



Nordic Council
of Ministers

Screening of Chlorinated Paraffins, Dechloranes and UV-filters in Nordic Countries



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Preface

The aim of the Nordic Screening Group is to increase knowledge of the occurrence and distribution of hazardous substances in the Nordic environment in order to provide supporting information on contaminants of emerging concern, that may serve as fundament and/or support for regulatory action. To this end, the group regularly plans screening studies in order to obtain a snapshot of the occurrence of potentially hazardous substances, both in regions most likely to be polluted as well as in some very pristine environments. The focus is on less known, anthropogenic substances and their derivatives, which are either used in high volumes or are likely to be persistent and hazardous to humans and other organisms.

In 2019, the project steering group decided to perform a screening on chlorinated paraffins, dechloranes and UV-filters. The following Nordic countries and self-governing areas are included in the project: Finland, Sweden, Norway, Denmark, Faroe Islands, Iceland and Greenland.

The matrices selected for analyses are:

- Air
- Pine needles
- Bird eggs
- Marine and freshwater fish
- Marine and terrestrial mammals

The Nordic screening project is run by a steering group with representatives from the Danish Centre for Environment and Energy, Aarhus University, Denmark, the Finnish Environment Institute, the Environment Agency of Iceland, the Environment Agency of the Faroe Islands, the Climate and Pollution agency in Norway, the Swedish Environmental Protection Agency, and the Swedish Chemicals Agency. The project is financed and supported by the Nordic Council of Ministers through the Nordic Chemicals Group and the Aquatic Ecosystems Group as well as the participating institutions.

The chemical analyses in this project have been carried out jointly by NILU – Norwegian Institute for Air Research and Norwegian Institute for Water Research (NIVA). The participating Nordic countries organised sample selection, collection and transport of samples based on a sample protocol and manuals provided by the analytical laboratories.

The national representatives in the Nordic Screening group have been responsible for collection of the samples. Acknowledgements can be found in chapter 5.

Summary

In 2019, the Nordic screening group decided to perform a Nordic screening on chlorinated paraffins, dechloranes and UV-filters. These compounds are used in a wide range of applications. They all have long range transport characteristics and can potentially be regulated under the Stockholm POP convention. However, there are still huge data gaps, which need to be addressed in order to fulfill regulation requests.

Several topics and questions were in focus for more measurements and a deeper understanding: (1) importance of long-range atmospheric transport and deposition, (2) differences/similarities in terrestrial versus marine food chains, and (3) variations between the Nordic countries and between urban and remote areas. Based on these priorities, availability of samples, and other practical reasons, samples from different Nordic countries, different environments, and both urban and remote places were selected. This study includes analysis of the compounds in air, marine and freshwater fish and marine mammals and bird eggs, but as the chlorinated paraffins also have been found to accumulate in the terrestrial food web, terrestrial mammals and bird eggs were included as well. Additionally, samples of pine needles were analysed both to look at the possibility for long range transport and to investigate it as a possible source of chlorinated paraffins for the terrestrial mammals.

Table 1: Detection frequency (as %) of the different compounds in the selected sample types (REM: Samples from remote site; URB: Samples from urban sites).

Matrix	Bird Eggs REM+URB	Trout REM	Perch REM	Perch URB	Cod Liver REM+URB	Grey seal REM	Terr. mammal REM	Air REM	Air URB	Pine needles REM	Pine needles URB
Number of samples	13+1	3	9	6	3+2	2	9	8	3	10	5
BP3	0	0	0	0	20	0	0	na	na	na	na
EHMC-E	14	0	0	0	0	0	0	na	na	na	na
EHMC-Z	0	0	0	0	0	0	0	na	na	na	na
OC	21	0	0	0	0	0	0	na	na	na	na
ODPABA	0	0	0	0	0	0	0	na	na	na	na
UV-320	21	0	0	17	60	100	0	na	na	na	na
UV-326	7	0	0	0	0	0	0	na	na	na	na
UV-327	50	0	0	17	60	50	0	na	na	na	na
UV-328	43	0	0	17	80	50	0	na	na	na	na
UV-329	0	0	0	0	60	0	0	na	na	na	na
DBA	0	0	0	0	0	0	0	0	0	0	0
Dec-602	100	100	0	67	100	100	78	0	0	0	0
Dec-603	71	0	0	0	60	50	0	0	0	0	0
Dec-604	0	0	0	0	0	0	0	0	0	0	0
Dec-601	0	0	0	0	0	0	0	0	0	0	0
DPsyn	7	0	0	0	0	50	0	25	67	0	0
DPanti	29	0	0	17	0	50	0	63	100	0	0
SCCPs	100	67	100	83	100	50	100	100	100	50	100
MCCPs	100	67	100	83	100	50	100	63	100	60	100
LCCPs	21	67	22	83	60	50	56	63	100	30	80

na: UV-compounds were not analyzed in air and pine needles.

In total, 6 out of 10 selected UV-compounds could be detected: EHMC-E, OC, UV-320, UV-326, UV-327, and UV-328. No spatial trend could be observed. Herring gull sample from Inner Oslofjord was the most contaminated sample with the highest number of UV-compounds above LoD. In this sample, UV-328 was significantly higher than in all remote samples. In only one sample of freshwater fish (liver of perch from lake Mjøsa in Norway), it was possible to detect some UV-filters above LoD. Four UV-filters could be detected frequently in cod liver samples. Samples taken in the open sea around Faroe Islands, showed the lowest concentrations close to LoD, whereas both the Skagerrak and Aarhus Bay samples showed slightly elevated concentrations of UV-320, 327, 328, and 329. Highest concentrations, especially of UV-328, were detected in the cod liver from Inner Oslofjord. Three UV-filters (UV-320, UV-327, and UV-328) could be detected in grey

seal samples from Denmark. None of the selected UV-filters could be detected in samples of the selected terrestrial mammals.

Dechlorane 602 was detected very frequently in nearly all type of biota samples, closely followed by dechlorane 603. However, the two parent compounds DPsyn and DPanti were only detected in herring gull eggs, urban perch, and grey seal. DPsyn was detected at Birkenes and Reykjavik stations, whereas DPanti was detected at Råö, Birkenes, and Reykjavik. There was no significant difference observed between the urban and remote sites for these compounds. None of the selected dechloranes could be detected in pine needles.

1 Background

In 2016 AMAP published the report "Chemicals of Emerging Arctic Concern" which included lists of chemicals in commerce identified with P, B and LRTP characteristics and for which no information on occurrence in Arctic environmental matrices was available at the time. These substances were later found in significant concentrations in Norwegian environmental samples (Norwegian Environment Agency, Screening Programme 2017: M1080, 2018 (Sakhi et al., 2019, Schlabach et al., 2018, Schlabach et al., 2017b, Schlabach et al., 2017a, Van Bavel et al., 2016, Krogseth et al., 2013)).

In 2019, the Nordic screening group therefore decided to perform a Nordic screening on chlorinated paraffins, dechloranes and UV filters. These compounds all have long range transport characteristics and can potentially be regulated under the Stockholm POP convention.

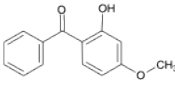
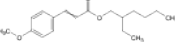
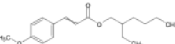
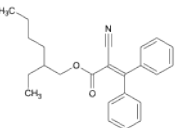
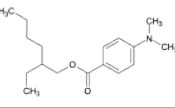
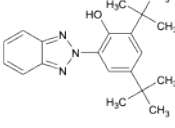
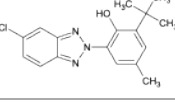
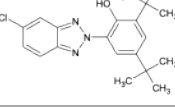
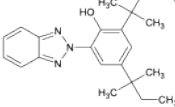
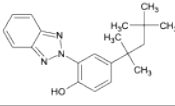
1.1 Selected compounds

1.1.1 UV-filters

The group of compounds named UV-filters are designed to protect human skin and technical products from UV radiation. They are found in sun screen products, plastics, textiles, furniture, etc. Their use in sunscreens for skin protection has been increasing in last centuries due to rising awareness to the chronic and acute effects of UV radiation. Some UV-filters have triggered significant concerns in the latter years for their enormous usage, persistent input and potential threat to ecological environment and human health. UV-compounds usually end up in wastewater. Since wastewater treatment plants are not efficient enough to remove UV-compounds, the lipophilic UV-compounds tend to sorb onto sludge and hydrophilic UV-compounds end up in river water. Both types can potentially contaminate aquatic biota (Sanchis et al., 2019). UV328 has recently been nominated to the Stockholm convention (Persistent Organic Pollutants Review Committee, 2020).

Several Norwegian screening studies performed by the project group on behalf of the Norwegian environment agency has proven the widespread contamination of waste water (Krzeminski et al., 2017), general environment (Thomas et al., 2014, Langford et al., 2015), and Arctic environment (Schlabach et al., 2018, Lucia et al., 2016) with UV-filters. NIVA's environmental analytical lab is world-wide leading in the analysis of UV-filters. UV-filters are well separated by GC-MS into the different individual compounds, relevant standards are commercially available and quantification can be done with an estimated measurement uncertainty around $\pm 25\%$ (Langford et al., 2015).

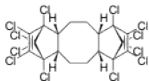
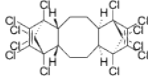
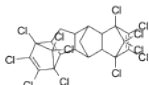
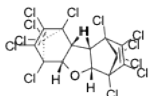
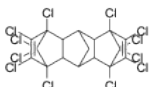
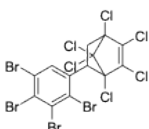
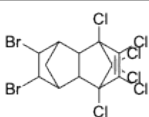
Table 2: UV filter compounds selected for this study

Name	Acronym	Structure	CAS	Log K _{OW}
Benzophenone-3	BP3		131-57-7	3.5
	EHMC-e		5466-77-3	
	EHMC-Z		5466-77-3	
Octocrylene	OC		6197-30-4	6.9
2-Ethylhexyl-4-dimethyl-aminobenzoate	ODPABA		21245-02-3	5.8
	UV-320		3846-71-7	6.3
Bumetrizole	UV-326		3896-11-5	5.6
	UV-327		3864-99-1	6.9
	UV-328		25973-55-1	
Octrizole	UV-329		3147-75-9	6.2

1.1.2 Dechloranes

The environmental occurrence of Dechlorane Plus (DP) was not documented until 2006 (Hoh et al., 2006). This late discovery was surprising, since this high production volume (HPV) chlorinated flame retardant has been produced for at least 40 years. During recent years both DP and other closely related compounds like Dechlorane 601 to 604 were detected in a lot of different environmental samples both in industrial areas (Sverko et al., 2011) and in the most rural Arctic (Carlsson et al., 2018, Verreault et al., 2018, Vorkamp et al., 2017, Schlabach et al., 2017a) and Antarctic environments (Gao et al., 2018). As shown in Figure 1, dechloranes are nicely separated by GC-ECNI-HRMS into the different individual compounds, relevant standards are commercially available and quantification can be done with an estimated measurement uncertainty around $\pm 25\%$.

Table 3: Dechlorane compounds selected for this study

Name	Acronym	Structure	CAS	Log K _{OW}
Dechlorane plus syn	DPsyn		135821-03-3	8.85
Dechlorane plus anti	DPanti		135821-74-8	8.85
Dechlorane 601	Dec601		13560-90-2	9.22
Dechlorane 602	Dec602		31107-44-5	7.37
Dechlorane 603	Dec603		13560-92-4	8.24
Dechlorane 604	Dec604		34571-16-9	8.84
Dibromoaldrin	DBALD		20389-65-5	5.77

1.1.3 Chlorinated paraffins

Chlorinated paraffins (CPs) are used in a wide range of applications such as high-pressure additives in metal working fluids, and flame retardants or plasticizers in rubbers, paints, plastics, coatings, sealants and adhesives. CPs are mixtures of different carbon chain lengths and number of chlorine atoms. Based on chain length, CPs can be divided into three groups: short chain (SCCPs: C10–C13), medium chain (MCCPs: C14–C17) and long chain (LCCPs: C18–C28). CPs are manufactured by radical chlorination of n-alkanes by treatment with ultraviolet (UV) light and/or high temperatures in the presence of chlorine gas. These reactions have low positional selectivity and the different technical products are made up by innumerable individual congeners (Tomy et al., 1998). CPs can emit into the environment during production, storage, transportation, use, and disposal of products. Emission can also occur by runoff, leaching, or volatilization from landfills, sludge, and waste burning. CPs are of emerging concern due to their high production volumes (up to 600–1000 ktons/year in China), high persistency (half-life >1 year in sediment and >0.5 d in air),

high bioaccumulation potential, and toxicity. Among CPs, short-chain CPs (SCCPs) have received the greatest attention. These compounds are classified as substances of very high concern and are included on the list of the European water framework directive to be monitored in water (van Mourik et al., 2015). SCCPs are also regulated under the Stockholm Convention in Annex A (Elimination). UK has recently submitted a proposal to list chlorinated paraffins with carbon chain lengths in the range C14–17 and chlorination levels $\geq 45\%$ chlorine by weight as persistent organic pollutant (POP).

Due to the complex mixture of innumerable congeners in each technical product environmental trace analysis of chlorinated paraffins is very difficult. As shown in Figure 1 for dechloranes, the majority of persistent organic pollutants can be analytically separated into single congeners. In most cases there are also isolated and purified standards for these single compounds available and all relevant congeners can be identified and quantified individually.

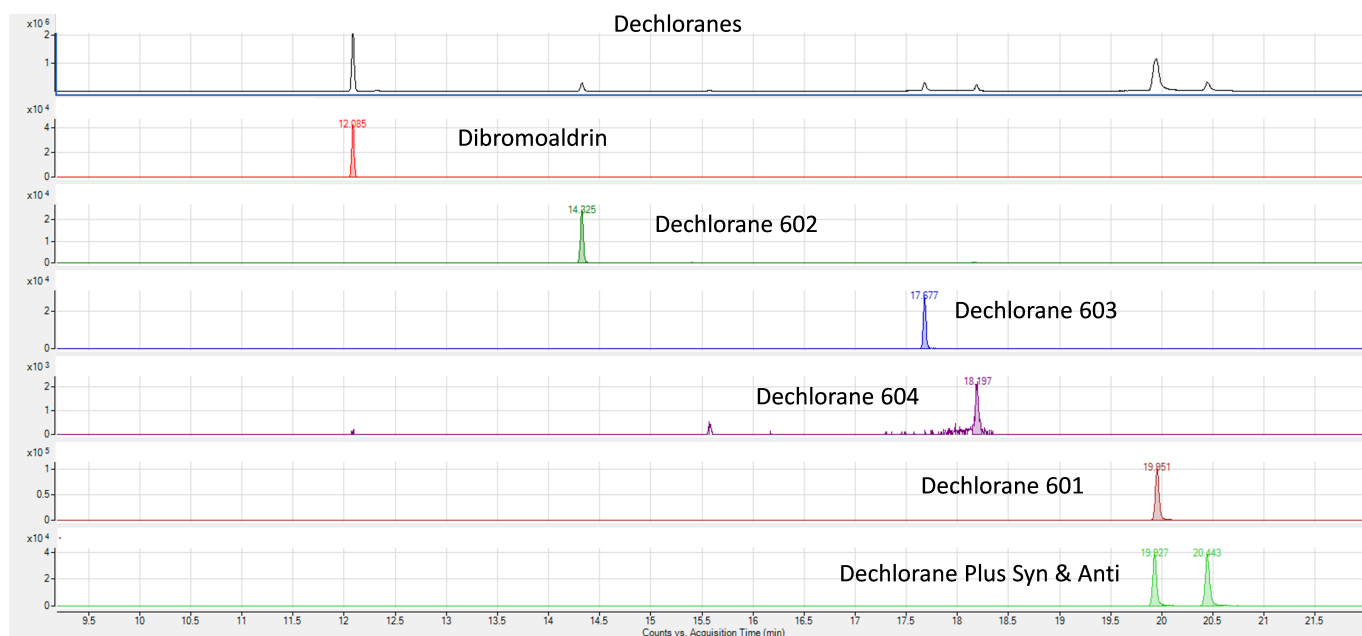


Figure 1: Total ion chromatogram of dechloranes, together with chromatograms of all dechloranes completely separated. The complete separation and the existence of isolated standard material for each compound allow a **compound specific analysis**.

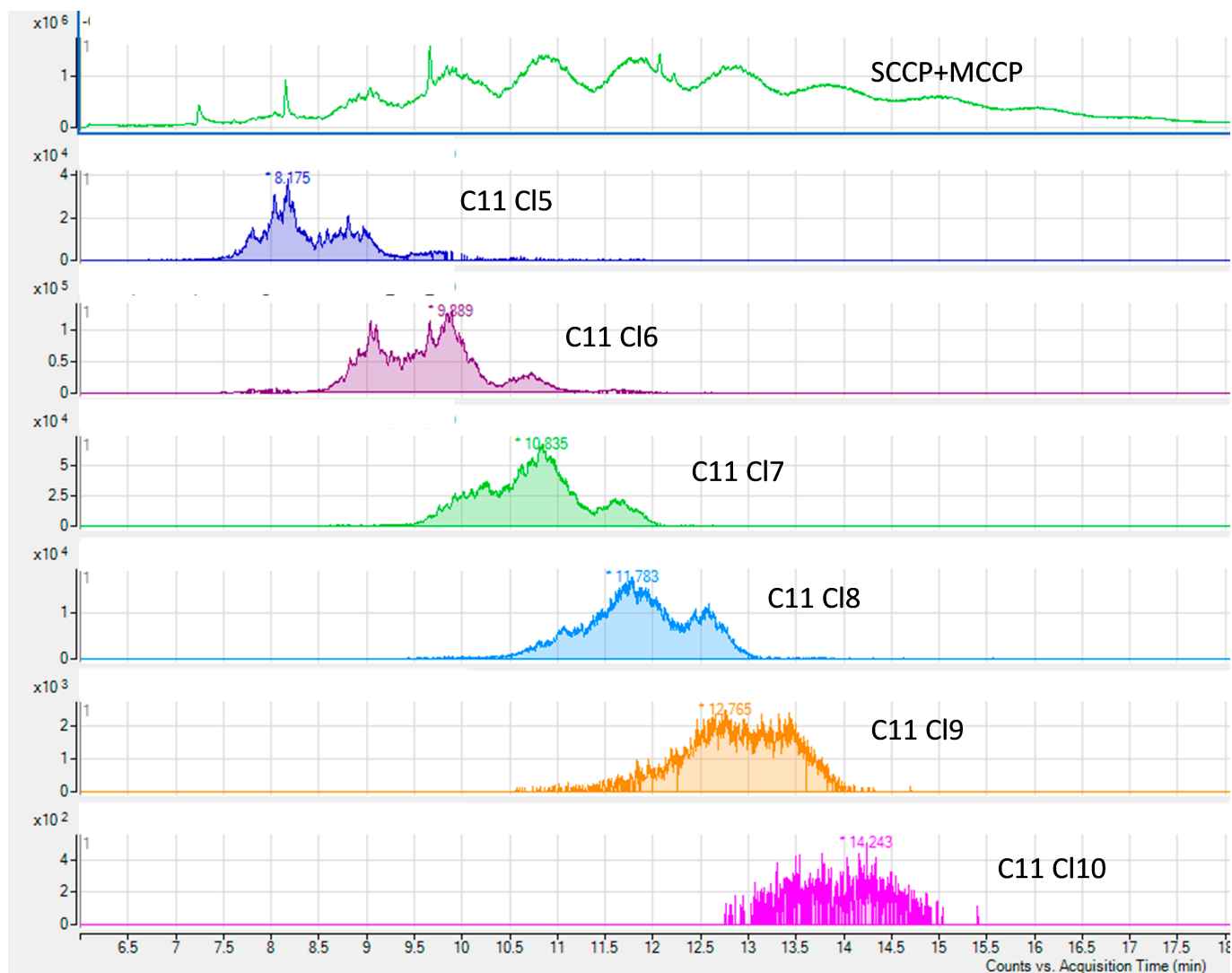


Figure 2: Total ion chromatogram of SCCPs and MCCPs, together with chromatograms of the congener groups C11–Cl5 to C11–Cl10. None of the possible thousands of congeners could be isolated as single peaks. Limited separation and the non-existence of isolated standard material for each congener allow only a **mixture analysis**.

In contrast to the ideal case of dechloranes or UV-filters, CPs can only be separated into congener groups with the same chain length and number of chlorine atoms, however, the different individual congeners remain unresolved Figure 2. In addition, there are only very few and little representative isolated single congener standards available, which can be used for identification and quantification. These facts make an accurate quantification very difficult. Different methods of highly variable quality have been developed during the last 20 years or so (van Mourik et al., 2015). The method of Tomy (Tomy et al., 1997) was applied by NILU for nearly 20 years. It is based on the use of different technical CP mixtures and the application of GC-HRMS in ECNI-mode. The method has shown to be the most accurate but also most expensive for determination of CPs. Due to the use of high mass resolution in GC/ECNI-HRMS little self-interferences between CPs and other compounds such as chlordanes, toxaphenes and PCBs can occur, which are a common problem for GC/ECNI-LRMS.

Very recently, an alternative technique based on APCI-qToF-HRMS and a

deconvolution algorithm have shown promising results (Bogdal et al., 2015). However, even this method is very difficult, time consuming and the outcome is very dependent on the selection of the right combination of technical mixtures used for calibration. Originally, a worldwide intercalibration and certification study was scheduled for 2019/2020 with NILU participating as one of the leading expert labs, which would have given valuable information on accuracy and precision of the different methods. However, this exercise was postponed twice due to COVID restrictions and related logistical problems.

Even with recent advances in the analysis of CPs, limited separation and the non-existence of isolated standard material for each congener allow only a **mixture analysis**, in contrast to UV-compounds and dechloranes, where complete separation and the existence of isolated standard material for each compound allow a **compound specific analysis**. The measurement uncertainty for the measurement of CPs is estimated to be much higher than for other POPs and probably much higher than $\pm 40\%$.

1.2 Selected sample types

This is not the first time these compounds are measured in the Nordic environment, but a follow up and supplementary study based on earlier findings in Norwegian and Swedish screening studies (Schlabach et al., 2018, Ruus et al., 2019, Schlabach et al., 2017b, Schlabach et al., 2017a, Vorkamp et al., 2019, Yuan et al., 2017, Yuan et al., 2019a) to give a better overview on the environmental threat and the spatial distribution of the selected compounds.

Several topics and questions were in focus for more measurements and a deeper understanding: (1) importance of long-range atmospheric transport and deposition, (2) differences/similarities in terrestrial versus marine food chains, and variations between the Nordic countries and between urban and remote areas. Based on these priorities, availability of samples, and other practical reasons the following samples from different countries and both urban and remote places were selected: Air, marine and freshwater fish and marine mammals and bird eggs. As the chlorinated paraffins also have been found to accumulate in the terrestrial food web, terrestrial mammals and one terrestrial bird species were included as well. Additionally, samples of pine needles were selected, both as a tracer for long-range atmospheric transport and to investigate vegetation as a possible source of chlorinated paraffins for the terrestrial mammals.

2 Methods

2.1 Sampling

The following samples were part of this study (acronyms in brackets): Ambient air (AIR), pine needles (PIN), bird eggs (EGG), marine (MFI) and freshwater fish (FFI), and marine (MMA) and terrestrial mammals (TMA). In air and pine needles only CPs and dechloranes were measured. However, in all other samples both UV-compounds, dechloranes, and CPs were measured.

Sampling was performed by the different countries according to the sampling manual enclosed in the Appendix C of this report. Sampling sites and the selection of sample matrices at each site are shown in Table 4, Figure 3 to Figure 6, and in appendix B.

Table 4: Sampling sites and sample matrices for all participating countries.

Matrix acronyms: FFI: Freshwater fish, MFI: Marine fish, MMA: Marine mammal, PIN: Pine needles, TMA: Terrestrial mammals;

Location type: URB: Urban sites, REM: Remote sites.

Latitude, longitude: All coordinates registered by the participants are converted to decimal coordinates in WGS84 format.

Country	Matrix acronym	Location type	Location	Species	Sample specification	Latitude	Longitude
FIN	AIR	REM	Pallas	Air		67.973302	24.115680
ICE	AIR	URB	Reykjavík	Air		64.130115	-21.874738
NO	AIR	REM	Birkenes	Air		58.388446	8.252055
SE	AIR	REM	Råö	Air		57.393998	11.913868
DK	EGG	REM	Græsholm	Herring gull (Larus argentatus)	Eggs	57.492000	10.604000
FO	EGG	REM	Koltur	Black guillemot (Cepphus grylle)	Eggs	61.977167	-6.957383
FO	EGG	REM	Sandoy	Fulmar (Fulmarus glacialis)	Eggs	61.872133	-6.913100
NO	EGG	URB	inner Oslofjord	Herring gull	Eggs	59.853170	10.728100
SE	EGG	REM	Stora Karlsö	Common guillemot	Eggs	57.284967	17.971945
SE	EGG	REM	Insjön	Ural owl	Eggs	60.642323	15.116698
DK	FFI	REM	Klokkeholm Møllesø	Perch	Muscle	57.214200	10.162200
DK	FFI	REM	Stadil Fjord	Perch	Muscle	56.159467	9.214378

FIN	FFI	REM	River Juutua	Brown trout	Muscle	68.906826	27.003609
FIN	FFI	REM	Kivilahti	Perch	Whole fish	68.796311	27.508358
FIN	FFI	URB	Vallisaari	Perch	Whole fish	60.131593	24.987946
FO	FFI	REM	Fjallavatn	Brown trout (Salmo trutta)	Muscle	62.115000	-7.307333
NO	FFI	URB	Mjøsa	Perch	Liver	60.756030	11.076780
SE	FFI	REM	Krageholmssjön	Perch	Muscle	55.501152	13.744153
SE	FFI	REM	Brännträsket	Perch	Muscle	65.535092	21.396842
DK	MFI	REM	Skagerrak	Cod	Liver	57.758994	9.971547
DK	MFI	URB	Aarhus Bugt	Cod	Liver	56.141583	10.235250
FO	MFI	REM	Mýlingsgrunnur	Cod	Liver	62.366667	-7.450000
NO	MFI	URB	Inner Oslofjord	Cod	Liver	59.832690	10.580430
DK	MMA	REM	Horsens Fjord	Grey seal	Blubber	55.853167	10.011667
DK	MMA	REM	Sønderho, Fanø	Grey seal	Blubber	55.347694	8.475139
DK	PIN	REM	Tornby Klitplantage	Pine needles		57.542878	9.918256
DK	PIN	REM	Låsby	Pine needles		56.147667	9.819111
FIN	PIN	REM	Hollola	Pine needles		61.058361	25.334975
FIN	PIN	REM	Inari	Pine needles		68.905834	26.995323
FIN	PIN	URB	Helsinki	Pine needles		60.220498	25.119256
FO	PIN	URB	Tórshavn	Pine needles		62.016533	-6.780533
FO	PIN	URB	Tórshavn	Pine needles		62.016600	-6.781300
ICE	PIN	URB	Reykjavík	Pine needles		64.129973	-21.876159
NO	PIN	REM	Birkenes	Pine needles		58.390590	8.248255
SE	PIN	REM	Råö	Pine needles		57.393736	11.913671
FIN	TMA	REM	Kurkimäki	Moose	Liver	62.798703	27.499224
FIN	TMA	REM	Kurkimäki	Moose	Muscle	62.798703	27.499224
FIN	TMA	REM	Oraniemi	Reindeer	Muscle	67.644112	27.307775
FIN	TMA	REM	Kutuharju station	Reindeer	Muscle	68.775225	26.818071
NO	TMA	REM	Folldal Einunnfjeller	Red deer	Muscle	62.202270	10.350730
NO	TMA	REM	Folldal Knutshø	Reindeer	Muscle	62.239830	9.891900
NO	TMA	REM	Folldal Sønkletten	Reindeer	Muscle	62.075170	10.052170
SE	TMA	REM	Grimsö	Moose	Muscle	57.704792	15.576077
SE	TMA	REM	Norrkaitum Sameby	Reindeer	Muscle	68.262938	19.857487

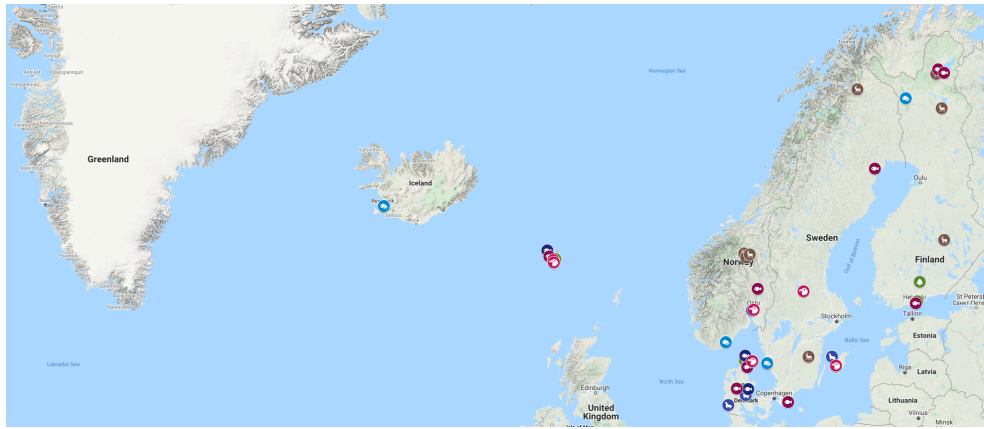


Figure 3: Overview of all sampling sites and sample types of this study.

-  PIN
-  FFI
-  TMA
-  EGG
-  AIR
-  MFI
-  MMA

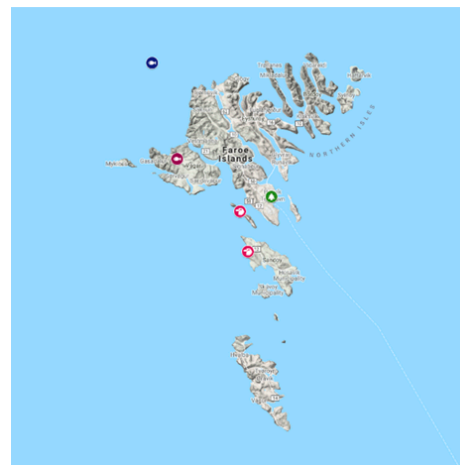
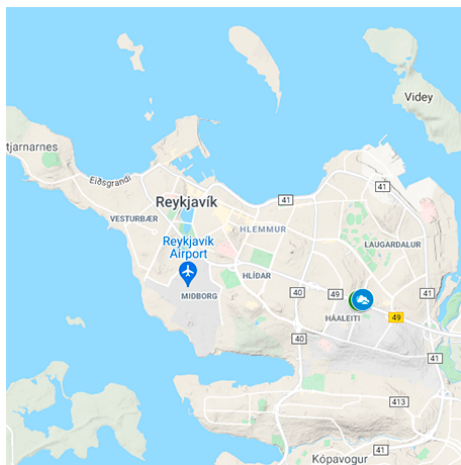


Figure 4: Sampling sites in Reykjavik, Iceland and on Faroe Islands.

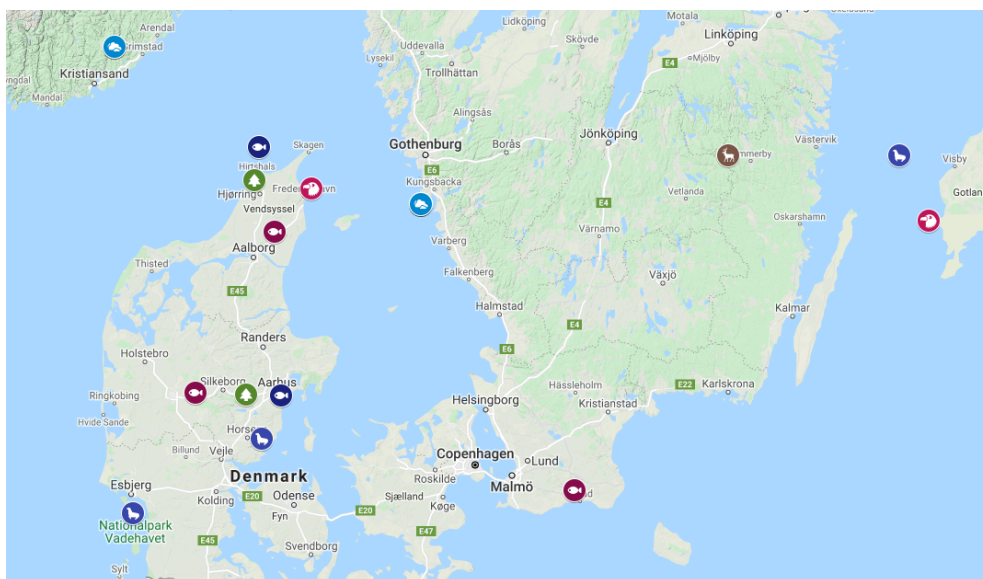


Figure 5: Sampling sites in Southern Scandinavia



Figure 6: Sampling sites in central and North-eastern Scandinavia.

2.2 Chemical Analysis

2.2.1 UV-filters

2.2.1.1 Sample extraction and clean-up

Samples were spiked with isotopically labelled internal standards before extraction. The samples were also added zinc chloride solution to improve extraction efficiency. Samples were then extracted twice with organic solvents in an ultrasonic bath. The organic-solvent extracts were removed and concentrated with vacuum under nitrogen flow before clean up with gel permeation chromatography (GPC). Most samples were also undergoing a final clean-up step with PSA sorbent to remove interferences. The final extracts were filtered using Spin-X 0.2 µm and concentrated to approximately 0.2 mL prior to the analysis.

2.2.1.2 Instrumental Analysis

Samples from egg, fish and mammals were analysed with Agilent 7890B GC system equipped with two 15-meter HP-5MS-UI columns coupled to an Agilent 7010B GC-MS Triple Quad operated in EI mode.

2.2.2 Dechloranes

2.2.2.1 Sample extraction and clean-up

Prior to extraction, the samples were added a mixture of isotope labelled PCB, SCCP (one single isomer) and dechloranes for quantification purposes. The water-, sediment-and biota-samples were extracted with organic solvents and concentrated under nitrogen flow, followed by a clean-up procedure using concentrated sulphuric acid and a silica column to remove lipids and other interferences prior to analysis.

2.2.2.2 Analysis

Prior to analysis, all samples were concentrated to ~150 µL sample volume. The extracts were injected into an Agilent 7890N GC system coupled to an Agilent 7200 QToF mass spectrometer operated in electron capture negative ionization mode (GC-ECNI-HRMS) and PCB-153 and the dechlorane compounds were quantified based on the use of internal standards.

2.2.3 Chlorinated paraffins

2.2.3.1 Sample extraction and clean-up

Prior to extraction, the samples were added a mixture of isotope labelled PCB, SCCP (one single isomer) and dechloranes for quantification purposes. The water-, sediment-and biota-samples were extracted with organic solvents and concentrated under nitrogen flow, followed by a clean-up procedure using concentrated sulphuric acid and a silica column to remove lipids and other interferences prior to analysis.

2.2.3.2 Analysis

Chlorinated paraffins both SCCPs, MCCPs, and LCCPs are complex mixtures of chlorinated alkanes with varying carbon chain length, varying degree of chlorination and position of the chlorines. The analytical tools available today cannot separate the different structural isomers (congeners) and today only mixtures can be separated and quantified. This is in contrast to UV-compounds and dechloranes which were analysed with a compound specific analytical method. Prior to analysis, all samples were concentrated to ~150 µL sample volume. SCCPs and MCCPs were analyzed using an Agilent 7890B GC, 7200 QToF (GC/HRMS). To achieve a necessary separation, an HP-5MS UI 15 m×0.25 mm id, fused silica capillary column was used with a constant Helium flow of 1.2 mL/min. PTV injection solvent vent mode. The GC temperature program for SCCPs was: 55 °C (2 mins), 70 °C/min to 200 °C (1 min), 10 °C/min to 280 °C (1 min), 10 °C/min to 310 °C (0 mins), 70 °C/min to 325 °C, 4 mins. The MS was operated in ECNI mode using methane as moderating gas. A selection of $[M-Cl]^-$ or $[M-HCl]^-$ ions for both SCCPs and MCCPs were extracted and the quantification was performed according to a method described by (Tomy et al., 1997). ^{13}C -labelled hexachlorodecane was used as internal standard. LCCPs were analyzed using an Agilent 1290 UHPLC, 6546 QToF (LC/HRMS). To achieve a necessary separation, an ACE Excel 5 Super C18, 75x2.1 mm column was used with a constant flow of 0.4 mL/min. The mobile phase was at start 70% water and 30% MeOH both containing 0.05mM of tetramethylammonium chloride. After 5 mins the mobile phase was adjusted to 100% of MeOH with 0.05mM of tetramethylammonium chloride. The MS was operated in negative ESI mode. A selection of $[M+Cl]^-$ ions were extracted and the quantification was performed according to (Bogdal et al., 2015).

2.3 Limit of detection

The limits of detection (LoD) for both UV-compounds, dechloranes and chlorinated paraffins were calculated for each sample, using a standard method described by IUPAC (IUPAC Goldbook, 2019), i.e. the average of blanks plus 3 times the standard deviation for blanks. As samples are analysed in batches, separate blank samples with various results were relevant for the different batches, which in some circumstances lead to deviating LoD for the same sample type.

2.4 Uncertainties

When performing environmental screening studies for contaminants of emerging concern, all steps in the process, starting with study design, selection of the sampling sites, sampling frequency, time of sampling, performing the sampling, the transport and storage of samples, chemical analysis and data treatment, to some extent generate some degree of uncertainty (Thomas et al., 2014). To quantitatively estimate the contribution of all steps is an extremely difficult task. However, we will discuss the relevance of the different contributions in a qualitative way.

2.4.1 Study design

The concentrations of the different compounds of interest in environmental samples vary considerably due to variations in sample types and by biological, temporal, or local variations. Different important decisions may have an influence on the outcome of the study such as the selection of sample sites, relevant season, relevant selection of sample types, right balance between number of individual samples contra number of different sampling sites.

2.4.2 Sampling and sample handling

Factors with influence on sampling uncertainty are analyte loss due to adsorption to sample containers, contamination (for some compounds), and degradation during transport and storage. An important factor especially for pine needles is the problem in preparation of representative and homogenous sub-samples. Pine needles are very heterogeneous matrices as exposure to the deposition of pollutants is depending on exposure time and also position of the needles on the trees. In theory it is possible to prepare pine needle composite samples in a way that identical subsamples can be taken. However, this would require that needles from all part of the tree are sampled and homogenized for several days with specialized equipment. The complete homogenisation of all samples, aiming for identical subsamples, would consume the whole budget for chemical analysis. In addition extensive sample treatment can have negative impact on the integrity of the true concentration of the analytes, either due to contamination or due to loss by evaporation or adsorption to the homogenisation instruments in use. Therefore, normal practice in a study like this is to find an acceptable balance between homogeneity and limited sample pretreatment. The following example may illustrate the consequence for this study: If it is the case that most of the CP-load of pine needle sample is bound to only five microplastic particles in this sample, it will be impossible to make ten identical sub-samples without disintegrating and milling these particles. This example is obviously quite extreme, but it illustrates that the concentration of particle bound pollutants may vary considerably from sub-sample to sub-sample.

2.4.3 Chemical analysis

The uncertainty of the chemical analysis is governed by sample homogeneity, loss during extraction and clean-up, interference from other compounds, trueness of analytical standards, instrumental parameters, and contamination at all stages of work.

A normal approach to estimate and quantify these factors is the participation in a laboratory intercalibration. However, the analyses of these compounds are still in a developing phase and only a limited number of intercalibration studies are available. The uncertainty is expected to be larger for compounds which are analysed infrequently than for compounds which are analyzed commonly. That means that most compounds will probably have analytical uncertainties in the range of 20 to 40% for the **compound specific methods** (UV-compounds and dechloranes), where single standards for each compound are available. For the CPs, where only a mixture analysis is possible the uncertainty is estimated to be much higher. SCCPs and MCCPs consists of several thousand different compounds. Further, each congener group will consist of several hundred different isomers where complete chromatographic separation is impossible to achieve with present technology. Hence

single congener standards are not possible to isolate from a crude mixture and the ones available are very limited and not chemically representative. The analytical response factors within the different congener groups will then not be possible to determine when the signals of the single congeners are overlapping. The responses will most likely depend greatly on the chlorine positions and are therefore subject to great variations. One of the most common approaches to quantification is to use average response factors from a number of standard mixtures, which are limited, with the closest resemblance to the samples as possible. Another approach which has been widely accepted during the last years is the deconvolution method. This method is based on the linear combination of several standard mixtures to determine response factors which is applied to the samples. The limitations are again the standard mixtures available, but most likely this approach is by now the most promising way to quantify CPs in environmental samples. Another addition to the great uncertainty in GC/MS analysis of CPs is the fact that response factors increase with increasing concentrations. This means that not only is it important to incorporate standards or a combination of standards with pattern resemblance, but also incorporate standards with responses within each congener group according to the samples. The latter is much more important in CP analysis than traditional single compound analysis even when the responses are within the instruments linear area.

For all analytes we consider the analytical uncertainty as adequate for a screening study, however, to use these results for future time trend studies is not advisable.

2.4.4 Overall uncertainty

To test and illustrate some of the above mentioned effects NILU have analyzed parallel subsamples of three pine needle samples for SCCPs, MCCPs, and LCCPs (see Table 5). Pine needles are a matrix, which is expected to be very inhomogeneous due to the fact that needles will be of different age or exposure time, different exposure to deposal and removal mechanisms depending on the position towards wind, rain and solar radiation. In addition the surface area is very large compared to the sample weight and have a high affinity to attract potential contamination during sampling, sample storage, and homogenization. Furthermore, CP analyses are expected to have a much higher analytical uncertainty compared to UV compounds and dechloranes. In contrast to the other sample types and analytes, pine needles and CPs will be a worst case test. The first two parallels were treated as the other pine needle samples. The third parallel of each sample were washed with double-distilled water in order to remove non-bound depositions.

Table 5: Results from parallel analysis of three randomly selected pine needle samples of this study.

Country	Sample site	Parallel	SCCPs	MCCPs ng/g dw	LCCPs
FIN	Hollola	Normal 1	44.5	55.3	303
		Normal 2	<20	<20	<20
		Extra wash	23.0	123	<20
NO	Birkenes	Normal 1	<3	<6	<20
		Normal 2	<3	59.7	<20
		Extra wash	<3	47.0	<20
ICE	Reykjavík	Normal 1	4.03	10.5	5.90
		Normal 2	60.1	198	72.8
		Extra wash	61.2	174	51.2

The variation of the parallels of each sample are higher than assessed for the chemical measurements only (chapter 2.4.3). A considerable part of the additional uncertainty is related to sample inhomogeneity. Whereas animal tissue of a given type, like muscle, blubber or liver, from one individual animal show little variation in pollutant concentration, this is not the case for needles from pine trees or other conifers. In contrast to animals there are nearly no internal transport of pollutants in most type of plants and the measured level are the result of direct pollutant uptake in the needles or leaves. Uptake is mainly depending on air concentration, particle deposition, temperature, wind speed, and exposure time (Hellstrom, 2003). Whereas air concentration is more or less the same on all places in a canopy, particle deposition is very depending on the density of the vegetation around the individual needles, which results in significant influence of the position on the tree and on the density of the forest on pollutant content in the needles (Kylin et al., 2003). In the context of this study it was not possible to homogenize the complete sample delivered to the lab, only the amount used for each single analysis was mixed before extraction. In order to reduce variation a very strict and rigorous sampling regime for pine needle samples should be applied, as described by the German Environmental Specimen bank (Klein et al., 2018).

3 Results and Discussion

3.1 UV-filters

3.1.1 Bird eggs

Egg samples of black guillemot (*Cephus grylle*), common guillemot (*Uria aalge*), fulmar (*Fulmarus glacialis*), herring gull (*Larus argentatus*), and Ural owl (*Strix uralensis*) from different Nordic countries were analysed for a selected range of UV filters. In this study in total 6 out of 10 selected UV-compounds could be detected: EHMC-E, OC, UV-320, UV-326, UV-327, and UV-328, see Table 6.

Table 6: Concentration of UV filters in samples of bird eggs (Black guillemot, Common guillemot, Fulmar, Herring gull, and Ural owl).

For the calculation of the average concentration only results above the limit of detection (LoD) are included.

	EHMC-E	OC	UV-320	UV-326	UV-327	UV-328
Sample type (number)	(Min-max) Average		ng/g ww			
	Detection frequency					
Bird eggs	(<1.5-1.89)	(<1.2-1.36)	(<0.05-0.19)	(<0.1-0.40)	(<0.04-0.22)	(<0.05-1.83)
(14)	1.73	1.29	0.13	0.40	0.10	0.38
	14%	21%	21%	7%	50%	43%

Since there were taken different species in the different areas, no specific spatial trend could be observed. In addition, it was not possible to identify bioaccumulation. It should be mentioned that for herring gull eggs, 8 eggs were collected at the same site (Græsholmen, Denmark) and analysed individually, whereas other species and sites only are represented by single samples or composite samples made from very few subsamples. In consequence, the reported average might be dominated by a single species, from one site.

The herring gull sample from Inner Oslofjord was the most contaminated sample in this study with the highest number of UV-compounds above LoD. In this sample UV-328 was significantly higher than in all remote samples (Figure 7), which could be related to the urban feeding habits of the Inner Oslofjord population.

The concentrations of UV compounds measured in this study are in the same range as earlier findings in the Norwegian screening study of 2017 (Schlabach et al., 2018). However, in the follow up screening study 2018 some Herring gull samples from Inner Oslofjord showed much higher concentrations of UV-328 of up to 60 ng/g w.w. (Schlabach et al., 2019).

The concentrations of the detected UV compounds in this study are in the same range as earlier findings in the Norwegian screening study of 2017 (Schlabach et al., 2018).

3.1.3 Marine fish

Cod (*Gadus morhua*) were selected as marine fish for this study and taken in both open sea and in bays/fjords close to urban settlements. Four UV-filters could be detected frequently in cod liver samples, see Table 8. Samples taken in the open sea around Faroe Islands showed the lowest concentration close to LoD, whereas both the Skagerrak and Aarhus sample showed slightly elevated concentrations of UV-320, 327, 328, and 329. Highest concentrations, especially of UV-328 were detected in the cod liver from Inner Oslofjord. The level of UV-328 in cod liver from Inner Oslofjord was in the same range as an earlier measurement from the same area: 16.2 ng/g ww (Ruus et al., 2019).

Table 8: Concentration of UV filters in liver samples of cod.

For the calculation of the average concentration only results above the limit of detection (LoD) are included.

	BP3	UV-320	UV-327	UV-328	UV-329
Sample type (Number)	(Min-max) Average Detection frequency		ng/g ww		
Cod liver (5)	(<0.2-0.29) 0.29 20%	(<0.05-2.15) 0.86 60%	(<0.05-1.83) 0.95 60%	(<0.06-7.53) 2.11 80%	(<0.20-2.78) 1.31 60%

3.1.4 Marine mammals

Two samples of blubber of grey seal (*Halichoerus grypus*) were delivered by Denmark. Three UV-filters (UV-320, UV-327, and UV-328) could be detected in these samples, see Table 9. In the Norwegian screening study of 2017 (Schlabach et al., 2018) blood plasma samples of polar bear from Svalbard were analyzed, however, the compounds, which were detected in grey seal from Denmark (UV-320, UV-327, and UV-328), were below LoD (~0.3 ng/g ww) in polar bear plasma.

Table 9: Concentration of UV filters in samples of marine mammals.

For the calculation of the average concentration only results above the limit of detection (LoD) are included.

	UV-320	UV-327	UV-328
Sample type (Number)	(Min-max) Average Detection frequency		ng/g ww
Seal blubber (2)	(0.10-0.29) 0.20 100%	(<0.20-0.60) 0.60 50%	(<0.10-0.80) 0.80 50%

3.1.5 Terrestrial mammals

Moose (*Alces alces*), red deer (*Cervus elaphus*), and reindeer (*Rangifer tarandus*) samples were analysed for UV-filters. None of the selected UV-filters could be detected in samples of the selected terrestrial mammals.

3.2 Dechloranes

3.2.1 Bird eggs

Egg samples of Black guillemot (*Cephus grylle*), Common guillemot (*Uria aalge*), Fulmar (*Fulmarus glacialis*), Herring gull (*Larus argentatus*), and Ural owl (*Strix uralensis*) from different Nordic countries were analysed for selected dechloranes. In this study the dechlorane derivate Dec-602 was detected in all species and Dec603 was detected in most species (Table 10). However, the two parent compounds DPsyn and DPanti were only detected in herring gull eggs.

Table 10: Concentration of Dechloranes in samples of bird eggs (Black guillemot, Common guillemot, Fulmar, Herring gull, and Ural owl).

For the calculation of the average concentration only results above the limit of detection (LoD) are included.

	Dec602	Dec603	DPsyn	DPanti
Sample type	(Min-max) Average Detection frequency			ng/g ww
Bird eggs	(0.03-0.52) 0.17 100%	(<0.01-0.11) 0.05 71%	(<0.11-0.29) 0.29 7%	(<0.12-0.80) 0.32 29%

Since there were taken different species in the different areas, no clear spatial trend could be observed. In addition, it is difficult to identify bioaccumulation. It should be mentioned that for herring gull eggs, 8 eggs were collected at the same site (Græsholmen, Denmark) and analysed individually, whereas other species and sites only are represented by single samples or composite samples made from very few subsamples. In consequence, the reported average might be dominated by a single species, from one site.

The levels of Dec-602 measured here were in the same range as found in the Norwegian screening study 2017 (Schlabach et al., 2018). The detection frequency and levels of DPsyn and DPanti were higher in the Norwegian study 2017, compared to what is found in the current study. However, different species were selected. In herring gull sample from Inner Oslofjord the concentration of DPsyn and DPanti is significantly higher than in all remote samples (Figure 8), which could be related to the urban feeding habits of the Inner Oslofjord population. These levels are in the same range as earlier reported averages from the same area DPsyn/anti 0.18/0.62 ng/g f.w. (Ruus et al., 2018).

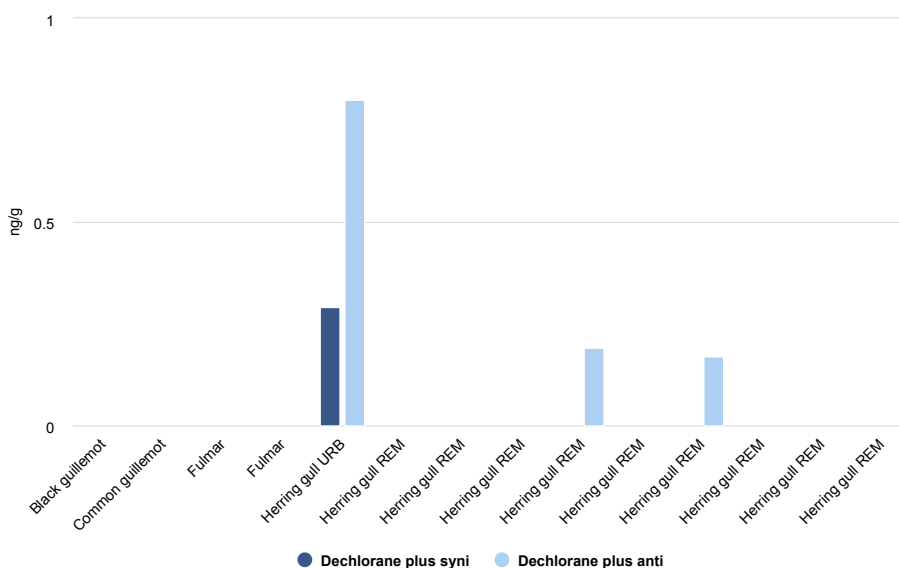


Figure 8: DPsyn and DPanti levels in bird eggs

3.2.2 Freshwater fish

Perch (*Perca fluviatilis*) and Brown trout (*Salmo trutta*) were selected for this study. For brown trout muscle sample were taken and analysed. For perch both whole fish, muscle and liver samples were taken and analysed. Only Dec602 were detected in more than one sample. Dec602 was detected in all samples of brown trout and in samples of perch from urban sampling sites (Table 11). The parent compound DPanti was only detected in one sample, namely perch liver from Lake Mjøsa (Table 11).

The levels of Dec-602 measured in Brown trout from Finland were in the same range as in Brown trout from Lake Mjøsa measured in the Norwegian freshwater ecosystem monitoring in 2017 (Jartun et al., 2018).

Table 11: Concentration of Dechloranes in samples of muscle of brown trout from remote areas and whole fish or liver of perch from urban areas.

For the calculation of the average concentration only results above the limit of detection (LoD) are included.

	Dec602	DPanti
Sample type (Number)	(Min-max) Average Detection frequency	ng/g ww
Brown trout (3)	(0.010-0.019) 0.014 100%	(0.02) 0%
Perch URB (6)	(<0.005-0.020) 0.009 67%	(<0.02-0.32) 0.32 17%

3.2.3 Marine fish

Cod (*Gadus morhua*) were selected as marine fish for this study and taken in both open sea and in bays/fjords close to urban settlements. The two dechlorane derivatives Dec602 and 603 could be detected frequently in cod liver samples (Table 12). In contrast to UV-compounds, remote and urban cod liver samples show concentrations in the same order of magnitude.

Table 12: Concentration of Dechloranes in liver samples of cod (*Gadus morhua*).

For the calculation of the average concentration only results above the limit of detection (LoD) are included.

	Dec602	Dec603
Sample type (Number)	(Min-max) Average Detection frequency	ng/g ww
Cod liver	(0.06-0.29) 0.013 100%	(<0.01-0.08) 0.04 60%

The levels of Dec-602 and Dec603 in cod liver samples in this study are lower compared to Norwegian measurements in cod liver from Inner Oslofjord Dec-602/ 603: 0.68/0.16 ng/g f.w. (Ruus et al., 2018). This difference reflects the higher contamination level in the Inner Oslofjord, which must be described as an urban environment.

3.2.4 Marine mammals

Two samples of blubber of grey seal (*Halichoerus grypus*) were taken by Denmark. Four Dechloranes could be detected in these samples, see Table 13.

Table 13: Concentration of Dechloranes in samples of grey seal.

For the calculation of the average concentration only results above the limit of detection (LoD) are included.

	Dec602	Dec603	DPsyn	DPanti
Sample type	(Min-max) Average Detection frequency			
Seal blubber	(0.33-56-4) 28.4 100%	(<0.04-0.34) 0.34 50%	(<0.21-0.96) 0.96 50%	(<0.23-1.79) 1.79 50%

The dechlorane levels measured in grey seal blubber from Denmark were significantly higher compared to levels measured in ringed seal liver from Svalbard with DPsyn/anti of 0.10/0.17 ng/g ww (Schlabach et al., 2017a). In addition the grey seal samples showed a different pattern with much higher concentration of Dec602 compared to DPsyn and anti. Dec602 was below LoD (<0.02 ng/g ww) in ringed seal liver.

3.2.5 Terrestrial mammals

Moose (*Alces alces*), red deer (*Cervus elaphus*), and reindeer (*Rangifer tarandus*) samples were analysed for dechloranes. Only Dec602 were frequently detected in samples of the selected terrestrial mammals.

Table 14: Concentration of Dechloranes in samples of liver and muscle of terrestrial mammals.

	Dec602
Sample type	(Min-max) Average Detection frequency
Terrestrial mammals	(<0.001-0.032) 0.007 78%

Dechloranes were earlier detected in red foxes from urban environments (bigger Oslo area) with around 10 times higher Dec602 concentrations, whereas DPsyn and DPanti were measured above LoD with mean concentrations of syn/anti 0.17/0.19 ng/g ww (Heimstad et al., 2019).

3.2.6 Air

Ambient air samples were taken at four different stations, three remote stations: Råö, Sweden, Birkenes, Norway, and Pallas, Finland; and one urban station: Reykjavik, Iceland. In contrast to all other samples of this study, relevant field blank samples were available for ambient air. None of the dechlorane compounds were detected in the field blank samples.

DPsyn was detected at Birkenes and Reykjavik stations, whereas DPanti was detected at Råö, Birkenes, and Reykjavik. There was no significant difference observed between the urban and remote sites for these compounds. These levels are in the same range as measured at the Norwegian air monitoring observatories Birkenes and Zeppelin (Bohlin-Nizzetto et al., 2020).

Table 15: Concentration of Dechloranes in ambient air.

For the calculation of the average concentration only results above the limit of detection (LoD) are included.

Sample type (Number)	DPsyn	DPanti
	(Min-max)	
	Average	pg/m ³
	Detection frequency	
Ambient air (11)	(<0.02-0.27) 0.17 36%	(<0.02-0.95) 0.37 73%

3.2.7 Pine needles

Pine needles were collected at six remote sites: Tornby Klitplantage, Låsby, Hollola, Inari, Inari, Birkenes, and Råö; and three urban sites: Helsinki, Tórshavn, and Reykjavik. None of the selected dechloranes could be detected above LoD.

3.3 Chlorinated paraffins

3.3.1 Bird eggs

Egg samples of black guillemot (*Cephus grylle*), common guillemot (*Uria aalge*), fulmar (*Fulmarus glacialis*), herring gull (*Larus argentatus*), and Ural owl (*Strix uralensis*) from different Nordic countries were analysed for selected chlorinated paraffins. In this study SCCPs and MCCPs were detected in all species and samples (Table 16). However, LCCPs were only found in two samples of herring gull eggs and in the egg sample from Ural owl.

Table 16: Concentration of chlorinated paraffins in samples of bird eggs (Black guillemot, common guillemot, fulmar, herring gull, and Ural owl).

For the calculation of the average concentration only results above the limit of detection (LoD) are included.

	SCCPs	MCCPs	LCCPs
Sample type	(Min-max) Average Detection frequency		ng/g ww
Bird eggs (NMR)	(2.46-22.3) 10.4 100%	(11.7-79.6) 31.4 100%	(<10-341) 132 21%

Since there were taken different species in the different areas, no specific spatial trend could be observed. In addition, it was not possible to identify bioaccumulation. It should be mentioned that for herring gull eggs, 8 eggs were collected at the same site (Græsholmen, Denmark) and analysed individually, whereas other species and sites only are represented by single samples or composite samples made from very few subsamples. In consequence, the reported average might be dominated by a single species, from one site.

For nearly all bird egg samples the concentrations of MCCPs were higher than the SCCP concentrations. For the cases where LCCPs were detected, the concentration was as high or higher than the SCCP concentration. It was not possible to identify a spatial trend in this sample set, and no significant difference between remote and urban sample was found. Taking into account that the results in this report are given in ng/g wet weight (ww) and the results in an earlier study in Scandinavia are reported on lipid weight (lw), the concentrations are in the same order of magnitude (Yuan et al., 2019b). However, in bird eggs from the urban terrestrial environment in the Oslo area much higher concentrations of SCCPs and MCCPs were frequently detected (Heimstad et al., 2019). For nearly all samples the concentrations of MCCPs are higher than the SCCP concentration. The same is true for the few cases where LCCPs were detected above LoD.

3.3.2 Freshwater fish

Perch (*Perca fluviatilis*) and brown trout (*Salmo trutta*) were selected for this study. For brown trout muscle sample were taken and analysed. For perch both whole fish, muscle and liver samples were taken and analysed. SCCPs and MCCPs were detected in most of the samples. LCCPs were detected in about 50% of all samples (Table 17).

Table 17: Concentration of chlorinated paraffins in samples of muscle of brown trout and samples of muscle and whole perch from remote areas, and in samples of liver and whole perch from urban areas.

For the calculation of the average concentration only results above the limit of detection (LoD) are included.

	SCCPs	MCCPs	LCCPs
Sample type (Number)	(Min-max) Average Detection frequency		ng/g ww
Brown trout REM (3)	(<0.25-9.04) 7.27 67%	(<0.65-28.0) 22.5 67%	(<2-9.69) 8.75 67%
Perch REM (10)	(<0.25-4.04) 2.40 100%	(<0.65-31.9) 14.6 100%	(<2-5.02) 3.86 22%
Perch URB (6)	(<0.60-42.4) 14.8 83%	(<1.52-138) 44.0 83%	(<2-37.8) 16.5 83%

For nearly all samples of freshwater fish the concentrations of MCCPs were higher than the SCCP concentrations. For the cases where LCCPs were detected, the concentration was as high as the SCCP concentration. The levels of SCCPs and MCCPs were in the same range as measured in pooled samples of fish liver of brown trout, perch and pike taken at more than 10 different Norwegian lakes (Jartun et al., 2018). To our best knowledge this is the first time LCCPs were detected in freshwater fish from the Nordic environment. For nearly all samples the concentrations of MCCPs are higher than the SCCP concentration. For the cases where LCCPs were detected, the concentration was as high as the SCCP concentration.

3.3.3 Marine fish

Cod (*Gadus morhua*) were selected as marine fish for this study and taken in both open sea and in bays/fjords close to urban settlements. SCCPs and MCCPs could be detected in all samples (Table 18) and LCCPs were detected in 60% of all samples. Remote and urban samples show concentrations in the same order of magnitude. However, the sample from Inner Oslofjord showed slightly higher concentrations for all three compound groups (Figure 9). For all cod liver samples the concentrations of MCCPs were in the same range as the SCCP concentrations. For the cases where LCCPs were detected, the concentration was as high or higher than the SCCP concentration. The SCCPs and MCCPs levels measured in this study were lower than in cod liver from earlier measurements from Inner Oslofjord (Ruus et al., 2019, Ruus et al., 2018).

Table 18: Concentration of chlorinated paraffins in liver samples of cod.

	SCCPs	MCCPs	LCCPs
Sample type (Number)	(Min-max) Average Detection frequency	ng/g ww	
Cod liver (5)	(15.7-75.4) 33.9 100%	(22.0-106) 52.0 100%	(<10-143) 132 60%

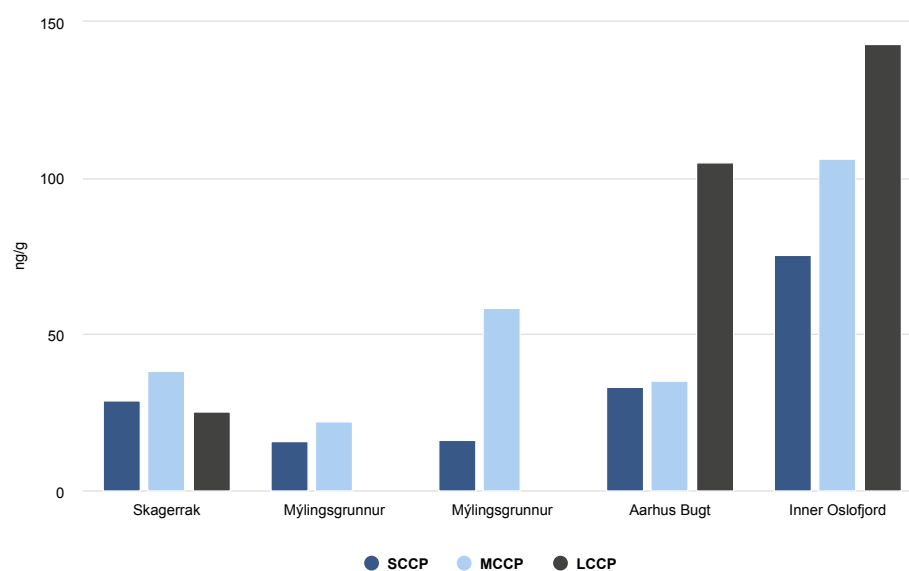


Figure 9: Levels of CPs in cod liver samples.

3.3.4 Marine mammals

Two samples of blubber of grey seal (*Halichoerus grypus*) were delivered by Denmark. All three compound groups could be detected in one or the other of the two samples (Table 19). The measured levels of SCCPs, MCCPs, and LCCPs are in the same range as measured earlier by (Yuan et al., 2019b).

Table 19: Concentration of Chlorinated paraffins in samples of marine mammals.

	SCCPs	MCCPs	LCCPs
Sample type (Number)	(Min-max) Average Detection frequency	ng/g ww	
Seal blubber (2)	(<20-166) 166 50%	(<20-48.8) 48.8 50%	(<20-284) 132 50%

3.3.5 Terrestrial mammals

Moose (*Alces alces*), red deer (*Cervus elaphus*), and reindeer (*Rangifer tarandus*) samples were analysed for chlorinated paraffins. SCCPs and MCCPs were detected in all samples of selected terrestrial mammals (Table 20). LCCPs were detected in 60% of all selected samples. For nearly all samples of terrestrial mammals the concentrations of MCCPs were as high as the SCCP concentrations. For the cases where LCCPs were detected, the concentration was in the same range as the SCCP concentrations. Taking into account that the concentrations in this study were given on wet weight base and given a very low fat content in muscle of moose and deer, these levels are in the same order of magnitude as measured recently by (Yuan et al., 2019b).

Table 20: Concentration of Chlorinated paraffins in samples of liver and muscle of terrestrial mammals.

	SCCPs	MCCPs	LCCPs
Sample type (Number)	(Min-max) Average Detection frequency	ng/g ww	
Terrestrial mammals (9)	(0.57-11.9) 4.70 100%	(2.55-14.5) 9.68 100%	(<21-13.8) 10.1 60%

3.3.6 Air

Ambient air samples were taken at four different stations, three remote stations: Råö, Sweden, Birkenes, Norway, and Pallas, Finland; and one urban station: Reykjavik, Iceland. In contrast to all other samples of this study for ambient air relevant field blank samples were available (Table 21). The measured levels of CPs were depending on the total amount of air volume sampled and were well below the levels measured in real samples. Field blank concentrations were subtracted, when calculating the ambient air concentration reported here.

SCCPs were found in all samples from all stations (Table 21). MCCPs and LCCPs were found in 73% of all samples. In contrast to most of the biota samples the

concentrations of SCCPs, MCCPs, and LCCPs were quite similar for the remote air samples. SCCPs and MCCPs showed significantly higher concentrations in ambient air taken at the urban site in Reykjavik. The levels of SCCPs and MCCPs measured at the remote site were in the same range as measured at the Norwegian air monitoring observatory Birkenes (Bohlin-Nizzetto et al., 2020) and the Swedish air monitoring stations Råö and Aspvreten (Fredricsson et al., 2021).

Table 21: Concentration of chlorinated paraffins in samples of ambient air from the three remote sites (Råö, Birkenes, and Pallas), from the urban site (Reykjavik), and field blank samples.

	SCCPs	MCCPs	LCCPs
Sample type (Number)	(Min-max) Average Detection frequency		ng/g ww
Ambient air REM (8)	(43.6-547) 194 100%	(<1160-2612) 570 63%	(<100-190) 97.0 63%
Ambient air URB (3)	(1792-3006) 2473 100%	(1160-1606) 1325 100%	(12452-33548) 21202 100%
Field blank air	~8	~12	~14

The levels of SCCPs and MCCPs measured at the urban site were in the same range as measurements with passive air samplers in Oslo, SCCPs/MCCPs: 300-5900/80-1130 pg/m³ (Heimstad et al., 2018, Heimstad et al., 2019, Heimstad et al., 2020). However, the Oslo sampling sites were not as close to main roads as the Reykjavik site in this study. In addition, passive air sampling often underestimate particle bound pollutants.

In contrast to the biota samples the concentrations of SCCPs, MCCPs, and LCCPs were quite similar for the remote air samples. In the urban air sample from Reykjavik LCCPs were highest and MCCPs lowest.

The higher levels of CPs found in urban air might be caused by tire wear particles (TWP). A recent study measured low but significant levels of all three CP classes in car tires (Brandsma et al., 2019). However, other sources of chlorinated paraffins cannot be excluded.

3.3.7 Pine needles

Pine needles were collected at six remote sites: Tornby Klitplantage, Låsby, Hollola, Inari, Birkenes, and Råö; and three urban sites: Helsinki, Tórshavn, and Reykjavik. All three compound groups were frequently found in all samples (Table 22 to Table 23). To our best knowledge this is the first time SCCPs, MCCPs, and LCCPs were detected in pine needles from the Nordic environment. The SCCP levels found in this study were one or two orders of magnitude lower compared to measurements from

Beijing, China: 400-4 010 ng/g dw (Wang et al., 2015) and in the same range as samples from the European Alps: 26-450 ng/g dw (Iozza et al., 2009).

Table 22: Summarized overview over concentration of chlorinated paraffins in samples of pine needles from remote and urban sites.

	SCCPs	MCCPs	LCCPs
Sample type (Number)	(Min-max) Average Detection frequency		ng/g ww
Pine needles REM	(<3-297) 112 50%	(<6-72.5) 38.4 60%	(<20-1296) 687 30%
Pine needles URB	(3.38-198) 48.9 100%	(10.5-31.8) 22.9 100%	(1<20-1035) 436 80%

Table 23: Detailed results of chlorinated paraffins in samples of pine needles from remote and urban sites.

	SCCPs	MCCPs	LCCPs
	ng/g dw		
Tornby REM	166	13.7	<20
Låsby REM	297	18.5	<20
Hollola REM	44.5	55.3	303
Inari REM	23.8	72.5	461
Inari REM	26.9	69.2	1296
Birkenes REM	<3	<6	<20
Birkenes REM	<3	<6	<50
Birkenes REM	<3	<6	<20
Råö REM	<3	<6	<20
Råö REM	<3	1.39	<20
Helsinki URB	198	27.9	<20
Tórshavn URB	30.1	31.8	1035
Tórshavn URB	3.38	23.4	275
Tórshavn URB	8.82	21.1	429
Reykjavík URB	4.03	10.5	5.90

As shown in chapter 2.4.4, the overall measurement uncertainty of the CP results of pine needles are very high and much higher than the measurement uncertainty for the other sample types. In contrast to air samples, no clear spatial trend nor remote/urban difference could be identified. Even with this higher uncertainty it is beyond any doubt that pine needles and of course any other vegetation even in very remote areas are contaminated by CPs. The only reasonable pathway for this contamination is atmospheric long range transport and deposition. The accumulation of CPs on pine needles and other vegetation can be an important driver for the elevated levels of CPs in terrestrial animals, which are feeding on these plants.

4 Conclusions

The selected UV-compounds were frequently detected in samples related to the marine food web (bird eggs, cod liver, and grey seal). Freshwater biota is much less polluted with UV-compounds and only the perch liver sample from Lake Mjøsa showed results above detection limit. In samples of terrestrial mammals, it was not possible to detect any of these UV-compounds. The compounds UV-320, 327, and 328 were most frequently found. The Herring gull sample from Inner Oslofjord was the most contaminated sample in this study with the highest number of UV-compounds above LoD. In this sample, UV-328 was significantly higher than in all remote samples, which could be related to the urban feeding habits of the Inner Oslofjord population. The results of this study confirm earlier findings of the UV-compounds in the Nordic environment and are highly relevant for the ongoing process in the review committee of the Stockholm convention.

In the group of dechloranes, Dec602 was detected most frequently in samples related to the marine, freshwater, and terrestrial food web. Urban samples often showed higher levels of Dec602 than remote samples of the same sample type. The parent compounds DPsyn and DPanti were only occasionally found in biota samples. However, in air samples, only the parent compounds DPsyn and DPanti could be detected.

SCCPs and MCCPs were found in most of the samples, and LCCPs with a slightly lower detection frequency. For nearly all biota samples, the concentrations of MCCPs were higher than the SCCP-concentrations. For the cases where LCCPs were detected, the concentration was as high or higher than the SCCP-concentration. In contrast to the biota samples, the concentrations of SCCPs, MCCPs, and LCCPs were quite similar for the remote air samples. In the urban air sample from Reykjavik, LCCPs were highest and MCCPs lowest.

The results of this study confirm earlier findings of CPs in the Nordic environment. In addition, this study report for the first time detection of LCCPs in freshwater fish and of SCCPs, MCCPs, and LCCPs in pine needles. These results are highly relevant to understand and discuss the fate and environmental hazard of MCCPs and LCCPs. The presence of SCCPs, MCCPs, and LCCPs in both air and pine needles confirm the long-range atmospheric transport potential of these compound groups.

This project has shown that CPs were present in all samples reported above detection limit. However, even with high resolution mass spectrometry and continuous improvements in quantification methods, the measurement uncertainty of CPs is still considerably higher than for most of the other organic pollutants. In addition, CPs together with many other emerging pollutants, are present in many technical products and articles of daily use and the risk for sample contamination is much higher compared to legacy compounds like DDT or PCB, which have been regulated a long time ago. Even with strict sampling protocols, there is a need to monitor and control any risk of contamination at all stages (sampling, transport, storage, homogenization, extraction, clean-up, and instrumental analysis). Field blanks were successfully applied for air samples in this study, but for many other sample types, the selection of potential field blank material is not easy and should be discussed in more detail.

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Appendix A

Complete data table

NILU number	NIVA number	Country	Matrix acronym	Location type	Species	Location	Sample specification	Lat	Long
20/0764		FIN	AIR	REM	Air	Pallas		67.973302	24.115680
20/0766		FIN	AIR	REM	Air	Pallas		67.973302	24.115680
20/1145		NO	AIR	REM	Air	Birkenes		58.388446	8.252055
20/1314		NO	AIR	REM	Air	Birkenes		58.388446	8.252055
20/1589		NO	AIR	REM	Air	Birkenes		58.388446	8.252055
20/1807		NO	AIR	REM	Air	Birkenes		58.388446	8.252055
20/0763		SE	AIR	REM	Air	Rådö		57.393998	11.913868
20/0765		SE	AIR	REM	Air	Rådö		57.393998	11.913868
20/0548		ICE	AIR	URB	Air	Reykjavík	202702-003	64.130115	-21.874738
20/0549		ICE	AIR	URB	Air	Reykjavík	202702-004	64.130115	-21.874738
20/0550		ICE	AIR	URB	Air	Reykjavík	202702-005	64.130115	-21.874738
20/1127	2019-14662	FO	EGG	REM	Black guillemot	Koltur	Eggs	61.977167	-6.957383
20/1141	2019-14708	SE	EGG	REM	Common guillemot	Stora Karlsö	Eggs	57.284967	17.971945
20/1128	2019-14663	FO	EGG	REM	Fulmar	Sandoy	Eggs	61.872133	-6.913100
20/1129	2019-14664	FO	EGG	REM	Fulmar	Sandoy	Eggs	61.872133	-6.913100
19/ 1470-1484	2019-14699	NO	EGG	URB	Herring gull	inner Oslofjord	Eggs	59.853170	10.728100
20/1094	2019-14614-1	DK	EGG	REM	Herring gull	Græsholm	Egg	57.492000	10.604000
20/1095	2019-14614-2	DK	EGG	REM	Herring gull	Græsholm	Egg	57.492000	10.604000
20/1096	2019-14614-3	DK	EGG	REM	Herring gull	Græsholm	Egg	57.492000	10.604000
20/1097	2019-14614-4	DK	EGG	REM	Herring gull	Græsholm	Egg	57.492000	10.604000
20/1098	2019-14614-5	DK	EGG	REM	Herring gull	Græsholm	Egg	57.492000	10.604000
20/1099	2019-14614-6	DK	EGG	REM	Herring gull	Græsholm	Egg	57.492000	10.604000
20/1100	2019-14614-7	DK	EGG	REM	Herring gull	Græsholm	Egg	57.492000	10.604000
20/1101	2019-14614-8	DK	EGG	REM	Herring gull	Græsholm	Egg	57.492000	10.604000
20/1140	2019-14707	SE	EGG	REM	Ural owl	Insjön	Eggs	60.642323	15.116698
20/1117	2019-14650	FIN	FFI	REM	Brown trout	River Juutua	Muscle	68.906826	27.003609
20/1123	2019-14657	FO	FFI	REM	Brown trout	Fjallavatn	Muscle	62.115000	-7.307333

20/1124_rep	2019-14658	FO	FFI	REM	Brown trout	Fjallavatn	Muscle	62.115000	-7.307333
20/1102	2019-14615	DK	FFI	REM	Perch	Klokkeholm Møllesø	Muscle	57.214200	10.162200
20/1107	2019-14622	DK	FFI	REM	Perch	Stadil Fjord	Muscle	56.159467	9.214378
20/1118	2019-14653-1	FIN	FFI	REM	Perch	Kivilahti	Whole perch	68.796311	27.508358
20/1119	2019-14653-2	FIN	FFI	REM	Perch	Kivilahti	Whole perch	68.796311	27.508358
20/1120	2019-14653-3	FIN	FFI	REM	Perch	Kivilahti	Whole perch	68.796311	27.508358
20/1121	2019-14653-4	FIN	FFI	REM	Perch	Kivilahti	Whole perch	68.796311	27.508358
20/1122	2019-14653-5	FIN	FFI	REM	Perch	Kivilahti	Whole perch	68.796311	27.508358
20/1138	2019-14705	SE	FFI	REM	Perch	Krageholms- sjön	Muscle	55.501152	13.744153
20/1139	2019-14706	SE	FFI	REM	Perch	Brännträsket	Muscle	65.535092	21.396842
20/1108	2019-14643-1	FIN	FFI	URB	Perch	Vallisaari	Whole perch	60.131593	24.987946
20/1109	2019-14643-2	FIN	FFI	URB	Perch	Vallisaari	Whole perch	60.131593	24.987946
20/1110	2019-14643-2	FIN	FFI	URB	Perch	Vallisaari	Whole perch	60.131593	24.987946
20/1111	2019-14643-4	FIN	FFI	URB	Perch	Vallisaari	Whole perch	60.131593	24.987946
20/1112	2019-14643-5	FIN	FFI	URB	Perch	Vallisaari	Whole perch	60.131593	24.987946
20/1131	2019-14692	NO	FFI	URB	Perch	Mjøsa	Liver	60.756030	11.076780
20/1103	2019-14617	DK	MFI	REM	Cod	Skagerrak	Liver	57.758994	9.971547
20/1125	2019-14659	FO	MFI	REM	Cod	Mýlings- grunnur	Liver	62.366667	-7.450000
20/1126	2019-14660	FO	MFI	REM	Cod	Mýlings- grunnur	Liver	62.366667	-7.450000
20/1104	2019-14618	DK	MFI	URB	Cod	Aarhus Bugt	Liver	56.141583	10.235250
20/1130	2019-14691	NO	MFI	URB	Cod	Inner Oslofjord	Liver	59.832690	10.580430
20/1105	2019-14620	DK	MMA	REM	Grey seal	Horsens Fjord	Seal blubber	55.853167	10.011667
20/1106	2019-14621	DK	MMA	REM	Grey seal	Sønderho, Fanø	Seal blubber	55.347694	8.475139
20/0946B	2019-14616	DK	PIN	REM	Pine needles	Tornby		57.542878	9.918256
20/0947B	2019-14619	DK	PIN	REM	Pine needles	Låsby		56.147667	9.819111
20/0949b	2019-14644	FIN	PIN	REM	Pine needles	Hollola		61.058361	25.334975
20/0949 c1	as above	FIN	PIN	REM	Pine needles	Hollola		61.058361	25.334975
20/0949 c2	with washing	FIN	PIN	REM	Pine needles	Hollola		61.058361	25.334975
20/0950b	2019-14651	FIN	PIN	REM	Pine needles	Inari		68.905834	26.995323
20/0951b	2019-14652	FIN	PIN	REM	Pine needles	Inari		68.905834	26.995323
20/1935b	NO, Birkenes	NO	PIN	REM	Pine needles	Birkenes		58.390590	8.248255

20/1935b	as above	NO	PIN	REM	Pine needles	Birkenes		58.390590	8.248255
20/1935b	with washing	NO	PIN	REM	Pine needles	Birkenes		58.390590	8.248255
20/1936b	NO, Birkenes	NO	PIN	REM	Pine needles	Birkenes		58.390590	8.248255
20/1937b	NO, Birkenes	NO	PIN	REM	Pine needles	Birkenes		58.390590	8.248255
20/0761	2019-14712	SE	PIN	REM	Pine needles	Råö		57.393736	11.913671
20/0762	2019-14713	SE	PIN	REM	Pine needles	Råö		57.394572	11.914117
20/0948b	2019-14642	FIN	PIN	URB	Pine needles	Helsinki		60.220498	25.119256
20/0952b	2019-14654	FO	PIN	URB	Pine needles	Tórshavn		62.016533	-6.780533
20/0953b	2019-14655	FO	PIN	URB	Pine needles	Tórshavn		62.016433	-6.780533
20/0954b	2019-14656	FO	PIN	URB	Pine needles	Tórshavn		62.016600	-6.781300
20/0955	2019-14678	ICE	PIN	URB	Pine needles	Reykjavík		64.129973	-21.876159
20/0955 c1	as above	ICE	PIN	URB	Pine needles	Reykjavík		64.129973	-21.876159
20/0955 c2	with washing	ICE	PIN	URB	Pine needles	Reykjavík		64.129973	-21.876159
20/1113	2019-14645	FIN	TMA	REM	Moose	Kurkimäki	Liver	62.798703	27.499224
20/1113	2019-14646	FIN	TMA	REM	Moose	Kurkimäki	Muscle	62.798703	27.499224
20/1135	2019-14702	SE	TMA	REM	Moose	Grimsö	Muscle	57.704792	15.576077
20/1134	2019-14698	NO	TMA	REM	Red deer	Folldal Einunnfjeller	Muscle	62.202270	10.350730
20/1115	2019-14648	FIN	TMA	REM	Reindeer	Oraniemi	Muscle	67.644112	27.307775
20/1116	2019-14649	FIN	TMA	REM	Reindeer	Kutuharju exp. station	Muscle	68.775225	26.818071
20/1132	2019-14696	NO	TMA	REM	Reindeer	Folldal Knutshø	Muscle	62.239830	9.891900
20/1133	2019-14697	NO	TMA	REM	Reindeer	Folldal Sønkletten	Muscle	62.075170	10.052170
20/1136	2019-14703	SE	TMA	REM	Reindeer	Norrkaitum Sameby	Muscle	68.262938	19.857487

Country	Species	Location	Unit	BP3	EHMC-E	EHMC-Z	OC	ODPABA	UV-320	UV-326	UV-327	UV-328	UV-329
FO	Black guillemot	Koltur	ng/g	<1.50	<1.50	<0.70	<1.20	<0.03	<0.05	<0.10	<0.04	<0.05	<0.30
SE	Common guillemot	Stora Karlsö	ng/g	<1.50	<1.50	<0.70	1.19	<0.03	<0.05	<0.10	0.12	<0.05	<0.30
FO	Fulmar	Sandoy	ng/g	<1.50	<1.50	<0.70	<1.20	<0.03	0.14	<0.10	0.07	0.05	<0.30
FO	Fulmar	Sandoy	ng/g	<1.50	1.57	<0.70	1.33	<0.03	0.19	<0.10	0.07	<0.05	<0.30
NO	Herring gull	inner Oslofjord	ng/g	<1.50	1.89	<0.70	1.36	<0.03	0.06	0.40	0.22	1.83	<0.30

DK	Herring gull	Græs-holm	ng/g	<1.50	<1.50	<0.70	<1.20	<0.03	<0.05	<0.10	<0.04	0.07	<0.30
DK	Herring gull	Græs-holm	ng/g	<1.50	<1.50	<0.70	<1.20	<0.03	<0.05	<0.10	<0.04	<0.05	<0.30
DK	Herring gull	Græs-holm	ng/g	<1.50	<1.50	<0.70	<1.20	<0.03	<0.05	<0.10	<0.04	<0.05	<0.30
DK	Herring gull	Græs-holm	ng/g	<1.50	<1.50	<0.70	<1.20	<0.03	<0.05	<0.10	0.07	0.19	<0.30
DK	Herring gull	Græs-holm	ng/g	<1.50	<1.50	<0.70	<1.20	<0.03	<0.05	<0.10	<0.04	<0.05	<0.30
DK	Herring gull	Græs-holm	ng/g	<1.50	<1.50	<0.70	<1.20	<0.03	<0.05	<0.10	0.09	0.07	<0.30
DK	Herring gull	Græs-holm	ng/g	<1.50	<1.50	<0.70	<1.20	<0.03	<0.05	<0.10	<0.04	<0.05	<0.30
DK	Herring gull	Græs-holm	ng/g	<1.50	<1.50	<0.70	<1.20	<0.03	<0.05	<0.10	<0.04	0.05	<0.30
SE	Ural owl	Insjön	ng/g	<1.50	<1.50	<0.70	<1.20	<0.03	<0.05	<0.10	0.05	<0.05	<0.30
FIN	Brown trout	River Juutua	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
FO	Brown trout	Fjallavatn	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
FO	Brown trout	Fjallavatn	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
DK	Perch	Klokker-holm Møllesø	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
DK	Perch	Stadil Fjord	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
FIN	Perch	Kivilahti	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
FIN	Perch	Kivilahti	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
FIN	Perch	Kivilahti	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
FIN	Perch	Kivilahti	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
FIN	Perch	Kivilahti	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
SE	Perch	Krage-holmssjön	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
SE	Perch	Bränn-träsket	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
FIN	Perch	Vallisaari	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
FIN	Perch	Vallisaari	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
FIN	Perch	Vallisaari	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
FIN	Perch	Vallisaari	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
FIN	Perch	Vallisaari	ng/g	<0.20	<0.05	<0.02	<1.00	<0.02	<0.03	<0.06	<0.04	<0.06	<0.40
NO	Perch	Mjøsa	ng/g	<0.20	<0.30	<0.05	<2.50	<0.04	0.05	<0.20	0.10	0.12	<0.20

DK	Cod	Skagerrak	ng/g	0.29	<0.30	<0.05	<2.50	<0.04	0.31	<0.20	0.51	0.36	2.78
FO	Cod	Mýlings-grunnur	ng/g	<0.20	<0.30	<0.05	<2.50	<0.04	<0.05	<0.20	<0.10	0.12	0.38
FO	Cod	Mýlings-grunnur	ng/g	<0.20	<0.30	<0.05	<2.50	<0.04	<0.05	<0.20	<0.10	<0.06	<0.20
DK	Cod	Aarhus Bugt	ng/g	<0.20	<0.30	<0.05	<2.50	<0.04	0.11	<0.20	0.51	0.41	0.77
NO	Cod	Inner Oslofjord	ng/g	<0.20	<0.30	<0.05	<2.50	<0.04	2.15	<0.20	1.83	7.53	<0.20
DK	Grey seal	Horsens Fjord	ng/g	<0.30	<0.40	<0.08	<5.00	<0.08	0.29	<0.30	0.60	0.80	<0.50
DK	Grey seal	Sønderho Fanø	ng/g	<0.30	<0.40	<0.08	<5.00	<0.08	0.10	<0.30	<0.20	<0.10	<0.50
FIN	Moose	Kurkimäki	ng/g	<1.40	<1.00	<0.50	<1.20	<0.05	<0.03	<0.05	<0.02	<0.02	<0.70
FIN	Moose	Kurkimäki	ng/g	<1.40	<1.00	<0.50	<1.20	<0.05	<0.03	<0.05	<0.02	<0.02	<1.70
SE	Moose	Grimsö	ng/g	<1.40	<1.00	<0.50	<1.20	<0.05	<0.03	<0.05	<0.02	<0.02	<0.50
NO	Red deer	Folldal Einunnfjeller	ng/g	<1.40	<1.00	<0.50	<1.20	<0.05	<0.03	<0.05	<0.02	<0.02	<0.50
FIN	Reindeer	Oraniemi	ng/g	<1.40	<1.00	<0.50	<1.20	<0.05	<0.03	<0.05	<0.02	<0.02	<1.00
FIN	Reindeer	Kutuharju exp. station	ng/g	<1.40	<1.00	<0.50	<1.20	<0.05	<0.03	<0.05	<0.02	<0.02	<0.10
NO	Reindeer	Folldal Knutshø	ng/g	<1.40	<1.00	<0.50	<1.20	<0.05	<0.03	<0.05	<0.02	<0.02	<0.50
NO	Reindeer	Folldal Sønkleppen	ng/g	<1.40	<1.00	<0.50	<1.20	<0.05	<0.03	<0.05	<0.02	<0.02	<0.60
SE	Reindeer	Norrkåstum Sameby	ng/g	<1.40	<1.00	<0.50	<1.20	<0.05	<0.03	<0.05	<0.02	<0.02	<0.50

Country	Species	Location	Unit	Dibromodrin	Dechlorane 602	Dechlorane 603	Dechlorane 604	Dechlorane 601	Dechlorane plus syn	Dechlorane plus anti	SCCPs	MCCPs	LCCPs
FIN	Air'	Pallas	pg/m3	<0.01	<0.02	<0.02	<0.05	<0.01	<0.02	<0.02	74.0	59.1	35.6
FIN	Air'	Pallas	pg/m3	<0.01	<0.02	<0.02	<0.07	<0.02	<0.03	<0.03	105	66.9	17.3
NO	Air'	Birkenes	pg/m3	<0.08	<0.02	<0.02	<0.39	<0.10	<0.16	0.21	547	2 612	190
NO	Air'	Birkenes	pg/m3	<0.13	<0.03	<0.03	<0.93	<0.17	0.27	0.95	258	<1160	<100
NO	Air'	Birkenes	pg/m3	<0.12	<0.03	<0.03	<0.90	<0.16	0.13	0.34	179	<1160	<100
NO	Air'	Birkenes	pg/m3	<0.13	<0.03	<0.03	<0.93	<0.17	<0.12	0.30	280	<1160	130
SE	Air'	Råö	pg/m3	<0.01	<0.01	<0.01	<0.05	<0.01	<0.02	0.07	66.5	45.7	112
SE	Air'	Råö	pg/m3	<0.05	<0.01	<0.01	<0.26	<0.07	<0.11	<0.12	43.6	67.3	<50.00
ICE	Air'	Reykjavík	pg/m3	<0.03	<0.01	<0.01	<0.16	<0.04	<0.07	0.13	3 006	1 160	17 607

ICE	Air'	Reykjavík	pg/m3	<0.03	<0.01	<0.01	<0.17	<0.04	0.18	0.71	2 622	1 209	12 452
ICE	Air'	Reykjavík	pg/m3	<0.03	<0.01	<0.01	<0.18	<0.04	0.11	0.26	1 792	1 606	33 548
FO	Black guillemot	Koltur	ng/g	<0.05	0.03	<0.01	<0.25	<0.06	<0.11	<0.12	3.22	15.6	<10
SE	Common guillemot	Stora Karlsö	ng/g	<0.05	0.52	<0.01	<0.25	<0.06	<0.11	<0.12	2.68	46.0	<10
FO	Fulmar	Sandoy	ng/g	<0.05	0.27	<0.01	<0.25	<0.06	<0.11	<0.12	12.3	13.0	<10
FO	Fulmar	Sandoy	ng/g	<0.05	0.44	<0.01	<0.25	<0.06	<0.11	<0.12	14.1	18.6	<10
NO	Herring gull	inner Oslofjord	ng/g	<0.07	0.09	0.05	<0.19	<0.03	0.29	0.8	22.0	25.0	<10
DK	Herring gull	Græs-holm	ng/g	<0.05	0.05	0.04	<0.25	<0.06	<0.11	0.12	22.3	49.5	<10
DK	Herring gull	Græs-holm	ng/g	<0.05	0.04	0.04	<0.25	<0.06	<0.11	<0.12	16.4	11.7	<10
DK	Herring gull	Græs-holm	ng/g	<0.05	0.06	0.06	<0.25	<0.06	<0.11	<0.12	7.28	15.9	<10
DK	Herring gull	Græs-holm	ng/g	<0.05	0.15	0.04	<0.25	<0.06	<0.11	0.19	11.9	78.2	341
DK	Herring gull	Græs-holm	ng/g	<0.05	0.06	0.05	<0.25	<0.06	<0.11	<0.12	6.35	18.1	<10
DK	Herring gull	Græs-holm	ng/g	<0.05	0.26	0.11	<0.25	<0.06	<0.11	0.17	2.46	24.0	42.3
DK	Herring gull	Græs-holm	ng/g	<0.05	0.07	0.05	<0.25	<0.06	<0.11	<0.12	6.63	27.2	<10
DK	Herring gull	Græs-holm	ng/g	<0.05	0.09	0.05	<0.25	<0.06	<0.11	<0.12	14.2	17.7	<10
SE	Ural owl	Insjön	ng/g	<0.05	0.23	0.05	<0.25	<0.06	<0.11	<0.12	3.82	79.6	11.5
FIN	Brown trout	River Juutua	ng/g	<0.010	0.019	<0.002	<0.05	<0.01	<0.02	<0.02	9.04	17.0	7.81
FO	Brown trout	Fjallavatn	ng/g	<0.010	0.012	<0.002	<0.05	<0.01	<0.02	<0.02	5.50	28.0	9.69
FO	Brown trout	Fjallavatn	ng/g	<0.013	0.01	<0.004	<0.09	<0.02	<0.02	<0.02	<0.25	<0.65	<2
DK	Perch	Klokker-holm Møllesø	ng/g	<0.010	<0.002	<0.002	<0.05	<0.01	<0.02	<0.02	2.67	11.0	<2
DK	Perch	Stadil Fjord	ng/g	<0.127	<0.026	<0.034	<0.70	<0.16	<0.21	<0.23	1.47	1.82	<2
FIN	Perch	Kivilahti	ng/g	<0.010	<0.002	<0.002	<0.05	<0.01	<0.02	<0.02	4.04	12.6	<2
FIN	Perch	Kivilahti	ng/g	<0.011	<0.002	<0.003	<0.06	<0.01	<0.02	<0.02	2.36	11.6	2.70
FIN	Perch	Kivilahti	ng/g	<0.010	<0.002	<0.002	<0.05	<0.01	<0.02	<0.02	1.88	9.36	<2
FIN	Perch	Kivilahti	ng/g	<0.010	<0.002	<0.002	<0.05	<0.01	<0.02	<0.02	2.94	31.9	<2
FIN	Perch	Kivilahti	ng/g	<0.010	<0.002	<0.002	<0.05	<0.01	<0.02	<0.02	2.94	31.9	5.02

SE	Perch	Krage- holmssjön	ng/g	<0.010	<0.002	<0.002	<0.05	<0.01	<0.02	<0.02	1.37	8.06	<2
SE	Perch	Bränn- träsket	ng/g	<0.010	<0.002	<0.002	<0.05	<0.01	<0.02	<0.02	1.89	13.1	<2
FIN	Perch	Vallisaari	ng/g	<0.024	<0.005	<0.004	<0.17	<0.02	<0.02	<0.02	<0.60	<1.52	<2
FIN	Perch	Vallisaari	ng/g	<0.024	<0.005	<0.007	<0.16	<0.03	<0.02	<0.02	16.9	48.5	37.8
FIN	Perch	Vallisaari	ng/g	<0.010	0.008	<0.002	<0.05	<0.01	<0.02	<0.02	4.18	7.25	4.21
FIN	Perch	Vallisaari	ng/g	<0.010	0.004	<0.002	<0.05	<0.01	<0.02	<0.02	4.77	11.6	5.61
FIN	Perch	Vallisaari	ng/g	<0.010	0.005	<0.002	<0.05	<0.01	<0.02	<0.02	5.57	14.5	2.30
NO	Perch	Mjøsa	ng/g	<0.05	0.02	<0.01	<0.25	<0.06	<0.11	0.32	42.4	138	32.7
DK	Cod	Skagerrak	ng/g	<0.06	0.12	0.02	<0.31	<0.07	<0.11	<0.12	28.9	38.4	25.1
FO	Cod	Mýlings- grunnur	ng/g	<0.06	0.06	<0.02	<0.32	<0.08	<0.11	<0.12	15.7	22.0	<10
FO	Cod	Mýlings- grunnur	ng/g	<0.05	0.06	<0.01	<0.25	<0.06	<0.11	<0.12	16.2	58.3	<10
DK	Cod	Aarhus Bugt	ng/g	<0.05	0.13	0.02	<0.29	<0.06	<0.11	<0.12	33.1	35.1	105
NO	Cod	Inner Oslofjord	ng/g	<0.05	0.29	0.08	<0.25	<0.06	<0.11	<0.12	75.4	106	143
DK	Grey seal	Horsens Fjord	ng/g	<0.19	56.4	0.34	<1.33	<0.31	0.96	1.79	166	<20	284
DK	Grey seal	Sønderho, Fanø	ng/g	<0.14	0.33	<0.04	<0.75	<0.18	<0.21	<0.23	<20	48.8	<20
DK	Pine needles	Tornby	ng/g	<0.15	<0.03	<0.04	<0.99	<0.25	<0.13	<0.16	166	13.7	<20
DK	Pine needles	Låsby	ng/g	<0.13	<0.03	<0.03	<0.96	<0.18	<0.13	<0.16	297	18.5	<20
FIN	Pine needles	Hollola	ng/g	<0.16	<0.03	<0.04	<1.14	<0.21	<0.15	<0.19	44.5	55.3	303
FIN	Pine needles	Hollola	ng/g	na	na	na	na	na	na	na	<20	<20	<20
FIN	Pine needles	Hollola	ng/g	na	na	na	na	na	na	na	23.0	123	<20
FIN	Pine needles	Inari	ng/g	<0.15	<0.03	<0.04	<1.08	<0.19	<0.14	<0.18	23.8	72.5	461
FIN	Pine needles	Inari	ng/g	<0.14	<0.03	<0.04	<1.04	<0.19	<0.14	<0.18	26.9	69.2	1 296
NO	Pine needles	Birkenes	ng/g	<0.18	<0.04	<0.04	<1.32	<0.24	<0.18	<0.22	<3	<6	<20
NO	Pine needles	Birkenes	ng/g	na	na	na	na	na	na	na	<3	59.7	<20
NO	Pine needles	Birkenes	ng/g	na	na	na	na	na	na	na	<3	47.0	<20
NO	Pine	Birkenes	ng/g	<0.41	<0.08	<0.10	<2.98	<0.54	<0.40	<0.50	<3	<6	<50

needles													
NO	Pine needles	Birkenes	ng/g	<0.16	<0.03	<0.04	<1.17	<0.21	<0.16	<0.20	<3	<6	<20
SE	Pine needles	Råö	ng/g	<0.17	<0.03	<0.04	<1.22	<0.22	<0.16	<0.20	<3	<6	<20
SE	Pine needles	Råö	ng/g	<0.16	<0.03	<0.04	<1.14	<0.21	<0.15	<0.19	<3	1.39	<20
FIN	Pine needles	Helsinki	ng/g	<0.14	<0.03	<0.06	<0.98	<0.35	<0.13	<0.23	198	27.9	<20
FO	Pine needles	Tórshavn	ng/g	<0.15	<0.03	<0.04	<1.10	<0.20	<0.15	<0.19	30.1	31.8	1 035
FO	Pine needles	Tórshavn	ng/g	<0.16	<0.03	<0.04	<1.17	<0.21	<0.16	<0.20	3.38	23.4	275
FO	Pine needles	Tórshavn	ng/g	<0.17	<0.03	<0.04	<1.19	<0.21	<0.16	<0.20	8.82	21.1	429
ICE	Pine needles	Reykjavík	ng/g	<0.16	<0.03	<0.04	<1.17	<0.21	<0.16	<0.20	4.03	10.5	5.90
ICE	Pine needles	Reykjavík	ng/g	na	na	na	na	na	na	na	60.1	198	72.8
ICE	Pine needles	Reykjavík	ng/g	na	na	na	na	na	na	na	61.2	174	51.2
FIN	Moose	Kurkimäki	ng/g	<0.050	0.032	<0.012	<0.25	<0.06	<0.11	<0.12	11.9	39.4	<2
FIN	Moose	Kurkimäki	ng/g	<0.005	<0.001	<0.001	<0.03	<0.01	<0.01	<0.01	2.10	5.92	2.95
SE	Moose	Grimsö	ng/g	<0.005	<0.001	<0.001	<0.03	<0.01	<0.01	<0.01	7.04	200	72.5
NO	Red deer	Folldal Einunnfjeller	ng/g	<0.005	0.008	<0.001	<0.03	<0.01	<0.01	<0.01	1.74	6.81	<1
FIN	Reindeer	Oraniemi	ng/g	<0.005	0.003	<0.001	<0.03	<0.01	<0.01	<0.01	2.60	10.6	13.7
FIN	Reindeer	Kutuharju exp. station	ng/g	<0.005	0.001	<0.001	<0.03	<0.01	<0.01	<0.01	8.07	7.74	13.8
NO	Reindeer	Folldal Knutshø	ng/g	<0.005	0.001	<0.001	<0.03	<0.01	<0.01	<0.01	0.57	2.55	<1
NO	Reindeer	Folldal Sønkletten	ng/g	<0.005	0.003	<0.001	<0.03	<0.01	<0.01	<0.01	2.33	13.0	<1
SE	Reindeer	Norrkai-tum Sameby	ng/g	<0.005	0.002	<0.001	<0.03	<0.01	<0.01	<0.01	5.91	14.5	2.70

Appendix B

Sample Information Reported by the Countries

Denmark: Screening of Chlorinated Parffins, Deschloranes and UV filters in Nordic countries

Sample list

									LAT WGS84			LONG WGS84		
Country	Sample no	Matrix	Sample ident.	Location	Site	Species etc	Tissue	Sampling date	Deg	Decimal min	N	Deg	Decimal min	W/E
DK	1	EGG	NR-2019-14614	Græsholm	10 eggs collected from n	Herring gull (<i>Larus argentatus</i>)	Whole egg	10.06.2019	57	29°31,2	N	10	36°14,4	E
DK	2	FFI	NR-2019-14615	Klokkerholm Møllesø		Perch	Whole fish	28.08.2019	57	12°51,12	N	10	09°43,92	E
DK	3	PIN	NR-2019-14616	Tornby Klitplantage		Mountain pine (<i>Pinus mugo</i>)	Pine needles	20.11.2019	57	32°34,36	N	9	55°05,72	E
DK	4	MFI	NR-2019-14617	Skagerrak	North of Hirtshals	Cod	Liver	15.11.2019	57	45°32,38	N	9	58°17,57	E
DK	5	MFI	NR-2019-14618	Aarhus Bugt	Århus Harbour	Cod	Liver	04.12.2019	56	08°29,7	N	10	14°06,9	E
DK	6	PIN	NR-2019-14619	Låsby	Close to Highway	Mountain pine (<i>Pinus mugo</i>)	Pine needles	08.12.2019	56	08°51,6	N	9	49°08,8	E
DK	7	MMA	NR-2019-14620	AU ID 60232*	NB merking 60323(akr)	Grey seal	Blubber				N			E
DK	8	MMA	NR-2019-14621	AU ID 60324*		Grey seal	Blubber				N			E
DK	9	FFI	NR-2019-14622	Stadil Fjord		Perch	Whole fish	21.08.2019	56	09°34,082	N	9	12°51,761	E
DK	10		NR-2019-14623								N			E
DK	11		NR-2019-14624								N			E
DK	12		NR-2019-14625								N			E

NOTES

* further details will be sent

Country	Matrix	Acronym	Matrix	Sample 2	Sample 4:	Sample 5:	Sample 9:
DK	AIR	Air		Individual fish	Sampling dates: 13-11-19, 15-11-19 and 17-11-19	Sampling dates: 1-16-2019 to 6-12-2019	Individual fish:
FI	PIN	Pine needle		Length	Individual fish:	Individual fish	Length
FO	FFI	Freshwater fish		Weight	Weight	Weight	Weight
GL	MFI	Marine fish		21,5 cm	42 cm	11500 g	8,2 cm
IS	EGG	Bird eggs		137,1 g	27 cm	775g	7,4 g
NO	TMA	Terrestrial mammals		23,0 cm	37 cm	500 g	17,0 cm
SE	MMA	Marine mammal		165,5 g	39 cm	1300 g	70,3 g
				204,6 g	40 cm	600 g	83,1 g
				24,0 cm	40 cm	850 g	17,5 cm
				192,4 g	36 cm	850 g	80,0 g
				22,5 cm			19,4 cm
				197,4 g			137,8 g
							19,5 cm
							144,4 g
							18,7 cm
							124,0 g

Faroe Islands: Screening of Chlorinated Parffins, Deschloranes and UV filters in Nordic countires

Sample list

Select from list		Select from list							LAT WGS84			LONG WGS84		
Country	Sample no	Matrix	Sample ident.	Location	Site	Species etc	Tissue	Sampling date	Deg	Decimal min	N	Deg	Decimal min	W
FO	1	PIN	NR-2019-14654	Torshavn	Vidarlundin	Pine	Twigs	15.11.2019	62	0,992	N	6	46,832	W
FO	2	PIN	NR-2019-14655	Torshavn	Vidarlundin	Pine	Twigs	15.11.2019	62	0,986	N	6	46,832	W
FO	3	PIN	NR-2019-14656	Torshavn	Vidarlundin	Pine	Twigs	17.11.2019	62	0,996	N	6	46,878	W
FO	4	FFI	NR-2019-14657	Fjallavatn		Brown trout (Salmo trutta)	Muscle	31.07.2019	62	6,900	N	7	18,440	W
FO	5	FFI	NR-2019-14658	Fjallavatn		Brown trout (Salmo trutta)	Muscle	31.07.2019	62	6,900	N	7	18,440	W
FO	6	MFI	NR-2019-14659	Mýlingsgrunnur		Cod (Gadus morhua)	Liver	27.09.2019	62	22	N	7	27	W
FO	7	MFI	NR-2019-14660	Mýlingsgrunnur		Cod (Gadus morhua)	Liver	27.09.2019	62	22	N	7	27	W
FO	8	MMA*	NR-2019-14661	Hvalvik		Pilot whale (Globicephala)	Blubber	02.08.2019	62	11,368	N	7	1,752	W
FO	9	EGG	NR-2019-14662	Koltur		Black guillemot (Cepphus grylle)	Eggs	jun.18	61	58,630	N	6	57,443	W
FO	10	EGG	NR-2019-14663	Sandoy	Lonin	Fulmar (Fulmarus glacialis)	Eggs	21.05.2019	61	52,328	N	6	54,786	W
FO	11	EGG	NR-2019-14664	Sandoy	Lonin	Fulmar (Fulmarus glacialis)	Eggs	21.05.2019	61	52,328	N	6	54,786	W
FO	12	MMA*	NR-2019-14665	Sandagerdi		Pilot whale (Globicephala)	Blubber	29.05.2019	62	0,034	N	6	46,731	W
FO	13	MMA*	Kine fill in	Vestmanna		Pilot whale (Globicephala)	Blubber	27.08.2019	62	9,182	N	7	9,229	W

*Original labels not used, and minimum one sample delivered in glass jar purified by us (by heat treatment at +450C for min. 4 hrs after washing and rinsing with dist water)

NOTES

Country	Matrix Acronym	Matrix
DK	AIR	Air
FI	PIN	Pine needle
FO	FFI	Freshwater fish
GL	MFI	Marine fish
IS	EGG	Bird eggs
NO	TMA	Terrestrial mammals
SE	MMA	Marine mammal

Brown trout samples were taken during July and August 2019. The pooled samples are "Trout M1": 3 male fish 32.5 to 40.2 cm fork length (IDs: Fg 387 to 391). Cod liver samples are "Cod L1": 10 individuals (Gm1412 to 1421), 6 females and 4 males, 46 to 67 cm fork length, and "Cod L2": 7 individual (IDs: Fg 387 to 391). FO-10 EGG: Fulmar eggs pooled sample, subsamples of 12 g from each of 5 fork homogenised eggs (IDs: Fg 387 to 391). FO-11 EGG: Fulmar

MMA Hvalvik: Juvenile males, 3 indiv. (020819-4, 15 and 16), 346 to 478 cm fork length.
MMA Sandagerdi: Juvenile males, 3 indiv. (290519-5, 55 and 84), 370 to 448 cm fork length.
MMA Vestmanna: Juvenile males, 4 indiv. (270819-40, 61, 76 and 77), 390 to 410 cm fork length.

Finland: Screening of Chlorinated Parffins, Deschloranes and UV filters in Nordic countires

Sample list

									LAT WGS84			LONG WGS84		
Country	Sample no	Matrix	Sample ident.	Location	Site	Species etc	Tissue	Sampling date	Deg	Decimal min	N	Deg	Decimal min	W/E
FI	1	PIN	NR-2019-14642	Helsinki	Viiikki, experimental farm	pine	needle	04.12.2019	60	2204978	N	25	119256	E
FI	2	MFI	NR-2019-14643	Helsinki	Vallisaari	perch	whole	17.10.2019	60	1315932	N	24	987946	E
FI	3	PIN	NR-2019-14644	Hollola	Sairakkala	pine	needle	27.11.2019	61	61.058361	N	25	334975	E
FI	4	PIN	NR-2019-14645	Kuopio	tba	moose	liver	15.04.2019			N			E
FI	5	TMA	NR-2019-14646	Kuopio	Kurkimäki	moose	muscle	15.11.2019	62	62.798703	N	27	27.499224	E
FI	6		NR-2019-14647	NO SAMPLE		n.a.	n.a.				N			E

JAAKKO MANNIO, SYKE/Helsinki
p. +358 295 251 406

NOTES

Country	Matrix Acronym	Matrix
DK	AIR	Air
FI	PIN	Pine needle
FO	FFI	Freshwater fish
GL	MFI	Marine fish
IS	EGG	Bird eggs
NO	TMA	Terrestrial mammals
SE	MMA	Marine mammal

Fish is perch, coastal, outside Helsinki

Sweden: Screening of Chlorinated Parffins, Deschloranes and UV filters in Nordic countires

Sample list

Select from list									LAT WGS84			LONG WGS84		
Country	Sample no	Matrix	Sample ident.	Location	Site	Species etc	Tissue	Sampling date	Deg	Decimal min	N	Deg	Decimal min	W/E
SE	1	TMA	NR-2019-14702	Lindesbergs kommun	Grimsö	Moose	Muscle	28.10.2019	57	42,2875	N	15	34,5646	E
SE	2	TMA	NR-2019-14703	Kiruna kommun	Norrkaitum Sameby	Reindeer	Muscle	28.10.2019	68	15,7763	N	19	51,4492	E
SE	3	MMA	NR-2019-14704	Baltic Proper	Baltic Proper	Grey seal	Blubber	28.10.2019	57	42,0745	N	17	37,1759	E
SE	4	FFI	NR-2019-14705	Ystad kommun	Krageholmssjön	Perch	Muscle	29.10.2019	55	30,0691	N	13	44,6492	E
SE	5	FFI	NR-2019-14706	Piteå kommun	Brännträsket	Perch	Muscle	29.10.2019	65	32,1055	N	21	23,8105	E
SE	6	EGG	NR-2019-14707	Leksands kommun	Insjön	Ural owl	Egg content	30.10.2019	60	38,5394	N	15	7,0019	E
SE	7	EGG	NR-2019-14708	Gotlands kommun	Stora Karlsö	Common guillemot	Egg content	30.10.2019	57	17,098	N	17	58,3167	E
SE	8		NR-2019-14709								N			E
SE	9		NR-2019-14710								N			E
SE	10		NR-2019-14711								N			E
											N			E
											N			E

Naturhistoriska riksmuséet

NOTES

Country	Acronym	Matrix
DK	AIR	Air
FI	PIN	Pine needle
FO	FFI	Freshwater fish
GL	MFI	Marine fish
IS	EGG	Bird eggs
NO	TMA	Terrestrial mammals
SE	MMA	Marine mammal

Coordinates for Individuals included in Sample ID: NR-2019-14702 vary somewhat, the given coordinate is approximated to be within almost the same distance to all sites.
Actual sites: Grimsö, Nyckelmossen, Kylan, Lövön & Hågernäs (Västernmanland).

Coordinates for individuals included in sample ID: NR-2019-14704 vary somewhat, the given coordinate is approximated to be within almost the same distance to all sites.
Actual coordinates are: N 57 22,9999 E 17 1,9999, N 57 18,06 E16 50,7400, N 57 57,1000 E 16 50,5999, N 57 57,303 E 19 5,509 & N 56 59,709 E18 23,8660

Sample list

♀ 2,5 år >
♂ 0,5 år
♂ 2,5 år >

NOTES

Country	Matrix	
	Acronym	Matrix
DK	AIR	Air
FI	PIN	Pine needle
FO	FFI	Freshwater fish
GL	MFI	Marine fish
IS	EGG	Bird eggs
NO	TMA	Terrestrial mammals
SE	MMA	Marine mammal

~~Krav 9: 32V0559906 / UTM 0840432~~

Iceland: Screening of Chlorinated Parffins, Deschloranes and UV filters in Nordic countires

Sample list

Select from list		Select from list							LAT WGS84			LONG WGS84		
Country	Sample no	Matrix	Sample ident.	Location	Site	Species etc	Tissue	Sampling date	Deg	Decimal min	N	Deg	Decimal min	W/E
IS	1	PIN	NR-2019-14678	Reykjavik	Gunnar	Picula sitchensis		10/3/2014		12.973	N	-21	87.619	E
IS	2		NR-2019-14679								N			E
IS	3		NR-2019-14680								N			E
IS	4		NR-2019-14681								N			E
IS	5		NR-2019-14682								N			E
IS	6		NR-2019-14683								N			E
IS	7		NR-2019-14684								N			E
IS	8		NR-2019-14685								N			E
IS	9		NR-2019-14686								N			E
IS	10		NR-2019-14687								N			E
IS	11		NR-2019-14688								N			E
IS	12		NR-2019-14689								N			E

NOTES

Country	Matrix Acronym	Matrix
DK	AIR	Air
FI	PIN	Pine needle
FO	FFI	Freshwater fish
GL	MFI	Marine fish
IS	EGG	Bird eggs
NO	TMA	Terrestrial mammals
SE	MMA	Marine mammal

Appendix C

Sampling manual

Sampling manual

Each country is asked to contribute with different samples according to "sample overview".

Sample type	Matrix Acronym MAT
Air	AIR
Pine needle	PIN
Freshwater fish	FFI
Marine fish	MFI
Bird eggs	EGG
Terrestrial mammals	TMA
Marine mammal	MMA

Equipment provided

120 ml glass jars

Al-foil and Plastic bags

Labels

Nitrile gloves Size L

Sampling protocol.

Planning the sampling

Start by opening the provided "Sampling protocol" in excel format. Fill in data for each planned sample, one sample on each row. Use the suggested indication of matrix type or change among the possible choices on the list. This will give each sample a *Sample identification* in the format *CO-MAT* where *CO* indicates country, and *MAT* indicates matrix. The samples should be labelled with their respective Sample identification.

Example: DK-FFI, the Danish Freshwater fish sample.

Use a printout of the sample list to record sample date and other relevant observations. The extra sheet "Notes" can also be used.

Please give coordinates as LAT and LONG in the WGS84 reference system expressed

as degrees and decimal minutes. See example in the sampling protocol. We strongly suggest to cross-check the registered coordinates with an independent geographic tool like Google Earth or similar. Select all six Excel cells containing the coordinates, copy the content with Ctrl-C and paste it into the "fly to" window in the upper-left corner of Google Earth. By clicking onto the magnifier symbol Google Earth should show you the correct sample position.

General precautions to be taken to avoid contamination

Collection and handling of samples and material should be carried out in order to avoid contamination of potential environmental pollutants and protect the samples from any kind of impact that will affect their usages as research materials.

For this project UV filters and Chloroparaffins, know sources are grouting, sealing compounds (eg in mixmaster/handblender), soap, cosmetic, creams and lotions, but there are other potential sources, so we recommend some general good sampling routines. Do not use products such as skin lotions, sun cream or other kind of personal care products which might contain UV filters on the day of sampling. Products of the label "Neutral" are accepted. Only specially cleaned sampling containers provided by the laboratory should be used. There should be NO contact between skin and sample/inside of lid/sample container/alumini foil. Use the gloves provided through the process of sampling. There should also be no contact between the sample and plastic of any kinds.

Equipment and cleaning procedures for preparation of the sample.

All surfaces that will be in contact with the sample must be covered with clean aluminum foil. The tissue samples should not be in contact with the same foil as the fish/mammal etc,. Any areas that will get in contact with the tissue samples must be covered with aluminum foil. The sample tubes must be labelled. All tools used for sampling should be of either stainless steel or of glass, quartz or other in-organic ceramic materials. The equipment should be cleaned in accordance with the procedure below.

- Washing with in-organic (base) soap
- Rinsed extra-long time with clean water
- Wash with an organic solvent like methanol, ethanol, acetone or cyclohexane.

Sample glass cleaning: The sample glasses should be un-used, and any organic residues should be burned by heating the glasses for 2 hours at 500 ° C. The glasses are sealed with burned aluminium foil under the lids. (This glass is provided by NILU/NIVA).

A. Sampling of Air

Air sampling should be performed only by personal trained in using the local air sampling device. The air sampling device and the local routines should be in accordance with the requirements given in the EMEP Manual for Sampling and

Analysis (<https://projects.nilu.no//ccc/manual/index.html>). Both sampling material (filter and PUF) and sampling device can be sources for CP contamination, in order to get best possible control on contamination, we suggest to use sampling material supplied by NILU and to take a field blank sample.

B. Sampling of Pine needle

- Put on the supplied gloves.
- Take pine needles shoot from the current year (metal scissor can be used)
- Fill the jar as full as possible with needles.
- Mark the sample with Sample identification.
- Make notes on the sample protocol.
- Store the samples in a freezer (-18°C).

Minimum sample amount: 50 gram

C. Sampling of fish

- Put on the supplied gloves.
- Wrap each fish individually in Al-foil provided.
- Put the Al-foil packages in a plastic bag provided. Mark the samples with Sample identification.
- Make notes on the sample protocol.
- Store the samples in a freezer (-18°C).

Minimum sample amount: 100 gram

D. Sampling of Bird egg

- Put on the supplied gloves.
- Wrap each egg in Al-foil provided.
- Put the Al-foil packages in a plastic bag provided
- Mark the samples with Sample identification
- Make notes on the sample protocol.
- Store the samples in a freezer (-18°C).

Minimum sample amount: 60 gram

E. Sampling of Mammals

- Use gloves in the contact with the sample.
- Fill the jar with the sample (liver, muscle or lipids/blubber).
- Mark the samples with Sample identification
- Make notes on the sample protocol.
- Store the samples in a freezer (-18°C).

Minimum sample amount: 100 gram

Storage and transport

Send all samples to NIVA in Oslo as soon as possible and in such a way that the samples will reach the laboratory as soon as possible (DHL or equivalent courier service). It is most important to reduce the transport time, so a good idea is to send the samples early in the week to prevent samples being stored during the weekend. For the closes big cities an overnight transport is normal possible. If you want to discuss the shipment you can contact Kine Bæk at NIVA. Send samples in the same containers used for providing sampling material. Make sure to insulate glass jars properly to avoid breakage during transport. Include a printout of the Sampling protocol. Send the samples to the address below.

When sending the samples please send also an e-mail with the filled in Sample protocol attached to Kine Bæk (kine.bak@niva.no), Malcolm Reid (malcolm.reid@niva.no), and Martin Schlabach/NILU (martin.schlabach@nilu.no). This is important so we can follow up that the samples actual are arriving the lab.

Address

Norwegian Institute for Water Research (NIVA)

Att Kine Bæk

Gaustadalléen 21

NO-0349 Oslo

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