (1:1). After concentration, the extract was cleaned-up with EZ-POP SPE and concentrated. For all samples, d11-Tonalide and d6-Galaxolide were added as the internal standard prior to extraction and 13C-PCB-159 was added as the recovery standard immediately prior to analysis on a GC-MS/MS with EI ionisation.	3	N
	Phantolide	PANT	15323-35-0		0.81		3	N
	Iso-E-super	OTNE	54464-57-2		7.21		3	N
	Acetyl cedrene	MCKETON	32388-55-9		3.27		3	N
	Galaxolide	HHCB	1222-05-5		3.71		2	Y
	Tonalide	TONA	21145-77-7		1.02		2	Y
	Celestolide	KELE	13171-00-1		0.85		3	N

Parameter group	Name parameter	CAS Number	Blank subtraction and determination of LOQ	LOQ range ng/g or ng/L	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
UV compounds	Benzophenone-3	131-57-7	Three blanks per batch. Blank-subtraction and LOQ based on average signal of blanks + 3*std. Octocylene has the highest levels in blanks, followd by Homosalate. This is reflected in the LOQ.	0.3-8	Internal Standard (IS) added. Samples then extracted twice, followed by clean-up via GPC and/or PSA. GC-MS/MS detection	3	Yes
	Sum Ethylhexylmethoxycinnamate (EHMZ)	5466-77-3		0.6-1		2	Yes
	Octocrylene	6197-30-4		6-10		2	Yes
	UV-327	3864-99-1		0.1		2	Yes
	UV-328	25973-55-1		0.1-0.3		2	Yes
	UV-329	3147-75-9		0.4-2		3	Yes
	Homosalate	118-56-9		4-5.3		2	Yes

Comment:

Tests of the extraction and analysis recovery Benzophenone-3 of based on spiking experiments give results outside the range of 60-140%. The most possible consequences are that levels can be underestimated. Tests of the extraction and analysis recovery of UV-329 based on spiking experiments give results outside the range of 60-140%. The blanks also had significant variance. Therefore, no results are reported over LOQ for UV-329.

Parameter group	Name parameter	CAS Number	Blank subtraction and determination of LOQ	LOQ range, ng/g or ng/L	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
Biocides	Brodifacoum	56073-10-0	One blank pr batch. LOQ based on 10 x signal-to-noise as measured in each sample	1	Internal Standard (IS) added. Solid samples then extracted twice, while water samples were pre-concentrated on SPE. Clean-up via PSA when required. LC-MS/MS detection.	2	No
	Bromodiolone	28772-56-7		1		2	No
	Difenacoum	56073-07-5		1		2	No
	Difethialone	104653-34-1		1		2	No
	Flocumafen	90035-08-8		1		2	No
	Permethrin (cis)	52645-53-1		1-2	IS added. Samples then extracted twice before clean-up via GPC and/or PSA. GC-MS/MS detection	2	Yes
	Permethrin (trans)	52645-53-1		1.5-4		2	Yes

Compound group	Compound name	Cas no	Blank	Method	LOD range * ng/g	LOQ range* ng/g	Uncertainty category	Stable isotope labelled (SIL) analogue
Bisphenols	4,4-bisphenol A	80-05-7	Method blanks following sample series. LOD/LOQ based on calculation of 3 and 10 stdev respectively (or instrument detection limit if this is higher)	In-house method. Internal standard addition, extraction, clean-up using molecularly imprinted polymer SPE. LC/HRMS (orbitrap)	2-5.1		3	Y
	2,4-bisphenol A	837-08-1			0.5-1.2		3	N
	Bisphenol E	2081-08-5			0.4-2.2		3	N
	Bisphenol G	127-54-8			1.1-2.7		3	N
	Bisphenol AP	1571-75-1			0.4-1.4		3	N
	Bisphenol FL	3236-71-3			0.7-1.8		3	N
	Bisphenol B	77-40-7			0.4-2.5		3	Y
	2,4-bisphenol S	5397-34-2			0.2-0.3		3	Y
	4,4-bisphenol F	620-92-8			0.6-1.5		3	Y
	2,4-bisphenol F	2467-03-0			1.4-3.4		3	N
	TBBPA	79-94-7			1.9-5		3	Y
	Bisphenol M	13595-25-0			0.2-0.6		3	N
	Bisphenol Z	843-55-0			1.1-2.6		3	Y
Alkylphenols	4-tert-octylphenol	140-66-9		In-house methods. Internal standard addition, extraction, clean-up using molecularly imprinted polymer SPE. LC/HRMS (orbitrap)	1.2-3		3	Y
	4-octylphenol	1806-26-4			1-2.6		3	N
	4-nonylphenol	104-40-5			0.4-1.1		3	Y
	4-dodecylphenol	104-43-8			0.2-0.6		3	N
Other phenolic compounds	MB1	118-82-1		In-house method. Internal standard addition, extraction. LC/MS	1-2.6		3	N
	Isobutyl-4-Hydroxybenzoate	4247-02-3'			0.02		3	Y
	Butyl-4-Hydroxybenzoate	94-26-8			0.02		3	N
	Butylated Hydroxyanisole BHA	25013-16-5			0.24		3	N
	4-(4-isopropoxyphenylsulfonyl)phenol	95235-30-6			0.04		3	Y
	3-tert-butyl-4-hydroxyanisole	121-00-6			5		3	N
	4-tert-butyl-phenol	98-54-4			33		3	Y
	Methyl-4-Hydroxybenzoate	99-76-3			0.04		3	Y
	Benzyl-4-Hydroxybenzoate	94-18-8			0.03		3	N
	Propyl-4-Hydroxybenzoate	94-13-3			0.03		3	Y
	Isopropyl-4-Hydroxbenzoate	4191-73-5			0.03		Y	N

*Wide range in detection limits caused by high detection limits due to matrix interferences for some samples

Parameter group	Name of parameter	Cas nr	Blank	LOQ range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
Phthalates, soil, blood serum	DEP	84-66-2	Three blanks pr batch. Blank subtraction for each batch based on the blank average. LOD and LOQ calculated from 3 x stdev and 10 x stdev. from blanks	2-10	2-5 g of sample was dried overnight and 2 g of dry material and deuterated internal standard was added before extraction with acetone using vortex and three times sonication for 10min. After centrifugation and up-concentration, the sample was transferred to analytical glass. Recovery standard added before analysis on LC-MSMS.	2	N
	DiBP	84-69-5		1-4		2	Y
	DnBP	84-74-2		1-4		2	N
	DNHP	84-75-3		0.5-2		2	N
	BBP	85-68-7		1-4		2	N
	DEHP	117-81-7		5-20		2	Y
	DCHP	84-61-7		0.5-2		2	N
	DNOP	117-84-0		0.5-2		2	N
	DiNP	28553-12-0		2--6		2	N
	DNNP	84-76-4		2--6		2	N
	DDPT	85507-79-5		5-20		2	N
	SDPHP_DIDP	53306-54+ 68515-49-1		5-20		2	N

Comment: DEP is generally lost during evaporation

5 Appendix 2: Results

5.1 Metals

Metals were analysed in all samples, except dog serum, see Table 28. The concentrations of metals in the various samples are in agreement with data from previous years in the urban terrestrial monitoring program (Heimstad et al., 2023a and 2023b; Heimstad et al., 2024b) where Zn was the dominating metal in all samples.

One sample of soil exceeded the As threshold value of 8 mg/kg, and two soil samples in exceeded the threshold value of Pb of 60 mg/kg when soil legally is considered to be contaminated; Chapter 2, Appendix 1 of the Regulations Relating to Pollution Control for when soil legally is considered to be contaminated[10].

This year, the highest concentrations of Cu, Sn, Sb and Pb were detected in one of the two pooled samples of red fox liver. The Pb level of the one pooled red fox liver of 809 mg/kg is much higher than a proposed toxicity threshold of 10 mg/kg (Ziętara et al, 2019). For comparison, the hazard for predators (secondary poisoning) of Pb is set to 10.9 mg/kg food by ECHA and to 3.6 mg/kg through EQS Dossier 2011, see table in Appendix.

Cd concentration in earthworms and liver samples of red fox and badger exceeded the PNECoral value of 0.16 mg/kg food. The concentration of As in two pooled samples of brown rat liver exceeded PNECoral value for predators in food of 1 mg/kg ww[11], and As concentration in all soil samples exceeded the PNECsoil value of 2.9 mg/kg dw for soil living organisms.

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

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

Table 28: Metal concentrations given as median and min-max in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. Median concentrations and min-max interval are given otherwise single concentrations are reported. Concentrations below LOD are included as < LOD/2 values. All concentrations, except in soil (mg/kg dw), are given in mg/kg ww. Concentrations exceeding PNEC or other thresholds are shown in bold

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	SH egg n=3	RF liver n=2	EB liver n=2
Cr	43.9 31.1. – 72.2.	6.29 1.75 – 7.39	0.11 0.02- 0.25	0.08 0.06 – 0.32	0.02 0.01 - 0.03	0.46 0.038- 0.89	0.14 0.12 - 0.16
Ni	27.3 19.5.- 39.1.	4.00 1.24. – 4.72	0.13 0.04 – 0.18	0.01 <0.01- 0.20	0.01 <0.005- 0.019	0.27 <0.01- 0.53	0.080 0.077- 0.083
Cu	37.2 19.8. – 49.4	2.52 1.61 – 2.83	0.32 0.20 – 0.44	3.66 3.00 – 4.52	0.27 0.24 - 0.30	146 5.98 - 286	26.9 26.6 - 27.2
Zn	162 75.2. - 232	129 53.6- 227	5.64 3.58 – 7.95	28.20 23.07- 32.40	4.22 3.31 - 4.40	40.8 26.7 - 54.8	85.9 43.9 - 128
As	**6.08** **4.01** – **8.12**	0.343. 0.222-0.879	0.002 0.001 – 0.005	0.59 0.15- **2.66**	0.0008 0.0005- 0.0008	0.012 0.009- 0.015	0.019 0.019 - 0.020
Ag	0.26 0.095 – 0.36	0.03 0.01- 0.06	0.0005 0.0003 - 0.0008	0.002 0.001-0.002	0.00008 0.00005- 0.0001	0.011 0.007 - 0.016	0.038 0.035- 0.040
Cd	0.24 0.18- 0.79	**1.44** 0.46- **2.19**	0.0002 0.00008- 0.0003	0.022 0.013- 0.040	0.0001 0.00007 - 0.0001	0.152 0.055- **0.250**	**2.00** **1.37 - 2.63**
Sn	0.36 0.18- 0.97	0.014 <0.014 – 0.14	0.05 0.04 – 0.09	0.014 <0.013- 0.042	0.023 0.019 - 0.024	0.298 <0.013- 0.582	<0.014
Sb	0.02 0.02- 0.03	0.01 0.01 – 0.03	<0.0002	0.016 0.006 – 0.047	0.00007 <0.00006- 0.0002	2.14 0.001 - 4.28	0.003 0.001- 0.004
Gd	6.3 3.71. – 6.86	0.06 0.02 – 0.08	<0.0001	0.0002 <0.00005 - 0.0007	<0.00002	0.001 0.001- 0.002	0.001 0.0007 - 0.002
Pb	52.3 13.0. - **131**	0.58 0.21- 1.18	0.003 0.002 – 0.014	0.122 0.041 - 0.561	0.002 0.002 - 0.004	**404** 0.09- **809**	0.652 0.493 - 0.811
Hg	0.10 0.03 – 0.2	0.11 0.02 – 0.19	0.008 0.001– 0.013	0.002 0.0004- 0.0074	0.099 0.041 - 0.100	0.066 0.024- 0.108	0.107 0.079 - 0.135

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Figure 18: Box plot of metal concentrations. Concentrations are given as mg/kg ww. Concentrations of metals not detected in any sample are excluded. LOD values are included.

5.2 PCBs

PCB-153 was the dominating congener in most of the samples, see Table 29. The highest concentrations were detected in sparrowhawk egg, also on a lipid weight basis when comparing with fieldfare eggs. None of the concentration were exceeding known threshold effect levels.

Table 29: PCB concentrations given as median and min-max in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. Median concentrations and min-max interval are given. Concentrations below LOD are included as < LOD/2 values. All concentrations are given in ng/g.

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	SH egg n=3	RF liver n=2	EB liver n=2
PCB-28	0.014 <0.017- 0.054	0.110 0.071 - 0.117	0.033 0.014 - 0.043	0.031 <0.006 - 0.042	2.54 0.236 - 2.73	<0.011	0.019 <0.011 - 0.027
PCB-52	0.016 <0.016 - 0.10	0.044 0.033 - 0.060	0.443 0.117 - 4.81	0.015 <0.010 - 0.028	4.03 0.304 - 4.97	0.028 <0.015 - 0.041	<0.015
PCB-101	0.216 0.067 - 0.677	0.143 0.095 - 0.198	1.11 0.925 - 20.2	0.059 0.036 - 0.075	19.2 2.91 - 35.0	0.124 0.077 - 0.170	0.047 <0.028 - 0.066
PCB-118	0.195 0.062 - 0.479	0.051 0.047 - 0.124	0.542 0.431 - 10.8	0.144 0.123 - 0.498	46.7 8.99 - 93.7	0.321 0.295 - 0.347	0.690 0.160 - 1.22
PCB-138	0.725 0.149 - 1.90	0.215 0.185 - 0.490	4.32 3.05 - 19.3	1.24 0.830 - 2.01	120 30.0 - 203	1.78 1.68 - 1.88	1.66 0.655 - 2.66
PCB-153	0.828 0.167 - 2.23	0.409 0.310 - 0.706	7.73 4.99 - 22.5	1.67 1.06 - 2.47	228 71.6 - 304	8.23 7.22 - 9.24	3.22 1.42 - 5.03
PCB-180	0.577 0.089 - 1.53	0.148 0.099- 0.255	3.07 1.83 - 7.61	1.39 0.697 - 2.47	161 48.2 - 216	10.3 8.27 - 12.4	2.34 1.32 - 3.36

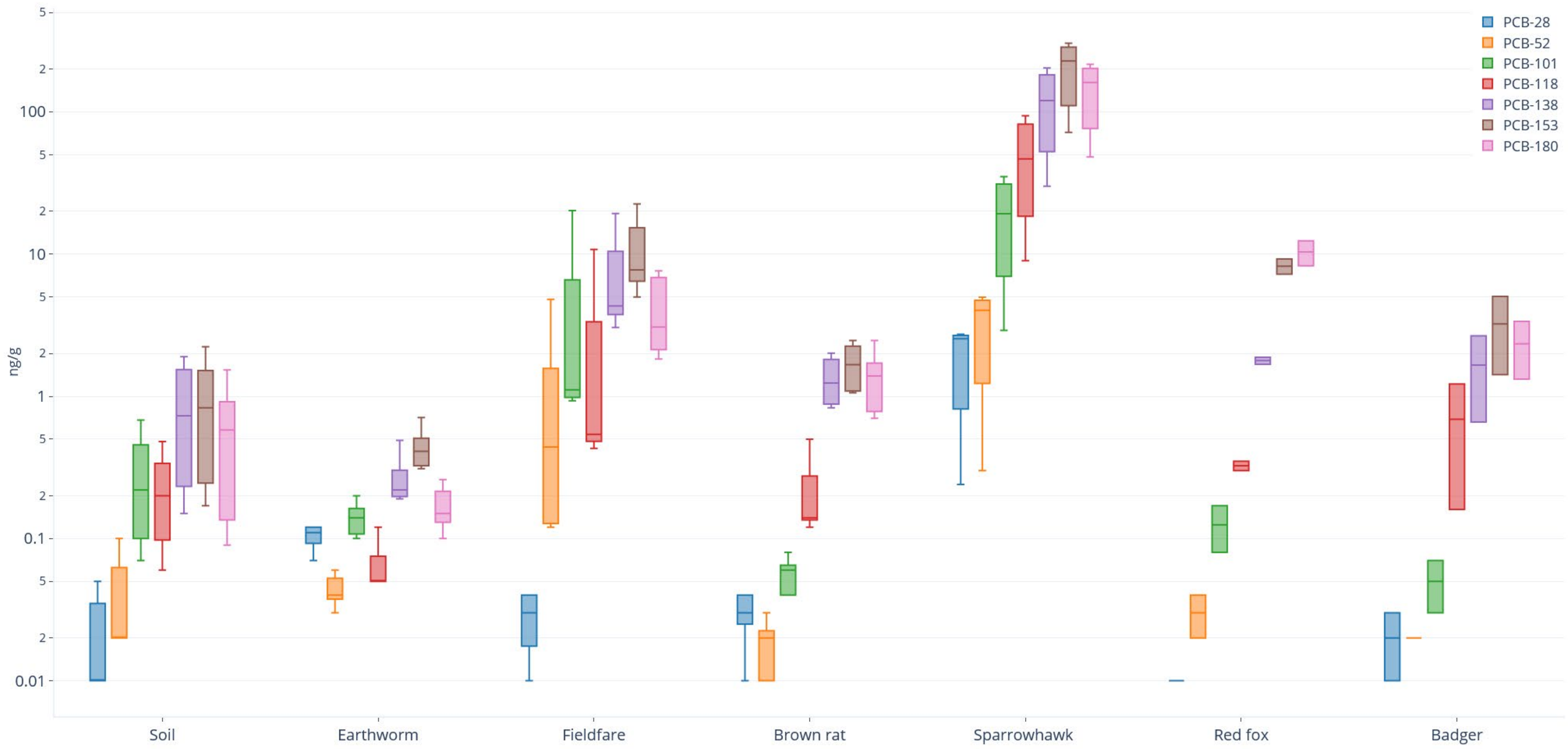


Figure 19: Box plot of PCB concentrations in the matrices with two or more samples. LOD/2 values are inclu

5.3 BFRs

Many BFR compounds were not detected in the various samples.

Table 30: BFR concentrations in Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver . All concentrations are given in ng/g ww. Concentrations below LOD are given as <LOD/2 values

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	SH egg n=3	RF liver n=2	EB liver n=2
α-HBCD	0.033 <0.029- 2.87	0.008 <0.007- 0.161	0.049 0.025 - 0.091	0.145 <0.012- 0.568	1.82 0.699 - 2.08	<0.014	<0.016
β-HBCD	0.051 <0.039- 0.263	<0.008	<0.004	<0.005	<0.004	<0.009	<0.009
g-HBCD	0.023 <0.020- 0.580	<0.012	<0.006	<0.010	<0.006	<0.012	<0.012
ATE	<0.019	0.010 <0.010- 0.045	0.013 <0.014- 0.022	0.047 <0.010 - 0.125	<0.010	0.035 <0.019 - 0.052	<0.019
α-TBECH	<0.091	<0.045	<0.127	0.045 <0.045 - 0.106	<0.120	<0.091	<0.091
β-TBECH	<0.068	<0.034	<0.106	0.034 <0.034 - 0.084	<0.099	<0.068	<0.068
g/d-TBECH	<0.038	0.019 <0.019 - 0.074	<0.076	0.019 <0.019 - 0.069	<0.062	<0.038	<0.038
BATE	<0.046	0.023 <0.023 - 0.099	0.023 <0.021- 0.071	0.082 <0.023 - 0.097	<0.023	<0.046	<0.046
PBT	<0.057	0.028 <0.028 - 0.096	0.028 <0.030- 0.049	0.081 <0.028 - 0.117	<0.028	<0.057	<0.057
PBEB	<0.049	0.024 <0.024 - 0.086	0.024 <0.026- 0.078	0.073 <0.024- 0.113	<0.024	<0.049	<0.049
PBBZ	<0.064	0.032 <0.032 - 0.100	<0.037	0.032 <0.032 - 0.146	<0.032	<0.064	<0.064
PTBX	0.063 <0.063- 0.128	0.032 <0.032 - 0.083	0.032 <0.034- 0.083	0.032 <0.032 - 0.091	0.032 <0.032- 0.077	<0.063	<0.063
HBB	<0.081	0.041 <0.041- 0.117	<0.041	0.089 <0.041 - 0.133	<0.041	<0.081	<0.081
DPTE	<0.0384	0.019 <0.019 - 0.065	0.019 <0.020- 0.036	0.049 <0.019 - 0.064	<0.0192	<0.038	<0.038
EHTBB	<0.0560	0.028 <0.028 - 0.091	<0.041	0.132 <0.029 - 0.178	<0.0280	<0.123	<0.112
BTBPE	<0.091	<0.045	<0.045	<0.045	<0.045	<0.091	<0.091
TBPH	<0.152	<0.077	<0.370	<0.113	<0.086	<0.255	<0.152
DBDPE	1.84 <1.84 - 5.40	<0.920	<1.00	<0.920	<0.920	<1.84	<1.84

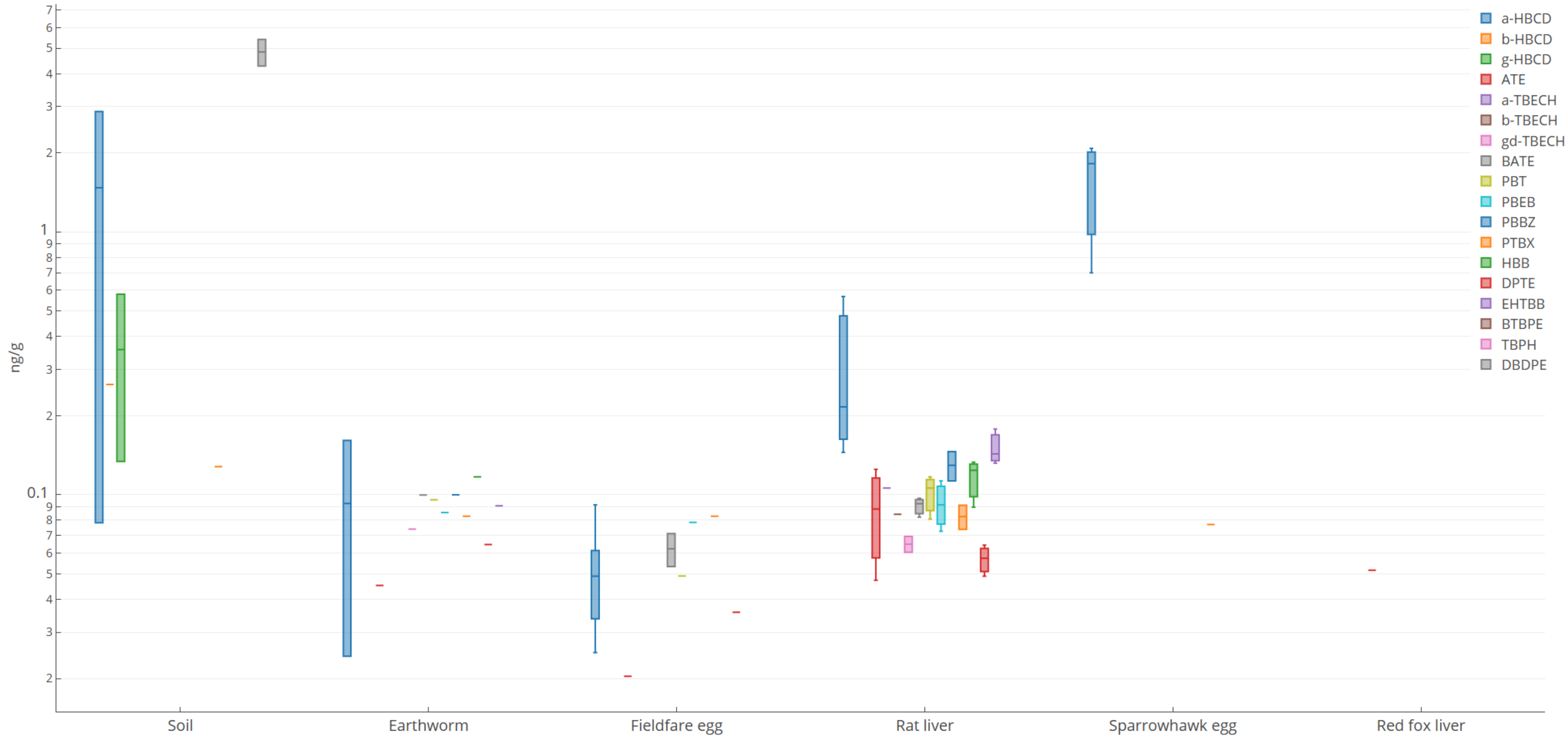


Figure 20: Box plot of detected BFR concentrations in matrices.

5.4 PFAS

The PFAS group consists of numerous per- and polyfluorinated compounds. We have chosen to separate this large class of compounds into four subgroups dependent on functional groups and properties: The perfluorinated sulfonates (PFSA), the perfluorinated carboxylates (PFCA), and the relatively new fluorotelomer sulfonates (newPFAS) with the compounds 4:2 FTS, 6:2 FTS, 8:2 FTS, 10:2 FTS and 7:3 FTCA. In this chapter and in the summary, SumPFAS is the sum of all sub-groups. SumPFOS is the sum of the branched and linear PFOS.

PFAS could be detected in all samples and PFOS was the dominating compound.

It is known that longer-chain PFAS degrades to trifluoro acetic acid (TFA) in the environment, for example via oxidation by OH radicals in the atmosphere (Garavagno et al., 2024). Current research suggests that the water soluble TFA and other short-chain PFAS do not bioaccumulate in food chains, but a number of studies reported that direct uptake from the atmosphere can contribute to high levels of TFA in terrestrial plant leaves, and some terrestrial plants have been found to bioaccumulate TFA (Garavagno et al., 2024). The LOD for TFA was higher this year than previous years and only detected above LOD in the five soil samples and two of the rat liver samples.

The compound 7:3 FTCA was detected in many of the samples, and highest amount in the badger liver samples. 7:3 FTCA is known to be an intermediate degradation product of other compounds and has been shown to bioaccumulate, and higher concentration has been detected in liver compared to muscle samples which is likely related to protein binding in liver (Xie et al., 2020). The compounds 8:2 FTS and 10:2 FTS were highest in fieldfare egg.

Highest PFOS concentrations were detected in fieldfare eggs, rat and badger liver. Several samples exceeded the PNECoral of 37 ng/g ww (see Appendix) and QSbiota of 33 ng/g ww for secondary poisoning of predators for PFOS, set by the European Commission (Ankley et al., 2021).

Several samples also exceeded the low QSbiota value for PFOA of 0.9 ng/g for secondary poisoning of predators set by Valsecchi et al., 2017 (Ankley et al., 2021). Highest concentration of PFOA was detected in badger liver samples.

The TOP assay was also used on the pooled blood serum sample of dog in addition to the target analysis. The median (min-max) values in the tables are calculated on the basis of both results, therefore n=2 for dog. TOP assay concentrations were in agreement with concentrations using target analysis which indicated that not many precursor of PFAS were present in the pooled dog serum sample. Largest change after use of TOP assay was found for PFBA and PFBS, as revealed by the min-max range in the tables. TOP assay was applied in year 2022 of several samples of fieldfare egg, rat liver and Spanish slug. The concentration of targeted PFAS after the samples have been processed through TOP assay had increased for both PFCA and PFSA, which indicated that several precursors of PFCA and PFSA were present in the samples. For some of the samples the sumPFAS concentrations were nearly doubled after use of TOP assay. TOP assay is therefore a useful tool to investigate the total load of extractable PFAS in the samples.

Table 31: PFCA concentrations (median, min-max) in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). <LOD/2 values were used in the calculations. PFCA compounds with known PNEC values are marked with orange background colour.
**n=2 for Targeted and TOPA analysis*

	Soil n=5	Earthworm n=5	FF egg n=5	BR liver n=5	Dog serum n=2*	SH egg n=3	RF liver n=2	EB liver n=2
TFA	2.94 1.14-4.72	<2	<2	2 <2- 7.46	<2	<2	<2	<2
PFPrA	<0.3	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
PFBA	<0.06	0.88 0.23 - 1.74	<0.05	<0.05	0.23 0.03 - 0.44	<0.05	<0.05	<0.05
PFPA	0.18 <0.06 - 0.55	0.88 0.11- 2.32	0.05 <0.05- 0.18	<0.05	0.10 <0.05- 0.16	<0.05	<0.05	<0.05
PFHxA	0.19 <0.06- 0.35	0.050 <0.05 - 1.48	0.05 <0.05 - 0.11	<0.05	<0.05	<0.05	<0.05	<0.05
PFHpA	0.22 <0.06 - 0.31	<0.04	0.04 <0.04- 0.44	<0.038	0.06 <0.04- 0.08	<0.04	<0.04	0.081 <0.04 - 0.13
PFOA	0.46 0.18- 0.79	1.64 0.70 - 3.40	0.70 0.20 - 2.73	0.03 <0.03- 3.78	1.11 1.10 - 1.12	1.41 1.40 - 3.27	0.57 0.17- 0.98	10.7 8.60 - 12.7
PFNA	0.20 0.12 - 0.367	1.37 0.18 - 1.98	1.37 0.68 - 2.89	5.37 <0.03- 9.47	1.24 1.22 - 1.26	2.87 1.41 - 3.14	1.84 1.47 - 2.21	18.6 17.1 - 20.1
PFDA	0.18 <0.06- 0.45	0.81 0.45 - 1.98	3.56 1.03 - 8.53	3.68 1.02 - 33.9	0.40 0.37 - 0.44	5.42 1.99 - 85.2	2.19 1.57 - 2.82	19.4 14.2 - 24.7
PFUnDA	0.11 <0.06 - 0.27	<0.04	4.75 <0.04 - 8.32	<0.04	0.50 0.46 - 0.53	7.43 2.13 - 16.7	<0.04	<0.04
PFDoDA	0.13 <0.06 - 0.21	1.35 0.95 - 3.26	9.76 3.50 - 43.2	1.41 1.11 - 34.1	<0.05	18.7 3.96 - 71.6	1.07 0.97 - 1.17	16.7 8.66 - 24.8
PFTrDA	<0.10	0.05 <0.05 - 1.29	0.05 <0.05 - 23.7	0.05 <0.05 - 18.4	<0.05	13.0 <0.05 - 13.5	<0.05	<0.05
PFTeDA	<0.06	0.05 <0.05 - 0.49	1.08 <0.05 - 12.9	<0.05	<0.05	5.36 1.23 - 6.12	<0.05	<0.05
PFHxDA	<0.06	0.05 <0.05- 0.86	1.80 0.50 - 4.05	<0.05	0.93 0.88 - 0.98	1.57 0.48 - 1.83	<0.05	1.73 1.10 - 2.37
PFOcDA	<0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Table 32: PFSA concentrations in Soil, Earthworm EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text. PFSA compounds with known PNEC values are marked with orange background colour. Concentrations exceeding PNEC or other thresholds are shown with orange background colour.

	Soil n=5	Earthworm n=5	FF egg n=5	BR liver n=5	Dog n=2*	SH egg n=3	RF liver n=2	EB liver n=2
PFEtS	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PFPrS	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PFBS	<0.05	0.45 <0.03- 3.35	<0.03	<0.03	1.98 0.85 - 3.12	<0.03	<0.03	0.25 0.14 - 0.36
PFPS	<0.05	0.03 <0.03- 0.98	<0.03	<0.03	<0.03	<0.03	<0.03	0.14 0.07 - 0.21
PFHxS	<0.05	0.03 <0.03 - 1.49	0.25 0.15 - 5.04	0.03 <0.03- 0.99	1.54 1.54 - 1.54	0.49 0.31 - 0.82	0.57 0.29 - 0.85	2.37 1.33 - 3.42
PFHpS	<0.05	0.56 0.24 - 3.38	0.40 0.20 - 2.21	0.11 <0.03 - 1.80	0.22 0.18 - 0.26	0.55 0.46 - 1.19	0.31 0.18- 0.44	2.28 2.01 - 2.54
brPFOS	0.14 0.03 - 0.31	0.32 0.24 - 1.87	1.52 0.56 - 12.5	4.68 0.47 - 51.4	2.74 2.43 - 3.06	2.29 1.88 - 10.1	2.10 1.27 - 2.93	14.5 10.1 - 19.0
SumPFOS	1.16 0.67 - 3.25	12.9 7.63 - 40.7	44.5 17.2 - 379	22.3 4.50 - 256	9.74 9.46 - 10.0	30.3 26.4 - 117	43.5 31.2 - 55.9	185 134 - 236
PFNS	<0.05	<0.05	0.05 <0.05 - 0.57	0.05 <0.05 0.32	<0.05	0.05 <0.05- 0.28	<0.05	0.21 0.12 - 0.30
PFDS	<0.05	0.49 0.41 - 1.35	4.88 0.44 - 19.8	0.57 0.54 - 35.9	<0.05	2.13 0.43 - 5.63	0.30 <0.05- 0.56	3.67 1.51 - 5.82
PFUnS	<0.05	<0.05	0.05 <0.05- 0.44	<0.05	<0.05	0.05 <0.05- 0.16	<0.05	<0.05
PFDoS	<0.05	0.05 <0.05- 0.29	0.42 <0.05 - 2.27	<0.05	<0.05	0.25 <0.05- 0.44	<0.05	<0.05
PFTrS	<0.05	<0.05	0.05 <0.05-0.13	<0.05	<0.05	<0.05	<0.05	<0.05

**n=2 for Targeted and TOPA analysis*

Table 33: newPFAS concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text. Compounds with known PNEC values are marked with orange background colour.

	Soil n=5	Earthworm n=5	Fieldfare egg n=5	Brown rat liver n=5	Dog serum n=2	Sparrowhawk egg n=3	Red fox liver n=2	Badger liver n=2
4:2 FTS	<0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
6:2 FTS	<0.06	0.05 <0.05 - 0.35	0.25 0.08 - 7.07	0.05 <0.05- 2.22	<0.05	<0.05	<0.05	0.60 0.30- 0.90
8:2 FTS	<0.06	0.05 <0.05- 3.10	3.51 <0.05- 140	0.40 <0.05- 27.3	<0.05	0.41 0.38 - 1.07	<0.05	5.82 1.85 - 9.80
10:2 FTS	<0.06	0.05 <0.05-2.54	3.30 <0.5-58.8	0.5 <0.5-4.02	<0.5	0.5 <0.5-1.98	<0.5	6.06 4.30-7.81
12:2 FTS	<0.06	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
7:3 FTCA	<0.06	0.05 <0.05 - 2.17	0.68 0.26 - 12.1	1.39 0.60 - 18.0	0.11 <0.05- 0.16	0.76 0.19 - 1.06	2.49 1.16 - 3.82	27.9 10.0 - 45.8
PFECHS	<0.1	<0.1	0.1 <0.1-0.2	<0.1	<0.1	0.1 <0.1-0.29	<0.1	<0.1

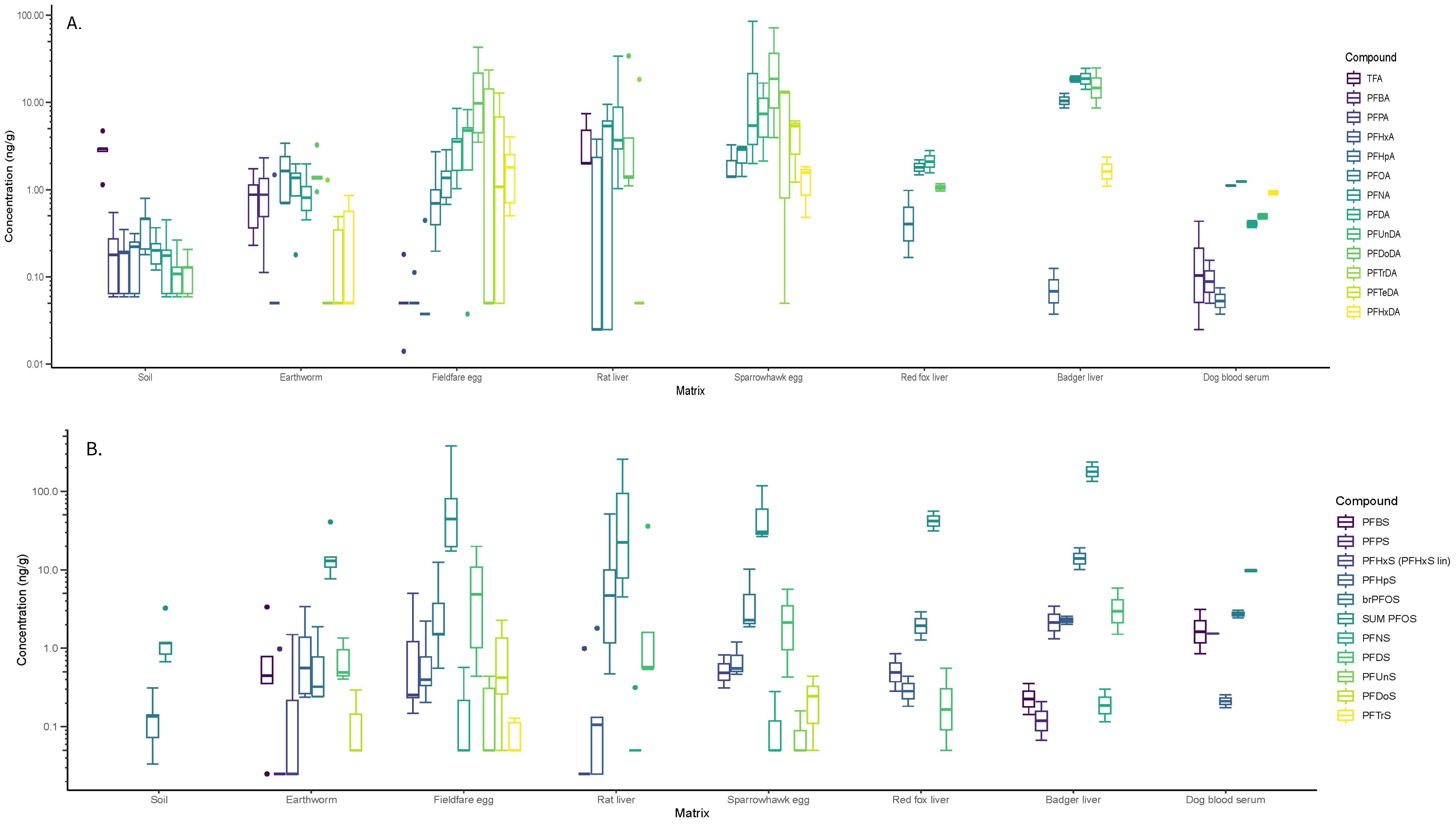


Figure 21: Box plots of PFCA (A.) and PFSA (B.) components in all samples. Concentrations below LOD are included as ½ LOD.

5.5 Chlorinated paraffins, CPs

Chlorinated paraffins include short-chain (C10-C13), medium-chain (C14-C17), and long-chain (C18-C28) chlorinated paraffins (SCCPs, MCCPs, and LCCPs, respectively). LCCP were detected in many samples, SCCP concentrations were below LOD in all samples, except sparrowhawk eggs, and MCCP were detected in some of the samples, see Table 8**.**

As observed in past years' results in this program, rat liver sample had some of the highest detected concentrations of both LCCPs and MCCPs, both on wet and lipid weight basis. Highest concentration of LCCPs in brown rat liver was 3190 ng/g ww (79080 ng/g lw) and the average concentration in rat liver was 739 ng/g ww (32122 ng/g lw). We have not been able to compare this level to other studies of liver from mammals living in urban areas. However, in a study of samples collected between 2006 to 2017 from Sweden, Denmark, and the Baltic Sea, the terrestrial species had, in general, higher concentrations than marine species (Yuan et al., 2019). The LCCP concentrations were highest in peregrine falcon muscle samples, up to 1200 ng/g lw (Yuan et al., 2019). For the CPs investigated in wildlife from paddy fields in the Yangtze River delta in China, the average and min-max concentrations of LCCPs in 6 muscle samples of peregrine falcon were 690 ng/g lw (530-10000 ng/g lw) (Du et al., 2018).

Occurrence data for LCCPs in German coastal, terrestrial, and freshwater ecosystems revealed LCCP concentrations ranging from <MDL to 140 ng/g lw for deer liver samples collected in 2018 (Yuan et al., 2022).

None of the samples in the Oslo area exceeded the PNECoral values of 5500 ng/g food for the SCCPs or 10 000 ng/g food (wet weight) for the MCCPs and LCCPs. The LCCP concentration in all soil samples were below the PNECsoil of 4.64 g/kg soil dw[12].

Table 34: CP concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text.

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	Dog n=1	SH egg n=3	RF liver n=2	EB liver n=2
SCCPs	<12.8	<6.40	<6.40	<7.68	<10.5	6.40 <6.40 - 14.0	<12.8	<12.8
MCCPs	17.6 <17.6 - 87.0	30.0 <8.80 - 34.1	25.0 <8.80 - 33.0	78 <8.80 - 219	<46.5	8.80 <8.80 - 24.0	<17.5	<17.5
LCCPs	48.8 20.9 - 380	3.20 <0.40 - 16.1	17.9 10.2 - 47.7	739 7.53 - 3190	<10.5	165 69.4 - 194	15.1 4.15 - 26.1	2.26 <0.80 - 3.72

[12] https://echa.europa.eu/brief-profile/-/briefprofile/100.058.300

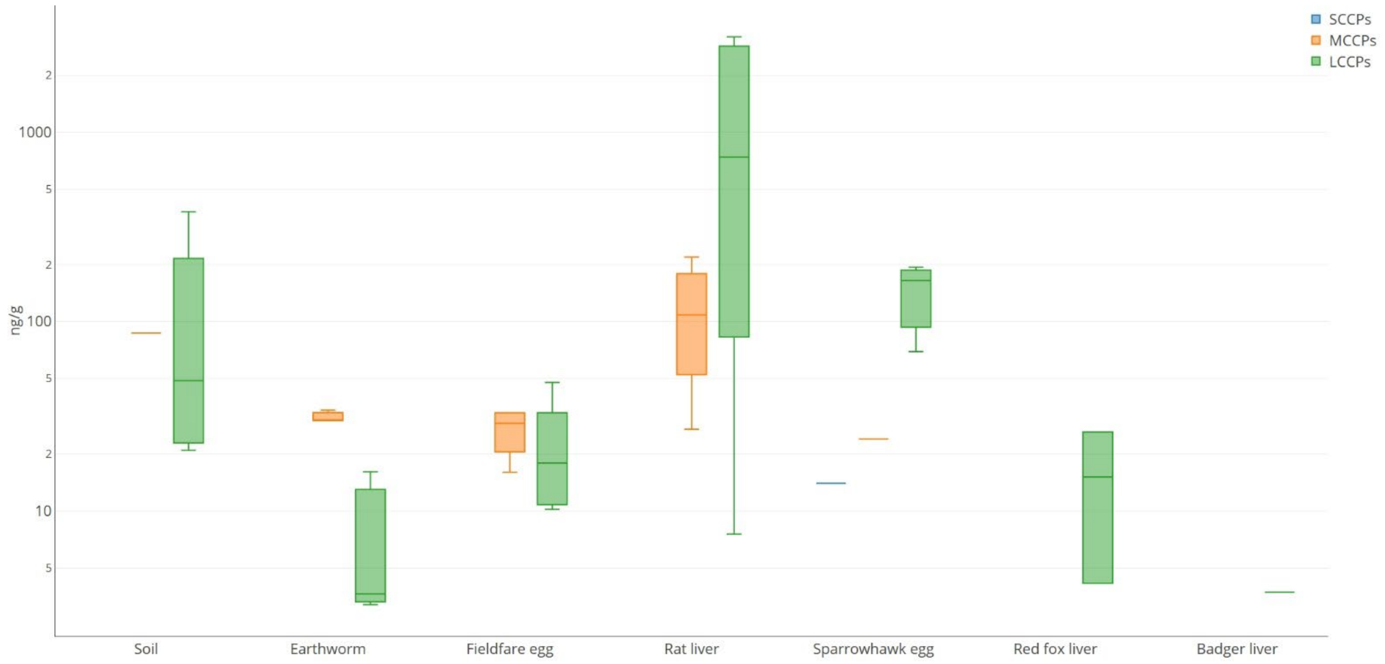


Figure 22: Box plots of detected concentrations in SCCPs, MCCPs and LCCPs.

The fractional contribution of each isomer/congener group was investigated and calculated from the total detected concentrations of SCCPs, MCCPs, and LCCPs, respectively.

For SCCPs detected in one of the sparrowhawk egg the isomer groups with 12 carbon atoms dominated, with highest amount of C12Cl9 followed by C12Cl8, C12Cl10 and C13Cl8.

For MCCPs, the isomer groups C14Cl6 and C14Cl7, were dominating groups in earthworm, fieldfare eggs and sparrowhawk eggs. This agrees with results from previous years in MILBY. The C14 isomer classes of MCCPs were also dominating in the Scandinavian study of Yuan et al., 2019.

For the one sample of soil with detected concentrations, C14Cl6 also dominated as in the biota samples, followed by C15Cl6 and C14Cl9. For brown rat liver the isomer groups containing 16 and 17 carbon atoms dominated. See overview of the most dominating isomer groups of MCCPs below:

Soil :	C14Cl6> C15Cl6>C14Cl9> C16Cl7> C16Cl8
EW:	C14Cl6> C14Cl7> C15Cl6> C15Cl7
FF egg:	C14Cl6> C14Cl7> C15Cl6> C15Cl7
SH egg:	C14Cl6 >C14Cl7> C14Cl5
BR liver:	C16Cl8> C16Cl7> C17Cl9> C16Cl9> C17Cl10

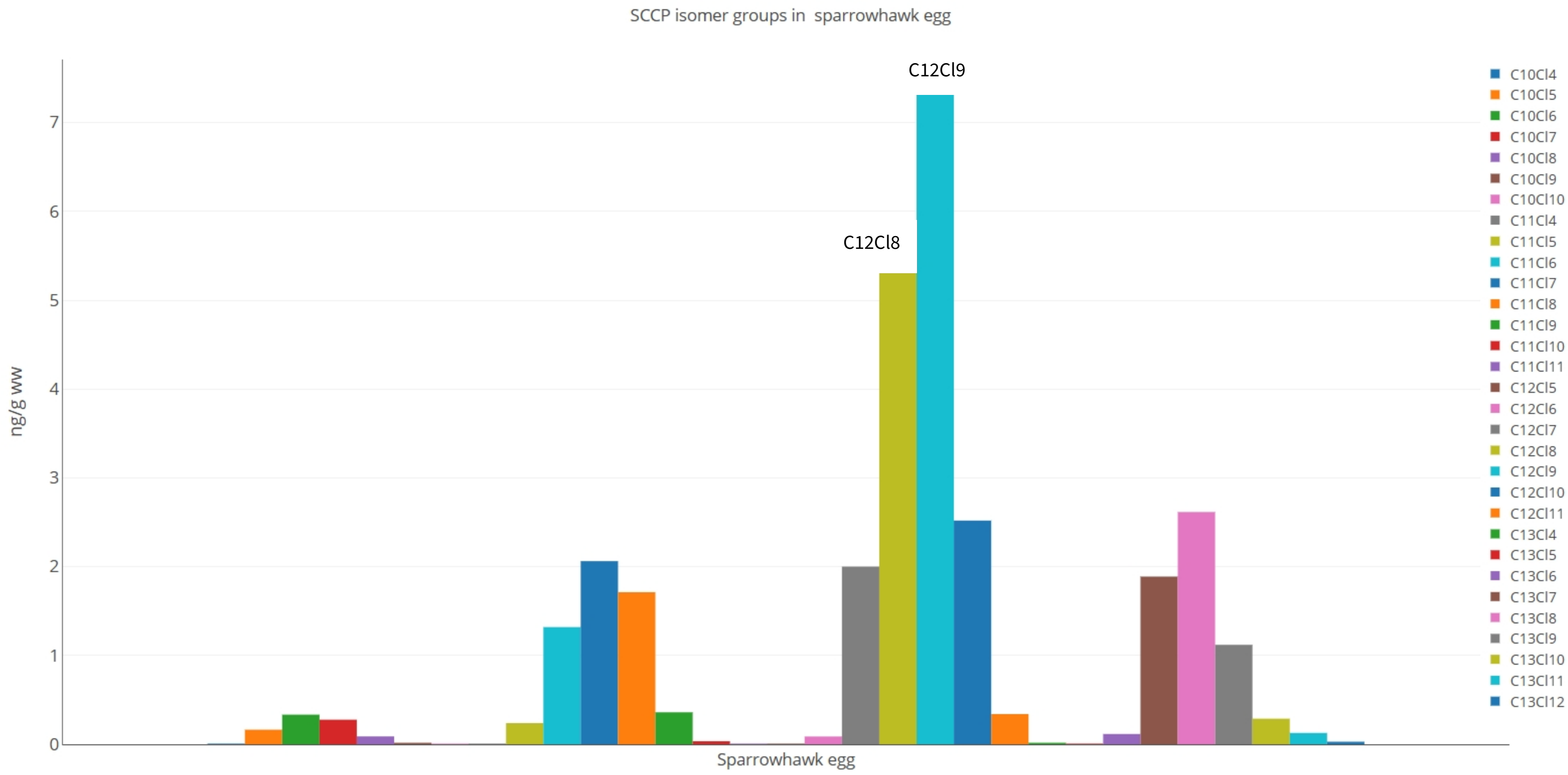


Figure 23: Patterns of SCCP isomers in the one pooled sparrowhawk (SH) egg with detected SCCP concentration .

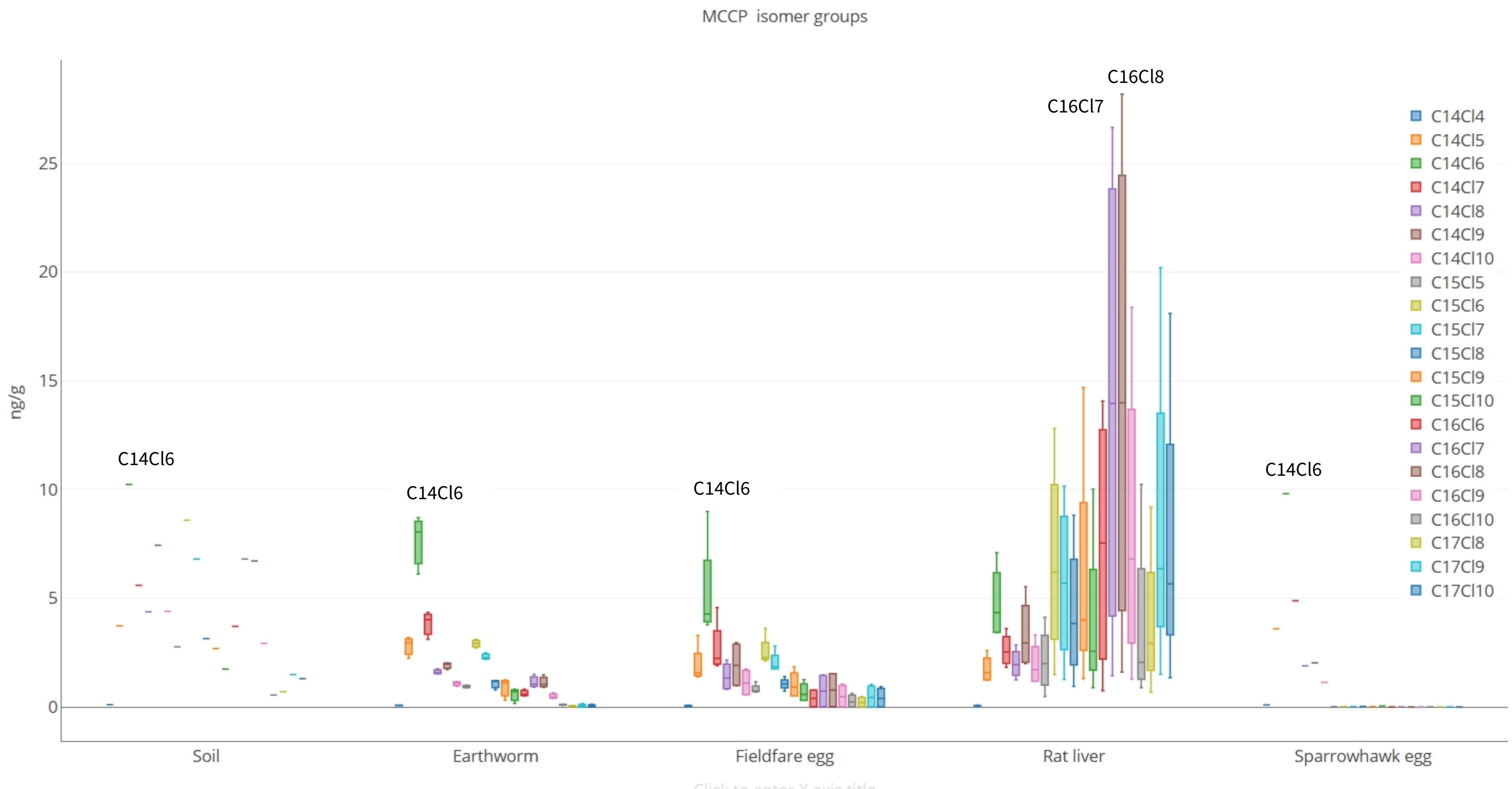
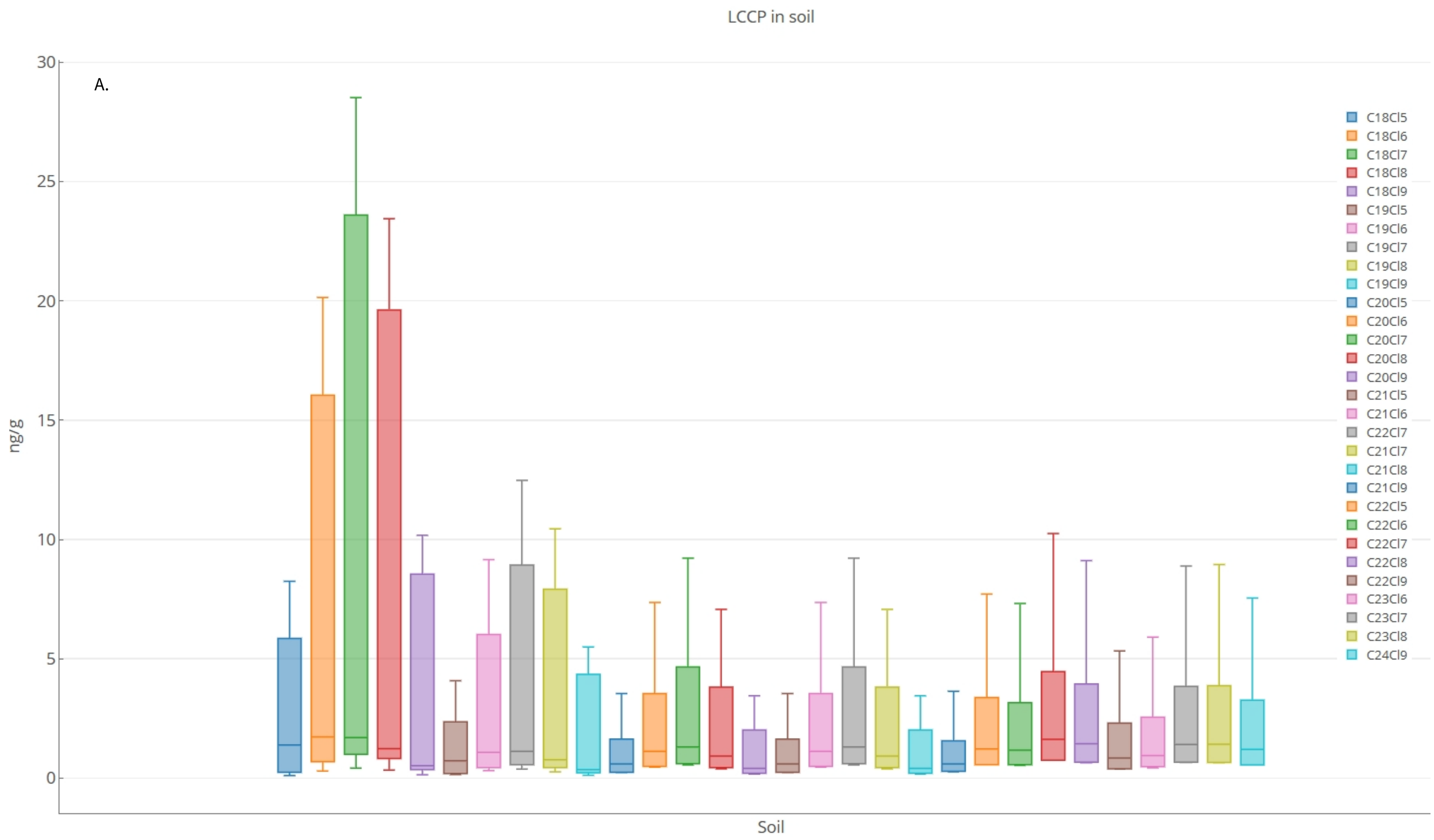


Figure 24: Patterns of MCCP isomers in samples with detected concentrations.

Many isomer groups were detected for LCCPs in the samples, especially in the rat liver, as also observed last year.

Below is listed the most dominating isomer groups based on average values in the samples with detected concentrations. The pattern for dominating LCCP isomer groups was similar for soil, earthworm and fieldfare eggs, and red fox liver. The pattern for sparrowhawk eggs were comparable to isomer pattern in badger and brown rat liver. LCCP isomer pattern with dominating C22-C26 isomer groups were observed in peregrine falcon muscle samples in the Scandinavian study of Yuan et al., 2019.

Soil	C18Cl7> C18Cl8> C18Cl6> C19Cl7
Earthworm	C18Cl7 >C18Cl8> C18Cl6 > C19Cl7
Fieldfare egg	C18Cl7 >C18Cl8> C18Cl6> C19Cl7
Sparrowhawk egg	C22Cl7~ C21Cl7>C22Cl8~C23Cl8~C23Cl7
Red fox liver	C18Cl7 >C18Cl8> C18Cl6> C22Cl7
Badger liver	C22Cl7~ C21Cl7> C22Cl8~ C23Cl7
Brown rat liver	C22Cl7~ C21Cl7> C22Cl8>C23Cl8~C23Cl7



LCCP in soil
A.
ng/g
30
25
20
15
10
5
0
Soil
C18Cl5
C18Cl6
C18Cl7
C18Cl8
C18Cl9
C19Cl5
C19Cl6
C19Cl7
C19Cl8
C19Cl9
C20Cl5
C20Cl6
C20Cl7
C20Cl8
C20Cl9
C21Cl5
C21Cl6
C22Cl7
C21Cl7
C21Cl8
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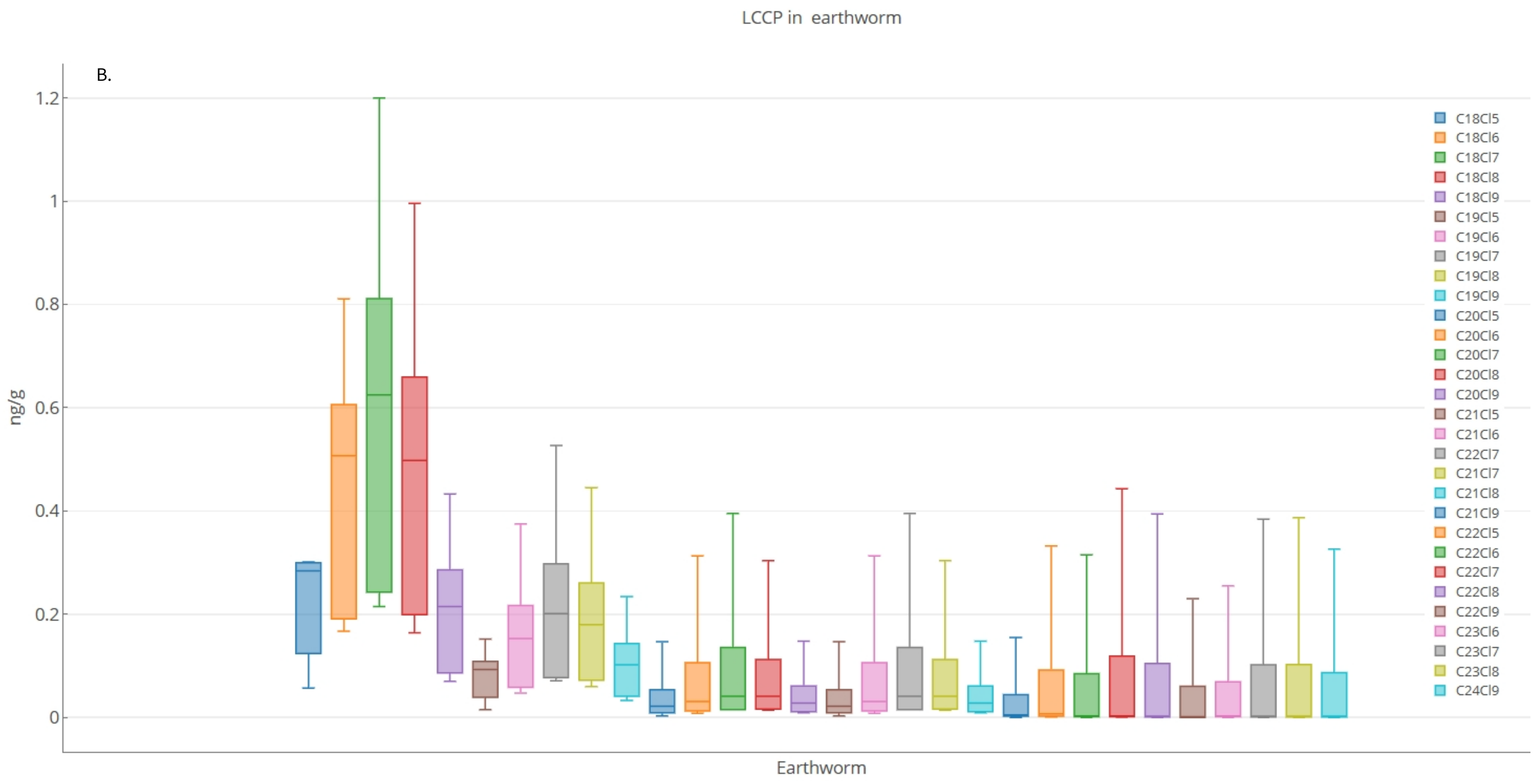
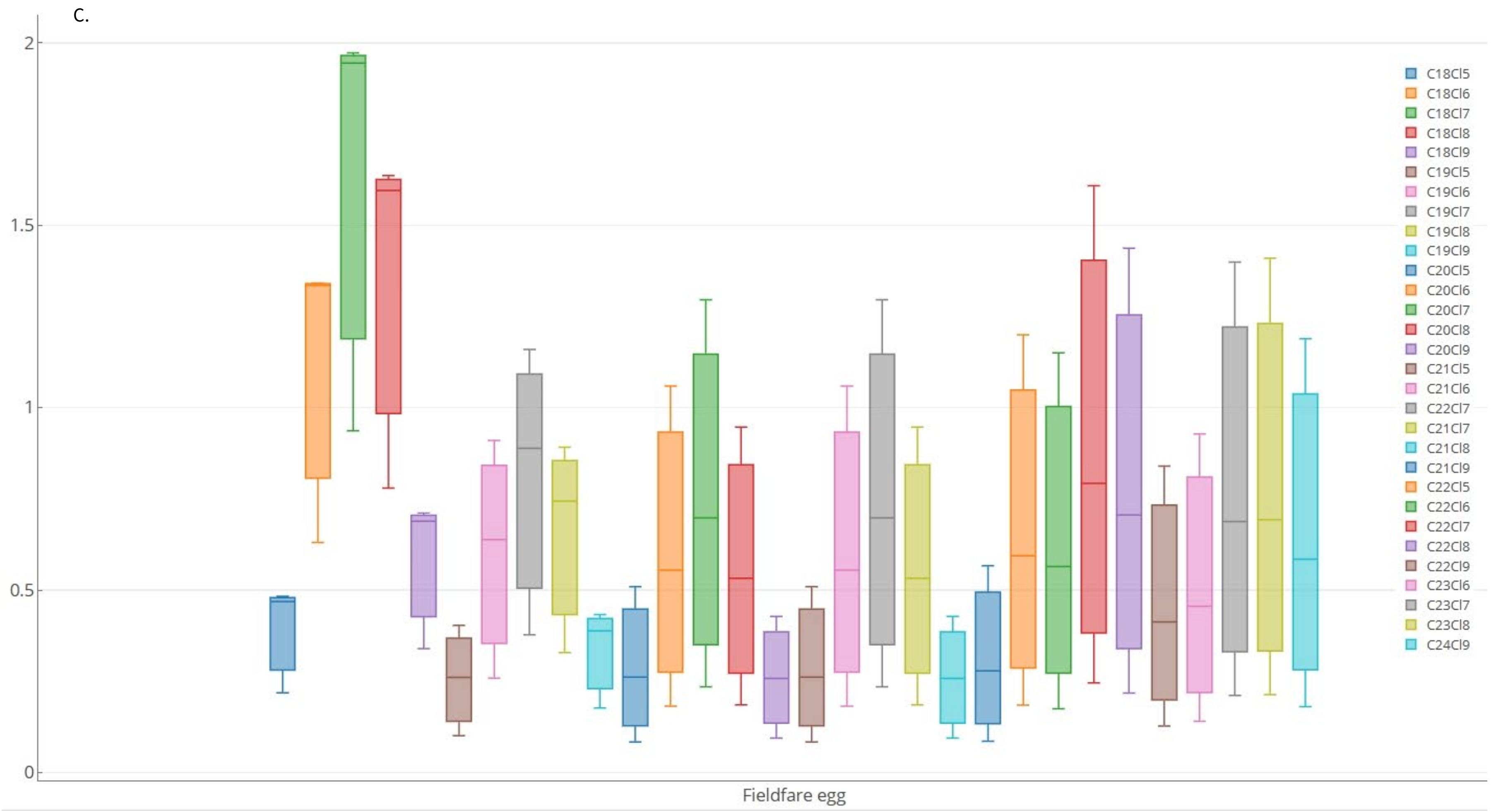
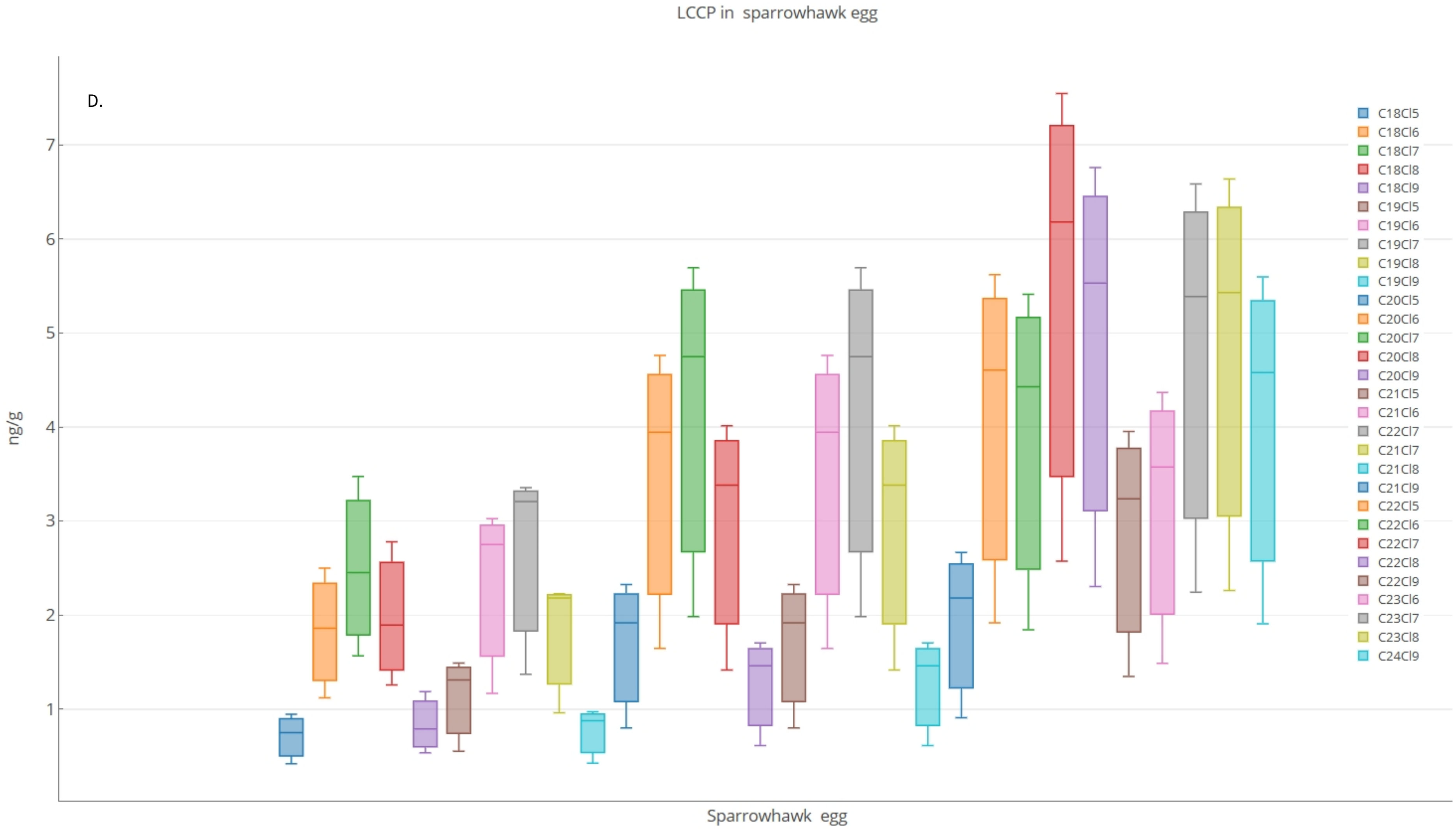
C23Cl7
C23Cl8
C24Cl9



LCCP in earthworm
B.
ng/g
1.2
1
0.8
0.6
0.4
0.2
0
Earthworm
C18Cl5
C18Cl6
C18Cl7
C18Cl8
C18Cl9
C19Cl5
C19Cl6
C19Cl7
C19Cl8
C19Cl9
C20Cl5
C20Cl6
C20Cl7
C20Cl8
C20Cl9
C21Cl5
C21Cl6
C22Cl7
C21Cl7
C21Cl8
C21Cl9
C22Cl5
C22Cl6
C22Cl7
C22Cl8
C22Cl9
C23Cl6
C23Cl7
C23Cl8
C24Cl9

LCCP in fieldfare egg




LCCP in sparrowhawk egg
D.
ng/g
1
2
3
4
5
6
7
Sparrowhawk egg
C18Cl5
C18Cl6
C18Cl7
C18Cl8
C18Cl9
C19Cl5
C19Cl6
C19Cl7
C19Cl8
C19Cl9
C20Cl5
C20Cl6
C20Cl7
C20Cl8
C20Cl9
C21Cl5
C21Cl6
C22Cl7
C21Cl7
C21Cl8
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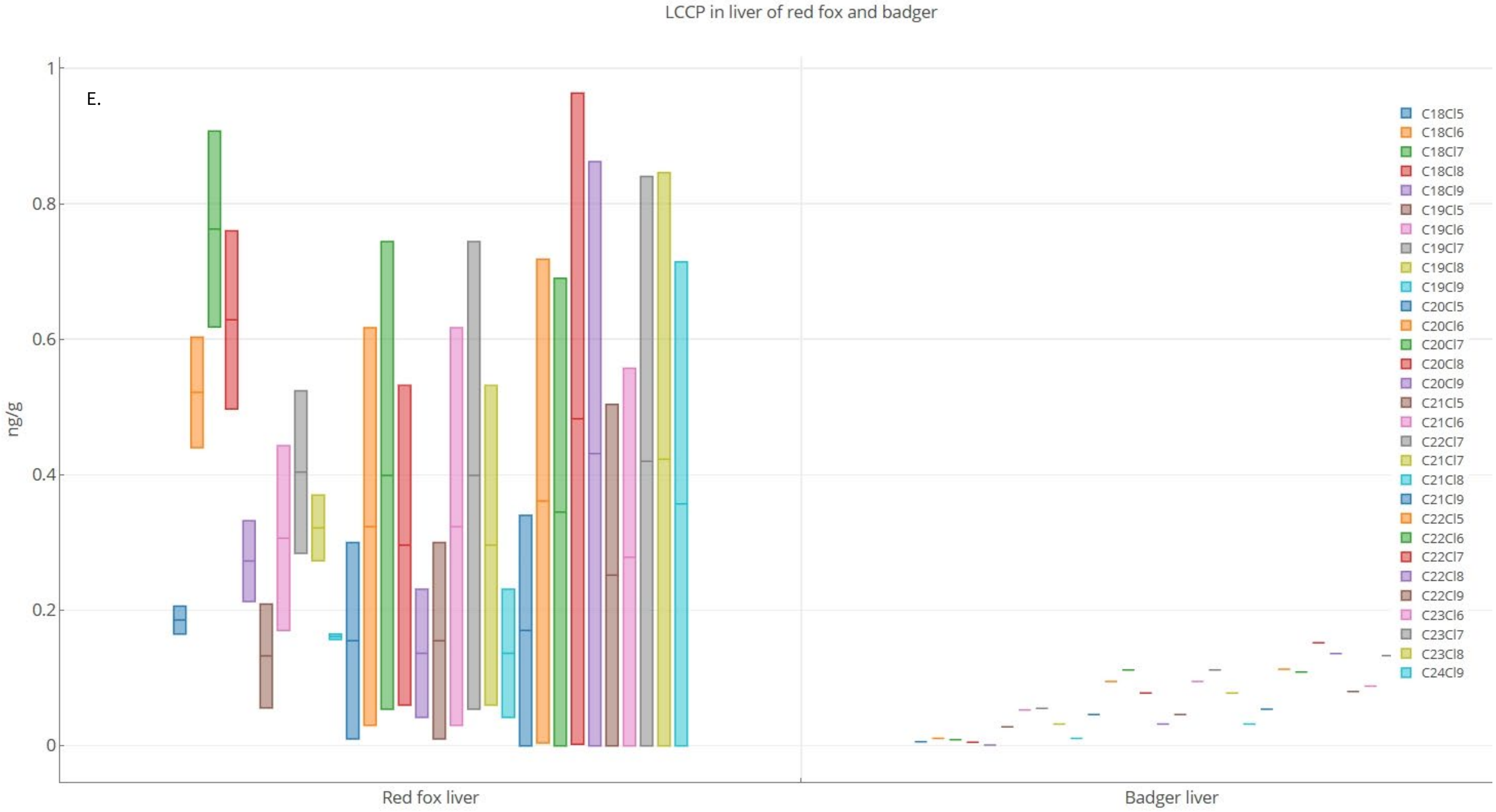
C23Cl7
C23Cl8
C24Cl9


LCCP in liver of red fox and badger
E.
ng/g
1
0.8
0.6
0.4
0.2
0
Red fox liver
Badger liver
C18Cl5
C18Cl6
C18Cl7
C18Cl8
C18Cl9
C19Cl5
C19Cl6
C19Cl7
C19Cl8
C19Cl9
C20Cl5
C20Cl6
C20Cl7
C20Cl8
C20Cl9
C21Cl5
C21Cl6
C22Cl7
C21Cl7
C21Cl8
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C23Cl8
C24Cl9

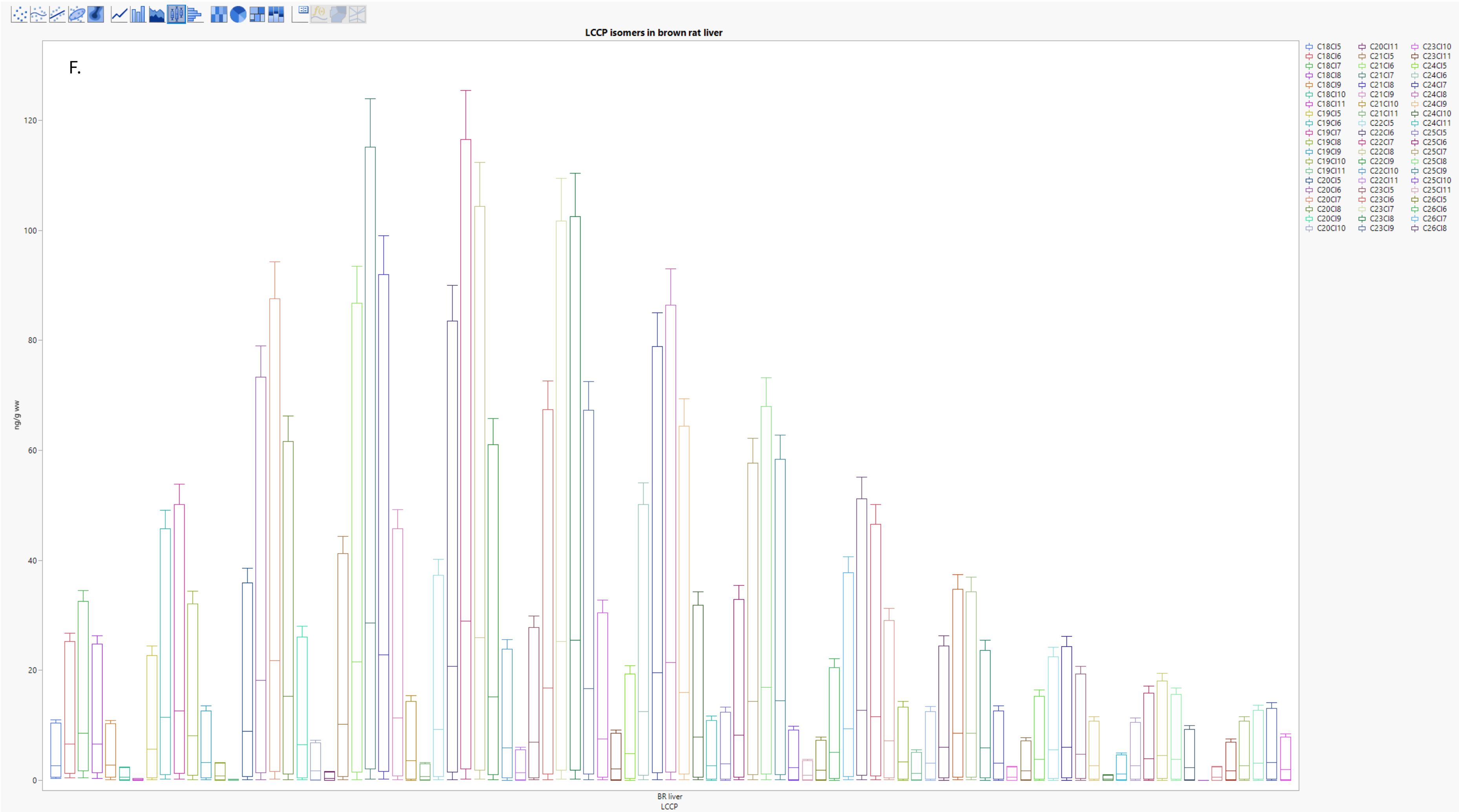

Figure 25: Box plots (programJMP) of the most dominating LCCP isomers in soil (A.), earthworm (B.), fieldfare egg (C.), sparrowhawk egg (D.), fox and badger liver (E.) and rat liver (F.)

5.6 Siloxanes

The cyclic siloxanes, D4, D5 and D6 were detected in all the samples.

As previous years, the highest concentrations on a wet and lipid weight basis were detected in brown rat liver, but the maximum level was much lower than in year 2023. Linear siloxanes and M3TPH were not detected in any sample.

None of the biological samples exceeded the available PNEC values for secondary poisoning available at the ECHA chemical information web site[13] (see also Appendix 1).

Table 35: Siloxane concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text.

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	SH egg n=3	Red fox liver n=2	Badger liver n=2
D4	0.24 <0.06 - 1.55	0.72 0.53 - 1.06	0.86 0.40 - 1.36	1.10 0.71 - 13.2	0.19 0.15 - 0.23	0.32 0.31 - 0.33	0.59 0.28 - 0.89
D5	0.37 <0.08 - 3.41	0.97 0.45 - 1.02	2.16 1.35 - 7.95	3.89 1.05 - 4.47	3.79 1.81 - 9.40	0.74 0.69- 0.79	1.00 0.56 - 1.45
D6	0.68 <0.21 - 5.05)	0.86 <0.21 - 0.97	1.41 1.22 - 2.12	1.68 1.13 - 4.32	1.54 1.35 - 2.09	0.91 0.70 - 1.13	1.57 0.71 - 2.44
L3	<0.129	<0.0476	<0.0914	<0.0241	<0.015	<0.012	<0.051
L4	<0.128	<0.235	<0.404	<0.0721	<0.035	<0.0392	<0.112
L5	<0.687	<0.647	<0.739	<0.485	<0.111	<0.240	<0.396
M3TPH	<0.0681	<0.0345	<0.0655	<0.284	<0.0787	<0.140	<0.285

[13] https://echa.europa.eu/da/search-for-chemicals

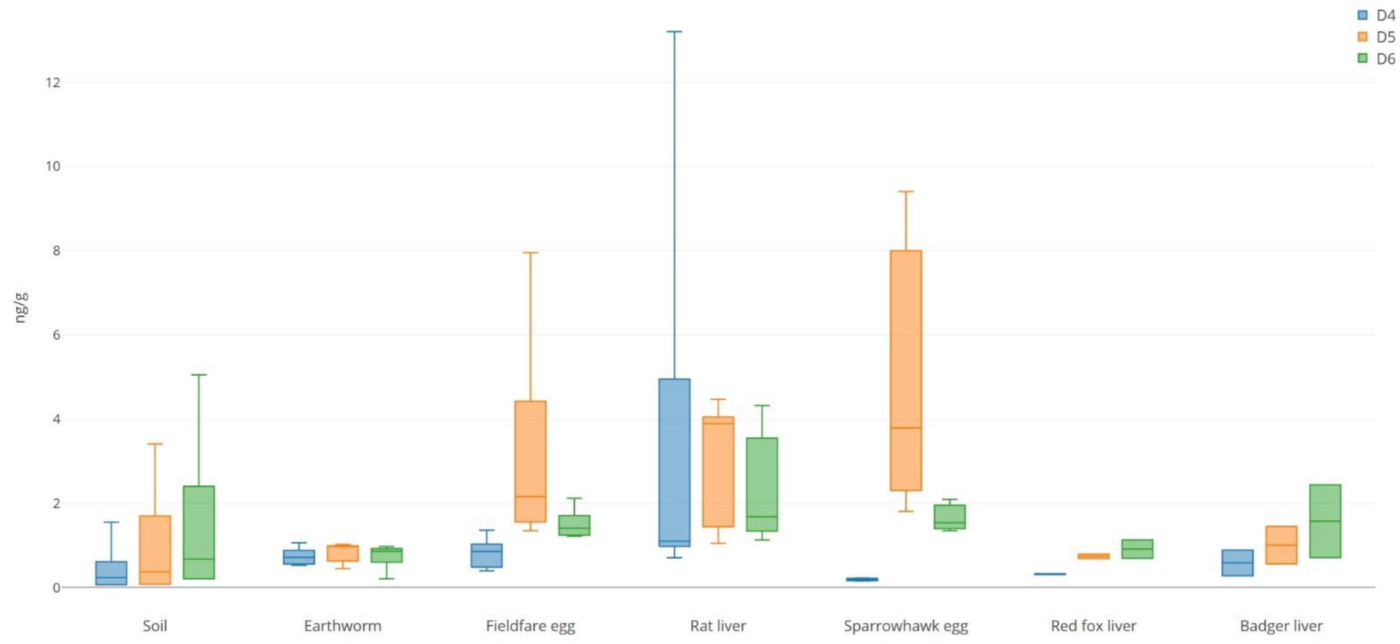

Figure 26: Box plot of detected siloxane compounds. LOD/2 values are included.

5.7 Organophosphorous flame retardants, OPFR

OPFR compounds had highest detection frequencies in soil and earthworm samples. TCPP were detected in all the analysed samples, which agrees with the previous years' data in the MILBY program, but higher concentrations of TEP were detected in some of the samples. TEP did not exceed PNECsoil of 640 ng/g dw in soil [14], and TCPP did not exceed known PNECsoil (1.3-1.7 mg/kg soil dw) or PNECoral (11600 g/kg food) in biota[15].

Table 36: OPFR concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver and European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and are displayed as grey text

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	Dog n=1	SH egg n=3	RF liver n=2	EB liver n=2
TCEP	0.24 <0.05 - 0.84	<0.50	<0.50	<0.50	<0.05	<0.50	<0.50	<0.50
TCPP	5.71 0.48 - 16.4	13.5 8.32 - 25.9	0.92 0.31 - 1.69	1.36 0.70- 4.56	0.68	0.82 0.78 - 1.05	2.26 1.93 - 2.59	2.70 0.85 - 4.55
TDCPP	<0.15	<0.25	<0.25	<0.25	<0.10	<0.25	<0.25	<0.25
TBEP	0.58 0.39 - 13.1	0.28 <0.10 -0.76	0.10 <0.10 - 0.43	0.10 <0.10 - 0.35	<0.05	0.10 <0.10 - 0.30	0.18 <0.10 - 0.26	0.24 <0.10 - 0.37
EHDP	0.25 <0.05 - 2.19	<0.25	<0.25	<0.25	<1.30	<0.25	10.8 <0.25- 21.4	<0.25
TCP	1.24 <0.05 - 6.03	<0.25	<0.25	<0.25	<0.05	<0.25	<0.25	<0.25

[14] Brief Profile - ECHA
[15] https://echa.europa.eu/brief-profile/-/briefprofile/100.033.766

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	Dog n=1	SH egg n=3	RF liver n=2	EB liver n=2
TBP	0.15 <0.05 - 0.54	3.47 2.92 - 9.53	<0.10	<0.10	0.2	<0.10	<0.10	0.44 <0.10 - 0.79
TIBP	0.15 <0.05 - 0.33	4.81 3.19 - 5.38	0.10 <0.10 - 0.47	<0.10	<0.05	<0.10	<0.10	0.34 <0.10- 0.57
TEP	2.80 <1.20 - 3.51	2.50 <2.50 - 19.9	2.50 <2.50 - 14.8	2.50 <2.50 - 20.4	<0.65	12.2 <2.50 - 29.1	<2.50	<2.50
TPRP	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
BdPhP	<0.05	<0.10	<0.10	<0.10	<0.05	<0.10	<0.10	<0.10
TPP	0.35 <0.05 - 2.70	0.10 <0.10 - 0.27	<0.10	<0.10	<0.05	0.10 <0.10 - 14.1	0.24 <0.10 - 0.38	0.36 <0.10 - 0.63
DBPhP	<0.05	<0.10	<0.10	<0.10	<0.05	<0.10	<0.10	<0.10
TXP	0.43 <0.05- 0.94	<0.50	<0.50	<0.50	<0.05	<0.50	<0.50	<0.50
TIPPP	<0.05	<0.10	<0.10	<0.10	<0.05	<0.10	<0.10	<0.10
TTBPP	n.a.	n.a.	n.a.	n.a.	<0.05	n.a.	n.a.	n.a.
TEHP	1.96 0.85 - 12.3	0.13 <0.05 - 1.40	<0.05	0.05 <0.05- 0.12	<0.10	<0.050	<0.05	<0.05

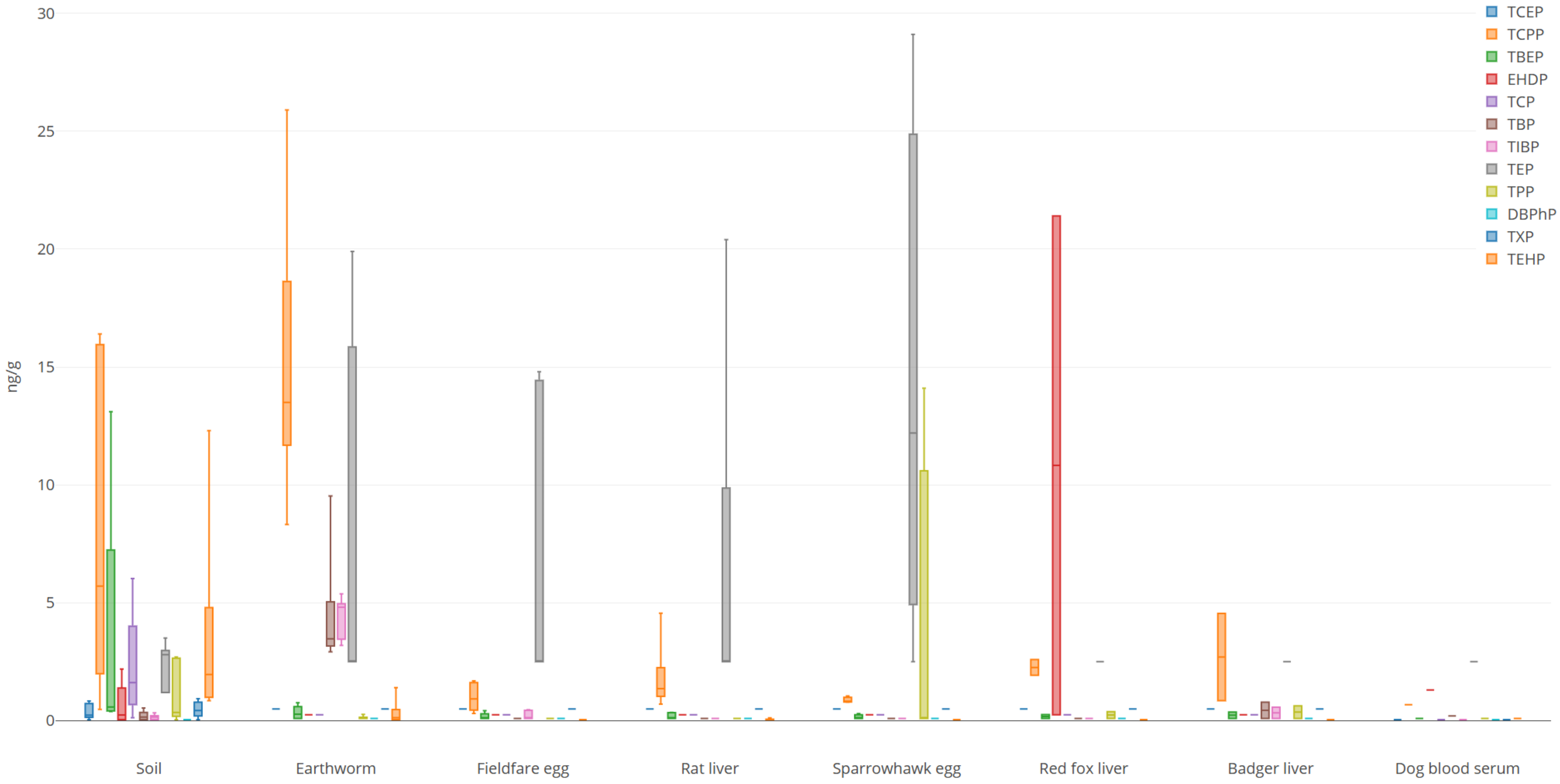

Figure 27: Box plot of OPFR compounds. LOD/2 values are included. Compounds not detected in any samples are excluded.

5.8 UV compounds

Highest detection frequences of UV compounds were found in fieldfare eggs and brown rat liver. UV-328 was the compound detected in all the various sample groups, except badger liver samples. Homosalate was detected in earthworm, fieldfare eggs and in the one pooled blood serum sample from dogs.

Table 37: UV compound concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver, European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text.

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	Dog n=1	SH egg n=3	RF liver n=2	EB liver n=2
OC	<5.00	<3.00	3.00 <3.00 - 9.00	<3.00	<5.00	<3.00	<3.00	<3.00
BP3	<4.00	0.70 0.50 -1.40	0.15 <0.15- 1.40	0.15 <0.15 -0.70	<4.00	<0.15	<0.15	0.32 <0.15 - 0.50
EHMC	<0.50	<0.30	0.30 <0.30-1.70	0.30 <0.30 - 0.80	<0.500	<0.30	<0.30	<0.30
UV-327	0.05 <0.05-0.90	<0.05	0.30 0.10 - 1.70	0.20 <0.05 - 7.90	0.7	0.80 0.60- 0.90	<0.05	<0.05
UV-328	0.90 <0.15 -2.60	0.10 <0.05 -0.20	0.60 0.20 -2.00	0.30 <0.05- 14.4	0.7	2.10 1.40 - 2.70	0.12 <0.05 -0.20	<0.05
UV-329	<1.00	<0.20	<0.20	<0.20	<1.00	<0.20	<0.20	<0.20
Homosalate	<2.00	2.65 <2.65 -6.50	2.65 <2.65 - 5.80	<2.65	6.00	<2.65	<2.65	<2.65

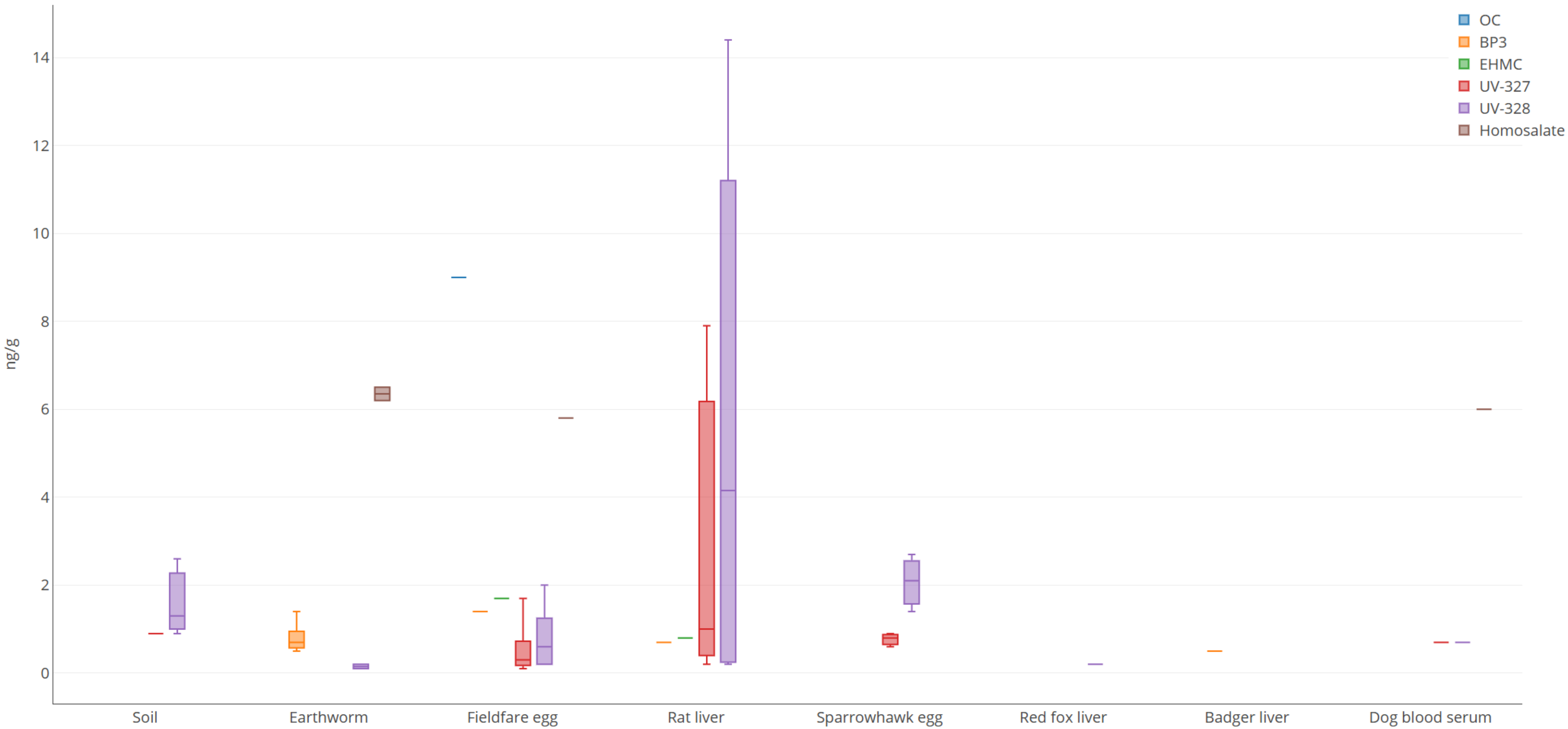

Figure 28: Box plot for detected concentrations of UV protecting compounds.

5.9 Dibromoaldrin and dechloranes

Dibromoaldrin (DBA) and dechloranes were detected in most samples. DBBALD, Dec-60 and 604 were not detected in any sample. Syn- and anti-DP were detected in highest number of samples and had highest concentrations in most of the samples. Dec-603 was only detected in the egg samples, and Dec-602 was only detected in the eggs and badger liver.

Table 38: Dibromoaldrine and dechlorane concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum, Sparrowhawk (SH) egg, Red fox (RF), liver European badger (EB) liver. All concentrations are given in ng/g ww except for soil (ng/g dw). Concentrations below LOD are given as< LOD/2 values.

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	Dog serum	SH egg n=3	RF liver n=2	EB liver n=2
DBALD	<0.41	<0.21	<0.21	<0.25	<0.21	<0.21	<0.41	<0.41
Dec-601	<0.10	<0.05	<0.05	<0.06	<0.05	<0.05	<0.10	<0.10
Dec-602	<0.06	<0.03	0.06 <0.03- 0.36	<0.04	<0.03	0.45 0.31 - 1.19	<0.06	0.14 <0.06- 0.22
Dec-603	<0.08	<0.04	0.20 <0.04- 0.61	<0.05	<0.04	0.62 0.27- 0.99	<0.08	<0.08
Dec-604	<1.91	<0.95	<0.96	<1.15	<0.96	<0.95	<1.91	<1.91
syn-DP	0.38 <0.16-0.93	0.20 <0.08 - 0.32	0.08 <0.08- 0.49	0.37 <0.08 - 0.85	<0.08	1.52 0.67 - 1.72	<0.16	<0.16
anti-DP	0.59 <0.19 - 3.62	0.21 <0.10 - 0.41	0.12 <0.10- 0.30	0.37 <0.10- 1.08	<0.10	3.71 2.23 - 5.02	<0.19	<0.19

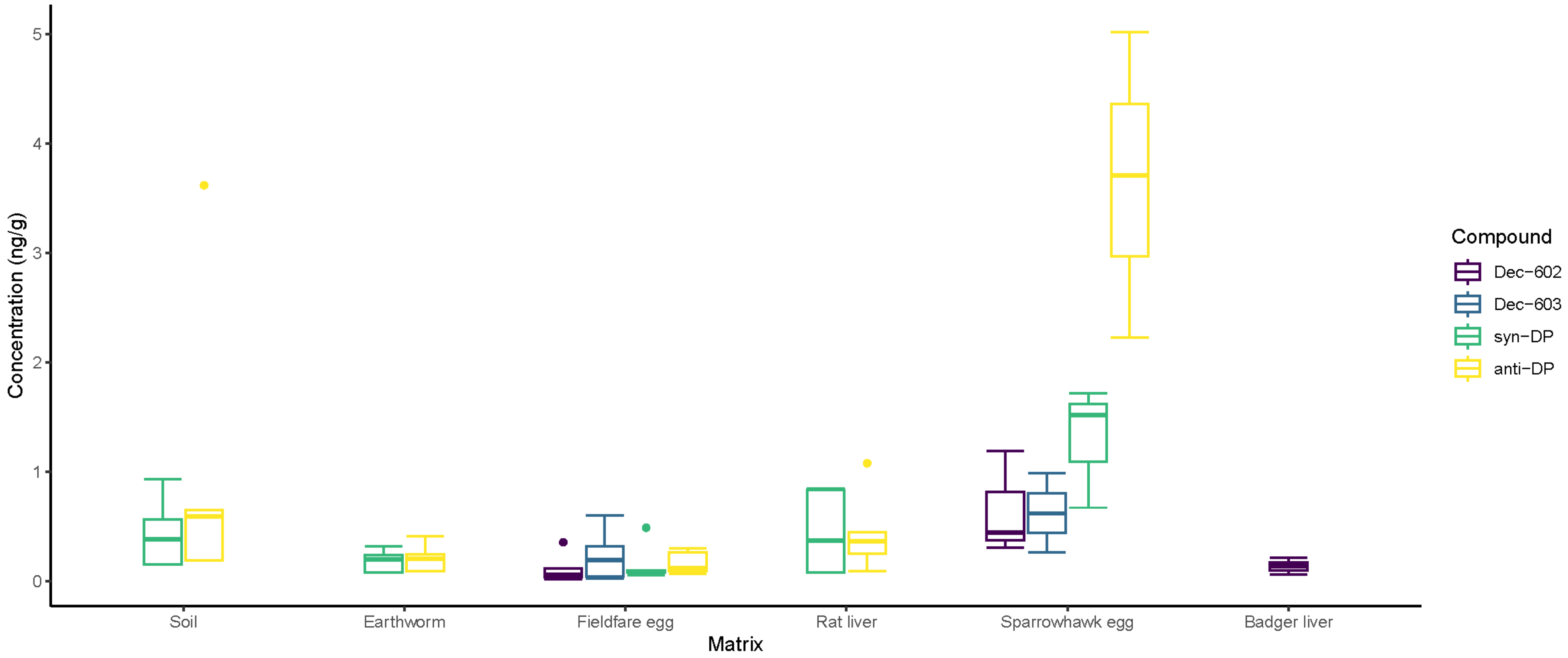

Figure 29: Box plots of dechlorane compounds in matrices. LOD/2 values are included. Compounds are not included where all concentrations were below LOD.

5.10 Bisphenols and phenols

In general, bisphenols and alkylphenols are sensitive to matrix effects, and especially in biological samples. Over the years in MILBY, this has been a known challenge for analysis of these components, which can give low recovery or interfering components in the chromatogram, thereby higher uncertainty in the data. Bisphenols and phenols were not analysed in fieldfare eggs this year due to the lack of sufficient sample amount.

The phenolic compounds with highest detection frequencies were Bisphenol A (BPA), 4-tert-octylphenol and Bisphenol F (BPF). Most of the other phenolic compounds were below LOD or near LOD. The results are more or less in agreement with previous years' result.

Table 39: Concentrations of phenols in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Dog serum (Dog), Sparrowhawk (SH) egg, Red fox (RF) liver and European badger (EB) liver. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and and are displayed as grey text.

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	Dog n=1	SH egg n=3	RF liver n=2	EB liver n=2
TBBPA	<0.95	<1.78	n.a.	<2.36	<2.25	2.38 <2.22 - 4.76	<2.38	<2.22
BPA	3.70 <1.00 - 14.9	<2.35	n.a.	6.18 <2.47 - 15.0	<2.40	<2.43	<2.54	<2.37
BPA24	<0.25	<0.60	n.a.	<0.60	<0.60	<0.593	<0.62	<0.58
BPS24	<0.07	<0.10	n.a.	0.10 <0.11 - 0.50	<0.10	0.20 <0.11- 0.46	<0.11	<0.10
BPF	0.30 <0.30 - 3.75	<0.70	n.a.	0.90 <0.72- 2.60	<0.70	0.73 <0.73 - 1.42	<0.73	<0.68
BPF24	0.70 <0.69 - 5.20	<1.60	n.a.	<1.62	<1.60	1.70 <1.59 - 16.9	<1.70	3.18 <1.62 - 4.73
BPG	<0.62	<1.25	n.a.	<1.33	<1.30	<1.29	<1.34	<1.25
BPFL	<0.36	<0.85	n.a.	<0.88	<0.85	<0.88	<0.91	<0.85
BPAP	<0.22	<0.45	n.a.	<0.50	<0.45	<0.62	<0.46	<0.45
BPZ	<0.55	<1.20	n.a.	<1.33	<1.30	<1.31	<1.37	<1.27
BPE	<0.19	<0.77	n.a.	<0.46	<0.45	<0.44	<0.46	<0.43
BPB	<0.20	<0.90	n.a.	<0.50	<0.50	<0.48	<0.50	<0.47
BPM	<0.10	<0.26	n.a.	<0.25	<0.25	<0.23	<0.24	<0.23
MB1	<0.49	<1.15	n.a.	<1.18	<1.15	<1.16	<1.22	<1.13
NOPHE4	<0.20	<0.38	n.a.	<0.50	<0.50	<0.51	<0.53	<0.49
OCPHE4N	<0.51	<1.15	n.a.	<1.24	<1.25	<1.23	<1.28	<1.20
OCPHEpt	1.35 <0.60 - 2.09	4.90 <1.50 - 7.35	n.a.	6.10 5.70 - 13.0	50.5	1.50 <1.39 - 7.38	<1.28	3.03 <1.42 - 4.64

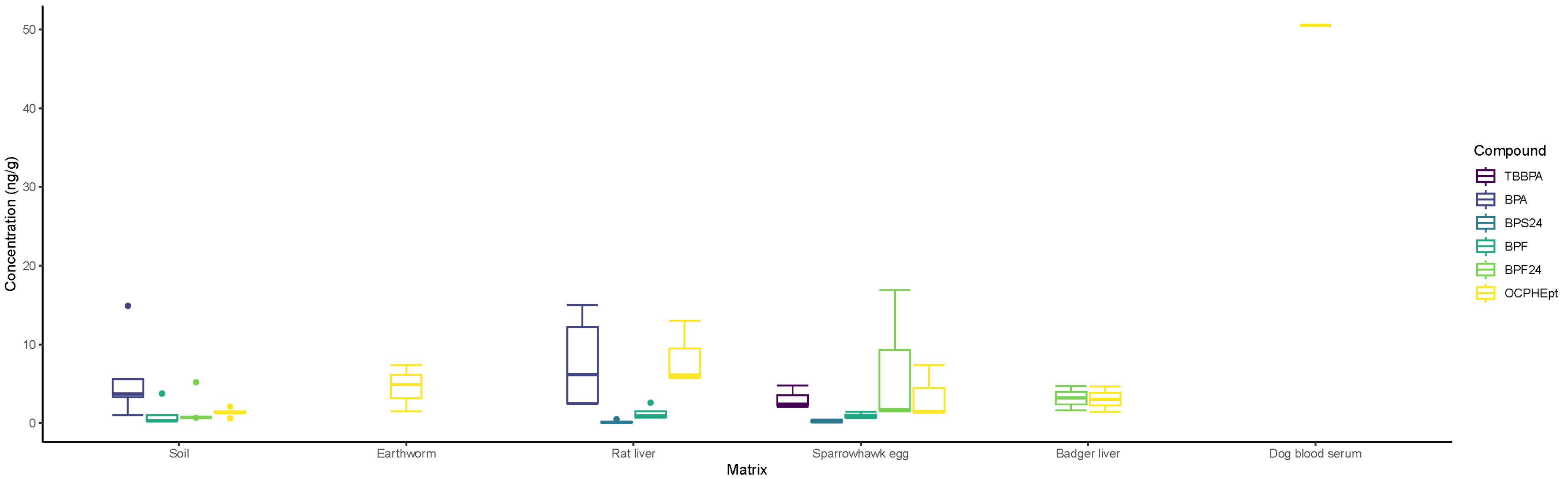

Figure 30: Box plots of bisphenol an phenol compounds in matrices. LOD/2 values are included. Compounds are not included where all concentrations were below LOD.

5.11 Musk compounds

The musk compounds Galaxolide (HHCB) and Tonalide (TONA) were only detected in a few samples of earthworm, brown rat liver and sparrowhawk eggs and at low concentrations.

Table 40: Musk concentration (median, min-max range) in the various samples. ½ LOD is used in the calculations and shown in the table.

	Soil n=5	EW n=5	FF egg n=5	BR liver n=5	SH egg n=3	Red fox liver n=2	Badger liver n=2
OTNE	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
HHCB	<0.003	0.005 <0.003-0.007	<0.003	0.003 <0.003 - 0.008	<0.003	<0.003	<0.003
TONA	<0.0005	0.005 (0.002 - 0.010)	<0.0005	<0.0005	0.0005 <0.0005 - 0.0042)	<0.0005	<0.0005
TRAS	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
PANT	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
KELE	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
MCKETON	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04

5.12 Biocides (rodenticides)

BRDIL, BRDIFA and DIFEN were detected in all the four liver samples of red fox and badger. BRDIOL dominated in the liver samples where highest concentrations were detected in badger and red fox liver samples on both wet weight (274 and 250 ng/g ww, respectively) and lipid weight basis. BRDIFA had second highest concentration in the liver samples of red fox and badger. The Oral LD50 for BRDIFA is about 0.4 mg/kg bw for male rat and mice.[16] The levels of BRDIOL and also other rodenticides have shown high variability from sample to sample over the years. The levels are in general lower this year for red fox and badger liver than previous program period, and the concentrations in rat liver were comparable to results from previous years.

[16] https://echa.europa.eu/documents/10162/581b315d-16e6-c4b4-85c1-9e68de106b6d

Table 41: Biocide concentrations in sparrowhawk eggs and in the liver samples of brown rat, red fox and badger, and dog serum. All concentrations are given in ng/g ww. Concentrations below LOD are given as < LOD/2 values and are displayed in grey text.

	BR liver n=5	SH egg n=3	Red fox liver n=2	Badger liver n=2	Dog serum n=1
Bromadiolone (BRDIOL)	4.40 1.10 - 23.2	<0.50	211 171 - 250	170 66.2 - 274	n.a
Brodifacoum (BRDIFA)	<0.50	<0.50	111 59.6 - 163	107 94.2 - 119	n.a
Flocumafen (FLOCO)	<0.50	<0.50	<0.50	<0.50	n.a
Difenacoum (DIFEN)	<0.50	<0.50	10.0 7.30 - 12.8	18.8 18.1 - 19.4	n.a
Difethialone (DIFET)	<0.50	<0.50	<0.50	<0.50	n.a
Permethrin (PERM)	0.65 <0.65 - 2.00	0.65 <0.65 - 2.00	1.32 <0.65 - 2.00	7.82 <0.65 - 15.0	<1.5

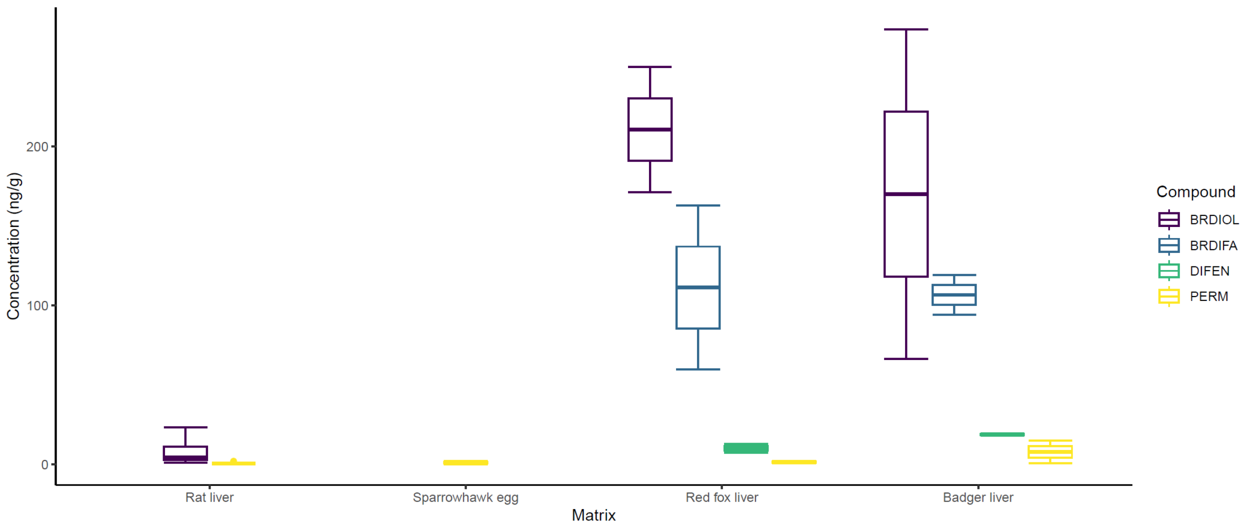

Figure 31: Box plot of biocides in rat liver, sparrowhawk egg, red fox liver and badger liver. LOD/2 values are included. Compounds are not included where all concentrations were below LOD.

5.13 Phthalates in soil and dog serum

Phthalates were analysed in the five soil samples and the one pooled dog serum sample. As previous years, DEHP and DiNP dominated in the soil samples. The median values of these two compounds in 2024 are comparable to median concentrations of 2023 and 2022, but the maximum concentrations were higher in 2024. In the one pooled blood serum sample of dog, only DEP was detected. For comparison, hazard for secondary poisoning in predators (PNECoral) of DEP is 33 mg/kg food[17].

The concentration of DEHP was well below the PNECsoil value of 13 mg/g dw, and DnBP is also below the PNECsoil value of 50 ng/g dw (ECHA chemical information, see Appendix).

Table 42: Concentrations of phthalate compounds soil and dog serum samples. Concentrations are given in ng/g ww for dog serum and ng/g dw for soil. Concentrations below LOD are given as <LOD/2 values and are displayed in grey text.

	Soil n=5	Dog serum n=1
DEHP Di(2-ethylhexyl)phthalate	57.3 13.8 - 380	<6.90
SDPHP_DIDP Sum (DPHP+ Diisodecyl phthalate (DIDP))	<100	<100
DiNP Diisononyl phthalate	25.0 <25.0 - 324	<25.0
DiBP Diisobutyl phthalate	1.40 <1.40 - 9.14	<1.10
DnBP Dibutyl phthalate	2.60 <2.60 - 9.62	<0.25
DEP Diethyl phthalate	<8.20	4.34
BBP Butyl benzyl phthalate	6.84 <0.50 - 7.34	<0.30
DCHP Dicyclohexyl phthalate	1.00 <1.00 - 9.60	<0.30
DNHP Dihexyl phthalate	<0.50	<0.30
DNOP Di-n-octyl phthalate	0.50 <0.50 - 19.8	<0.50
DNNP Dinonyl phthalate	1.50 <1.50 - 15.0	<0.35
DDPT 1,2-Benzenedicarboxylic acid, 1,2-diundecyl ester, branched and linear	<100	<100

[17] Brief Profile - ECHA

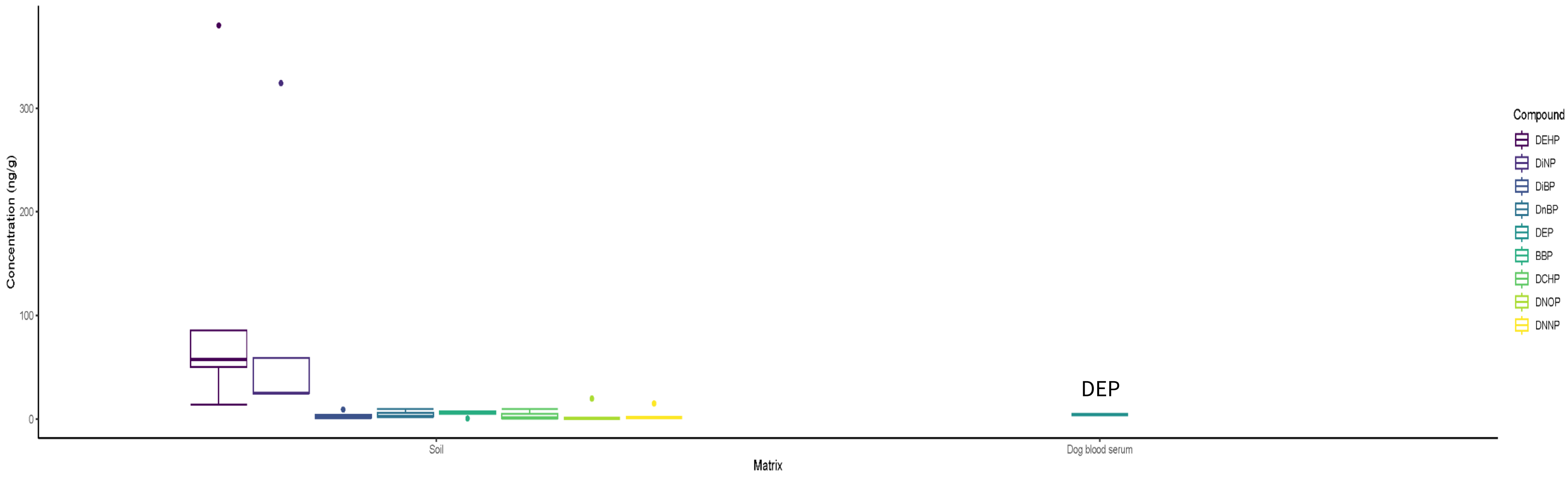

Figure 32: Box plots of phthalates in soil and the one pooled sample of dog serum. LOD/2 values are included.

5.14 Antioxidants in dog serum

Some antioxidant compounds were chosen to be analysed in the one pooled sample of dog serum. Many of these compounds belong to the compound group parabens. Several compounds were below LOD or below the levels detected in the empty vial used to sample the blood serum (Blank serum vial).

Table 43: Selecected antioxidants in the pooled dog serum sample. All concentrations are given in ng/g ww.

		Dog serum n=1 ng/g ww
Isobutyl-4-Hydroxybenzoate	IBHB	<0.012
Butyl-4-Hydroxybenzoate	BUPAR	<0.011
Butylated Hydroxyanisole	BHA	<0.120
4-(4-isopropoxyphenylsulfonyl)phenol	4IPPSP	<0.015
3-tert-butyl-4-hydroxyanisole	3BHA	<2.50
4-tert-butyl-phenol	BUPHE4T	<16
Ethyl-4-Hydroxybenzoate	EPA	<0.035
Methyl-4-Hydroxybenzoate	MPA	0.24
Benzyl-4-Hydroxybenzoate	B4HB	<0.015
Propyl-4-Hydroxybenzoate	PPA	0.16
Isopropyl-4-Hydroxbenzoate	IPPA	<0.015

5.15 Dominating pollutant groups in the species

The dominant pollutant groups within each sample type were evaluated with respect to their summed concentration. Concentrations below LOD were not included in the summed average concentrations. Metals with high detection frequencies in the samples, were also the pollutant class with the highest concentrations in all samples, and are excluded from the comparison of pollutant classes below.

Table 44: Dominating organic pollutant groups in the various samples based on average summed concentrations on a wet weight basis for biota and dry weight basis for soil.

Matrix*	Dominating organic pollutant group in the matrices
Soil	Phthalates> CPs> OPFR
Earthworm	CPs> OPFRs> PFSA
Fieldfare egg	PFSA >newPFAS> CPs
Rat liver	CPs>> PFSA>PFCA
Dog serum	Phenols> PFSA> UV comp.
Sparrowhawk egg	PCBs> CPs> PFCA
Red fox liver	Biocides>PFSA >PCBs
Badger liver	Biocides>PFSA >PFCA

* *Phthalates were only analysed in soil, biocides only analysed in liver samples and sparrowhawk eggs, antioxidants only in dog serum. Only 4-t-octylphenol as part of phenols was detected in dog serum.*

The figure below compares the percentage distributions of the organic pollutant groups in the various sample types on a wet weight basis for all samples except soil, which used dry weight.

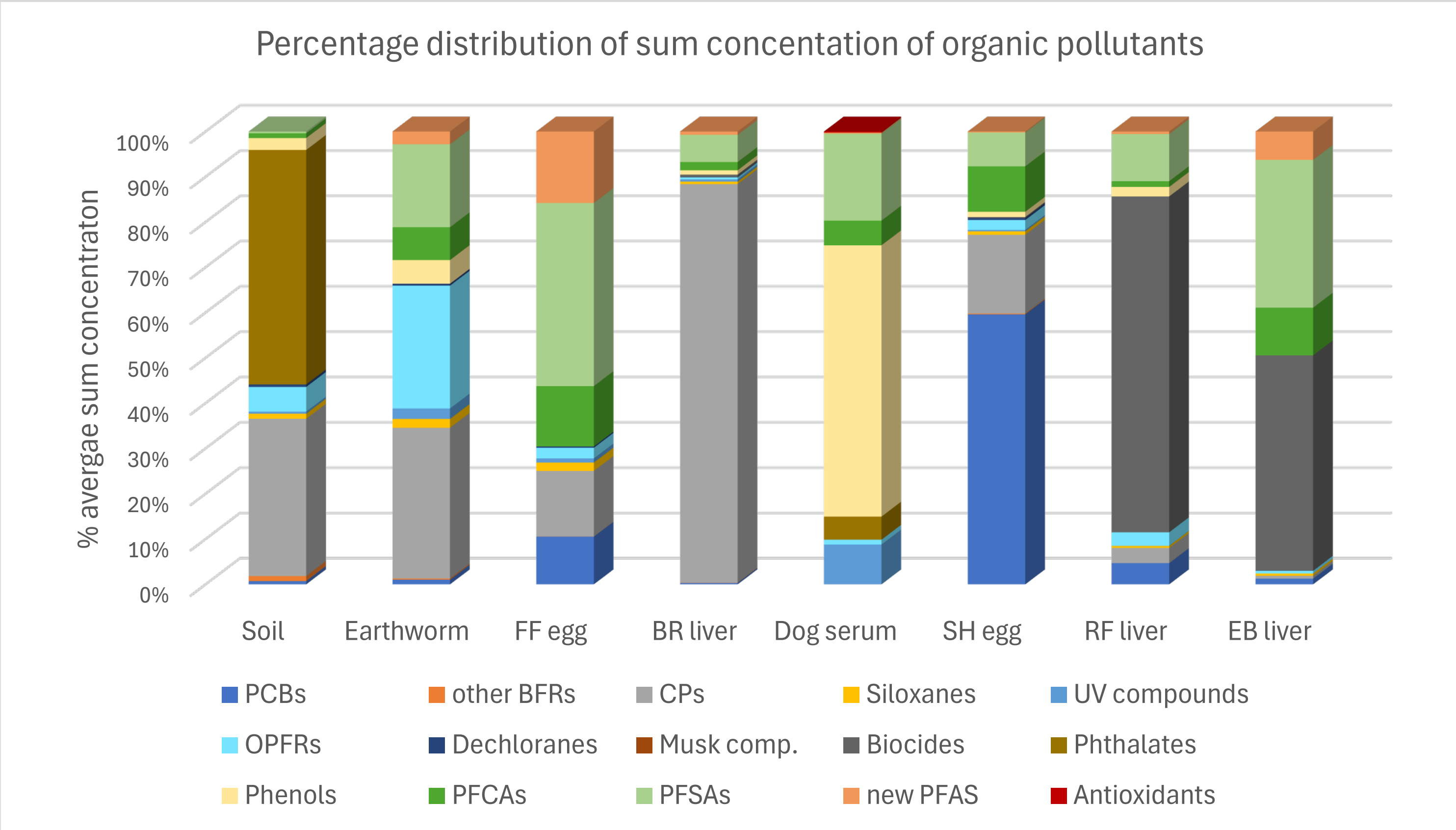

Figure 33: Percentage distributions of average summed concentrations of organic compound classes in various matrices: Soil, earthworm, fieldfare (FF) egg, brown rat (BR) liver, Dog serum, sparrowhawk (SH) egg, red fox (RF) liver and European badger (EB) liver. Phthalates were only analysed in the soil, antioxidant only in dog serum, biocides only in SH egg, RF and EB liver. LOD values are not included.

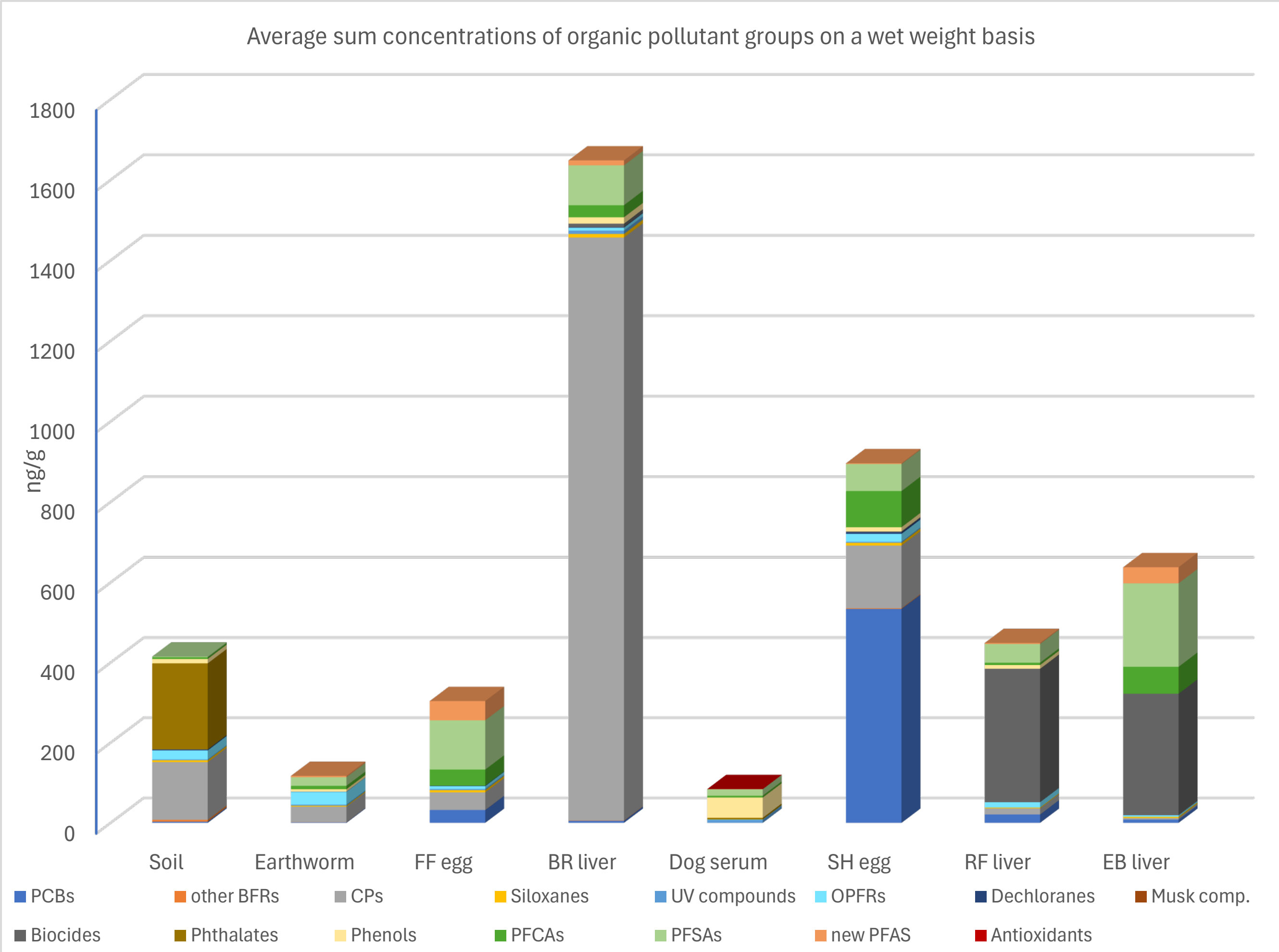

Figure 34: Average sum concentrations on wet weight basis of organic compound classes in various matrices: Soil, earthworm, fieldfare (FF) egg, brown rat (BR) liver, Dog serum, sparrowhawk (SH) egg, red fox (RF) liver and European badger (EB) liver. Phthalates were only analysed in the soil , antioxidant only in dog serum, biocides only in SH egg, RF and EB liver. LOD values are not included.

5.16 Trophic relationship

δ15N values were used to estimate the relative trophic positions of the different organisms. Terrestrial food chains are generally short and biomagnification is 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 the 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 pelagic food webs, which often are longer (McGarvey et al., 2016). 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 the feeding habits of the species. In general, the more lipophilic chemicals show stronger relationships between measured tissue concentrations and trophic position.

δ13C 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 δ13C value than samples from terrestrial locations. However, direct comparisons with the data presented in this report should be done with care, since different tissues were analysed for the different species in the study (egg, liver, whole individuals). Different tissues may have different δ13C turnover rates and may reflect the dietary exposure differently. In an optimal study design, only data from the same tissue type should be compared (optimally muscle tissue, due to their slow turnover rates).

Figure 35 shows the relationship between the samples with stable isotope data by plotting δ15N (y-axis) as a function of δ13C (x-axis).

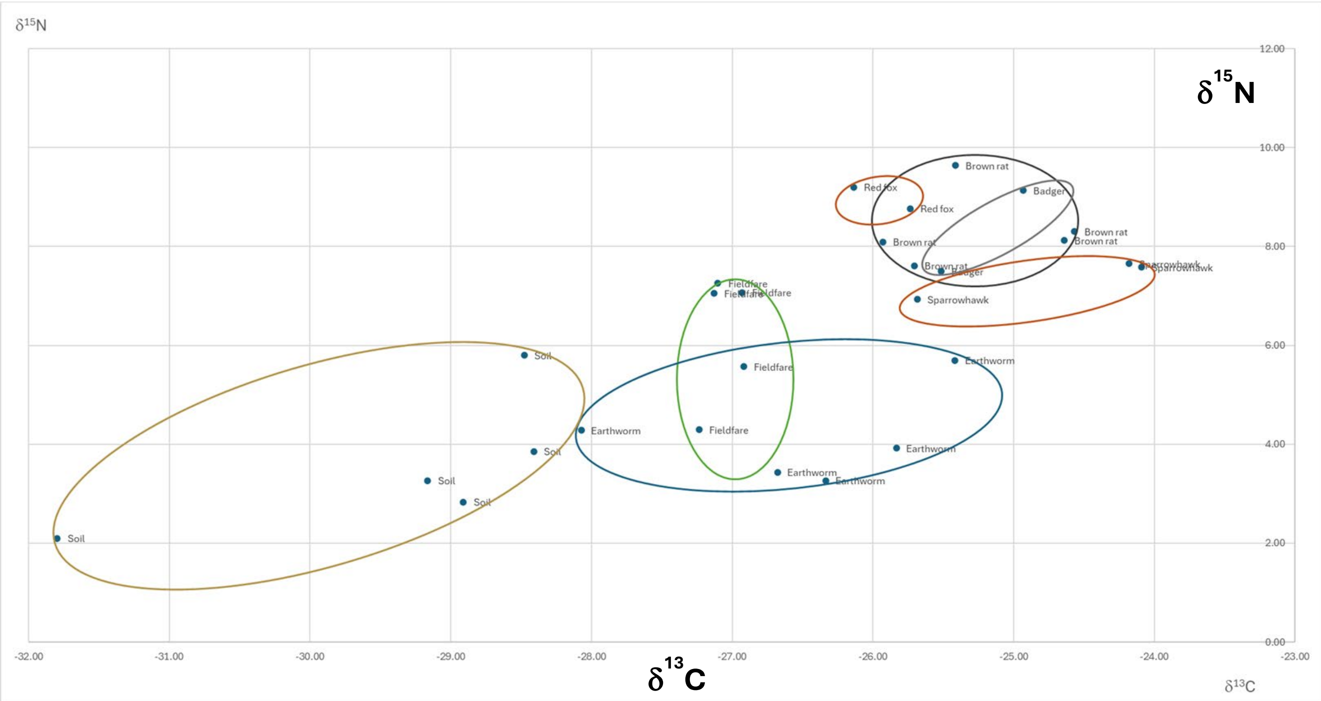

Figure 35: Relationship between the dietary descriptors, δ15N (y-axis) and δ13C (x-axis), in soil and biota samples from urban terrestrial environment in Oslo, 2024; soil, earthworm (EW), brown rat liver (BR liver) , fieldfare egg (FF egg), sparrowhawk (SH) egg, red fox (RF) liver and European badger (EB) liver.

Soil revealed lower $\delta^{13}C$ values than earthworm, but comparable $\delta^{15}N$ values. As can be seen from the plot, the five soil and earthworm samples encompassed a larger area than the other samples, and soil and earthworms from most of the same locations had comparable $\delta^{15}N$, i.e. trophic position (see Figure 36 in Appendix 2). This might be explained by differences in soil properties at the various locations which are in a large extent mirrored in the earthworm samples. Total organic content (TOC) in soil varied from 3.4 to 6.0 % across locations where Ammerud (lower left corner) had lowest TOC value and Svartdalen had the highest TOC (Figure 36). Fieldfare prey on earthworm and the $\delta^{13}C$ values of the two species are overlapping, but $\delta^{15}N$ values of most fieldfare egg samples were higher than earthworm, pointing to a higher trophic level than earthworm and enrichment of $\delta^{15}N$. The three sparrowhawk egg samples had a slightly higher average $\delta^{15}N$ value than fieldfare, and the isotopic niches had no overlap, and this can be explained by a small sample size of the species and other factors.

If fieldfare was the main prey of the sparrowhawks we would expect a larger gap in $\delta^{15}N$ values (see Heimstad et al., 2024a; Fremlin et al., 2020). Liver samples of brown rat, red fox and badger had higher $\delta^{15}N$ values than the other samples, indicating higher trophic levels.

Trophic magnification factors based on all species were not calculated in 2024 because many of the present organisms were not necessarily linked by diet (Kidd et al., 2019) by at least 3 trophic levels (Borgå et al, 2012, Kidd et al, 2019). Earthworms are known to be a major diet of fieldfare and fieldfare are known to be one of several preys of sparrowhawk. The average $\delta^{15}N$ difference between fieldfare eggs and earthworm was 2.13 ‰, while the $\delta^{15}N$ gap between sparrowhawk egg and fieldfare was only 1.13 ‰. It should be noted that only three pooled samples of sparrowhawk were analysed, and not from the same locations as the fieldfare eggs. As a general rule, a 2 to 4‰ enrichment in $\delta^{15}N$ from diet is expected, and in a Canadian terrestrial food web including birds an average value of 2.88 ‰ was determined and used (Fremlin et al, 2020). Due to the low $\delta^{15}N$ gap between sparrowhawk egg and fieldfare egg this indicated that the three species were not necessarily connected through a true prey predator relationship with three trophic levels, see Heimstad et al. 2024a for more details. Instead, we chose to assess if bioaccumulation from soil to biota and biomagnification factors from prey to predators could be calculated.

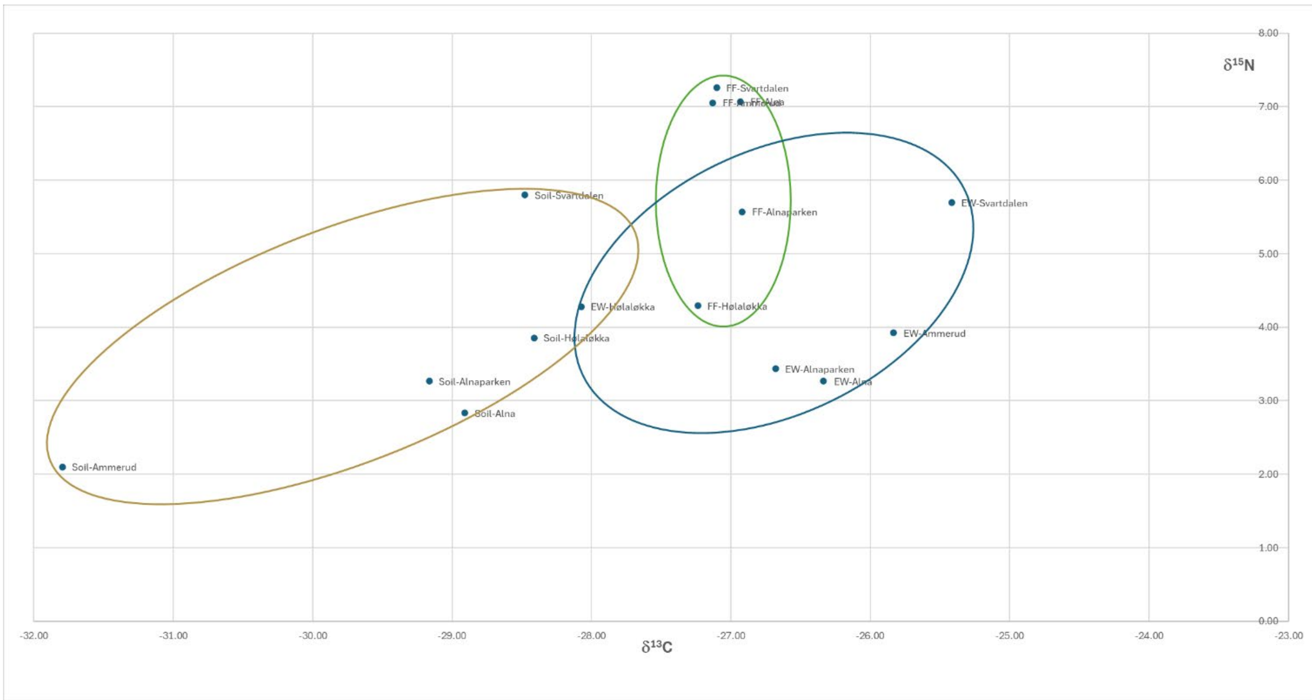

Figure 36: Relationship between the dietary descriptors, $\delta^{15}N$ (y-axis) and $\delta^{13}C$ (x-axis), in soil, earthworm (EW) and fieldfare egg (FF) from the locations Alna, Alnaparken, Ammerud, Hølaløkka and Svartdalen.

Trophic magnification factors were not calculated in 2024 because many organisms were not necessarily linked by diet through the food web (Kidd et al., 2019) by at least 3 trophic levels (Borgå et al, 2012, Kidd et al, 2019). Instead, we chose to assess if bioaccumulation from soil to biota and biomagnification factors from prey to predators could be calculated.

5.17 Bioaccumulation and biomagnification factors

Biota soil accumulation factor (BSAF) was calculated where contaminant data was detected for soil and earthworm (EW) in year 2024.

BMF was calculated for the most relevant prey-predator pair, such as earthworm-fieldfare and fieldfare-sparrowhawk, earthworm-badger where only earthworm (EW) has whole body concentrations. Egg concentrations were used for fieldfare (FF) and sparrowhawk (SH), and liver from badger (EB), and should be interpreted as a tentative BMF, and more uncertain for cases where prey and predator were not sampled at different locations, such as earthworm and badger.

Note that number of samples were three for sparrowhawk eggs and two for badger livers, compared to five samples for soil, earthworms and fieldfare eggs. Soil, earthworm and fieldfare egg were sampled in the same locations or nearby.

The calculations are first and foremost valuable for BSAF where soil and earthworm are sampled at the same time at the same locations, and BMF for earthworm and fieldfare eggs since the locations are near each other.

In addition to the use of average concentrations across the locations for each sample, calculations were done per location for both accumulation factor from soil to earthworm and biomagnification factor from earthworm to fieldfare egg.

Table 45: BSAF normalized to organic content in soil and lipid weight in earthworm for the various locations with detected concentrations in both soil and earthworm.

$BSAF(EW_{lw}/Soil_{TOC})$	Alna	Alnaparken	Ammerud	Hølaløkka	Svartdalen
PCB-28	11.8				
PCB-52	5.7	2.40			
PCB-101	3.35	0.88	2.98	11.32	
PCB-118	2.74	0.43	1.53	4.29	2.68
PCB-138	2.19	0.45	2.46	6.93	2.95
PCB-153	3.51	0.59	4.00	14.0	4.42
PCB-180	2.28	0.39	2.34	11.6	2.25
TCPP	10.4	2.03	117	12.6	45.9
TBEP		0.23	0.18		11.5
TBP	41.2	49.5			169
TIBP		64.8		123	171
TEP					64
TEHP	0.53	0.45		0.30	
a-HBCD		0.03			
D4	2.15	7.49		15.8	
D5	0.84	2.44		14.0	
D6		1.92		7.61	
LCCP	0.14	0.17	0.47		
MCCP		1.4			
Syn-DP	5.37	1.71			
Anti-DP	4.42	0.27			
UV-328	0.98	0.31		0.59	
OCPHEpt	23.1	14			

Table 46: BMF normalized to lipid weight in earthworm and fieldfare or the various locations with detected concentrations in both matrices. Alna and Alnaparken are not included since lipid percentage could not be determined due to lack of sample material.

BMF($FFegg_{lw}/EW_{lw}$)	**Ammerud**	**Hølaløkka**	**Svartdalen**
PCB-28	0.2	0.04	0.1
PCB-52	1.2	0.7	2.7
PCB-101	4.2	2.1	3.8
PCB-118	4.0	3.2	3.0
PCB-138	10.2	6.1	6.3
PCB-153	10.9	4.7	6.3
PCB-180	13.5	3.4	10.5
TCPP	0.02	0.03	0.03
TBEP			0.09
TBP		0.04	0.03
a-HBCD		0.07	
D4	0.35	0.21	0.33
D5	0.73	0.41	0.64
D6	0.63	0.43	0.35
LCCP	2.4		
MCCP	0.5		
UV-328		5.92	2.01

Table 47: Average BSAF and BMF on a lipid weight basis for detected concentrations. Average concentration across locations are used in the calculations.

Compounds	BSAF(EW_{lw}/$Soil_{TOC}$)	BMF($FFegg_{lw}$/EW_{lw})	BMF($SHegg_{lw}$/$FFegg_{lw}$)	BMF($EBliver_{lw}$/EW_{lw})
PCB-28	-	0.1	28	0.1
PCB-52	3.4	1.5	7	-
PCB-101	2.7	2.8	7	5.4
PCB-118	1.7	2.7	42	5.0
PCB-138	1.7	5.8	11	3.0
PCB-153	2.7	6.1	11	3.5
PCB-180	1.6	7.3	18	6.7
TCPP	11	0.03	0.35	0.08
TBEP	0.47	0.26	-	0.50
TBP	78	-	-	0.09
TIBP	114	0.03	-	0.07
TEP	36.5	-	-	-
TEHP	0.65	-	-	-
a-HBCD	0.3	0.1	22	-
D4	5.9	0.4	0.1	0.4
D5	2.8	0.7	1.3	0.6
D6	2.0	0.5	0.6	0.9
LCCP	0.3	0.7	5.3	0.3
MCCP	-	0.4	-	-
Dec-602	-	-	4.1	-
Dec-603	-	-	1.4	-
Syn-DP	2.4	-	-	-
Anti-DP	1.0	-	-	
UV-327	-	-	0.6	-
UV-328	0.5	2.1	1.1	
OCPHEpt	19.8	-	-	-

PFAS compounds

The BAF and BMF calculations in the present study were first and foremost done on a dry weight basis for soil and wet weight basis for biota since PFAS are known to be protein associated compounds and the lack of protein content in the samples. We used the term BAF for accumulation from soil to primary consumer on a wet weight basis and BSAF for soil concentrations normalised to organic content.

BAF and BMF were both calculated for each location in addition to average concentrations.

Table 48: A: BAF for PFAS with detected concentrations on a wet weight basis in earthworm and dry weight basis for soil at the various locations.

$BAF(EW_{ww}/Soil_{dw})$	Alna	Alnaparken	Ammerud	Hølaløkka	Svartdalen
PFPeA	13.0	1.6			4.9
PFOA	7.3	0.9	3.9	7.9	5.2
PFNA	9.8	0.5	6.1	11.4	6.4
PFDA	9.8	1.0			6.2
PFDoDA	25.3	6.4			11.1
PFOS	34.9	2.3	19.3	12.8	12.3

Table 49: BMF for PFAS with detected concentrations on a wet weight basis in earthworm and dry weight basis for soil at the various locations.

$BMF(FFegg_{ww}/EW_{ww})$	Alna	Alnaparken	Ammerud	Hølaløkka	Svartdalen
PFOA	0.8	1.0	0.6	0.1	0.4
PFNA	1.5	9.0	1.0	0.5	0.9
PFDA	4.3	7.9	2.9	1.3	3.6
PFDoDA	13.3	7.4	3.3	3.7	15.2
PFTeDA				3.1	
PFHxDA			0.9		2.9
PFHpS	0.7	1.7	1.3	0.4	0.6
PFOS	9.3	5.8	1.5	1.6	5.5
PFDS	14.7	5.1	1.0	2.5	22
PFDoS	7.8				9.3
6:2 FTS					0.4
8:2FTS		1.1			2.5
7:3 FTCA	0.3	24.8			

Table 50: A: Average BAF and BMF values for PFAS with detected concentrations on a wet weight basis in biota and dry weight basis for soil B: BSAF for PFAS with detected concentrations on wet weight basis in biota and normalised to organic content in soil. Average concentrations across locations were used.

A.

Compounds	BAF(EW_{ww}/$Soil_{dw}$)	BMF($FFegg_{ww}$/EW_{ww})	BMF($SHegg_{ww}$/$FFegg_{ww}$)	BMF($EBliver_{ww}$/EW_{ww})
PFOA	4.2	0.6	2.0	25
PFNA	5.5	1.2	1.7	87
PFDA	3.5	3.8	8.3	70
PFUnDA	-	-	1.8	-
PFDoDA	10.8	9.9	1.9	108
PFTrDA	-	-	0.7	-
PFTeDA	-	16.6	0.6	-
PFHxDA	-	2.7	0.7	-
PFHpS	-	0.7	0.9	-
PFOS (sum)	12.2	6.2	0.5	68.5
PFDS	-	10.1	0.4	-
PFDoS	-	4.9	0.3	-
8:2FTS	-	15.8	0.02	-
7:3 FTCA	-	3.0	0.2	-

B.

Compounds	BSAF(EW_{ww}/$Soil_{TOC}$)
PFOA	0.2
PFNA	0.3
PFDA	0.2
PFDoDA	0.5
PFOS	0.6

The general conclusion is that these bioaccumulation calculations, first and foremost, can indicate which compounds are more likely to bioaccumulate when BSAF (or BAF) and BMF are well above 1, and those that are less likely to (i.e., more uncertain BSAF/BAF and BMF with lower values below or near 1). For an overview of the bioaccumulation and biomagnification potential of PFAS based on data from previous programs periods (2013 to 2020), see Heimstad et al., 2024a.

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