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Environmental monitoring at the Nalunaq Gold Mine, South Greenland 2004

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Data sheet

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Abstract:	Monitoring was performed in the Nalunaq Gold Mine area, Nanortalik municipality, South Greenland during 20-26 August 2004. This was eight months after the first shipment of ore. Samples were collected at four marine stations in the Kirkespir Bay, Arctic char were sampled in the Kirkespir River, and lichens were collected at 20 stations in the Kirkespir Valley. Samples were analysed for 10 elements with an ICP-MS. Concentrations of Zn, Cu, Cr, As and Co were elevated 3-9 times compared to background concentrations found prior to mine start. The increased level of contamination in the local area is moderate compared to contaminations found around closed mines in Greenland, i.e. Maarmorilik, Ivittuut and Mestersvig.
Keywords:	Monitoring, Elements, Blue mussel, Brown seaweed, Shorthorn sculpin, Arctic char, *Cetraria nivalis*, Nalunaq Gold Mine, Greenland
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Contents

Preface

This is the first monitoring report since the Nalunaq Gold Mine officially started mining in August 2004. Late 2003 the mining company prepared for mining and shipment of already mined ore, and by the turn of the year the first load of gold ore was shipped for processing in Spain. The monitoring study was performed according to the exploitation licence of 19 March 2004, Phase 2, §§ 10-19, chapter 5. The exploitation licence was issued by the Bureau of Minerals and Petroleum (BMP), the Greenland Home Rule.

The monitoring program is in short that mussels, seaweed and sculpins are sampled at four marine stations in the Kirkespir Bay, Arctic char is sampled in the Kirkespir River and lichens are collected at 18 stations around the different mining activities. Samples are analysed for eight elements and the results are compared with baseline concentrations. NERI performed environmental baseline studies in the Nalunaq area during 1998-2001, and Nalunaq I/S financed these studies.

We wish to thank Nalunaq Gold Mine A/S and Tanja Nielsen, environmental co-ordinator of the company, for help with sampling, preparation of samples, accommodation etc.

Summary

Monitoring period

The monitoring study was performed in the Nalunaq gold mining area, Nanortalik municipality, South Greenland, during 20-26 August 2004. Sampling took place shortly after the second shipment of ore, and about eight months after the first shipment. Monitoring was performed according to the exploitation licence of 19 March 2004 issued by the Bureau of Minerals and Petrolum (BMP), the Greenland Home Rule.

Sampling program and analyses

Blue mussels, Brown seaweed and Shorthorn sculpin were sampled at four marine stations in the Kirkespir Bay, resident Arctic char were sampled in the Kirkespir River and lichens *Cetraria nivalis* were collected at 20 stations in the Kirkespir Bay and Valley area (Fig. 1). Samples were analysed for 10 elements (Hg, Cd, Pb, Zn, Cu, Cr, Ni, As, Se and Co) and the results were compared with baseline levels.

Elevated concentrations of Zn, Cu, Cr, As and Co

Zn, Cu, Cr, As and Co shoved on average higher concentrations than baseline concentrations. Except for Cr, elevated concentrations of the above elements could be expected from analyses of drainage from ore and waste rock performed prior to mining activities.

Marine environment impacted from the mine area

In the Kirkespir Bay, mussels and seaweed from stations closer to the Kirkespir River outflow had slightly higher concentrations of some elements compared to the organisms from stations closer to the pier. This indicates that elevated concentrations in the marine organisms stem from the mining area, whereas the pier area seems not to contribute to measurable contamination of the marine environment.

Freshwater environment

Resident Arctic char had higher concentrations of Cr and Co in their liver compared to background concentrations.

Terrestrial environment impacted from camp and pier area

In the Kirkespir Valley and Bay area higher concentrations of mainly Cu, Cr, As and Co were found in lichens near the pier, the camp and an area near the waterfall. Elevated concentrations in the pier and the camp area are likely to be a result of dispersed dust from ore stockpiles. Elevated concentrations in the waterfall area could be an effect of wind-borne dust from the stockpiles in the camp area.

Moderate local pollution

The present study found higher concentrations of some elements in some organisms when compared to the baseline level. Elevations were found within 5-10 km of coastline near the mouth of the Kirkespir River. This is considered a moderate impact, since only a small area is affected and increases in element concentrations are small. The impact at Nalunaq is much less than at the closed mines at Maarmorilik, Ivittuut and Mestersvig. At these three sites lead is elevated 100-1000 times and 40-100 km of coastline is affected. Because monitoring at Nalunaq is performed annually the contamination can be followed and mitigating steps can be taken, if necessary.

Possible actions

Prevention of dust from the two stockpile areas should be discussed with the mining company.

Resumé

Moniteringsperiode

Moniteringen blev udført i Nalunaq området, Nanortalik kommune i Sydgrønland, i perioden 20.-26. august 2004. Den fandt således sted kort tid efter den anden malm-udskibning, der blev afsluttet den 12. august 2004 og ca. otte måneder efter den første malmtransport. Moniteringen blev udført i henhold til udnyttelsesgodkendelsen af 19. marts 2004 fra Råstofforvaltningen, Grønlands Hjemmestyre.

Indsamlings- og analyseprogram

Blåmusling, blæretang og almindelig ulk blev indsamlet på fire marine stationer i Kirkespir Bugt, standformen af fjeldørred blev indsamlet i Kirkespir Elv og laven *Cetraria nivalis* blev samlet på 20 stationer i Kirkespir Bugt og Dal (Figur 1). Prøverne blev analyseret for 10 grundstoffer (Hg, Cd, Pb, Zn, Cu, Cr, Ni, As, Se og Co) og resultaterne sammenlignet med baggrundskoncentrationerne.

Forhøjede koncentrationer af Zn, Cu, Cr, As og Co

Der blev fundet 3-9 gange højere koncentrationer af Zn, Cu, Cr, As og Co i forhold til baggrundskoncentrationerne. Bortset fra Cr kunne der efter minestart forventes forhøjede niveauer af de ovenstående elementer ud fra analyser af drænvand fra malm og gråbjerg, udført før de egentlige mineaktiviteter.

Det marine miljø påvirkes primært fra mineområdet

Muslinger og tang indsamlet i Kirkespir Bugt på stationer relativt tæt på Kirkespirelvens udløb, havde lidt højere koncentrationer af nogle elementer i forhold til muslinger og tang fra området ved udskibningsmolen. De forhøjede niveauer i bugten synes derfor at stamme fra minen og ikke i nævneværdig grad fra udskibningsområdet.

Ferskvandsmiljøet

Stationære fjeldørreder havde 2-3 gange højere koncentrationer af Cr og Co i forhold til de målte baggrundsniveauer.

Det terrestriske miljø påvirkes af mine- og moleområderne

I Kirkespir Dal og Bugt blev der i mole -, mine - og vandfaldsområderne fundet 4-10 gange højere koncentrationer af Cu, Cr, As og Co i laver. De forhøjede koncentrationer i mole- og mineområderne kan sandsynligvis henføres til støvspredning fra de to malmlagre. De forhøjede koncentrationer i området omkring vandfaldet kunne skyldes støvspredning fra malmlagrene i lejrområdet.

Moderat lokal forurening

Der er i denne undersøgelse fundet 2-10 gange højere koncentrationer af nogle elementer i nogle organismer i forhold til baggrundsniveauerne. Forhøjelserne findes indenfor en 5-10 km lang kyststrækning ud for Kirkespirelvens munding. Forureningen betragtes som moderat da det kun er et lille område der er påvirket af lettere forhøjede elementkoncentrationer. Forureningen ved Nalunaq er betydelig mindre end ved de lukkede miner ved Maarmorilik, Ivittuut og Mestersvig. I disse tre områder er bly forhøjet 100-1000 gange og 40-100 km kyststrækning er påvirket. Da moniteringen ved Nalunaq udføres en gang om året kan forureningen følges og der kan eventuelt foretages afhjælpende foranstaltninger.

Mulig indgriben

Forebyggelse af støvspredning fra de to malmlagre bør diskuteres med mineselskabet.

Eqikkaaneq

Piffissaq nalunaarsuiffik

Nalunaarsuineq Nalunap eqqaani, Kujataani Nanortallip Kommuneaniittumi, piffissami 20.-26. august 2004-mi ingerlanneqarpoq. Taamaalilluni tamanna aatsitassartalimmik aappassaanik umiarsuarmut usilersuussinerit aappaata 12. august 2004-mi naammassineqartup kingornagut, aamma aatsitassartalimmik assartuinerup siulliup kingorna qaammatit arfineq pingasut miss. qaangiuttut ingerlanneqarpoq. Nalunaarsuineq Namminersornerullutik Oqartussani Aatsitassanut Ikummatissanullu Pisortaqarfimmit piiaanissamut akuersissut 19. marts 2004-meersoq naapertorlugu ingerlanneqarpoq.

Katersuineq misissueqqissaarnerlu

Uillut, equutit kanassullu Nalunap kangerliumarnani imaani sumiiffinni sisamani katersorneqarput, eqaluit nuttanngitsut Nalunap kuuani kiisalu orsuaasat *Cetraria nivalis* Nalunap kangerliumarnani sumiiffinni 20-ni katersorneqarlutik (Titartagaq 1). Misiligutissatut katersukkat tunngaviusumik sananeqaatinik grundstoffinik qulinik (Hg, Cd, Pb, Zn, Cu, Cr, Ni, As, Se aamma Co) akoqassusersiorneqarput, tamatumanilu paasisat eqitersimassutsinut tunuliaqutaasunut sanilliussorneqarlutik.

Zn, Cu, Cr, As aamma Co-mik akoqarnerulersimapput

Eqitersimassutsinut tunuliaqutaasunut sanilliullugit Zn, Cu, Cr, As aamma Co-mik 3-9-riaammik akoqarnerulersimasut paasineqarpoq. Akuusut qulaani taaneqartut Cr kisiat pinnagu aatsitassartalimmit ujaraannarmillu pisunik imaarsaarnernit misissuinerit, aatsitassarsiulivinnerup siornagut ingerlanneqartut aallaavigalugit aatsitassarsiorfiup aallartinnerata kingorna qaffariarsimanissaat naatsorsuutigineqarpoq.

Imaani avatangiisit aatsitassarsiornermit sunnerneqarnerupput

Uillut qeqqussallu Nalunap kangerliumarnani, Nalunap kuuata akuanut qanittumi katersorneqartut uillunit qeqqussanillu nunniukkap usilersuisarfiup eqqaani katersukkanit akoqarnerutiterput. Taamaammat kangerliumanermi akoqarnerulersimaneq aatsitassarsiorfimmit pisuunerusimasorinarpoq, usilersuisarfiup eqqaanit pivallaarani.

Imerme avatangiisit

Eqaluit nuttanngitsut eqimassutsinut tunuliaqutaasunut uuttortarneqarsimasunut sanilliullugit Cr-imik Co-millu marluk-pingasoriaammik akoqarnerulersimapput.

Nunap qaani avatangiisit aatsitassarsiorfimmit nunniukkamillu sunnerneqarput

Nalunap qooruani kangerliumarnanilu nunniukkap, aatsitassarsiorfiup qorlortullu eqqaanni orsuaasani Cu, Cr, As aamma Co 4-10-riaammik annerusoq akuusoq paasineqarpoq. Nunniukkap aatsitassarsiorfiullu eqqaanni akoqarnerulersimaneq aatsitassamik uninngasuusivinnit marluusunit pujoralaap siammarterneratigut pisimassagunarpoq. Qorlortup eqqaani taaneqartunik akoqarnerulersimaneq sulisut najugaqarfiata eqqaani aatsitassamik uningasuusivinnit pisimasinnaavoq.

Tamaani mingutsitsineq annikitsutut oqaatigisariaqarpoq

Misissuinermi tamatumani uumassusillit ilaanni eqitersimassutsinut tunuliaqutaasunut sanilliullugu akut ilaat 2-10-riaammik annerusut paasineqarpoq. Taamaattoqarnerulersimaneq Nalunap kuuata akuata nalaani sinerissami 5-10 km-inik isorartussusilimmi malugineqarpoq.

Mingutsitsineq annikitsuinnartut isigineqarpoq, tassa akoqarnerulaalerfiusoq isorartunngimmat. Nalunami mingutsitsineq Maarmorilimmi, Ivittuuni Mestersvigimilu aatsitassarsiorfikuni matoreersuni mingutsitsinermit annikinneralaarsuuvoq. Sumiiffinni taaneqartuni pingasuni aqerloq 100-1000-eriaammik alleriarsimavoq aamma sineriak 40-100 km-inik isorartussusilik sunnerneqarsimalluni. Nalunami nalunaarsuisarneq ukiumut ataasiarluni ingerlanneqartarmat mingutsitsineq malittarineqarsinnaavoq, immaqalu tamanna annikillisarniarlugu iliuuseqartoqarsinnaalluni.

Akuliussinnaaneq

Aatsitassamik uninngasuusivinnit pujoralaap siammarterneqarsinnaanerata pitsaaliornissaa pillugu aatsitassarsiortitseqatigiiffik oqaloqatigineqartariaqarpoq.

1 Introduction

Ore exploitation and shipment to date

The Nalunaq Gold Mine A/S opened officially on 26 August 2004. Prior to the mine start extensive exploration programs have been carried out since the find of gold bearing veins in 1992. In connection with the last part of the exploration, which included tunnel driving, c. 54,000 tonnes of ore were stockpiled in the area. Late December 2003, approximately 31,000 tonnes of ore were shipped from the Pier in the Nalunaq area (Fig. 1) to Spain for gold extraction. On 12 August 2004 c. 40,000 tonnes of ore were shipped to Spain, and the third shipment of c. 28,000 tonnes took place 22 November 2004 (CCN Matthews 2005).

Monitoring program in the BMP exploitation licence

Requirements for monitoring of the environment in relation to the mining activity is described in the BMP exploitation licence of 19 March 2004, Phase 2, §§ 10-19, chapter 5:

The objective of monitoring is to document environmental impacts associated with the activities. BMP finds that the environmental monitoring program described in the approval of the shipment of the stockpiled ore from the exploration phase (refer to BMP's approval of 2 May 2003), also should apply for the exploitation plan, Phase 2.

The sampling stations for Brown seaweed, Blue mussel, Shorthorn sculpin and Arctic char must be placed relatively close to, and on each side of the shipping plant (Fig. 1). Sampling stations for the lichen *Cetraria nivalis* must be placed both in connection with the above marine stations and around existing ore stockpiles at the Kirkespir Valley campsite and along the road. The following samples must be collected at the number of stations specified:

- Brown seaweed: 4 stations with 2 samples per station; a total of 8 samples.
- Blue mussel: 4 stations with 2 samples (2 different size groups) per station; a total of 8 samples.
- Liver from Shorthorn sculpin and Arctic char: 2-4 stations with a total of 20 specimens.
- Lichens *Cetraria nivalis*: 18 stations; a total of 18 samples.

The samples collected must be analysed for the following elements: arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), mercury (Hg), lead (Pb) and zinc (Zn).

BMP may demand changes to the scope and content of the environmental monitoring if it considers such monitoring inadequate based on the collected results and experience from performing the approved activities.

Samples must be collected on an annual basis during operations and closure and for a period of two years after closure. Samples must be analysed immediately after being collected. The analytical findings must be data processed, and a report prepared. This report must reach BMP no later than four months after the samples have been collected.

The samples must be collected and analysed in accordance with guidelines prepared by NERI.

Monitoring August 2004

The monitoring study was performed in the Nalunaq area during 20-26 August 2004. Monitoring took place immediately after the second shipment of ore finalised on 12 August 2004, and about eight months after the first shipment.

Sampling was carried out in accordance with the monitoring program described in the exploitation licence with the following divergences:

- Blue mussels were sampled at one more station, AMI1, on the north-east side of the Amitsoq island about 15 km from the Kirkespir Bay. The purpose was to collect mussels from an uncontaminated area and transplant these mussels to the harbour area where relatively few mussels were found earlier in 2004.
- Lichens were sampled at two more stations.
- The 20 fish liver analyses were separated in 16 Shorthorn sculpin livers from the four marine stations and 4 Arctic char livers from the Kirkespir River near the waterfall. The chars were of the resident form.

Analyses were done according to the program, however, 58 samples were analysed in stead of 54. Moreover, 10 elements including nickel (Ni) and selenium (Se) were analysed for.

A preliminary report was issued to BMP on 4 January 2005 (Glahder & Asmund 2005).

2 Methods

2.1 Collection of samples

Sampling in the Kirkespir Bay was performed with a small rubber dinghy with a 6 HK outboard motor. Sampling of Blue mussels at the north-eastern point of Amitsoq (AMI1) was performed using a speedboat with a more powerful motor. Sampling of mussels and seaweed took place each day at the only low tide with daylight.

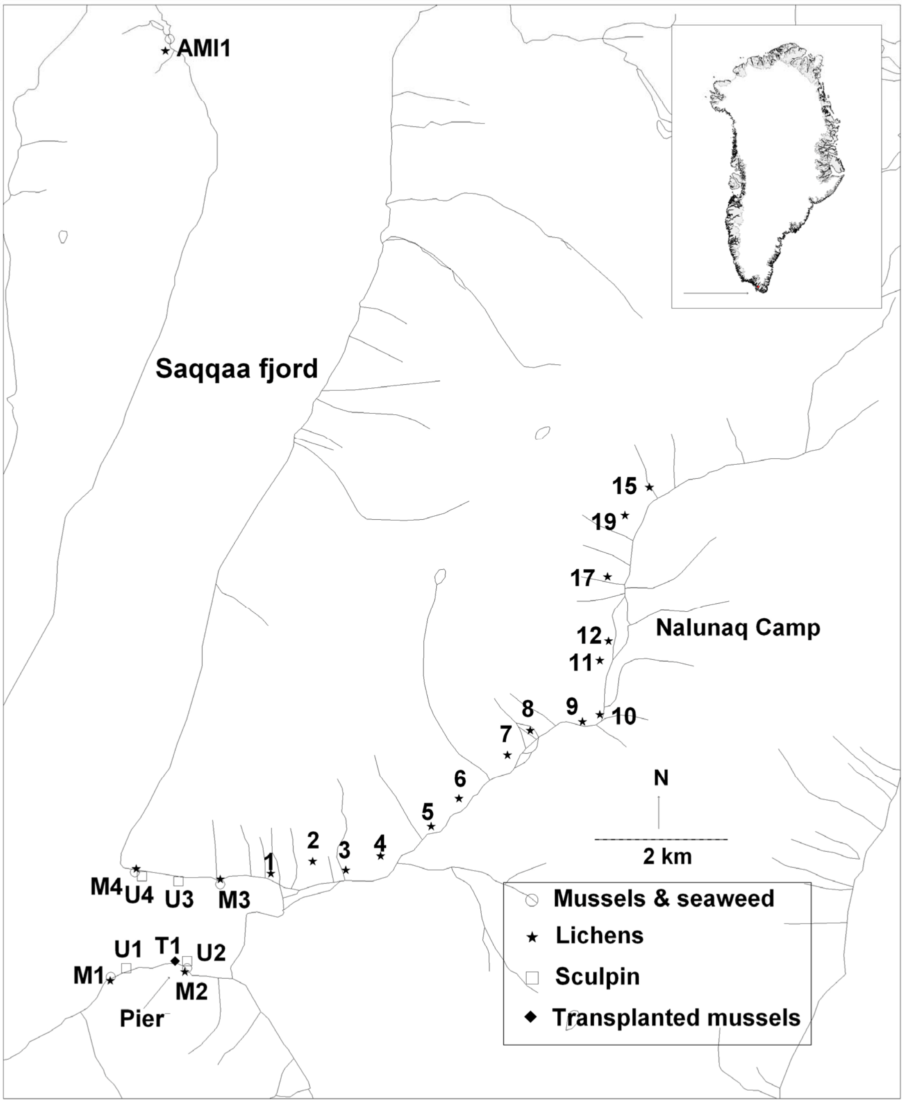

Figure 1. Sampling stations in the Nalunaq Gold Mine area, Nanortalik municipality, South Greenland
M: Marine stations (Blue mussel, Brown seaweed). U: Shorthorn sculpin stations. T1: Blue mussels transplanted 2004 on the pier, sampled at station AMI1 on NE Amitsoq island. Arctic char were sampled near the lichen station 9 close to the waterfall.

Co-ordinates

All co-ordinates are given in WGS 84.

Blue mussel

Two size groups of mussels were collected at each station with the following size groups represented: M1 (3-4 and 4-8 cm); M2 (3-4 and 4-7 cm); M3 (4-5 and 5-8 cm); M4 (4-5 and 5-8 cm). Average shell length was calculated for each size group at each station (see Appendix 2). All mussels in a sample were opened, the soft parts cut free and the resulting sample was frozen. In the north-western Amitsoq Island, Blue mussels for transplantation (size groups 4-5, 5-6 and 6-7 cm) were sampled. These mussels were placed in a net hanging from the barge in the harbour area, T1. Other mussels (size groups 5-6 and 6-7 cm) from the Amitsoq area, AMI1, were collected to analyse for the baseline level. Mussels were transplanted to secure that there were mussels available in the harbour area for monitoring.

Brown seaweed

The tips from this year were cut, washed in freshwater from upstream the camp and frozen. Stations were similar to the blue mussel stations M1-M4.

Shorthorn sculpin

Pound nets with a mesh width of 50.5 mm were set at two stations, U3 and U4. Probably due to too large mesh size (optimal size 25-35 mm) only few large sculpins were caught. Instead we jigged for sculpins at all four stations, U1-U4, and caught on average 10 fish per station, in total 37 specimens. Whole fish were frozen.

Arctic char

A total of 21 Arctic char were fished in the Kirkespir River near the waterfall. Of these, six were resident fish, while the remainder was migratory. All char were frozen as whole fish.

Lichens, Cetraria nivalis

Lichens were sampled at 20 stations: Ten from the Kirkespir Valley downstream the camp, three stations in the camp area, two upstream of the camp, four in the Kirkespir Bay area and one at Amitsoq. Station 15 is omitted in chapter 3, Results and evaluation, because it is probably not localised correctly; we suspect it to be situated much closer to the Nalunaq camp area. The lichens were transported to DMU on 27 August while the remainder samples were shipped frozen one week later.

2.2 Analyses

Species and elements

The analyses were performed according to the "Analyserapport nr. 34" (Asmund 2004). A total of 58 samples grouped in Blue mussel (10), Brown seaweed (8), livers of Shorthorn sculpin (16), livers of Arctic char (4) and lichen *Cetraria nivalis* (20) were analysed for the following 10 elements: Mercury (Hg), cadmium (Cd), lead (Pb), zinc (Zn), copper (Cu), chromium (Cr), nickel (Ni), arsenic (As), selenium (Se) and cobalt (Co).

Methods

Samples were opened in suprapur nitric acid under pressure in Teflon bombs in a microwave oven. The samples where then diluted to c. 25 grams and all elements were analysed in an ICP-MS (an accredited method according to DANAK No. 411). Simultaneously with the Nalunaq samples the reference materials Dorm-2 and Tort-2 were analysed. In Table 1 the analytical results are compared to the certificates. In general the ICP-MS analytical results are close to those of the certificates, but there is a tendency for some elements to have 10-20 % higher concentrations. This must be taken into account when evaluating the results.

Table 1. ICP-MS analytical results of reference material (Dorm-2 and Tort-2) compared to the certificates. Ten different elements are analysed. Concentrations are in mg/kg. Std. dev: Standard deviation.

	% dry matter	Hg	Cd	Pb	Zn	Cu	Cr	Ni	As	Se	Co
Dorm	95.11	3.80	0.063	0.084	27.5	3.16	46.75	23.49	17.12	1.39	0.238
Dorm	95.11	4.02	0.048	0.047	35.1	2.94	48.77	23.66	17.40	1.50	0.240
Dorm	95.11	3.69	0.048	0.045	35.9	2.93	46.20	23.05	16.89	1.38	0.230
Dorm	95.11	4.26	0.045	0.103		2.94	47.55	24.19	17.52	1.38	
mean		**3.94**	**0.051**	**0.070**	**32.8**	**2.99**	**47.32**	**23.60**	**17.23**	**1.41**	**0.236**
Std. dev.		0.25	0.008	0.028	4.6	0.11	1.12	0.47	0.28	0.06	0.005
Certificate		***4.64***	***0.043***	***0.065***	***25.6***	***2.34***	***34.70***	***19.40***	***18.00***	***1.40***	***0.182***
95%confidence		*0.26*	*0.008*	*0.007*	*2.3*	*0.16*	*5.50*	*3.10*	*1.10*	*0.09*	*0.031*
Tort	93.45	0.255	25.34	0.37	221.9	122.2	1.20	2.65	18.64	5.27	0.665
Tort	93.46	0.259	27.73	0.68	184.1	143.1	1.67	3.23	21.42	5.96	0.802
Tort	93.46	0.263	27.87	0.36	198.8	152.0	1.82	3.54	22.27	5.69	0.793
Tort	93.46	0.251	25.73	0.36	157.5	130.9	1.30	2.90	19.72	5.46	0.679
mean		**0.257**	**26.67**	**0.44**	**190.6**	**137.1**	**1.50**	**3.08**	**20.51**	**5.60**	**0.735**
Std. dev.		0.005	1.32	0.16	27.0	13.1	0.30	0.39	1.64	0.30	0.073
Certificate		***0.270***	***26.70***	***0.35***	***180.0***	***106.0***	***0.77***	***2.50***	***21.60***	***5.63***	***0.510***
95%confidence		*0.060*	*0.60*	*0.13*	*6.0*	*10.0*	*0.15*	*0.19*	*1.80*	*0.67*	*0.090*

3 Results and evaluation

Average concentration overview

The analytical results are given in Appendix 3. To present an overview of the results we first give the average concentrations of the 10 different elements in all five sample types, not taking stations into account. These average concentrations are compared to background concentrations found in the same area prior to the mine start (Table 2). We have grouped the average concentrations in three categories:

Not elevated <2 times background Normal fond

Slightly elevated 2-5 times background **Bold fond**

Elevated>5-10 times background ***Bold Italics fond***

Table 2. Elements in biota from the Nalunaq area
The table includes concentrations from samples collected at the monitoring study and from background studies. Figures are given in mg/kg dry weight (mussels, seaweed and *Cetraria nivalis*) and mg/kg wet weight (sculpins and chars). Std. dev: Standard deviation.

		Hg	Cd	Pb	Zn	Cu	Cr	Ni	As	Se	Co
Blue mussels Monitoring	average	0.0931	2.63	0.725	84.95	9.58	1.30	1.99	12.60	4.365	**0.562**
	std.dev	0.0219	1.22	0.263	19.92	1.82	0.41	0.52	2.60	0.679	0.133
Background	average	0.1310	5.49	1.195	87.82	7.58	0.73		11.80		0.239
	std.dev	0.0253	1.97	0.365	16.42	1.08	0.28		1.59		0.053
Brown seaweed Monitoring	average	0.0092	1.05	0.158	**21.07**	***7.30***	***0.89***	2.06	52.69	0.379	**0.713**
	std.dev	0.0028	0.23	0.091	6.29	3.29	0.75	0.80	8.85	0.184	0.369
Background	average	0.011	1.77	0.105	7.57	1.04	0.11		47.55		0.209
	std.dev	0.0077	0.51	0.039	2.38	0.24	0.12		8.47		0.045
Lichen *Cetraria nivalis* Monitoring	average	0.0280	0.074	1.116	13.42	**2.86**	**1.64**	1.59	**1.01**	0.082	**0.527**
	std.dev	0.0090	0.026	0.549	5.13	1.56	1.05	1.00	1.32	0.034	0.469
Background	average	0.0329	0.081	1.076	21.61	0.97	0.68		0.24		0.157
	std.dev	0.0056	0.029	0.378	7.28	0.77	1.22		0.27		0.157
Shorthorn sculpin liver Monitoring	average	0.0182	0.526	0.0050	21.85	2.30	**0.065**	0.053	2.58	0.632	0.038
	std.dev	0.0096	0.304	0.0030	6.13	2.80	0.026	0.035	1.34	0.129	0.040
Background	average	0.0276	1.041	0.0045	32.14	1.80	0.016		3.23		0.021
	std.dev	0.0127	0.404	0.0037	1.64	0.66	0.019		2.07		0.017
Arctic char liver Monitoring	average	0.033	0.107	0.0079	21.24	12.32	**0.063**	0.188	0.24	2.780	**0.114**
	std.dev	0.013	0.042	0.0051	5.87	9.29	0.013	0.087	0.11	1.497	0.043
Background	average	0.0245	0.077	0.0057	34.88	8.72	0.025		0.45		0.041
	std.dev	0.0094	0.026	0.0023	6.13	10.22	0.022		0.13		0.013

Statistical differences

Students t-test on the differences between monitoring and background averages shows that all the values marked with bold in Table 2 are significantly higher than the background on a 98% confidence level, except for Cr in seaweed where the confidence level is 95%.

Elevated average concentrations are found only for Cu and Cr in brown seaweed. All remainder concentrations are either slightly elevated (not significantly) or not elevated. Slightly elevated average concentrations are found for Zn in brown seaweed, Cu and As in lichens, Cr in lichens, sculpins and Arctic char and for Co in all sample types except in Shorthorn sculpin liver.

According to the Nalunaq I/S Environmental Baseline Study, 1998-1999, freshwater and sediment samples from the Kirkespir River and drainage from ore and waste rock dumps were analysed for metal concentrations prior to adit (tunnel) driving and mining. Freshwater samples were compared to Ontario water quality objectives for surface waters (Glahder & Asmund 2000, Lakefield Research Ltd 1998a,b, 1999a-d). Freshwater samples had slightly elevated natural concentrations of Co and aluminium (Al), and sediments had slightly elevated to elevated natural concentrations of As. Drainage from ore and waste rock had slightly elevated concentrations of As, Cd, Pb and Zn, and elevated concentrations of Al, Co, Cu and Hg.

If the element concentrations in drainage from ore and waste rock derived from the Nalunaq I/S Environmental Baseline Study are compared to the present monitoring study, slightly elevated concentrations of As and Zn, and elevated concentrations of Cu are found in both studies. Co is in the present study found only in slightly elevated concentrations. Elevated concentrations of Cr are found only in the present study.

In the Lakefield reports it was concluded that concentrations of As were high in ore (656 mg/kg) and waste rock (862 mg/kg), but that the majority does not dissolve in water.

Elevated concentrations in different environments

Following the above general overview a more thorough assessment is presented on element concentrations in the marine environment in Kirkespir Bay (Fig. 1), in the Kirkespir River and in the terrestrial environment of the Kirkespir Valley. Element concentrations at the different stations will be evaluated. Reference is made to Appendix 3.

The marine environment in Kirkespir Bay

Four mussel and seaweed stations and four sculpin stations are situated in the Kirkespir Bay (Fig. 1). Average concentrations in *Brown seaweed* were slightly elevated to elevated compared to baseline concentrations for Zn (3x), Cu (7x), Cr (9x) and Co (3x). In *sculpin livers* the average concentration of Cr was elevated 4 times. No average concentrations were elevated in *Blue mussel*.

At single marine stations concentrations in *Blue mussel* was slightly elevated (2-3x) for Cu, Cr and Co at station 3. In *Brown seaweed*, elevated concentrations of Pb (3x) and Cr (14x) were found at station 4, elevated concentrations of Co (6x) at station 3, and elevated concentrations of Zn (4x) and Cu (10x) at station 2. In *sculpin livers* elevated concentrations of Cu (2x) was found at station 4, Cr (5x) at station 3 and Co (3-4x) at station 1.

Source in the marine environment

If the marine organisms are impacted by elements transported from the mine area through the Kirkespir River, then the highest concentrations should be expected at station 3. If, on the other hand, the main impact comes from the pier area due to ore stockpiling and loading, then highest concentrations should be expected at station 2. The highest concentrations of all analysed elements in Blue mussel are found at station 3, and highest concentrations in Brown seaweed are found at station 4. No trend was found in element concentrations in sculpin livers. This indicates that elevated concentrations of mainly Zn, Cu, Cr and Co in the marine organisms stem from the mining area.

Affected coast area

Station M1 is not elevated in any of the elements investigated. This gives an indication of the extension of the coastal pollution. Since station M4 in some cases is elevated it is likely that the area with elevated concentrations continue towards north for a few kilometres. The length of coastline with elevated element concentrations can roughly be estimated to 5-10 km.

The Kirkespir River environment

Resident Arctic char had, compared to background concentrations, 2-3 times higher concentrations in their liver of Cr and Co. Resident char stay all their life in the river, whereas the migratory form summers in the Kirkespir Bay and Saqqaa Fjord.

The terrestrial environment of the Kirkespir Valley

The 19 lichen stations in the Kirkespir Valley and Bay area had on average 2-4 times higher concentrations of Cu, Cr, As and Co compared to background levels.

If single lichen stations are considered, there are three areas with 4-10 times higher concentrations of mainly Cu, Cr, As and Co. These areas are the pier area (station M2), the lower waterfall area (stations 7 and 8) and the camp area (station 11) (Fig. 2).

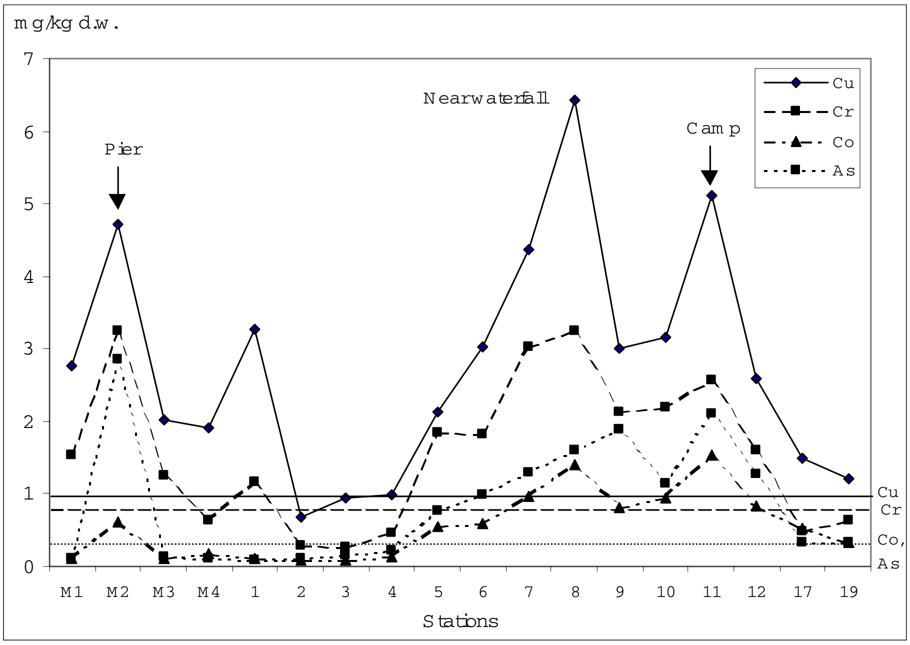

Figure 2. Concentrations of copper (Cu), chromium (Cr), cobalt (Co) and arsenic (As) in the lichen *Cetraria nivalis*.
For localisation of lichen stations refer to Fig. 1. M1-M4 are stations in the Kirkespir Bay area, stations 1-19 are situated in the Kirkespir Valley from coast (1) to up-stream camp area (19). Horizontal lines indicate average background concentrations of the four metals (Refer to Table 2). d.w. = dry weight.

In the pier area where ore is stored and loaded and in the camp area where ore is stored, these elevated concentrations can be explained by the dispersal of dust from stockpiles. It is less obvious how to explain the elevated concentrations in the third area, the lower waterfall area. It could be an effect of dust carried by the wind from the stockpiles in the camp area and down the valley. This explanation is supported by lower concentrations of elements in the lichens the further down the valley they are situated. The less elevated concentrations that were found at stations 9 and 10 in the waterfall area could be an effect of the stations placed in areas sheltered from the wind.

4 Conclusions

General trend: Elevated or slightly elevated concentrations of Zn, Cu, Cr, As and Co

In general, the elements that showed elevated or slightly elevated concentrations in one or more organic tissues were Zn, Cu, Cr, As and Co. Arsenic was slightly elevated only in lichens (airborne), whereas Zn was slightly elevated only in Brown seaweed (waterborne). Elevated concentrations were on average 3-9 times higher compared to the baseline level measured in the same area prior to mine start. Except for Cr, these elevated concentrations of the above elements could be expected after the start of the mine. Drainage from ore and waste rock prior to mining activities showed elevated or slightly elevated concentrations of Al, Co, Cu, Hg, As, Cd, Pb and Zn compared to Ontario's water quality guidelines.

Marine environment impacted from the mine area

In Kirkespir Bay, marine mussel and seaweed stations (M3 and M4) closer to the Kirkespir River outflow had slightly higher concentrations of some elements compared to the stations closer to the pier area (M1 and especially M2). This indicates that elevated concentrations in the marine organisms stem from the mining area from where elements are transported via the Kirkespir River. The pier area seems therefore not to contribute specifically to elevated concentrations in the marine environment.

Freshwater environment

Resident Arctic char had 2-3 times higher concentrations of Cr and Co in their liver compared to background concentrations.

Terrestrial environment impacted through dust from mine and pier area

In the Kirkespir Valley and Bay area, 4-10 times higher concentrations of mainly Cu, Cr, As and Co in lichens were found in three areas. These areas are the pier area, the camp area and an intermediate area near the waterfall. Elevated concentrations in the pier and the camp area can be explained by the dispersal of dust from ore stockpiles. Elevated concentrations in the third area could be an effect of dust carried by the wind from the stockpiles in the camp area and down the valley.

Moderate local pollution

It is documented that there is an impact from the mine on the local environment. Concentrations of some of the analysed elements in some of the organisms were elevated 2-10 times compared to the baseline level found during surveys in 2000 and 2001 (Asmund 2000, 2001). Elevated concentrations were found within 5-10 km of coastline near the mouth of the Kirkespir River. This is considered a moderate impact, since only a small area is affected and increases in element concentrations are small. The impact at Nalunaq is much less than at the closed mines at Maarmorilik (Johansen et al. 2003), Ivittuut (Johansen & Asmund, 2005) and Mestersvig (Aastrup et al. 2003).

At Maarmorilik and Ivittuut lead is elevated up to about 1000 times, and more than 100 km of coastline is affected at Maarmorilik and 50 km at Ivittuut. At Mestersvig lead is elevated up to 100 times and more than 40 km of coastline is affected.

Because monitoring must be performed on an annual basis it is possible to follow the development of the contamination and take mitigating steps.

Possible actions

Prevention of dust from the two stockpile areas should be discussed with the mining company. Also, a possible explanation of the observed elevated concentrations of elements in lichens in the water fall area should be discussed with the company.

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Appendix 1. Samples and stations

ID-No	Sample type	Latin name	Collection date	Station	Lat deg	Lat min and sec	Long deg	Long min and sec
31973	Lichen	Cetraria nivalis	20040825	1	60	19’34	44	55’22
31974	Lichen	Cetraria nivalis	20040825	2	60	19’38	44	54’4
31975	Lichen	Cetraria nivalis	20040825	3	60	19’35	44	54’1
31976	Lichen	Cetraria nivalis	20040825	4	60	19’43	44	53’38
31977	Lichen	Cetraria nivalis	20040825	5	60	19’57	44	52’48
31978	Lichen	Cetraria nivalis	20040825	6	60	20’1	44	52’18
31979	Lichen	Cetraria nivalis	20040825	7	60	20’32	44	51’37
31980	Lichen	Cetraria nivalis	20040825	8	60	20’44	44	51’07
31981	Lichen	Cetraria nivalis	20040825	9	60	20’49	44	50’14
31982	Lichen	Cetraria nivalis	20040825	10	60	20’51	44	49’58
31984	Lichen	Cetraria nivalis	20040825	11	60	21’17	44	49’57
31985	Lichen	Cetraria nivalis	20040825	12	60	21’28	44	49’49
31986	Lichen	Cetraria nivalis	20040825	15	60	22’43	44	49’08
31987	Lichen	Cetraria nivalis	20040825	17	60	21’59	44	49’52
31983	Lichen	Cetraria nivalis	20040825	19	60	22’3	44	49’31
31924	Lichen	Cetraria nivalis	20040822	M 1	60	18’408	44	58’006
31959	Lichen	Cetraria nivalis	20040824	M 2	60	18’46	44	56’47
31990	Lichen	Cetraria nivalis	20040823	M 3	60	19’288	44	56’152
31991	Lichen	Cetraria nivalis	20040823	M 4	60	19’345	44	57’372
31905	Lichen	Cetraria nivalis	20040821	AMI 1	60	26’203	44	57’04
31922	Brown seaweed	Fucus vesiculosus	20040822	M 1	60	18’408	44	58’006
31923	Brown seaweed	Fucus vesiculosus	20040822	M 1	60	18’408	44	58’006
31960	Brown seaweed	Fucus vesiculosus	20040824	M 2	60	18’46	44	56’47
31961	Brown seaweed	Fucus vesiculosus	20040824	M 2	60	18’46	44	56’47
31925	Brown seaweed	Fucus vesiculosus	20040823	M 3	60	19’288	44	56’152
31926	Brown seaweed	Fucus vesiculosus	20040823	M 3	60	19’288	44	56’152
31927	Brown seaweed	Fucus vesiculosus	20040823	M 4	60	19’345	44	57’372
31928	Brown seaweed	Fucus vesiculosus	20040823	M 4	60	19’345	44	57’372
31954	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 1	60	18’47	44	57’45
31955	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 1	60	18’47	44	57’45
31956	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 1	60	18’47	44	57’45
31901	Shorthorn sculpin	Myoxocephalus scorpius	20040821	U 1	60	18’47	44	57’45
31902	Shorthorn sculpin	Myoxocephalus scorpius	20040821	U 1	60	18’47	44	57’45
31957	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 2	60	18’45	44	56’46
31958	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 2	60	18’45	44	56’46
31964	Shorthorn sculpin	Myoxocephalus scorpius	20040824	U 2	60	18’45	44	56’46
31965	Shorthorn sculpin	Myoxocephalus scorpius	20040824	U 2	60	18’45	44	56’46
31966	Shorthorn sculpin	Myoxocephalus scorpius	20040824	U 2	60	18’45	44	56’46
31967	Shorthorn sculpin	Myoxocephalus scorpius	20040824	U 2	60	18’45	44	56’46
31968	Shorthorn sculpin	Myoxocephalus scorpius	20040824	U 2	60	18’45	44	56’46
31969	Shorthorn sculpin	Myoxocephalus scorpius	20040824	U 2	60	18’45	44	56’46
31971	Shorthorn sculpin	Myoxocephalus scorpius	20040824	U 2	60	18’45	44	56’46
31972	Shorthorn sculpin	Myoxocephalus scorpius	20040824	U 2	60	18’45	44	56’46
31933	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 3	60	19’308	44	56’53
31934	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 3	60	19’308	44	56’53
31935	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 3	60	19’308	44	56’53
31936	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 3	60	19’308	44	56’53

ID-No	Sample type	Latin name	Collection date	Station	Lat deg	Lat min and sec	Long deg	Long min and sec
31937	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 3	60	19’308	44	56’53
31938	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 3	60	19’308	44	56’53
31939	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 3	60	19’308	44	56’53
31940	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 3	60	19’308	44	56’53
31941	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 3	60	19’308	44	56’53
31942	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 4	60	19’335	44	57’309
31943	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 4	60	19’335	44	57’309
31944	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 4	60	19’335	44	57’309
31945	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 4	60	19’335	44	57’309
31946	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 4	60	19’335	44	57’309
31947	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 4	60	19’335	44	57’309
31948	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 4	60	19’335	44	57’309
31949	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 4	60	19’335	44	57’309
31950	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 4	60	19’335	44	57’309
31951	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 4	60	19’335	44	57’309
31952	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 4	60	19’335	44	57’309
31953	Shorthorn sculpin	Myoxocephalus scorpius	20040823	U 4	60	19’335	44	57’309
31970	Shorthorn sculpin	Myoxocephalus scorpius	20040824	U 4	60	19’335	44	57’309
31920	Blue mussel	Mytilus edulis	20040822	M 1	60	18’408	44	58’006
31921	Blue mussel	Mytilus edulis	20040822	M 1	60	18’408	44	58’006
31962	Blue mussel	Mytilus edulis	20040824	M 2	60	18’46	44	56’47
31963	Blue mussel	Mytilus edulis	20040824	M 2	60	18’46	44	56’47
31929	Blue mussel	Mytilus edulis	20040823	M 3	60	19’288	44	56’152
31930	Blue mussel	Mytilus edulis	20040823	M 3	60	19’288	44	56’152
31931	Blue mussel	Mytilus edulis	20040823	M 4	60	19’345	44	57’372
31932	Blue mussel	Mytilus edulis	20040823	M 4	60	19’345	44	57’372
31903	Blue mussel	Mytilus edulis	20040821	AMI 1	60	26’203	44	57’04
31904	Blue mussel	Mytilus edulis	20040821	AMI 1	60	26’203	44	57’04
31906	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31907	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31908	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31909	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31910	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31911	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31912	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31913	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31914	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31915	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31916	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31917	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31918	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31919	Arctic char	Salvelinus alpinus	20040822	Near waterfall	60	20’79	44	50’53
31988	Arctic char	Salvelinus alpinus	20040826	Near waterfall	60	20’79	44	50’53
31989	Arctic char	Salvelinus alpinus	20040826	Near waterfall	60	20’79	44	50’53

Appendix 2. Blue mussel average shell lengths

Station	Average length (cm) in different size groups including standard deviation and number in brackets						
	3-4	4-5	5-6	6-7	4-7	4-8	5-8
M1	3.41 (0.26; 33)					5.52 (0.97; 19)	
M2	3.48 (0.26; 24)				4.65 (0.73; 23)		
M3		4.17 (0.27; 11)					6.29 (0.84; 14)
M4		4.13 (1.05; 29)					5.86 (0.90; 15)
AMI1			5.43 (0.33; 23)	6.50 (0.29; 14)			

Appendix 3. Chemical analyses

Concentrations are given in mg/kg d.w. (mussels, seaweed and *Cetraria nivalis*) and mg/kg w.w. (sculpins and chars).

ID no.	Lab no	% dry matter	Species	Shell size,cm	Sta-tion	Hg	Cd	Pb	Zn	Cu	Cr	Ni	As	Se	Co
31921	646	17.43	Myt. edu.	3-4	M 1	0.1081	1.527	0.459	63.78	7.02	0.788	1.87	10.80	4.37	0.429
31921	647	17.43	Myt. edu.	3-4	M 1	0.0984	1.774	0.516	73.65	8.28	0.945	2.20	12.30	4.52	0.514
31920	648	15.76	Myt. edu.	4-8	M 1	0.1121	2.329	0.791	75.65	7.97	1.028	1.78	12.25	4.06	0.470
31962	649	16.27	Myt. edu.	3-4	M 2	0.0968	1.697	0.859	91.20	11.61	1.841	2.92	14.91	5.32	0.730
31963	650	14.8	Myt. edu.	4-7	M 2	0.0909	2.341	0.719	88.97	10.03	1.534	2.44	13.84	4.49	0.617
31929	651	15.1	Myt. edu.	4-5	M 3	0.0863	1.389	0.504	96.47	12.23	1.413	2.36	14.76	5.20	0.768
31930	652	12.38	Myt. edu.	5-8	M 3	0.1397	4.093	1.328	71.99	9.40	1.937	2.13	16.62	4.12	0.717
31932	653	18.58	Myt. edu.	4-5	M 4	0.0569	1.813	0.405	101.64	10.34	0.988	1.75	10.61	4.25	0.493
31931	654	16.81	Myt. edu.	5-8	M 4	0.0855	4.652	0.805	96.12	9.18	1.097	1.59	12.10	4.69	0.557
31903	655	18.15	Myt. edu.	5-6	AMI 1	0.0728	2.707	0.643	91.19	10.18	1.027	1.28	10.37	3.55	0.434
31904	656	17.71	Myt. edu.	6-7	AMI 1	0.0772	4.632	0.958	83.78	9.25	0.984	1.58	10.11	3.45	0.455
31922	657	100	Fuc. ves.		M 1	0.0131	1.177	0.065	15.54	3.76	0.164	1.20	46.58	0.20	0.341
31922	658	100	Fuc. ves.		M 1	0.0076	1.177	0.069	14.93	3.45	0.364	1.10	48.87	0.41	0.349
31923	659	100	Fuc. ves.		M 1	0.0077	0.977	0.072	14.72	3.57	0.197	1.01	43.25	0.27	0.336
31960	690	100	Fuc. ves.		M 2	0.0112	0.821	0.150	27.47	11.05	0.498	1.95	49.73	0.61	0.550
31960	691	100	Fuc. ves.		M 2	0.0073	0.850	0.170	29.68	12.41	0.785	1.93	53.65	0.35	0.557
31961	692	100	Fuc. ves.		M 2	0.0095	0.879	0.177	29.74	8.11	1.779	2.78	50.38	0.48	0.710
31925	693	100	Fuc. ves.		M 3	0.0099	1.052	0.148	18.46	5.26	0.596	2.05	63.44	0.18	1.178
31926	694	100	Fuc. ves.		M 3	0.0055	0.831	0.121	17.59	7.57	0.908	2.60	50.75	0.19	1.452
31927	695	100	Fuc. ves.		M 4	0.0071	1.579	0.373	24.11	10.85	0.725	2.69	68.44	0.62	0.904
31928	696	100	Fuc. ves.		M 4	0.0133	1.205	0.237	18.45	6.95	2.363	3.32	51.85	0.47	0.749
31924	697		Cet. niv.		M 1	0.0333	0.052	0.725	10.39	3.77	2.511	1.84	0.14	0.12	0.103
31924	698		Cet. niv.		M 1	0.0319	0.053	0.818	13.62	1.77	0.577	0.72	0.10	0.07	0.100
31959	699		Cet. niv.		M 2	0.0421	0.108	1.315	18.36	4.71	3.243	2.88	2.85	0.11	0.615
31990	700		Cet. niv.		M 3	0.0279	0.063	0.807	14.87	2.01	1.249	0.95	0.14	0.07	0.099
31991	701		Cet. niv.		M 4	0.0316	0.105	1.354	24.77	1.91	0.644	0.87	0.11	0.07	0.176
31905	702		Cet. niv.		AMI 1	0.0291	0.034	0.872	3.63	2.84	2.373	1.68	0.07	0.07	0.091
31973	703		Cet. niv.		1	0.0279	0.043	1.113	13.48	3.27	1.156	1.64	0.10	0.06	0.104
31974	705		Cet. niv.		2	0.0206	0.044	0.399	7.35	0.69	0.292	0.33	0.12	0.04	0.079
31975	706		Cet. niv.		3	0.0164	0.109	0.447	17.44	0.95	0.253	0.33	0.16	0.05	0.088
31976	707		Cet. niv.		4	0.0258	0.042	0.826	12.90	0.98	0.456	0.58	0.21	0.08	0.135
31977	708		Cet. niv.		5	0.0183	0.062	1.026	10.97	2.12	1.848	1.65	0.76	0.06	0.549
31978	709		Cet. niv.		6	0.0273	0.080	1.218	16.95	3.03	1.811	1.71	0.99	0.10	0.593
31979	710		Cet. niv.		7	0.0283	0.067	1.391	13.34	4.38	3.029	2.77	1.29	0.12	0.965
31980	711		Cet. niv.		8	0.0241	0.080	1.396	18.92	6.43	3.239	4.07	1.60	0.07	1.400
31981	712		Cet. niv.		9	0.0223	0.068	1.216	7.54	3.01	2.129	1.82	1.89	0.09	0.810
31982	713		Cet. niv.		10	0.0272	0.101	1.674	13.30	3.15	2.200	1.98	1.13	0.12	0.942
31984	714		Cet. niv.		11	0.0490	0.124	2.894	10.58	5.10	2.570	2.94	2.12	0.16	1.527
31985	715		Cet. niv.		12	0.0395	0.074	1.704	7.63	2.60	1.600	1.52	1.26	0.10	0.831
31986	716		Cet. niv.		15	0.0215	0.077	1.014	9.77	4.60	1.526	2.15	5.65	0.06	1.010
31987	717		Cet. niv.		17	0.0106	0.067	0.436	12.39	1.49	0.476	0.49	0.34	0.03	0.524
31983	718		Cet. niv.		19	0.0345	0.120	0.791	14.50	1.21	0.628	0.59	0.34	0.07	0.322
31954	735		Myo. sco.		U 1	0.0200	0.547	0.004	25.96	4.73	0.073	0.07	2.74	0.63	0.089
31955	736		Myo. sco.		U 1	0.0263	1.107	0.005	24.14	2.52	0.051	0.07	3.02	0.98	0.125
31956	737	28.45	Myo. sco.		U 1	0.0066	0.254	0.001	14.15	0.82	0.044	0.02	1.24	0.52	0.012
31964	738	39.82	Myo. sco.		U 2	0.0070	0.129	0.005	15.14	1.01	0.065	0.03	1.30	0.63	0.031
31964	739	39.82	Myo. sco.		U 2	0.0068	0.127	0.004	16.72	1.10	0.068	0.08	1.39	0.68	0.031
31965	740	18.66	Myo. sco.		U 2	0.0256	1.081	0.014	32.04	3.22	0.088	0.04	6.28	0.77	0.064
31966	741	38.4	Myo. sco.		U 2	0.0111	0.427	0.005	15.97	0.90	0.055	0.04	2.41	0.48	0.015
31968	742	23.29	Myo. sco.		U 2	0.0390	0.767	0.005	30.51	1.00	0.058	0.03	3.55	0.59	0.023

ID no.	Lab no	% dry matter	Species	Shell size,cm	Sta-tion	Hg	Cd	Pb	Zn	Cu	Cr	Ni	As	Se	Co
31972	743	31.55	Myo. sco.		U 2	0.0130	0.920	0.002	18.33	0.88	0.089	0.02	1.96	0.52	0.021
31934	744	32.32	Myo. sco.		U 3	0.0333	0.845	0.001	25.75	1.65	0.101	0.03	4.39	0.69	0.032
31935	745	33.51	Myo. sco.		U 3	0.0065	0.229	0.003	14.41	1.35	0.044	0.04	1.04	0.52	0.016
31936	746	32.2	Myo. sco.		U 3	0.0088	0.258	0.005	16.33	1.62	0.113	0.14	1.56	0.55	0.022
31937	747	31.22	Myo. sco.		U 3	0.0128	0.425	0.004	22.67	1.11	0.087	0.01	1.62	0.60	0.023
31945	748	18.81	Myo. sco.		U 4	0.0249	0.825	0.006	33.51	13.22	0.089	0.11	2.86	0.82	0.153
31943	754	32.7	Myo. sco.		U 4	0.0216	0.395	0.008	17.99	1.08	0.025	0.03	1.58	0.51	0.012
31943	755	32.7	Myo. sco.		U 4	0.0256	0.471	0.010	24.05	1.53	0.053	0.07	2.38	0.60	0.019
31944	756	26.97	Myo. sco.		U 4	0.0257	0.486	0.006	25.56	2.48	0.095	0.03	2.12	0.57	0.013
31970	757	29.55	Myo. sco.		U 4	0.0147	0.335	0.002	17.52	1.58	0.091	0.08	3.29	0.68	0.012
31970	758	29.55	Myo. sco.		U 4	0.0173	0.372	0.005	24.49	1.92	0.031	0.07	4.26	0.66	0.014
31908	750		Sal. alp.			0.0244	0.144	0.006	26.63	24.20	0.060	0.22	0.41	0.99	0.157
31909	751		Sal. alp.			0.0516	0.094	0.004	25.89	16.67	0.084	0.19	0.22	4.02	0.088
31910	752		Sal. alp.			0.0202	0.050	0.006	17.26	6.12	0.073	0.06	0.13	1.87	0.063
31989	753	18.81	Sal. alp.			0.0375	0.144	0.016	15.18	2.28	0.083	0.28	0.21	4.25	0.147

d.w. = Dry weight; w.w = Wet weight; Myt. edu. = Blue mussel; Fuc. ves. = Brown seaweed; Cet. niv = Lichen, *Cetraria nivalis*; Myo. sco. = Shorthorn sculpin; Sal. alp. = Arctic char.

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Monitoring was performed in the Nalunaq Gold Mine area, Nanortalik municipality, South Greenland during 20-26 August 2004. This was eight months after the first shipment of ore. Samples were collected at four marine stations in the Kirkespir Bay, Arctic char were sampled in the Kirkespir River, and lichens were collected at 20 stations in the Kirkespir Valley. Sam-ples were analysed for 10 elements with an ICP-MS. Concentrations of Zn, Cu, Cr, As and Co were elevated 3-9 times compared to background con-centrations found prior to mine start. The increased level of contamination in the local area is moderate compared to contaminations found around closed mines in Greenland, i.e. Maarmorilik, Ivittuut and Mestersvig.

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