NILU report 25/2024

Environmental pollutants in the terrestrial and urban environment 2023

MILBY 2023

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NILU report 25/2024

ISBN 978-82-425-3170-4
ISSN 2464-3327

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Stiftelsen NILU
Org.nr. 941 705 561

Certifications
NS-EN ISO 9001
NS-EN ISO 14001

Accreditation
NS-EN ISO/IEC 17025

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Cover picture:
Anders Endrestøl, NINA

Title
Environmental pollutants in the terrestrial and urban environment 2023

Norwegian title
Miljøgifter i terrestrisk og bynært miljø 2023

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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 samples that were analysed were soil, earthworm, fieldfare egg, brown rat liver, roe deer liver, vegetation, honeybee, and Spanish slug. 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 prøvene som ble analysert var jord, meitemark, egg fra gråtrost, lever fra brunrotte, lever fra rådyr, vegetasjon, bier og brunsnegl. Biomagnifiseringspotensial ble estimert basert på detekterbare data for relevante rov- og byttedyrpar.

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

Number of pages	**Classification**
108	A-Open
Project leader	**NILU project number**
Linda Hanssen & Eldbjørg S. Heimstad	O-121061
Client/Report prepared for	**Contract reference**
Norwegian Environment Agency	21087022, Gunn Lise Haugestøl
Signature of the responsible person	**Date**
Aasmund Fahre Vik, Deputy director and CTO	30.08.2024

Citation:
Heimstad, E. S., Moe, B., Davie-Martin, C. L., Borgen, A. R., Enge, E. K., Nordang, U. M, Løge, O. S., Harju, M., Bæk, K., Hanssen, L. (2024). Environmental pollutants in the terrestrial and urban environment 2023 (NILU report 25/2024). Kjeller: NILU.

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 2023

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 pollutant 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 collecting samples 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), and dechloranes were measured in the following samples:

- one pooled sample of soil from three locations
- one pooled sample of earthworm from three locations
- one pooled sample of fieldfare egg from three locations
- one pooled sample of brown rat liver from two locations
- five individual samples from five locations of roe deer liver
- four pooled samples of rowan leaves from four locations
- three pooled samples from three locations of honeybee
- three pooled samples from three locations of Spanish slugs

The sampling and analyses in 2023 are more or less similar to those in 2021, except that no sampling and analyses of fieldfare chick liver, bumble bees, or spiders were performed.

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 biocides each required a dedicated sample preparation.

GPS coordinates of the samples are given in Appendix 2.

2 Plan for sampling and analysis in 2023

An overview of the analysed species and samples 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 Coordinated Environmental Monitoring Program, CEMP, of the OSPAR commission[1]. The samples and collection procedures for 2023 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. The sampling site in Svartdalsparken is at a former landfill, which has been converted and restored to a recreational area. Steinbruvannet is located in a recreational and forest area in the northern part of Oslo, called Nordmarka. The other locations reflect where one was able to find nests and species, in addition to areas for where animals were taken/sampled/shot by others (such as roe deer and brown rat). Locations for rowan leaves (a relevant diet for roe deer) corresponded to some of the roe deer locations.

[1] CEMP Guidelines for Monitoring Contaminants in Biota (Agreement 1999-02). Revision 2018

2.1 Sampling plan in 2023

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 2). Locations correspond to those shown in Figure 1.

Sample type	Sampling strategy	No. of samples	Locations	Year
Soil	Pool of 3 soil samples from 3 locations	1	Alnabru, Steinbruvannet, Svartdalsparken	2023
Earthworms Lumbricidae	Pool of samples from 3 locations consisting of 20 individuals	1	Alnabru, Steinbruvannet, Svartdalsparken	2023
Fieldfare Turdus pilaris	Pool of 2 eggs from 3 nests/locations	1	Alnabru, Alnaparken, Svartdalsparken	2023
Brown rat liver Rattus norvegicus	Pool of 3 individual livers, same gender	1	Rosenlundgata & Haraldrudveien	2023
Roe deer Capreolus capreolus	Individual liver samples	5	Bærums verk, Nesodden, Nesoddtangen, Stabekk, Hosle	2023
Rowan Sorbus aucuparia	Pooled samples from each location	4	Bærum, Nesodden, Ekeberg, Alna	2023
Honey bee Apis mellifera	Pooled samples from each location	3	Gartneriet, Nedre Vaggestein, Sørli gård	2023
Spanish slug Arion vulgaris	Pooled samples from each location	3	Ekeberg, Steinbruvannet, Svartdalsparken	2023

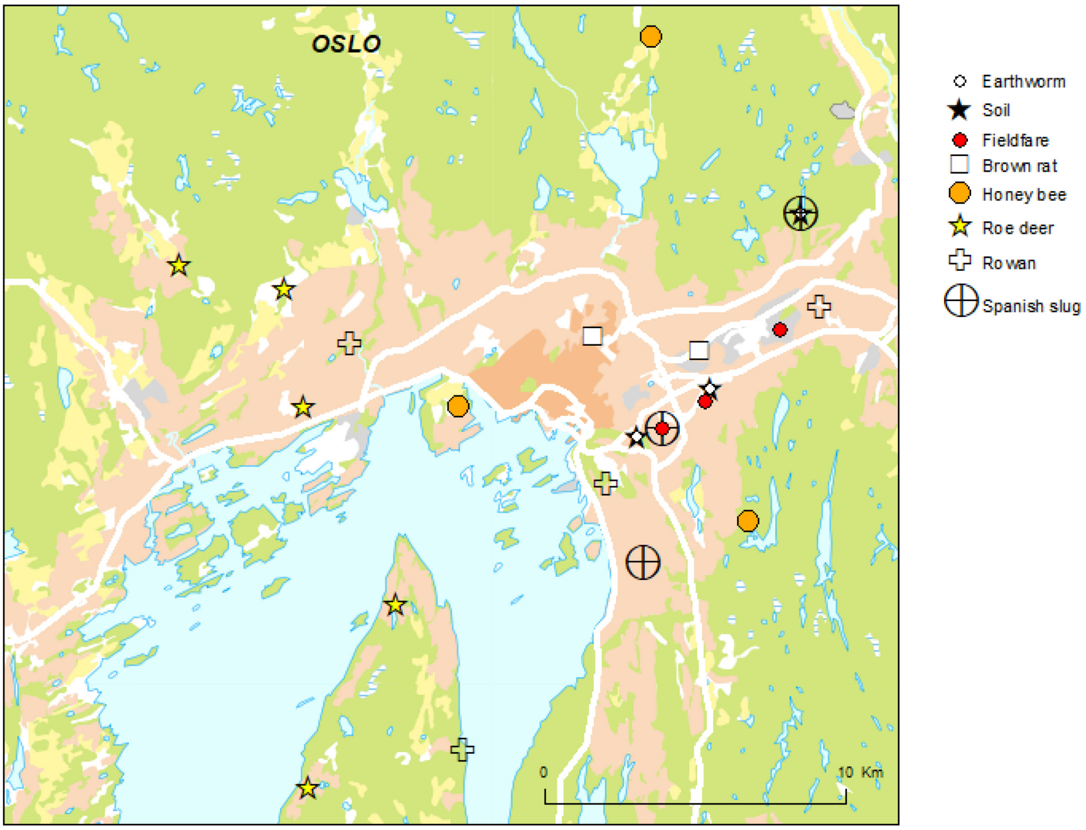


Figure 1: Locations of samples collected and analysed in 2023. See below for the corresponding table of sample types and locations, and Appendix 2 for coordinates of the sites. Fieldfare refers to eggs. Note that some samples were pooled together across locations (see Table 1), and note that more samples were collected but not analysed in 2023, and these are not shown here.

Table 2: Locations of all samples collected and analysed in 2023. Locations are shown in the map in Figure 1.

Municipality	Sampling sites	Soil	Earth-worm	Spanish slug	Fieldfare Egg	Brown rat	Roe deer	Rowan	Honey bee
Oslo	**Alna**	**X**	**X**		**X**			**X**	
Oslo	**Alnaparken**				**X**				
Oslo	**Ekeberg**			**X**				**X**	
Oslo	**Svartdalsparken**	**X**	**X**	**X**	**X**				
Oslo	**Steinbruvannet**	**X**	**X**	**X**					
Oslo	**Gartneriet**								**X**
Oslo	**Nedre Vaggestein**								**X**
Oslo	**Sørli gård**								**X**
Oslo	**Rosenlundgata**					**X**			
Oslo	**Haraldrudveien**					**X**			
Nesodden	**Fjellstrand**						**X**	**X**	
Nesodden	**Nesoddtangen**						**X**		
Bærum								**X**	
Bærum	**Bærums Verk**						**X**		
Bærum	**Stabekk**						**X**		
Bærum	**Hosle**						**X**		

Table 2: Locations of all samples collected and analysed in 2023. Locations are shown in the map in Figure 1.

2.2 Pollutants and other analytical endpoints in 2023 matrices

The various contaminant classes and other analytical endpoints are given in Table 3. Phthalates were only analysed in the one pooled soil sample. Biocides were only analysed in brown rat liver, and musk compounds were only analysed in soil, earthworm, brown rat liver, and fieldfare egg. Lipid content was not determined in vegetation or honeybees. The detection rates of the analytical endpoints are given in Table 4.

Table 3: Type of matrices and analytical endpoints in 2023

Type of sample	Contaminant classes analysed in the samples
Soil	Metals, PCBs, PFCAs, PFSAs, nPFAS, new PFAS, Other BFRs, Dechloranes, Siloxanes, CPs, OPFRs, UV-compounds, Phenols, Musk compounds, Phthalates, Stable isotopes $\delta^{15}N$ and $\delta^{13}C$, TOC, and pH
Earthworm	Metals, PCBs, PFCAs, PFSAs, nPFAS, new PFAS, Other BFRs, Dechloranes, Siloxanes, CPs, OPFRs, UV-compounds, Phenols, Musk compounds, Stable isotopes $\delta^{15}N$ and $\delta^{13}C$, lipid content
Brown rat liver	Metals, PCBs, PFCAs, PFSAs, nPFAS, new PFAS, Other BFRs, Dechloranes, Siloxanes, CPs, OPFRs, UV-compounds, Phenols, Musk compounds, Biocides, Stable isotopes $\delta^{15}N$ and $\delta^{13}C$, lipid content
Fieldfare egg	Metals, PCBs, PFCAs, PFSAs, nPFAS, new PFAS, Other BFRs, Dechloranes, Siloxanes, CPs, OPFRs, UV-compounds, Phenols, Musk compounds, Stable isotopes $\delta^{15}N$ and $\delta^{13}C$, lipid content
Roe deer liver	Metals, PCBs, PFCAs, PFSAs, nPFAS, new PFAS, Other BFRs, Dechloranes, Siloxanes, CPs, OPFRs, UV-compounds, Phenols, Stable isotopes $\delta^{15}N$ and $\delta^{13}C$, lipid content
Rowan	Metals, PCBs, PFCAs, PFSAs, nPFAS, new PFAS, Other BFRs, Dechloranes, Siloxanes, CPs, OPFRs, UV-compounds, Phenols, Stable isotopes $\delta^{15}N$ and $\delta^{13}C$
Honey bee	Metals, PCBs, PFCAs, PFSAs, nPFAS, new PFAS, Other BFRs, Dechloranes, Siloxanes, CPs, OPFRs, UV-compounds, Phenols, Stable isotopes $\delta^{15}N$ and $\delta^{13}C$
Spanish slug	Metals, PCBs, PFCAs, PFSAs, nPFAS, new PFAS, Other BFRs, Dechloranes, Siloxanes, CPs, OPFRs, UV-compounds, Phenols, Stable isotopes $\delta^{15}N$ and $\delta^{13}C$, lipid content

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

In the chapters below, tables with median, minimum, and maximum concentrations are given for each component where the number of samples equals three or more. For soil, earthworm, brown rat, and fieldfare egg, only one concentration is available for the one pooled sample.

Table 4 shows the detection frequency 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 is also the case for the PCBs, followed by the CPs and PFAS.

Musk compounds were only analysed in soil, earthworm, fieldfare eggs, and rat liver. Biocides were only analysed in livers from rat, and phthalates were only analysed in soil.

Only key findings are given in this chapter. Appendix 2, Results give the full overview.

		n=1	n=1	n=3	n=1	n=1	n=5	n=4	n=3
Compound group	Abbreviation	Soil	Earthworm	Spanish slug	Fieldfare egg	Rat liver	Roe deer liver	Vegetation	Honey bee
Metals	Sn	100	100	100	100	100	20	100	n.a.
Metals	Sb	100	100	100	100	100	100	100	n.a.
Metals	Gd	100	100	100	0	100	40	100	n.a.
Metals	Pb	100	100	100	100	100	100	100	n.a.
Metals	Hg	100	100	100	100	100	100	100	n.a.
Metals	Cr	100	100	100	100	100	100	100	n.a.
Metals	Ni	100	100	100	100	100	100	100	n.a.
Metals	Cu	100	100	100	100	100	100	100	n.a.
Metals	Zn	100	100	100	100	100	100	100	n.a.
Metals	As	100	100	100	100	100	0	100	n.a.
Metals	Ag	100	100	100	100	100	100	100	n.a.
Metals	Cd	100	100	100	100	100	100	100	n.a.
PCBs	CB28	100	100	100	100	100	0	100	0
PCBs	CB52	100	100	67	100	0	0	100	0
PCBs	CB101	100	100	67	100	100	0	100	0
PCBs	CB118	100	100	67	100	100	80	100	33
PCBs	CB138	100	100	67	100	100	80	100	33
PCBs	CB153	100	100	67	100	100	100	100	33
PCBs	CB180	100	100	67	100	100	80	100	33
other BFRs	a-HBCD	0	100	0	100	100	0	25	0
other BFRs	b-HBCD	0	0	0	100	0	0	50	0
other BFRs	y-HBCD	0	0	0	0	0	0	50	0
other BFRs	ATE	0	0	0	0	0	0	0	0
other BFRs	a-TBECH	0	0	0	0	0	0	25	0
other BFRs	B-TBECH	0	0	0	0	0	0	25	0
other BFRs	y/d-TBECH	0	0	0	0	0	0	25	0
other BFRs	BATE	0	0	0	0	0	0	0	0
other BFRs	PBT	0	0	0	0	0	0	0	0
other BFRs	PBEB	0	0	0	0	0	0	0	0
other BFRs	PBBZ	0	0	0	0	0	0	0	0
other BFRs	PTBX	0	0	0	100	100	40	25	0
other BFRs	HBB	0	0	0	0	0	0	25	0
other BFRs	DPTE	0	0	0	0	0	0	25	0
other BFRs	EHTBB	0	0	0	0	0	0	0	0
other BFRs	BTBPE	0	0	0	0	0	0	0	0
other BFRs	TBPH	0	0	0	0	0	0	0	0
other BFRs	DBDPE	0	0	0	0	100	0	0	0
PFCAs	TFA	0	0	100	0	100	100	100	100
PFCAs	PFPrA	0	0	0	0	0	0	0	0
PFCAs	PFBA	0	0	0	0	0	0	0	0
PFCAs	PFPA	0	0	0	0	0	0	0	0
PFCAs	PFHXA	0	100	0	0	0	20	0	33
PFCAs	PFHPA	100	0	0	100	0	0	0	33
PFCAs	PFOA	100	100	0	100	0	60	25	33
PFCAs	PFNA	0	100	0	100	100	100	25	33
PFCAs	PFDA	100	100	0	100	100	40	25	33
PFCAs	PFUnDA	0	0	0	100	100	0	0	33
PFCAs	PFDoDA	0	100	0	100	100	0	0	33
PFCAs	PFTrDA	0	100	0	100	100	0	0	33
PFCAs	PFTeDA	0	100	0	100	100	0	0	0
PFCAs	PFHxDA	0	0	0	0	0	0	0	0
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	0	0	100	0	0	0	0
PFSAs	PFPS	0	0	0	0	0	0	0	0
PFSAs	PFHXS	0	0	0	100	0	20	25	0
PFSAs	PFHPS	0	0	0	100	0	0	0	0
PFSAs	PFOS	100	100	100	100	100	100	25	0
PFSAs	PFNS	0	0	0	0	0	0	0	0
PFSAs	PFDS	0	100	0	100	0	0	0	0
PFSAs	PFUNS	0	0	0	0	0	0	0	0
PFSAs	PFDOS	0	0	0	0	0	0	0	0
PFSAs	PFTRS	0	0	0	0	0	0	0	0
PFSAs	PFTS	0	0	0	0	0	0	0	0

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=1	n=1	n=3	n=1	n=1	n=5	n=4	n=3
Compound group	Abbreviation	Soil	Earthworm	Spanish slug	Fieldfare egg	Rat liver	Roe deer liver	Vegetation	Honey bee
neutral PFAS	FOSA	0	0	0	0	0	0	0	0
neutral PFAS	N-MeFBSA	0	0	0	0	0	0	0	0
neutral PFAS	N-EtFBSA	0	0	0	0	0	0	0	0
neutral PFAS	PFBSA	0	0	0	0	0	0	0	0
neutral PFAS	meFOSA	0	0	0	0	0	0	0	0
neutral PFAS	etFOSA	0	0	0	0	0	0	0	0
neutral PFAS	meFOSE	0	0	0	0	0	0	0	0
neutral PFAS	etFOSE	0	0	0	0	0	0	0	0
neutral PFAS	FOSAA	0	0	0	0	0	0	0	0
neutral PFAS	meFOSAA	0	0	0	0	0	0	0	0
neutral PFAS	etFOSAA	0	0	0	0	0	0	0	0
new PFAS	4:2 FTS	0	0	0	0	0	0	0	0
new PFAS	6:2 FTS	0	0	33	0	0	40	0	67
new PFAS	8:2 FTS	100	0	0	100	0	20	0	0
new PFAS	10:2 FTS	0	0	0	0	0	0	0	0
new PFAS	PFECHS	0	0	0	0	0	0	0	0
CPs	SCCP	0	100	100	0	0	20	100	0
CPs	MCCP	0	100	100	100	100	60	100	100
CPs	LCCP	100	0	0	100	100	0	75	0
Siloxanes	D4	0	100	0	0	100	40	0	0
Siloxanes	D5	0	100	0	100	100	40	0	0
Siloxanes	D6	0	0	0	0	100	0	0	0
Siloxanes	L3	0	0	0	0	0	0	0	0
Siloxanes	L4	0	0	0	0	0	0	0	0
Siloxanes	L5	0	0	0	0	0	0	0	0
Siloxanes	M3T (Ph)	0	0	0	0	100	0	0	0
UV compounds	OC	100	0	0	0	0	60	100	67
UV compounds	BP3	0	0	0	0	0	0	0	0
UV compounds	EHMC	0	0	0	0	0	0	100	0
UV compounds	UV-327	0	0	0	100	0	0	100	0
UV compounds	UV-328	100	0	0	100	100	0	100	0
UV compounds	UV-329	0	0	0	0	0	0	0	0
UV compounds	Homosalate	0	0	0	0	0	0	100	0
OPFRs	TCEP	0	0	0	0	0	0	0	0
OPFRs	TCPP	100	0	100	0	0	0	75	100
OPFRs	TDCPP	0	0	0	0	0	0	0	0
OPFRs	TBEP	0	0	33	0	0	0	0	0
OPFRs	EHDP	0	0	67	0	0	0	0	0
OPFRs	TCP	100	0	0	0	0	0	75	0
OPFRs	TBP	0	100	0	0	0	0	75	0
OPFRs	TIBP	0	100	0	0	0	0	100	0
OPFRs	TEP	0	0	0	0	0	0	0	0
OPFRs	TPRP	0	0	0	0	0	0	0	0
OPFRs	BdPhP	0	0	0	0	0	0	0	0
OPFRs	TPP	0	0	0	0	0	20	100	0
OPFRs	DBPhP	0	0	0	0	0	0	0	0
OPFRs	TXP	0	0	0	0	0	0	0	0
OPFRs	TIPPP	0	0	0	0	0	0	0	0
OPFRs	TTBPP	0	0	0	0	0	0	0	0
OPFRs	TEHP	0	0	0	0	0	0	0	0

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).

		n=1	n=1	n=3	n=1	n=1	n=5	n=4	n=3
Compound group	Abbreviation	Soil	Earthworm	Spanish slug	Fieldfare egg	Rat liver	Roe deer liver	Vegetation	Honey bee
Dechloranes	DBALD	0	0	0	0	0	0	0	0
Dechloranes	Dec-602	0	0	0	100	0	0	0	0
Dechloranes	Dec-603	0	0	0	100	0	0	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	0	0	33	100	100	0	50	0
Dechloranes	anti-DP	100	0	33	100	100	0	0	0
Phenols	TBBPA	0	0	0	0	0	0	0	0
Phenols	BPA	0	100	0	0	0	0	0	0
Phenols	BPA24	0	0	0	0	0	0	0	0
Phenols	BPS24	0	0	0	0	0	0	0	0
Phenols	BPF	0	0	67	0	0	0	0	0
Phenols	BPF24	0	0	67	0	0	0	0	0
Phenols	BPG	0	0	0	0	0	0	0	0
Phenols	BPFL	0	0	0	0	0	0	0	0
Phenols	BPAP	0	0	0	0	0	0	0	0
Phenols	BPZ	0	0	0	0	0	0	0	0
Phenols	BPE	0	0	0	0	0	0	0	0
Phenols	BPB	0	0	0	0	0	0	0	0
Phenols	BPM	0	0	0	0	0	0	0	0
Phenols	MB1	0	0	0	0	0	0	0	0
Phenols	DDPHE4	0	0	0	0	0	0	0	0
Phenols	NOPHE4	0	0	0	0	0	0	0	0
Phenols	OCPHE4N	0	0	0	0	0	0	0	0
Phenols	OCPHEpt	0	0	0	0	0	0	0	0
Musk compounds	HHCB	0	0	n.a.	0	0	n.a.	n.a.	n.a.
Musk compounds	TONA	0	100	n.a.	0	100	n.a.	n.a.	n.a.
Musk compounds	TRAS	100	0	n.a.	0	0	n.a.	n.a.	n.a.
Musk compounds	PANT	0	0	n.a.	0	0	n.a.	n.a.	n.a.
Musk compounds	KELE	0	0	n.a.	0	0	n.a.	n.a.	n.a.
Musk compounds	MCKETON	0	0	n.a.	0	0	n.a.	n.a.	n.a.
Musk compounds	OTNE	0	0	n.a.	0	0	n.a.	n.a.	n.a.
Biocides	BRDIOL	n.a.	n.a.	n.a.	n.a.	100	n.a.	n.a.	n.a.
Biocides	BRDIFA	n.a.	n.a.	n.a.	n.a.	100	n.a.	n.a.	n.a.
Biocides	FLOCO	n.a.	n.a.	n.a.	n.a.		n.a.	n.a.	n.a.
Biocides	DIFEN	n.a.	n.a.	n.a.	n.a.	100	n.a.	n.a.	n.a.
Biocides	DIFET	n.a.	n.a.	n.a.	n.a.		n.a.	n.a.	n.a.
Biocides	PERM	n.a.	n.a.	n.a.	n.a.		n.a.	n.a.	n.a.
Phthalates	DEHP	100	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Phthalates	SDPHP_DIDP	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Phthalates	DINP	100	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Phthalates	DIBP	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Phthalates	DBPH	100	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Phthalates	DEP	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Phthalates	BBP	100	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Phthalates	DCHP	100	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Phthalates	DNHP	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Phthalates	DNOP	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Phthalates	DNNP	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Phthalates	DDPT	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

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).

3.1 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, and 10:2 FTS, and the neutral group, denoted n-PFAS. 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 investigated matrices and PFOS was the dominating compound in soil, earthworm, fieldfare egg, and rat liver. PFCA had highest concentrations in roe deer liver, rowan leaves, honeybees, and Spanish slug due to the relatively high concentrations of the ultra-short chain carboxylate compound, TFA (Table 5). This pattern was also observed in the 2021 data when comparing the dominant PFAS compounds in the samples. Rowan leaf samples had TFA concentrations ranging from 37.9 to 84.9 ng/g dw in 2023. In 2021, TFA concentrations in rowan leaves ranged from 106 to 278 ng/g ww.

It is known that longer-chain PFAS degrade 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 PFOS concentration detected in the one pooled fieldfare egg sample of 55.9 ng/g ww (linear PFOS of 52.8 ng/g ww) exceeded the PNECoral of 37 ng/g ww (see Appendix) and QSbiota of 33 ng/g ww for secondary poisoning of predators, set by the European Commission (Ankley et al., 2021).

PFOA in fieldfare eggs, 1.72 ng/g, exceeded the low QSbiota value of 0.9 ng/g for secondary poisoning of predators set by Valsecchi et al., 2017 (Ankley et al., 2021).

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey bee n=3
TFA	<0.50	<0.4	8.39 4.91-9.38	<0.4	5.75	13.6 11.5-21.4	55.4 37.9-84.9	17.5 6.40-23.4
PFPrA	<1.2	<1	<1	<1	<1	<1	<1	<1
PFBA	<0.12	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFPA	<0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
PFHxA	<0.03	0.20	<0.03	<0.03	<0.03	0.03 <0.03 - 0.31	<0.03	0.03 <0.03 - 0.44
PFHpA	0.13	<0.03	<0.03	0.06	<0.03	<0.03	<0.03	0.03 <0.03 - 0.93
PFOA	0.18	0.90	<0.03	**1.72**	<0.03	0.07 <0.03 - 0.41	0.03 <0.03 - 0.37	0.03 <0.03 - 0.90
PFNA	<0.03	0.55	<0.03	2.97	0.36	0.09 0.06 - 1.15	0.03 0.03 - 0.94	0.03 <0.03 - 0.83
PFDA	0.09	0.33	<0.03	5.88	2.34	0.03 <0.03 - 0.21	0.03 <0.03 - 0.25	0.03 <0.03 - 0.92
PFUnDA	<0.03	<0.03	<0.03	6.83	1.91	<0.03	<0.03	0.03 <0.03 - 0.95
PFDoDA	<0.06	0.86	<0.05	29.0	6.83	<0.05	<0.05	0.05 <0.05 - 0.71
PFTrDA	<0.06	1.01	<0.05	18.0	13.1	<0.05	<0.05	0.05 <0.05 - 0.32
PFTeDA	<0.06	0.11	<0.05	3.05	0.87	<0.05	<0.05	<0.05
PFHxDA	<0.09	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PFOcDA	<0.09	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08

Table 5: PFCA concentrations in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg, Brown rat (BR liver), Roe deer liver (Deer liver), Rowan leaves (Rowan), and Honey bee. Where the number of samples equaled three or higher, median concentrations and min-max interval are given, otherwise single concentrations are reported. 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. PFCA compounds with known PNEC values are marked with orange background colour. Concentrations exceeding PNEC or other thresholds are shown in bold and with orange background colour.

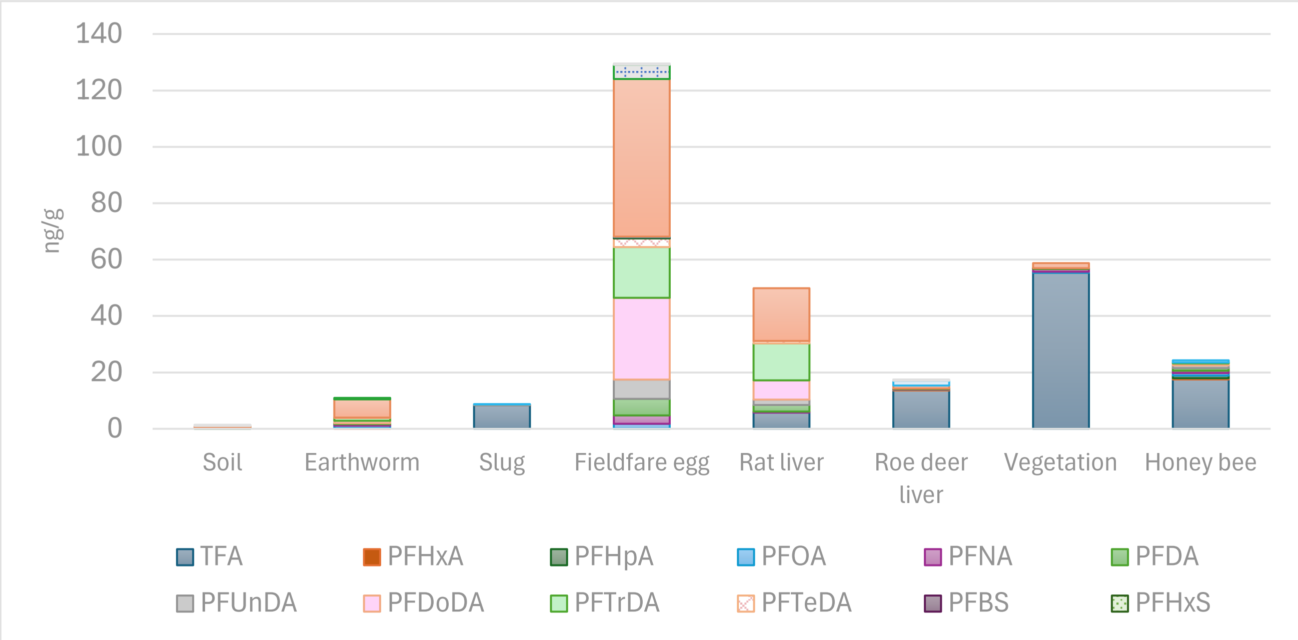
	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey bee n=3
PFEtS	<1.2	<1	<1	<1	<1	<1	<1	<1
PFPrS	<1.2	<1	<1	<1	<1	<1	<1	<1
PFBS	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
PFPS	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
PFHxS	<0.01	<0.01	<0.01	0.42	<0.01	0.01 <0.01 - 0.04	0.01 <0.01 - 0.04	<0.01
PFHpS	<0.03	<0.03	<0.03	0.20	<0.02	<0.02	<0.02	<0.02
SumPFOS	0.62	6.48	0.18 0.17 -0.46	**55.9**	18.7	1.05 0.58 - 2.12	0.02 <0.02 - 1.81	<0.02
PFNS	<0.09	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PFDS	<0.09	0.52	0.52	5.04	<0.08	<0.08	<0.08	<0.08
PFUnS	<0.18	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFDoS	<0.18	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFTrS	<0.18	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFTS*	<0.18	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15

Table 6: PFSA concentrations in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg, Brown rat (BR liver), Roe deer liver (Deer liver), Vegetation (Rowan), and Honey bee. Where the number of samples equaled three or higher, median concentrations and and min-max interval are given, otherwise single concentrations are reported. All concentrations, except in soil (ng/g dw) and are given in ng/g ww. 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 in bold and with orange background colour.

	Soil n=1	Slug n=3	FF egg n=1	Deer liver n=5	Honey bee n=3
4:2 FTS	<0.12	<0.10	<0.10	<0.10	<0.10
6:2 FTS	<0.09	0.08 <0.08- 0.19	<0.08	0.08 <0.08- 3.27	0.25 <0.08- 1.33
8:2 FTS	0.43	<0.08	0.48	0.08 <0.08 - 0.46	<0.08
10:2 FTS	<0.12	<0.10	<0.10	<0.10	<0.10
PFECHS	<0.18	<0.15	<0.15	<0.15	<0.15

Table 7: newPFAS concentrations in samples with at least one detected concentration. Where the number of samples equaled three or higher, median concentrations and min-max interval are given, otherwise single concentrations are reported. 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.

A.



B.

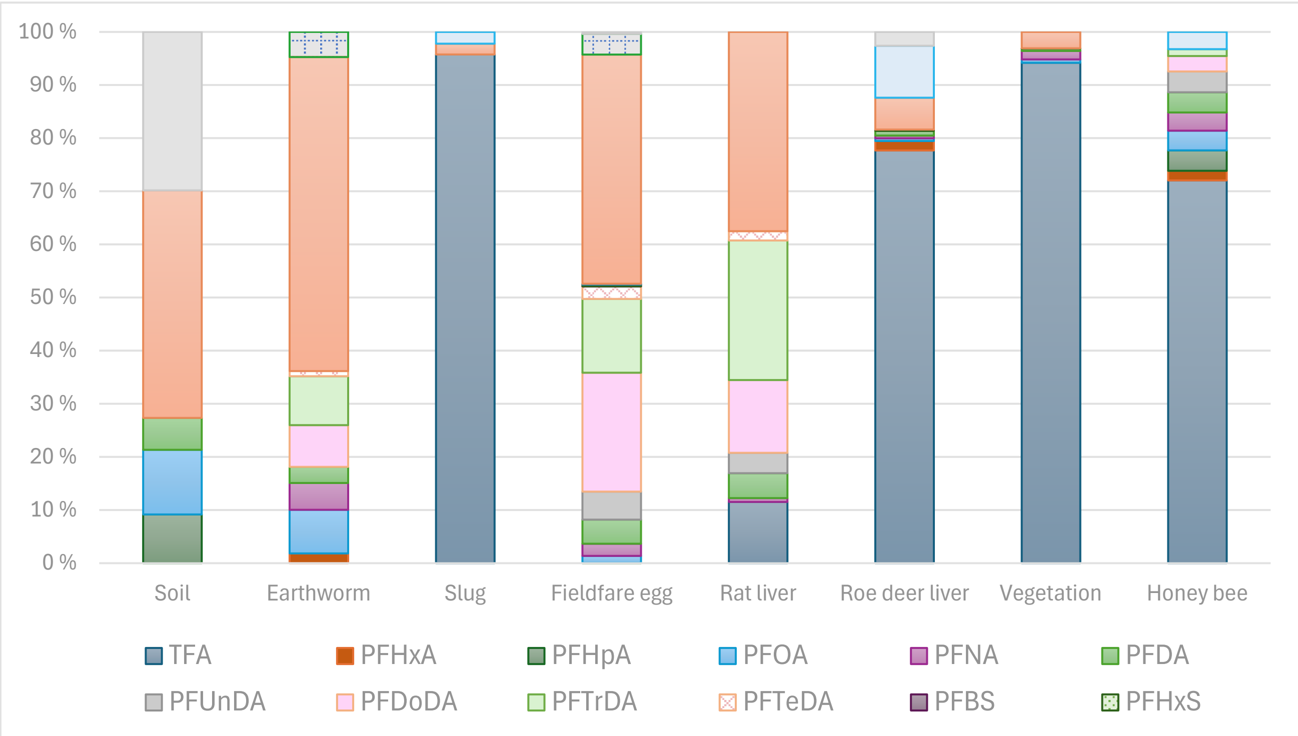


Figure 2: Concentrations (median; ng/g ww in biota and vegetation, ng/g dw in soil) of detected PFAS in all matrices (A) and their contribution (%) to the summed concentration (B).

Neutral PFAS (n-PFAS) were not detected in any sample.

3.2 Chlorinated paraffins, CPs

Short-chain (C10-C13), medium-chain (C14-C17), and long-chain (C18-C28) chlorinated paraffins (SCCPs, MCCPs, and LCCPs, respectively) were detected in many samples, see Table 8 A high concentration of LCCPs (192 ng/g ww) was detected in the one sample of brown rat liver. This was the highest concentration on a lipid weight basis (6427 ng/g lw) when compared to the detected LCCPs concentration in fieldfare egg.

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).

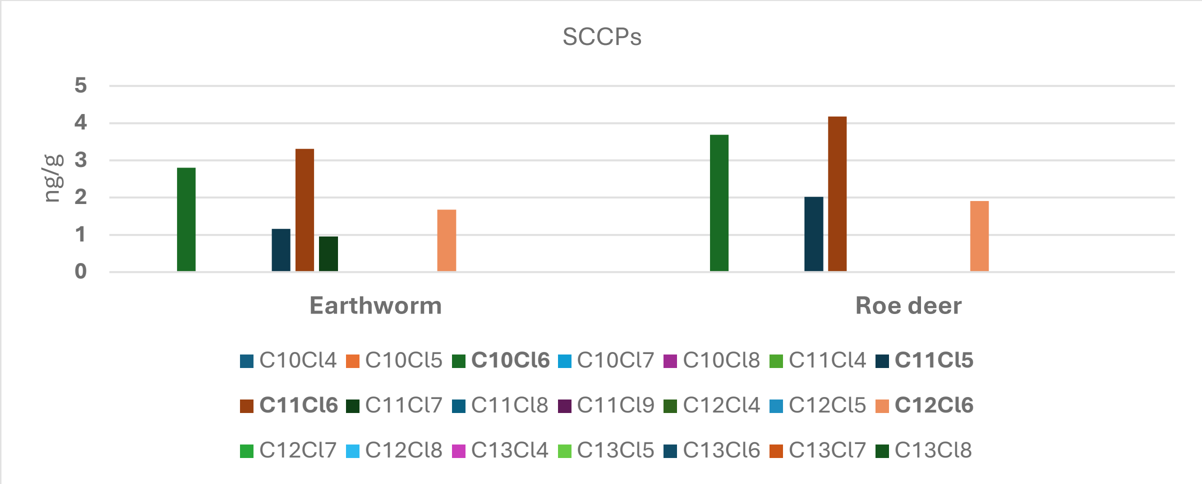
None of the samples in the Oslo area exceeded the PNECoral values of 5500 ng/g food for the SCCPs or 10 000 ng/g food (wet weight) for the MCCPs and LCCPs. The LCCP concentration in soil (9.6 ng/g dw) was far below the PNECsoil of 4.64 g/kg soil dw[2].

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey bee n=3
SCCPs	<1.80	9.85	4.92 3.78 - 36.0	<4.40	<4.40	4.40 <4.40 - 11.8	7.25 3.98 - 9.80	<4.40
MCCPs	<0.75	11.1	11.1 9.68 - 19.5	18.3	11.7	3.22 <1.50 - 11.6	19.5 15.4 - 22.7	16.6 13.3 - 19.7
LCCPs	9.6	<1.70	<1.70	24.4	192	<1.70	3.45 <0.35 - 7.79	<1.70

Table 8: CP concentrations in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare egg (FF), Brown rat (BR liver), Roe deer liver (Deer liver), Rowan leaves (Rowan), and Honey bee. Where the number of samples equaled three or higher, median concentrations and min-max intervals are given, otherwise single concentrations are reported. 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 in grey text.

The fractional contribution of each isomer/congener group was investigated and calculated from the total detected concentrations of SCCPs, MCCPs, and LCCPs, respectively. Average concentrations were used for matrices with detected concentrations in more than one sample.

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



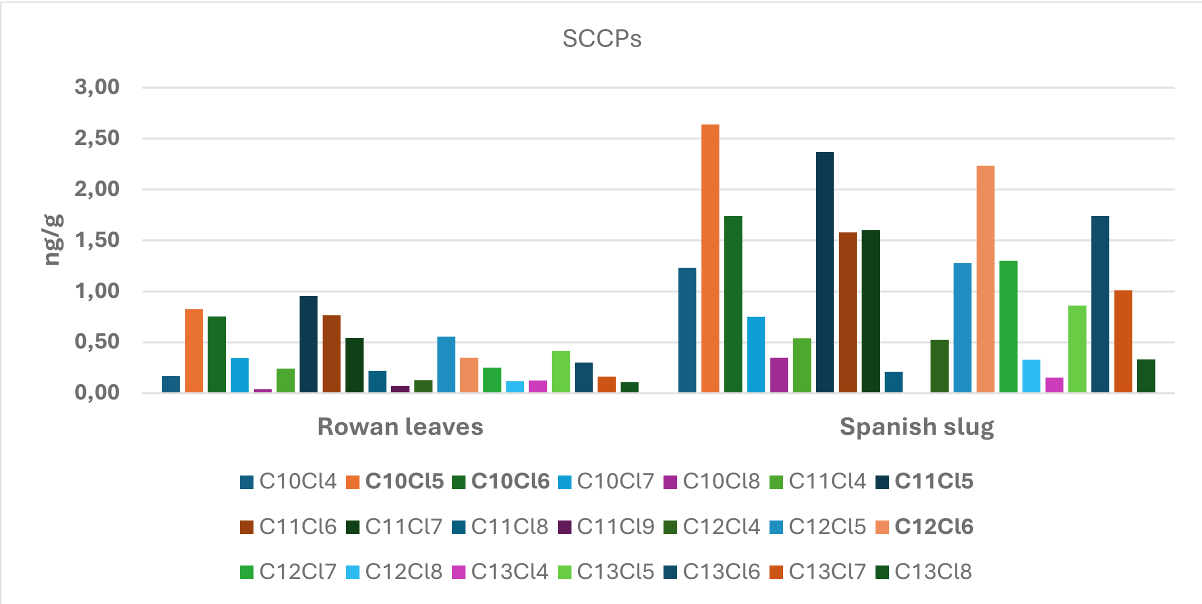
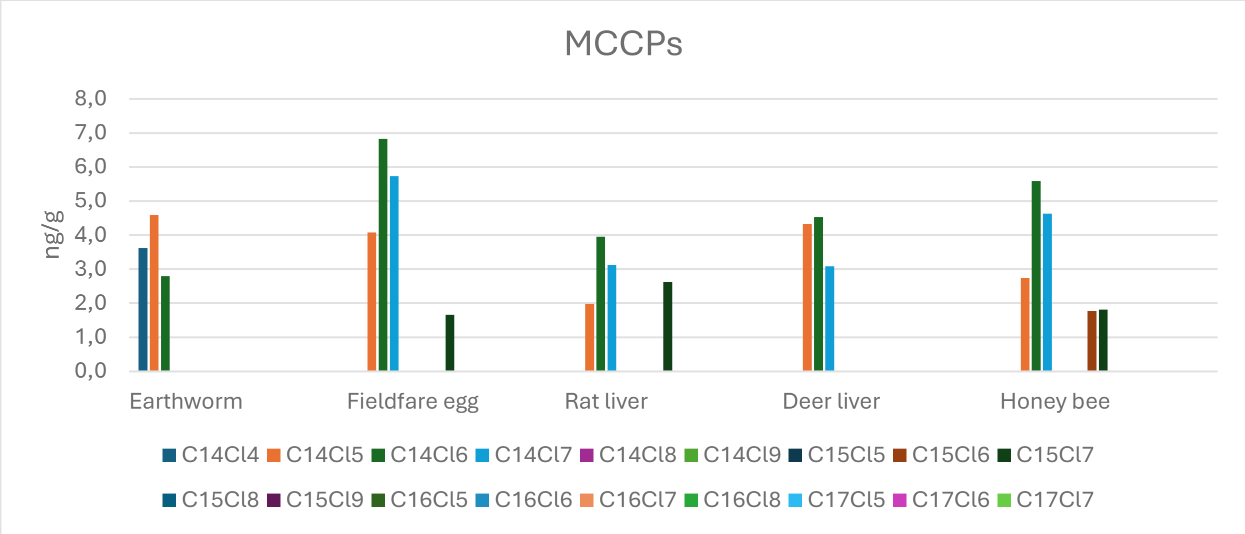


Figure 3: Patterns of SCCP isomers in samples with detected concentrations. The most dominating isomers are marked in bold font in the legend.

For SCCPs, the isomers, C10Cl6, C11Cl5, C11Cl6, and C12Cl6 were commonly observed in the samples, and rowan and slug samples had a more varied isomer distribution. C10Cl6 and C11Cl6 were also observed as dominating isomer classes in the 2021 and 2022 data from MILBY, and also agree with data from bank vole and lynx muscle samples in the Scandinavian study of Yuan et al., 2019.



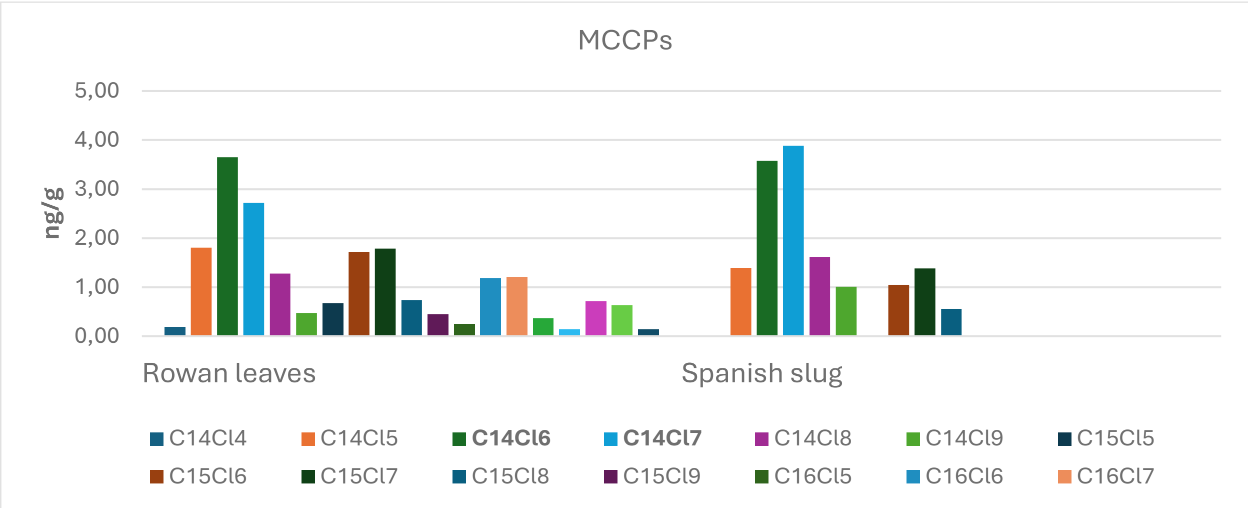


Figure 4: Patterns of MCCP isomers in samples with detected concentrations. The most dominating isomers are marked in bold font in the legend.

For MCCPs, the isomers C14Cl5, C14Cl6, C14Cl7, and partly C15Cl7 were dominating. This agrees with the MILBY 2021 and 2022 data. C14 isomer classes of MCCPs were also dominating in the Scandinavian study of Yuan et al., 2019. Rowan leaves were characterized by many isomer groups with low percentage contributions, which also agrees with the 2021 MILBY data when rowan leaves were sampled and analysed.

Figure 5: Patterns of LCCP isomers in samples with detected concentrations. The most dominating isomers are marked in bold font.

LCCP isomer patterns were characterised by many isomer groups among the samples, especially for rat and also fieldfare egg, to some degree. For the rat samples, the C22 to C30 chain lengths dominated over the C18 to C22 chain lengths. This is in agreement with the relative abundance distribution of LCCPs isomers in peregrine falcon muscle samples in the Scandinavian study of Yuan et al., 2019.

3.3 Cyclic siloxanes (cVMS)

Of the cyclic siloxanes, D4 and D5 were detected in earthworm, fieldfare egg, and in liver samples from brown rat and roe deer (see concentrations in Table 9). The highest concentrations on a wet and lipid weight basis were detected in brown rat liver, where D5 was 104 ng/g ww (3478 ng/g lw). Linear siloxanes were not detected and M3TPH was only detected in brown rat liver. Levels above 100 ng/g ww of D5 have been detected in cod liver samples over the years in the Urban fjord program[3]. The highest D5 concentrations in cod liver from the Urban fjord program were detected in four samples from 2016 and 2017, and varied from 6349 to 7949 ng/g ww (adopted from https://vannmiljo.miljodirektoratet.no/). In the Urban fjord program in 2017, the maximum concentration in herring gull eggs were 2340 ng/g lw (Ruus et al., 2018; Knudtzon et al., 2021).

Brown rats can be found wherever humans are living, particularly in urban areas. It is a true omnivore, feeding on everything, including human waste. How the rat has been exposed to D5 is not fully understood, but one likely source can be waste from insulation products (e.g., polyurethane foam or polyvinyl chloride) or other human waste, such car polishing waxes and hair shampoos, including from the sewage water and air.

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).

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey bee n-=3
D4	<1.58	4.39	<1.58	<1.58	33.6	1.58 <1.58 - 4.73	<1.58	<1.58
D5	<1.30	4.39	<1.30	5.75	104	1.30 <1.30 - 4.10	<1.30	<1.30
D6	<1.86	<1.86	<1.86	<1.86	26.6	<1.86	<1.86	<1.86
L3	<0.066	<0.093	<0.341	<0.081	<0.107	<0.324	<0.107	<0.078
L4	<0.196	<0.317	<0.350	<0.378	<0.298	<0.489	<0.505	<0.362
L5	<1.24	<0.413	<0.564	<0.488	<16.0	<0.894	<0.428	<0.531
M3TPH	<0.150	<0.184	<0.203	<0.210	1.31	<0.233	<0.194	<0.194

Table 9: Siloxane concentrations in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg, Brown rat (BR liver), Roe deer liver (Deer liver), Rowan leaves (Rowan), and Honey bee.Where the number of samples equaled three or more, median concentrations

[3] Vannmiljø (miljodirektoratet.no)
[4] https://echa.europa.eu/da/search-for-chemicals

and min-max interval are given, otherwise single concentrations are reported. 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 in grey text.

3.4 Organic phosphorus flame retardants, OPFR

TCPP was the dominant OPFR compound in the samples, which agrees with the previous years' data in the MILBY program. None of the OPFR compounds were detected in the one fieldfare egg sample or the one brown rat liver sample.

The highest TCPP concentrations were detected in Rowan leaves, followed by Spanish slug and honey bees. None of the OPFR concentrations in soil exceeded known PNECsoil values or PNECoral in biota.

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey bee n-=3
TCEP	<0.05	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35
TCPP	0.3	<1.05	4.86 2.92 - 13.4	<1.05	<1.05	<1.05	35.1 <1.05 - 39.6	3.38 2.51 - 4.59
TDCPP	<0.10	<0.25	<0.25	<0.25	<0.25	<0.250	<0.25	<0.25
TBEP	<0.10	<0.25	0.25 <0.25 - 4.38	<0.25	<0.25	<0.250	<0.25	<0.25
EHDP	<0.05	<0.25	0.67 <0.25 - 8.12	<0.25	<0.25	<0.250	<0.25	<0.25
TCP	0.2	<0.25	<0.25	<0.25	<0.25	<0.250	0.65 <0.25 - 1.42	<0.25
TBP	<0.05	2.15	<0.25	<0.25	<0.25	<0.250	1.24 <0.25 - 1.67	<0.25
TIBP	<0.10	1.56	<0.45	<0.45	<0.45	<0.45	2.35 1.56 - 2.77	<0.45
TEP	<0.50	<14.2	<14.2	<14.2	<14.2	<14.2	<14.2	<14.2
TPRP	<0.05	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
BdPhP	<0.05	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
TPP	<0.05	<0.25	<0.25	<0.25	<0.250	0.25 <0.25 - 1.80	4.46 1.88 - 12.5	<0.25
DBPhP	<0.05	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
TXP	<0.10	<0.25	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
TIPPP	<0.05	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
TTBPP	<0.10	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
TEHP	<0.05	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25

Table 10: OPFR concentrations in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg, Brown rat (BR liver), Roe deer liver (Deer liver), Rowan leaves (Rowan), and Honey bee.Where the number of samples equaled three or more, median concentrations and min-max interval are given, otherwise single concentrations are reported. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as LOD/2 values and displayed in grey text.

3.5 UV compounds

As in MILBY 2021, UV compounds had the highest detection frequencies in Rowan leaves and as in MILBY 2021 and 2022, homosalate and OC had the highest concentrations in Rowan leaves. OC was detected in roe deer liver and honeybee, in addition to Rowan leaves. Many of the other UV stabilising compounds were not detected in the samples, but UV-328 was detected in soil, fieldfare egg, brown rat liver, and rowan leaves.

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey bee n-=3
OC	3.3	<0.75	<7.50	<0.65	<3.40	2.90 <1.05 - 8.10	11.8 8.40 - 35.0	3.80 <1.80 - 6.20
BP3	<0.20	<0.20	<0.18	<0.05	<0.25	<0.15	<0.562	<0.15
EHMC	<0.15	<0.10	<0.15	<0.10	<0.15	<0.15	1.05 0.70 - 1.10	<0.10
UV-327	<0.05	<0.05	<0.08	0.1	<0.15	<0.05	0.15 0.10 - 0.30	<0.05
UV-328	0.7	<0.10	<0.30	0.2	8.9	<0.05	0.55 0.20- 1.10	<0.05
UV-329	<0.55	<0.20	<0.42	<0.15	<0.65	<0.35	<0.925	<0.150
Homosalate	<0.90	<0.75	<1.45	<0.55	<0.85	<0.78	48.0 9.00 - 66.0	<1.22

Table 11: UV compound concentrations in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg, Brown rat (BR liver), Roe deer liver (Deer liver), Rowan leaves (Rowan), and Honey bee.Where the number of samples equaled three or more, median concentrations and min-max interval are given, otherwise single concentrations are reported. All concentrations are given in ng/g ww, except for soil (ng/g dw). Concentrations below LOD are given as <LOD/2 values and displayed in grey text.

3.6 Phenols

Many phenol compounds were not detected. 4,4’ Bisphenol A (BPA) was only detected in earthworm, and 4,4’ Bisphenol F (BPF) and 2,4’ Bisphenol F (BP24) were only detected in Spanish slug. None of the other bisphenols or phenols were detected above the LOD.

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey bee n-=3
TBBPA	<2.38	<2.38	<2.38	<2.38	<2.90	<2.64	<2.12	<2.38
BPA	<2.54	11.4	<2.54	<2.54	<2.54	<2.38	<2.27	<2.54
BPA24	<0.620	<2.12	<1.19	<0.740	<2.00	<1.14	<0.971	<0.890
BPS24	<0.113	<0.297	<0.212	<0.110	<0.330	<0.300	<0.115	<0.110
BPF	<4.82	<0.890	3.05 <3.05 - 7.92	<0.730	<2.44	<1.23	<2.58	<1.42
BPF24	<8.85	<1.70	30.2 <1.70 - 42.2	<1.70	<3.88	<2.06	<4.86	<2.34
BPG	<1.34	<2.70	<1.60	<1.69	<1.88	<1.27	<1.20	<2.00
BPFL	<0.915	<1.66	<1.00	<1.04	<3.06	<1.73	<1.33	<1.26
BPAP	<0.486	<1.10	<0.647	<0.685	<1.62	<0.917	<0.889	<0.790
BPZ	<1.37	<1.37	<1.37	<1.37	<1.37	<1.28	<1.22	<1.37
BPE	<0.460	<0.750	<0.467	<0.470	<1.35	<0.767	<0.558	<0.580
BPB	<0.505	<1.42	<0.880	<0.520	<1.20	<0.814	<0.690	<3.66
BPM	<0.244	<0.332	<0.259	<0.240	<0.820	<0.344	<0.556	<0.240
MB1	<1.22	<1.22	<1.22	<1.22	<1.16	<1.47	<1.35	<1.22
DDPHE4	<0.276	<2.26	<0.388	<0.650	<0.670	<0.386	<0.316	<0.420
NOPHE4	<0.530	<3.06	<0.597	<0.880	<0.810	<0.571	<0.487	<0.680
OCPHE4N	<1.28	<1.28	<1.28	<1.28	<1.34	<1.21	<1.15	<1.28
OCPHEpt	<1.50	<1.50	<1.50	<1.50	<1.54	<1.40	<1.34	<1.50

Table 12: Concentrations of phenols in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg, Brown rat (BR liver), Roe deer liver (Deer liver), Rowan leaves (Rowan), and Honey bee.Where the number of samples equaled three or more, median concentrations and min-max interval are given, otherwise single concentrations are reported. 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.

3.7 Biocides (rodenticides) in brown rat liver

Biocides (rodenticides) were analysed in the one pooled rat liver sample. Six biocides (bromadiolone, brodifacoum, flocumafen, difenacoum, difethialone, and permethrin) were selected for analysis.

BRDIFA dominated in the rat sample with 16.7 ng/g ww, followed by BRDIOL and DIFEN. The other biocides were below the LOD. The Oral LD50 for BRDIA is about 0.4 mg/kg bw for male rat and mice.[5]

	Brown rat n=1
Bromadiolone (BRDIOL)	4.95
Brodifacoum (BRDIFA)	16.7
Flocumafen (FLOCO)	<0.500
Difenacoum (DIFEN)	4.60
Difethialone (DIFET)	<0.500
Permethrin (PERM)	<0.670

Table 13: Biocide concentrations in brown rat liver. All concentrations are given in ng/g ww. Concentrations below LOD are given as< LOD/2 values and are displayed in grey text.

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

3.8 Phthalates in soil

Phthalates were only analysed in the one pooled soil sampled across three locations. DiNP and DEHP dominated, with a measured concentrations of 49.1 and 40.6 ng/g dw, respectively, and are also in agreement with the results from MILBY 2021 and 2022.

The concentration of DEHP is 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).

	Soil ng/g dw
DEHP Di(2-ethylhexyl)phthalate	40.6
SDPHP_DIDP Sum (DPHP+ Diisodecyl phthalate (DIDP))	<6.50
DiNP Diisononyl phthalate	49.1
DiBP Diisobutyl phthalate	<1.10
DnBP Dibutyl phthalate	6.24
DEP Diethyl phthalate	<1.50
BBP Butyl benzyl phthalate	2.09
DCHP Dicyclohexyl phthalate	0.770
DNHP Dihexyl phthalate	<0.500
DNOP Di-n-octyl phthalate	<2.20
DNNP Dinonyl phthalate	<6.50
DDPT 1,2-Benzenedicarboxylic acid, 1,2-diundecyl ester, branched and linear	<6.50

Table 14: Concentrations of phthalate compounds in the one pooled soil sample. Concentrations below LOD are given as <LOD/2 values and are displayed in grey text.

3.9 Dominating pollutant groups in the species

The dominant pollutant groups with respect to the average detection frequencies of each pollutant group were assessed:

Compound group	Soil	Earthworm	Spanish slug	Fieldfare egg	Rat liver	Roe deer liver	Rowan leaves	Honey bee
Metals	100	100	100	92	100	80	100	n.a.
PCBs	100	100	72	100	86	49	100	19
PFCAs	20	47	7	53	47	21	12	24
PFSAs	9	18	9	45	9	11	5	0
new PFAS	20	0	6.6	20	0	12	0	13.4
neutral PFAS	0	0	0	0	0	0	0	0
CPs	33	67	67	67	67	27	92	33
Dechloranes	14	0	9	57	29	0	7	0
OPFRs	12	12	12	0	0	1	25	6
UV compounds	29	0	0	29	14	9	71	10
Siloxanes	0	29	0	14	57	11	0	0
other BFRs	0	6	0	17	17	2	15	0
Phenols	0	6	7	0	0	0	0	0
Musk compounds	14	14	n.a.	0	14	n.a.	n.a.	n.a.
Biocides	n.a.	n.a.	n.a.	n.a.	50	n.a.	n.a.	n.a.
Phthalates	42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Table 15: Detection frequency (DF, %) of pollutant groups within each sample type. The DF within in each matrix is coloured as a function of % DF, from dark blue (100%) to white (0 %).

The dominant groups with respect to average detection frequency in each sample type:

Soil	Metals = PCBs > Phthalates > CPs > UV comp > PFCA = newPFAS
Earthworm	Metals = PCBs > CPs > PFCAs > Siloxanes
Spanish slug	Metals > PCBs > CPs > OPFRs > PFSAs
Fieldfare egg	PCBs > metals > CPs > Dechloranes > PFCAs > PFSAs
Rat liver	Metals > PCBs > CPs > Siloxanes > Biocides
Roe deer liver	Metals > PCBs > CPs > PFCAs > newPFAS
Rowan leaves	Metals = PCBs > CPs > UV comp > OPFRs
Honey bee	CPs > PFCAs > PCBs > new PFAS > UV comp

The dominant pollutant groups within each sample type were also evaluated with respect to their summed concentration. Concentrations below LOD were not included in the summed concentrations. For matrices with three or more samples, the average sum value was used. Metals with high detection frequencies in the samples, were also the pollutant class with the highest concentrations. PCBs, with some of the highest detection frequencies, were not the dominant group when comparing the summed concentrations, except in fieldfare egg on a lipid weight basis. The dominating pollutant groups based on summed concentrations were to a large extent in agreement with previous results from MILBY 2021 when we had the same kind of samples.

Matrix*	Ordered groups based on the Sum of group concentrations (wet weight).
Soil	Metals > Phthalates > CPs > PCBs > UV comp > Dechloranes > PFSAs > OPFRs > new PFAS > PFCAs > Musk compounds
Earthworm	Metals > CPs > Phenols > Siloxanes > PFSAs > PFCAs > OPFRs > PCBs > Musk compounds > other BFRs
Spanish slug	Metals > CPs > Phenols > OPFRs > PFCAs > PFSAs > PCBs > new PFAS > Dechloranes
Fieldfare egg	Metals > PFCAs > PFSAs > CPs > PCBs > Siloxanes > Dechloranes > new PFAS > UV > other BFRs
Rat liver	Metals > CPs > Siloxanes > PFCAs > Biocides > PFSAs > other BFRs > UV > PCBs > Dechloranes > Musk compounds
Roe deer liver	Metals > PFCAs > CPs > Siloxanes > UV > new PFAS > OPFRs > PFSAs > PCBs > other BFRs
Rowan leaves	Metals > UV > PFCAs > OPFRs > CPs > other BFRs > PFSAs > PCBs > Dechloranes
Honey bee	PFCAs > CPs > UV > OPFRs > new PFAS > PCBs

* *Phthalates were only analysed in soil, musk compounds were only analysed in soil, earthworm, fieldfare egg, and brown rat liver, and biocides were only analysed in brown rat liver.*

Table 16: Dominant pollutant groups in the various samples based on summed concentrations on a wet weight basis for biota and rowan leaves, and dry weight basis for soil.

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.

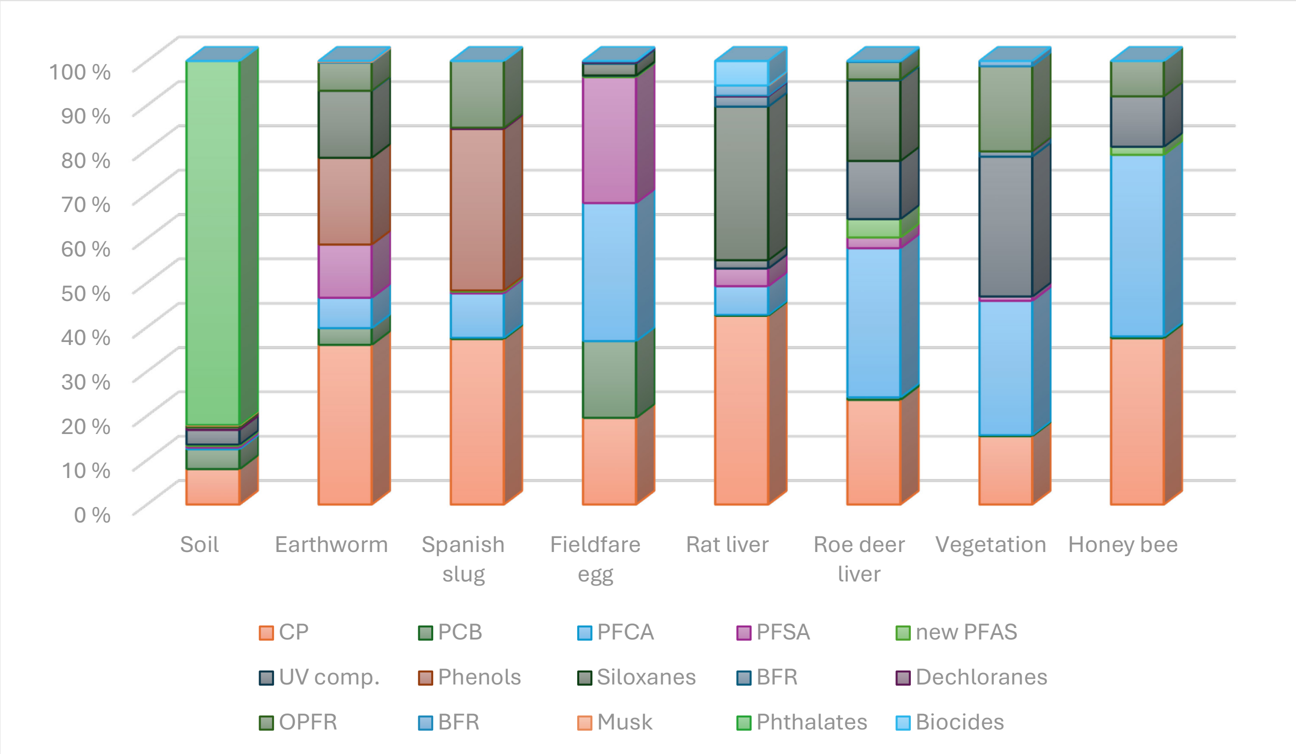


Figure 6: Percentage distributions of summed concentrations of organic compond classes in various matrices: Soil, earthworm, Spanish slug, fieldfare egg, brown rat liver, roe deer liver, vegetation (Rowan leaves), and honey bee. Biota and rowan leaves used in ng/g ww, whereas soil was in ng/g dw. Phthaltes were only analysed in the soil sample, while biocides were only analysed in the rat liver sample.

3.10 Trophic relationship

$\delta^{15}N$ 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.

$\delta^{13}C$ values provide information regarding the source of dietary carbon, e.g., whether and to what extent an organism feeds on marine or freshwater organisms, or aquatic or terrestrial organisms. For example, samples from marine locations are expected to show a less negative $\delta^{13}C$ value than samples from terrestrial locations. However, direct 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 δ^{13}C 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).

When relating all samples in 2023 against δ^{13}C (x-axis) and δ^{15}N (y-axis), the graph in Figure 7 results.

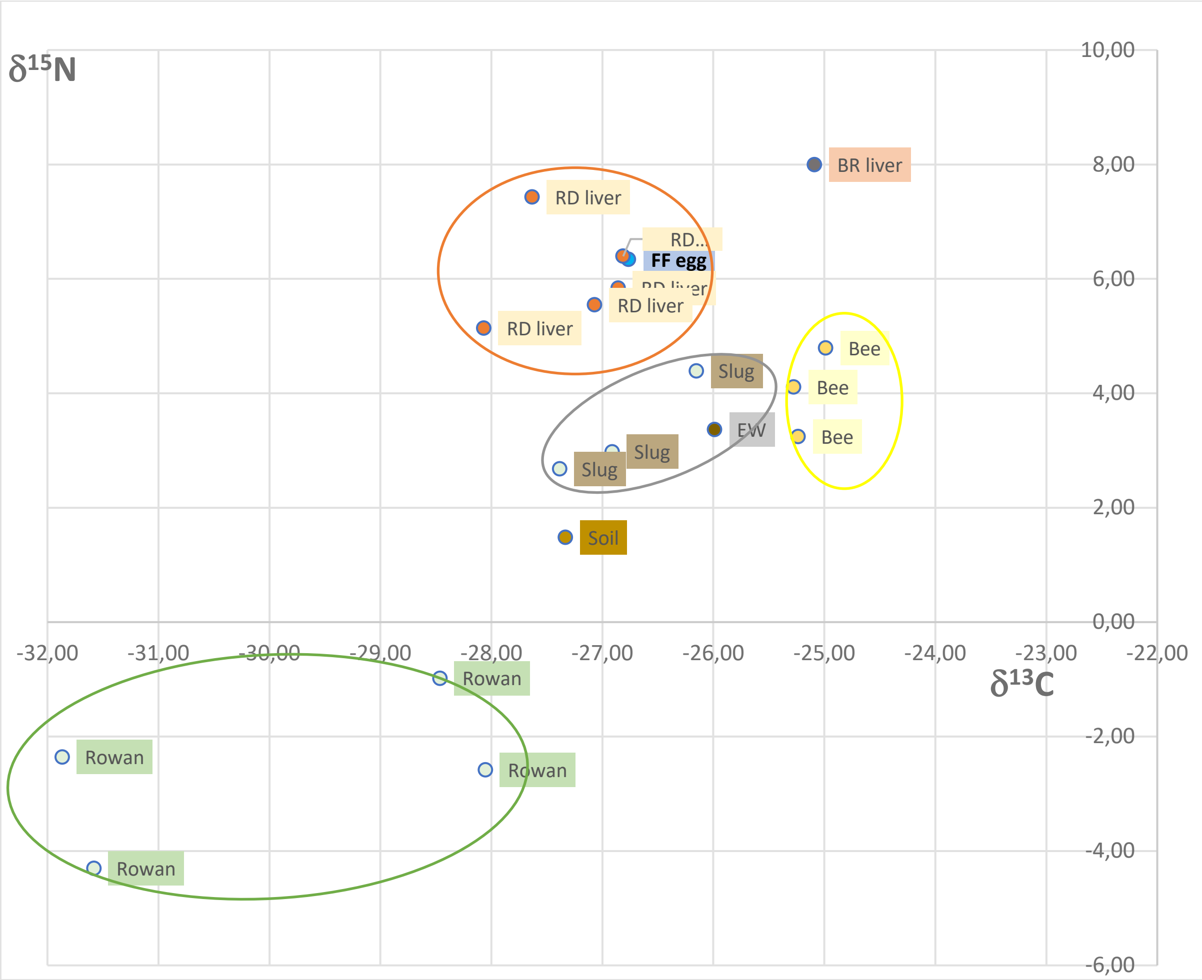


Figure 7: Relationship between the dietary descriptors, δ^{15}N and δ^{13}C, in soil and biota samples from urban terrestrial environment in Oslo, 2023; soil, earthworm (EW), brown rat liver (BR liver), Spanish slug (Slug), fieldfare egg (FF egg), Roe deer liver (RD liver), rowan leaves (Rowan), and honey bee (Bee).Note that only one sample exists for soil, earthworm, fiedlfare egg, and brown rat liver.

As can been seen from the δ^{15}N and δ^{13}C plot, the rowan leaf vegetation is distinctly different from the other species, with the lowest δ^{15}N and δ^{13}C values in the plot. Low δ^{13}C values are associated with a terrestrial signal. The single Spanish slug and earthworm samples show comparable δ^{15}N values, an indication of a similar trophic level. Soil revealed lower δ^{15}N and δ^{13}C values than earthworm and some of the slug samples. For Roe deer (liver), where rowan leaves are assumed to be an important part of the diet, δ^{15}N values were comparable to the one pooled sample of fieldfare egg and higher than those of the honey bees. The one pooled brown rat sample had higher δ^{15}N signals than the other samples. Brown rat is known to be an omnivore and will consume almost anything in their environment. They will scavenge through trash or eat any food that is left unprotected.

Trophic magnification factors were not calculated in 2023 because most organisms were not 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 and biomagnification factors could be calculated for those compounds with detected concentrations.

3.11 Bioaccumulation and biomagnification

Biota soil accumulation factor (BSAF) was calculated where contaminant data was detected for soil and earthworm (EW) and slug in the same year. Spanish-slug concentrations were collected across three locations where two of those were similar to soil locations, and the average concentrations were used for calculations of BSAF. BMF was calculated for the most relevant prey-predator pair, such as earthworm-fieldfare, where only earthworm (EW) has whole body concentrations. Egg concentrations were used for fieldfare (FF) and should be interpreted as a tentative BMF.

Be aware that the number of samples is very small with only one pooled sample of soil, earthworm, and fieldfare egg, and three samples of slug.

Unfortunately, very few hydrophobic compounds were detected above the LOD in pairs of soil and earthworm, soil and slug, and the prey-predator pair of earthworm and fieldfare. In addition to the PCB congeners, only D5, α-HBCD, and the MCCPs had detectable concentrations.

Rowan leaves may be a food item for roe deer. However, we have no TOC value for rowan leaves to normalise concentration to organic content in rowan leaves. The wet weight/dry weight concentration ratio between roe deer liver and rowan leaves were above 1 for PCB-153 and PCB-180. This ratio was also above 1 for the SCCPs, but not for the MCCPs. For other compounds with detected concentrations in both row deer liver and rowan, the ratio was below 1.

Compounds	BSAF(EW_{lw}/$Soil_{TOC}$)	*BSAF($Slug_{lw}$/$Soil_{TOC}$)	BMF($FFegg_{lw}$/EW_{lw})
PCB-28	0.83	0.85	1.33
PCB-52	0.72	0.95	7.32
PCB-101	0.64	0.32	6.32
PCB-118	0.60	0.28	5.98
PCB-138	0.66	0.16	6.56
PCB-153	0.87	0.20	8.02
PCB-180	0.35	0.10	12.6

Table 17: BSAF (EW_{lw}/$Soil_{TOC}$), BSAF ($Slug_{lw}$/$Soil_{TOC}$)), and BMF on a lipid weight basis for fieldfare egg for the PCB congeners

Compounds	BMF($FFegg_{lw}$/EW_{lw})
D5	0.58
MCCP	0.73
α-HBCD	8.2

Table 18: BMF (FF/EW) for D5, α-HBCD, and MCCP

None of the other hydrophobic compounds had detectable concentrations for calculation of BSAF and BMF. Only the PCB congeners and α-HBCD revealed BMF values above 1, which are indicative of biomagnification.

3.12 PFAS compounds

The BAF and BMF calculations in the present study were done on a wet weight basis for both soil and earthworm since PFAS are known to be hydrophilic or protein associated compounds. We used the term BAF for accumulation from soil to primary consumer on a wet weight basis instead of BSAF, since BSAF is mostly used for soil concentrations normalised to organic content.

Compounds	n=1 for Soil and EW **BAF (EW/soil)$_{ww}$**	n=1 for EW and FF$_{egg}$ **BMF (FF$_{egg}$/EW)$_{ww}$**
PFOA	6.3	1.9
PFNA	-	5.4
PFDA	4.7	17.6
PFDoDA	-	33.7
PFTrDA	-	17.8
PFTeDA	-	28.9
PFOS (sum)	12.9	8.6
8:2FTS	-	4.80

Table 19: BAF(C_{EW} / C_{soil}) and BMF(C_{FF} / C_{EW}) values for PFAS with detected concentrations on a wet weight basis.

A BAF could only be calculated for PFOS (0.44) with slug, because the other PFAS were not detected in both soil and slug.

The general conclusion is that these bioaccumulation calculations, first and foremost, can indicate which compounds are more likely to bioaccumulate (when BSAF/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., 2024.

3.13 Recommendations

The third program period (2021-2025) of the urban terrestrial monitoring programme included several new species, new substances within some of the contaminant classes, and some new contaminant groups. In 2023, the new species monitored were roe deer (liver), vegetation (rowan tree leaves), honeybees, and Spanish slug.

- In order to use BMF, there should be a clear prey-predator relationship where samples are collected at the same location or area. This was fulfilled this year for the prey-predator pair of earthworm and fieldfare egg, although the necessary measurement of concentrations in the whole bird were not fulfilled.
- It is recommended that other relevant prey-predator pairs in the terrestrial food web be collected and analysed.
- 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. It is also necessary to measure concentrations from the whole animals or from muscle samples. This is not very easy to fulfil, but should be the aim if TMF is found to be the most important and reliable biomagnification parameter for regulatory purposes.
- For comparisons between studies, it is recommended to analyse individual samples with relevant metadata such as physiological parameters, location, time of sampling, and possible age/gender of the species. Location is important for prediction of biomagnification and also to pinpoint to possible pollution sources.
- For temporal studies and trend analysis, it is recommended to select the same species and locations over several years.
- For analysis of rowan leaves, the content of TOC or protein would be of interest to investigate.

3.14 Acknowledgements

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

NINA:

Ida Ward Myran (NINA) and Kristine Roaldsnes Ulvund (NINA), prepared the egg and liver samples before analysis. Lisa Åsgård, Carina Berentsen, Gjøran Stenberg, Anders Endrestøl (NINA), Sveinn Are Hanssen (NINA), Nina Eide (NINA), Neri Horntvedt Thorsen (NINA).

Anticimex for collecting brown rat samples.

Wildlife managers at Nesodden, Asker, Bærum, and Oslo municipality were involved in collecting roe deer and red fox livers.

IFE:

Ingar Johansen, who was responsible for the stable isotope analysis.

NIVA:

Laura Röhler and Jan Tomas Rundberget, for chemical analysis of biocides and UV compounds.

NILU, sample preparation and chemical analyses;

Silje Winnem, Vladimir Nikiforov, Nahla Ibrahim Zainalabdeen, Silje Thomassen, Kirsten Davanger, Inger Christin Steen, Sheryl Rodrigo, Stine M. Bjørneby, Mebrat Ghebremeskel, Heidi Eikenes, Hans Gundersen, Hilde T. Uggerud, Marit Vadset, Morten Bjørklund.

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 three locations as 2021 (Table 20). 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.

Location for soil and earthworms	Date	Soil depth	Site description
Alnabru/Alna	July 24	15	The samples were collected in the green corridor along the river Alna.
Svartdalsparken	July 24	18	Park area for recreation and playground. Samples taken in birch forest near park and river.
Steinbruvannet	July 24	34	Forest near freshwater lake, samples taken near track

Table 20: Sampling information for soil and earthworm sampling.

4.1.2 Fieldfare eggs

Two fieldfare eggs were collected on the 5 and 6th of May 2023 from each of three nest locations at Alna, Alnabru, and Svartdalsparken, 6 eggs in total, 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. When emptying, the whole content of the 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 6.2 to 8.3 grams.

Location fieldfare eggs	Date	Year	Content
Alnaparken	May 6	2023	Fetus
Alnaparken	May 6	2023	Fetus
Alna	May 6	2023	Fetus
Alna	May 6	2023	Embryo
Svartdalsparken	May 7	2023	Embryo
Svartdalsparken	May 7	2023	Embryo

Table 21: Locations and informatioon of fieldfare eggs

4.1.3 Brown rat

Ten rats were caught during April and May 2023 using clap-traps (avoiding rat poison), see Table below. For the one pooled liver sample, three female brown rats from two locations in Oslo (two rats from Haraldrudveien and one from Rosenlundgata) were selected, marked in bold font below. All three rats contained fetuses. 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 bodyweight of the three rats making the one pooled sample was from 309 to 437 g. The rat livers were sent frozen packed in aluminium foil in zip locked bags by express mail to NILU for analyses.

Location for rat samples	Date	Sex	Body weight (g)	Liver weight (g)	LabID	Notes
Rosenlundgata 6. 0474 Oslo	**19.05.2023**	**F**	**375.3**	**270.**	**001-2023**	5 fetus
Torggata 24. 0183 Oslo	27.04.2023	M	205.3	11.8	002-2023	
Haraldrudveien 7. 0582 Oslo	**24.04.2023**	**F**	**437.3**	**21.0**	**003-2023**	14 fetus
Haraldrudveien 7. 0582 Oslo	24.04.2023	M	431.9	11.5	004-2023	
Haraldrudveien 7. 0582 Oslo	**24.04.2023**	**F**	**308.9**	**13.9**	**005-2023**	8 fetus
Brobekkveien 87. 0582 Oslo	20.04.2023	M	382.3	18.4	006-2023	
Brobekkveien 87. 0582 Oslo	20.04.2023	M	402.4	19.3	007-2023	
Brobekkveien 87. 0582 Oslo	20.04.2023	M	461.7	19.2	008-2023	
Brobekkveien 87. 0582 Oslo	20.04.2023	M	477.5	19.5	009-2023	
Brobekkveien 87. 0582 Oslo	20.04.2023	M	542.4	18.7	010-2023	

Table 22: Information on the rat samples.

4.1.4 Roe deer

Liver samples were collected from five individual roe deer, see Table 23. Two roe deer were collected by wildlife managers after being killed by road traffic at Nesodden (Fjellstrand and Nesoddtangen). Another three roe deer were collected by wildlife managers in Bærum (Bærums verk, Stabekk, Hosle). One of them was killed after being attacked by a dog, and the other two were killed because of apparent disease or injury. All the roe deer were dissected by a wildlife manager. The entire liver was removed, wrapped in aluminium foil, and stored in zip-lock bags at -20°C before being shipped by express mail to NINA. The two deer from Nesodden weighted 23 (male) and 28 kg (female), while body mass could not be obtained for the three deer from Bærum (two males, one female).

Location for roe deer samples	Date	Info	weight (kg)
Fjellstrand, Nesodden	June 6 2023	killed by road traffic	28
Nesoddtangen	June 6 2023	killed by road traffic	23
Stabekk	August 29 2023	apparent disease or injury, put down on spot	
Hosle	September 4 2023	attacked by dog, put down on spot	
Bærums verk	August 20 2023	apparent disease or injury, put down on spot	

Table 23: Information on the roe deer samples.

4.1.5 Rowan

As in the 2021 sampling campaign, we collected and analysed leaves, included the stem, from rowan trees. The four rowan samples (more than 200 gram fresh weight per sample) were collected in mixed forests at four locations; Nesodden, Bærum, Ekeberg, and Alna, i.e., one sample per location.

At each location, rowan samples were collected from 2-4 rowan trees within a 100 m circumference. Sampling took place the 11th July 2023. Samples were put in aluminium foil and plastic zip-lock bags, stored at -20°C, and sent by standard mail to NILU on the 25th August 2023.

4.1.6 Honeybee

Three relevant honeybee farms were found in the three areas; Gartneriet at Bygdøy, Nedre Vaggestein in Maridalen, and Sørli Gård at Nøklevann. We collected the bees during two sampling days at each farm (15th or 16th June, 23rd August). All the collected bees were workers (drones were avoided), probably Krainer breed. We collected the bees using an insect sweeping net around different hives at the different honeybee farms. Individual bees were taken out of the net using polypropylene tubes. The tubes were then closed, and the bees were therefore never touch by the collector. The bees were directly transferred to a -20°C freezer to be euthanized and stored. Bees were emptied on aluminium foil and transferred to three 50 ml tubes, one tube containing all 55 bees from each farm, and sent to NILU for subsequent chemical analyses.

Collection of honeybees at the farm in Maridalen in August 2023. Photo: Anders Endrestøl, NINA.

4.1.7 Spanish slug

Four large Spanish slugs (at least 20 gram per sample) were collected at three locations; Ekeberg 3rd July 2023, Steinbruvannet and Svartdalsparken 10th August 2023. The slugs from Ekeberg were collected in a small park of deciduous forest and a pond in a residential area. Svartdalsparken is a deciduous forest park in the city centre, and the location at Steinbruvannet is a grass area between a residential area and a large forest. The samples were put in aluminium foil and plastic zip-lock bags and stored at -20°C, before being sent frozen to NILU by express mail.

4.2 GPS coordinates for sampling locations in 2023.

NILU ID	Sample	Location	Latitude	Longitude
23/2212	Soil	Steinbruvannet	59.974079	10.882380
	Soil	Alnabru (Alna)	59.920027	10.834630
	Soil	Svartdalsparken	59.904378	10.792510
23/2214	Earthworm	Steinbruvannet	59.974079	10.882380
	Earthworm	Alnabru (Alna)	59.920027	10.834630
	Earthworm	Svartdalsparken	59.904378	10.792510
23/2229	Spanish slug	Ekeberg	59.867000	10.801690
23/2230	Spanish slug	Steinbruvannet	59.974079	10.882376
23/2231	Spanish slug	Svartdalsparken	59.907348	10.808115
23/2215	Fieldfare egg	Alna	59.916376	10.832284
	Fieldfare egg	Svartdalsparken	59.907348	10.808115
	Fieldfare egg	Alnaparken	59.939133	10.873901
23/2216	Brown rat	Haraldrudveien 7	59.931240	10.826630
	Brown rat	Rosenlundgata 6	59.933590	10.762460
23/2217	Roe deer	Fjellstrand,Nesodden	59.794000	10.612350
23/2218	Roe deer	Nesoddtangen	59.850000	10.657120
23/2219	Roe deer	Stabekk	59.907000	10.594450
23/2220	Roe deer	Hosle	59.942000	10.578370
23/2221	Roe deer	Bærums Verk	59.947000	10.514430
23/2222	Rowan leaves	Nesodden	59.808000	10.702400
23/2223	Rowan leaves	Bærum	59.927000	10.619230
23/2224	Rowan leaves	Ekeberg	59.890000	10.777120
23/2225	Rowan leaves	Alna	59.947000	10.896840
23/2226	Honey bee	Gartneriet, Bygdøy	59.910040	10.686050
23/2227	Honey bee	Nedre Vaggastein, Maridalen	59.881530	10.861920
23/2228	Honey bee	Sørli gård, Nøklevann	60.023790	10.786140

All samples are given in ng/g ww, except for soil samples, which are given in ng/g dw.

4.3 Investigated environmental pollutants

In this study a total of 169 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 (soil, earthworm, fieldfare egg, and rat liver), phthalates (soil), and biocides (rat samples). In addition, the stable isotopes $\delta^{15}N$ and $\delta^{13}C$ were monitored. An overview of the analysed compounds is given in Table 24.

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.(PCB)		
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
BFR		
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

Compounds	Abbreviation	CAS
1,2,3,4,5 Pentabromobenzene	PBBZ	608-90-2
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
Organic phosphorous flame retardants (OPFR)		
Tri(2-chloroethyl)phosphate	TCEP	115-96-8

Compounds	Abbreviation	CAS
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
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
4-Nonylphenol (branched)	NOPHE4I	84852-15-3

Compounds	Abbreviation	CAS
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
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
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

4.4 PNEC values

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

Compound	$PNEC_{Soil}$	Unit in soil	Reference	Safety factor	Comment
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
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			
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

Compound	$PNEC_{Soil}$	Unit in soil	Reference	Safety factor	Comment
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
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

Compound	$PNEC_{Soil}$	Unit in soil	Reference	Safety factor	Comment
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 25: PNEC values for Soil ecosystem, with references. Most data adopted from Andersen et al 2012[6], 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.

[6] 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	$PNEC_{oral}$ 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	90	Developmental

Compound	$PNEC_{oral}$ mg/kg food	Reference	Safety factor	Comment
		doi:10.1016/j.jhazmat.2016.04.055		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
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	

Compound	$PNEC_{oral}$ mg/kg food	Reference	Safety factor	Comment
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
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

Compound	$PNEC_{oral}$ mg/kg food	Reference	Safety factor	Comment
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

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.

4.5 Biomagnificaiton

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 wet weight basis for both the concentrations of pollutants in soil and earthworm for comparison to previous years' BAF values in the MILBY program.

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

BMF was also calculated on a wet weight basis for fieldfare (FF), as the predator, and earthworm (EW), as the prey. The one sample of fieldfare egg was divided by the one earthworm sample for detected concentrations.

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, in general ,15-20 individuals. Samples of fieldfare eggs consisted of two eggs from the same nest in order to get sufficient material for all of the analyses. One pooled sample was used for the brown rat liver consisting of three individual liver samples of the same gender from the two locations. For honeybees, many individuals made up the pooled samples.

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.

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	

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 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	0.001-0.03	0.003-0.1	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 (autspec)	1	Y
	PCB 52	35693-99-3		0.002-0.07	0.004-0.2		1	Y
	PCB 101	37680-73-2		0.001-0.1	0.003-0.3		1	Y
	PCB 118	31508-00-6		0.001-0.1	0.003-0.4		1	Y
	PCB 138	35065-28-2		0.001-0.5	0.004-1.4		1	Y
	PCB 153	35065-27-1		0.002-0.7	0.006-2		1	Y
	PCB 180	35065-29-3		0.001-0.2	0.004-0.5		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	1.8-8.8	6-27	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		0.6-3	3-9		3	
	LCCPs	85535-86-0		0.7-3.4	10	In-house method. Internal standard addition, extraction, GPC and/or H2SO4 cleanup followed by adsporption 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	0.003-0.03	0.01-0.07	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		0.02-0.2	0.05-0.5		2	N
	β-TBECH	1232836-49-5		0.05-0.2	0.04-0.4		2	N
	g/d-TBECH			0.008-0.09	0.01-0.09		2	N
	BATE	99717-56-3		0.003-0.03	0.01-0.8		2	N
	PBT	87-83-2		0.006-0.06	0.01-0.2		2	N
	PBEB	85-22-3		0.003-0.03	0.008-0.09		2	N
	PBBZ	608-90- 2		0.05-0.5	0.2-2		2	y
	HBB	87-82-1		0.02-0.2	0.04-0.4		2	y
	DPTE	35109-60-5		0.004-0.03	0.01-0.07		2	N
	EHTBB	183658-27-7		0.04-0.06	0.1-0.2		2	y
	BTBPE	37853-59-1		0.008-0.06	0.03-0.2		2	y
	TBPH (BEH /TBP)	26040-51-7		0.06-0.1	0.2-0.4		2	N
	DBDPE	84852-53-9		2.6-28	7.76		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	0.1-0.2	0.07-0.4	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		0.003-0.3	0.007-0.07		2	y
	Dechlorane 603	13560-92-4		0.004-0.04	0.01-0.1		2	N
	Dechlorane 604	34571-16-9		0.07-0.7	0.2-1.6		2	N
	Dechlorane 601	13560-90-2		0.006-0.07	0.02-0.2		2	N
	Dechlorane plus syn	135821-03-3		0.02-0.2	0.04-0.4		2	Y
	Dechlorane plus anti	135821-74-8		0.01-0.1	0.03-0.3		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	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.		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 bu 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				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				2	N
	PFPrS	423-41-6				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
	PFOSA	754-91-6		0.05-0.15		2	Y
	N-MeFBSA	68298-12-4		0.05-0.15		2	N
	N-EtFBSA	40630-67-9		0.15-0.5		2	N
	PFBSA	30334-69-1		0.05-0.15		2	N
	MeFOSA	31506-32-8		0.05-0.15		2	N
	EtFOSA	4151-50-2		0.05-0.15		2	N
	MeFOSEA*	25268-77-3		0.50-1.0		3	N
	MeFOSE	24448-09-7		0.05-0.15		2	N
	EtFOSE	1691-99-2		0.05-0.15		2	N
	FOSAA	2806-24-8		0.05-0.15		2	N
	Me-FOSAA	2355-31-9		0.05-0.15		2	N
	Et-FOSAA	2991-50-6		0.05-0.15		2	N
	4:2 FTS	757124-72-4		0.10-0.50		2	N

Parameter group	Name of parameter	Cas nr	Blank	LOD range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
	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

*	PFTS	No single standard available for these compounds. Retention time and MS settings based on similar isomers and literature references
	MeFOSEA	
	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	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.		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				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				2	N
	PFPrS	423-41-6				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
	PFOSA	754-91-6		0.05-0.15		2	Y
	N-MeFBSA	68298-12-4		0.05-0.15		2	N
	N-EtFBSA	40630-67-9		0.15-0.5		2	N
	PFBSA	30334-69-1		0.05-0.15		2	N
	MeFOSA	31506-32-8		0.05-0.15		2	N
	EtFOSA	4151-50-2		0.05-0.15		2	N
	MeFOSEA*	25268-77-3		0.50-1.0		3	N
	MeFOSE	24448-09-7		0.05-0.15		2	N
	EtFOSE	1691-99-2		0.05-0.15		2	N
	FOSAA	2806-24-8		0.05-0.15		2	N
	Me-FOSAA	2355-31-9		0.05-0.15		2	N
	Et-FOSAA	2991-50-6		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

Parameter group	Name of parameter	Cas nr	Blank	LOD range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
	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

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

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. Samples was centrifuged and sample was 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				2	Y

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 homogenized and added deuterated internal standard and later extracted with acetone three times with vortexing and sonication for 10 min. Extract was evaporated and added acetic acid/water and vortex and later extracted three times with hexane using vortex and 10min sonication and centrifugation. Extract was 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		1-2		2	Y

Comment: 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
Musk, soil and biota	OTNE	54464-57-2	For biota: three blanks pr batch since we used the siloxane extract also for musk analysis. For soil, only one blank. LOD and LOQ calculated from 3 x stdev and 10 x stdev. from blanks		1-2 g of biota or soil was homogenized and added deuterated internal standard before extraction, up-concentration and clean up. ^{13}CPCB 159 added as recovery standard before analysis on GC/MSD.	3	N
	GALAXOLIDE	1222-05-5				3	N
	Tonalide	1506-02-1				2	Y
	Traseolide	68140-48-7				3	N
	Phantolide	15323-35-0				3	N
	Celestolide	13171-00-1				3	N
	Acetyl cedrene	32388-55-9				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 usually has the highest levels in blanks.	0.16-3.4	Internal Standard (IS) added. Samples then extracted twice, followed by clean-up via GPC and/or PSA. GC-MS/MS detection	2	
	Ethylhexylmethoxycinnamate (EHMZ-Z)	5466-77-3		0.2-0.7		2	
	Ethylhexylmethoxycinnamate (EHMZ-E)	5466-77-3		0.9-2.8		2	
	Octocrylene	6197-30-4		3.0-11		2	
	UV-327	3864-99-1		0.1-1.4		2	
	UV-328	25973-55-1		0.4-1.3		2	
	UV-329	3147-75-9		0.6-2.1		3	
	Homosalate	118-56-9		0.7-2.2		3	

Comment:

UV-329 Tests of the extraction and analysis recovery of UV-329 based on spiking experiments give results outside the range of 60-140%. The measured results of the analysis of complex samples (such as liver) could be overestimates consequently. An alternative and more appropriate internal standard will be considered to improve accuracy in future analyses.

Homostate There was no spiked sample with homosalate for the batch reported. However, there are spiked results for samples from the project “Urban fjord”, analysed in the same period with expectable recoveries.

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)	4-5	13-16.5	3	Y
	2,4-bisphenol A	837-08-1			1.2-4.3	4-14	3	N
	Bisphenol E	2081-08-5			0.9-1.9	3-6,3	3	N
	Bisphenol G	127-54-8			2.1-4.9	6.9-16	3	N
	Bisphenol AP	1571-75-1			0.9-2.3	3-7.6	3	N
	Bisphenol FL	3236-71-3			1.7-4.3	5.6-14	3	N
	Bisphenol B	77-40-7			1-12	3.3-40	3	Y
	2,4-bisphenol S	5397-34-2			0.2-0.8	0.7-2.6	3	Y
	4,4-bisphenol F	620-92-8			1.5-12	5-40	3	Y
	2,4-bisphenol F	2467-03-0			1.4-26	4.6-85	3	N
	TBBPA	79-94-7			4-8.6	13.2-28	3	Y
	Bisphenol M	13595-25-0			0.4-2.9	1.3-9,6	3	N
	Bisphenol Z	843-55-0			2.2-2.7	7,3-9	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)	2.4-3	8-10	3	Y
	4-octylphenol	1806-26-4			2.1-2.7	8-9	3	N
	4-nonylphenol	104-40-5			0.8-6	2.6-20	3	Y
	4-dodecylphenol	104-43-8			0.5-1	1.7-3.3	3	N
Other phenolic compounds	MB1	118-82-1		In-house method. Internal standard addition, extraction. LC/MS	2-5	7-17	3	N

*Wide range in detection limits caused by high detection limits for honey bee (very low sample amount) and rowan (matix interferences)

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	
	Bromodiolone	28772-56-7		1		2	
	Difenacoum	56073-07-5		1		2	
	Difethialone	104653-34-1		1		2	
	Flocumafen	90035-08-8		1		2	
	Permitrin (cis)	52645-53-1		3.0-10	IS added. Samples then extracted twice before clean-up via GPC and/or PSA. GC-MS/MS detection	3	
	Permitrin (trans)	52645-53-1		3.0-10		3	

Comment:

Permethrin - Tests of the extraction and analysis recovery of Permethrin based on spiking experiments give results in the range of 60-140%. The measured results of the analysis of complex samples could be overestimates as a consequence. An alternative and more appropriate internal standard will be considered to improve accuracy in future analyses.

Parameter group	Name of parameter	Cas nr	Blank	LOQ range ng/g	Method	Uncertainty category	Stable isotope labeled (SIL) analogue
Phthalates, soil	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 soil 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 honeybee, 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., 2022; Heimstad et al., 2023) where Zn was the dominating metal in all samples. In agreement with previous years, in soil and earthworm Pb, Cr and Cu concentrations had highest concentration when excluding Zn. In the other samples, Cu had the second highest concentration after Zn. None of the metals in soil exceeded the threshold value in Chapter 2, Appendix 1 of the Regulations Relating to Pollution Control for when soil legally is considered to be contaminated[7]. Cd concentration in earthworms, slug and deer liver exceeded the PNECoral value of 0.16 mg/kg food, but Pb was below the PNECoral value of 3.60 mg/kg food for predators of earthworms. The concentration of As in the pooled sample of brown rat liver exceeded PNECoral value for predators in food of 1 mg/kg ww[8], and As concentration in soil exceeded the PNCEsoil value of 2.9 mg/kg dw for soil living organisms.

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey Bee n=3
Cr	44.2	1.11	1.52 0.79-2.76	0.09	0.10	0.21 0.13-1.21	1.05 0.36-2.21	n.a.
Ni	26.7	0.79	0.88 0.71-1.92	0.07	0.02	0.02 0.02-0.38	0.59 0.46-1.73	n.a.
Cu	23.7	2.01	13.7 10.6-14.2	0.51	4.75	17.1 10.9-43.1	2.65 2.57-2.74	n.a.
Zn	105.0	79.8	78.9 71.1-118	10.5	29.5	39.2 27.5-103.5	9.17 6.11-22.33	n.a.
As	3.91	0.58	0.23 0.08-0.27	0.004	2.51	<0.001	0.02 0.02-0.05	n.a.
Ag	0.15	0.02	0.06 0.01-0.07	0.0001	0.003	0.01 0.002-0.21	0.001 0.001-0.004	n.a.
Cd	0.32	1.56	0.70 0.33-0.90	0.001	0.06	0.40 0.11-0.86	0.04 0.04-0.07	n.a.
Sn	0.30	0.015	0.013 0.008 - 0.042	0.084	0.011	0.002 <0.002 - 0.003	0.06 0.05-0.07	n.a.
Sb	0.03	0.011	0.005 0.003 - 0.014	0.000	0.007	0.0004 0.0001-0.0005	0.03 0.02- 0.04	n.a.
Gd	4.4	0.018	0.011 0.007 - 0.033	<0.00002	0.00071	<0.00002 <0.00002-0.0001	0.03 0.02-0.15	n.a.
Pb	31.8	2.67	0.13 0.08-0.50	0.009	0.09	0.02 0.01-0.07	0.19 0.12-0.33	n.a.
Hg	0.02	0.11	0.006 0.003 - 0.012	0.014	0.015	0.0006 0.0004- 0.02	0.01 0.005-0.01	n.a.

Table 28:Metal concentrations in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg, Brown rat (BR liver), Deer liver, Vegetation (Rowan) and Honey bee. Where the number of samples are higher than one, median concentrations and and min-max interval are given otherwise single concentrations are reported. Concentrations below LOD are given as < LOD/2 values. All

[7] https://lovdata.no/dokument/SF/forskrift/2004-06-01-931/KAPITTEL_1-2#KAPITTEL_1-2
[8] https://echa.europa.eu/brief-profile/-/briefprofile/100.028.316

concentrations, except in soil (mg/kg dw), are given in mg/kg ww. Concentrations exceeding PNEC or orther thresholds are shown in bold.

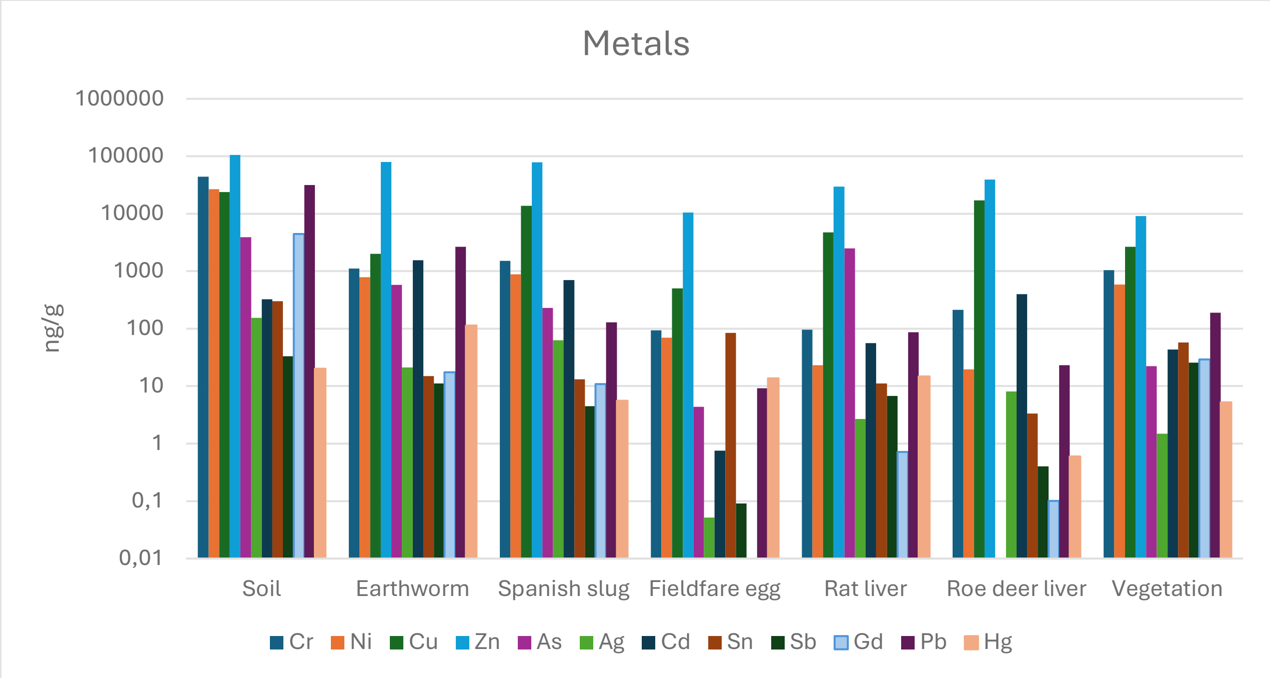


Figure 8: Concentrations (median; ng/g ww in biota and vegetation, ng/g dw in soil) of detected metals in matrices. Note: y-axis on a log scale.

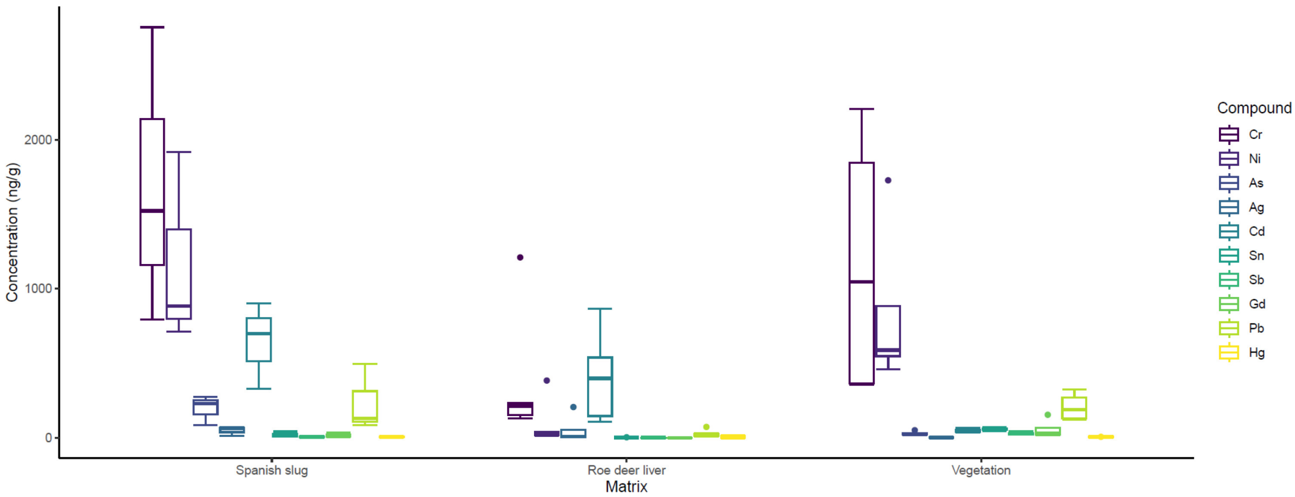


Figure 9:Box plot of metal concentrations (ng/g ww) in matrices with three or more samples.

5.2 PCB

PCB-153 was the dominating congener in most of the samples, see Table 29. As previous years 2021 and 2022, on a wet weight basis, the lowest PCB concentrations were detected in bees, deer liver and vegetation, and the highest concentrations were detected in fieldfare egg. None of the concentration were exceeding known threshold effect levels.

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey Bee n-=3
PCB-28	0.08	0.04	0.018 0.006 - 0.022	0.123	0.021	<0.006	0.007 0.004 - 0.077	<0.006
PCB-52	0.14	0.06	0.023 <0.004- 0.031	0.991	<0.008	<0.008	0.017 0.011 - 0.104	<0.080
PCB-101	0.69	0.27	0.034 <0.007 - 0.067	3.88	0.042	<0.014	0.034 0.020 - 0.180	<0.014
PCB-118	0.48	0.18	0.020 <0.004- 0.041	2.36	0.087	0.026 <0.008 - 0.051	0.028 0.013- 0.118	0.009 <0.009 - 0.024
PCB-138	1.45	0.59	0.0310 <0.008- 0.087	8.77	0.237	0.051 <0.016- 0.078	0.043 0.019 - 0.177	0.016 <0.016 - 0.042
PCB-153	1.56	0.84	0.042 <0.0120 - 0.112	15.2	0.327	0.117 0.0480 - 0.212	0.054 0.024 - 0.213	0.024 <0.024 - 0.082
PCB-180	1.05	0.23	0.016 <0.004 - 0.035	6.43	0.158	0.054 <0.008 - 0.090	0.023 0.011 - 0.071	0.008 <0.008 - 0.027

Table 29: PCB concentrations in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg,, Brown rat (BR liver), Deer liver, Rowan leaves, Honey bee. Where the number of samples equal three or higher, median concentrations and min-max interval are given otherwise single concentrations are reported. All concentrations are given in ng/g ww except for soil (ng/g dw). Concentrations below LOD are given as< LOD/2 values.

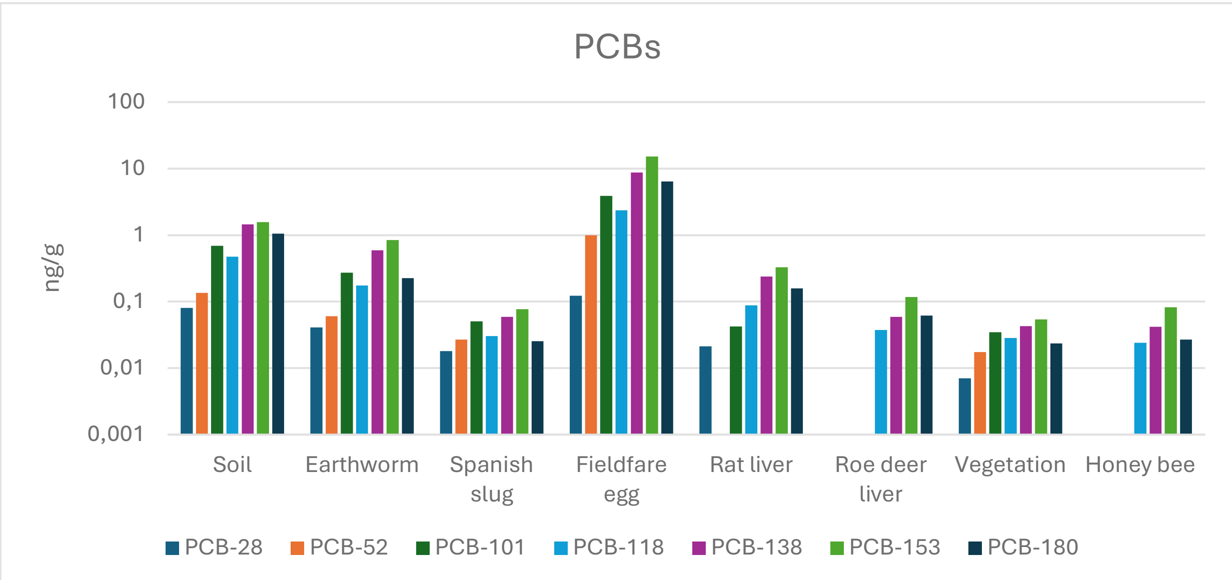


Figure 10: Concentrations (median; ng/g ww in biota and vegetation, ng/g dw in soil) of detected PCB compounds in all matrices. Note: y-axis on a log scale.

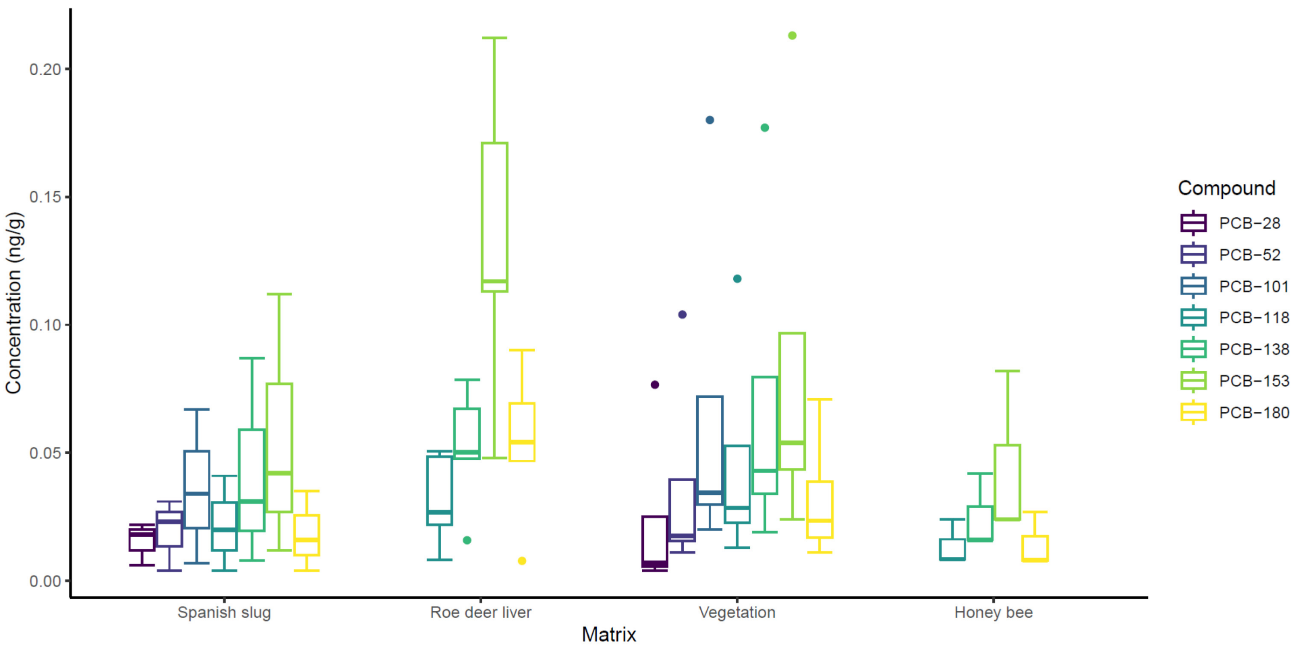


Figure 11: Box plot of PCB concentrations in matrices with three or more samples.

5.3 BFR

Many BFR compounds were not detected in the various samples. Highest number of BFR compounds were detected in the rowan leaves samples. DBDPE concentration was 10.5 ng/g ww in the one pooled brown rat liver sample. The compound PTBX had highest detection frequency (DF) across the samples, but in low levels, Table 30.

	EW n=1	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4
α-HBCD	0.0123	0.228	0.416	<0.005	0.014 <0.013 - 1.01
β-HBCD	<0.00272	0.007	<0.005	<0.004	0.004 <0.002 - 0.636
g-HBCD	<0.00495	<0.00495	<0.006	<0.005	0.026 <0.004 - 4.14
ATE	<0.0152	<0.0132	<0.015	<0.022	<0.005
α-TBECH	<0.147	<0.172	<0.185	<0.27	0.054 <0.044 - 0.136
β-TBECH	<0.0940	<0.109	<0.118	<0.17	0.037 <0.030- 0.822
g/d-TBECH	<0.032	<0.037	<0.039	<0.058	0.018 <0.015 - 0.048
BATE	<0.0229	<0.0229	<0.023	<0.023	<0.01
PBT	<0.0284	<0.0284	<0.028	<0.028	<0.012
PBEB	<0.0244	<0.0244	<0.024	<0.024	<0.011
PBBZ	<0.0319	<0.0319	<0.032	<0.032	<0.014
PTBX	<0.0318	0.064	0.099	0.032 <0.032 - 0.079	0.016 <0.013 - 0.055
HBB	<0.0407	<0.0407	<0.041	<0.041	0.020 <0.020 - 0.021
DPTE	<0.0192	<0.0192	<0.019	<0.019	0.001 <0.008 - 0.027
EHTBB	<0.0280	<0.0280	<0.047	<0.028	<0.013
BTBPE	<0.0454	<0.0454	<0.045	<0.045	<0.020
TBPH	<0.0760	<0.0760	<0.164	<0.081	<0.226
DBDPE	<0.920	<0.920	10.5	<0.920	<0.51

Table 30: BFR concentrations in Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Deer liver and Vegetation (Rowan). Samples with no detected concentrations are not shown. Where the number of samples equal three or higher, median concentrations and and min-max interval are given otherwise single concentrations are reported. All concentrations are given in ng/g ww. Concentrations below LOD are given as <LOD/2 values

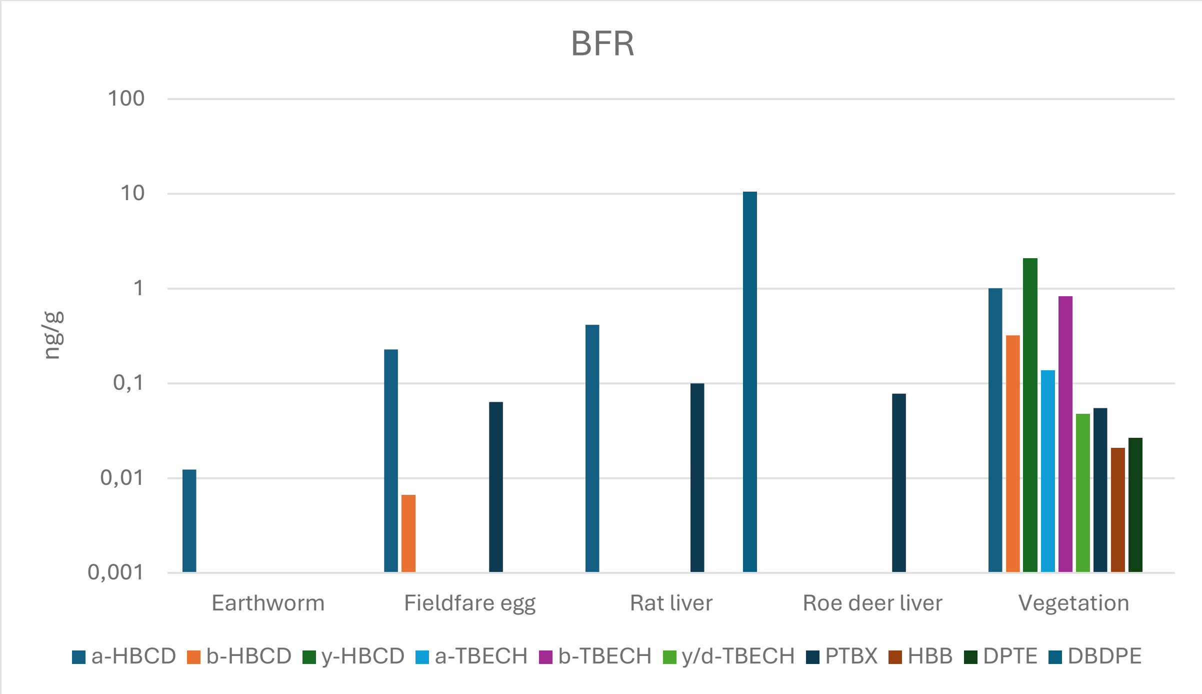


Figure 12: Concentrations (median; ng/g ww in biota and vegetation, ng/g dw in soil) of detected BFR compounds in matrices. Note: y-axis on a log scale.

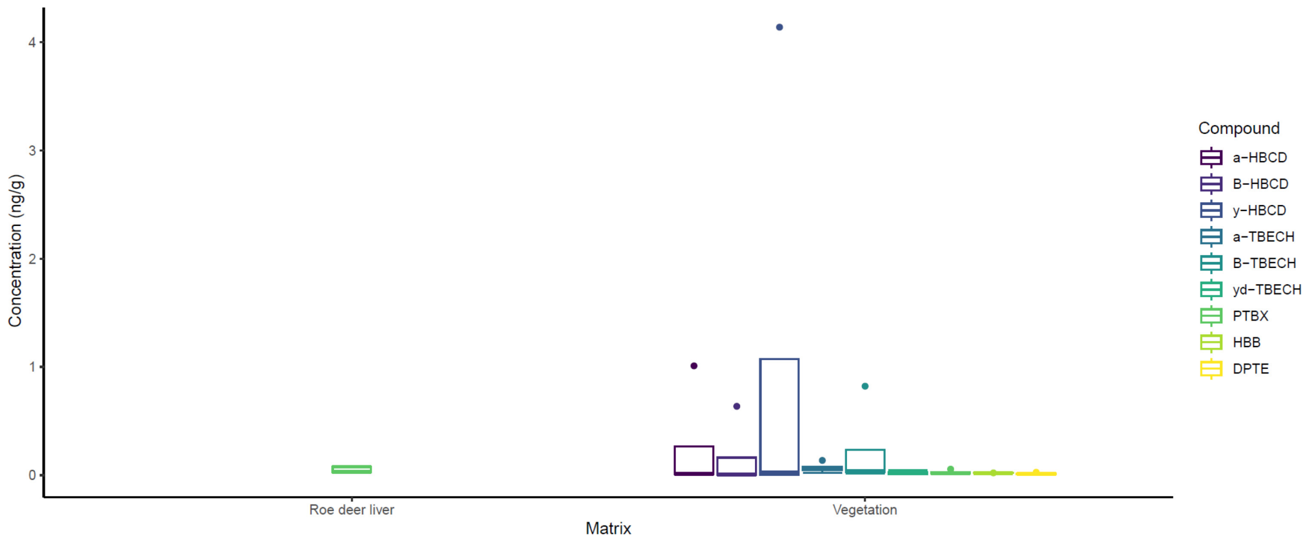


Figure 13: Box plot of BFR concentrations in matrices with three or more samples.

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 and 10:2 FTS. In this chapter and in the summary, SumPFAS is the sum of all sub-groups. sumPFOS is the sum of branched and linear PFOS.

PFAS compounds could be detected in all investigated matrices where PFOS was the dominating compound in soil, earthworm, fieldfare egg and rat liver. PFCA had highest concentrations in roe deer liver, rowan leaves, bees and Spanish slug due to relatively high concentration of the ultra-short chain carboxylate compound TFA (Table 31). This pattern was also observed in the year 2021 data when comparing the dominating PFAS compounds in the samples. Rowan leaf samples had TFA concentrations ranging from 37.9 to 84.9 ng/g dw in 2023. In 2021, TFA concentrations in rowan leaves ranged from 106 to 278 ng/g ww.

It is known that longer-chain PFASs degrade to trifluoro acetic acid (TFA) in the environment, for example via oxidation by OH radical 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 PFOS concentration detected in the one pooled fieldfare egg sample of 55.9 ng/g ww (linear PFOS of 52.8 ng/g ww) exceeded the PNECoral of 37 ng/g ww (see Appendix) and QSbiota of 33 ng/g ww for secondary poisoning of predators, set by the European Commission (Ankley et al., 2021). For comparison.

PFOA in fieldfare eggs, 1.72 ng/g, exceeded the low QSbiota of 0.9 ng/g for secondary poisoning of predators set by Valsecchi et al., 2017 (Ankley et al., 2021).

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey Bee n=3
TFA	<0.50	<0.4	8.39 4.91-9.38	<0.4	5.75	13.6 11.5-21.4	55.4 37.9-84.9	17.5 6.40-23.4
PFPrA	<1.2	<1	<1	<1	<1	<1	<1	<1
PFBA	<0.12	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFPA	<0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
PFHxA	<0.03	0.20	<0.03	<0.03	<0.03	0.03 <0.03 - 0.31	<0.03	0.03 <0.03 - 0.44
PFHpA	0.13	<0.03	<0.03	0.06	<0.03	<0.03	<0.03	0.03 <0.03 - 0.93
PFOA	0.18	0.90	<0.03	**1.72**	<0.03	0.07 <0.03 - 0.41	0.03 <0.03 - 0.37	0.03 <0.03 - 0.90
PFNA	<0.03	0.55	<0.03	2.97	0.36	0.09 0.06 - 1.15	0.03 0.03 - 0.94	0.03 <0.03 - 0.83
PFDA	0.09	0.33	<0.03	5.88	2.34	0.03 <0.03 - 0.21	0.03 <0.03 - 0.25	0.03 <0.03 - 0.92
PFUnDA	<0.03	<0.03	<0.03	6.83	1.91	<0.03	<0.03	0.03 <0.03 - 0.95
PFDoDA	<0.06	0.86	<0.05	29.0	6.83	<0.05	<0.05	0.05 <0.05 - 0.71
PFTrDA	<0.06	1.01	<0.05	18.0	13.1	<0.05	<0.05	0.05 <0.05 - 0.32
PFTeDA	<0.06	0.11	<0.05	3.05	0.87	<0.05	<0.05	<0.05
PFHxDA	<0.09	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PFOcDA	<0.09	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08

Table 31: PFCA concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Deer liver, Rowan leaves, Honey bee and Spanish slug (Slug). Where the number of samples equal three or higher, median concentrations and min-max interval are given otherwise single concentrations are reported. All concentrations are given in ng/g ww except for soil (ng/g dw). Concentrations below LOD are given as < LOD/2 values. Concentration exceeding PNEC or orther thresholds are shown in bold.

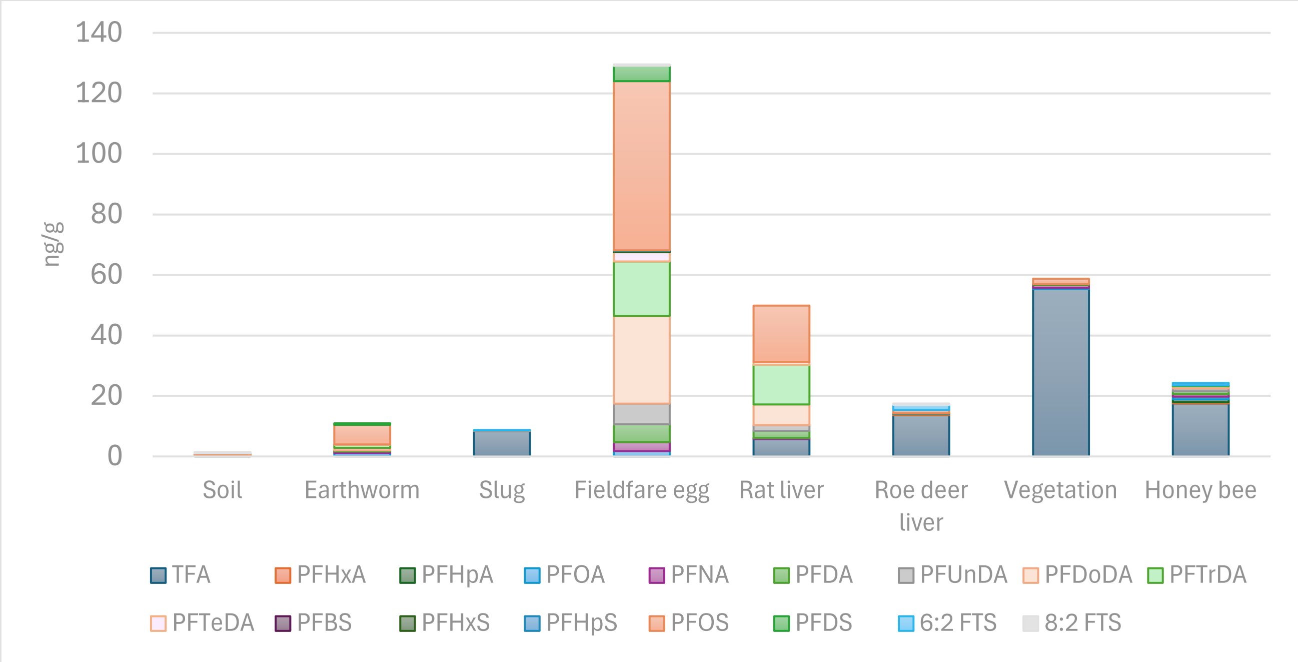
	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey Bee n=3
PFEtS	<1.2	<1	<1	<1	<1	<1	<1	<1
PFPrS	<1.2	<1	<1	<1	<1	<1	<1	<1
PFBS	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
PFPS	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
PFHxS	<0.01	<0.01	<0.01	0.42	<0.01	0.01 <0.01 - 0.04	0.01 <0.01 - 0.04	<0.01
PFHpS	<0.03	<0.03	<0.03	0.20	<0.02	<0.02	<0.02	<0.02
SumPFOS	0.62	6.48	0.18 0.17 -0.46	**55.9**	18.7	1.0 0.58 - 2.12	0.02 <0.02 - 1.81	<0.02
PFNS	<0.09	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
PFDS	<0.09	0.52	0.52	5.04	<0.08	<0.08	<0.08	<0.08
PFUnS	<0.18	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFDoS	<0.18	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFTrS	<0.18	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
PFTS	<0.18	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15

Table 32: PFSA concentrations in Soil, Earthworm (EW), Spanish slug (slug), Fieldfare (FF) egg, Brown rat (BR liver), Deer liver, Vegetation (Rowan), Honey bee. Where the number of samples equal three or higher, median concentrations and and min-max interval are given otherwise single concentrations are reported. All concentrations, except in soil (ng/g dw) are given in ng/g ww. Concentrations below LOD are given as <LOD/2 values. Concentration exceeding PNEC or orther thresholds are shown in bold.

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey Bee n=3
4:2 FTS	<0.12	<0.10	<0.10	<0.10	<0.100	<0.100	<0.100	<0.10
6:2 FTS	<0.09	<0.08	0.08 <0.08- 0.19	<0.08	<0.08	0.08 <0.08- 3.27	<0.08	0.25 <0.08- 1.33
8:2 FTS	0.43	<0.08	<0.08	0.484	<0.08	0.08 <0.08 - 0.46	<0.08	<0.08
10:2 FTS	<0.12	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
PFECHS	<0.18	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15

Table 33: newPFAS concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg, Brown rat (BR liver), Deer liver, Rowan leaves, Honey bee and Spanish slug (Slug). Where the number of samples equal three or higher, median concentrations and min-max interval are given otherwise single concentrations are reported. All concentrations are given in ng/g ww except for soil (ng/g dw). Concentrations below LOD are given as< LOD/2 values.

A.



B.

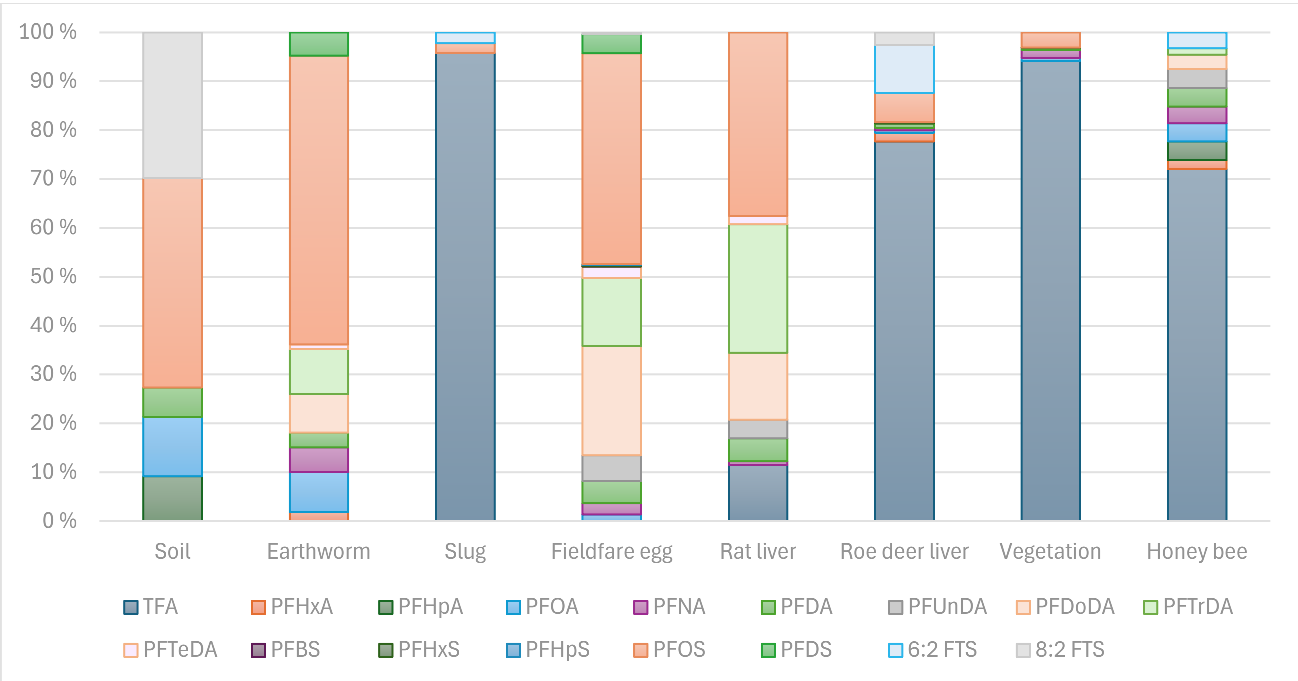


Figure 14: Concentrations (median; ng/g ww in biota and vegetation, ng/g dw in soil) of detected PFAS compounds in all matrices (A) and their contribution (%) to the sum concentration (B).

Neutral PFAS (n-PFAS) were not detected in any sample.

5.5 Chlorinated paraffins, CPs

SCCPs, MCCPs and LCCPs were detected in many samples, see Table 34. A high concentration of LCCPs of 192 ng/g ww was detected in the one sample of brown rat liver. This was the highest concentration on a lipid weight basis (6427 ng/g lw) when comparing

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 LCCPs concentrations were highest in peregrine falcon muscle samples of 1200 ng/g lw (Yuan et al., 2019). For 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 of LCCPs in German coastal, terrestrial and freshwater ecosystems revealed LCCPs concentration in the range of <MDl to 140 ng/g lw for deer liver samples collected in year 2018 (Yuan et al., 2022).

None of the samples in the Oslo area exceeded the PNECoral values of 5500 ng/g food for SCCP and 10 000 ng/g food (wet weight) for MCCPs and LCCPs. LCCPs in soil (9.6 ng/g dw) was far below the PNECsoil of 4.64 g/kg soil dw[9].

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey Bee n=3
SCCPs	<1.80	9.85	4.92 3.78 - 36.0	<4.40	<4.40	4.40 <4.40 - 11.8	7.25 3.98 - 9.80	<4.40
MCCPs	<0.75	11.1	11.1 9.68 - 19.5	18.3	11.7	3.22 <1.50 - 11.6	19.5 15.4 - 22.7	16.6 13.3 - 19.7
LCCPs	9.6	<1.70	<1.70	24.4	192	<1.70	3.45 <0.35 - 7.79	<1.70

Table 34: CP concentrations in Soil, Earthworm (EW), Fieldfare (FF) egg and liver, Brown rat (BR liver), Deer liver, Rowan leaves, Honey bee, Bumble bee (Bu-Bee), Spider and Spanish slug (Slug). Where the number of samples equal three, median concentrations and min-max interval are given otherwise single concentrations are reported. All concentrations are given in ng/g ww except for soil (ng/g dw). Concentrations below LOD are given as < LOD/2 values

The fractional contribution of each isomer/congener group was investigated and calculated of the detected total concentrations of SCCP, MCCP and LCCP respectively. Average concentrations were used for matrices with detected concentrations in more than one sample.

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

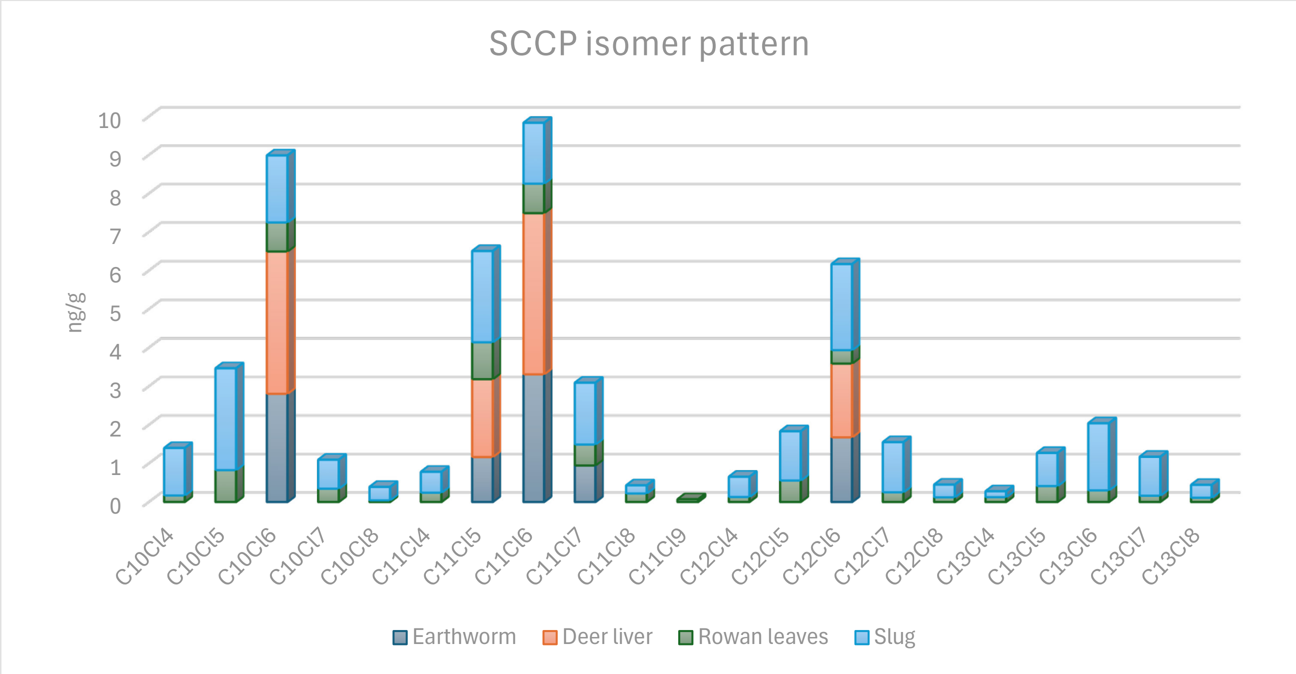


Figure 15: Pattern of SCCP isomers in samples with detected concentrations

For SCCP, the isomers C10Cl6, C11Cl5, C11Cl6 and C12Cl6 were common for the samples, and rowan and slug samples had a more varied isomer distribution. C10Cl6 and C11Cl6 was also observed as dominating isomer classes in 2021 and 2022 of MILBY data, and in agreement together with C10Cl5 and C11Cl5 from bank vole and lynx muscle samples in the Scandinavian study of Yuan et al., 2019.

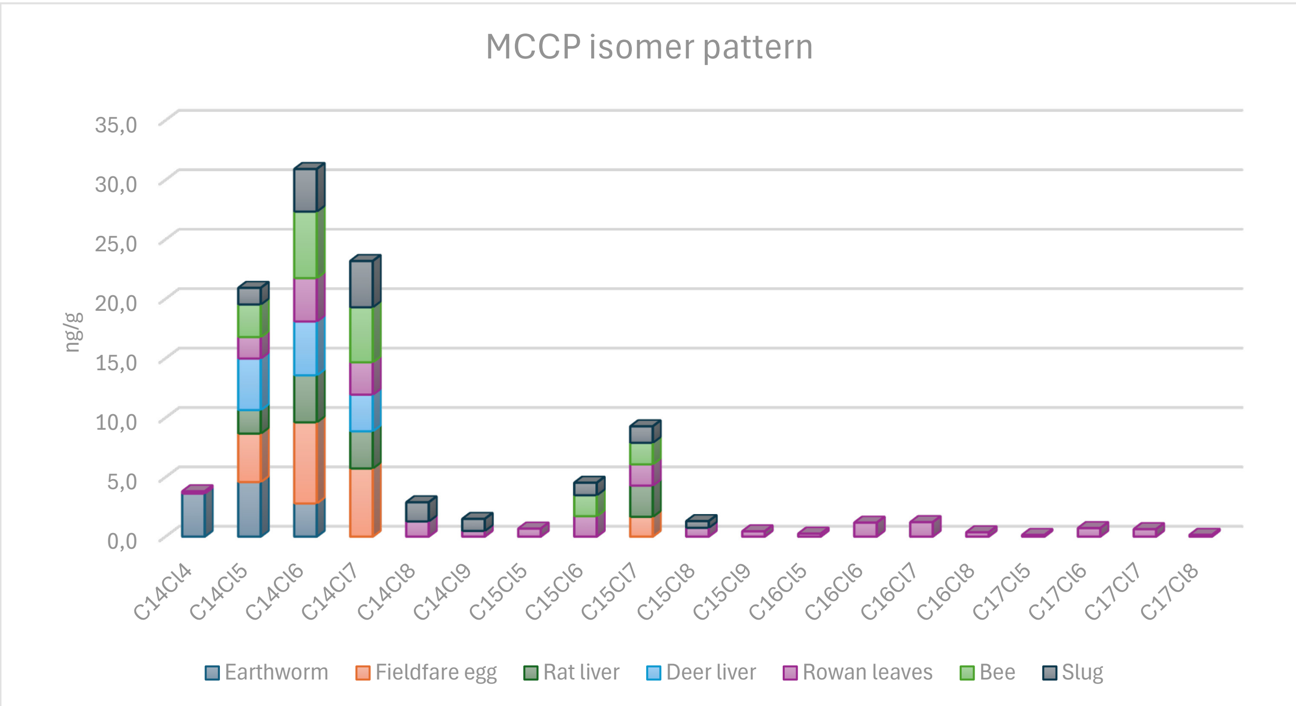


Figure 16: Pattern of MCCP isomers in samples with detected concentrations

For MCCP, the isomers C14Cl5, C14Cl6, C14Cl7 and partly C15Cl7 were dominating pattern in the samples. This is in agreement with MILBY 2021 and 2022 data. C14 isomer class were also dominating class of MCCPs in the Scandinavian study of Yuan et al., 2019. Rowan leaves were characterized by many isomer groups with low percentage contribution which is agreement with 2021 MILBY data when rowan leaves were sampled and analysed.

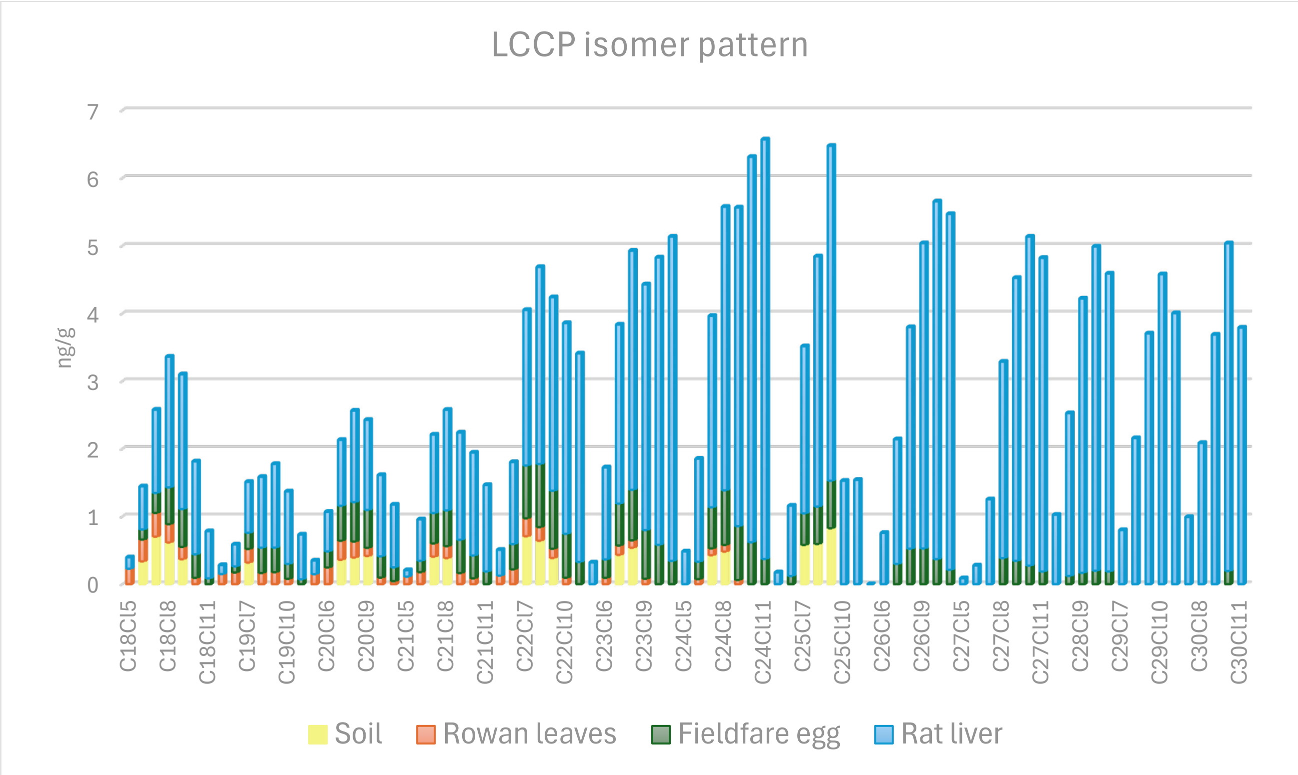


Figure 17: Pattern of LCCP isomers in samples with detected concentrations

LCCP pattern was characterised by many isomer groups among the samples, especially for rat and to some degree also fieldfare egg. For the rat samples, the longer chain LCCP (C22 to C30) dominated compared to shorter carbon length (C18 to C22). This is in agreement with the relative abundance distribution of LCCPs isomers in peregrine falcon muscle samples in the Scandinavian study of Yuan et al., 2019.

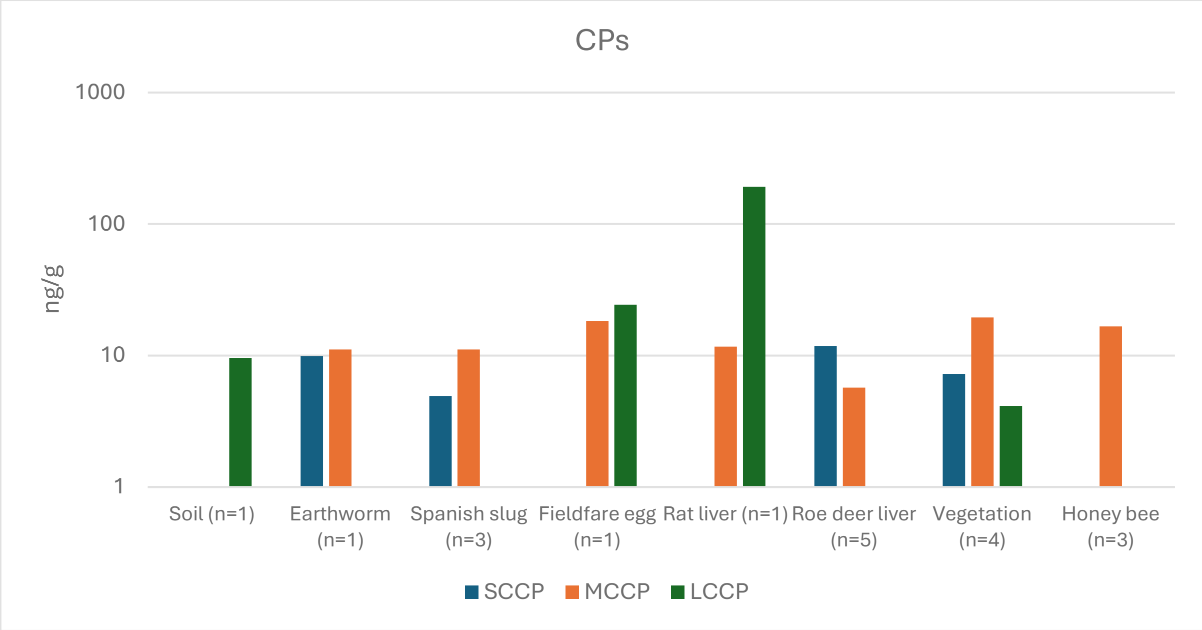


Figure 18: Concentrations (median; ng/g ww in biota and vegetation, ng/g dw in soil) of detected CP compounds in all matrices. Note: y-axis on a log scale.

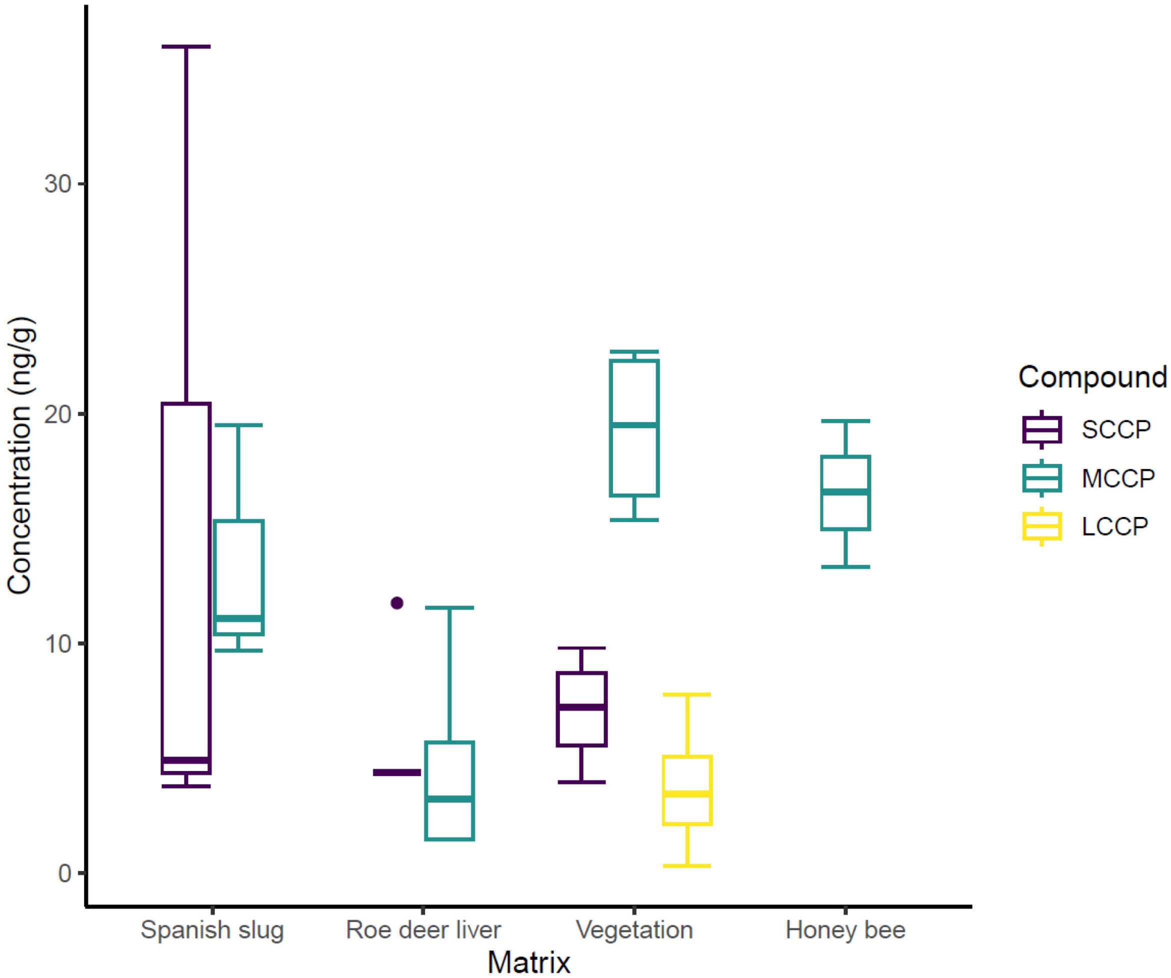


Figure 19: Box plot of SCCP, MCCP, LCCP in matrices with three or more samples.

5.6 Cyclic siloxanes (cVMS)

Of the cyclic siloxanes, D4 and D5 were detected earthworm, fieldfare egg and liver samples from brown rat and deer, see concentrations in Table 35. Highest concentrations on a wet weight basis were detected in brown rat liver where D5 was 104 ng/g ww (3478 ng/g lw). Linear siloxanes were not detected and M3T was only detected in brown rat liver. Levels above 100 ng/g ww of D5 have been detected in cod liver samples over the years in the Urban fjord program[10]. The highest D5 concentrations in cod liver from Urban fjord program were detected in four samples from 2016 and 2017 varying from 6349 to 7949 ng/g ww (adopted from https://vannmiljo.miljodirektoratet.no/).

The mean D5 concentration in the cod liver on a lipid weight basis (6677 ng/g ± 3985 standard deviation) was detected in the Urban fjord program in 2017 where the maximum concentration in herring gull eggs were 2340 ng/g lw (Ruus et al., 2018; Knudtzon et al., 2021).

The brown rat can be found wherever humans are living, particularly in urban areas. It is a true omnivore, feeding on everything, including human waste. How the rat has been exposed to D5 is not fully understood, but one likely source can be waste from insulation products (ex. polyurethane foam, PVC), possible other human waste such car polishing waxes and hair shampoos, including from the sewage water and air.

None of the biological samples exceeded the available PNEC values for secondary poisoning, available at the ECHA chemical information web site[11] (see also Appendix 1).

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey Bee n-=3
D4	<1.58	4.39	<1.58	<1.58	33.6	1.58 <1.58 - 4.73	<1.58	<1.58
D5	<1.30	4.39	<1.30	5.75	104	1.30 <1.30 - 4.10	<1.30	<1.30
D6	<1.86	<1.86	<1.86	<1.86	26.6	<1.86	<1.86	<1.86
L3	<0.066	<0.093	<0.341	<0.081	<0.107	<0.324	<0.107	<0.078
L4	<0.196	<0.317	<0.350	<0.378	<0.298	<0.489	<0.505	<0.362
L5	<1.24	<0.413	<0.564	<0.488	<16.0	<0.894	<0.428	<0.531
M3T (Ph)	<0.150	<0.184	<0.203	<0.210	1.31	<0.233	<0.194	<0.194

Table 35: Siloxane concentrations in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg, Brown rat (BR liver), Deer liver, Rowan leaves and Honey bee.Where the number of samples equal three or more, median concentrations and min-max interval are given otherwise single concentrations are reported. All concentrations are given in ng/g ww except for soil (ng/g dw). Concentrations below LOD are given as< LOD/2 values.

[10] Vannmiljø (miljodirektoratet.no)
[11] https://echa.europa.eu/da/search-for-chemicals

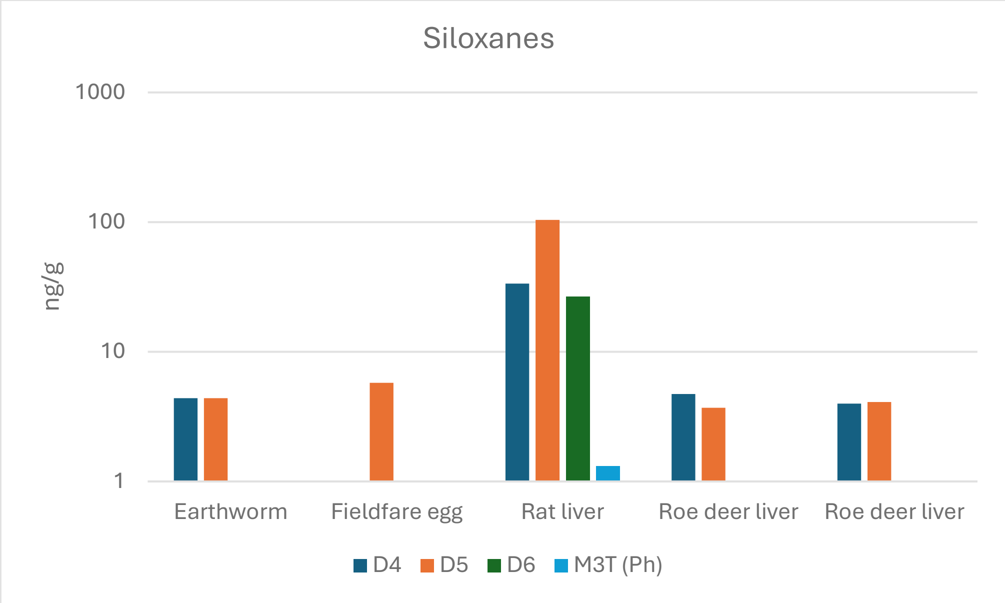


Figure 20: Concentrations (median; ng/g ww) of detected siloxane compounds in matrices. Note: y-axis on a log scale.

5.7 Organic phosphorous flame retardants, OPFR

TCPP was the dominating OPFR compound in the samples. None of the OPFR compounds were detected in the one fieldfare egg sample and the one brown rat liver sample. Highest TCPP concentrations were detected in rowan followed by slug and bees. None of the OPFR concentrations in soil exceeded known PNECsoil values or PNECoral in biota.

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey Bee n-=3
TCEP	<0.05	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35
TCPP	0.3	<1.05	4.86 2.92 - 13.4	<1.05	<1.05	<1.05	35.1 <1.05 - 39.6	3.38 2.51 - 4.59
TDCPP	<0.10	<0.25	<0.25	<0.25	<0.25	<0.250	<0.25	<0.25
TBEP	<0.10	<0.25	0.25 <0.25 - 4.38	<0.25	<0.25	<0.250	<0.25	<0.25
EHDP	<0.05	<0.25	0.67 <0.25 - 8.12	<0.25	<0.25	<0.250	<0.25	<0.25
TCP	0.2	<0.25	<0.25	<0.25	<0.25	<0.250	0.65 <0.25 - 1.42	<0.25
TBP	<0.05	2.15	<0.25	<0.25	<0.25	<0.250	1.24 <0.25 - 1.67	<0.25
TIBP	<0.10	1.56	<0.45	<0.45	<0.45	<0.45	2.35 1.56 - 2.77	<0.45
TEP	<0.50	<14.2	<14.2	<14.2	<14.2	<14.2	<14.2	<14.2
TPRP	<0.05	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
BdPhP	<0.05	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
TPP	<0.05	<0.25	<0.25	<0.25	<0.250	0.25 <0.25 - 1.80	4.46 1.88 - 12.5	<0.25
DBPhP	<0.05	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
TXP	<0.10	<0.25	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
TIPPP	<0.05	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
TTBPP	<0.10	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
TEHP	<0.05	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25

Table 36: OPFR concentrations in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg, Brown rat (BR liver), Deer liver, Rowan leaves and Honey bee.Where the number of samples equal three or more, median concentrations and min-max interval are given otherwise single concentrations are reported. All concentrations are given in ng/g ww except for soil (ng/g dw). Concentrations below LOD are given as< LOD/2 values.

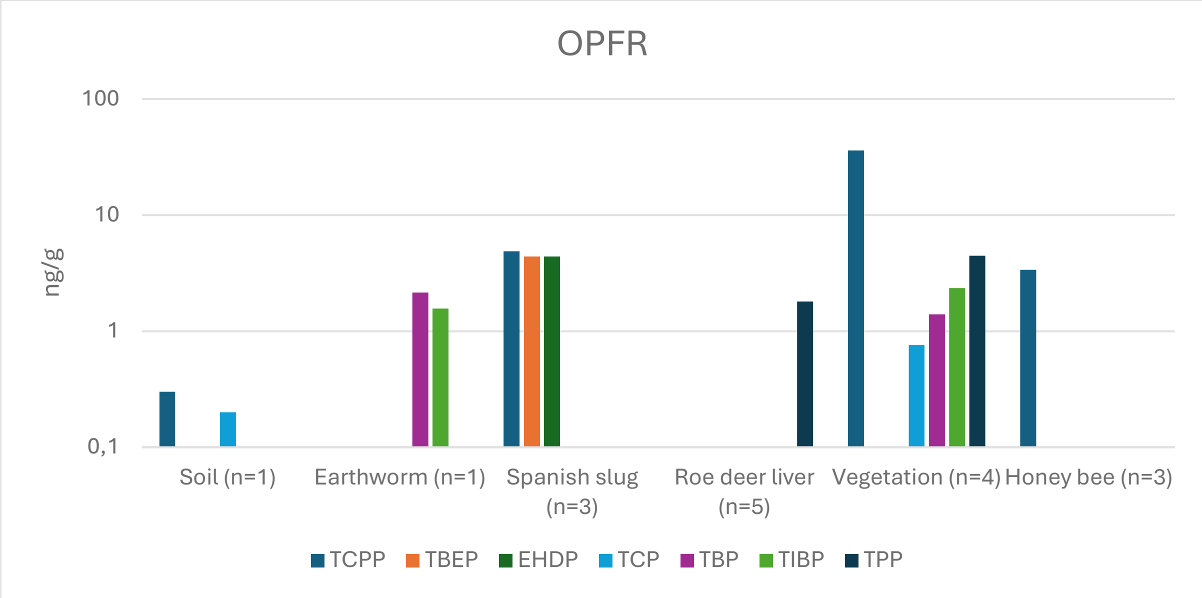


Figure 21: Concentrations (median; ng/g ww in biota and vegetation, ng/g dw in soil) of detected OPFR compounds in all matrices. Note: y-axis on a log scale.

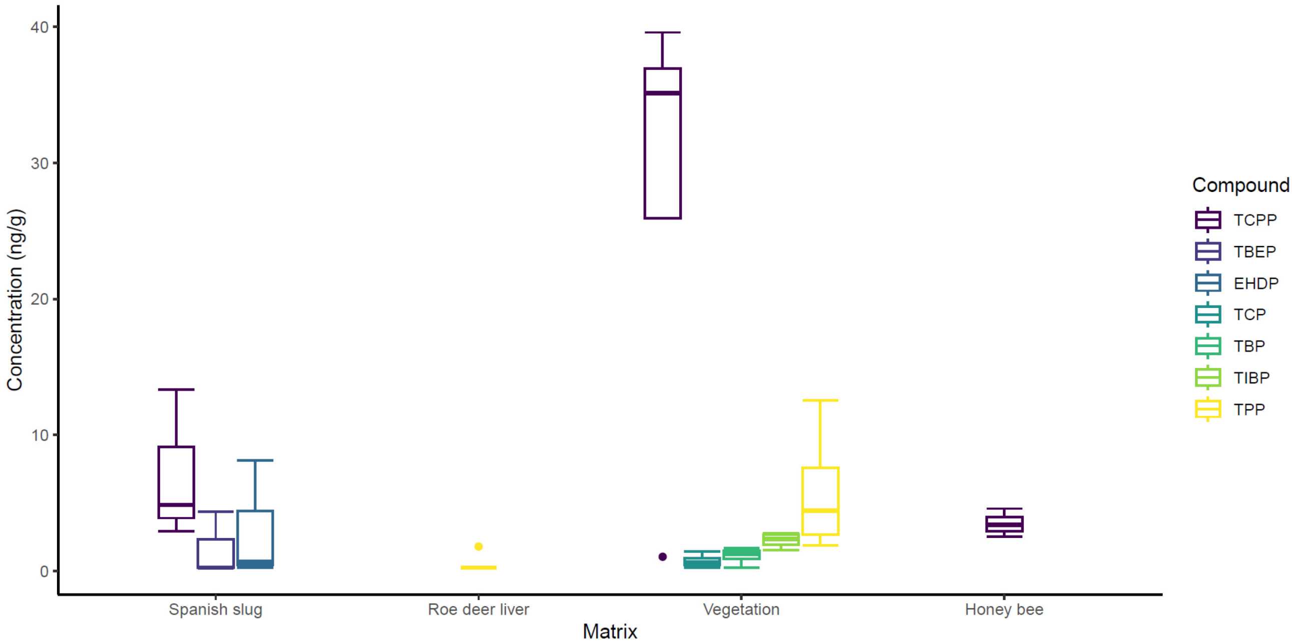


Figure 22: Box plot of OPFR compounds in matrices with three or more samples.

5.8 UV compounds

As in year 2021, UV compounds had highest detection frequencies in rowan leaves, and as in 2021 and 2022, homosalate and OC had the highest concentrations in rowan leaves. OC was detected in deer liver and honeybee in addition to rowan leaves. Many of the other UV stabilising compounds were not detected in the samples, but UV-328 was detected in soil, fieldfare egg, brown rat liver and rowan leaves.

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey Bee n-=3
OC	3.3	<0.75	<7.50	<0.65	<3.40	2.90 <1.05 - 8.10	11.8 8.40 - 35.0	3.80 <1.80 - 6.20
BP3	<0.20	<0.20	<0.18	<0.05	<0.25	<0.15	<0.562	<0.15
EHMC	<0.15	<0.10	<0.15	<0.10	<0.15	<0.15	1.05 0.70 - 1.10	<0.10
UV-327	<0.05	<0.05	<0.08	0.1	<0.15	<0.05	0.15 0.10 - 0.30	<0.05
UV-328	0.7	<0.10	<0.30	0.2	8.9	<0.05	0.55 0.20- 1.10	<0.05
UV-329	<0.55	<0.20	<0.42	<0.15	<0.65	<0.35	<0.925	<0.150
Homosalate	<0.90	<0.75	<1.45	<0.55	<0.85	<0.78	48.0 9.00 - 66.0	<1.22

Table 37: UV compound concentrations in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg, Brown rat (BR liver), Deer liver, Rowan leaves and Honey bee.Where the number of samples equal three or more, median concentrations and min-max interval are given otherwise single concentrations are reported. All concentrations are given in ng/g ww except for soil (ng/g dw). Concentrations below LOD are given as< LOD/2 values.

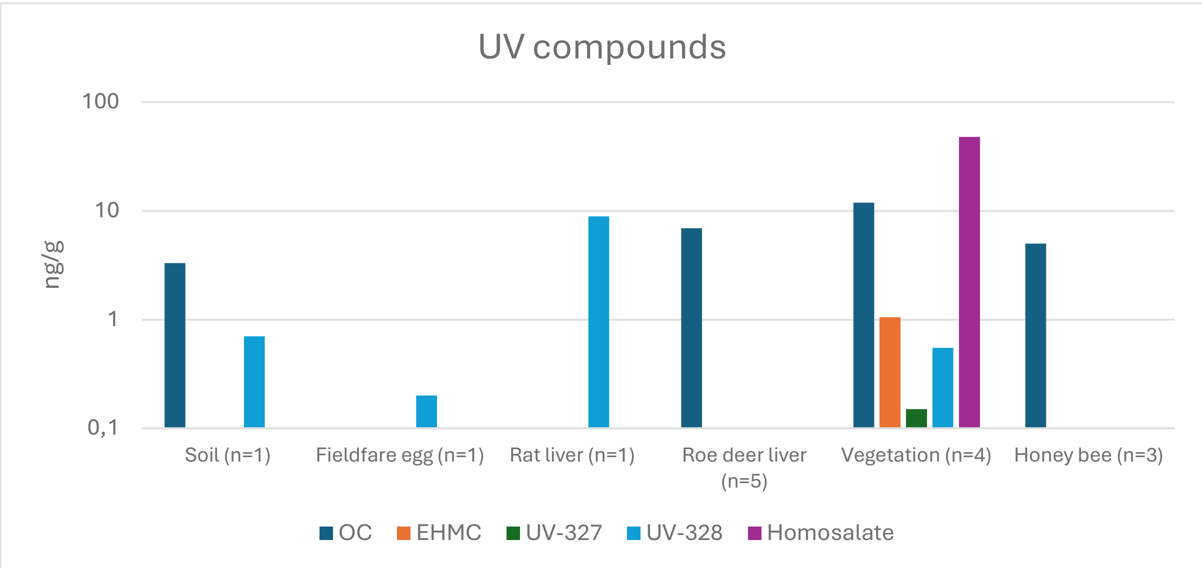


Figure 23: Concentrations (median; ng/g ww in biota and vegetation, ng/g dw in soil) of detected UV compounds in all matrices. Note: y-axis on a log scale.

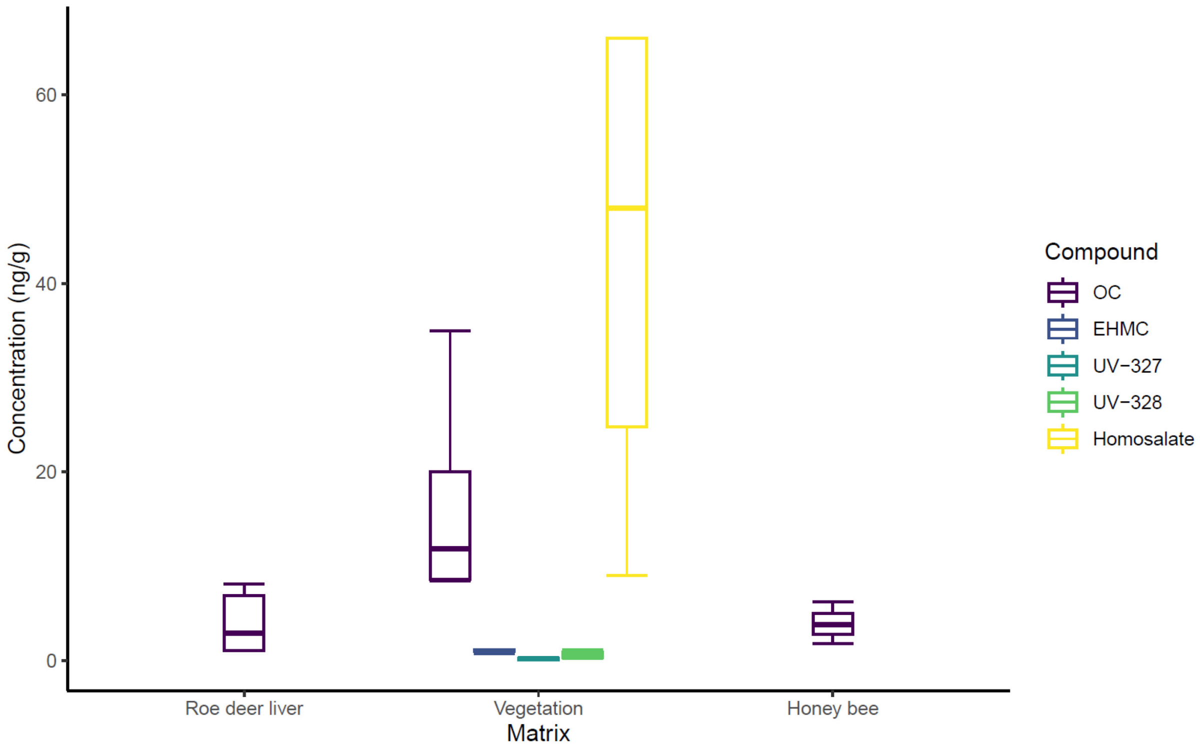


Figure 24: Box plot of UV compound concentrations in matrices with three or more samples.

5.9 Dibromoaldrin and dechloranes

Dibromoaldrin (DBA) and dechloranes were detected in few samples. Anti-DP were detected in four samples and had highest concentration (wet weight basis) in the one sample of brown rat liver, see Table 38. Highest amount of dechlorane compounds were detected in the fieldfare egg where dec-602, dec-603 and anti-DP were detected.

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey Bee n=3
DBALD	<0.31	<0.10	<0.05	<0.10	<0.10	<0.11	<0.02	<0.10
Dec-601	<0.05	<0.02	<0.009	<0.02	<0.04	<0.04	<0.003	<0.02
Dec-602	<0.04	<0.01	<0.006	0.10	<0.01	<0.02	<0.002	<0.01
Dec-603	<0.04	<0.01	<0.006	0.16	<0.02	<0.02	<0.003	<0.01
Dec-604	<0.55	<0.35	<0.141	<0.34	<0.5	<0.57	<0.08	<0.37
syn-DP	<0.07	<0.04	0.01 <0.01 - 0.09	0.21	0.29	<0.06	0.009 <0.006 - 0.024)	<0.03
anti-DP	0.70	<0.04	0.02 <0.02 - 0.10	0.23	0.31	<0.07	<0.011	<0.05

Table 38: Dibromoaldrine and dechlorane concentrations in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg, Brown rat (BR liver), Deer liver, Rowan leaves and Honey bee.Where the number of samples equal three or more, median concentrations and min-max interval are given otherwise single concentrations are reported. All concentrations are given in ng/g ww except for soil (ng/g dw). Concentrations below LOD are given as< LOD/2 values.

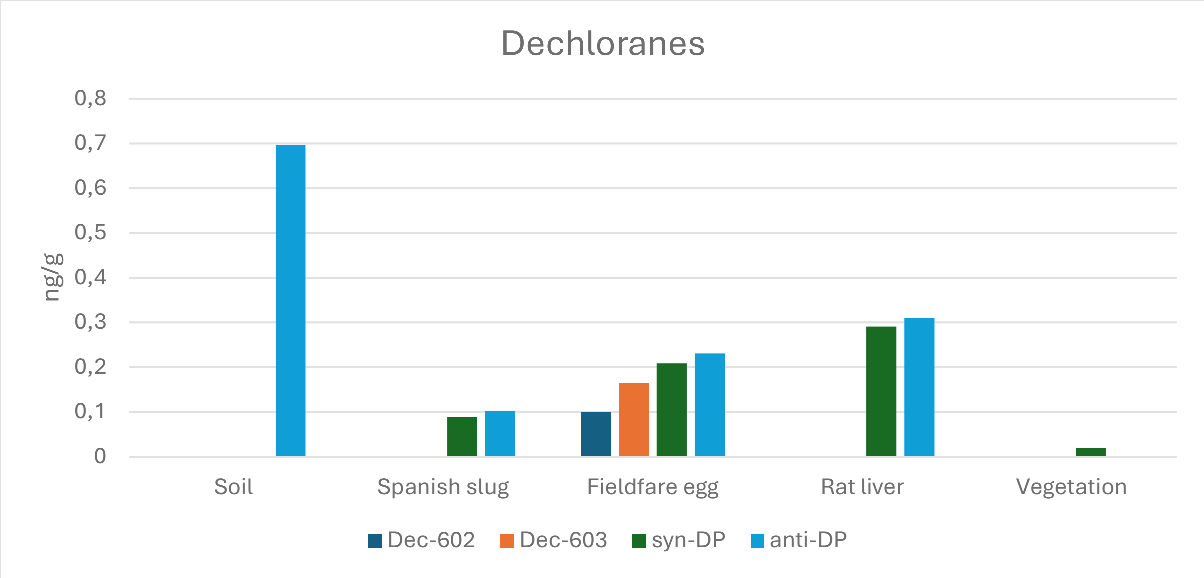


Figure 25: Concentrations (median; ng/g ww in biota and vegetation, ng/g dw in soil) of detected dechlorane compounds in matrices.

5.10 Phenols

Of the phenol compounds, many were not detected. 4,4' Bisphenol A (BPA) was only detected in earthworm. 4,4' Bisphenol F (BPF) and 2,4' Bisphenol F (BP24) only detected in Spanish slug. None of the others bisphenols or phenols were detected above LOD.

	Soil n=1	EW n=1	Slug n=3	FF egg n=1	BR liver n=1	Deer liver n=5	Rowan n=4	Honey Bee n-=3
TBBPA	<2.38	<2.38	<2.38	<2.38	<2.90	<2.64	<2.12	<2.38
BPA	<2.54	11.4	<2.54	<2.54	<2.54	<2.38	<2.27	<2.54
BPA24	<0.620	<2.12	<1.19	<0.74	<2.00	<1.14	<0.971	<0.89
BPS24	<0.113	<0.297	<0.212	<0.11	<0.33	<0.300	<0.115	<0.11
BPF	<4.82	<0.890	3.05 <3.05 - 7.92	<0.73	<2.44	<1.23	<2.58	<1.42
BPF24	<8.85	<1.70	30.2 <1.70 -42.2	<1.70	<3.88	<2.06	<4.86	<2.34
BPG	<1.34	<2.70	<1.60	<1.69	<1.88	<1.27	<1.20	<2.00
BPFL	<0.915	<1.66	<1.00	<1.04	<3.06	<1.73	<1.33	<1.26
BPAP	<0.486	<1.10	<0.647	<0.685	<1.62	<0.917	<0.889	<0.79
BPZ	<1.37	<1.37	<1.37	<1.37	<1.37	<1.28	<1.22	<1.37
BPE	<0.460	<0.750	<0.467	<0.47	<1.35	<0.767	<0.558	<0.58
BPB	<0.505	<1.42	<0.880	<0.52	<1.20	<0.814	<0.690	<3.66
BPM	<0.244	<0.332	<0.259	<0.24	<0.82	<0.344	<0.556	<0.24
MB1	<1.22	<1.22	<1.22	<1.22	<1.16	<1.47	<1.35	<1.22
DDPHE4	<0.276	<2.26	<0.388	<0.65	<0.67	<0.386	<0.316	<0.42
NOPHE4	<0.530	<3.06	<0.597	<0.88	<0.81	<0.571	<0.487	<0.68s
OCPHE4N	<1.28	<1.28	<1.28	<1.28	<1.34	<1.21	<1.15	<1.28
OCPHEpt	<1.50	<1.50	<1.50	<1.50	<1.54	<1.40	<1.34	<1.50

Table 39: Concentrations of phenols in Soil, Earthworm (EW), Spanish slug (Slug), Fieldfare (FF) egg, Brown rat (BR liver), Deer liver, Rowan leaves and Honey bee.Where the number of samples equal three or more, median concentrations and min-max interval are given otherwise single concentrations are reported. All concentrations are given in ng/g ww except for soil (ng/g dw). Concentrations below LOD are given as < LOD/2 values.

5.11 Musk compounds

Analysis of musk compounds was done for samples of soil, earthworm, fieldfare egg and brown rat liver. Many musk compounds were not detected. Tonalide (TONA) was detected in earthworm and brown rat liver, and Traseolide (TRAS) was only detected in soil; all at relatively low concentrations.

	Soil n=1	EW n=1	FF egg n=1	BR liver n=1
OTNE (Iso-E-super)	<0.577	<0.577	<0.577	<0.577
HHCB (Galaxolide)	<0.292	<0.292	<0.292	<0.292
TONA (Tonalide)	<0.0430	0.167	<0.0430	0.086
TRAS (Traesolide)	0.066	<0.0315	<0.0315	<0.0315
PANT (Phantolide)	<0.0450	<0.0450	<0.0450	<0.0450
KELE (Celestolide)	<0.0385	<0.0385	<0.0385	<0.0385
MCKETON (Acetyl cedrene)	<0.198	<0.198	<0.198	<0.198

Table 40: Concentrations of musk compounds in Soil, Earthworm (EW), Fieldfare (FF) egg and Brown rat (BR liver). All concentrations are given in ng/g ww except for soil (ng/g dw). Concentrations below LOD are given as< LOD/2 values.

5.12 Biocides (rodenticides) in brown rat liver

Biocides (rodenticides) were analysed in the one pooled rat liver sample. Six biocides (bromadiolone, brodifacoum, flocumafen, difenacoum, difethialone and permethrin) were selected for analyses in these samples.

BRDIFA dominated in the rat sample with 16.7 ng/g ww followed by BRDIOL and DIFEN. The other biocides were below LOD. The Oral LD50 for BRDIA is about 0.4 mg/kg bw to male rat and mice.[12]

	Brown rat n=1
Bromadiolone (BRDIOL)	4.95
Brodifacoum (BRDIFA)	16.7
Flocumafen (FLOCO)	<0.50
Difenacoum (DIFEN)	4.60
Difethialone (DIFET)	<0.50
Permethrin (PERM)	<0.67

Table 41:Mean (median) concentrations with min-max interval below of biocides in red fox liver and brown rat liver. All concentrations are given in ng/g ww.

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

5.13 Phthalates in soil

Phthalates were only analysed in the one pooled soil samples across three locations. DiNP and DEHP were the dominating compound with a measured concentration of 49.1 and 40.6 ng/g dw followed by DnBP (13.9 ng/g dw).

The concentration of DEHP is 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).

	Soil ng/g dw
DEHP Di(2-ethylhexyl)phthalate	40.6
SDPHP_DIDP Sum (DPHP+ Diisodecyl phthalate (DIDP))	<6.50
DiNP Diisononyl phthalate	49.1
DiBP Diisobutyl phthalate	<1.10
DnBP Dibutyl phthalate	6.24
DEP Diethyl phthalate	<1.50
BBP Butyl benzyl phthalate	2.09
DCHP Dicyclohexyl phthalate	0.77
DNHP Dihexyl phthalate	<0.50
DNOP Di-n-octyl phthalate	<2.20
DNNP Dinonyl phthalate	<6.50
DDPT 1,2-Benzenedicarboxylic acid, 1,2-diundecyl ester, branched and linear	<6.50

Table 42:Concentrations of phthalate compounds in the one pooled soil sample

<LOD values are shown as <LOD/2.

5.14 Domination pollutant groups in the species

Dominating pollutant groups with respect to average detection frequencies in each pollutant group were assessed:

Compound group	Soil	Earthworm	Spanish slug	Fieldfare egg	Rat liver	Roe deer liver	Rowan leaves	Honey bee
Metals	100	100	100	92	100	80	100	n.a.
PCB	100	100	72	100	86	49	100	19
PFCA	20	47	7	53	47	21	12	24
PFSA	9	18	9	45	9	11	5	0
new PFAS	20	0	6.6	20	0	12	0	13.4
neutral PFAS	0	0	0	0	0	0	0	0
CP	33	67	67	67	67	27	92	33
Dechloranes	14	0	9	57	29	0	7	0
OPFR	12	12	12	0	0	1	25	6
UV compounds	29	0	0	29	14	9	71	10
Siloxanes	0	29	0	14	57	11	0	0
other BFR	0	6	0	17	17	2	15	0
Phenols	0	6	7	0	0	0	0	0
Musk compounds	14	14	n.a.	0	14	n.a.	n.a.	n.a.
Biocides	n.a.	n.a.	n.a.	n.a.	50	n.a.	n.a.	n.a.
Phthalates	42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Table 43: Average detection frequency of pollutant groups in each sample type

The most dominating groups with respect to average detection frequency in each sample type:

Soil	Metals=PCB> Phthalates> CP> UV> PFCA=newPFAS
Earthworm	Metals=PCB>CP> PFCA>Siloxanes
Spanish slug	Metals> PCB>CP> OPFR>PFSA
Fieldfare egg	PCB> metals>CP>Dechloranes>PFCA>PFSA
Rat liver	Metals>PCB>CP>Siloxanes>Biocides
Roe deer liver	Metals>PCB> CP> PFCA> newPFAS
Rowan leaves	Metals=PCB>CP>UV comp>OPFR
Honey bee	CP>PFCA> PCB>new PFAS>UV comp

Dominating pollutant groups within each sample type were evaluated. Concentrations below LOD were not included in the sum concentrations. For matrices with three or more samples, the average sum value was used. The dominating sum concentrations were in large extent in agreement with previous results from 2021 when we had the same kind of samples.

	Soil	Earthworm	Spanish slug	Fieldfare egg	Rat liver	Roe deer liver	Vegetation	Honey bee
Metals	240582	88649	106060	11255	37014	73174	16787	n.a.
CP	9.6	21	28	43	203	10.8	30	16
PCB	5.4	2.2	0.2	38	0.87	0.26	0.36	0.18
PFCA	0.4	4	7.6	68	31	15.4	59	18
PFSA	0.6	7	0.3	62	19	1.1	1.9	<lod
new PFAS	0.4	<lod	0.19	0.48	<lod	1.9	<lod	0.8
UV	4	<lod	<lod	0.3	8.9	6	61	5
Phenols	<lod	11	28	<lod	<lod	<lod	<lod	<lod
Siloxanes	<lod	8.8	<lod	5.8	165	8.3	<lod	<lod
BFR	<lod	0.01	<lod	0.3	11	0.1	2.3	<lod
Dechlor	0.7	<lod	0.2	0.7	0.6	<lod	0.02	<lod
OPFR	0.5	3.7	11	<lod	<lod	1.8	37	3.5
BFR	<lod	0.01	<lod	0.3	11	0.1	2.3	<lod
Musk	0.1	0.2	n.a.	<lod	0.1	n.a.	n.a.	n.a.
Phthalates	99	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Biocides	n.a.	n.a.	n.a.	n.a.	26.3	n.a.	n.a.	n.a.

Table 44:Sum concentrations of all compound groups, ng/g ww for all sampeles except ng/dw for soil.

Metals were significantly higher than all other pollutant groups in all samples analysed for metals.

On a wet weight basis for biota and rowan, and dry weight for soil:

Matrix	Ordered groups based on the Sum of group concentrations
Soil*	Metals > Phthalates > CPs > PCBs > UV > Dechloranes > PFSAs > OPFRs > new PFAS > PFCAs > Musk compounds
Earthworm	Metals > CPs > Phenols > Siloxanes > PFSAs > PFCAs > OPFRs > PCBs > Musk compounds > other BFRs
Spanish slug	Metals > CPs > Phenols > OPFRs > PFCAs > PFSAs > PCBs > new PFAS > Dechloranes
Fieldfare egg	Metals > PFCAs > PFSAs > CPs > PCBs > Siloxanes > Dechloranes > new PFAS > UV > other BFRs
Rat liver	Metals > CPs > Siloxanes > PFCAs > Biocides > PFSAs > other BFRs > UV > PCBs > Dechloranes > Musk compounds
Roe deer liver	Metals > PFCAs > CPs > Siloxanes > UV > new PFAS > OPFRs > PFSAs > PCBs > other BFRs
Rowan leaves	Metals > UV > PFCAs > OPFRs > CPs > other BFRs > PFSAs > PCBs > Dechloranes
Honey bee	PFCAs > CPs > UV > OPFRs > new PFAS > PCBs

*Phthalates only analysed in soil, musk only in soil, earthworm, fieldfare egg and brown rat liver

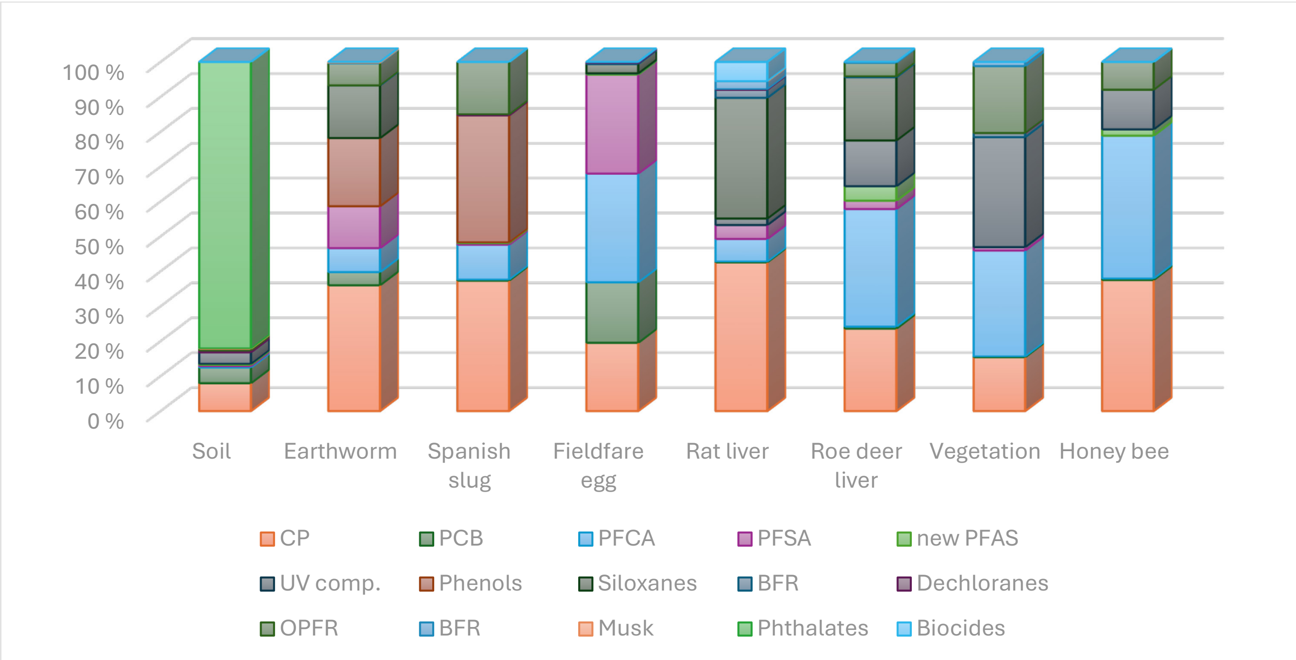


Figure 26: Percentage distribution of sum concentrations of organic compond classes in matrices: Soil, earthworm, Spanish slug, fieldfare egg, brown rat liver, roe deer liver, vegetation (Rowan) and honey bee. Biota and rowan in ng/g ww, soil in ng/g dw. Phthaltes were only analysed in the soil sample, and biocides only in the rat liver sample.

	Soil	Earthworm	Spanish slug	Fieldfare egg	Rat liver	Roe deer liver	Vegetation	Honey bee
CP	9.6	21	28.3	42.7	203	10.8	30	16.5
PCB	5.4	2.2	0.2	37.8	0.87	0.26	0.36	0.18
PFCA	0.4	4	7.6	68	31	15.4	59	18
PFSA	0.5	7	0.3	62	19	1.1	1.9	<lod
new PFAS	0.35	<lod	0.19	0.48	<lod	1.9	<lod	0.8
UV comp.	4	<lod	<lod	0.3	8.9	6	61.3	5
Phenols	<lod	11.4	27.6	<lod	<lod	<lod	<lod	<lod
Siloxanes	<lod	8.8	<lod	5.8	165	8.3	<lod	<lod
BFR	<lod	0.01	<lod	0.3	11	0.1	2.3	<lod
Dechloranes	0.7	<lod	0.2	0.7	0.6	<lod	0.02	<lod
OPFR	0.5	3.7	11.4	<lod	<lod	1.8	37.3	3.5
BFR	<lod	0.01	<lod	0.3	11	0.1	2.3	<lod
Musk	0.1	0.2	n.a.	<lod	0.1	n.a.	n.a.	n.a.
Phthalates	98.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Biocides	n.a.	n.a.	n.a.	n.a.	26.3	n.a.	n.a.	n.a.

Table 45: Dominating organic groups in the various sample types based on sum concentration on wet weight basis.

Metals were dominating all sample types analysed for metals. Metals were also the dominating group when all organic group, except PFCA, PFSA and newPFAS, were normalised to organic content/lipids for soil and biological sample. Analysis of extractable organic matter was not performed for rowan leaves and honeybee. Results are comparable with wet weight data, but the water soluble PFAS groups were less dominating.

Matrix	Ordered groups based on the lipid normalized sum concentrations (except metals and PFAS groups)
Soil	Metals > Phthalates > CPs > PCBs > UV > Dechloranes > OPFRs
Earthworm	Metals > CPs > Phenols > Siloxanes > OPFRs > PCBs > Musk compounds
Spanish slug	Metals > CPs > Phenols > OPFRs > PCBs ~ Dechloranes
Fieldfare egg	Metals > CPs > PCBs > Siloxanes > PFCA > PFSA >Dechloranes
Rat liver	Metals > CPs > Siloxanes > Biocides > other BFRs > UV > PFCA
Roe deer liver	Metals > CPs > Siloxanes > UV > OPFRs > PFCA> PCB>other BFR

5.15 Trophic relationship

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

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

When relating all samples in 2023 against $\delta^{13}C$ (x-axis) and $\delta^{15}N$ (y-axis), the graph in Figure 18 is achieved.

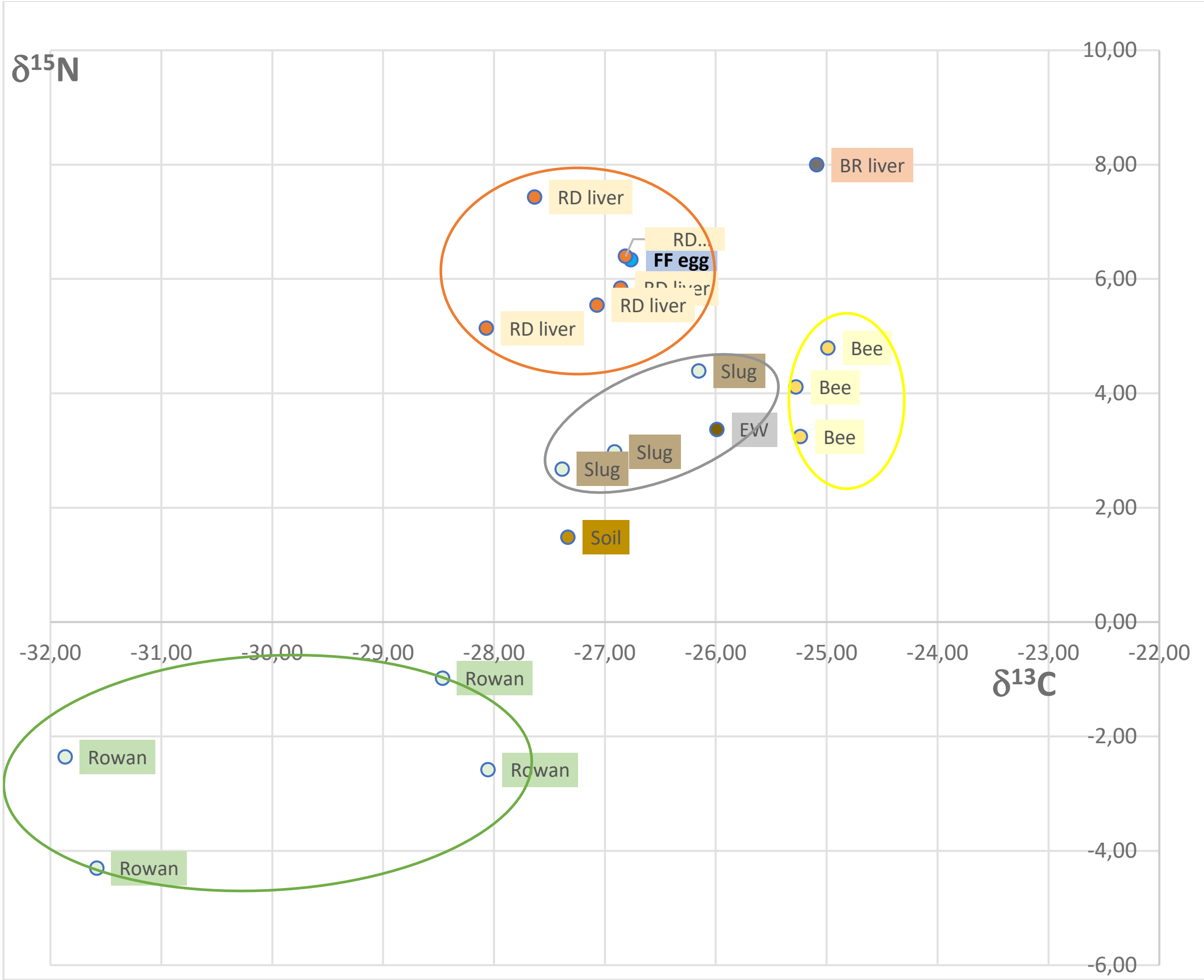


Figure 27: Relationship between the dietary descriptors δ15N and δ13C in soil and biota samples from urban terrestrial environment in Oslo, 2023; soil, earthworm (EW), brown rat liver(BR liver), slug, fieldfare egg (FF egg), Roe deer liver (RD liver), rowan, honey bee (bee).Note that only one sample exist for soil, earthworm, fiedlfare egg and rat.

As can been seen from the $\delta^{15}N$ and $\delta^{13}C$ plot, the vegetation rowan blades are distinct different with lowest $\delta^{15}N$ and $\delta^{13}C$ values in the plot. Low $\delta^{13}C$ values are associated with a terrestrial signal. The one sample of slug and earthworm show comparable $\delta^{15}N$ values, an indication to similar trophic level, and soil revealed lower $\delta^{15}N$ and also $\delta^{13}C$ values than earthworm and some of the slug samples. Roe deer (liver), where rowan is assumed to be important part of diet, show comparable $\delta^{15}N$ values to the one pooled sample of fieldfare egg, and higher than bees. The one pooled brown rat sample has higher $\delta^{15}N$ signal than the other samples. Brown rat is known to be an omnivore and will consume almost anything in their environment. They will scavenge through trash or eat any food that is left unprotected.

Trophic magnification factors were not calculated in 2023 since few organisms were linked by diet through the food web (Kidd et al., 2019) and of at least 3 trophic levels (Borgå et al, 2012, Kidd et al, 2019). Instead, we chose to assess if bioaccumulation and biomagnification factors could be calculated for those compounds with detected concentrations.

5.16 Bioaccumulation and biomagnification factors

Biota soil accumulation factor (BSAF) was calculated where contaminant data was detected for soil and earthworm (EW) and slug in the same year. Spanish-slug concentrations were collected across three locations where two of those were similar to soil locations, and average concentrations were used for calculations of BSAF, and should be interpreted as a tentative BMF.

BMF was calculated for the most relevant prey-predator pair earthworm-fieldfare where only earthworm (EW) has whole body concentrations. Egg concentrations were used for fieldfare (FF).

Be aware that the number of samples are very small with only pooled sample of soil, earthworm, fieldfare egg and three samples of slug.

	TOC % dw (2023)
soil	3.1

Table 46: % TOC in the one pooled soil sample

Compounds	BSAF(EW_{lw}/$Soil_{TOC}$)	*BSAF($Slug_{lw}$/$Soil_{TOC}$	BMF($FFegg_{lw}$/EW_{lw})
PCB-28	0.83	0.85	1.33
PCB-52	0.72	0.95	7.32
PCB-101	0.64	0.32	6.32
PCB-118	0.60	0.28	5.98
PCB-138	0.66	0.16	6.56
PCB-153	0.87	0.20	8.02
PCB-180	0.35	0.10	12.6

*Average concentration of three slug samples was used

Table 47: BSAF and BMF for PCB congeners

Unfortunately, very few other hydrophobic compounds were detected above LOD in both soil and earthworm, soil and slug, and the prey-predator pair earthworm and fieldfare. In addition to PCB congeners, only D5, a-HBCD and MCCP had detectable concentrations.

Rowan leaves may be a food item for roe deer. We have no TOC value for rowan leaves. The wet weight/dry weight ratio between roe deer liver and rowan leaves where above 1 for PCB-153 and PCB-180. This ratio was also above 1 for SCCP, but not for MCCP. For other compounds with detected concentrations in both deer liver and rowan, the ratio was below 1.

Compounds	BMF($FFegg_{lw}/EW_{lw}$)
D5	0.58
MCCP	0.73
a-HBCD	8.2

Table 48: BMF (FF/EW) for D5, a-HBCD and MCCP

None of the other hydrophobic compounds had detectable concentrations for calculation of BSAF and BMF.

PFAS compounds

The BAF and BMF calculations in the present study were done on a wet weight basis for both soil and earthworm. We have chosen to use the term BAF instead of BSAF since BSAF is associated to soil concentrations normalised to organic content.

Compounds	n=1 for Soil and EW **BAF ($EW/soil)_{ww}$**	n=1 for EW and FF_{egg} **BMF ($FF_{egg}/EW)_{ww}$**
PFOA	6.3	1.9
PFNA	-	5.4
PFDA	4.7	17.6
PFDoDA	-	33.7
PFTrDA	-	17.8
PFTeDA	-	28.9
PFOS (sum)	12.9	8.6
8:2FTS	-	4.80

Table 49: BAF(C_{EW} / C_{soil}) and BMF(C_{FF} / C_{EW}) values for PFAS compounds with detected concentrations on a wet weight basis.

When normalising soil concentration of PFAS to organic content while keeping wet weight concentrations in earthworm, the above BAF ratios were below 1.

Only BAF for PFOS (0.44) could be calculated for slug, the other PFAS compounds were not detected in both soil and slug.

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

References

Ankley, G. T., Cureton, P., Hoke, R. A., Houde, M., Kumar, A., Kurias, J., … & Sample, B. E. (2021). Assessing the ecological risks of per-and polyfluoroalkyl substances: Current state-of-the science and a proposed path forward. *Environmental toxicology and chemistry*, *40*(3), 564-605.

Borgå, K., Kidd, K. A, Muir, D. C. G., Berglund, O., Conder, J. M., Gobas, F. A. P. C., … & Powell, D. A. (2012). Trophic magnification factors: considerations of ecology, ecosystems, and study design. *Integrated Environmental Assessment and Management, 8*(1)*,* 64-84.

Du, X., Yuan, B., Zhou, Y., Benskin, J. P., Qiu, Y., Yin, G., & Zhao, J. (2018). Short-, medium-, and long-chain chlorinated paraffins in wildlife from paddy fields in the Yangtze River Delta. *Environmental science & technology, 52*(3), 1072-1080.

ECHA (2021). UV-328 Draft risk profile – ECHA. https://echa.europa.eu/documents/10162/c0604545-a115-9c61-a2ec-fefa5bdc5880

Freeling, F., Scheurer, M., Koschorreck, J., Hoffmann, G., Ternes, T. A., & Nödler, K. (2022). Levels and Temporal Trends of Trifluoroacetate (TFA) in Archived Plants: Evidence for Increasing Emissions of Gaseous TFA Precursors over the Last Decades. *Environmental Science & Technology Letters, 9*(5), 400-405.

Garavagno, M. D. L. A., Holland, R., Khan, M. A. H., Orr-Ewing, A. J., & Shallcross, D. E. (2024). Trifluoroacetic Acid: Toxicity, Sources, Sinks and Future Prospects. *Sustainability, 16*(6), 2382.

Heimstad, E. S., Moe, B., Nygård, T., Herzke, D., & Bohlin-Nizzetto, P. (2021). *Environmental pollutants in the terrestrial and urban environment 2020* (Norwegian Environment Agency report, M-2049|2021) (NILU report, 20/2021). Kjeller: NILU. https://hdl.handle.net/11250/3051772.

Heimstad, E.S., Moe, B., Borgen, A.R, Enge, E.K., Nordang, U.M., Bæk, K., Nipen, M., Harju, M., & Hanssen, L. (2023). Environmental pollutants in the terrestrial and urban environment 2021. Revised report (Norwegian Environment Agency, M-2324|2022) (NILU report, 1/2023). https://hdl.handle.net/11250/3051772.

Heimstad, E.S., Moe, B., Borgen, A.R, Enge, E.K., Nordang, U.M., Bæk, K., Nipen, M., Harju, M., & Hanssen, L. (2023). Environmental pollutants in the terrestrial and urban environment 2022 (NILU report, 23/2023) (Norwegian Environment Agency, M-2609|2023). https://hdl.handle.net/11250/3100336.

Heimstad, E. S., Nygård, T., Moe, B., & Herzke, D. (2024). New insights from an eight-year study on per-and polyfluoroalkyl substances in an urban terrestrial ecosystem. *Environmental Pollution*, *347.*

Knudtzon, N. C., Thorstensen, H., Ruus, A., Helberg, M., Bæk, K., Enge, E. K., & Borgå, K. (2021). Maternal transfer and occurrence of siloxanes, chlorinated paraffins, metals, PFAS and legacy POPs in herring gulls (Larus argentatus) of different urban influence. *Environment International, 152.*

Huang, K., Li, Y., Bu, D., Fu, J., Wang, M., Zhou, W., … & Jiang, G. (2022). Trophic Magnification of Short-Chain Per-and Polyfluoroalkyl Substances in a Terrestrial Food Chain from the Tibetan Plateau. *Environmental Science & Technology Letters, 9(*2), 147-152.

Kidd, K. A., Burkhard, L. P., Babut, M., Borgå, K., Muir, D. C., Perceval, O., ... & Embry, M. R. (2019). Practical advice for selecting or determining trophic magnification factors for application under the European Union Water Framework Directive. *Integrated environmental assessment and management, 15*(2), 266-277.

McGarvey, R., Dowling, N., & Cohen, J. E. (2016). Longer food chains in pelagic ecosystems: trophic energetics of animal body size and metabolic efficiency. *The American Naturalist, 188*(1), 76-86.

Ruus, A., Bæk, K., Petersen, K., Allan, I., Beylich, B., Schlabach, M., ... & Helberg, M. (2018). Environmental contaminants in an Urban Fjord, 2017 (Norwegian Environment Agency, M-1131|2018) (NIVA report, 7368). http://hdl.handle.net/11250/2593147

Sage, M., Fourel, I., Cœurdassier, M., Barrat, J., Berny, P., & Giraudoux, P. (2010). Determination of bromadiolone residues in fox faeces by LC/ESI-MS in relationship with toxicological data and clinical signs after repeated exposure. *Environmental Research, 110*(7), 664-674.

Savoca, D., & Pace, A. (2021). Bioaccumulation, biodistribution, toxicology and biomonitoring of organofluorine compounds in aquatic organisms. *International Journal of Molecular Sciences, 22*(12), 6276.

van den Brink, N. W., Arblaster, J. A., Bowman, S. R., Conder, J. M., Elliott, J. E., Johnson, M. S., ... & Shore, R. F. (2016). Use of terrestrial field studies in the derivation of bioaccumulation potential of chemicals. *Integrated environmental assessment and management, 12*(1), 135-145.

Yuan, B., Rüdel, H., de Wit, C. A., & Koschorreck, J. (2022). Identifying emerging environmental concerns from long-chain chlorinated paraffins towards German ecosystems. *Journal of hazardous materials, 424,* 12760.

Yuan, B., Vorkamp, K., Roos, A. M., Faxneld, S., Sonne, C., Garbus, S. E., ... & De Wit, C. A. (2019). Accumulation of short-, medium-, and long-chain chlorinated paraffins in marine and terrestrial animals from Scandinavia. *Environmental science & technology, 53(7),* 3526-3537.

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