

Heavy metals in water, ice and biological material from Spitsbergen, Svalbard

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Concentrations of heavy metals Zn, Mn, Cu, Fe, Ni, Cr, Pb, Cd, Hg and Co were determined in surface waters, glacier ice and plant and animal materials from three regions in Spitsbergen, Svalbard. The concentrations of these metals in two samples of surface waters and in the vascular plants from Spitsbergen were found to be lower than what is commonly found in Central Europe. Elevated concentrations were found in old ice from the surface of a glacier. The concentrations of heavy metals in algae were lower than in vascular plants. The concentrations of metals in the samples of feathers and animal hair from Spitsbergen were higher than what is common for Central Europe.

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Introduction

The concentrations of heavy metals in the glacier ice, plants and animals of Svalbard have been studied since the 1960s (Jaworowski 1967; Fjerdningstad et al. 1978; Jaworowski et al. 1981; Jóźwik 1988; Jaworowski 1989; Grodzińska & Godzik 1991). During the Czechoslovak botanical expedition to Svalbard in July and August 1988, samples of surface water, glacier ice, plants, reindeer hair and gull feathers were collected for the determination of Zn, Mn, Cu, Fe, Ni, Cr, Pb, Cd, Hg and Co. The sampling was carried out in three areas of Spitsbergen: (a) near Linnévatnet and Kongressvatnet on the western coast south of Isfjorden, (b) in Petuniabukta in the central part of Spitsbergen, and (c) near the thermal springs Jotunkjeldane and Trollkjeldane in Bockfjorden Bay in the northern part of Spitsbergen (Fig. 1).

Methods

Two 2-liter samples, one from Linnévatnet, taken from the surface layer in the middle of the lake, and the second from a cold-water spring in Petuniabukta, were collected in polyethylene bottles which had previously been rinsed with water, nitric acid (about 0.5M), distilled water and deionised water. Immediately after collection, 5 ml of 65% nitric acid p.a. per liter was added to the samples. At the expedition base the samples were concentrated 40-times by evaporation in boiling flasks (type Simax, Czechoslovakia) on a gas cooker. The concentrated samples were transported to Czechoslovakia in 100 ml polyethylene bottles.

Ten blocks of old surface ice (each of about 1000 cm³ volume) were collected from an area of about 1 km², near the snout

of the glacier, Adolffreen. The blocks were placed in rinsed polyethylene bags. After thawing, the meltwater was poured into 2-liter polyethylene bottles and processed in the same manner as the surface water samples, and then pooled into one sample.

Samples of filamentous algae were collected along a 20 m section of a stream. The clusters of algae were pooled into one sample. The lichens, mosses, vascular plants, and reindeer hair and gull feathers from dead animals were collected on the coastal terraces. The plant samples (Fig. 1, samples 4 and 8) were taken from 10 locations, each covering an area of about 1 km². Each type of material from one location was air-dried and pooled into one sample before the chemical analysis.

After drying in a platinum crucible to constant weight, 6 to 7 g plant samples were carbonised by careful heating over a gas burner and then ashed in an electric furnace at 420°C, dissolved in nitric acid (1:3) and filtered. The insoluble fraction, collected on the filters, was ashed in a platinum crucible at a temperature not surpassing 450°C. The remaining solids were digested with a mixture of hydrofluoric and perchloric acid and diluted with nitric acid (1:3). The combined liquid fractions were made up to 100 ml with deionised water. Samples of feathers and hair (Fig. 1, samples 9–11) were processed in the same manner as the plant material, except that hydrofluoric and perchloric acid were not used for the digestion.

In the mineralised samples the concentration of metals was determined by atomic absorption spectrophotometry with the AAS 3 (Zeiss Jena) analyser. The content of mercury was determined in the original air-dried samples, using the seal close analyser, TMA 254 (Institute of Chemical Technology, Prague, Czechoslovakia), enabling the determination of whole mercury content without losses. The quality control was compared with the "Certified reference material BCR No. 60" and reference material "P- ALFALFA" from the Institute of Radiology and Applied Nuclear Techniques, Košice (Czechoslovakia).

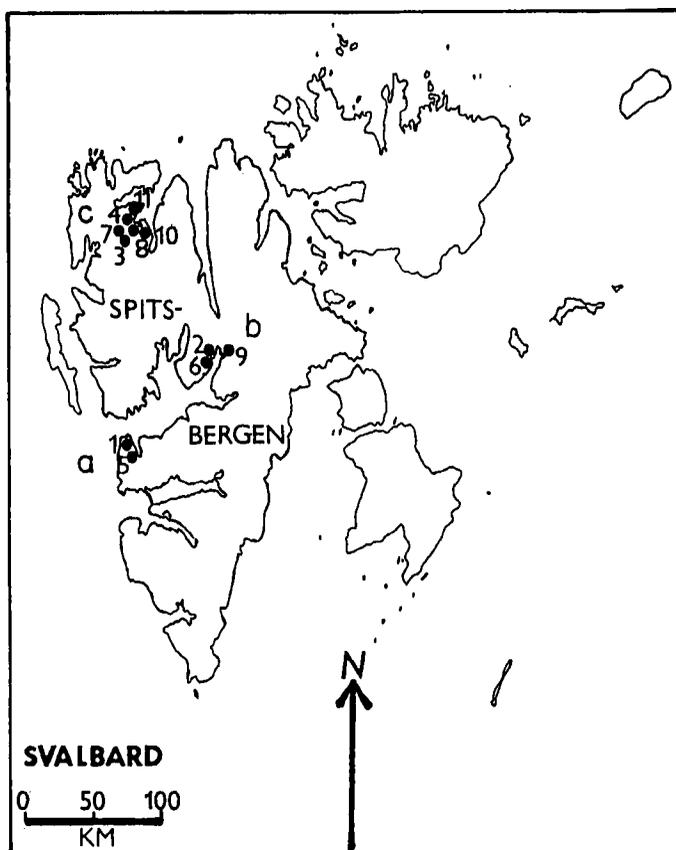


Fig. 1. Location of the sampling sites.

1. Linnévatnet – lake water.
2. Petuniabukta – spring water from the coastal terrace.
3. Adolfbreen – melted glacier ice.
4. Jotunkjeldane – filamentous algae (*Conjugatophyceae* – *Zygnema* sp.) from a thermal spring.
5. Kongressvatnet – lichen (*Cetraria nivalis*) from the surface of stones.
6. Petuniabukta – moss (*Tamethyphnum nitens*) from the coastal terrace.
7. Bockfjorden – moss (*Rhacomitrium lanuginosum*) from the coastal terrace.
8. Bockfjorden – vascular plant (*Cassiope tetragona*) from the coastal terrace.
9. Adolfbukta – feathers of dead birds (*Larus argentatus*).
10. Bockfjorden – feathers of dead birds (*Larus argentatus*).
11. Sjøøvernbukta – hair of dead reindeer (*Rangifer tarandus* ssp. *platyrhynchus*).

Results and discussion

The concentrations of heavy metals found in water samples from Linnévatnet and from the secondary spring situated on an elevated coastal terrace in Petuniabukta were considerably lower than the levels commonly found in the surface waters of

Central Europe (Förster & Müller 1974; Drbal & Bastl 1984; Drbal 1991).

The old ice from the surface of the Adolfbreen glacier (Bockfjorden) was rich in heavy metals. Similar values have been reported, for example, by Förster & Müller (1974) and Pasternak & Antoniewicz (1970) for heavy metal concentrations

Table 1. The concentrations of heavy metals in water ($\mu\text{g}/\text{kg}$) and biological samples ($\mu\text{g}/\text{g}$).

Locality no. and type of sample	Zn	Mn	Cu	Fe	Ni	Cr	Pb	Cd	Hg	Co
1. Lake water	0.30	0.50	1.00	6.60	1.50	1.25	0.775	0.50	—	1.50
2. Spring water	0.50	11.75	1.00	457.50	1.50	1.25	1.25	0.50	—	1.50
3. Glacier ice	43.75	42.75	11.25	2552.50	7.25	19.25	16.75	4.50	—	1.50
4. Algae	11.50	10.10	5.50	255.00	3.25	1.10	0.53	0.16	0.06	<1.30
5. Lichen	13.40	14.90	1.40	237.00	1.60	0.89	4.98	0.10	0.113	<0.50
6. Moss	31.80	89.50	—	2654.00	6.40	5.40	—	—	0.195	1.60
7. Moss	11.50	24.10	3.10	1205.00	2.40	1.44	7.25	0.21	0.167	0.79
8. Vascular plant	33.50	106.80	10.70	1556.00	4.10	1.86	1.56	0.19	0.143	1.34
9. Feather	91.30	53.20	10.40	6197.00	9.90	3.18	—	—	0.925	3.00
10. Feather	168.30	34.10	13.20	601.00	1.90	1.89	9.30	0.57	0.301	0.46
11. Hair	55.20	12.10	9.60	641.00	4.76	1.03	1.98	0.24	0.302	1.98

in surface waters of Central Europe. However, the surface of old ice near the glacier fronts is more exposed to a much longer fallout of atmospheric dust than the old ice from deep unexposed layers (Jaworowski 1989). Sublimation and outflow of meltwater may also change the concentration of heavy metals in old surface ice. Results from surface glacier ice are therefore difficult to interpret. Nevertheless, the concentration of cadmium in our sample of glacier ice is within the range of values found by Jaworowski et al. (1981) in contemporary firn strata from Svalbard and higher than average in 700 year-old ice. The concentration of lead found in our samples was somewhat higher than the level reported by the above authors, but it is similar to values found by Fjeringstad et al. (1978) in red snow on Svalbard.

The concentrations of heavy metals found in vascular plants on Svalbard were somewhat lower than concentrations found in aquatic macrophytes in Central Europe, e.g. in Czechoslovakia (Bican et al. 1982) and in Hungary (Bosserman 1985). However, the seasonal changes may influence the heavy metal concentrations in plants (Ozimek 1985), and analyses from more localities are necessary for a reliable geographical comparison (Grodzińska & Godzik 1991).

Lower plants, especially algae, are able to accumulate heavy metals to higher levels than vascular aquatic plants. Nevertheless, we have found lower metal concentrations in algae than in vascular plants; this result could be dependent on the low concentrations of heavy metals in the surface waters of Svalbard. Atmospheric depositions may also contribute to the accumulation of heavy metals in vascular plants. Elevated concentrations of copper and zinc in *Cassiope tetragona*, as compared with mosses and lichens, were also reported by Ottar et al. (1986). Low concentrations of heavy metals were found in the lichen *Cetraria nivalis*; the values are in accordance with those given by Józwick (1988). Similar low concentrations of lead in lichens *Cladonia mitis* from Hornsund ranging 1.45 to 4.34 µg/g were found by Jaworowski (1967).

The concentrations of heavy metals found in the feathers and hair of dead animals were generally higher than the corresponding values recorded in Czechoslovakia (Hanák & Drbal 1987). The concentration of lead in the hair of reindeer (Table 1) was lower than in the hair of the European bison (3.5 µg/g) (Jaworowski 1967). This important problem needs further special investigation.

Conclusions

Our data from a small set of samples do not yield any information about the time and space variation of the concentration of heavy metals in Svalbard. The Arctic environment is influenced by chemical elements of both anthropogenic and natural origin, from remote as well as local sources (Jaworowski 1989). Spitsbergen seems to be affected by airborne pollutant originating in western and eastern Europe and to a lesser extent in North America (Rahn & Show 1982; Rahn 1984; Maenhaut et al. 1989), but the contribution from local sources of heavy metals must be elucidated.

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