PERSISTENT ORGANIC POLLUTANTS IN SNOW AND MELTWATER FROM BJØRNØYA (BEAR ISLAND)

Ellen Katrin Enge[1], Guttorm Christensen[3], Roland Kallenborn[2], Dorte Herzke[2], Martin Schlabach[1] and Trond Skotvold[3]

[1]Norwegian Institute for Air Research, P.O. Box 100, NO-2027 Kjeller, Norway, e-mail: Ellen.Katrin.Enge@nilu.no
[2] Norwegian Institute for Air Research, The Polar Environmental Centre, NO-9296 Tromsø, Norway
[3] Akvaplan-niva, The Polar Environmental Centre, NO-9296 Tromsø, Norway

Introduction

Today, it is well known that snow and ice play an important role in the hydrological cycle of the Arctic. The presence of snow and ice strongly influence the behaviour of Persistent Organic Pollutants (POPs) in the environment by modifying chemical cycling between the atmosphere and the Earth's surface. However, until today only few studies have been performed investigating the role of snow as deposition medium for persistent contaminants in Northern Environments. A first study on PCB contamination of surface snow in the pristine valley of Dividalen (Troms county, North Norway) revealed considerable concentrations of polychlorinated biphenyls (PCB) in snow and melt water samples[1]. In 1998, Skotvold *et.al*[2] presented results from a sampling campaign in 1994 describing high contamination levels of persistent organic pollutants (POPs) in the freshwater fish arctic char (*Salvelinus alpinus*) and in sediment from Lake Ellasjøen (Bjørnøya). Based on these findings, a national research endeavour was started to gain scientific insight into the contamination status and distribution processes for POPs on Bjørnøya, specifically in the Lake Ellasjøen region. The still ongoing project is co-ordinated by Akvaplan-niva and jointly founded by the Norwegian Research Council and the State Pollution Control Authorities of Norway (SFT). Snow and meltwater samples were collected in 1999/2000 in order to assess transport and deposition pathways of POPs within the Bjørnøya ecosystem. In the presented study, an assessment will be discussed about the role of snow as carrier, deposition and storage medium for POPs at Bjørnøya.

Material and Methods

Selected PCBs and chlorinated pesticides were analysed in snow and meltwater samples from Bjørnøya. Samples were collected both close to the meteorological station and Lake Ellasjøen (Figure 1).

During a first, preliminary, sampling campaign 1999/2000 within a three-year national research project on Bjørnøya, two meltwater samples and one deposition snow sample were collected for POP analyses at the meteorological station. At Lake Ellasjøen, two meltwater and three snow deposition samples were quantified (Table 2). The quantification method for PCB and chlorinated pesticides is described in an earlier publication[1].

Table 1: persistent chlorinated contaminants selected for analysis in ambient air and fog water.

Sample type	Polychlorinated biphenyls (PCB)	Chlorinated pesticides
Snow and meltwater	PCB 28/31, 52, 99, 101, 105, 118, 128, 138/163, 149, 153, 156, 169, 170, 180, 183, 187, 194.	α-HCH, γ-HCH, HCB

Meltwater was sampled at the meteorological station and Lake Ellasjøen using a 1 m^2 meltwater collector (Figure 2A). The snow on the surface was collected over a long period of time (1-2 month) and allowed to melt under natural conditions. The meltwater was collected in a 50-litre stainless steel container. Thus, the meltwater samples represent an integrated sample over a long period of time. Remobilization and evaporation processes influence the POP pattern of the meltwater sample.

The snow deposition samples were collected in a 0.4 m^2 snow deposition collector (Figure 2B). Fresh fallen snow was directly collected in a 0.4 m^2 funnel and transferred into a 50-litre stainless steel container. After the container was filled such a snow deposition sample represents one/few deposition events. The POP pattern in the sample will reflect the contaminant distribution in fresh fallen snow. Thus, no evaporation from the snow surface and remobilization processes will influence the POP pattern of the sample. After storage at the Meteorological station at Bjørnøya, the gas tight stainless steel containers were shipped to the laboratory of the Norwegian Institute for Air Research (NILU) for subsequent extraction, clean-up and quantification.

For gas chromatographic separation, a 30m DB5MS capillary column was used (id: 025 mm, film thickness: 0.25µm, J&W, Folsom, CA, USA). The main column was connected to a deactivated guard column (J&W). The following temperature program was applied for the GC/MS analysis: Initial temperature 70°C (2 min isotherm), heating rate 15°C/min to 180°C, heating rate 5°C /min to final temperature 280°C (10 min isotherm).

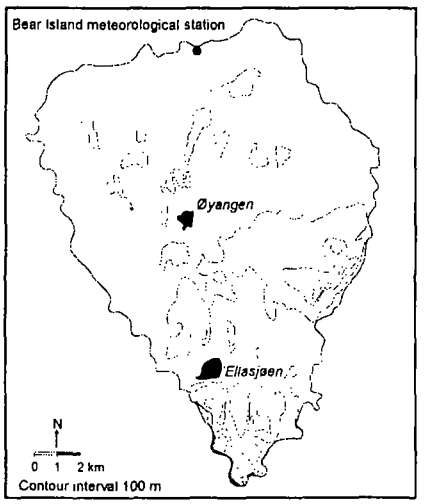

Figure 1 Bjørnøya (Bear Island, 74°N, 19°E) and the sampling sites Lake Ellasjøen and the meteorological station

Helium (He, 5.0 quality, Hydrogas, Porsgrunn, Norway) was used as carrier gas at a flow rate of 1 mL/min. A final volume of 2 µl of the sample extract was injected on-column into the gas chromatograph for separation. Mass spectrometric detection was used for the quantification (MD800, Finnigan, San Jose, CA). The low-resolution mass spectrometric measurements were performed in electron impact mode (LRMS-EI). The samples were quantified in Single Ion Monitoring (SIM). All compounds were quantified using ^{13}C labelled certified PCB internal standards added prior to extraction[1]. The concentration data are presented in Table 2.

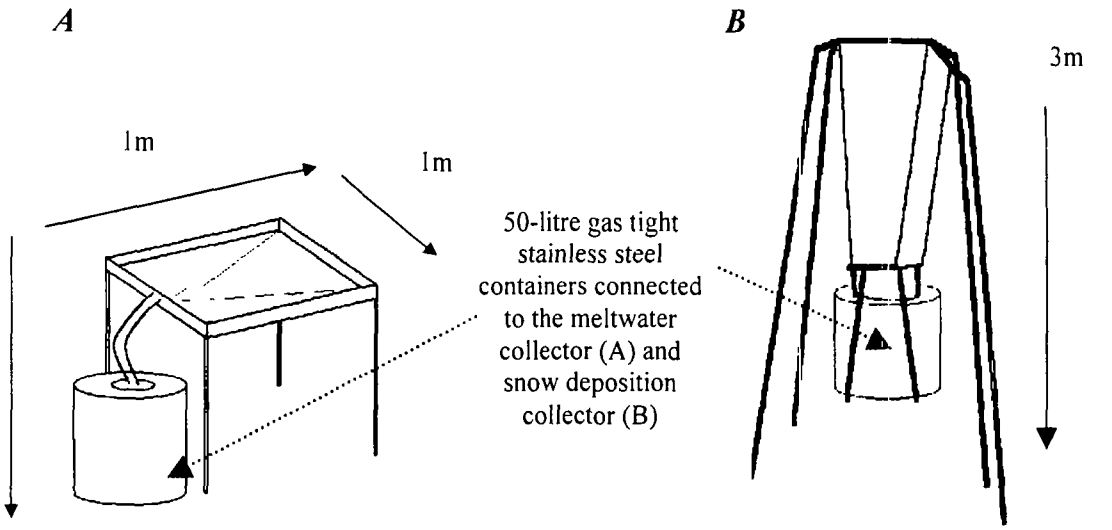

Figure 2: Snow deposition - and meltwater collectors used for sampling of snow and melt water at Bjørnøya.

Results and Discussions

In all deposition snow samples, PCB levels are dominating. HCHs are the main contributors for the chlorinated pesticides whereas HCB is a minor contaminant in snow and meltwater from Bjørnøya. In two meltwater samples (MW2 and MW 4), HCH is the dominating compound class (Table 2). Due to relatively high volatility, HCB probably re-evaporate into atmosphere. Therefore, HCB dominates in Bjørnøya ambient air samples[3]. However only minor contamination was detected in meltwater and deposition snow. The highest PCB concentrations were found for snow deposition, collected close to the meteorological station at the North coast of the island (Figure 1). The DS1 sample contained 7.2 ng/l PCB. The highest HCH content was determined in a meltwater sample collected close to the Bjørnøya meteorological station (MW 2 = 1.8 ng/l). These findings already indicate the characteristic differences found for the distribution of HCHs and PCBs in snow deposition and melt water. In all snow deposition samples, only minor contribution of the HCHs was determined. However, the contribution of HCH to the overall contamination is significantly higher in meltwater samples, in two cases even exceeding the PCB levels considerably (Figure 2). This may partly be caused be re-evaporation of low chlorinated PCBs into the atmosphere and the parallel continuous uptake of water soluble α- and γ-HCH from the atmosphere. However, the number of the samples analysed is to small to draw final conclusions about this hypothesis on snow surface/ atmosphere exchange processes. In addition, during the summer season, both rain and snow deposition is collected and therefore, a clear correlation between meltwater properties and POP contamination is not possible.

Table 2: Persistent organic pollutant levels in snow deposition and meltwater samples from Bjørnøya [pg/l]. SUM PCB = 17 polychlorinated biphenyl congeners, SUM HCH = α and γ-hexachlorocyclohexane, HCB = hexachlorobenzene, MW = Meltwater, DS = deposition snow, I = interference in the chromatogram, n.a. = not analysed.

Meteorological station					Lake Ellasjøen				
ampl. period	Sample type	SUM PCB	SUM HCH	HCB	Sampl. period	Sample type	SUM PCB	SUM HCH	HCB
lay 00	DS 1	7219	78	2	Summer 99	DS 2	2737	n.a.	n.a.
ul-Sept.* 00	MW 1	1178	491	I	Summer 99	DS 3	2485	n.a.	n.a.
ept-Nov. 00	MW 2	845	1799	I	Summer 00	DS 4	3200	32	I
					July 99	MW 3	2438	n.a.	n.a.
					Juni-Sept 00	MW 4*	391	921	I

*) During the summer period of the year, a substantial amount of rain deposition was collected in addition to snow.

The same method was used for meltwater samples collected at the Dividalen valley and at Bjørnøya. The concentration levels in Bjørnøya meltwater were comparable with the samples from the Norwegian mainland. For the two meltwater samples from Dividalen valley sum PCB concentrations of 3.6 ng/l and 1.5 ng/l were determined.

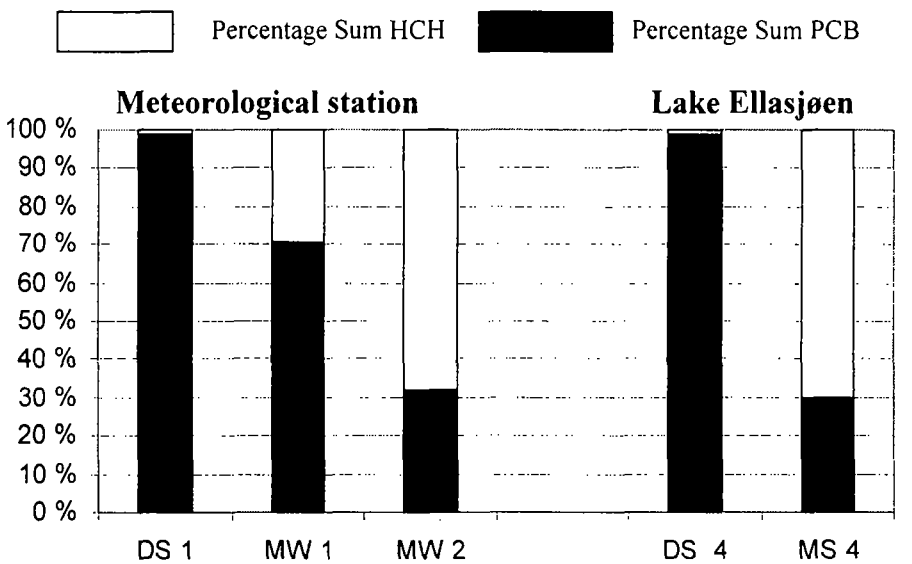

Figure 3. Percentage distribution of sum HCH and sum PCB in snow and meltwater samples from Bjørnøya (Bear Island). SUM HCH+PCB = 100 %. Abbreviations, see Table 2.

The two meltwater samples taken at the Bjørnøya meteorological station, were slightly lower contaminated as the Lake Ellasjøen and the Dividalen valley samples. No distinct difference in the PCB levels between the Bjørnøya samples and the meltwater taken at the Norwegian mainland were found. This is a rather surprising result, since no local PCB source is known for the Bjørnøya region, whereas, several sources closer to the Dividalen valley sampling site are known. However, to what extent biological sources like Sea bird guano[4] influence the PCB levels, patterns and

distribution of other persistent organic pollutants in snow (deposition and surface) remains to be found and will be subject for further studies within the ongoing Norwegian research initiative. Indications for pattern differences in meltwater and deposition snow were found and will be further investigation during the sampling season 2001. Isomer and congener specific pattern and level distributions will be discussed in the final presentation.

Acknowledgement
We thank Gro Hammerseth and Sissel Planting (NILU) for the support during analysis and quantification of the samples. Ivan C. Burkow (NILU) and Dennis Gregor (Akvaplan-niva) are thanked for the administrative support during the sampling campaign as well as for helpful discussions. The here presented study is a part of a project jointly funded by the Norwegian Research Council 135632/720 and the State Pollution Control Authority of Norway (SFT).

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