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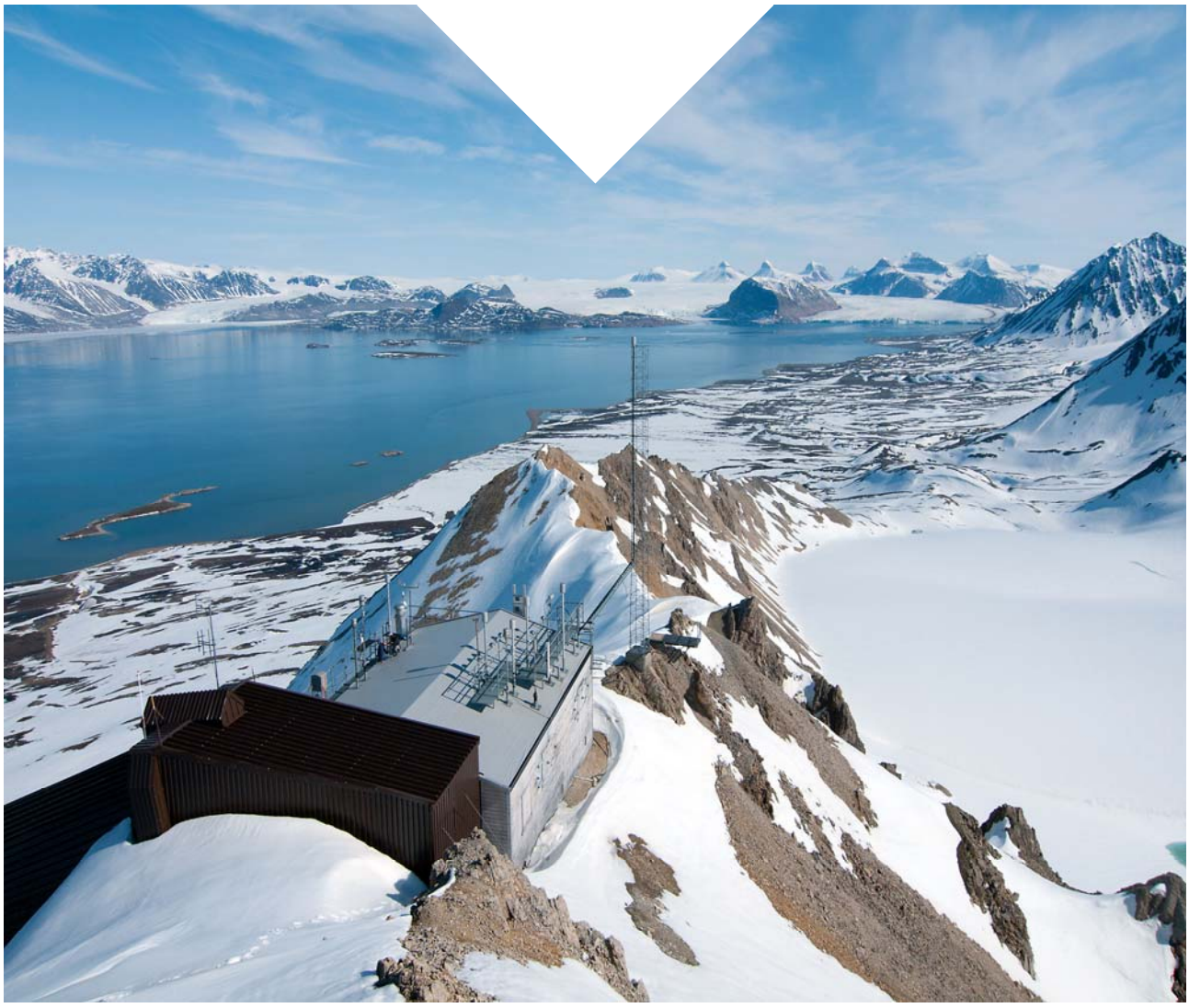
Monitoring of environmental contaminants in air and precipitation, annual report 2014



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Overvåkning av miljøgifter i luft og nedbør, årsrapport 2014
Monitoring of environmental contaminants in air and precipitation, annual report 2014

Summary – sammendrag

This report presents results from 2014 for persistent organic pollutants (POPs) and heavy metals from the rural air- and precipitation chemistry monitoring network in Norway. These results are compared to previous years.
Denne rapporten beskriver resultater fra overvåkingen av miljøgifter i luft og nedbør på norske bakgrunnsstasjoner i 2014, og disse er sammenlignet med tidligere år.

4 emneord

Miljøkjemi
Langtransportert luftforurensning
POP - Persistente organiske miljøgifter
Miljøovervåkning

4 subject words

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Front page photo

Zeppelin Observatory

Content

Summary

This report presents the results for 2014 from the Norwegian rural air- and precipitation chemistry monitoring network. The purpose of the monitoring is to increase the knowledge on long-range transported pollutants as a source to pollution in Norway as well as reporting to international conventions, programmes and networks. The monitoring network includes monitoring of: i) persistent organic pollutants (POPs) and heavy metals including mercury in air at three sites (i.e. Birkenes, Andøya and Zeppelin), ii) heavy metals in precipitation at four sites (i.e. Birkenes, Hurdal, Kårvatn and Svanvik), and iii) mercury and POPs in precipitation at one site (i.e. Birkenes). Two classes of emerging organic pollutants (i.e. cyclic volatile methyl siloxanes and short and medium chained chlorinated paraffins) were included at one site (i.e. Zeppelin).

In 2014, the highest annual mean concentrations of heavy metals measured in precipitation were found at Svanvik in Sør-Varanger. This is due to emissions from smelters in Russia. The wet deposition, however, was generally highest in Southern Norway. In general, the air concentrations of heavy metals were 2-3 times higher at Birkenes in southern Norway than those observed at Andøya and Zeppelin in the North. The same was seen for polycyclic aromatic hydrocarbons (PAHs), DDTs and per- and polyfluorinated alkyl substances (PFAS). This is mainly due to Birkenes being closer to the emission sources at the European Continent. For other legacy POPs as well as mercury, there were no large differences between the sites. This indicates that these pollutants have a large potential to be transported far from emission sources, and a lack of regional primary sources.

The concentrations of lead and cadmium in both air and precipitation at the mainland sites were substantially higher in 2014 than in 2013, but similar to those observed in 2009-2010. The wet deposition at Birkenes was additionally high due to extraordinary high precipitation amounts in 2014. In a longer perspective there has been a significant reduction of heavy metals in precipitation in Norway since 1980; i.e. more than 90% reduction for lead at Birkenes and Kårvatn. From 1990, the reductions of lead has been between 60-90%, except at Svanvik where no significant trend for this period has been observed. Similar reductions have been observed for cadmium in precipitation while somewhat less for zinc. The levels of mercury, hexachlorobenzene (HCB) and hexachlorohexanes (HCHs) in precipitation in southern Norway (i.e. Lista + Birkenes observatories) have been significantly reduced since the beginning of the monitoring in 1990.

At Lista/Birkenes there has been a significant reduction in air concentration for almost all heavy metals (As, Cd, Co, Cr, Pb, Ni and V) for the period 1991 to 2014. At Zeppelin, there has also been a significant reduction since 1994 for several heavy metals (As, Cd, Cu, Pb, Ni and V). The reduction of lead has been 77% and 51%, respectively at Birkenes and Zeppelin. For cadmium, similar trends have been observed, with 58% and 50% reductions respectively. No significant trends have been observed for mercury at Birkenes, while a weak reduction of 8% have been observed at Zeppelin since 1994.

POPs in air do not show as significant decreasing trends as the heavy metals. The largest reduction in concentration has been observed for HCHs both at Birkenes and at Zeppelin. Reduced concentrations are also observed for DDTs, chlordanes (CHLs), and polychlorinated

biphenyls (PCBs), but trends are not as significant due to more fluctuating concentrations. In contrast, an increase in concentrations during the last 10 years has been observed for HCB at Zeppelin.

In 2014, PAHs, PCBs and DDTs were highest in the south at Birkenes while HCB was highest in the north at Zeppelin. The concentrations of polybrominated diphenyl ethers (PBDEs), HCHs, and CHLs were similar or just slightly lower in 2014 than previous years. Together with results from previous years, this suggests a declining long-term trend for these chemicals and shows that the decline may have reached a plateau. In contrast, the levels of HCB, DDTs, PCBs, and PAHs were slightly higher than previous years. Surprisingly, the highest levels in many years were observed at Birkenes for DDTs, PCBs, and PAHs, at Andøya for HCB, DDTs, and at Zeppelin for HCB, PCB and PAHs. For HBCDs and PFAS most measurements were below detection limit.

The second year of monitoring of the emerging pollutants; cyclic volatile methyl siloxanes (cVMS) and short and medium chained chlorinated paraffins (S/MCCPs) showed levels in agreement with the first year (2013). As in 2013, the concentrations of these pollutants are found at the same levels as PAHs, which in turn are up to three orders of magnitude higher than the concentrations of legacy POPs (i.e. PCBs, organochlorine pesticides (OCPs), PBDEs, PFAS). This suggests ongoing emission of both cVMS and S/MCCPs. It also emphasizes the importance of continuous monitoring of these emerging POPs to follow their emission trends.

Sammendrag

Denne rapporten presenterer resultater fra det nasjonale overvåkningsprogrammet for atmosfæriske tilførsler av miljøgifter for 2014. Formålet med overvåkningen er å fremskaffe kunnskap om langtransport av miljøgifter som kilde til forurensning i Norge og ivareta rapportering til internasjonale konvensjoner, programmer og nettverk. Overvåkings-programmet inkluderer observasjoner av i) organiske miljøgifter, tungmetaller og kvikksølv i luft på tre stasjoner (Birkenes, Andøya og Zeppelin), ii) organiske miljøgifter og kvikksølv i nedbør på en stasjon (Birkenes), samt iii) tungmetaller i nedbør på fire stasjoner (Birkenes, Hurdal, Kårvatn og Svanvik). To klasser av nye miljøgifter (siloksaner og klorparafiner) er inkludert 2013 på én lokalitet (Zeppelin).

I 2014 ble den høyeste årlige gjennomsnittskonsentrasjonen for de fleste tungmetallene målt i nedbør ble funnet på Svanvik i Sør-Varanger. Dette skyldes utslipp fra smelteverkene i Russland. Våtavsetning er derimot generelt høyest i Sør-Norge. Konsentrasjonen av de fleste tungmetallene målt i luft på Birkenes er 2-3 ganger høyere enn det som er observert ved Andøya og Zeppelin. Det samme er også tilfellet for de organiske miljøgiftene: PAHs, DDTer og PFAS. En årsak kan være at Birkenes er nærmere utslippskildene på det europeiske kontinentet. For de andre internasjonalt regulerte organiske miljøgiftene samt kvikksølv er det ikke store forskjeller mellom stasjonene da de har stort potensiale for langtransport og det indikerer at det ikke er dominerende primære utslippskilder i regionen.

Konsentrasjonen av bly og kadmium i både luft og nedbør var en god del høyere i 2014 enn hva som ble observert i 2013 på fastlandstasjonene og samme nivå som i 2009-2010. På Birkenes ble våtavsetningen av disse metallene ekstra høy og forsterket pga unormalt store nedbørmengder i Sør Norge i 2014. I et lengre perspektiv har det derimot vært en betydelig reduksjon av tungmetaller i nedbør i Norge siden 1980; for bly mer enn 90% på Birkenes og Kårvatn. Fra 1990 har det vært en reduksjon av bly mellom 60-90%, unntatt på Svanvik der det ikke er noen signifikant trend for denne perioden. Det er tilsvarende reduksjoner for kadmium i nedbør, mens noe mindre for sink. For kvikksølv, HCB og HCH i nedbør, har det vært en signifikant reduksjon siden 1990 hvis man kombinerer datasettene fra de nærliggende observatoriene Lista og Birkenes.

På Lista/Birkenes har det vært en betydelig reduksjon i luftkonsentrasjon for nesten alle tungmetaller som er målt (As, Cd, Co, Cr, Pb, Ni og V) for perioden 1991 til 2013. På Zeppelinobservatoriet, har det også vært en betydelig reduksjon siden 1994 for flere tungmetaller (As, Cd, Cu, Pb, Ni, V). Reduksjonen av bly har vært på 77% og 41% hhv. på Birkenes- og Zeppelinobservatoriet. For kadmium er det lignende reduksjoner, hhv. 58% og 50%. Det er ingen signifikante trender for elementært kvikksølv i luft på noen av stasjonene.

De organiske miljøgiftene i luft viser ikke en så tydelig nedadgående trend som tungmetallene. Den største reduksjonen observeres for HCH'ene. Det er også en reduksjon i de observerte luftkonsentrasjonene for DDT, klordaner og PCB, men for disse observeres også store årlige variasjoner. For HCB er det derimot observert en økning i luftkonsentrasjonen på Zeppelinobservatoriet de siste ti årene. For andre miljøgifter har overvåkningen pågått i for få år til å si noe om trender.

I 2014 var nivåene av PAH, PCB og DDT høyest på Birkenes i sør mens nivået av HCB var høyest på Zeppelin i nord. Nivåene av PBDE, HCH og klordaner var på samme nivå eller lavere enn tidligere år, hvilket bekrefter den generelle nedadgående trend for disse komponentene. Til sammenlikning, er nivåene av HCB, DDT, PCB og PAH høyere enn tidligere år. På Birkenes er det observerte nivået av DDT, PCB og PAH høyere enn på mange år. Det samme gjelder for HCB og DDT på Andøya, og HCB, PCB og PAH på Zeppelin. HBCD og PFAS var hovedsakelig under deteksjonsgrensen.

Konsentrasjonen av siloksaner og klorinerte parafiner var på samme nivå i 2014 som 2013. Selv om måle- og analysemetodene er usikre kan man observere at nivåene av disse miljøgiftene er på samme konsentrasjonsnivå som PAH, men opp til en faktor tusen ganger høyere enn de regulerte POPene (PCB, OCP, PBDE, PFAS). Dette viser at det er viktig å fortsatt overvåke disse nye stoffene for å følge utviklingen fremover.

1. The monitoring programme

Heavy metals and persistent organic pollutants (POPs) can undergo long-range environmental transport, are toxic, bioaccumulative and persistent in the environment. Due to their harmful impacts on the human health or on the environment, monitoring of these pollutants is of high priority for Norwegian authorities. For many of these contaminants, long-range transport via air is the most important source to pollution in remote areas where there are few or no local sources. Recognition of long-range atmospheric transport of environmental contaminants to remote areas, such as the Arctic, has contributed to the regulation of several of these compounds both on a regional and global scale.

The Convention on Long-range Transboundary Air Pollution (CLRTAP) with the 1998 Aarhus Protocol on Heavy Metals (UN/ECE, 1998a), targets three particularly harmful metals: cadmium, lead and mercury. Signatures to the protocol will have to reduce their emissions of these three metals below their levels in 1990. The Protocol was amended in 2012, to adopt more stringent controls of heavy metals. The use and production of mercury is also regulated by the Minimata convention on mercury (UNEP, 2013). The 1998 Aarhus Protocol on POPs, also called the POP-protocol, is another protocol of the CLRTAP (UN/ECE, 1998b). This protocol regulates or ban POPs on a European scale. Initially it included 16 substances/substance groups and after the addition of seven more chemicals to the Protocol in 2009 the total number is now 23 (UN/ECE, 2010). The use and production of POPs is also regulated or banned by the Stockholm Convention on POPs (Stockholm Convention, 2007). The Stockholm Convention is a global treaty, ratified by 179 countries, with the aim to protect human health and the environment from the harmful effects of POPs. The convention originally included 12 POPs and now includes 26 compounds (Stockholm Convention, 2013). At the Conference of the Parties to the Stockholm Convention in April-May 2015 three new POPs were included in the Convention; hexachlorobutadiene, polychlorinated napthalenes and pentachlorophenol, including its salts and esters (Stockholm Convention, 2015). The global ban on these chemicals will enter into force in 2016.

This report presents results from 2014 for environmental contaminants in air and precipitation from the annual monitoring in Norwegian rural background environments. The results are part of the national monitoring programme of long-range transported air pollutants, which is conducted by NILU on behalf of The Norwegian Environment Agency, and the Ministry of Climate and Environment. The purpose of this monitoring programme is to obtain information of atmospheric contribution of both regulated and emerging contaminants to the Norwegian environment, and to monitor any changes in the contaminants' levels over time and space. This documentation is essential for compliance monitoring of existing abatement strategies and for development of new policies for emerging contaminants. Data and results from the national monitoring program are reported and used in several international fora, including: EMEP (European Monitoring and Evaluation Programme) under the CLTRAP, CAMP (Comprehensive Atmospheric Monitoring Programme) under OSPAR (the Convention for the Protection of the marine Environment of the North-East Atlantic) and AMAP (Arctic Monitoring and Assessment).

To document the long-range transport of air pollution, the monitoring stations/observatories have been placed/located, as far as possible, in areas that are not influenced by any local sources. Further, the number of observatories and the geographical distribution are selected

in order to represent different parts of Norway. The observatories in the monitoring programme are to a large extent part of the long-term national measurement programme of atmospheric composition.

Monitoring of heavy metals in precipitation has been part of the Norwegian national monitoring programme since 1980, while POPs were included in 1991. Air measurements of heavy metals and POPs started in 1991 at Lista observatory in southern Norway as part of the CAMP Programme under the OSPAR Convention (http://www.ospar.org). Lista closed down in 2004, but the extended measurement programme continued at the nearby observatory in Birkenes. In 1994, air measurements of heavy metals and POPs were included at the Zeppelin Observatory as part of the AMAP programme (http://www.amap.no). Both sites became part of the EMEP programme (http://www.emep.int) under the CLRTAP (http://www.unece.org/env/lrtap) in 1999, (Tørseth et al, 2012). In the end of 2009, a new monitoring station for heavy metals and POPs was established at Andøya as part of the national Marine Pollution Monitoring Programme (Green et al., 2011). The monitoring station was after a couple of years incorporated in the national monitoring programme, and data are today reported to AMAP, EMEP and CAMP. A subset of the data are also reported to the European Commission as defined in the air quality directive (EU, 2008).

The 2014 measurements presented in this report is a compilation of results from three different national projects and programs:

- Measurements of heavy metals and POPs (except PAHs) in air at Birkenes, Andøya and Zeppelin, heavy metals in precipitation at Birkenes, and emerging substances (i.e. cyclic volatile methyl siloxanes and short and medium chained chlorinated paraffins) at Zeppelin are part of the national monitoring programme of environmental contaminants of The Norwegian Environment Agency
- Heavy metals in precipitation at Svanvik are measured as part of the Norway-Russia measurement programme on behalf of The Norwegian Environment Agency
- POPs in precipitation at Birkenes, heavy metals in precipitation at Hurdal and Kårvatn and PAHs in air at Zeppelin are part of the long-term dataseries programme on behalf of the Ministry of Climate and Environment, as well as NILUs internal monitoring programme.

In 2014, the monitoring of environmental contaminants comprised six observatories of which three include measurements of POPs. The locations of the observatories are shown in Figure 1.1, and the measurement programme is described in Table 1.1. Information of sampling and analytical methods is given in Annex 3. In addition, heavy metals in air were measured at Karpdalen, close to the Russian border. These data are presented in Berglen et al. (2015) and not included in this report. Further information of the sites, site descriptions are available at http://www.nilu.no/projects/ccc/sitedescriptions/. All the data presented in this report are available at http://ebas.nilu.no/.

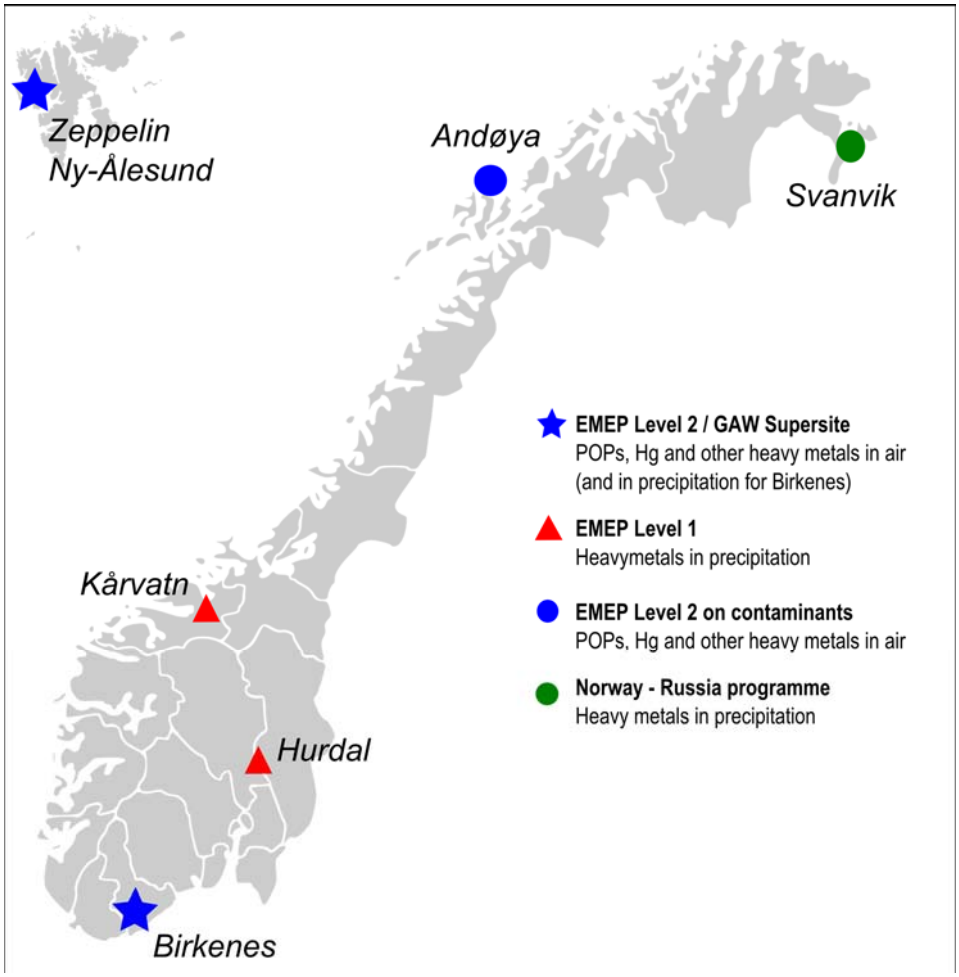

Figure 1.1: Norwegian background stations measuring environmental contaminants in 2014.

Table 1.1: Norwegian monitoring stations and the sampling programme of heavy metals and persistent organic pollutants, 2014

Station code and name		Lat	Long	hasl	Heavy metals		Persistent Organic Pollutants (POPs)*	
					precipitation	air and aerosols	precipitation	air and aerosols
NO0001-2R	Birkenes	58 23 N	8 15 E	190 / 219	As, Cd, Cr, Co, Cu, Pb, Hg, Mn, Ni, V, Zn	As, Cd, Cr, Co, Cu, Pb, Hg, Ni, V, Zn	HCB, HCHs, PCBs	HCB, HCHs, DDTs, CHLs, PCBs, PBDEs, HBCDs, PAHs, PFAS
NO0056R	Hurdal	60 22 N	11 4 E	300	Cd, Pb, Zn			
NO0039R	Kårvatn	62 47 N	8 53 E	210	Cd, Pb, Zn			
NO0047	Svanvik	69 27 N	30 2 E	30	Al, As, Cd, Cr, Co, Cu, Pb, Mn, Ni, V, Zn			
NO0090R	Andøya	69 16 N	16 0 E	380		As, Cd, Cr, Co, Cu, Pb, Mn, Hg, Ni, V, Zn		HCB, HCHs, DDTs, PCBs, PBDEs, PFAS
NO0042G	Zeppelin	78 54 N	11 53 E	474		As, Cd, Cr, Co, Cu, Pb, Mn, Hg, Ni, V, Zn		HCB, HCHs, DDTs, CHLs, PCBs, PBDEs, HBCDs, PAHs, PFAS, Siloxanes, SCCP, MCCP

* Full names given in Chapter 3.1.

2. Heavy metals

Heavy metals have been part of the Norwegian national monitoring programme since 1980. Measurements of lead, zinc and cadmium in weekly precipitation samples were initiated in February 1980 at Birkenes and Kårvatn, in October 1986 at Nordmoen Hurdal, and in March 1987 at Svanvik. Measurements of heavy metals in air were included in the programme in 1991 at Lista and 1994 at Zeppelin, while 2010 at Andøya.

There were no changes in the monitoring programme from 2013 to 2014.

2.1 Heavy metals in precipitation

Annual mean volume weighted concentrations and total wet deposition of heavy metals are given in Table 2.1 and Table 2.2. The results presented in these tables show that the highest annual mean concentrations are, except for zinc, observed at Svanvik. This is due to high emissions from the smelters in Nikel (Russia) close to the Norwegian border. When there is easterly wind from Russia and the Kola Peninsula the levels of contaminants increase significantly at the Norwegian side of the border. Further details and discussion of these data can be found in the annual report for the programme "Russian-Norwegian ambient air monitoring in the border areas" (Berglen et al., 2015).

The levels observed at Hurdal and Birkenes are comparable while the lowest levels are observed at Kårvatn, which is also furthest away from the main emission sources in continental Europe. For wet deposition, the highest levels are generally observed at Birkenes, despite for some exceptions like Ni, As, Cu and Co, which have very high levels in Svanvik.

Table 2.1: Annual average volume weighted mean concentrations of heavy metals (mg/L) and mercury (ng/L) in precipitation in 2014.

Site	Pb	Cd	Zn	Ni	As	Cu	Co	Cr	Mn	V	Al	Hg
Birkenes	1.12	0.025	5	0.16	0.1	1.35	0.01	0.06	1.08	0.21	-	4.8
Hurdal	0.58	0.026	6.4	-	-	-	-	-	-	-	-	-
Kårvatn	0.31	0.013	2.9	-	-	-	-	-	-	-	-	-
Svanvik	1.13	0.065	5.2	17.7	1.21	28.7	0.52	0.22	-	0.48	21.5	-

Table 2.2: Total wet deposition of heavy metals (mg/m^2) and mercury (ng/m^2) in 2014.

Site	Pb	Cd	Zn	Ni	As	Cu	Co	Cr	Mn	V	Al	Hg
Birkenes	2509	56	11179	369	214	3040	34	142	2415	471	-	11193
Hurdal	808	36	8979	-	-	-	-	-	-	-	-	-
Kårvatn	316	14	2967	-	-	-	-	-	-	-	-	-
Svanvik	442	25	2022	6917	474	11184	205	84	-	188	8393	-

Calculated monthly mean concentrations and depositions for all the elements are shown in Annex A.1.1-A.1.24. The monthly mean concentration for lead, cadmium and mercury are shown in Figure 2.1. There is no clear seasonal variation for lead, but a large peak is observed at Birkenes in May. The reason for this peak is not clear. All the four weekly measurements in May show elevated levels so it is not likely due to a single contamination episode. These high

levels in May are outside what is normally observed. The deposition of lead at Birkenes show elevated levels in winter in addition to the May period (table A.1.14).
For cadmium there is a clear seasonal pattern both in concentration and deposition with elevated levels during wintertime. For mercury, somewhat higher concentrations were observed during the summertime compared to winter, although the deposition peaks in January and in the autumn (table A.1.16). The precipitation intensities in February and October (2014) were unusually high in South and East Norway contributing to the high metal deposition at Birkenes and Hurdal in these months.

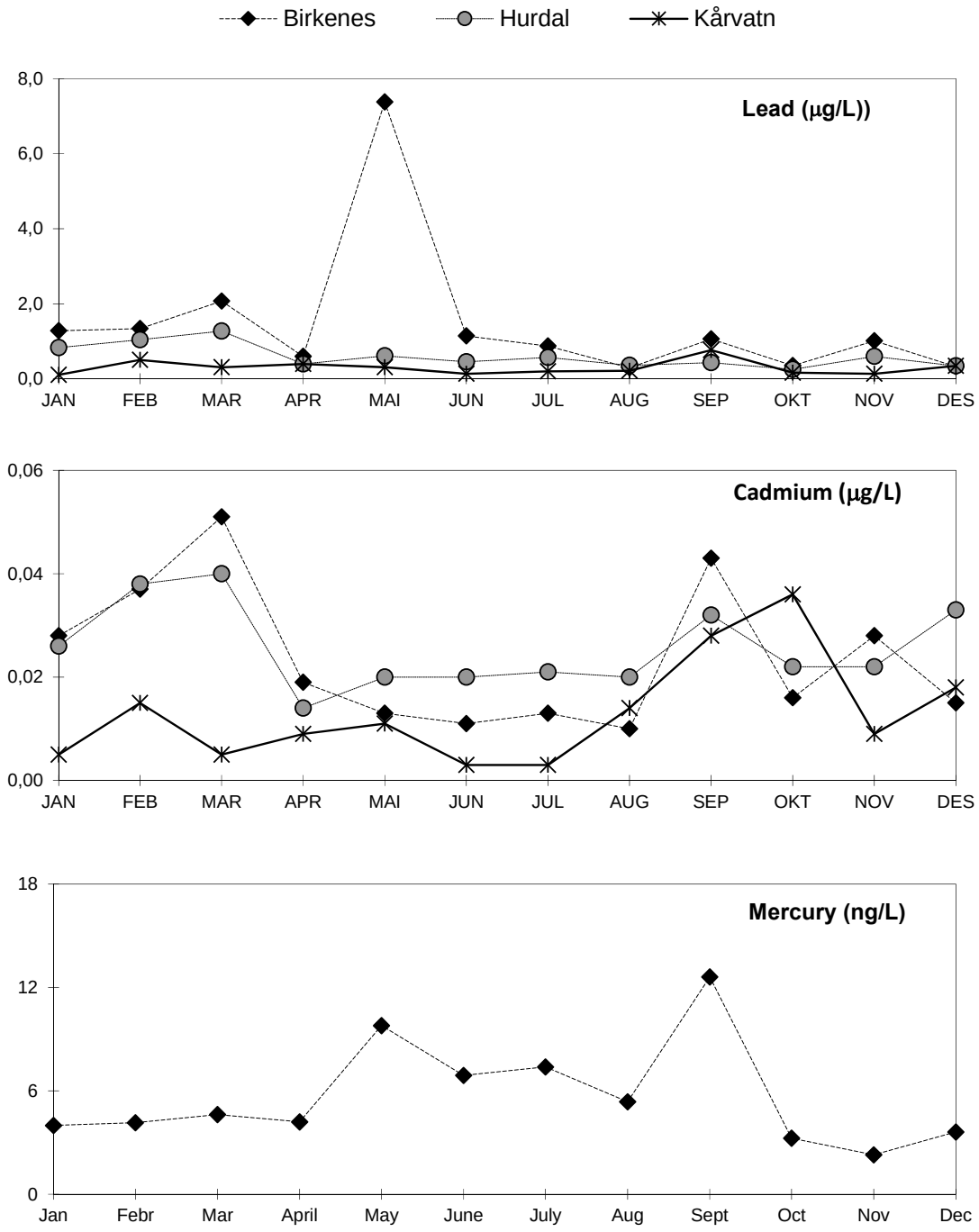

Figure 2.1: Monthly average volume weighted mean concentrations of lead, cadmium and mercury in precipitation in 2014.

Figure 2.2 and Table A.1.25 show volume weighted annual mean concentrations from 1980-2014. Compared to 2013, the levels of cadmium and lead in precipitation in 2014 are substantially higher at all the sites. The same is observed for the heavy metals in air at the mainland sites (chapter 2.2). The levels in 2014 are similar to the levels measured in 2009-2010. The reason for this increase is not clear. The levels of mercury at Birkenes in 2014 are lower than in 2013 continuing the clear reduction seen in the long-term perspective. The levels of lead at Birkenes and Kårvatn have been reduced with more than 90% between 1980 and 2014 and between 60-90% since 1990, which is also observed at Nordmoen/Hurdal. In contrast, at Svanvik, no significant trend has been observed. The levels of cadmium at Birkenes and Kårvatn have also been reduced with more than 90% since 1980, and between 30% and 68% since 1990. A similar significant trend has not been observed at Svanvik.

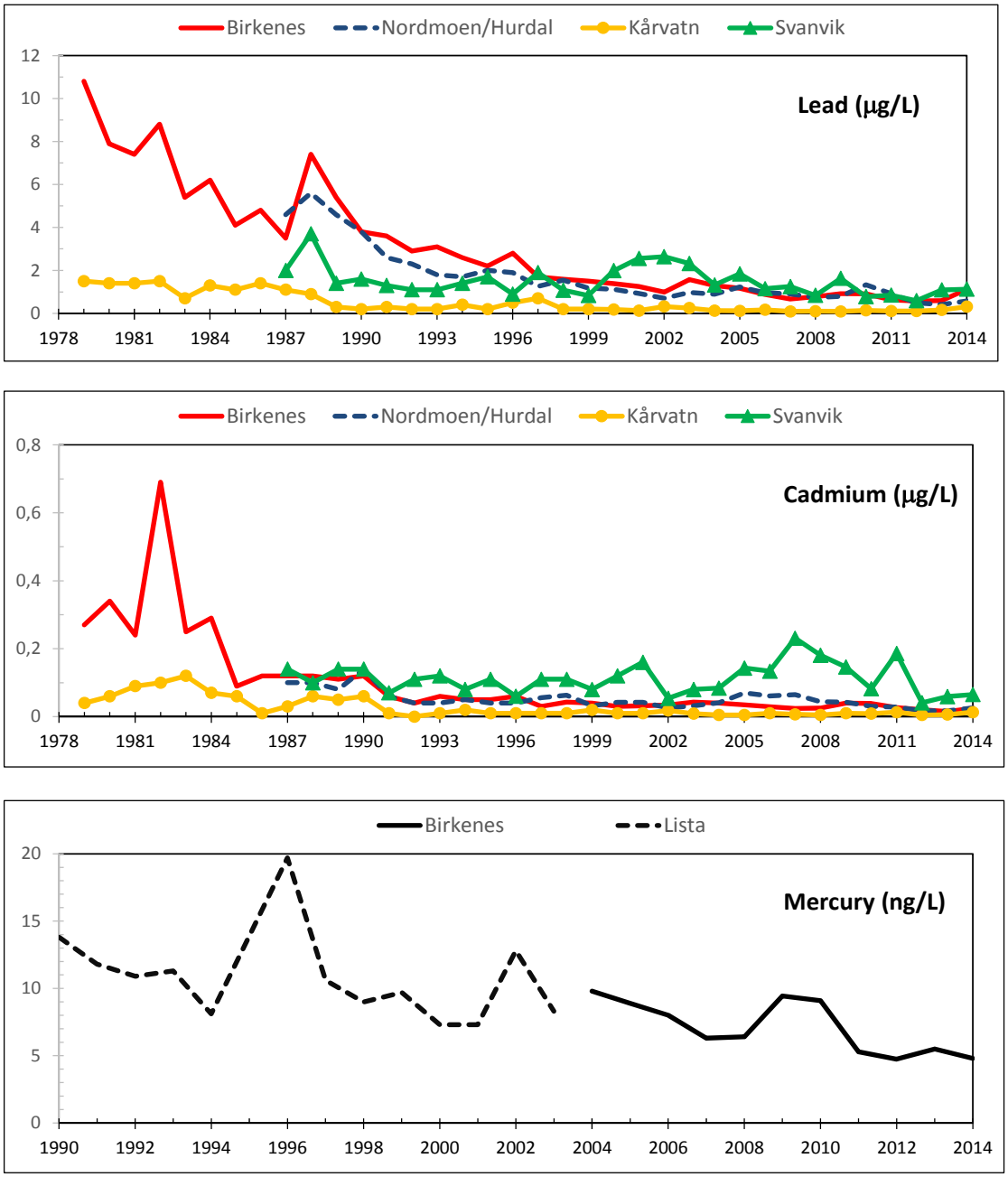

Figure 2.2: Time series of annual volume weighted mean of lead, cadmium and mercury in precipitation at Norwegian background stations.

The concentrations of zinc in precipitation have been reduced by 50-70% since 1980 and approximately by 40% since 1990 at Birkenes. A significant increase is however seen at Hurdal and Kårvatn during the last period. There are quite large annual variations in zinc, with increases at some sites for some years. This may be due to possible contamination of zinc during sampling.

When combining the datasets from Lista and Birkenes, mercury levels appear to have been significantly reduced (59%) since 1990. However, the precipitation amount and deposition rates may differ between these sites. The results from a trend analysis that combines the datasets is therefore somewhat uncertain. On the other hand, it is believed that Lista, which was closed down after 2003 was influenced by similar air masses as Birkenes, both situated at the south coast of Norway.

For the other elements, such as nickel, cobalt and copper, there has been an increase in concentrations at Svanvik since the monitoring started in 1987. There are large annual variations in the concentration levels, and this may be due to meteorological variations as well as changes in the composition of the ore used at the smelters in the Kola Peninsula. For further discussion, it is referred to the report by Berglen et al. (2015).

2.2 Heavy metals in air

The annual mean concentrations of the heavy metals measured in air in 2014 are given in Table 2.3, and the weekly concentrations of lead and cadmium are illustrated in Figure 2.3. The monthly mean concentrations can be found in Annex 1, tables A.1 26-28.

In general, the air concentrations of most heavy metals at Birkenes in 2014 are 2-3 times higher than those observed at Andøya and Zeppelin. This is because Birkenes is closer to the emission sources at the European Continent. For mercury, there are only minor differences in air concentrations between the sites. A reason may be that the gaseous mercury has a longer residence time in the atmosphere than the particulate bound heavy metals, and therefore has larger potential to be transported far from emissions sources. As a consequence, mercury may be distributed over greater geographical distances and is a global pollutant to a greater extent than the other heavy metals.

Table 2.3: Annual average mean concentrations of heavy metals in air and aerosols in 2014, Unit: ng/m^3.

	As	Cd	Cr	Co	Cu	Pb	Mn	Ni	V	Zn	Hg(g)
Birkenes II	0.21	0.033	0.18	0.03	0.59	0.88		0.40	0.45	4.5	1.53
Andøya	0.07	0.025	0.10	0.037	0.25	0.28	0.46	0.13	0.15	1.3	1.50
Zeppelin	0.05	0.012	0.14	0.012	0.22	0.22	0.60	0.14	0.06	1.7	1.48

As previous years, the annual mean concentrations at Andøya and Zeppelin are comparable; some elements are higher at one of the sites while others are higher at the other site. These differences are due to individual episodes with high concentrations of heavy metals arriving Zeppelin and Andøya, especially during the winter at Zeppelin in 2014, and these episodes are not corresponding between the sites (Figure 2.3).

The episodes with high levels of cadmium and lead at Birkenes and Zeppelin are well correlated at the individual sites (Figure 2.3). This not necessarily because they have similar

emission sources, but because the polluted air is well mixed, and the episodes with high levels are happening when the meteorology favors long range transport from the emission sources at the continent. There is one large cadmium episode at Zeppelin 6-8 august 2014, which is not seen in the lead concentration, though elevated levels of Ni, Mn, Cu and Zn are observed. The air masses during this period are from Greenland and North America.

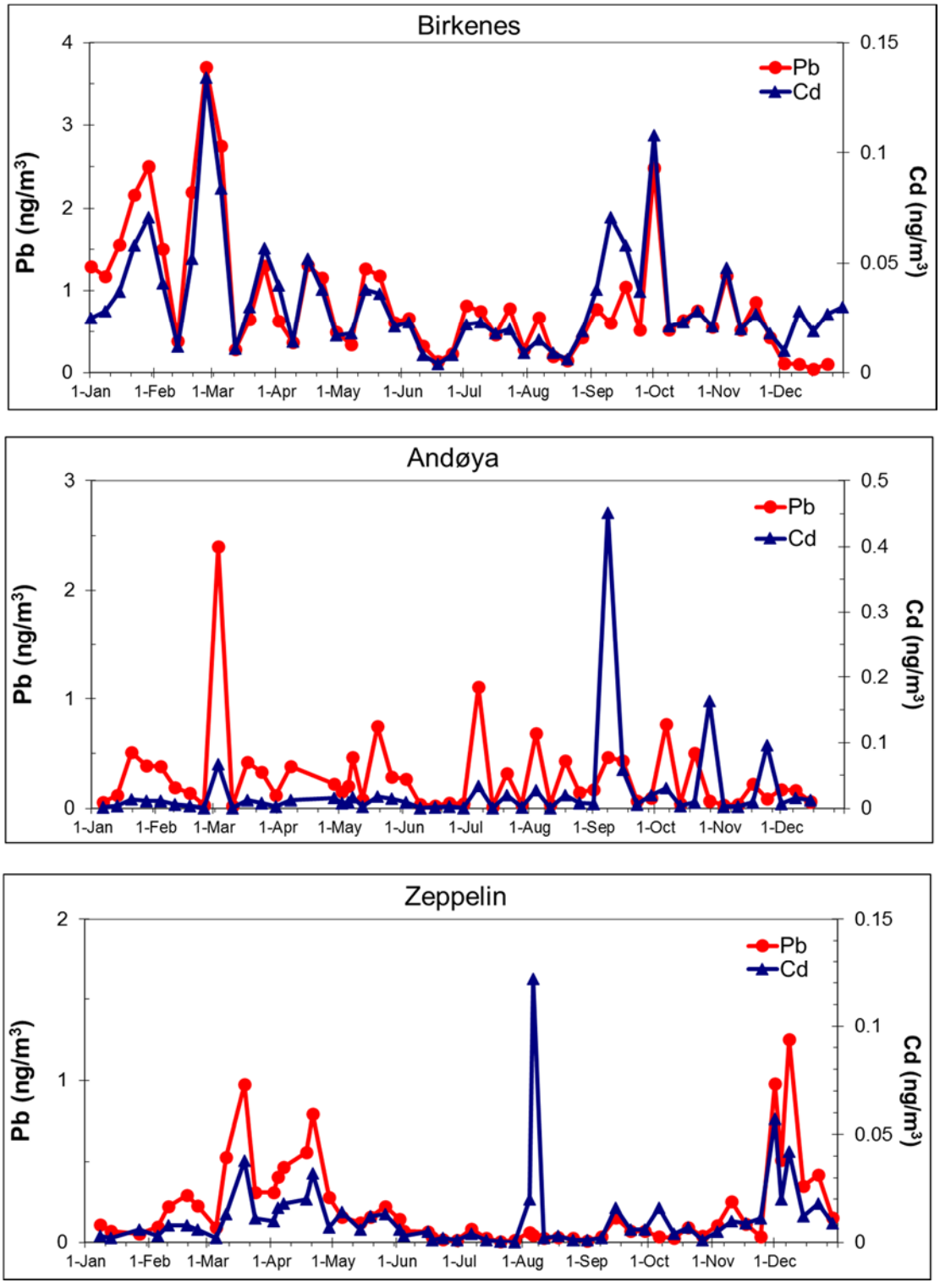

Figure 2.3: Weekly concentrations of lead and cadmium in air at Norwegian background stations in 2014, Unit: ng/m³.

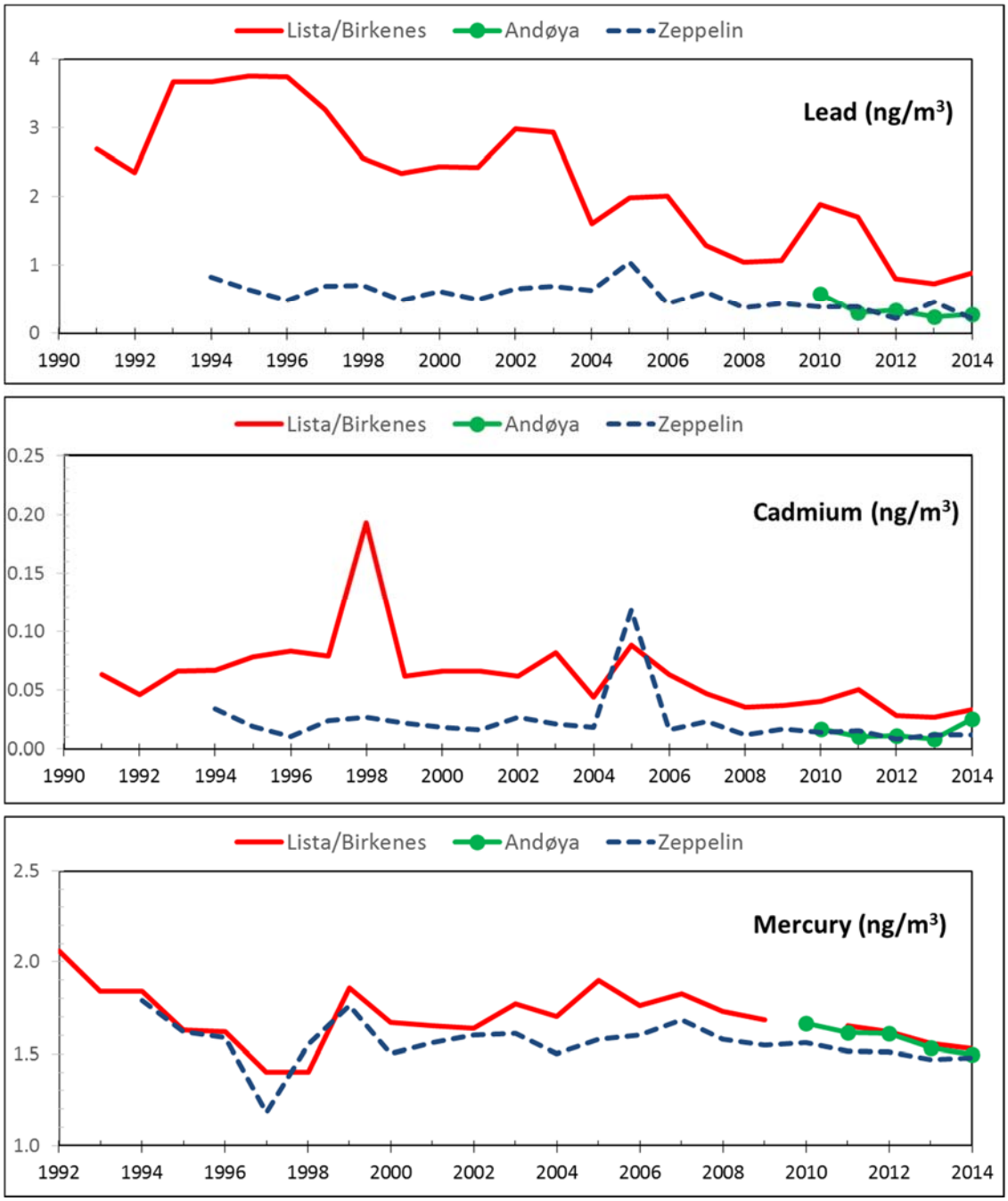

Figure 2.4: Time series of annual mean average concentrations of lead, cadmium and mercury in air and aerosols, 1991-2014, Unit: ng/m³ (note that the y-axis for mercury begins at 1.0 ng/m³).

As seen for heavy metals in precipitation there is an increase in lead and cadmium concentration in 2014 compared to 2013 at the mainland sites. Especially Cd at Andøya was high in 2014. In contrast, there is a decrease in air concentrations of lead and no change in the air concentrations of cadmium at Zeppelin. For mercury, the concentrations are slightly lower or similar to those in 2013 for all the sites.

The long-term time series of the annual mean concentrations of lead, cadmium and mercury are shown in Figure 2.4. The annual concentrations for all the elements for all years and sites can be found in Annex Table A.1.29.

At Lista/Birkenes there has been a significant reduction in air concentration for almost all the elements (As, Cd, Co, Cr, Pb, Ni and V) for the period 1991 to 2014. At Zeppelin, there has also been a significant reduction since 1994 for several elements (As, Cd, Cu, Pb, Ni, V). The reduction for lead has been 77% and 51% respectively at Birkenes and Zeppelin. For cadmium, there were similar trends, 58% and 50% reductions respectively. No significant trends were found for mercury at Birkenes, but at Zeppelin a weak reduction of 8% since 1994 is seen.

3. Persistent organic pollutants (POPs)

This monitoring report includes 12 different classes of organic pollutants, of which eight are classified as POPs and four show POP-like characteristics. POPs are characterized by being persistent in the environment, bioaccumulative, toxic to humans and wildlife, and having potential for long-range atmospheric transport (Stockholm Convention, 2007). The monitored compounds additionally represent a range of different sources such as industrially produced chemicals used as pesticides, biocides, flame retardants, etc., and unintentionally produced chemicals generated as by-products of various industrial/combustion processes. The industrially produced POPs enter the environment differently depending on their application; either by direct spreading in the nature; from production-lines; or by emission/leaking from products in which they are used.

The organic pollutants in air have been monitored at Zeppelin since 1991, while the monitoring started later at Birkenes and Andøya. The components included in the monitoring at each observatory are presented in Table 1.1. In general, HCB, HCHs, DDTs, PCBs, PBDEs and PFAS are monitored at all three observatories while CHLs, hexabromocyclo-dodecane (HBCD) and PAHs are only monitored at Birkenes and Zeppelin. In addition, two groups of emerging organic pollutants were included in the monitoring programme at Zeppelin in 2013; i.e. cyclic volatile methylsiloxanes (cVMS) and short and medium chained chlorinated paraffins (SCCP, MCCP) (see Chapter 4).

Sampling was done continuously on a weekly basis throughout the year with specific sampling lengths for each observatory and class of pollutants. The sampling methodologies have been optimized to achieve maximum detection while minimizing the influence of possible sampling artefacts. For example, PCB, HCB, DDT, HCH are sampled on a weekly basis at all three stations, but with different sampling length at the individual stations (e.g. 24-72 h). Sampling of the cVMS did not follow the weekly sampling frequency, instead they were sampled in one winter campaign during November and December 2014. Details on sampling and analyses are given in Annex 3, Table A.3.4.

Data for the individual POP classes at each observatory are presented as annual mean concentrations in Figure 3.1 - Table 4.2, and as monthly mean concentrations in Figure 3.2 - Figure 4.3. Detailed data (monthly mean concentrations for individual components within each class) are presented in Annex 2. The results are presented below on POP class basis due to the high amount of POP classes and individual components within each class.

3.1 Persistent organic pollutants in air

3.1.1 Hexachlorobenzene (HCB)

HCB is produced both as an unintentional by-product and as an intentionally made chemical mainly used as a fungicide for crop seed as well as to make fireworks, ammunition, and synthetic rubber. The intentional use and production of HCB is regulated by the Aarhus Protocol on POPs under the CLRTAP (UN/ECE, 1998b) and the Stockholm Convention on POPs (Stockholm Convention, 2007). Intentional production and use of HCB is therefore assumed to have cease globally. However, HCB is still unintentionally produced and released as a by-

product during manufacture of other chemicals as well as through incomplete combustion from old dumpsites.

HCB has been monitored at Birkenes and Zeppelin since 1993, and at Andøya since 2009. It was detected in all samples from all sites in 2014. The weekly concentrations ranged between: 21-70 pg/m^3 at Birkenes (excluding two high outliers); 7-62 pg/m^3 at Andøya (excluding one high outliers); and 64-110 pg/m^3 at Zeppelin. The reason for the high individual episodes at Birkenes and Andøya is unknown. Yet, one possible explanation is that it is related to the unintentional production and release of HCB. The annual mean concentrations of HCB in 2014 were, as previous years, 1.5-3 times higher at Zeppelin (83 pg/m^3) than at Birkenes (51 pg/m^3) and Andøya (31 pg/m^3).

The annual mean concentration at Birkenes is in agreement with the levels measured in 2010-2013 (Figure 3.1) and are in line with typical European levels (Halse 2011, Jaward 2004) suggesting constant emission patterns during the last years. The annual mean concentrations at Andøya and Zeppelin were higher than in 2013 and the highest since 2009 and 1999 respectively. These results are in agreement with the increasing trend observed at Zeppelin since the beginning of 2000 (Figure 3.1). The reason for this trend has been suggested to be increased re-emissions from deposited HCB due to higher temperature and ice-free winters, or to a continuous use of pesticides containing HCB in some parts of the world (Hung et al., 2010). The levels of HCB measured in 2014 at Zeppelin are similar to the levels measured in the end of 1990s, but are still below those observed in the beginning-middle of 1990s. In contrast, the long-term observations at Birkenes indicate that the declining trend from the beginning of the 2000s seem to have flattened out during the last five years (Figure 3.1). The declining trend at Birkenes may indicate a reduction in primary emissions in western and central Europe, but more research is needed before any conclusion can be drawn.

No clear seasonal variations were seen at Zeppelin (Figure 3.2) although the individual lowest concentrations were observed during the coldest season (i.e. January and February) and the individual highest concentrations observed during early autumn and spring. In contrast, a strong seasonality was found at Andøya and Birkenes, with a factor of three-four lower concentrations in summertime (June-August) than in wintertime (October-March) (Figure 3.2). This may be a result of higher combustion emissions during colder periods and thereby higher levels in winter time or a result of increased breakthrough in the sampler during warmer periods and thereby underestimations of the summer concentrations.

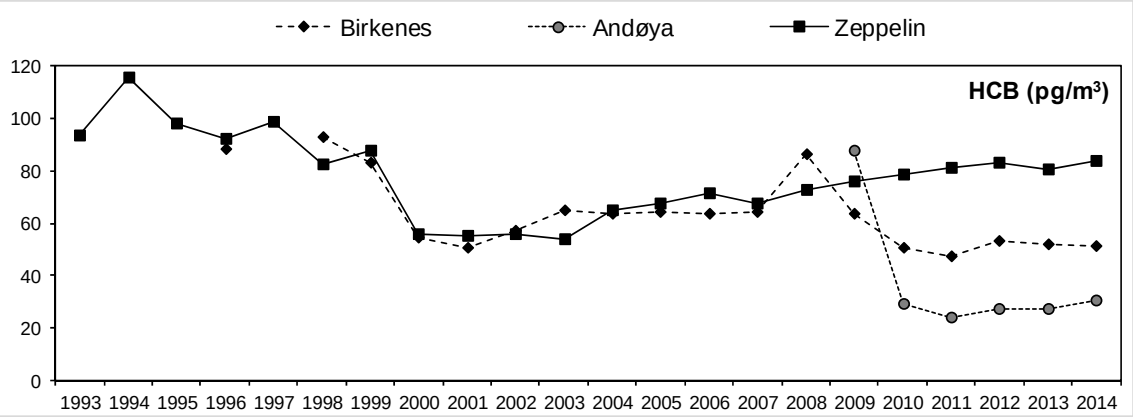

Figure 3.1: Annual mean concentrations of HCB (pg/m^3) in air.

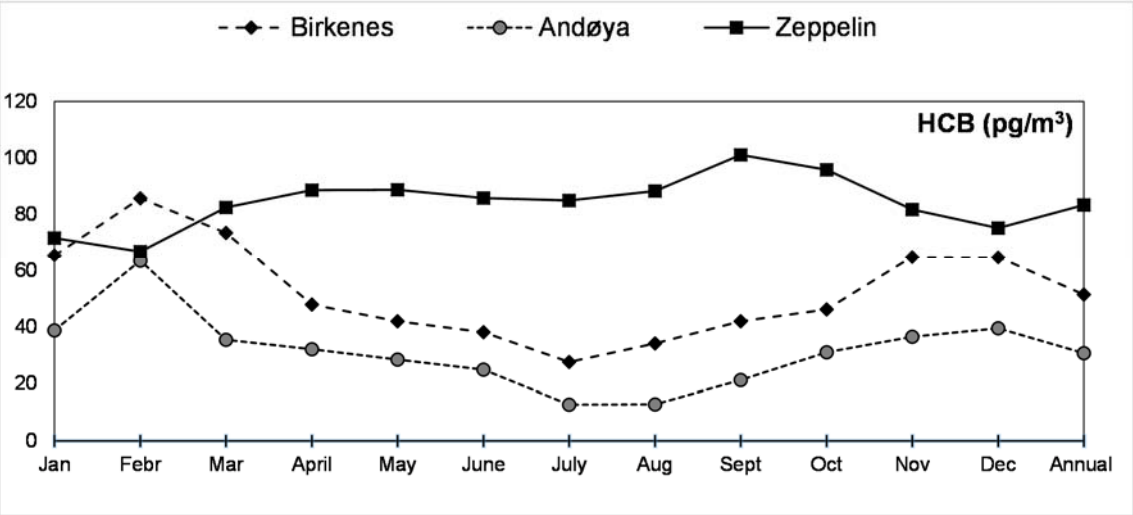

Figure 3.2: Monthly and annual mean concentrations (pg/m3) of HCB in air for 2014.

3.1.2 Hexachlorohexanes (HCHs)

HCHs are intentionally produced chemicals that have been and are to some extent still used as insecticides worldwide. The technical mixture consists of five stable isomers: α-, β-, γ-, δ-, and ε-HCH. γ-HCH, also known as lindane, has been used both as an agricultural insecticide and as a pharmaceutical treatment for lice and scabies. The production and use of HCHs are regulated regionally and globally by the Aarhus protocol on POPs (UN/ECE, 1998b) and the Stockholm Convention on POPs (Stockholm Convention, 2007). However, the Stockholm Convention still accept the production and use of lindane/γ-HCH for pharmaceutical control of head lice and scabies and as a result it is still allowed in some countries.

Two HCH isomers; α- and γ-HCHs, have been monitored at Birkenes since 1991, at Zeppelin since 1993, and at Andøya since 2010. Both isomers were above detection limit in all samples from all sites in 2014. The weekly concentrations of sum HCHs (α+γ) ranged from: 2.8-23 pg/m^3 at Birkenes; 1.6-8.8 pg/m^3 at Andøya; and 2.8-11 pg/m^3 at Zeppelin. The annual mean concentrations of sum HCHs and the individual isomers in 2014 were in the same range at all observatories. The concentrations were in agreement or slightly lower than 2013 continuing the decreasing trends from previous years (Figure 3.3:). Overall, HCHs are the POPs that have shown the largest reduction in air concentrations since the beginning of the air monitoring at Zeppelin and Birkenes (a factor of 15 and 25). The two isomers are declining with similar pattern at both observatories although a somewhat larger reduction is observed for γ-HCH than for α-HCH. As previous years, the ratios of α-/γ-HCH were found to increase from south to north; 1.8 at Birkenes; 4.2 at Andøya; and 7.0 at Zeppelin. The lower ratios in the south might indicate ongoing use of Lindane. Lower ratios in summertime and higher in wintertime at Birkenes also support this hypothesis. However, among the 179 Parties to the Stockholm Convention officially only Canada, Sri Lanka and China have registered continuous use of lindane for pharmaceutical control of head lice and scabies. The higher ratios in the north instead indicates re-emission from secondary sources or long distance to primary emissions.

A strong seasonality was observed at Birkenes, with up to three times higher concentrations during late summer than wintertime. A similar seasonality, although less strong, was also observed at Andøya and Zeppelin with a tendency of lower concentrations in wintertime

(December-March) (Figure 3.4). Higher concentrations during warmer periods may be due to revolatilisation from soil or other environmental surface media during warmer periods (i.e. secondary emissions) or may in part also be due to remaining applications during summer months (i.e. primary emission) (Halse, 2012).

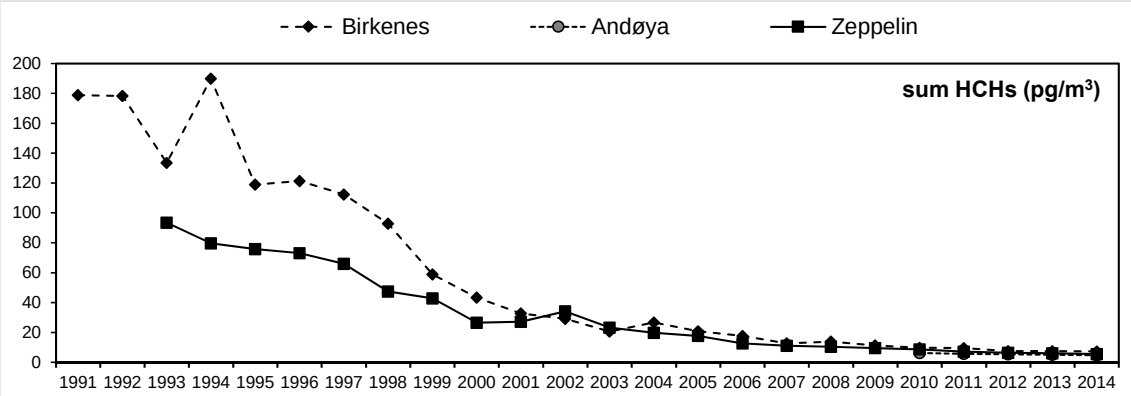

Figure 3.3: Annual mean concentrations of sum HCHs (pg/m³) in air.

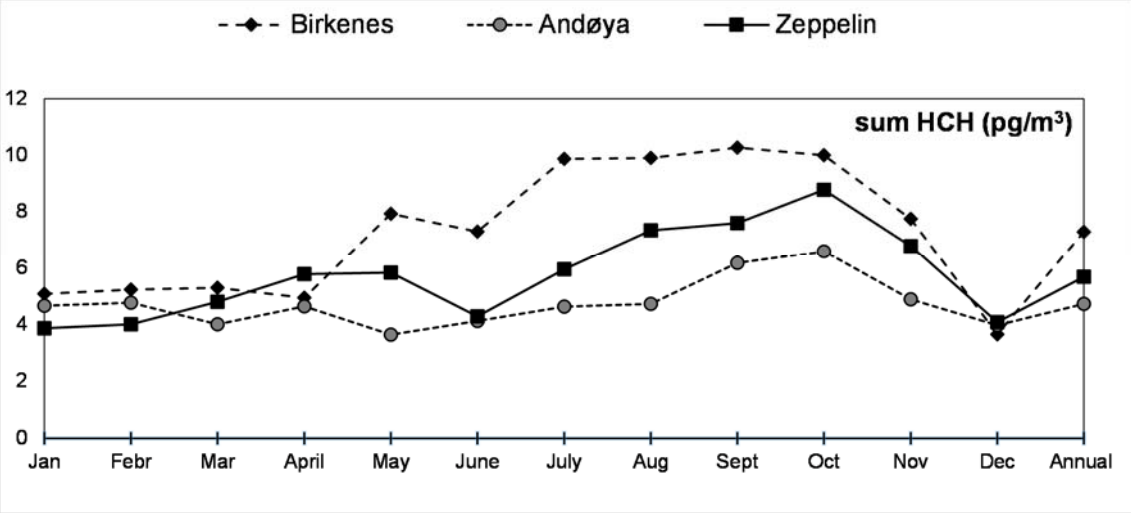

Figure 3.4: Monthly and annual mean concentrations (pg/m³) of sum HCHs in air for 2014.

3.1.3 DDTs

DDTs are intentionally produced chemical that has been used worldwide as a pesticide to protect humans and agricultural crops from vector-borne diseases. The production and use of DDTs were banned in Europe, US and Canada during 1970s to 2000 and is further regulated by the Aarhus protocol (UN/ECE, 1998b) and the Stockholm Convention on POPs (Stockholm Convention, 2007), but is still in use in some parts of the world for disease (primarily malaria) vector control. For example, the World Health Organization (WHO) recommends indoor residual spraying with DDT as one of three primary means of malaria control, the others being use of insecticide treated bednets and prompt treatment of confirmed cases with artemisinin-based combination therapies (WHO, 2006). The Conference of the Parties to the Stockholm Convention on POPs evaluates the continued need for DDT for disease vector control approximately every second year in consultation with WHO.

The six DDT congeners; o,p'- and p,p'- DDT, DDD, and DDE, have been monitored at Zeppelin since 1994, and at Birkenes and Andøya since 2010. The detection frequencies varied among the individual congeners and between the sites. For example, only p,p'-DDE was detected in all samples at all sites, while low detection (i.e. low concentrations) was observed for p,p'-DDT at all sites, and for o,p'-DDD, o,p'-DDE, p,p'-DDD at Zeppelin. p,p'-DDE was also the most abundant congener at all sites. The weekly concentrations of sum DDTs during 2014 ranged between: 0.4-5.9 pg/m^3 at Birkenes (excluding one high outlier); 0.1-3.8 pg/m^3 at Andøya; and 0.1-2.5 pg/m^3 at Zeppelin.

The annual mean concentrations of sum DDTs and the individual congeners in 2014 were as previous years up to four times higher at Birkenes (2.1 pg/m^3) compared to Andøya (0.8 pg/m^3) and Zeppelin (0.6 pg/m^3) (Figure 3.5:). The annual mean concentrations of sum DDT at Birkenes and Andøya in 2014 were higher than those observed in 2013 and the highest since the beginning of the monitoring in 2010 at Birkenes and the second highest since 2010 in Andøya. The annual mean concentrations at Zeppelin in 2014 was similar to the previous four years suggesting the concentrations to have reached a plateau after the long-term declining trends. This was consistent for all congeners. Although the concentrations were higher at Birkenes, they were still 10-100 times lower than the concentrations found on the European continent (Halse 2011, Pribylova 2012). The reason for higher concentrations at Birkenes compared to the more northern Norwegian sites may be explained by being closer to possible emission sources, but more research is needed before any conclusions can be drawn. The indicator ratio (p,p'-DDE+p,p'-DDD/p,p'-DDT) were high (>10) at all sites throughout the year indicating input only from aged DDT.

A strong seasonality was observed at Zeppelin and Andøya with 5-10 times higher concentrations in wintertime (December-February) compared to warmer months (May-September) (Figure 3.6). This seasonality was seen for sum DDTs as well as o,p'- and p,p'-DDE and DDT but not for DDD. In contrast, a weaker seasonality was observed at Birkenes.

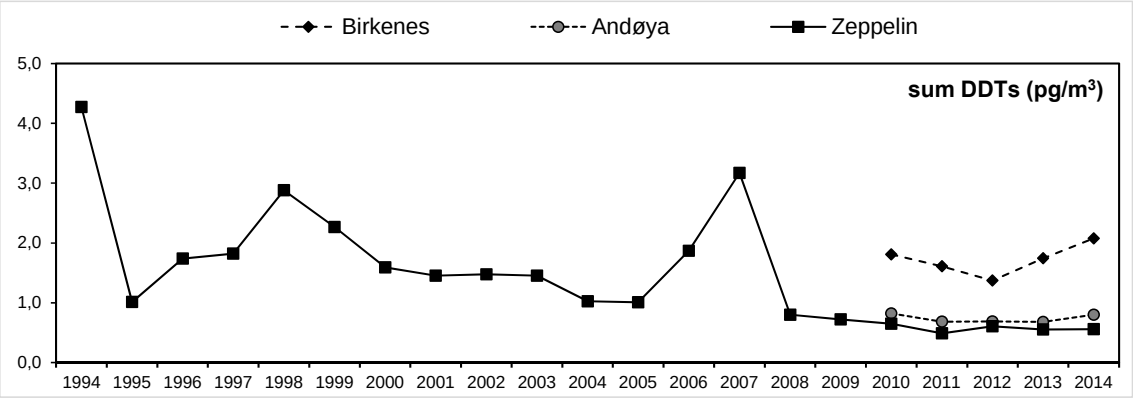

Figure 3.5: Annual mean concentrations of sum DDTs (pg/m^3) in air.

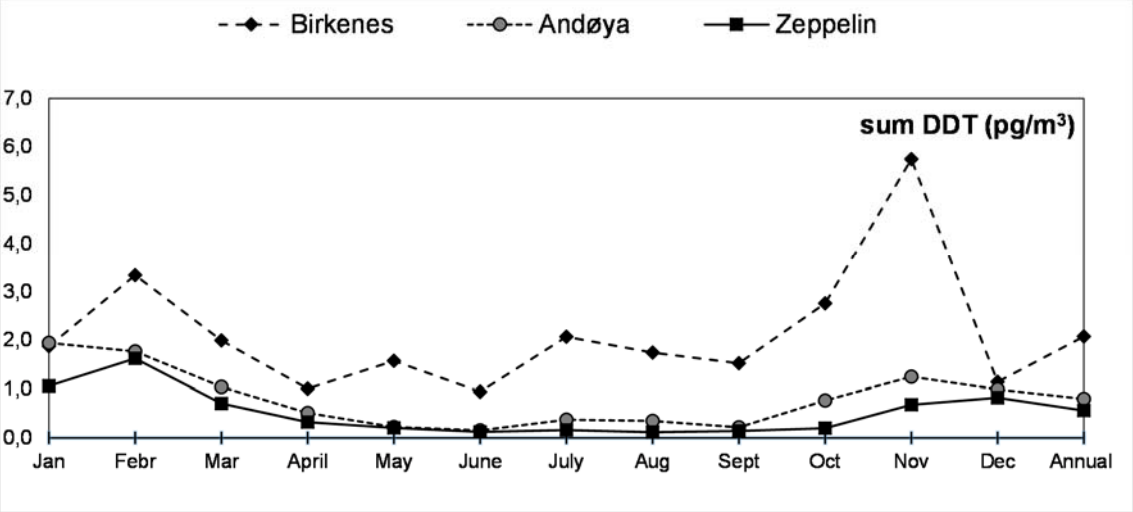

Figure 3.6: Monthly and annual mean concentrations (pg/m^3) of sum DDTs in air for 2014.

3.1.4 Chlordanes (CHLs)

CHLs are intentionally produced chemicals that have been used extensively as pesticides (insecticides). The use and production of CHLs have been banned under the Aarhus protocol (UN/ECE, 1998b) and the Stockholm Convention on POPs (Stockholm Convention, 2007).

The four stereoisomers of chlordane (i.e. cis- and trans-chlordane (CD), and cis- and trans-nonachlor (NO)) have been monitored at Zeppelin since 1993, at Birkenes since 2010 and are not included at Andøya. All the four isomers were detected in all samples at both sites. The major components were cis-CD and trans-NO contributing ~40% each to the sum CHLs. The weekly concentrations of sum CHLs ranged between: 0.5-1.9 pg/m^3 at Birkenes; and 0.3-1.7 pg/m^3 at Zeppelin.

The annual mean concentrations of sum CHLs in 2014 were in the same range at the two sites. The levels of sum CHL and the individual stereoisomers at Zeppelin and Birkenes were the lowest observed since the start of the monitoring and are in agreement with the small decreasing trends observed during the last years as well as the significant reduction of air concentrations observed at Zeppelin since the beginning of 1990s (Figure 3.7:). The ratio of trans-CD and cis-CD was low at both sites (0.1-0.7 compared to 1.17 in technical mixture) indicating input only from aged CHLs, since trans-CD degrades faster than cis-CD in the environment.

No seasonality was observed for sum CHLs at Birkenes, instead the concentrations fluctuated over the year (Figure 3.8). One of the individual isomers, however, showed seasonality; cis-NO was a factor of two-four higher in summertime (May-August) than in wintertime (November-April). Although a small concentration range also at Zeppelin, the lowest concentrations of sum CHLs were consistently observed during summertime and the highest during wintertime. A similar trend was seen for the individual isomers (especially trans-CD that were five-seven times lower in summer than in winter) with exception of cis-NO which in contrast had highest concentrations in summertime.

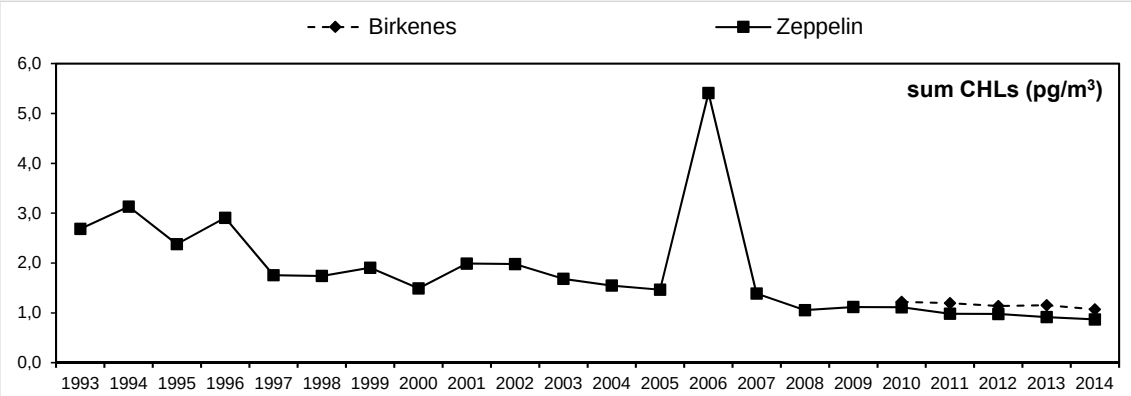

Figure 3.7: Annual mean concentrations of sum CHLs (pg/m³) in air.

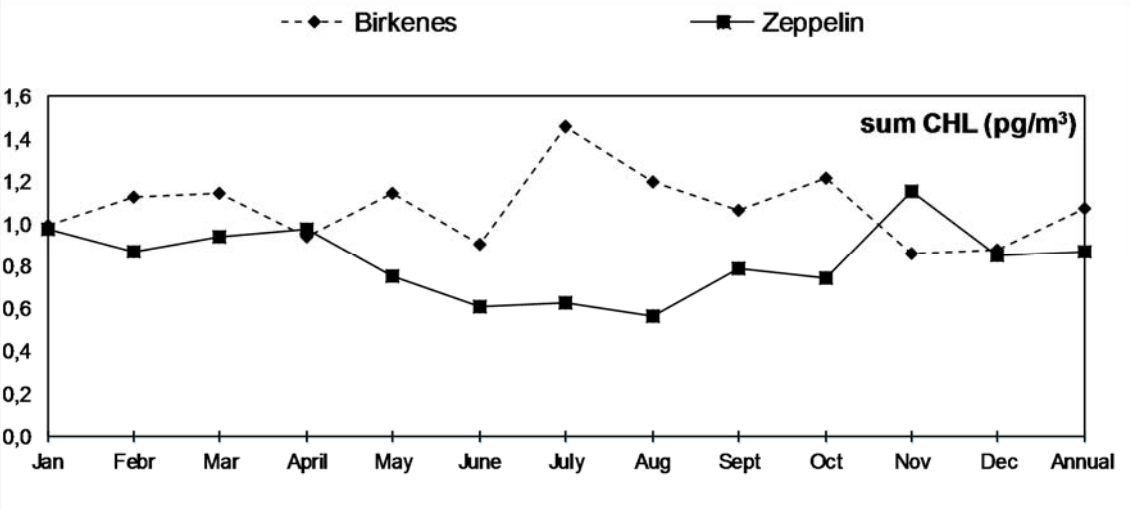

Figure 3.8: Monthly and annual mean concentrations (pg/m³) of sum CHLs in air for 2014.

3.1.5 Polychlorinated biphenyls (PCBs)

PCBs are industrially produced chemicals that have been used in a variety of industrial applications. They have been banned from active use in most countries since the mid 1970s and were further banned by the Aarhus protocol (UN/ECE, 1998b) and the Stockholm Convention on POPs (Stockholm Convention, 2007). Current sources of emissions to the environment are mainly from places where they have been disposed or stored, such as landfills or exposed soils, or from open burning of products containing PCBs, waste incinerations and accidental fires (Breivik et al., 2002; Cousins and Jones, 1998).

The PCBs theoretically consists of a group of 209 congeners. 32 of these (=sum PCBs) were measured at all three observatories in 2014. These 32 congeners include the seven European indicator congeners (PCB-7); PCB 28, 52, 101, 118, 138, 153, 180, as well as the 12 dioxin-like and most toxic congeners according to WHO; PCB 77, 81, 126, 169, 105, 114, 118, 123, 156, 157, 167, 189. Data are reported for sum of 32 PCBs as well as PCB-7.

PCBs have been monitored at Zeppelin since 2001 and Andøya since 2009. At Birkenes, the seven indicator PCBs have been monitored since 2004 and all the 32 since 2010. The detection frequencies varied among congeners as well as between sites. Generally, high detection frequencies were observed for tri-penta PCBs (until PCB 114) at all sites while penta-hepta

PCBs (from PCB 118) were detected to low or no extent. As previous years, the tri- and tetra-PCBs were the most common PCBs, comprising 70-80% of sum PCB. The weekly concentrations of sum PCBs during 2014 ranged between: 6.6-29.4 pg/m^3 at Birkenes; 2.7-12.5 pg/m^3 at Andøya; and 5.9-17.6 pg/m^3 at Zeppelin (excluding one high outlier).

The annual mean concentrations of sum PCBs and PCB-7 in 2014 were a factor of two higher at Birkenes and Zeppelin than at Andøya (Figure 3.9:). Reason for this is unknown. The annual mean concentrations in 2014 are higher than in 2013 at all observatories and the highest since 2010 at both Birkenes and Zeppelin. This deviates from the decreasing trends that have been observed at Zeppelin and Birkenes during the previous four years while the levels at Zeppelin still are a factor of two-three lower than the previous 5-10 years.

No seasonal trend was observed for sum PCBs and sum PCB-7 at Birkenes. The concentrations at Andøya varied up to a factor of four and the lowest levels were consistently observed in summertime (June-September) and the highest in wintertime (January-March). At Zeppelin the concentrations varied maximum a factor of three, but in contrast to Andøya the lowest concentrations were consistently found in wintertime (October-January) and the highest in summertime (May-August).

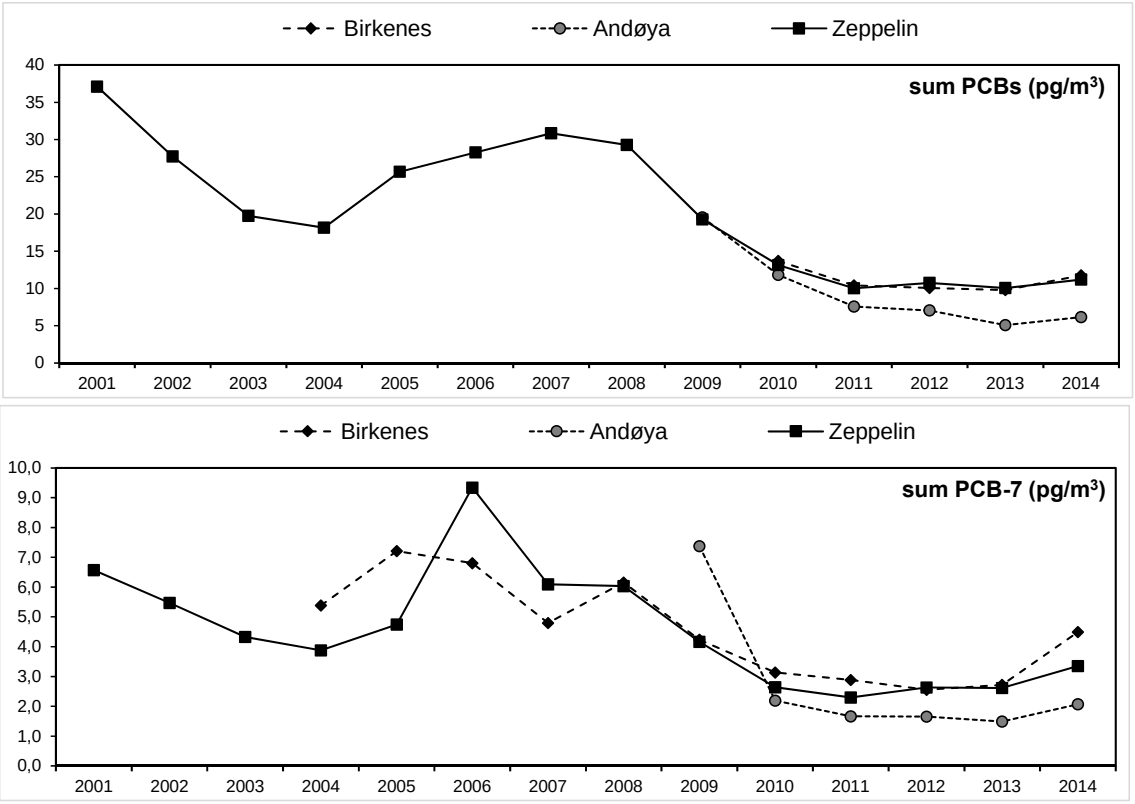

Figure 3.9: Annual mean concentrations of sum PCBs and sum PCB-7 (pg/m^3) in air.

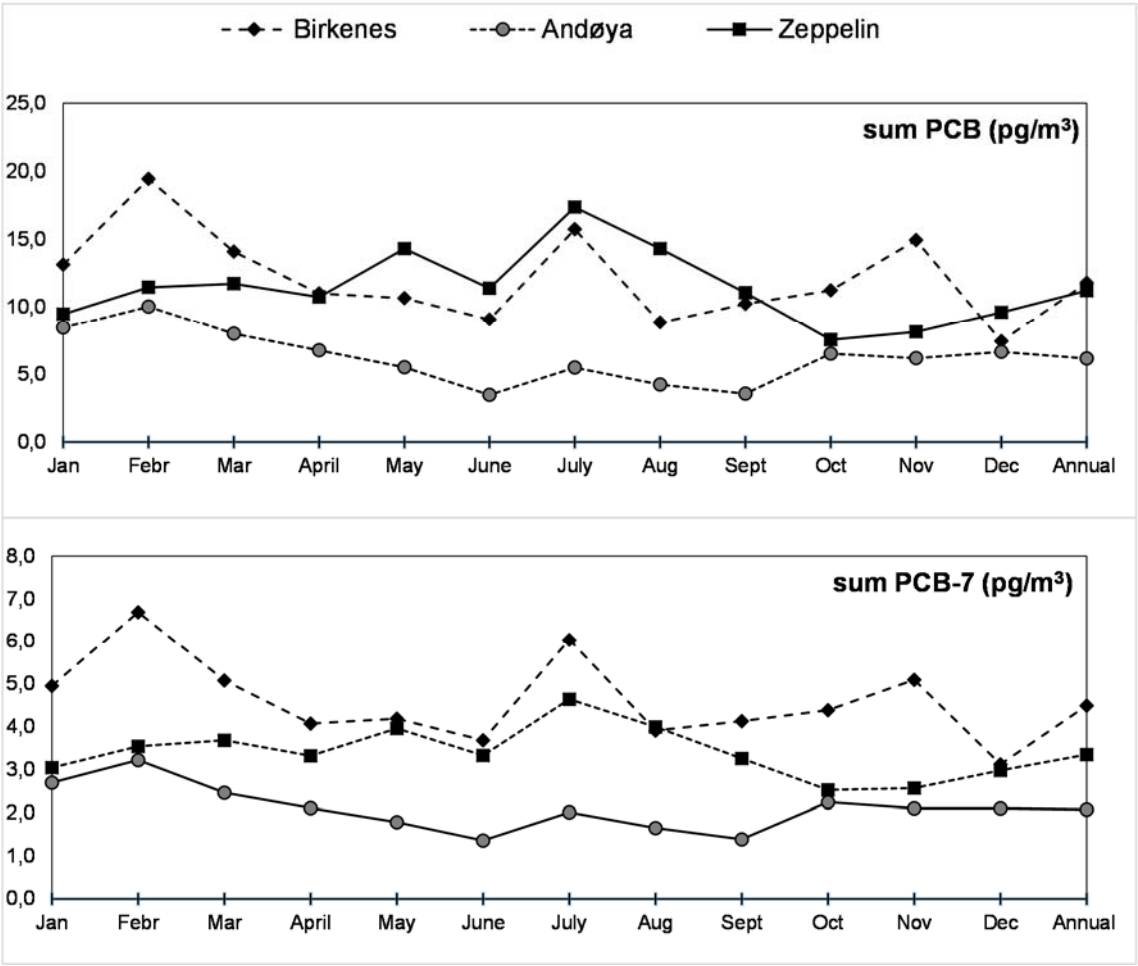

Figure 3.10: Monthly and annual mean concentrations (pg/m³) of sum PCBs and sum PCB-7 in air for 2014.

3.1.6 Polybrominated diphenyl ethers (PBDEs)

PBDEs are industrially produced chemicals that have been and still are used as flame retardants in a wide range of applications including plastics, textiles and electrical and electronic products. The production and use of the commercial PBDE mixtures: penta- and octa-BDE, are regulated by the Aarhus protocol (UN/ECE, 2010) and the Stockholm Convention on POPs (Stockholm Convention, 2013) and are today banned in most countries worldwide. On the other hand, the commercial PBDE mixture, deca-BDE, has not yet been subjected to the same restrictions and is still in use globally. Steps to limit or ban the use have been taken in some countries and regions including Norway where it is banned and the EU where it is banned in electrical products. Deca-BDE is currently also being considered for inclusion as a POP in the Stockholm Convention (Stockholm Convention, 2015). A restriction on the manufacturing, use and placing on the market of deca-BDE is further under discussion in the EU.

PBDEs theoretically comprise 209 congeners with different degrees of bromination from tetra- to deca-BDE. 17 of these congeners (=sum PBDEs) have been monitored at Zeppelin since 2006, at Birkenes since 2008, and at Andøya since 2009. The detection frequencies varied among congeners as well as between sites. Only six of the 17 measured congeners were observed with high detection frequencies (i.e. BDE-28, -47, -49, -66, -99, -100). The other

congeners, including BDE-209, were below detection limit in more than half of the samples at all sites. A low detection limit for most of these compounds indicates low concentrations at the sites. In contrast, the low detection frequency for BDE-209 is not due to very low air concentrations but is instead affected by analytical challenges related to possible contamination that causes elevated detection limits of BDE-209. The most abundant congeners were BDE-209 and BDE-47 representing on average 45-65% and 10-38% of sum BDEs. The winter concentrations of sum PBDEs ranged between: 0.09-13.8 pg/m^3 at Birkenes; 0.03-7.80 pg/m^3 at Andøya; and 0.31-1.78 pg/m^3 at Zeppelin.

The annual mean concentrations of sum PBDEs in 2014 were two-three times higher at Zeppelin (1.11 pg/m^3) and Birkenes (1.00 pg/m^3) than at Andøya (0.42 pg/m^3) (Figure 3.11:). Higher concentrations at Zeppelin and Birkenes were observed for several congeners while BDE-209 did not significantly differ between the sites. The concentrations of sum PBDEs and the individual congeners in 2014 were lower than in 2013 at all sites. While the levels of both sum PBDEs and BDE-209 at Andøya were the lowest since the start of the monitoring in 2009, the levels at Birkenes and Zeppelin were still higher or at the same range as those observed between 2008 and 2012. No significant long-term trends of sum PBDEs or BDE-209 can be seen at any of the sites. Instead the annual mean concentrations of both sum PBDEs and the individual congeners tend to fluctuate year by year.

No clear seasonality was observed for sum PBDEs nor the individual congeners (including BDE-209) at any site, instead the concentrations fluctuated from month to month (Figure 3.12). High levels at Zeppelin in July and at Birkenes in October are due to individual high measurements during these months and not a trend for the whole month. Mainly due to elevated levels of BDE-47 in July (Zeppelin) and BDE-209 in October (Birkenes). The reason for these individual high levels are not known.

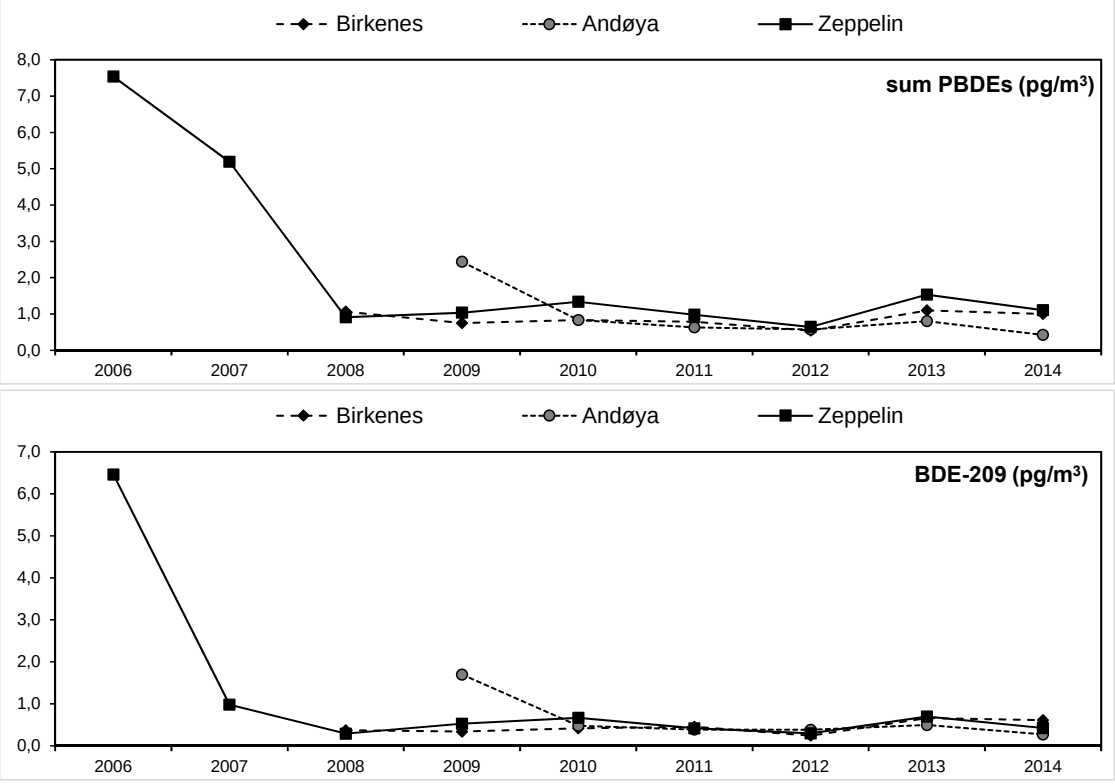

Figure 3.11: Annual mean concentrations of sum PBDEs and BDE-209 (pg/m^3) in air.

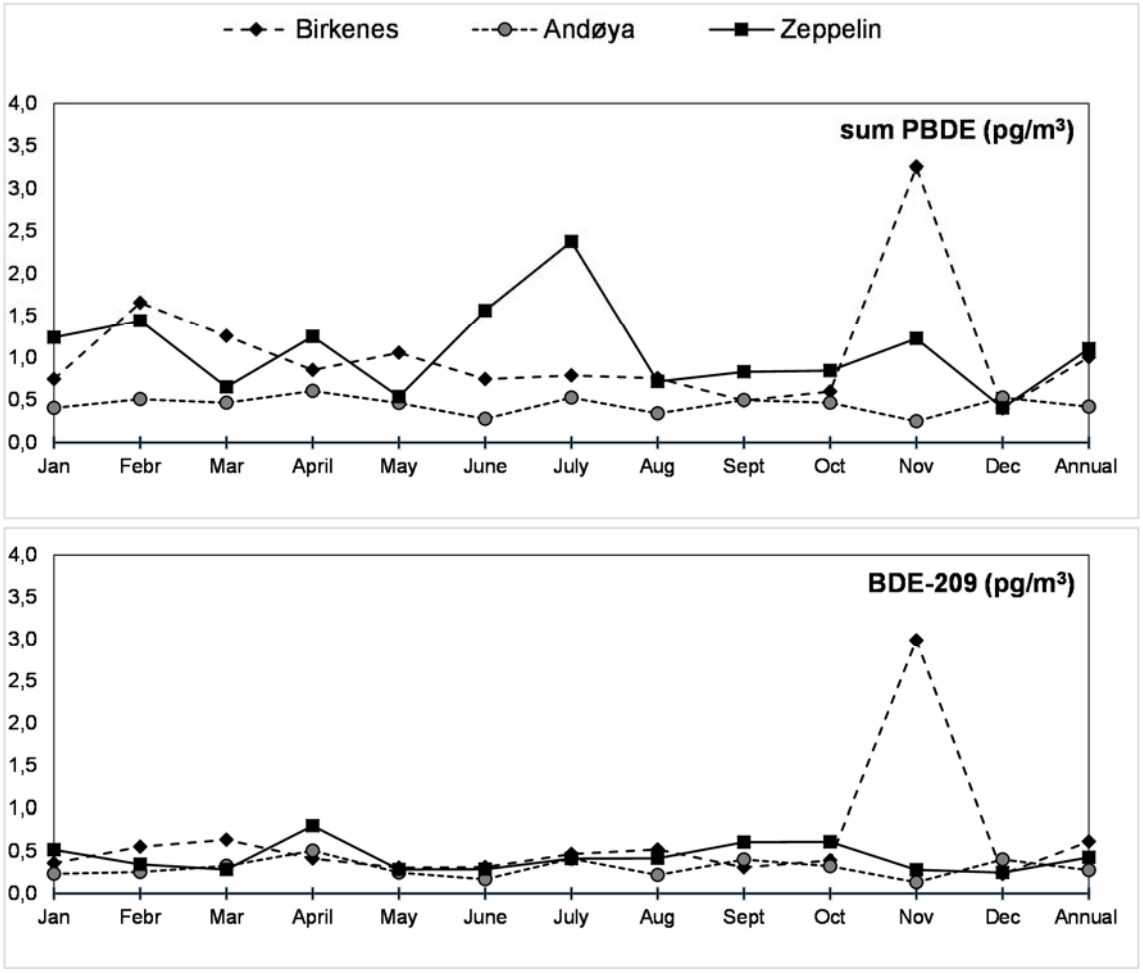

Figure 3.12: Monthly and annual mean concentrations (pg/m³) of sum PBDEs and BDE-209 in air for 2014.

3.1.7 Tribromanisol (TBA)

TBA is naturally produced by marine algae/sponges or by microbial degradation of tribromophenol (used for wood preservation and as an additive fire retardant). It shows POP like characteristics and have similar structure to other brominated pollutants.

TBA has been monitored at Birkenes and Zeppelin since 2007 and at Andøya since 2010. TBA was detected in all samples at all sites in 2014 and the weekly concentrations ranged between: 0.38-10.3 pg/m^3 at Birkenes; 0.03-9.18 pg/m^3 at Andøya; and 0.44-12.4 pg/m^3 at Zeppelin. The annual mean concentrations of TBA in 2014 were 5.37, 2.75, and 3.45 pg/m^3 at Zeppelin, Andøya, and Birkenes respectively (Figure 3.13:). In contrast to high levels observed in 2013, the levels at all sites in 2014 were among the lowest observed since the start of the monitoring.

The same seasonal trends were observed at all sites, lowest concentrations during spring and increasing levels during the summer and early autumn (Figure 3.14). This is in agreement with previous years. The higher levels in summertime may be a consequence of increased algal bloom during this period.

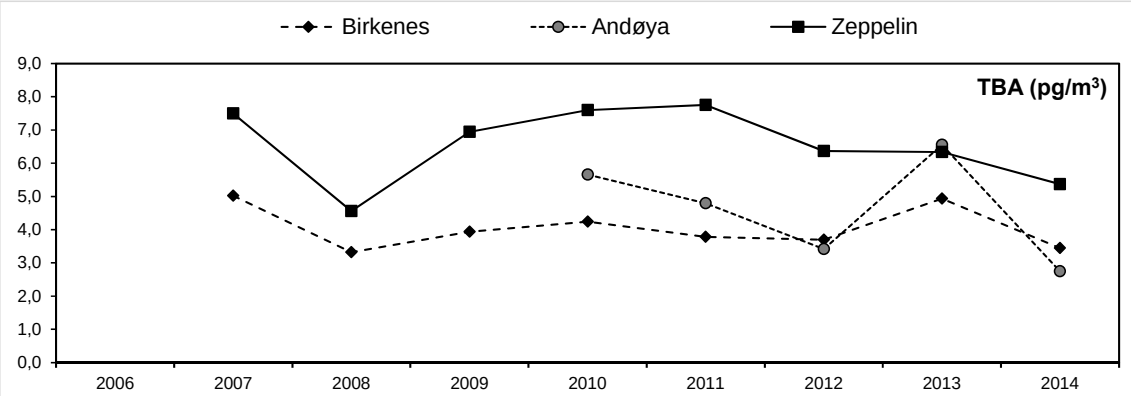

Figure 3.13: Annual mean concentrations of TBA (pg/m³) in air.

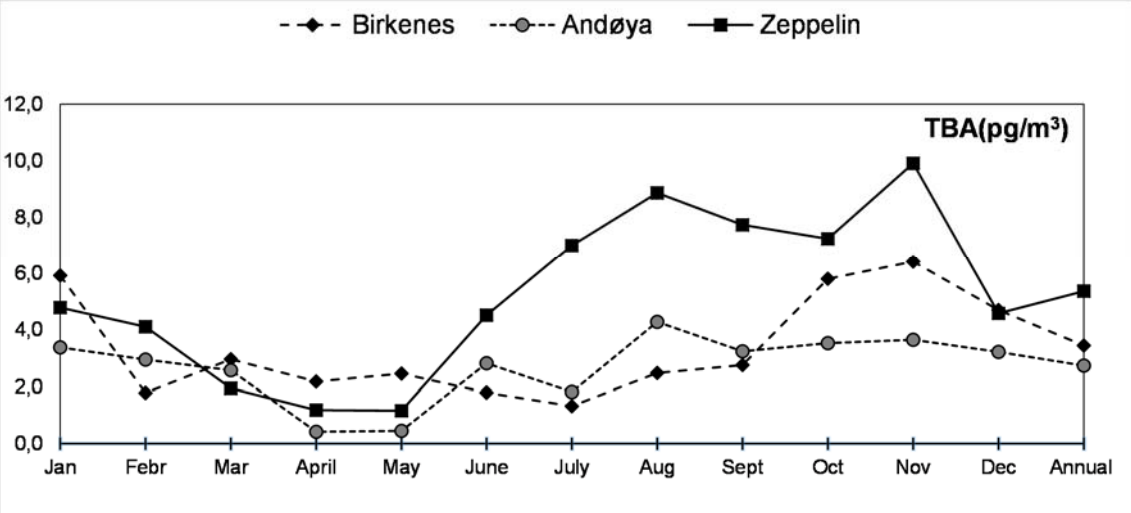

Figure 3.14: Monthly and annual mean concentrations (pg/m³) of TBA in air for 2014.

3.1.8 Hexabromocyclododecane (HBCD)

HBCD is an additive brominated flame retardant, with many applications. The main use is in extruded and expanded polystyrene for thermal insulation in building and construction materials. HBCD was listed in the Stockholm Convention on POPs in 2013 with a time-limited exception for production and use in some polystyrene applications. The global ban entered into force in November 2014 (Stockholm Convention, 2013).

The three main diastereomers: α-, ß-, and γ-HBCD (=sum HBCDs) have been monitored at Birkenes and Zeppelin since 2006, but are not included at Andøya. The HBCDs are detected with a low frequency at both sites. The individual isomers are below detection limit (i.e. very low concentrations) in more than 85% of the samples. As a result no annual or monthly mean concentrations for 2014 are included in this report.

In general, after high concentrations during the first two years of monitoring (2006-2007) the concentrations have significantly decreased at both sites, but the levels are fluctuating from year to year so that no clear time trend can be seen for 2008-2014.

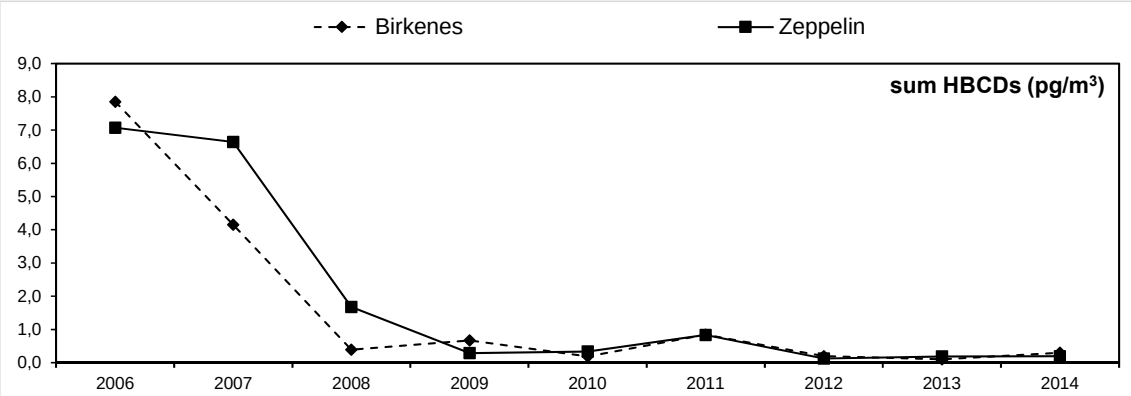

Figure 3.15: Annual mean concentrations of sum HBCDs (pg/m^3) in air.

3.1.9 Polycyclic aromatic hydrocarbons (PAHs)

PAHs are mainly produced through incomplete combustion of organic materials, both through antropogenic (i.e. industrial and domestic use) and natural causes. They are regulated in the Aarhus protocol on POPs (UN/ECE, 1998b) and the EU air quality directive (AQD) (EU, 2004). They show POP like characteristics, but are less persistent than those classified as POPs.

Seven methyl-PAH and 33 PAHs (=sum PAHs) including the 16 EPA-PAHs (=sum PAH-16) were measured at Birkenes and Zeppelin during 2014. PAHs have been monitored at Zeppelin since 1994, at Birkenes since 2009, and at Andøya between 2009 and 2012. The detection frequencies varied among PAH compounds and between the sites. Generally, more compounds had low detection frequency and were below detection limit at Zeppelin (~80%) than at Birkenes (~50%). A large range of weekly concentrations were observed at both sites: 0.33-70 pg/m^3 at Birkenes; and 0.20-19.5 pg/m^3 at Zeppelin. The annual mean concentrations of sum PAHs and sum PAH-16 in 2014 were, as previous years, about two times higher at Birkenes than at Zeppelin (Figure 3.16:). The annual mean concentrations at Zeppelin and Birkenes were somewhat higher than those observed in 2013 and the highest observed at Birkenes since the start in 2009 and the highest at Zeppelin since 2000. These results indicate a cut of the decreasing trend observed during the first decade of 2000. The levels of benzo(a)pyrene at both stations are one to three orders of magnitude below the European Air Quality Standard (1 ng/m^3) (EEA) as defined by the 4th daughter directive (EU, 2004).

A strong seasonality was observed for all PAHs at Zeppelin and Birkenes with up to one order of magnitude higher concentrations in wintertime (November-March) than in summertime (Figure 3.17). The same seasonality was seen both for sum PAHs and the individual PAHs.

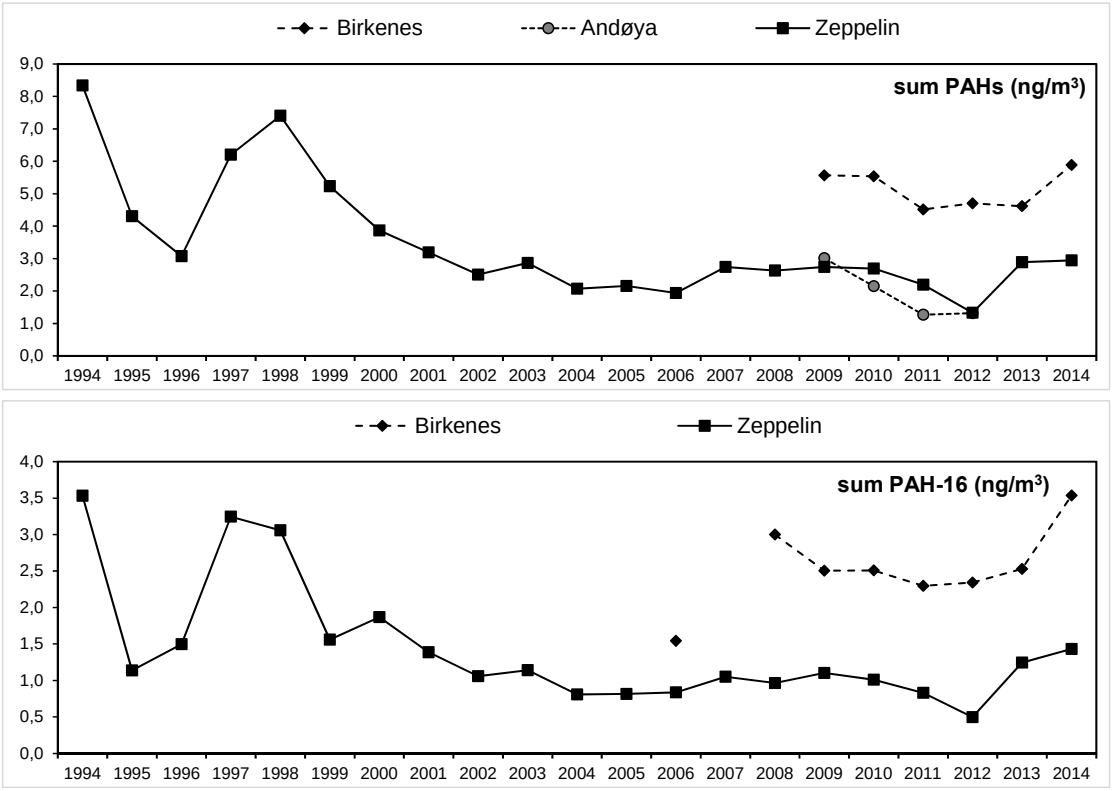

Figure 3.16: Annual mean concentrations of sum PAHs and sum PAH-16 (ng/m³) in air.

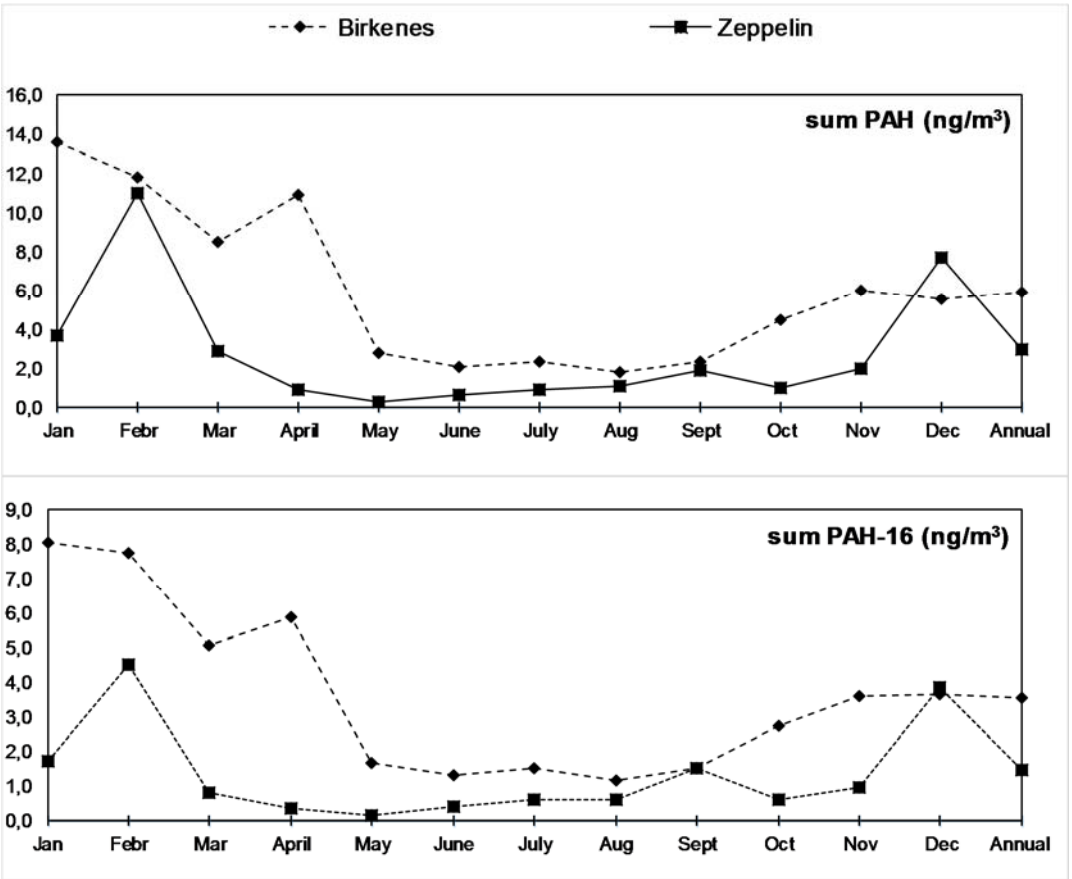

Figure 3.17: Monthly and annual mean concentrations (ng/m³) of sum PAHs and sum PAH-16 in air for 2014.

3.1.10 Per- and Polyfluorinated Alkyl Substances (PFAS)

PFAS comprise a large and complex group of industrially produced chemicals: ionic compounds like perfluoroalkyl sulfonates (PFOS) and perfluoroalkyl carboxylic acids (PFCAs); and neutral, volatile compounds like fluorotelomer alcohols (FTOHs) and N-alkylated fluorooctane sulphonamides and sulfonamidoethanols (FOSAs/FOSEs). During the last 50 years, the PFAS, such as PFOS, perfluorooctanoic acid (PFOA) and their related products, have been widely used in consumer products. PFOS together with its salt and perfluorooctane sulfonyl fluoride (PFOS-F) is the only PFAS that is regulated by the Aarhus protocol (UN/ECE, 2010) and the Stockholm Convention on POPs (Stockholm Convention, 2013). In Norway, both PFOS and PFOA are banned, and the C9-C14 PFCAs are on the Norway's Priority List of Hazardous substances ("Prioritetslisten") (Norwegian Environment Agency, 2015)

The monitoring includes 12 ionic PFAS compounds (=sum PFAS) at all three stations in 2014: FTS 6-2 (6:2 Fluorotelomer Sulfonate), PFBS (Perfluorobutane sulfonate), PFDcA (Perfluorodecanoic acid), PFDcS (Perfluorodecane sulfonate), PFHpA (Perfluoroheptanoic acid), PFHxA (Perfluorohexanoic acid), PFHxS (Perfluorohexane sulfonate), PFNA (Perfluorononanoic acis), PFOA, PFOS, PFOSA (Perfluorooctane sulphonamide), PFUnA (Perfluoroundecanoic acid). They have been monitored at Birkenes and Zeppelin since 2006 and at Andøya since 2009.

Most of the monitored PFAS were below the analytical detection limit in all samples at all sites. Only PFOA was frequently above the detection, with detection frequencies of ~50% limit and with monthly concentrations in the range of 0.10-0.48 pg/m^3 at all sites (Annex 2). The annual mean concentrations of PFOA at each site were 0.32 pg/m^3 at Birkenes, 0.19 pg/m^3 at Andøya, and 0.22 pg/m^3 at Zeppelin. In addition, PFOSA, PFOS, and PFNA were detected to some extent at Birkenes, and PFNA and PFOS to some extent at Andøya and Zeppelin. The provided concentrations in Annex 2 should therefore be taken with caution and considered as an upper limit.

The annual mean concentrations of sum PFAS in 2014 were similar at Andøya and Zeppelin. This is a result of most compounds being below the detection limit. The higher levels measured at Birkenes is a result of more compounds above the detection and might indicate current use and ongoing emission from anthropogenic applications. There is a big variability in levels from year to year and not a strong evidence of decreasing trends (Figure 3.18).

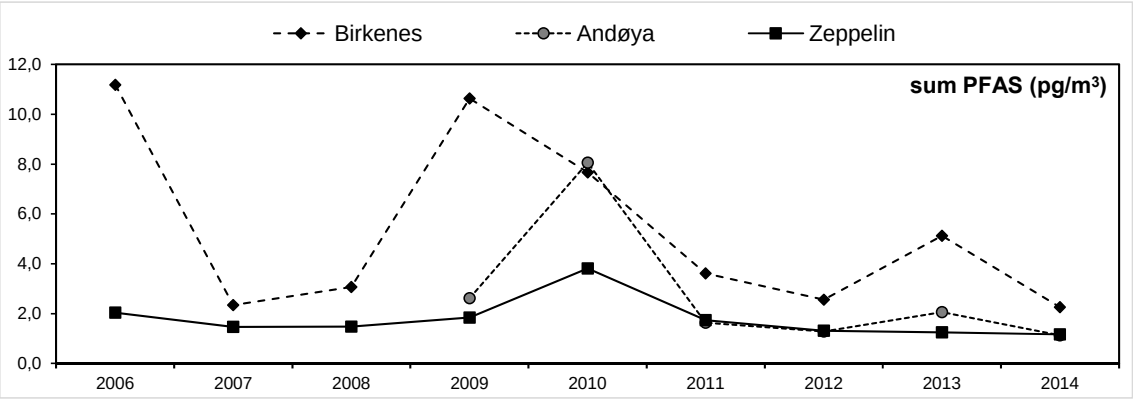

Figure 3.18: Annual mean concentrations of sum PFAS (pg/m^3) in air.

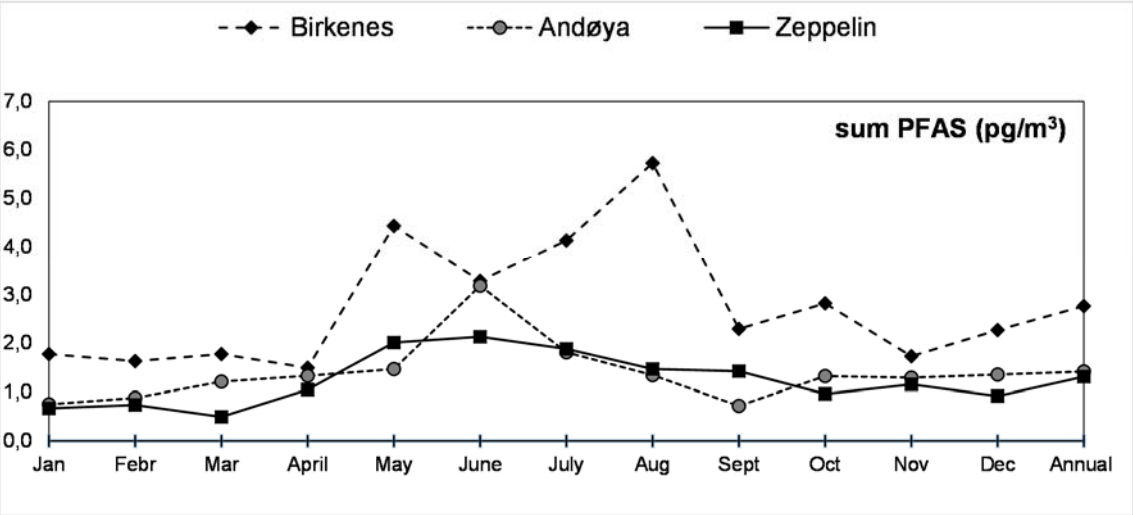

Figure 3.19: Monthly and annual mean concentrations (pg/m³) of sum PFAS in air for 2014.

3.2 Persistent organic pollutants in precipitation

Precipitation samples were as previous years collected at Birkenes and analysed for HCBs, HCHs and PCB-7 (Annex 3, and Table A.2.6). HCB and HCHs have been monitored since 1992 while PCB-7 since 2006.

The annual mean concentrations of HCB in precipitation in 2014 were similar to those observed during the last six years. A significant reduction of concentrations has been observed since the 1990s and the beginning of 2000 while the concentrations seem to have reached a plateau during the last six years (Figure 3.20). The same trend has been observed for the air concentrations at Birkenes. HCB showed small seasonal variations with higher concentrations during summertime than winter time (Figure 3.21).

The annual mean concentration for sum HCHs was the lowest since the beginning of the monitoring (in 1992) and as in air they followed the decreasing time-trend at Birkenes. The lowest monthly mean concentrations were observed in December-February while more homogeneous levels were observed for the rest of the year. High levels in July depends on general high concentrations in all samples during that month. This seasonality is similar to that found for air concentrations at Birkenes.

The annual mean concentration of PCB-7 in 2014 was lower than that observed in 2013, but the same as the previous four years. This was in contrast to the air levels that were the highest in many years at Birkenes. The lowest concentrations were observed in late summer while the highest in mid-wintertime.

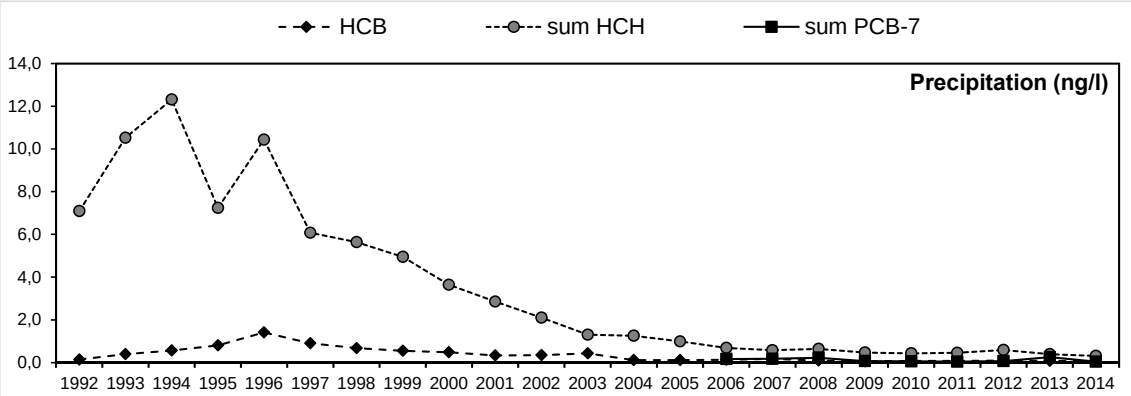

Figure 3.20: Annual mean concentrations of HCB, sum HCHs and sum PCB-7 (ng/l) in precipitation.

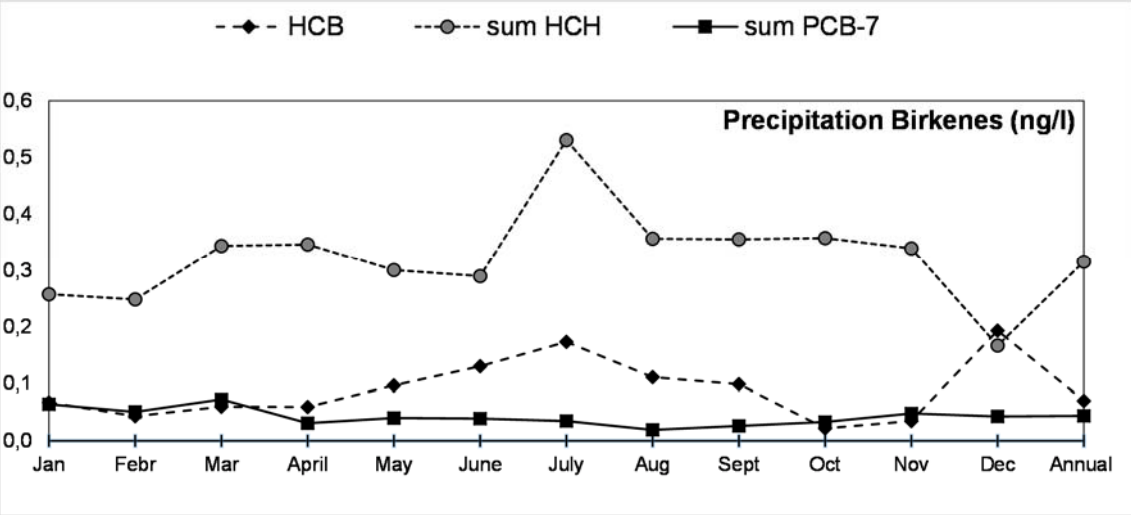

Figure 3.21: Monthly and annual mean concentrations (ng/l) of HCB, sum HCHs and sum PCB-7 in precipitation at Birkenes, 2014.

4. Emerging contaminants

4.1 Cyclic volatile methyl siloxanes (cVMS)

cVMS represent a subgroup of a large class of compounds called dimethylsiloxanes, or more commonly referred to as cyclic volatile methyl siloxanes. These compounds are produced in large volumes worldwide and are used in various applications, particularly in the cosmetic and personal-care products where they are often referred to as cyclomethicones, although various other trade names exist (Wang et al., 2013). Currently, there are no regulations on the production and use of cVMS within industrial and consumer products. However, the cyclic oligomers octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5), and dodecamethylcyclohexasiloxane (D6) have drawn increased attention in recent years from regulatory agencies and the scientific community regarding their environmental persistence (P), bioaccumulation (B), toxicity (T), and long range transport (LRT) potential (Brooke et al., 2009a; Brooke et al., 2009b; Brooke et al., 2009c; Canada, 2008a; Canada, 2008b). There has been much discussion/disagreement between regulatory agencies, industry, and the scientific community regarding the PBT properties of siloxanes, but restrictions on use of these chemicals have recently been submitted. For example; on April 15, 2015, the United Kingdom submitted a restriction proposal that D4 and D5 use in wash-off personal care products must not exceed 0.1% within the EU, and the ECHA Member State Committee (MSC) came to an agreement on April 22, 2015 that D4 and D5 meet the criteria for very biaccumulative (vB) and persistent (vP) substances defined in the REACH Regulation (EC) No 1907/2006 (ECHA, 2015). In addition, D4 and D5 are on Norway's priority substances list with the aim to stop emissions of these compounds by 2020 (Norwegian Environment Agency, 2015). Long-range transport of cVMS to Arctic regions has been shown to occur by several studies reporting their presence in Arctic air (Genualdi et al., 2011; Krogseth et al., 2013). However, their potential to deposit to surface media is considered to be minimal due to their inherent volatility (Wania, 2003; Xu and Wania, 2013).

The measurements reported here are from the monitoring campaign carried out in the winter of 2014. In addition, previous results from air monitoring conducted in 2013 (Nizzetto et al., 2014) and 2011 (Krogseth et al., 2013) are included for comparison purposes. Findings by Krogseth et al. (2013) reported conversion/breakdown of D5 and D6 to D4 on ENV+ sorbent used for sample collection. The reported concentrations have been corrected for sorbent related degradation during storage using methodology reported by Krogseth et al. (2013), but the data should be considered semi-quantitative. All samples were above limits of quantification. Highest average concentrations during the 2014 winter sampling campaign were observed for D5 (3.60 ± 1.78 ng/m^3) followed by D6 (0.39 ± 0.20 ng/m^3) (Table 4.1, Figure 4.1). Concentrations for both D5 and D6 were in agreement with results from winter sampling campaigns in 2013 (Nizzetto et al., 2014) and 2011 (Krogseth et al., 2013) (Figure 4.1). In 2014, one sample at the beginning of the sampling campaign showed concentrations of D5 twice as high compared to those collected later. This is likely attributed to daily variation that is expected to occur in atmospheric concentrations due to changes in atmospheric circulation patterns (McLachlan et al., 2010). In addition, modelled simulations of atmospheric concentrations for D5 show greater day to day variation in winter than in summer months (Krogseth et al., 2013).

Seasonality in atmospheric concentrations of cVMS was investigated in 2011 and 2013 (Figure 4.1). Higher concentrations were observed for D5 during wintertime compared to the summertime. This is attributed to the lower atmospheric concentration of hydroxyl radicals during this time of year, resulting in lower photodegradation (McLachlan et al., 2010). However, concentrations of D6 were observed to be higher in summer compared to winter in 2013 and were similar or greater compared to D5. These findings are opposite to observations in 2011 and were not expected based on known emission profiles and atmospheric behaviour of D5 and D6. Elevated concentrations of D6 during summer may be attributed to changes in atmospheric circulation where large concentration variations have been shown to occur for D5 over short time periods (McLachlan et al., 2010). However, a similar increase in concentration for D5 would also be expected to occur as it is more prevalent in the atmosphere compared to D6. However, this was not observed, and thus changes in atmospheric circulation are unlikely the cause for elevated D6 levels. Warner et al. (2010) observed higher concentrations of D6 compared to D5 in fish collected near the community of Ny Ålesund located below the Zeppelin station. Although this suggests that a different emission profile for D5 and D6 may occur locally to the aquatic environment, it is unclear if this source will impact atmospheric measurements and is only speculative at this point. Unfortunately, confirmation of D6 seasonality observed in 2013 could not be made in 2014 due to logistical problems in the summer. However, these findings highlight the need for future monitoring campaigns to evaluate differences in annual seasonal patterns for D6. This would also contribute to increased understanding of the atmospheric behaviour of D6 which is less well understood than that of D5.

Higher upper boundary limits were observed for D4 (2.98 ± 1.25) in 2014 compared to those reported in 2013 (1.27 ± 0.11 ng/m^3) and 2011 (1.48 ± 0.31). However, D4 concentration may be affected by sorbent degradation effects during storage, and thus no conclusions can be made regarding any trends in concentration nor its presence in Arctic air.

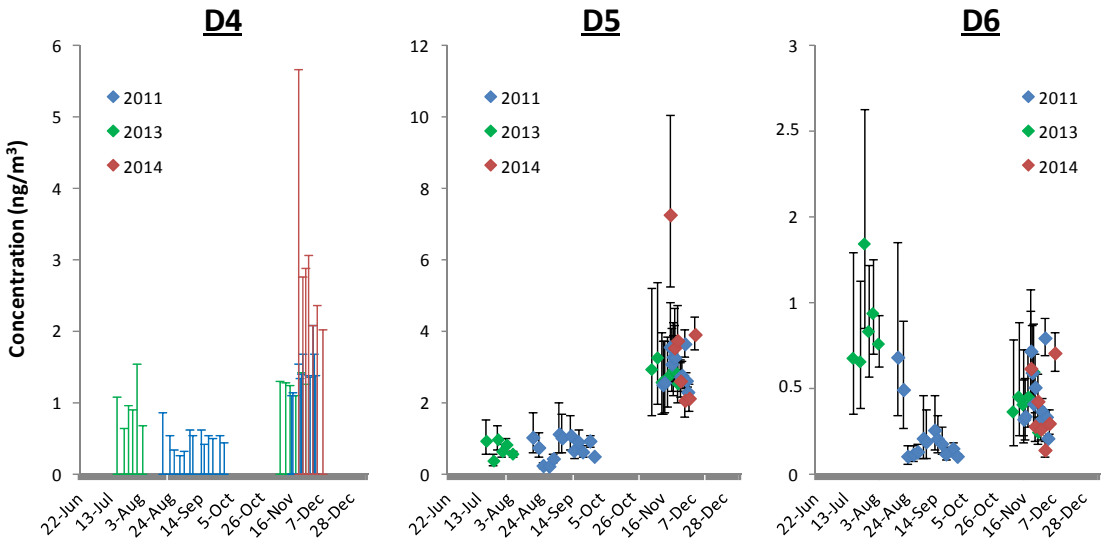

Figure 4.1: Measured concentrations of D4, D5 and D6 at Zeppelin in 2011 (blue), 2013 (green) and 2014 (red). Concentrations of D4 are reported as a range from non-detected to the upper limit detected. Concentrations of D5 and D6 are reported as a storage-corrected point-estimate with a range representing the 95% confidence interval of the storage correction.

Table 4.1: Air concentrations (ng/m^3) from Zeppelin in winter 2014. Concentrations reported represent average of two parallel samples.

Date		Air concentrations (ng/m^3)							
		D4		D5			D6		
Start	***End***	***Lower boundary***	***Upper boundary***	***Point estimate***	***Low estimate***	***High estimate***	***Point estimate***	***Low estimate***	***High estimate***
21.11.2014	24.11.2014	n.d.	5.66	7.26	5.25	10.04	0.62	0.40	0.95
24.11.2014	26.11.2014	n.d.	2.76	3.54	2.69	4.65	0.28	0.19	0.40
26.11.2014	28.11.2014	n.d.	2.88	3.73	2.95	4.73	0.42	0.31	0.58
28.11.2014	01.12.2014	n.d.	3.07	2.61	2.16	3.14	0.26	0.20	0.34
01.12.2014	04.12.2014	n.d.	2.08	2.06	1.62	2.64	0.14	0.10	0.20
04.12.2014	08.12.2014	n.d.	2.36	2.12	1.78	2.53	0.30	0.23	0.38
08.12.2014	10.12.2014	n.d.	2.03	3.91	3.48	4.39	0.71	0.60	0.83

4.2 Short and medium chained chlorinated paraffins (SCCP, MCCP)

Chlorinated paraffins (CPs), also referred to as polychlorinated n-alkanes, are semivolatile organic compounds (SVOCs) that have been used in large amounts for several decades in commercial products such as plasticizers, flame retardants, sealants and paints, and in industrial processes such as metalworking fluids and drilling (UNEP, 2010). Commercial mixtures of CPs are usually classified into three groups according to their carbon chain length; short chained CPs (SCCPs) with C10-C13, medium chain CPs (MCCPs) with C14-C17, and long chain CPs (LCCPs) with C18-C30. Some of the CPs have been found to be toxic, persistent in the environment, subject to long-range transport and bioaccumulative. Due to their harmful properties SCCPs are included in the Aarhus protocol on POPs (UN/ECE, 2010) and on Norway's priority list (Norwegian Environment Agency, 2015). They are currently also being reviewed by the Stockholm Convention on POPs for a possible inclusion as a POP (Stockholm Convention, 2015). In addition, SCCPs has received wide attention due to their high toxicity to certain aquatic organisms and rodents (UNEP, 2010). Despite this, information regarding levels and distribution of SCCPs in the environment remain limited, mainly due to analytical challenges (Tomy et al., 1997). The atmosphere is usually considered to be the main transport medium, but very few studies have been conducted to investigate the atmospheric levels and distribution of SCCPs.

SCCPs and MCCPs were included in the monitoring programme at Zeppelin in 2013. These are among the first measurements of M/SCCPs in Arctic air. Sampling was done on a weekly basis in parallel with sampling of PCBs and OCPs (Annex 3). As in other published studies, the blank levels for the SCCPs and MCCPs were variable and high, resulting in relatively high LOD values (10-50% of detected masses). Despite this only 6% of the measurements for SCCPs were below LOD, while about 40% of the measurements for MCCPs were below LOD. The presented data should be considered as semi-quantitative.

The annual mean concentrations for 2014 were 240 pg/m^3 for SCCPs and 30 pg/m^3 for MCCPs (Table 4.2). These are one to three orders of magnitude higher than the concentrations of most of the other studied POPs, but one order of magnitude lower than concentrations of sum PAHs and sum PAH-16. The annual mean concentrations of SCCPs in 2014 were slightly lower than in 2013 while the MCCPs concentrations were slightly higher in 2014 than 2013 (Figure 4.2). The differences between the years were not statistically significant. The concentrations of SCCPs and MCCPs measured at Zeppelin in 2014 in this study are similar to those observed in rural air in Canada, but almost three orders of magnitude lower than recent results from urban to rural sites in China and India (Wang et al., 2013, Chaemfa et al., 2014). The monthly mean concentrations in 2014 fluctuated from month to month and were influenced by individual high observations (Figure 4.3).

Table 4.2: Annual mean concentrations of SCCPs and MCCPs (pg/m^3) in air at Zeppelin.

Zeppelin	2013	2014
SCCP	361	245
MCCP	23	31

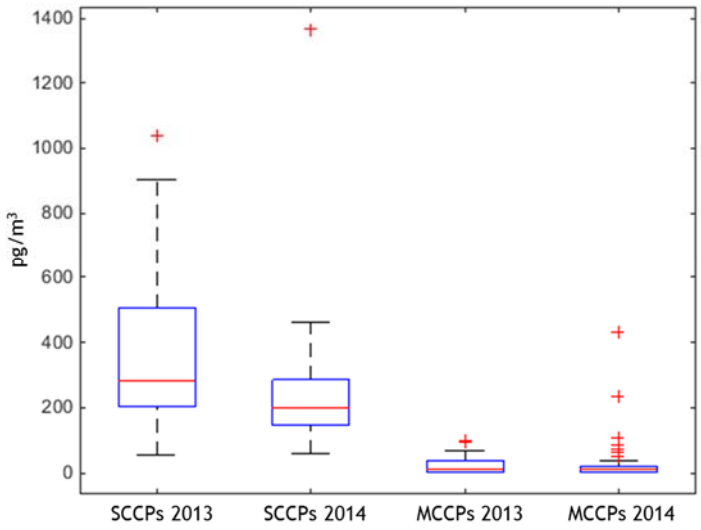

Figure 4.2: Box-whisker plot representing the annual mean concentrations and distribution of SCCPs and MCCPs in air at Zeppelin in 2013 and 2014 respectively.

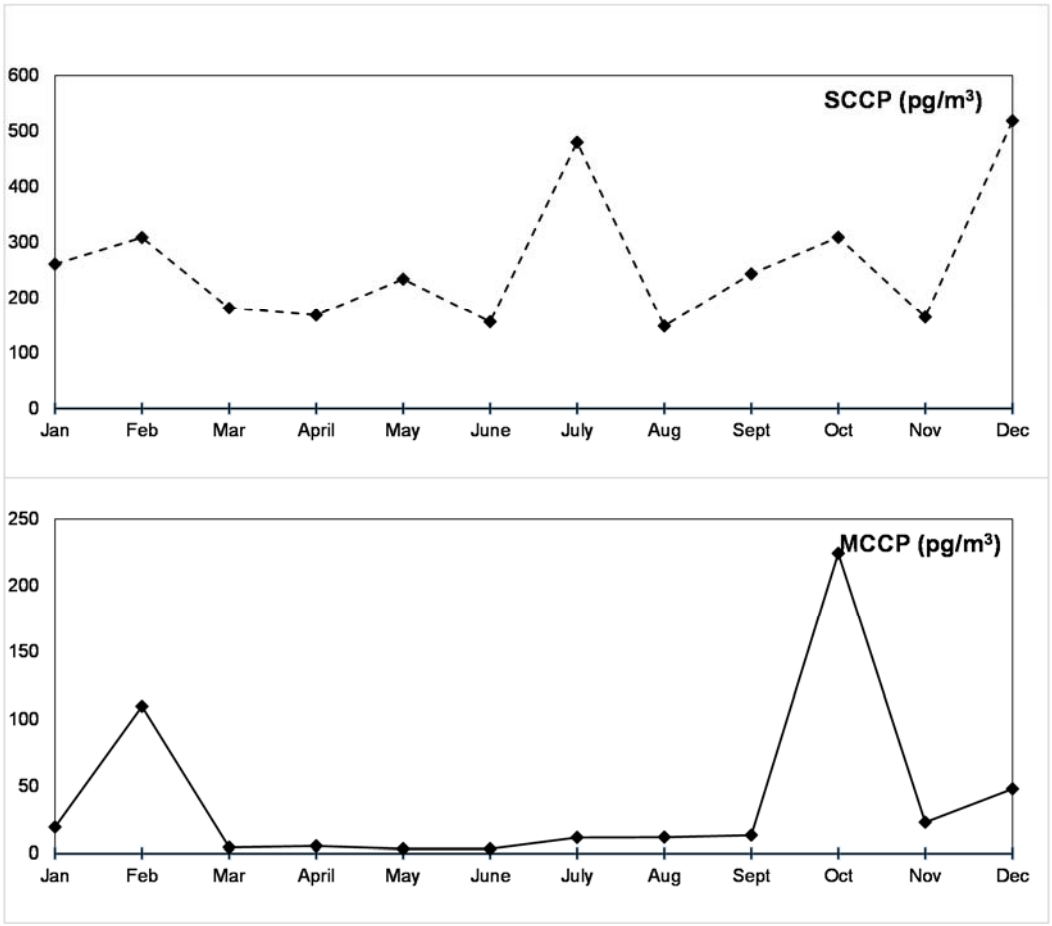

Figure 4.3: Monthly mean concentrations (pg/m³) of SCCPs and MCCPs in air at Zeppelin, 2014.

5. Summary organic pollutants

The overall annual mean concentrations for the different organic compound classes and observatories are presented in Table 5.1. In summary, the results from the air monitoring in 2014 show that the concentrations of most legacy POPs in air and precipitation are declining or have stabilized during the last years. The exception is HCB for which an increase in concentrations during the last 10 years has been observed at Zeppelin at Svalbard. Of all the monitored organic pollutants, the highest concentrations in 2014 were found for D5, followed by PAHs, D6, SCCP and the legacy POPs. HCB was found at highest level at Zeppelin, while DDTs, PAHs and PFAS were found at highest levels at Birkenes and lowest levels at Zeppelin. The levels of PCBs and PBDEs were generally lowest at Andøya while the other classes (i.e. HCHs, CHLs, TBA) were observed in similar levels at all observatories. The concentrations of the emerging contaminants cVMS and SCCP/MCCPs were up to three orders of magnitude higher than the concentrations of the legacy POPs (i.e. PCBs, OCPs, PBDEs, PFAS). The observation of high levels of emerging pollutants at Zeppelin at Svalbard, emphasizes the importance of continuous monitoring of these emerging POPs to follow their emission trends.

Table 5.1: Annual mean concentrations (pg/m^3) for all studied organic pollutants in air, 2014.

pg/m^3	HCB	sum HCHs	sum DDTs	sum CHLs	sum PCBs	sum PCB-7	sum PBDE	TBA	sum PAHs	sum PAH16	sum PFAS	SCCP	MCCP	cVMS (D5)	cVMS (D6)
Birkenes	51	7.3	2.1	1.1	11.8	4.5	1.0	3.4	5882	3538	2.3				
Andøya	31	4.7	0.8		6.2	2.1	0.4	2.7	-	-	1.1				
Zeppelin	83	5.7	0.6	0.9	11.2	3.3	1.1	5.4	2942	1433	1.2	242	30	3600	390

6. References

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Annex 1

Monthly and annual averages of heavy metals in air and precipitation

Table A.1.1: Monthly and annual volume weighted mean concentrations of lead in precipitation at Norwegian background stations 2014. Unit: µg/l.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	1,.28	1.34	2.07	0.60	7.38	1.14	0.87	0.29	1.06	0.35	1.01	0.32	1.12
Hurdal	0.83	1.04	1.27	0.39	0.61	0.45	0.57	0.36	0.43	0.25	0.60	0.34	0.58
Kårvatn	0.10	0.50	0.31	0.39	0.31	0.13	0.20	0.21	0.76	0.16	0.13	0.34	0.31
Svanvik	6.88	1.64	1.41	0.70	1.15	0.59	1.39	1.43	1.04	0.83	0.46	0.50	1.13

Table A.1.2: Monthly and annual volume weighted mean concentrations of cadmium in precipitation at Norwegian background stations 2014. Unit: µg/l.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	0.028	0.037	0.051	0.019	0.013	0.011	0.013	0.010	0.043	0.016	0.028	0.015	0.025
Hurdal	0.026	0.038	0.040	0.014	0.020	0.020	0.021	0.020	0.032	0.022	0.022	0.033	0.026
Kårvatn	0.005	0.015	0.005	0.009	0.011	0.003	0.003	0.014	0.028	0.036	0.009	0.018	0.013
Svanvik	0.755	0.086	00.069	0.024	0.087	0.032	0.058	0.057	0.059	0.062	0.015	0.054	0.065

Table A.1.3: Monthly and annual volume weighted mean concentrations of zinc in precipitation at Norwegian background stations 2014. Unit: µg/l.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	6.7	7.6	11.2	8.6	6.5	3.6	4.7	1.8	5.6	1.8	3.7	4.0	5.0
Hurdal	6.4	8.3	6.8	5.5	16.5	7.6	5.6	3.8	5.7	4.0	5.8	6.8	6.4
Kårvatn	0.9	14.5	1.9	2.0	3.7	1.3	4.4	5.4	2.9	2.8	3.6	2.4	2.9
Svanvik	12.5	18.2	3.5	9.1	4.8	9.3	8.4	2.1	3.7	3.1	5.3	13.0	5.2

Table A.1.4: Monthly and annual volume weighted mean concentrations of nickel in precipitation at Norwegian background stations 2014. Unit: µg/l.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	0.16	0.20	0.36	0.25	0.21	0.16	0.17	0.12	0.17	0.10	0.16	0.11	0.16
Svanvik	166.79	15.60	13.75	4.61	18.30	13.10	38.11	16.59	17.40	23.57	10.66	16.00	17.74

Table A.1.5: Monthly and annual volume weighted mean concentrations of arsenic in precipitation at Norwegian background stations 2014. Unit: µg/l.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	0.12	0.13	0.18	0.15	0.06	0.07	0.05	0.05	0.12	0.05	0.12	0.04	0.10
Svanvik	9.24	0.63	0.77	0.26	1.66	0.87	1.30	1.19	1.66	1.05	0.36	0.59	1.21

Table A.1.6: Monthly and annual volume weighted mean concentrations of copper in precipitation at Norwegian background stations 2014. Unit: µg/l.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	1.42	0.73	1.64	1.24	3.96	1.15	1.58	0.48	5.13	0.37	1.40	2.01	1.35
Svanvik	849.61	37.63	32.36	16.41	27.99	14.10	30.32	20.34	21.04	29.16	7.45	24.22	28.68

Table A.1.7: Monthly and annual volume weighted mean concentrations of cobalt in precipitation at Norwegian background stations 2014. Unit: µg/l.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	0.01	0.01	0.03	0.02	0.02	0.03	0.02	0.01	0.02	0.01	0.02	0.01	0.01
Svanvik	6.04	0.52	0.41	0.14	0.55	0.38	1.18	0.47	0.45	0.70	0.30	0.46	0.52

Table A.1.8: Monthly and annual volume weighted mean concentrations of chromium in precipitation at Norwegian background stations 2014. Unit: µg/l.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	0.04	0.07	0.13	0.19	0.07	0.07	0.06	0.05	0.05	0.05	0.07	0.06	0.06
Svanvik	1.30	0.29	0.19	0.26	0.21	0.24	0.66	0.13	0.19	0.30	0.16	0.28	0.22

Table A.1.9: Monthly and annual volume weighted mean concentrations of manganese in precipitation at Norwegian background stations 2014. Unit: µg/l.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	0.57	0.68	1.58	1.48	2.36	2.88	2.51	0.94	1.78	1.05	0.97	0.66	1.08

Table A.1.10: Monthly and annual volume weighted mean concentrations of vanadium in precipitation at Norwegian background stations 2014. Unit: µg/l.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	0.23	0.28	0.38	0.23	0.21	0.23	0.23	0.15	0.18	0.14	0.27	0.09	0.21
Svanvik	8.47	0.66	0.74	0.30	0.82	0.27	0.52	0.15	0.29	0.39	0.16	0.50	0.48

Table A.1.11: Monthly and annual volume weighted mean concentrations of aluminium in precipitation at Svanvik, 2014. Unit: µg/l.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Svanvik	67.2	18.5	15.4	11.6	16.8	19.7	114.4	13.3	23.8	25.0	18.6	49.6	21.5

Table A.1.12: Monthly and annual average volume weighted mean concentrations of mercury in precipitation at Birkenes in 2014. Unit: ng/L

Station	Jan	Febr	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	2014
Birkenes	4.0	4.2	4.6	4.2	9.8	6.9	7.4	5.4	12.6	3.3	2.3	3.6	4.8

Table A.1.13: Annual and monthly total precipitation in 2014, measured using the bulk collector which is used for sampling of heavy metals. Unit mm.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	350	372	109	58	75	56	60	275	136	388	234	134	2245
Hurdal	137	207	53	63	82	61	68	152	61	276	164	70	1394
Kårvatn	8	10	98	101	50	187	57	126	113	78	28	172	1028
Svanvik	2	8	21	12	74	70	23	87	34	21	20	19	390

Table A.1.14: Monthly- and annual wet deposition of lead at Norwegian background stations 2014. Unit: µg/m^2.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	447	499	224	35	551	64	52	78	143	134	236	43	2509
Hurdal	113	216	67	24	51	27	38	55	26	69	98	24	808
Kårvatn	1	5	31	40	16	25	12	27	86	13	4	59	316
Svanvik	17	14	29	8	85	42	31	124	36	17	9	9	442

Table A.1.15: Monthly- and annual wet deposition of cadmium at Norwegian background stations 2014. Unit: µg/m^2.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	9.7	13.7	5.6	1.1	1.0	0.6	0.8	2.7	5.9	6.0	6.5	2.0	55.6
Hurdal	3.6	7.9	2.1	0.9	1.7	1.2	1.4	3.0	1.9	6.2	3.6	2.3	35.9
Kårvatn	0.0	0.1	0.5	0.9	0.6	0.5	0.2	1.8	3.1	2.8	0.2	3.1	13.9
Svanvik	1.8	0.7	1.4	0.3	6.5	2.2	1.3	4.9	2.0	1.3	0.3	1.0	25.4

Table A.1.16: Monthly- and annual wet deposition of zinc at Norwegian background stations 2014. Unit: µg/m^2.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	2338	2828	1215	496	485	201	283	493	763	683	860	536	11179
Hurdal	879	1729	358	347	1354	462	378	581	347	1112	953	479	8979
Kårvatn	7	138	188	206	185	250	253	677	334	215	103	411	2967
Svanvik	30	154	73	108	352	651	191	178	128	64	102	248	2022

Table A.1.17: Monthly- and annual wet deposition of nickel at Norwegian background stations 2014. Unit: µg/m^2.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	57	75	39	14	15	9	10	33	23	41	38	15	369
Svanvik	400	132	285	54	1353	922	865	1435	593	483	208	304	6917

Table A.1.18: Monthly- and annual wet deposition of arsenic at Norwegian background stations 2014. Unit: µg/m^2.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	43	48	20	9	4	4	3	14	17	19	29	6	214
Svanvik	22	5	16	3	122	61	30	103	57	22	7	11	474

Table A.1.19: Monthly- and annual wet deposition of copper at Norwegian background stations 2014. Unit: µg/m^2.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	497	272	177	72	296	65	95	131	695	143	328	270	3040
Svanvik	2039	318	671	194	2069	993	688	1760	718	598	145	460	11184

Table A.1.20: Monthly- and annual wet deposition of cobalt at Norwegian background stations 2014. Unit: µg/m^2.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	4	5	3	1	2	2	1	3	2	4	4	1	34
Svanvik	14	4	9	2	41	27	27	41	15	14	6	9	205

Table A.1.21: Monthly- and annual wet deposition of chromium at Norwegian background stations 2014. Unit: µg/m^2.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	16	27	14	11	6	4	4	12	6	18	17	8	142
Svanvik	3	2	4	3	15	17	15	12	6	6	3	5	84

Table A.1.22: Monthly- and annual wet deposition of manganese at Norwegian background stations 2014. Unit: µg/m^2.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	198	252	171	86	177	162	151	259	241	409	226	88	2415

Table A.1.23: Monthly- and annual wet deposition of vanadium at Norwegian background stations 2014. Unit: µg/m^2.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	79	103	41	14	16	13	14	41	24	52	64	12	471
Svanvik	20	6	15	4	61	19	12	13	10	8	3	9	188

Table A.1.24: Monthly and annual wet deposition of mercury at Birkenes in 2014. Unit: ng/ m^2

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Birkenes	1632	1415	425	183	777	457	456	1519	1944	1398	628	359	11193

Table A.1.25a: Annual average volume weighed mean concentration of heavy metals in precipitation at Norwegian background sites, 1976, aug 1978-june 1979; 1980 (febr - dec), 1981-2014

Site	Year	Pb µg/l	Cd µg/l	Zn µg/l	Ni µg/l	As µg/l	Cu µg/l	Co µg/l	Cr µg/l	V µg/l	Al µg/l	Hg ng/l
Birkenes	1976	12.7	0.27	28.9								
	1978	10.8	0.27	17.9								
	1980	7.9	0.34	15.7								
	1981	7.4	0.24	6.2								
	1982	8.8	0.69	7								
	1983	5.4	0.25	6.6								
	1984	6.2	0.29	12.1								
	1985	4.1	0.09	9.4								
	1986	4.8	0.12	9								
	1987	3.5	0.12	9.2								
	1988	7.4	0.12	14.1								
	1989	5.4	0.11	11.4								
	1990	3.8	0.12	9.5								
	1991	3.6	0.06	7								
	1992	2.9	0.04	5.2								
	1993	3.1	0.06	6.5								
	1994	2.6	0.05	5								
	1995	2.2	0.05	6								
	1996	2.8	0.06	4.9								
	1997	1.7	0.03	4.2								
	1998	1.59	0.043	4.9								
	1999	1.5	0.040	4.4								
	2000	1.39	0.030	3.2								
	2001	1.25	0.032	4.7								
	2002	0.99	0.034	3.6								
	2003	1.57	0.043	3.9								
	2004	1.3	0.040	4.1	0.21	0.12	0.35	0.01	0.11	0.61		9.8
	2005	1.17	0.035	5.3	0.47	0.26	0.76	0.01	0.30	1.11		8.9
	2006	0.88	0.029	3.4	0.2	0.20	0.51	0.01	0.15	0.76		8.0
	2007	0.67	0.024	2.8	0.23	0.10	0.37	0.02		0.64		6.3
	2008	0.78	0.025	2.9	0.13	0.16	0.39	0.01	0.12	0.78		6.4
	2009	0.92	0.04	3.9	0.19	0.18	0.46	0.01	0.12	0.75		9.4
	2010	0.91	0.039	4.3	0.2	0.18	0.54	0.02	0.13	0.51		9.1
	2011	0.63	0.027	3.5	0.15	0.12	0.58	0.01	0.10	0.52		5.3
	2012	0.58	0.02	4.4	0.25	0.08	0.52	0.01	0.06	0.21		4.7
	2013	0.6	0.015	5.3	0.21	0.05	1.00	0.02	0.06	0.21		5.5
	2014	1.12	0.025	5.0	0.16	0.1	1.35	0.01	0.06	0.21		4.8
Nordmoen	1987	4.6	0.10	8.4								
	1988	5.6	0.10	11								
	1989	4.6	0.08	7.3								
	1990	3.8	0.14	5.6								
	1991	2.6	0.06	4.3								
	1992	2.3	0.04	4.4								
	1993	1.8	0.04	3.5								
	1994	1.7	0.05	4								
	1995	2	0.04	5.2								
	1996	1.9	0.04	4.3								

Table A.1.25a, cont.

Site	Year	Pb µg/l	Cd µg/l	Zn µg/l	Ni µg/l	As µg/l	Cu µg/l	Co µg/l	Cr µg/l	V µg/l	Al µg/l	Hg ng/l
Hurdal	1997	1.26	0.056	4.4								
	1998	1.55	0.063	4.9								
	1999	1.18	0.032	6.3								
	2000	1.13	0.042	4.2								
	2001	0.93	0.042	4.8								
	2002	0.7	0.026	4.1								
	2003	0.97	0.032	3.7								
	2004	0.89	0.041	10								
	2005	1.23	0.070	10.3								
	2006	0.96	0.061	8.4								
	2007	0.91	0.065	10.3								
	2008	0.74	0.044	7								
	2009	0.79	0.043	7.4								
	2010	1.33	0.030	8.9								
	2011	0.92	0.028	6.4								
	2012	0.49	0.017	6.8								
	2013	0.41	0.017	8								
	2014	0.58	0.026	6.4								
Kårvatn	1979	1.5	0.04	3								
	1980	1.4	0.06	4.2								
	1981	1.4	0.09	3								
	1982	1.5	0.10	3.1								
	1983	0.7	0.12	2.9								
	1984	1.3	0.07	3.6								
	1985	1.1	0.06	4								
	1986	1.4	0.01	3.2								
	1987	1.1	0.03	2.5								
	1988	0.9	0.06	4.2								
	1989	0.3	0.05	1.8								
	1990	0.2	0.06	1								
	1991	0.3	0.01	1								
	1992	0.2	<0.01	0.8								
	1993	0.2	0.01	0.6								
	1994	0.4	0.02	1.2								
	1995	0.2	0.01	1.2								
	1996	0.5	0.01	1.4								
	1997	0.7	0.01	1.6								
	1998	0.2	0.01	1.3	0.1	0.1	0.1	0.01	0.3		0.3	
	1999	0.2	0.02	2.1								
	2000	0.18	0.01	1								
	2001	0.13	0.01	1.4								
	2002	0.32	0.018	1.2								
	2003	0.25	0.009	1								
	2004	0.13	0.005	1.2								
	2005	0.12	0.005	0.9								
	2006	0.17	0.010	1.9								
	2007	0.09	0.007	0.9								
	2008	0.1	0.005	1.2								
	2009	0.09	0.010	1.3								
	2010	0.14	0.009	3.7								
	2011	0.11	0.013	1.4								
	2012	0.11	0.005	1.5								
	2013	0.16	0.006	6.5								
	2014	0.31	0.013	2.9								

Table A.1.25a, cont.

Site	Year	Pb µg/l	Cd µg/l	Zn µg/l	Ni µg/l	As µg/l	Cu µg/l	Co µg/l	Cr µg/l	V µg/l	Al µg/l	Hg ng/l
Svanvik	1987	2	0.14	6	19.9*	2.4*	21.8*					
	1988	3.7	0.1	7.4	12.8	1.6	14.6					
	1989	1.4	0.14	4.6	15.5	1.3	14.4					
	1990	1.6	0.14	6.2	11.4	1.8	13.6	0.4	0.5			
	1991	1.3	0.07	3.4	9.3	1.1	10.4	0.3	0.4			
	1992	1.1	0.11	2.8	8.0	1.1	11.9	0.3	0.5			
	1993	1.1	0.12	3	10.9	1.2	13.4	0.4	0.6			
	1994	1.4	0.08	5	13.4	1.4	12.5	0.4	0.4			
	1995	1.7	0.11	5.4	17.4	1.8	17.4	0.6	0.4			
	1996	0.9	0.06	3.3	17.5	1.1	18.7	0.6	0.4			
	1997	1.9	0.11	3.8	17.3	1.8	21.4	0.6	0.3			
	1998	1.08	0.11	4.1	23.7	2.34	28.1	0.72	0.39			
	1999	0.83	0.08	8.4	11.1	1.41	14.0	0.37	0.32			
	2000	1.99	0.12	5.4	17.8	1.85	20.3	0.53	0.25			
	2001	2.56	0.16	8.5	20.7	2.31	20.2	0.65	0.39			
	2002	2.64	0.054	7	11.1	1.26	12.0	0.32	0.21			
	2003	2.32	0.08	6.2	10.6	0.85	12.0	0.34	0.22			
	2004	1.32	0.084	6.5	36.9	0.91	31.0	0.95	0.39			
	2005	1.84	0.143	5.2	55.3	1.72	58.0	1.59	0.41			
	2006	1.15	0.134	8.5	33.4	1.31	44.5	1.14	0.31			
	2007	1.25	0.231	4.5	45.2	1.83	41.6	1.14	0.61			
	2008	0.84	0.181	4.7	29.8	1.3	25.4	0.90	0.48			
	2009	1.63	0.146	3.8	42.0	2.21	32.6	1.13	0.85	0.56	15	
	2010	0.78	0.082	4.2	22.6	0.64	11.9	0.50	3.12	0.66	31	
	2011	0.85	0.186	3.9	17.5	1.06	30.1	0.58	0.34	0.46	22	
	2012	0.59	0.041	2.9	15.7	0.81	24.5	0.47	0.18	0.33	22	
	2013	1.09	0.059	3.9	26.0	1.7	51.1	0.78	0.23	0.79	23	
	2014	1.13	0.065	5.2	17.7	1.21	28.7	0.52	0.22	0.48	22	

Table A.1.25b: Annual average volume weighed mean concentration of heavy metals in precipitation at Norwegian background sites, which has been closed down.

Site	Year	Pb µg/l	Cd µg/l	Zn µg/l	Ni µg/l	As µg/l	Cu µg/l	Co µg/l	Cr µg/l	Hg ng/l
Lista	1990									13.8
	1991									11.8
	1992									10.9
	1993									11.3
	1994	2.7	0.05	7.8	0.3	0.2	1		0.2	8.1
	1995	2.3	0.06	8.6	0.4	0.4	1.1		0.8	13.9
	1996	3	0.07	8.6	0.4	0.4			0.3	19.7
	1997	2.8	0.05	6.6	0.4	0.5	1	0.04	0.2	10.6
	1998	2.08	0.047	8.8	0.59	0.2	1.13	0.03	0.58	9
	1999	1.5	0.03	7.4	0.4	0.2	1.7	0.03	0.2	9.7
	2000	1.57	0.037	6.6	0.34	0.28	1.13	0.03	<0.2	7.3
	2001	1.52	0.056	7.4	0.37	0.18	1.28	0.02	0.31	7.3
	2002	2.15	0.033	6.8	0.3	0.29	1.3	0.02	0.16	12.8
	2003	1.92	0.063	7.5	0.5	1.01	1.3	0.04	0.31	8.3
Ualand	1994	2	0.04	4	0.2	0.1	0.5	0.02	0.1	
	1995	1.7	0.03	3.3	0.2	0.1	0.3	0.01	0.1	
	1996	1.3	0.03	2.5	0.2	0.1	0.9	0.01	0.2	
	1997	2.77	0.02	2.6	0.2	0.1	0.4	0.01	0.1	
	1998	1.24	0.024	2.7	0.19	0.1	0.3	0.02	0.17	
	1999	0.88	0.023	2.3	<0.2	<0.1	0.23	0.01	<0.2	
	2000	0.71	0.021	1.5	<0.2	<0.1	0.23	0.01	<0.2	
Solhomfjell	1994	2.4	0.06	6	0.2	0.1	0.7	0.02	0.1	
	1995	1.9	0.07	6	0.6	0.2	1.1	0.03	0.2	
	1996	2.3	0.05	5.7	0.3	0.2	0.9	0.02	<0.2	
Møsvatn	1994	1	0.04	2.9	0.6	0.1	0.5	0.03	<0.1	
	1995	0.9	0.03	2.8	0.3	0.1	0.9	0.01	0.1	
	1996	1	0.02	4.5	0.4	0.1	1	0.02	0.1	
	1997	1	0.02	4.5						
	1998	0.88	0.044			0.07		0.03	0.13	
	1999	1.05	0.042	5.7	0.29	<0.1	1.65	0.02	<0.2	
	2000	1.02	0.042	6.2	0.29	<0.1	1.72	0.01	<0.2	
Osen	1988	4.7	0.31	12.7						
	1989	2.7	0.08	5.4						
	1990	2.7	0.09	5.6						
	1991	2	0.03	4.2						
	1992	1.6	0.05	5.5						
	1993	1.2	0.06	3.5						
	1994	1.4	0.05	5.9						
	1995	2.1	0.07	8.8						
	1996	1.5	0.03	4.4						
	1997	0.9	0.02	4						
	1998	0.87	0.033	4.7						
	1999	1.05	0.042	7.1						
	2000	1.37	0.047	5.5						
	2001	0.59	0.019	3.3						
	2002	0.87	0.029	4.3						
	2003	0.61	0.031	5.1						
Valdalen	1994	1	0.03	4.2	0.1	0.1	0.6	0.01	0.1	
	1995	1.4	0.03	4.6	0.4	0.1	0.8	0.02	0.2	
	1996	1.1	0.03	4.1	0.3	0.1	1	0.03	0.2	
	1997	1.1	0.05	6.2	0.4	0.1	0.1	0.02	0.2	
	1998	0.76	0.03	4.8	0.17	0.09	0.57	0.02	0.16	
	1999	0.69	0.1	9.6	0.47	<0.1	1.13	0.02	0.37	
	2000	1.01	0.026	4.2	<0.2	<0.1	0.47	0.02	<0.2	

Table A.1.25b, cont.

Site	Year	Pb µg/l	Cd µg/l	Zn µg/l	Ni µg/l	As µg/l	Cu µg/l	Co µg/l	Cr µg/l
Namsvatn	1994	0.5	0.03	2.3	0.2	0.1	0.4	0.02	0.1
	1995	0.5	0.01	2.3	0.3	0.1	0.2	0.01	0.1
	1996	0.5	0.02	3	0.1	0.1	0.5	0.01	<0.2
Øverbygd	1995	0.4	0.01	2.3	0.4	0.1	0.5	0.02	0.1
	1996	0.5	0.03	3.5	0.4	0.1	1.3	0.02	0.3
	1997	0.5	0.01	2.7	0.1	0.1	0.3	0.01	0.1
	1998	0.4	0.01	3.8	0.2	0.1	0.6	0.02	0.1
	1999	0.54	0.01	5	<0.2	<0.1	0.33	0.01	<0.2
	2000	0.37	0.02	1.9	0.21	<0.1	0.38	0.01	<0.2
Jergul	1979	3.5	0.22	7.8					
	1980	2.6	0.08	4.5					
	1981	1.8	0.05	3.5					
	1982	2.3	0.11	3.1					
	1983	1.5	0.07	3.6					
	1984	2.2	0.09	9.8					
	1985	2	0.08	5					
	1986	2	0.03	5.2					
	1987	1.3	0.07	4.6					
	1988	1.3	0.07	5.1					
	1989	1.3	0.05	3.3					
	1990	0.7	0.16	2.7					
	1991	0.7	0.02	2.2					
	1992	0.5	0.05	1.6					
	1993	0.5	0.05	2.4					
	1994	0.5	0.03	4.1					
	1995	0.8	0.04	3.5					
	1996	0.5	0.02	3.3					
Karasjok	1997	0.6	0.02	3.1					
	1998	0.8	0.04	3.5					
	1999	0.44	0.03	5.8					
	2000	0.57	0.02	11.6					
	2001	0.67	0.03	4.8					
	2002	0.58	0.033	6.4					
	2003	0.59	0.013	3.4					
	2004	0.74	0.014	4					
	2005	0.5	0.019	4.3					
	2006	0.37	0.02	2.8					
	2007	0.47	0.029	4.7					
	2008	0.38	0.017	7.6					
	2009	0.28	0.024	4.7					

Table A.1.26: Monthly and annual average mean concentrations of heavy metals in aerosols and mercury in gas phase at Birkenes in 2014. Unit: ng/m³ Unit: ng/m³

	As	Cd	Cr	Co	Cu	Pb	Ni	V	Zn	Hg(g)
Jan	0.23	0.040	0.17	0.020	0.61	1.64	0.33	0.37	5.8	1.66
Febr	0.22	0.051	0.25	0.031	0.90	1.78	0.71	0.64	7.3	1.86
March	0.30	0.057	0.15	0.039	0.81	1.56	0.46	0.66	5.9	1.71
Apr	0.26	0.036	0.24	0.039	0.66	0.87	0.41	0.61	4.6	1.68
May	0.25	0.027	0.23	0.040	0.70	0.81	0.62	0.68	3.1	1.53
June	0.14	0.012	0.18	0.028	0.51	0.37	0.56	0.41	2.7	1.38
July	0.14	0.020	0.05	0.030	0.70	0.66	0.53	0.64	5.0	1.43
Aug	0.10	0.011	0.03	0.012	0.32	0.35	0.26	0.23	2.3	1.43
Sept	0.24	0.049	0.35	0.023	0.77	0.72	0.42	0.45	4.2	1.26
Oct	0.37	0.043	0.23	0.022	0.65	1.05	0.29	0.43	8.0	1.36
Nov	0.16	0.028	0.28	0.014	0.39	0.75	0.10	0.19	4.6	1.33
Dec	0.05	0.021	0.03	0.005	0.09	0.12	0.10	0.05	0.8	1.40
2014	0.21	0.033	0.18	0.025	0.59	0.88	0.40	0.45	4.5	1.53

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Table A.1.27: Monthly and annual average mean concentrations of heavy metals in aerosols and mercury in gas phase at Andøya in 2014. Unit: ng/m³

	As	Cd	Cr	Co	Cu	Pb	Mn	Ni	V	Zn	Hg(g)
Jan	0.06	0.007	0.14	0.128	0.25	0.27	0.56	0.12	0.12	1.1	1.69
Febr	0.03	0.005	0.10	0.095	0.17	0.18	0.35	0.12	0.10	0.9	1.66
March	0.09	0.020	0.19	0.129	0.32	0.72	0.86	0.21	0.13	2.3	1.62
Apr	0.12	0.011	0.10	0.014	0.24	0.26	0.46	0.17	0.17	1.1	1.52
May	0.07	0.011	0.11	0.013	0.20	0.31	0.41	0.12	0.16	1.3	1.27
June	0.05	0.003	0.13	0.012	0.31	0.09	0.61	0.12	0.21	0.9	1.41
July	0.07	0.013	0.12	0.018	0.47	0.33	0.99	0.19	0.27	2.0	1.41
Aug	0.18	0.014	0.04	0.011	0.35	0.32	0.27	0.28	0.20	1.6	1.38
Sept	0.07	0.109	0.04	0.006	0.24	0.25	0.23	0.09	0.13	0.9	1.37
Oct	0.07	0.052	0.08	0.007	0.18	0.35	0.26	0.10	0.13	2.9	1.45
Nov	0.02	0.028	0.04	0.005	0.06	0.09	0.24	0.03	0.05	0.3	1.54
Dec	0.02	0.011	0.08	0.004	0.18	0.13	0.18	0.02	0.04	0.4	1.61
2014	0.07	0.025	0.10	0.037	0.25	0.28	0.46	0.13	0.15	1.3	1.50

Table A.1.28: Monthly and annual averge mean concentrations of heavy metals in aerosols and mercury in gas phase at Zeppelin mountain in 2014. Unit: ng/m³

	As	Cd	Cr	Co	Cu	Pb	Mn	Ni	V	Zn	Hg(g)
Jan	0.01	0.004	0.10	0.003	0.11	0.08	0.21	0.04	0.03	0.6	1.44
Febr	0.04	0.006	0.05	0.003	0.08	0.21	0.17	0.21	0.05	1.0	1.69
March	0.11	0.014	0.11	0.009	0.20	0.43	0.28	0.12	0.04	1.4	1.55
Apr	0.12	0.017	0.19	0.021	0.35	0.47	0.65	0.17	0.13	2.1	1.31
May	0.03	0.011	0.19	0.017	0.22	0.17	0.57	0.15	0.06	2.0	1.13
June	0.01	0.003	0.33	0.007	0.08	0.06	0.30	0.17	0.04	0.4	1.49
July	0.02	0.001	0.01	0.004	0.03	0.03	0.08	0.09	0.13	0.4	1.62
Aug	0.02	0.030	0.25	0.034	0.68	0.04	2.95	0.44	0.05	7.8	2.27
Sept	0.01	0.006	0.13	0.009	0.14	0.07	0.48	0.07	0.05	1.1	NaN
Oct	0.02	0.007	0.02	0.003	0.08	0.05	0.18	0.02	0.04	0.47	1.40
Nov	0.03	0.009	0.06	0.007	0.20	0.13	0.38	0.04	0.04	0.6	1.56
Dec	0.15	0.026	0.12	0.011	0.25	0.61	0.57	0.09	0.06	1.6	1.57
2014	0.05	0.012	0.14	0.012	0.22	0.22	0.60	0.14	0.06	1.7	1.48

Table A.1.29: Annual mean concentration of heavy metals in air and aerosols at Norwegian background sites. Unit: ng/m³

Site	Year	As	Cd	Cr	Co	Cu	Pb	Mn	Ni	V	Zn	Hg (g)	Hg (part)	RGM apr-mai
Lista	1991	0.77	0.063	1.86		0.80	2.69		0.59		4.4			
	1992	0.19	0.046	1.79		0.47	2.35		1.33		3.9	2.06		
	1993	0.41	0.066	3.67		0.85	3.67		0.81		7.0	1.84		
	1994	0.36	0.067	2.80		0.90	3.67		0.88		4.5	1.84		
finfraksjon	1995	0.34	0.06	0.28		0.41	2.74		0.56	1.10	4.2	1.63		
PM(2.5)	1996	0.35	0.068	0.32		0.42	2.95		0.58	1.51	4.3	1.62		
	1997	0.24	0.063	0.57	0.02	0.50	2.55		0.68	1.29	5.0	1.40		
	1998	0.21	0.045	0.61	0.01	0.39	1.94		0.21	0.98	3.9	1.40		
	1999	0.19	0.05	0.18	0.02	0.27	1.82		0.30	0.66	3.9	1.86		
	2000	0.22	0.052	0.82	0.02	0.29	1.92		0.65	1.04	4.3	1.67		
	2001	0.49	0.055	0.37	0.02	0.32	1.98		0.62	6.40	5.4	1.65		
	2002	0.24	0.053	0.30	0.02	0.49	2.43		0.53	1.15	4.2	1.64		
	2003	0.40	0.073	0.28	0.02	0.48	2.47		0.94	1.98	7.5	1.77		
grovfraksjon (PM_{10}-$PM_{2.5}$)	1995	0.13	0.018	1.54		0.64	1.02		0.25	0.38	1.9			
	1996	0.10	0.015	0.77		0.46	0.79		0.26	0.33	1.5			
	1997	0.08	0.016	0.50	0.03	0.73	0.72		0.23	0.36	2.2			
	1998	0.06	0.148	0.93	0.02	0.40	0.62		0.41	0.25	3.1			
	1999	0.08	0.012	1.36	0.04	0.47	0.52		0.27	0.38				
	2000	0.07	0.014	0.69	0.01	0.37	0.52		0.10	0.35	1.8			
	2001	0.17	0.011	0.64	0.01	0.32	0.44		0.13	1.69	1.6			
	2002	0.06	0.009	0.74	0.01	0.44	0.56		0.11	0.33	1.6			
	2003	0.10	0.009	0.47	0.02	0.37	0.47		0.18	0.58	1.9			
Birkenes	2004	0.20	0.044	<DL		0.83	1.61		0.57	0.70	3.9	1.70		
	2005	0.52	0.088	1.07	0.08	3.45	1.99		2.18	1.44	15.1	1.90		
	2006	0.31	0.063	1.16	0.05	1.56	2.01		0.75	1.20	5.8	1.76		
	2007	0.21	0.047	0.52	0.029	0.82	1.29		0.61	0.81	4.3	1.83		
	2008	0.20	0.035	-	0.030	0.83	1.04		0.55	0.66	3.6	1.73		
	2009	0.21	0.037	1.45	0.028	0.71	1.07		0.66	0.82	5.4	1.69		
Birkenes II	2010	0.18	0.040	0.39	0.033	0.82	1.88		0.50	0.61	4.1	*(1.66)*		
	2011	0.33	0.050	0.71	0.039	0.93	1.70		0.61	0.61	6.1	1.65		
	2012	0.15	0.028	0.55	0.019	0.52	0.80		0.29	0.35	3.1	1.62		
	2013	0.15	0.027	0.33	0.026	0.52	0.73		0.38	0.39	3.9	1.56		
	2014	0.21	0.033	0.18	0.025	0.59	0.88		0.40	0.45	4.5	1.53		

Site	Year	As	Cd	Cr	Co	Cu	Pb	Mn	Ni	V	Zn	Hg (g)	Hg (part)	RGM apr-mai
Andøya	2010	0.07	0.017	0.44	0.011	0.53	0.58	0.38	0.32	0.25	1.3	1.67		
	2011	0.06	0.010	0.17	0.008	0.27	0.30	0.37	0.12	0.19	0.9	1.61		
	2012	0.06	0.011	0.24	0.013	0.49	0.34	0.58	0.17	0.15	1.5	1.61		
	2013	0.04	0.008	0.11	0.011	0.24	0.24	0.41	0.14	0.12	1.4	1.54		
	2014	0.07	0.025	0.10	0.037	0.25	0.28	0.46	0.13	0.15	1.3	1.50		
Zeppelin	1994	0.23	0.034	0.20	0.01	0.32	0.83	0.37	0.19	0.17	1.9	1.79		
	1995	0.14	0.019	0.22	0.01	0.31	0.64	0.42	0.15	0.19	1.5	1.62		
	1996	0.05	0.01	0.23	0.02	0.28	0.48	0.57	0.14	0.12	1.5	1.59		
	1997	0.13	0.024		0.02	0.40	0.69	0.34	0.13	0.20	1.5	1.18		
	1998	0.12	0.027	0.16	0.14	0.35	0.71	0.34	0.12	0.11	1.4	1.55		
	1999	0.10	0.022	0.14	0.06	0.33	0.49	0.47	0.14	0.17	1.6	1.76		
	2000	0.30	0.018	0.06	0.01	0.41	0.62	0.34	0.09	0.07	1.5	1.50		
	2001	0.40	0.016	0.04	0.01	0.31	0.50	0.24	0.08	0.12	1.3	1.56	1.62	
	2002	0.39	0.027	0.04	0.01	0.25	0.66	0.26	0.07	0.08	1.2	1.60	5.31	5.99
	2003	0.12	0.021	0.09	0.01	0.23	0.69	0.34	0.10	0.14	1.3	1.61	2.20	14.47
	2004	0.07	0.018	0.11	0.04	0.31	0.63	0.40	0.10	0.08	4.1	1.50		42.39
	2005	0.11	0.118	0.13	0.03	0.92	1.04	0.40	0.13	0.13	3.2	1.58		
	2006	0.05	0.016	0.08	0.01	0.30	0.44	0.34	0.05	0.10	1.6	1.60		
	2007	0.05	0.023	0.08	0.01	0.61	0.60	0.20	0.09	0.06	1.4	1.68		
	2008	0.05	0.012	0.07	0.007	0.37	0.37	0.23	0.08	0.08	1.6	1.58		
	2009	0.06	0.017	0.14	0.013	0.30	0.43	0.43	0.13	0.13	1.5	1.55		
	2010	0.05	0.014	0.10	0.013	0.17	0.38	0.45	0.14	0.10	1.0	1.56		
	2011	0.07	0.015	0.11	0.010	0.16	0.38	0.45	0.09	0.08	1.0	1.52		
	2012	0.04	0.008	0.09	0.008	0.13	0.22	0.35	0.07	0.05	1.2	1.51		
	2013	0.10	0.012	0.16	0.012	0.25	0.46	0.62	0.12	0.07	2.3	1.47		
	2014	0.05	0.012	0.14	0.012	0.22	0.22	0.60	0.14	0.06	1.7	1.48		

Annex 2

Monthly and annual concentrations of persistent organic pollutants in air and precipitation

Table A.2.1: Monthly and annual mean concentrations (pg/m^3) for organochlorine pesticides (OCPs) in air at Birkenes, 2014.

Birkenes	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
HCB	65.5	85. 8	73.6	48.0	42.0	38.2	27.7	34.2	42.1	46.2	64.9	64.8	51.5
α-HCH	3.26	2.89	3.15	3.42	4.80	4.44	4.89	5.85	7.70	5.13	5.28	2.92	4.50
γ-HCH	1.82	2.34	2.14	1.52	3.14	2.86	4.99	4.06	2.58	4.87	2.46	0.73	2.78
cis-CD	0.34	0.39	0.42	0.37	0.47	0.38	0.60	0.50	0.47	0.48	0.32	0.34	0.46
cis-NO	0.02	0.03	0.03	0.03	0.05	0.05	0.08	0.07	0.05	0.05	0.02	0.02	0.06
trans-CD	0.22	0.28	0.26	0.19	0.17	0.13	0.21	0.15	0.15	0.21	0.19	0.20	0.27
trans-NO	0.40	0.43	0.43	0.35	0.45	0.34	0.57	0.48	0.40	0.48	0.33	0.32	0.41
sum CHLs	0.99	1.13	1.14	2.05	1.15	0.90	1.46	1.20	1.07	1.22	0.86	0.88	1.07
p,p'-DDT	0.03	0.09	0.02	0.02	0.04	0.02	0.04	0.06	0.02	0.04	0.04	0.02	0.03
o,p'-DDT	*0.14*	<0.20	0.22	0.16	0.30	0.18	0.43	0.28	0.31	0.30	0.45	0.13	0.27
p,p'-DDE	1.34	2.37	1.40	0.60	0.80	0.45	0.90	0.91	0.80	1.94	4.66	0.77	1.36
o,p'-DDE	0.10	0.17	0.10	0.05	0.06	0.04	0.07	0.06	0.05	0.10	0.26	0.08	0.09
p,p'-DDD	0.17	0.37	0.22	0.16	0.35	0.24	0.58	0.38	0.33	0.34	0.34	0.10	0.29
o,p'-DDD	0.04	0.07	0.03	0.02	0.03	0.02	0.05	0.05	0.02	0.04	0.04	0.03	0.03
sum DDTs	1.88	3.34	2.00	1.00	1.57	0.94	2.07	1.74	1.53	2.76	5.75	1.14	2.08

Table A.2.2: Monthly and annual mean concentrations (pg/m^3) for PCBs in air at Birkenes, 2014

Birkenes	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
PCB-18	2.11	3.41	2.34	1.15	0.98	0.77	1.17	0.68	1.10	1.36	2.48	0.82	1.44
PCB-28	1.19	2.18	1.37	0.80	0.74	0.54	1.15	0.64	0.80	0.90	1.44	0.44	0.95
PCB-31	1.10	1.97	1.25	0.75	0.66	0.50	1.03	0.58	0.71	0.80	1.28	0.40	0.86
PCB-33	0.72	1.45	0.87	0.41	0.36	0.28	0.57	0.33	0.38	0.45	0.79	0.24	0.53
PCB-37	0.11	0.20	0.11	0.06	0.06	0.05	0.11	0.06	0.05	0.08	0.12	0.03	0.08
PCB-47	0.71	0.87	0.76	1.01	1.52	1.34	3.00	1.29	1.14	0.97	0.74	0.33	1.11
PCB-52	1.11	1.56	1.06	0.77	0.86	0.68	1.42	0.70	0.80	0.92	1.10	0.46	0.92
PCB-66	0.28	0.39	0.28	0.21	0.21	0.16	0.37	0.17	0.19	0.25	0.30	0.11	0.24
PCB-74	0.18	0.24	0.18	0.14	0.13	0.09	0.23	0.09	0.12	0.15	0.19	0.07	0.15
PCB-99	0.25	0.33	0.25	0.17	0.17	0.13	0.32	0.14	0.16	0.19	0.20	0.09	0.19
PCB-101	0.63	0.84	0.62	0.49	0.55	0.43	1.04	0.49	0.49	0.54	0.54	0.25	0.56
PCB-105	0.05	0.07	0.06	0.04	0.04	<0.03	0.08	0.04	0.04	0.04	0.04	<0.03	0.04
PCB-114	<0.014	<0.012	<0.015	*0.005*	*0.005*	<0.003	0.008	<0.005	<0.005	<0.004	0.005	<0.003	<0.007
PCB-118	<0.67	<0.68	<0.68	<0.67	<0.67	<0.68	<0.68	<0.69	<0.68	<0.68	<0.67	<0.67	<0.68
PCB-122	<0.013	<0.012	<0.015	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005
PCB-123	<0.015	<0.013	<0.016	<0.003	<0.003	<0.003	<0.005	<0.003	<0.003	<0.007	<0.006	<0.005	<0.007
PCB-128	*<0.019*	*0.040*	*0.028*	*0.023*	*0.026*	*<0.020*	*0.061*	*0.030*	*0.028*	*0.025*	*0.025*	*<0.015*	*0.03*
PCB-138	<0.79	<0.81	<0.80	<0.79	<0.80	<0.81	<0.81	<0.81	<0.80	<0.80	<0.79	<0.79	<0.80
PCB-141	<0.04	0.07	0.05	0.05	0.06	0.04	0.14	0.06	0.05	0.05	0.05	0.02	0.06
PCB-149	*0.47*	0.52	*0.43*	<0.43	<0.47	<0.45	0.85	<0.46	<0.43	<0.43	<0.41	<0.41	*0.47*
PCB-153	<0.49	*0.53*	<0.49	<0.49	<0.50	<0.49	*0.77*	<0.51	<0.49	<0.49	<0.48	<0.49	<0.52
PCB-156	*0.012*	0.014	0.019	0.009	0.008	*0.006*	0.020	0.011	*0.009*	0.008	0.010	<0.005	0.010
PCB-157	<0.005	<0.003	<0.004	<0.002	<0.002	<0.002	*0.003*	*0.002*	*0.002*	<0.002	<0.002	<0.002	<0.003
PCB-167	<0.006	<0.005	*0.009*	*0.005*	0.005	0.004	0.011	0.006	0.005	0.005	0.005	<0.003	0.006
PCB-170	<0.015	*0.027*	*0.019*	0.020	0.020	0.015	0.052	0.024	0.020	0.020	0.026	0.008	0.02

Table A.2.2, cont.

Birkenes	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
PCB-180	0.07	0.09	0.06	0.07	0.07	0.05	0.16	0.08	0.06	0.06	0.08	0.03	0.07
PCB-183	0.02	0.04	0.02	0.02	0.03	0.02	0.07	0.03	0.03	0.02	0.03	0.01	0.03
PCB-187	*0.09*	0.12	0.05	0.07	0.08	0.06	0.17	0.08	0.07	0.08	0.07	0.03	0.08
PCB-189	<0.009	<0.009	<0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003
PCB-194	<0.008	<0.006	<0.007	0.005	0.005	0.003	0.007	0.006	0.004	0.004	0.009	<0.002	0.006
PCB-206	<0.006	<0.005	<0.007	<0.002	0.003	<0.002	0.003	<0.002	<0.002	<0.002	0.003	<0.002	*0.003*
PCB-209	<0.007	<0.007	<0.009	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
sum-trichlor	7.00	12.32	7.96	4.47	3.74	2.78	5.13	2.88	3.96	4.84	8.41	2.61	5.16
sum-tetrachlor	2.34	3.06	2.28	2.74	3.09	2.47	5.40	2.41	2.44	2.57	2.70	1.11	2.67
sum-pentachlor	1.46	1.63	1.56	1.46	1.47	1.48	1.99	1.49	1.47	1.47	1.48	1.45	1.52
sum-hexachlor	*2.12*	*2.16*	*2.14*	*2.13*	*2.13*	*2.16*	*2.76*	*2.17*	*2.15*	*2.14*	*2.11*	*2.12*	*2.19*
sum-heptachlor	*0.19*	*0.27*	*0.14*	*0.18*	*0.21*	*0.17*	*0.45*	*0.21*	*0.19*	*0.19*	*0.21*	*0.12*	*0.21*
sum-PCB7	4.96	6.69	5.08	4.08	4.19	3.69	6.04	3.91	4.14	4.38	5.10	3.13	4.49
sum PCBs	13.13	19.45	14.09	10.99	10.64	9.07	15.75	8.84	10.22	11.22	14.93	7.42	11.78

Italic data means that more than 50% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.3: Monthly and annual mean concentrations (pg/m^3) for PBDEs and TBA in air at Birkenes, 2014

Birkenes	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
BDE-28	0.01	0.02	0.02	0.01	0.05	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02
BDE-47	0.10	0.21	0.11	0.18	0.43	0.27	0.15	0.10	0.06	0.05	0.08	0.05	0.15
BDE-49	0.009	0.020	0.013	0.016	0.040	0.019	0.016	0.008	0.008	0.008	0.008	0.005	0.014
BDE-66	0.010	<0.02	0.008	0.011	0.025	0.016	0.013	0.006	0.007	0.006	0.006	0.004	0.010
BDE-71	<0.005	<0.006	<0.005	<0.005	<0.010	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.005
BDE-77	<0.002	<0.002	<0.003	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.001	<0.002
BDE-85	<0.003	<0.002	<0.018	<0.007	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.002	<0.004
BDE-99	0.07	0.12	0.07	0.04	0.08	0.04	0.05	0.03	0.03	0.03	0.05	0.03	0.051
BDE-100	0.013	0.039	0.009	0.016	0.015	0.012	0.013	0.010	0.008	*0.007*	0.011	<0.007	0.012
BDE-119	<0.003	<0.006	<0.007	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003
BDE-138	<0.009	*0.047*	<0.018	<0.010	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.007	<0.006	<0.009
BDE-153	<0.013	*0.028*	*0.027*	<0.008	<0.013	<0.004	<0.005	<0.004	<0.005	*0.007*	*0.010*	*0.008*	*0.010*
BDE-154	*0.012*	*0.032*	*0.028*	*0.006*	*0.010*	*0.004*	0.005	*0.004*	0.005	*0.008*	0.008	*0.006*	*0.009*
BDE-183	*0.024*	0.071	0.102	0.013	*0.022*	*0.007*	*0.005*	*0.007*	*0.007*	*0.023*	*0.013*	*0.010*	*0.023*
BDE-196	<0.05	*0.25*	<0.07	<0.06	<0.02	<0.01	<0.01	<0.01	<0.01	<0.02	<0.02	<0.01	<0.03
BDE-206	*0.06*	*0.26*	0.12	<0.05	<0.02	<0.02	<0.03	<0.03	<0.02	<0.03	<0.04	<0.02	*<0.04*
BDE-209	<0.36	*0.55*	0.63	0.41	<0.31	<0.31	<0.47	<0.52	<0.31	<0.39	*2.99*	<0.23	<0.61
sum PBDEs	*0.75*	*1.66*	*1.26*	*0.85*	*1.06*	*0.75*	*0.79*	*0.76*	*0.50*	*0.60*	*3.26*	*0.40*	*1.00*
TBA	5.93	1.79	2.97	2.19	2.47	1.80	1.32	2.49	2.76	5.82	6.43	4.71	3.45

Italic data means that more than 50% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.4: Monthly and annual mean concentrations (pg/m^3) for HBCDs in air at Birkenes, 2014

Birkenes	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
α -HBCD	*0.18*	*0.88*	<0.03	<0.03	<0.04	<0.01	<0.02	<0.02	<0.01	<0.13	<0.13	<0.31	<0.13
β-HBCD	<0.02	*0.20*	<0.02	<0.02	<0.02	<0.03	<0.04	<0.03	<0.04	<0.25	<0.64	<0.47	<0.14
γ-HBCD	*0.14*	*0.20*	<0.02	<0.03	<0.02	<0.01	<0.03	<0.02	<0.02	<0.15	<0.31	<0.64	<0.12
sum HBCDs	*<0.34*	*<1.28*	*<0.06*	*<0.08*	*<0.08*	*<0.05*	*<0.08*	*<0.07*	*<0.07*	*<0.53*	*<1.07*	*<1.42*	*<0.39*

Italic data means that more than 50% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.5: Monthly and annual mean concentrations (ng/m^3) for PAHs in air at Birkenes, 2014

Birkenes	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Naphthalene	0.82	0.32	*0.36*	*0.60*	<0.09	<0.09	<0.13	<0.09	<0.09	0.13	0.36	0.24	0.28
2-Methylnaphthalene	0.34	0.16	0.14	0.25	<0.080	0.07	0.08	0.06	0.06	0.08	0.16	0.10	0.13
1-Methylnaphthalene	0.27	0.13	0.12	0.19	<0.051	0.04	0.05	0.04	0.04	0.05	0.13	0.08	0.10
Biphenyl	0.85	0.55	0.48	0.77	0.13	0.07	0.05	0.06	0.08	0.15	0.36	0.27	0.32
Acenaphthylene	0.06	*0.12*	<0.03	<0.03	<0.01	<0.03	<0.01	<0.01	<0.01	*0.02*	0.05	*0.05*	<0.03
Acenaphthene	0.11	0.09	0.06	0.08	0.07	0.06	0.06	0.08	0.07	0.07	0.13	0.09	0.08
Dibenzofuran	3.38	2.10	2.30	3.51	0.55	0.36	0.24	0.29	0.41	0.76	1.39	1.11	1.38
Fluorene	2.75	1.32	1.47	2.94	0.40	0.30	0.25	0.27	0.39	0.62	0.97	0.82	1.07
Dibenzothiophene	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.02	0.02	0.03	0.02	0.02	0.025
Phenanthrene	1.20	1.33	1.62	1.60	0.81	0.62	0.74	0.56	0.66	1.20	1.42	1.29	1.08
Anthracene	*0.04*	*0.10*	<0.02	<0.02	<0.01	<0.02	*0.01*	*0.01*	0.01	*0.04*	<0.03	*0.04*	<0.03
3-Methylphenanthrene	*0.22*	0.31	0.10	<0.08	0.06	<0.04	*0.10*	0.03	0.03	<0.09	<0.07	0.08	*0.09*
2-Methylphenanthrene	*0.28*	0.37	0.13	<0.10	0.07	*0.04*	*0.10*	0.03	0.04	0.11	*0.08*	*0.10*	*0.11*
2-Methylanthracene	*0.020*	<0.057	*0.005*	<0.008	<0.010	<0.013	<0.013	*0.008*	*0.004*	<0.014	*0.010*	<0.010	*0.013*
9-Methylphenanthrene	<0.09	0.21	*0.05*	<0.03	*0.02*	*0.02*	*0.05*	0.01	0.02	<0.04	<0.03	0.03	*0.04*
1-Methylphenanthrene	0.23	0.35	0.09	0.08	0.04	0.03	0.06	0.02	0.03	0.13	0.07	0.09	0.10
Fluoranthene	0.99	0.39	0.49	0.36	0.10	0.07	0.13	0.07	0.11	0.28	0.27	0.39	0.30
Pyrene	0.43	0.15	0.23	0.09	0.05	0.03	0.08	0.03	0.04	0.16	0.13	0.25	0.14
Benzo(a)fluorene	0.085	0.211	0.034	0.008	*0.004*	<0.004	<0.003	0.002	0.004	0.016	0.011	0.03	0.03
Retene	0.11	0.17	0.06	0.03	0.02	0.02	0.03	0.02	0.06	0.33	0.05	0.07	0.08
Benzo(b)fluorene	0.041	*0.112*	*0.016*	0.006	<0.004	<0.004	<0.003	<0.002	<0.002	<0.008	<0.005	*0.010*	0.02
Benzo(ghi)fluoranthene	0.22	0.50	0.10	0.02	0.02	0.01	0.010	0.01	0.02	0.03	0.04	0.08	0.07
Cyclopenta(cd)pyrene	<0.001	<0.001	<0.003	<0.002	<0.004	<0.004	<0.003	<0.002	<0.002	<0.003	<0.002	<0.003	<0.003
Benz(a)anthracene	0.21	0.58	0.10	0.009	0.01	0.004	0.004	0.002	0.003	0.019	0.014	0.05	0.07
Chrysene	0.418	0.859	0.152	0.050	0.037	0.02	0.02	0.01	0.03	0.07	0.07	0.13	0.13

Table A.2.5, cont.

Birkenes	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
Triphenylene	0.08	0.19	0.04	0.022	0.01	0.007	0.009	0.005	0.010	0.018	0.017	0.02	0.03
Benzo(b)fluoranthene	<0.41	*0.88*	*0.19*	<0.03	<0.03	<0.02	<0.02	<0.01	<0.04	<0.05	*0.08*	*0.11*	*0.13*
Benzo(k)fluoranthene	<0.17	<0.39	<0.08	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.02	*0.04*	<0.05
Benzo(a)fluoranthene	<0.047	<0.151	<0.025	<0.002	<0.002	<0.003	<0.003	<0.002	<0.001	<0.003	<0.004	<0.013	<0.017
Benzo(e)pyrene	0.21	0.45	0.09	0.02	0.03	0.01	0.01	*0.01*	0.02	0.04	0.048	0.07	0.07
Benzo(a)pyrene	<0.123	0.51	0.10	0.010	0.007	0.004	0.006	0.002	0.007	0.013	0.011	0.06	0.06
Perylene	<0.013	*0.06*	<0.013	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	*0.003*	<0.009	*0.008*
Inden(123-cd)pyrene	0.26	0.59	0.12	0.02	0.01	0.00	0.008	0.004	0.02	0.03	0.034	0.07	0.08
Benzo(ghi)perylene	<0.001	<0.010	<0.006	<0.001	<0.001	<0.003	<0.004	<0.001	<0.001	<0.001	<0.001	<0.020	<0.003
Anthanthrene	<0.004	0.067	*0.013*	<0.002	<0.003	<0.004	<0.003	<0.002	<0.002	<0.003	<0.003	*0.009*	*0.008*
Coronene	0.11	0.21	0.05	0.009	0.008	<0.005	0.005	*0.003*	0.008	0.016	0.018	0.03	0.03
Dibenzo(ae)pyrene	0.029	0.088	<0.004	0.004	<0.006	<0.008	<0.004	<0.004	*0.005*	0.005	*0.007*	*0.010*	*0.010*
Dibenzo(ai)pyrene	<0.005	*0.026*	<0.005	<0.004	<0.008	<0.012	<0.005	<0.004	<0.002	<0.003	<0.003	<0.004	<0.006
Dibenzo(ah)pyrene	<0.004	<0.009	<0.005	<0.004	<0.008	<0.012	<0.005	<0.004	<0.002	<0.003	<0.003	<0.004	<0.005
Dibenzo(ah)anthracene	0.047	*0.136*	*0.025*	*0.003*	*0.005*	<0.004	<0.002	<0.002	*0.002*	0.003	*0.003*	*0.010*	*0.010*
sum PAH16	8.04	7.74	5.04	5.84	1.65	1.28	1.49	1.15	1.50	2.70	3.60	3.63	3.54
sum PAHs	13.59	11.79	8.45	10.90	2.74	2.04	2.31	1.76	2.28	4.49	5.95	5.59	5.88

Italic data means that more than 60% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.6: Monthly and annual mean concentrations (pg/m^3) for PFAS in air at Birkenes, 2014

Birkenes	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
6:2 FTS	<0.38	<0.28	<0.49	<0.41	<1.67	<1.39	<1.40	<1.26	0.88	<0.78	<0.56	<0.77	<0.85
PFBS	<0.09	<0.09	<0.14	<0.10	<0.27	<0.24	<0.21	<0.17	<0.22	<0.20	<0.18	<0.20	<0.18
PFDcA	0.32	0.33	<0.23	<0.18	<0.49	<0.17	<0.19	<0.40	<0.16	<0.15	<0.12	<0.16	*0.42*
PFDcS	<0.07	<0.05	<0.09	<0.06	<0.19	<0.14	<0.14	<0.11	<0.08	<0.09	<0.07	<0.09	<0.10
PFHpA	<0.14	<0.14	<0.52	<0.36	<0.71	<0.54	<0.37	<0.24	<0.24	<0.21	<0.22	<0.28	<0.34
PFHxA	<0.16	<0.14	<0.23	<0.18	<0.51	<0.64	<0.42	<0.24	<0.33	<0.28	<0.21	<0.25	<0.30
PFHxS	<0.10	<0.05	<0.10	<0.13	<0.21	<0.21	<0.18	<0.10	<0.11	<0.10	<0.09	<0.12	<0.13
PFNA	*0.14*	0.11	0.24	<0.13	<0.28	<0.56	*0.35*	<0.16	<0.17	*0.23*	<0.13	<0.18	*0.23*
PFOA	0.28	0.39	*0.22*	0.26	0.43	*0.41*	0.48	*0.32*	<0.20	0.37	<0.21	*0.27*	*0.32*
PFOS	*0.21*	*0.15*	*0.14*	<0.05	<0.23	<0.16	<0.16	<0.12	<0.12	*0.12*	<0.09	*0.13*	*0.14*
PFOSA	<0.10	<0.09	<0.20	<0.10	<0.25	n.d.	0.71	<0.16	<0.20	<0.16	<0.16	<0.18	<0.19
PFUnA	<0.08	<0.07	<0.11	<0.08	<0.31	n.d.	<0.33	<0.15	<0.16	<0.62	<0.13	<0.17	<0.21
sum PFAS	*1.51*	*1.44*	*1.77*	*1.15*	*2.98*	*2.44*	*3.23*	*1.88*	*1.80*	*2.02*	*1.12*	*1.61*	*2.26*

Italic data means that more than 60% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.7: Monthly and annual mean concentrations (ng/l) for HCB, HCHs and PCBs in precipitation at Birkenes, 2014

ng/l	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
HCB	0.07	0.04	0.06	0.06	0.10	0.13	0.17	0.11	0.10	0.02	0.03	0.19	0.07
α-HCH	0.07	0.07	0.09	0.07	0.10	0.14	0.11	0.14	0.16	0.13	0.13	0.09	0.11
γ-HCH	0.19	0.18	0.25	0.28	0.20	0.15	0.42	0.22	0.20	0.22	0.21	0.07	0.21
sum HCHs	0.26	0.25	0.34	0.35	0.30	0.29	0.53	0.36	0.36	0.36	0.34	0.17	0.32
PCB-28	0.007	0.004	0.006	0.003	0.004	0.005	0.005	0.003	0.004	0.002	0.003	0.008	0.004
PCB-52	0.008	0.005	0.006	0.005	0.004	0.005	0.004	0.003	0.003	0.003	0.005	0.007	0.005
PCB-101	0.009	0.006	0.008	0.005	0.007	0.007	0.005	0.003	0.004	0.007	0.009	0.006	0.007
PCB-118	0.008	0.007	0.006	0.003	0.004	0.005	0.004	0.002	0.005	0.003	0.005	0.005	0.005
PCB-138	0.012	0.010	0.015	0.005	0.008	0.006	0.005	0.002	0.004	0.006	0.009	0.006	0.008
PCB-153	0.013	0.011	0.017	0.006	0.010	0.008	0.006	0.003	0.005	0.008	0.011	0.007	0.009
PCB-180	0.008	0.008	0.015	0.003	0.005	0.004	0.005	0.002	0.002	0.004	0.006	0.004	0.006
sum PCB7	0.064	0.051	0.073	0.031	0.040	0.039	0.035	0.019	0.026	0.033	0.048	0.043	0.044

Table A.2.8: Monthly and annual mean concentrations (pg/m^3) for organochlorine pesticides (OCPs) in air at Andøya, 2014

Andøya	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2014
HCB	38.8	63.5	35.5	32.2	28.5	25.0	12.7	12.8	21.3	31.0	36.5	39.6	30.8
α-HCH	3.58	3.36	3.19	3.62	3.03	3.50	2.85	3.62	5.40	5.23	4.02	3.41	3.73
γ-HCH	1.08	1.41	0.82	1.01	0.61	0.62	1.78	1.10	0.77	1.36	0.87	0.56	1.00
p,p'-DDT	0.03	0.02	<0.01	*0.01*	0.01	*0.01*	0.01	0.01	*0.01*	0.01	0.03	*0.01*	0.01
o,p'-DDT	0.21	0.21	0.15	0.11	0.05	0.03	0.10	0.09	0.04	0.13	0.17	0.11	0.12
p,p'-DDE	1.41	1.22	0.70	0.29	0.11	0.10	0.16	0.15	0.11	0.46	0.71	0.63	0.50
o,p'-DDE	0.13	0.12	0.08	0.05	0.02	0.02	0.02	0.02	0.02	0.03	0.08	0.09	0.06
p,p'-DDD	0.13	0.17	0.10	0.04	0.02	0.02	0.05	0.06	0.03	0.10	0.15	0.09	0.08
o,p'-DDD	0.03	0.02	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.05	0.03	0.02
sum DDTs	1.94	1.77	1.04	0.51	0.23	0.15	0.37	0.35	0.22	0.77	1.25	0.99	0.80

Italic data means that more than 60% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.9: Monthly and annual mean concentrations (pg/m^3) for PCBs in air at Andøya, 2014

Andøya	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
PCB-18	1.64	1.94	1.41	0.89	0.59	0.33	0.33	0.30	0.39	0.89	0.70	0.97	0.83
PCB-28	0.91	1.07	0.70	0.54	0.38	0.25	0.39	0.30	0.24	0.59	0.53	0.53	0.52
PCB-31	0.80	0.97	0.68	0.52	0.36	0.24	0.35	0.29	0.22	0.53	0.48	0.49	0.48
PCB-33	0.52	0.65	0.39	0.28	0.20	0.14	0.20	0.15	0.12	0.31	0.27	0.30	0.29
PCB-37	0.08	0.09	0.04	0.03	0.02	0.02	0.04	0.02	0.01	0.04	0.04	0.04	0.04
PCB-47	0.44	0.77	0.77	0.93	1.09	0.82	1.49	0.90	0.50	0.86	0.93	1.19	0.89
PCB-52	0.71	0.89	0.67	0.54	0.41	0.29	0.52	0.37	0.28	0.61	0.56	0.51	0.52
PCB-66	0.17	0.21	0.14	0.12	0.09	0.07	0.13	0.09	0.06	0.16	0.14	0.12	0.12
PCB-74	0.12	0.14	0.10	0.09	0.06	0.04	0.08	0.05	0.04	0.10	0.09	0.08	0.08
PCB-99	0.17	0.18	0.14	0.12	0.09	0.04	0.11	0.08	0.06	0.12	0.11	0.10	0.11
PCB-101	0.35	0.45	0.33	0.28	0.22	0.11	0.33	0.24	0.15	0.32	0.28	0.25	0.28
PCB-105	0.03	0.04	0.02	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02
PCB-114	<0.006	<0.003	<0.004	*0.002*	0.002	<0.001	0.002	<0.002	*0.001*	*0.003*	*0.003*	<0.003	*0.003*
PCB-118	<0.24	<0.24	<0.25	<<0.25	<0.26	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.27	<0.25
PCB-122	<0.005	<0.003	<0.003	<0.001	<0.001	<0.001	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002
PCB-123	*0.006*	<0.006	<0.003	<0.001	<0.001	<0.001	*0.002*	<0.001	*0.001*	*0.002*	0.001	*0.002*	*0.002*
PCB-128	0.013	0.017	0.012	0.010	0.008	0.007	0.012	0.012	0.007	0.012	0.011	0.010	0.01
PCB-138	<0.28	<0.28	<0.29	<0.30	<0.31	<0.28	<0.29	<0.29	<0.28	<0.28	<0.28	<0.32	<0.29
PCB-141	0.02	0.04	0.02	0.02	0.01	0.01	0.04	0.02	0.01	0.03	0.02	0.02	0.02
PCB-149	*0.20*	*0.25*	*0.20*	<0.17	<0.16	<0.14	0.27	<0.21	<0.15	*0.19*	*0.18*	<0.16	0.19
PCB-153	<0.20	<0.24	<0.20	<0.18	<0.19	<0.17	<0.21	<0.19	<0.17	<0.19	<0.19	<0.20	<0.19
PCB-156	*0.004*	0.008	*0.007*	0.003	0.003	*0.002*	0.003	0.003	*0.002*	0.004	0.004	<0.004	0.004
PCB-157	<0.002	<0.002	<0.002	<0.001	<0.001	*0.001*	*0.001*	*0.001*	*0.001*	<0.001	*0.001*	<0.001	<0.001
PCB-167	<0.002	*0.003*	*0.005*	0.002	0.001	0.001	0.002	0.002	0.001	0.002	0.002	<0.001	0.002
PCB-170	0.004	0.014	0.008	0.007	0.005	0.004	0.007	0.008	0.005	0.008	0.008	0.005	0.007

Table A.2.9, cont.

Andøya	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
PCB-180	0.02	0.04	0.03	0.02	0.02	0.01	0.04	0.03	0.02	0.03	0.03	0.02	0.02
PCB-183	0.01	0.02	0.02	0.01	0.01	0.005	0.01	0.01	0.007	0.01	0.01	0.01	0.01
PCB-187	0.04	0.05	0.05	0.04	0.02	0.02	0.06	0.04	0.02	0.03	0.04	0.03	0.04
PCB-189	<0.002	<0.002	<0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
PCB-194	*0.003*	<0.002	<0.002	0.001	0.001	0.001	0.002	0.001	0.002	0.001	0.002	*0.001*	0.002
PCB-206	<0.003	<0.002	<0.002	*0.001*	0.001	<0.001	0.002	*0.001*	*0.001*	*0.001*	0.001	<0.001	*0.001*
PCB-209	<0.003	<0.006	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003
sum-trichlor	5.40	6.31	4.53	3.19	2.13	1.29	1.66	1.32	1.27	3.13	2.70	3.12	2.91
sum-tetrachlor	1.53	2.02	1.97	2.13	1.92	1.33	2.34	1.51	0.95	1.91	1.93	2.02	1.77
sum-pentachlor	0.67	0.80	0.60	0.55	0.56	0.52	0.58	0.54	0.52	0.56	0.56	0.59	0.59
sum-hexachlor	0.75	0.76	0.77	0.79	0.82	0.76	0.77	0.76	0.76	0.76	0.75	0.85	0.78
sum-heptachlor	0.07	0.13	0.11	0.08	0.06	0.05	0.12	0.09	0.05	0.08	0.08	0.06	0.08
sum-PCB7	2.70	3.22	2.47	2.11	1.79	1.36	2.01	1.65	1.39	2.25	2.10	2.10	2.07
sum PCBs	8.43	10.02	7.99	6.75	5.50	3.48	5.48	4.23	3.55	6.50	6.17	6.65	6.16

Italic data means that more than 60% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.10: Monthly and annual mean concentrations (pg/m^3) for PBDEs in air at Andøya, 2014

Andøya	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
BDE-28	0.007	0.008	0.006	0.004	0.012	0.007	0.005	0.006	0.004	0.006	0.009	0.012	0.007
BDE-47	0.04	0.05	0.03	0.02	0.11	0.05	0.04	0.04	0.03	0.03	*0.04*	*0.03*	0.05
BDE-49	0.011	0.031	0.004	0.002	0.007	0.004	0.007	0.006	0.003	0.003	0.004	0.005	0.008
BDE-66	0.019	0.042	0.008	0.004	0.005	0.002	0.002	0.005	0.009	0.013	0.009	0.009	0.01
BDE-71	<0.010	<0.030	<0.003	<0.002	<0.004	<0.003	<0.003	<0.003	<0.003	<0.007	<0.003	<0.003	<0.006
BDE-77	<0.002	<0.001	<0.001	*0.001*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	*0.001*	<0.001
BDE-85	<0.001	<0.002	<0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	*0.001*	<0.001	<0.001	<0.002
BDE-99	0.02	0.03	0.02	0.01	0.03	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.02
BDE-100	0.005	0.006	0.005	0.004	0.009	0.004	0.004	0.004	0.004	*0.004*	0.005	*0.004*	0.005
BDE-119	<0.001	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
BDE-138	<0.004	<0.004	<0.007	<0.005	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.005
BDE-153	*0.004*	0.006	*0.006*	*0.003*	*0.003*	<0.003	<0.003	<0.003	<0.003	0.004	0.004	0.003	0.004
BDE-154	*0.003*	0.005	0.005	0.002	0.002	*0.002*	0.002	*0.003*	0.002	*0.003*	0.003	*0.003*	0.003
BDE-183	0.004	0.016	0.006	0.003	0.004	*0.003*	*0.003*	*0.006*	*0.003*	0.008	0.008	0.006	0.006
BDE-196	0.02	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
BDE-206	*0.02*	*0.01*	0.02	*0.02*	*0.01*	*0.01*	*0.01*	<0.01	<0.01	*0.04*	*0.01*	*0.02*	0.02
BDE-209	<0.23	0.25	0.33	0.51	*0.25*	<0.17	*0.41*	*0.22*	<0.40	*0.32*	*0.13*	*0.40*	*0.28*
sum PBDEs	*0.41*	*0.51*	*0.47*	*0.61*	*0.47*	*0.28*	*0.53*	*0.34*	*0.50*	*0.47*	*0.25*	*0.53*	*0.42*
TBA	3.39	2.96	2.58	0.42	0.46	2.83	1.82	4.29	3.25	3.54	3.65	3.23	2.75

Italic data means that more than 60% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.11: Monthly and annual mean concentrations (pg/m^3) for PFAS in air at Andøya, 2014

Andøya	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
6:2 FTS	<0.33	<0.23	<0.62	<0.56	<0.38	<0.50	<0.51	<0.40	<0.35	<0.39	<0.39	<0.34	<0.41
PFBS	<0.04	<0.08	<0.09	<0.07	<0.09	<0.09	<0.08	<0.09	<0.07	<0.10	<0.10	<0.10	<0.08
PFDcA	<0.10	<0.06	<0.06	<0.13	<0.05	<0.10	<0.09	<0.07	<0.20	<0.08	<0.10	<0.09	<0.09
PFDcS	<0.03	<0.07	<0.05	<0.05	<0.05	<0.05	<0.07	<0.05	<0.03	<0.05	<0.05	<0.03	<0.05
PFHpA	<0.06	<0.10	<0.16	<0.15	<0.23	<0.17	<0.22	<0.25	<0.30	<0.14	<0.17	<0.12	<0.15
PFHxA	<0.06	<0.10	<0.09	<0.11	<0.20	<0.14	<0.32	<0.18	<0.50	<0.20	<0.11	<0.74	<0.24
PFHxS	<0.03	<0.04	<0.04	<0.04	<0.06	<0.08	<0.07	<0.05	<0.04	<0.05	<0.05	<0.04	<0.05
PFNA	<0.06	<0.12	*0.08*	<0.09	<0.20	<0.13	<0.17	*0.18*	<0.18	<0.16	*0.14*	<0.30	*0.16*
PFOA	0.07	*0.10*	*0.10*	<0.10	<0.17	<0.25	*0.41*	*0.27*	<0.30	*0.22*	*0.22*	*0.16*	*0.19*
PFOS	<0.05	*0.06*	<0.06	<0.05	<0.05	<0.05	<0.08	<0.07	<0.05	<0.08	<0.06	*0.12*	*0.07*
PFOSA	<0.03	<0.07	<0.06	<0.12	<0.07	<0.14	<0.18	<0.06	<0.30	<0.10	<0.10	<0.09	<0.09
PFUnA	<0.02	<0.05	<0.05	<0.10	<0.36	<1.79	<0.15	<0.11	<0.30	<0.10	<0.08	<0.07	<0.23
sum PFAS	*0.47*	*0.62*	*0.78*	*0.78*	*1.04*	*1.75*	*1.37*	*1.12*	*1.14*	*0.95*	*0.97*	*1.24*	*1.12*

Italic data means that more than 60% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.12: Monthly and annual mean concentrations (pg/m^3) for organochlorine pesticides in air at Zeppelin, 2014

Zeppelin	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
HCB	71.7	66.9	82.5	88.6	88.8	85.9	85.0	88.4	101.1	95.8	81.9	75.3	83.4
α-HCH	3.26	2.91	4.04	4.94	5.08	3.80	5.26	6.71	6.63	8.01	5.93	3.62	4.94
γ-HCH	0.61	1.10	0.76	0.83	0.75	0.48	0.69	0.63	0.96	0.77	0.86	0.47	0.74
cis-CD	0.39	0.33	0.37	0.40	0.32	0.28	0.27	0.28	0.36	0.33	0.49	0.34	0.36
cis-NO	0.02	0.03	0.02	0.03	0.04	0.05	0.05	0.04	0.06	0.05	0.03	0.02	0.04
trans-CD	0.22	0.19	0.21	0.16	0.09	0.05	0.05	0.03	0.07	0.08	0.21	0.18	0.15
trans-NO	0.34	0.32	0.34	0.39	0.31	0.23	0.26	0.22	0.30	0.28	0.42	0.31	0.33
sum CHLs	0.98	0.87	0.94	0.98	0.75	0.61	0.63	0.57	0.79	0.74	1.15	0.85	0.87
p,p'-DDT	0.02	0.03	<0.01	<0.01	*0.02*	<0.01	*0.01*	<0.01	<0.01	<0.01	*0.02*	*0.03*	*0.02*
o,p'-DDT	0.12	0.20	0.12	0.09	0.05	0.02	0.03	0.02	0.04	0.04	0.11	0.10	0.08
p,p'-DDE	0.71	1.12	0.44	0.15	0.09	0.04	0.06	0.05	0.07	0.10	0.43	0.50	0.36
o,p'-DDE	0.10	0.11	0.07	0.05	*0.02*	<0.02	*0.01*	<0.01	*0.01*	0.02	0.05	0.08	0.05
p,p'-DDD	0.07	0.16	0.05	*0.03*	*0.02*	<0.02	0.03	*0.02*	*0.02*	0.02	0.07	0.08	0.05
o,p'-DDD	0.02	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.03	0.02
sum DDTs	1.06	1.62	0.70	0.32	0.21	0.12	0.16	0.12	0.14	0.20	0.68	0.82	0.56

Italic data means that more than 60% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.13: Monthly and annual mean concentrations (pg/m^3) for PCBs in air at Zeppelin, 2014

Zeppelin	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
PCB-18	1.85	2.08	2.15	1.84	2.66	1.97	3.24	2.71	1.80	1.12	1.56	1.85	2.05
PCB-28	1.06	1.31	1.36	1.27	1.92	1.50	2.49	1.98	1.38	0.83	0.90	1.09	1.39
PCB-31	0.97	1.20	1.23	1.18	1.78	1.40	2.28	1.90	1.29	0.73	0.85	1.03	1.29
PCB-33	0.72	0.89	0.91	0.83	1.43	1.08	1.81	1.43	1.01	0.55	0.59	0.73	0.97
PCB-37	0.09	0.11	0.12	0.10	0.18	0.13	0.22	0.17	0.12	0.07	0.07	0.09	0.12
PCB-47	0.28	0.36	0.38	0.31	0.37	0.23	0.37	0.31	0.26	0.17	0.22	0.28	0.29
PCB-52	0.63	0.77	0.83	0.69	0.75	0.52	0.80	0.67	0.56	0.42	0.53	0.65	0.65
PCB-66	0.12	0.19	0.20	0.15	0.15	0.10	0.15	0.12	0.12	0.10	0.11	0.16	0.14
PCB-74	0.10	0.12	0.13	0.11	0.10	0.06	0.10	0.08	0.08	0.06	0.08	0.10	0.09
PCB-99	0.12	0.16	0.16	0.12	0.08	0.05	0.07	0.07	0.07	0.07	0.09	0.13	0.10
PCB-101	0.28	0.35	0.35	0.28	0.23	0.15	0.22	0.19	0.20	0.17	0.21	0.28	0.24
PCB-105	0.02	*0.03*	0.03	0.02	*0.02*	<0.02	*0.02*	0.02	*0.02*	<0.02	0.02	0.04	*0.02*
PCB-114	<0.010	*0.012*	*0.002*	0.002	*0.002*	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	0.004	*0.004*
PCB-118	<0.37	<0.38	<0.39	<0.37	<0.36	<0.39	<0.39	<0.39	<0.38	<0.38	<0.32	<0.33	<0.36
PCB-122	<0.010	<0.011	<0.002	<0.002	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002	<0.003
PCB-123	<0.011	<0.012	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	*0.001*	0.002	*0.003*
PCB-128	0.015	*0.011*	0.012	*0.010*	*0.009*	<0.009	<0.009	0.009	*0.009*	<0.009	0.008	0.014	0.01
PCB-138	<0.43	<0.44	<0.46	<0.44	<0.42	<0.47	<0.46	<0.46	<0.45	<0.45	<0.37	<0.39	<0.43
PCB-141	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01
PCB-149	*0.23*	<0.24	<0.24	<0.23	<0.22	<0.24	<0.23	<0.23	<0.23	<0.23	<0.19	<0.20	<0.22
PCB-153	<0.27	<0.27	<0.28	<0.27	<0.26	<0.29	<0.28	<0.28	<0.28	<0.28	<0.23	<0.24	<0.26
PCB-156	*0.008*	*0.006*	0.005	*0.003*	*0.003*	<0.003	*0.003*	0.004	<0.003	<0.003	0.003	0.006	*0.004*
PCB-157	<0.004	<0.004	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	*0.002*	<0.002
PCB-167	*0.005*	*0.004*	*0.002*	*0.002*	<0.001	<0.002	<0.002	0.002	<0.002	*0.002*	0.002	0.003	*0.002*
PCB-170	*0.009*	*0.010*	*0.003*	0.004	0.004	0.003	0.005	0.007	0.003	0.003	0.004	0.006	*0.005*

Table A.2.13, cont.

Zeppelin	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
PCB-180	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02
PCB-183	0.006	0.011	0.007	0.007	0.006	0.003	0.005	0.007	0.006	0.004	0.007	0.007	0.007
PCB-187	0.02	0.05	0.03	0.02	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02
PCB-189	*0.006*	<0.007	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002
PCB-194	<0.006	*0.006*	<0.001	<0.001	*0.001*	<0.001	*0.002*	0.003	<0.001	<0.001	*0.001*	0.002	*0.002*
PCB-206	<0.005	*0.006*	<0.001	*0.001*	*0.001*	<0.001	*0.001*	*0.002*	*0.001*	*0.001*	0.001	0.001	*0.002*
PCB-209	<0.005	*0.006*	*0.004*	*0.005*	*0.004*	<0.004	*0.004*	<0.004	<0.004	<0.004	<0.003	*0.004*	*0.004*
sum-trichlor	6.27	7.71	7.84	7.17	10.76	8.19	13.63	10.84	7.78	4.58	5.28	6.38	7.84
sum-tetrachlor	1.13	1.61	1.74	1.52	1.57	1.02	1.59	1.33	1.15	0.85	1.09	1.38	1.34
sum-pentachlor	0.82	0.84	0.85	0.81	0.78	0.85	0.84	0.84	0.83	0.82	0.68	0.75	0.80
sum-hexachlor	1.16	1.18	1.23	1.17	1.14	1.25	1.22	1.22	1.21	1.20	0.99	1.03	1.15
sum-heptachlor	0.07	0.09	0.07	0.07	0.06	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.07
sum-PCB7	3.05	3.55	3.69	3.33	3.96	3.33	4.64	3.99	3.26	2.53	2.57	2.98	3.35
sum PCBs	9.46	11.45	11.72	10.74	14.31	11.38	17.36	14.31	11.05	7.54	8.12	9.60	11.2

Italic data means that more than 60% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.14: Monthly and annual mean concentrations (pg/m^3) for PBDEs and TBA in air at Zeppelin, 2014

Zeppelin	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
BDE-28	0.015	0.021	0.011	0.010	0.006	0.015	0.021	0.007	0.006	0.006	0.017	0.005	0.01
BDE-47	0.53	0.89	0.21	0.30	0.17	1.06	1.69	0.17	0.11	0.12	0.78	0.08	0.52
BDE-49	0.017	0.028	0.010	0.010	0.007	0.026	0.046	0.008	0.006	0.005	0.024	0.005	0.02
BDE-66	0.008	0.016	0.005	0.006	0.004	0.020	0.029	0.007	0.003	0.004	0.014	0.004	0.01
BDE-71	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	*0.006*	<0.004	<0.004	<0.004	<0.003	<0.003	<0.004
BDE-77	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
BDE-85	<0.004	<0.003	<0.005	<0.002	<0.002	<0.002	*0.002*	<0.002	<0.002	*0.002*	*0.002*	<0.002	<0.002
BDE-99	0.04	0.05	0.02	0.02	0.01	0.07	0.07	0.03	0.02	0.03	0.04	0.01	0.03
BDE-100	0.022	0.026	0.009	0.009	0.005	0.036	0.048	0.011	*0.006*	*0.009*	*0.023*	*0.005*	0.02
BDE-119	<0.004	<0.003	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.002
BDE-138	<0.012	<0.009	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.005	<0.006
BDE-153	<0.010	<0.008	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.005
BDE-154	<0.007	<0.005	<0.004	<0.003	<0.003	<0.003	0.004	*0.003*	<0.003	*0.003*	*0.003*	*0.002*	*0.003*
BDE-183	<0.005	<0.004	<0.007	<0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	*0.004*	<0.004
BDE-196	<0.03	<0.02	<0.04	<0.02	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.02
BDE-206	<0.02	<0.02	<0.03	*0.05*	<0.02	<0.02	*0.02*	*0.04*	*0.05*	*0.03*	<0.02	<0.02	*0.03*
BDE-209	*0.51*	*0.34*	<0.28	*0.80*	<0.28	<0.29	*0.41*	*0.41*	*0.60*	*0.61*	<0.28	<0.25	*0.43*
sum PBDEs	*1.24*	*1.44*	*0.66*	*1.25*	*0.54*	*1.56*	*2.38*	*0.72*	*0.84*	*0.85*	*1.23*	*0.41*	*1.11*
TBA	4.80	4.12	1.94	1.19	1.17	4.53	7.02	8.87	7.75	7.26	9.92	4.60	5.37

Italic data means that more than 60% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.15: Monthly and annual mean concentrations (pg/m^3) for HBCDs in air at Zeppelin, 2014

Zeppelin	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
α -HBCD	<0.02	*0.05*	<0.02	<0.01	<0.01	<0.01	<0.01	n.d	<0.95	<0.21	<0.21	<0.29	<0.16
β-HBCD	<0.02	<0.04	<0.03	<0.03	<0.02	<0.01	<0.03	<0.02	<0.16	<0.45	<1.27	<1.16	<0.31
γ-HBCD	*0.03*	*0.05*	*0.02*	<0.01	<0.01	<0.02	<0.02	<0.02	<0.13	*0.55*	<0.40	*0.71*	*0.19*
Sum HBCDs	*0.08*	*0.14*	*0.07*	*<0.06*	*<0.04*	*<0.04*	*<0.06*	*<0.04*	*<1.25*	*1.22*	*<1.88*	*2.16*	*0.65*

Italic data means that more than 60% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.16: Monthly and annual mean concentrations (ng/m^3) for PAHs in air at Zeppelin, 2014

Zeppelin	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Naphthalene	1.28	1.18	0.45	0.25	0.07	0.29	0.50	0.49	1.44	0.49	0.69	2.32	0.89
2-Methylnaphthalene	0.21	0.35	0.11	0.08	<0.03	0.09	0.09	0.22	0.11	0.04	0.09	0.51	0.18
1-Methylnaphthalene	0.15	0.24	0.07	0.05	<0.02	0.05	0.04	0.11	0.04	0.02	0.06	0.44	0.13
Biphenyl	0.68	1.45	0.78	0.14	0.02	0.03	0.04	0.04	0.05	0.13	0.33	1.33	0.47
Acenaphthylene	<0.008	<0.008	<0.006	<0.006	<0.005	<0.007	<0.007	<0.005	<0.005	<0.005	<0.005	<0.009	<0.007
Acenaphthene	<0.014	<0.022	<0.008	<0.010	<0.005	<0.013	<0.013	<0.010	<0.007	<0.011	<0.010	0.02	<0.012
Dibenzofuran	0.82	4.40	1.09	0.23	0.04	0.03	0.03	0.04	0.10	0.16	0.55	1.53	0.69
Fluorene	0.35	2.45	0.23	0.03	0.02	0.02	0.02	0.02	0.03	0.04	0.17	0.82	0.33
Dibenzothiophene	0.01	*0.01*	0.01	*0.003*	<0.002	<0.002	*0.003*	0.002	*0.002*	<0.001	*0.004*	0.02	*0.005*
Phenanthrene	0.05	0.50	0.06	0.02	0.03	0.02	0.04	0.04	0.02	0.02	0.02	0.28	0.091
Anthracene	<0.003	<0.005	<0.005	*0.01*	<0.005	<0.006	<0.004	<0.004	*0.008*	<0.003	<0.003	*0.005*	*0.005*
3-Methylphenanthrene	0.003	0.019	0.004	<0.005	*0.005*	<0.006	*0.012*	0.007	0.004	*0.003*	*0.003*	0.014	*0.007*
2-Methylphenanthrene	0.004	0.026	0.005	<0.004	0.005	0.006	0.013	0.008	0.005	0.003	0.003	0.017	*0.008*
2-Methylanthracene	*0.002*	<0.008	<0.002	<0.005	<0.004	<0.006	<0.006	*0.004*	*0.004*	*0.003*	*0.005*	*0.004*	*0.005*
9-Methylphenanthrene	<0.003	0.010	0.003	<0.004	*0.004*	*0.005*	*0.009*	0.006	0.004	<0.003	*0.002*	0.007	*0.005*
1-Methylphenanthrene	*0.002*	0.017	0.004	<0.005	*0.003*	<0.006	*0.009*	0.005	0.003	*0.003*	*0.003*	0.016	*0.007*
Fluoranthene	0.01	0.20	0.02	*0.005*	<0.005	<0.005	*0.007*	*0.007*	*0.005*	<0.005	0.01	0.16	0.040
Pyrene	*0.007*	0.04	*0.01*	<0.006	<0.006	<0.007	<0.007	*0.007*	*0.007*	<0.006	*0.007*	0.07	*0.018*
Benzo(a)fluorene	*0.001*	*0.007*	*0.001*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	*0.002*
Retene	<0.003	*0.006*	<0.003	<0.003	<0.003	<0.003	*0.004*	0.006	<0.003	<0.003	<0.003	0.010	*0.005*
Benzo(b)fluorene	<0.001	*0.003*	<0.001	<0.001	<0.001	<0.001	<0.002	<0.001	<0.001	<0.001	<0.001	0.004	*0.002*
Benzo(ghi)fluoranthene	0.002	0.011	0.001	<0.001	<0.001	<0.002	<0.002	*0.001*	<0.001	<0.001	0.001	0.020	*0.001*
Cyclopenta(cd)pyrene	<0.002	<0.004	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Benz(a)anthracene	*0.002*	0.018	*0.005*	*0.006*	<0.001	<0.002	<0.001	<0.001	<0.001	<0.001	*0.001*	*0.014*	*0.005*
Chrysene	0.003	0.035	0.004	<0.001	<0.001	<0.002	<0.002	<0.001	<0.001	<0.001	0.003	0.037	0.01

Zeppelin	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Triphenylene	*0.002*	*0.008*	*0.003*	<0.001	<0.001	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	*0.003*
Benzo(b)fluoranthene	*0.003*	*0.02*	*0.01*	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	*0.003*	*0.042*	*0.010*
Benzo(k)fluoranthene	*0.003*	*0.010*	*0.004*	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	*0.016*	<0.005
Benzo(a)fluoranthene	<0.001	*0.003*	<0.001	<0.001	<0.001	<0.002	<0.001	<0.001	<0.002	<0.002	<0.001	<0.003	<0.002
Benzo(e)pyrene	0.002	0.014	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.001	*0.002*	0.024	*0.005*
Benzo(a)pyrene	<0.001	0.008	*0.002*	<0.001	<0.001	<0.002	<0.001	<0.001	<0.002	<0.002	<0.001	0.014	*0.004*
Perylene	<0.001	*0.002*	<0.001	*0.001*	<0.001	<0.001	<0.001	<0.001	<0.002	<0.001	*0.002*	0.002	*0.001*
Inden(123-cd)pyrene	*0.002*	0.014	0.003	<0.001	<0.001	<0.002	<0.001	<0.001	<0.001	<0.001	*0.001*	0.021	0.005
Benzo(ghi)perylene	*0.002*	*0.011*	*0.001*	<0.001	<0.001	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.020	*0.001*
Anthanthrene	<0.002	<0.002	<0.001	<0.001	<0.001	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	*0.002*	<0.001
Coronene	*0.003*	*0.007*	*0.004*	<0.002	<0.001	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	*0.003*
Dibenzo(ae)pyrene	<0.004	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	*0.003*	<0.002
Dibenzo(ai)pyrene	<0.004	<0.004	<0.003	<0.003	<0.002	<0.003	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002
Dibenzo(ah)pyrene	<0.003	<0.003	<0.002	<0.003	<0.002	<0.003	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002
Dibenzo(ah)anthracene	<0.002	*0.002*	<0.001	<0.001	<0.001	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	*0.003*	<0.001
Sum PAH16	1.74	4.51	0.82	0.35	0.15	0.38	0.62	0.59	1.53	0.59	0.93	3.83	1.43
Sum PAHs	3.64	11.04	2.90	0.88	0.31	0.63	0.88	1.05	1.86	0.98	1.99	7.70	2.94

Italic data means that more than 60% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.17: Monthly and annual mean concentrations (pg/m^3) for PFAS in air at Zeppelin, 2014

Zeppelin	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
6:2 FTS	<0.14	<0.24	<0.35	<0.31	<0.89	<0.41	<0.47	<0.31	<0.39	<0.27	<0.30	<0.25	<0.33
PFBS	<0.03	<0.06	<0.19	<0.09	<0.09	<0.12	<0.12	<0.08	<0.10	<0.07	<0.09	<0.06	<0.09
PFDcA	*0.07*	*<0.07*	<0.10	<0.08	<0.11	<0.13	<0.07	*0.17*	<0.15	<0.08	*0.09*	*0.12*	*0.11*
PFDcS	<0.02	<0.04	<0.05	<0.03	<0.11	<0.04	<0.05	<0.03	<0.05	<0.03	<0.04	<0.03	<0.04
PFHpA	<0.05	<0.08	<0.13	<0.52	<0.18	<0.21	<0.46	<0.20	<0.14	<0.21	<0.11	<0.11	<0.22
PFHxA	<0.05	<0.09	<0.10	<0.24	<0.20	<0.21	<0.14	<0.15	<0.15	<0.32	<0.10	<0.07	<0.16
PFHxS	<0.03	<0.04	<0.04	<0.04	<0.09	<0.21	<0.08	<0.05	<0.05	<0.04	<0.03	<0.03	<0.06
PFNA	*0.08*	<0.06	*0.11*	*0.19*	<0.21	<0.22	*0.18*	0.18	0.10	<0.09	*0.13*	*0.07*	*0.14*
PFOA	*0.10*	<0.06	0.15	0.24	*0.41*	0.31	0.29	0.25	0.22	*0.16*	0.25	*0.12*	*0.22*
PFOS	*0.04*	<0.05	<0.06	*0.06*	<0.10	<0.05	*0.07*	0.07	0.08	*0.06*	<0.04	*0.05*	*0.06*
PFOSA	*0.12*	<0.07	*<0.15*	<0.30	<0.30	*0.49*	*0.42*	0.24	*0.17*	<0.10	<0.06	*0.07*	*0.16*
PFUnA	<0.03	<0.05	<0.15	<0.30	<0.30	<0.13	<0.13	<0.08	<0.11	<0.06	<0.13	<0.12	<0.10
sum PFAS	*0.59*	*0.49*	*1.00*	*1.44*	*1.71*	*1.67*	*1.72*	*1.36*	*1.14*	*0.86*	*0.88*	*0.77*	*1.17*

Italic data means that more than 60% of the data is below the detection limit and should be considered as the upper concentrations.

Table A.2.18: Monthly and annual mean concentrations (pg/m^3) for M/SCCPs in air at Zeppelin, 2014

Zeppelin	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
SCCP	260.8	308.3	181.0	168.0	233.8	172.0	480.0	148.3	243.2	309.0	171.8	317.8	242.5
MCCP	18.4	109.7	<3.35	5.4	<3.35	<3.35	11.7	12.0	11.9	224.1	23.1	48.0	30.2

Annex 3

Description of methods for sampling, chemical analysis and quality control

Heavy metals

For heavy metals, there are specific requirements for cleanliness for preparation and treatment of the equipment to avoid contamination, i.e. acid-washed equipment is used for sampling and preparations.

Except for mercury, all the trace elements are analyzed by inductively coupled plasma mass spectrometry (ICP-MS). The ion optic is optimized for 115 In. The samples are preserved with 1% HNO_3 and an internal standard is used (indium).

For precipitation, a bulk sampler (funnel+collector), from NILU Innovation is used. Precipitation amount is determined by weighing. The entire sample is sent to NILUs laboratory at Kjeller.

Table A.3.1: Quantification limits for heavy metals in precipitation.

Parameter	Lower quantification limit	
As	0.3	(µg As/l)
Zn	0.4	(µg Zn/l)
Pb	0.2	(µg Pb/l)
Ni	0.07	(µg Ni/l)
Cd	0.03	(µg Cd/l)
Cu	0.3	(µg Cu/l)
Cr	0.3	(µg Cr/l)
Co	0.01	(µg Co/l)
V	0.02	(µg V/l)

Sampling of air for the analysis of heavy metals in the particles at Birkenes occurs by means of a Kleinfiltergerät with a PM_{10}-impactor. Weekly samples on Whatman quartz 47 mm filter are collected. This is the same sampler and filter as is used to collect EC/OC. The airflow is 2.3 m^3/hour. At Andøya and the Zeppelin Observatory, sampling of heavy metals in particles are done using a Digitel high volume sampler without any defined size cut off. The airflow rate is 20 m^3/hour, and Whatman 41 filters are used. The filters are digested with nitric acid by Ultraclave, a microwave based decomposition technique.

Table A.3.2: Quantification limit for heavy metals in aerosols.

	Lower quantification limit (ng/m^3)		
	Birkenes	Andøya	Zeppelin
Pb	0.15	0.04	0.01
Cd	0.002	0.0003	0.0006
Zn	0.27	1.37	0.79
Cu	0.11	0.42	0.13
Ni	0.67	0.15	0.04
Cr	0.23	0.24	0.02
Co	0.005	0.004	0.0005
As	0.01	0.006	0.002
Mn		1.19	0.04
V	0.005	0.006	0.0007

Mercury

For precipitation sampling of mercury, the IVLs (Swedish Environmental Research Institute AB, Sweden) sampler designed for this element is used. The collector is produced by quartz. The sampler is protected against sunlight, and it is located 2 meters above the ground.

Mercury in precipitation is preserved with HCl. A day before analysis, BrCl is added to oxidise all the mercury in precipitation to Hg^{2+}. During the analysis, all the mercury is reduced to Hg^0 and absorbed on gold trap. Hg is desorbed form the gold traps using heat and detected using atomfluorescens spectrophotometry. The detection limit for the method is 0.2 ng Hg absolute amount.

Total gaseous mercury (TGM) is measured with a Tekran Hg monitor where the mercury collected on gold traps in time intervals of 5 minutes at a sampling rate of 1.5 l / min. Mercury is desorbed from the gold traps using heat and detected using atomfluorescens-spectrophotometry. The detection limit for the method is 0.2 ng Hg absolute amount.

POPs and emerging pollutants

Sampling of OCPs, PCBs, PBDEs, HBCDs, TBA, PAHs, PFAs and S/MCCPs

Air samples were collected with two types of high volume air samplers: Digitel and NILU sampler. The samplers consist of a pump that draws air through the samplers with an average air flow rate of 25 m^3/hour; a glass fiber filter (GFF) that collects the particle-associated compounds; and two pre-cleaned PUF plugs that collect the gas phase compounds. For PFAS, only a GFF was used. Specification on each sampler type is given in Table A.3.3. Flow-rate and sampling conditions were digitally monitored and documented (e.g., power failures, etc.) as an integrated part of the sampling and quality control procedure.

Table A.3.3: Specification on air samplers.

	DIGITEL	NILU sampler
Flow rate	~25 m^3/hour	~25 m^3/hour
Filter	GFF: Whatman Type GF/C	GFF: Gelman Type AE
PUF plugs	Diameter 75 mm, length 40 mm, density 25 kg/m^3	Diameter 110 mm, length 50 mm, density 25 kg/m^3
Usage	PBDEs, HBCDs, TBA (Zeppelin) OCPs, PCBs, PBDEs, HBCDs, TBA, PAHs, PFAS (Andøya) OCPs, PCBs, PBDEs, HBCDs, TBA, PAHs (Birkenes)	OCPs, PCBs, PAHs, PFAS, S/MCCPs (Zeppelin) PFAS (Birkenes)

Sampling was done on a weekly basis for each POP class at each observatory. The sampling duration for each sampling station and POP class varied according to Table A.3.4. The

variable sampling lengths resulted in actual total air volumes of 600-1950 m^3 (as reported on sampling protocols).

Table A.3.4: Sampling durations for individual POP classes at each sampling station.

	Birkenes	Andøya	Zeppelin
OCPs	24 h	72 h	48 h
PCBs	24 h	72 h	48 h
PAHs	24 h	-	48 h
PBDEs	48 h	72 h	72 h
HBCDs	48h	-	72 h
PFAS	24 h	48 h	48 h
S/MCCPs	24 h	-	-

After sampling, the exposed filters (GFF and PUFs) were sealed separately in gas-tight containers and transported to NILU's laboratory for further processing and quantification. In addition, a number of field blank samples followed the yearly sample batch in order to control potential contamination risks (as a part of the extensive quality control procedure of the NILU monitoring program). All exposed filters were registered and stored frozen (–20ºC) prior to analysis and quantification. The GFF and PUFs were extracted in the same solvent to obatin the bulk concentration (gas+particle phase) of the individual target compounds (below). Exceptions were PFAS for which only GFFs were used during sampling and the obtained concentrations represent the particle phase concentrations.

Sampling of Cyclic volatile methyl siloxanes (cVMS)

Sampling of cVMS differed from the rest of the compounds. Sampling was done with a solid-phase extraction active air sampling (SPE-AAS) method with an ENV+ sorbent (hydroxylated polystyrene divinylbenzene copolymer) (Kierkegaard and McLachlan, 2010, Krogseth et al., 2013a) with a flow rate of 1.0 m^3 per hour. Sampling was done during one sampling campaign in early winter (21th Nov-10th Dec) 2014. The campaign contained seven individual sampling events. The average sampling time was 82.3 ± 15.8 h, and the average volume of air sampled was 87.3 ± 17 m^3.

Analysis and quantification of OCPs, PCBs and S/MCCPs

Samples were spiked with 20 µL of internal standards (IS) containing 13C-labelled PCB congeners (~230 pg/µL), 20 µL IS containing 13C-labelled OCP congeners (~100-2500 pg/µL), 50 µL IS containing ^{13}C-labelled hexachlorodecane (~1000 pg/µL) for SCCP and 20 µL IS containing ^{13}C-labelled trans-CD (~500 pg/µL) for MCCP, and then Soxhlet extracted for 8 h in in diethylether/*n*-hexan (10:90, v:v). The filters and the corresponding PUF plugs were extracted separately but in the same solvent in order to unify the sample. The extract was concentrated and cleaned by acid treatment and silica fractionation. Before quantitative analysis, 20 µL of unlabelled tetrachloronaphthalene (TCN, 100 pg/µL) was added as recovery standard (RS).

Identification and quantification of the PCBs and OCPs was carried out using a high-resolution gas chromatography coupled to a high-resolution mass spectrometer as detector (HRGC/HRMS). The analyses were performed in Electron Impact ionization mode (EI: PCBs, HCB, HCHs, DDTs) and Negative Ion Chemical Ionization mode (NICI: Chlordanes) using selected ion monitoring (SIM) for the respective compounds groups. In total, 32 PCB congeners and 13 organochlorine pesticides (OCPs) were quantified.

SCCPs and MCCPs were identified and quantified using a GC coupled to a VG AutoSpec, HRMS operating in ECNI mode (GC/HRMS-ECNI).

Analysis and quantification of PAHs

Samples were spiked with 20 µL of IS containing deuterated PAH congeners (10 ng/µL) and then Soxhlet extracted for 8 h in in cyclohexane. The filters the corresponding PUF plugs were extracted separately but in the same solvent in order to unify the sample. The extract was then concentrated and cleaned by silica fractionation. Before quantitative analysis, 20 µL RS containing deuterated PAH congeners (1.5 ng/µL) was added.

Identification and quantification of the PAHs was carried out using a high-resolution gas chromatography coupled to a low-resolution mass spectrometer as detector (GC/LRMS). The analyses were performed in EI mode using SIM. In total, 28 PAH and 7 methyl-PAH were quantified.

Analysis and quantification PBDEs, TBA, HBCDs

Samples were spiked with 20 µL of internal standards (IS) containing 13C-labelled PBDE congeners (~270-2500 pg/µL) and 20 µL IS containing 13C-labelled HBCD congeners (100 pg/µL), and then Soxhlet extracted for 8 h in in diethylether/*n*-hexan (10:90, v:v). The filters and the corresponding PUF plugs were extracted separately but in the same solvent in order to unify the sample. The extract was then concentrated and cleaned by acid treatment and silica fractionation. Before quantitative analysis, the extract was split in two; one for PBDE/TBA and one for HBCD analysis. The extract for PBDE/TBA was spiked with 20 µL of unlabelled TCN (100 pg/µL) as recovery standard, and the extract for HBCD analysis was spiked with 20 µL RS containing deuterated ß-HBCD (130 pg/µL).

Identification and quantification of the PBDEs and TBA was carried out using a HRGC/HRMS operating in EI mode using SIM for the respective compounds groups. In total, 17 PBDE congeners plus TBA were quantified.

For identification and quantification of HBCDs, an aliquot of the final sample extract was solvent exchanged into methanol. The extract was then analysed using high performance liquid chromatography system in combination with a time-of-flight high resolution mass spectrometer as detector (HPLC/MS-TOF). The analyses were performed with Electrospray ionisation (ESI) in negative ion mode using full scan mass detection. In total 3 HBCDs were quantified.

Analysis and quantificition PFAS

The filters were spiked with 20 µL of internal standards (IS) containing 13C-labelled PFAS congeners (0.5 ng/µL) and then extracted using sonication bath for 3x10 min in methanol. The extract was then concentrated and cleaned by acid treatment. Before quantitative analysis, 10 µL of unlabeled 3,7-dimethyl PFOA (0.1 ng/µL) was added as recovery standard. Identification and quantification of the PFAS was carried out using HPLC/MS-TOF with ESI in negative ion mode using full scan mass detection. In total, 13 PFAS were quantified.

Sampling and analysis of POPs in precipitation

Precipitation samples were collected at Birkenes using bulk samplers. This sampler consists of a glass cylinder (60 mm height, 285 mm inner diameter), a glass funnel and a Pyrex glass bottle (1-2 L). The sampler is installed on a supporting system about 2 m above the ground level. Samples are collected on a weekly basis starting on Mondays, resulting in samples composed of one or more bottles depending on the amount of rain. The samplers are continuously open, both during dry and wet periods. It may result in non-wanted dry deposition in some samples.

Analysis and quantification of POPs in precipitation

The precipitation samples were spiked with 20 µL of IS containing 13C-labelled PCB/HCB/HCH/PAH congeners (0.1 ng/ µL) and then liquid extracted in cyclohexane for 4 h. After separation and removal of the water phase the solvent extract is split for further cleanup for PAHs and PCB/HCB/HCH separately. The PAH extract is cleaned by silica fractionation and the PCB/HCB/HCH extract is cleaned by acid treatment and silica fractionation.

Identification and quantification of the PCBs, HCB and HCHs was carried out using a HRGC/HRMS. The analyses were performed in EI mode for PCBs and HCB, and in NICI mode for HCHs. In total, 7 PCB congeners, HCB and 2 HCHs were quantified.

Identification and quantification of the PAHs was carried out using a GC/LRMS. The analyses were performed in EI mode using SIM. In total, 28 PAH and 7 methyl-PAH were quantified.

Quality assurance/Quality control (QA/QC)

All sampling equipment undergo routine controls and calibration of flow rates.
Field blank samples (n=3) and lab blank samples (n=12) were routinely included in order to control unintended contamination during storage, transport and analytical steps. Field blanks, consisting of pre-cleaned PUF plugs and filters, were sent to each station where they were exposed during the assembly and retrieval of the PUF plugs and filters in field, but kept unexposed in foil and air tight bags during the exposure time. They were then transported, stored, extracted, cleaned and analysed in the same way as and parallel with the real samples. The lab blanks (solvent blanks) were obtained by extracting solvent and using the same clean-up and analytical procedures as real samples and field blanks. The

The analytical procedure was accompanied by a comprehensive quality control program based on the requirements of NILU's accreditation, according to EU standard EN 45001. The instrument limit of detection (LOD) was determined by calculating the signal-to-noise ratio (S/N) > 3 for solvent blanks (using n-hexane). Based upon average blank concentrations (for both laboratory and field blanks) the limit of quantification (LOQ) was calculated for all compounds with LOQ = average blank value plus 3 standard deviations (STD) of the blank concentrations.

All samples within the range LOQ>×>LOD are considered to have high uncertainties and reported <LOQ (Table S8). All raw data are openly accessible from the NILU database (http://ebas.nilu.no) for thorough examinations. All values below LOD were excluded from further statistical treatment (treated as not detected (<LOD))

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

Our principal functions include monitoring the state of the environment, conveying environment-related information, exercising authority, overseeing and guiding regional and municipal authorities, cooperating with relevant industry authorities, acting as an expert advisor, and assisting in international environmental efforts.