ENVIRONMENTAL MONITORING AT THE QAQORTORSUAQ ANORTHOSITE MINE (WHITE MOUNTAIN) 2025

Technical Report from DCE – Danish Centre for Environment and Energy no. 392 2026

AARHUS UNIVERSITY
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Abstract: This environmental monitoring report for the Qaqortorsuaq Anorthosite Mine (White Mountain) is prepared by DCE – Danish Centre for Environment and Energy, Aarhus University, and Greenland Institute of Natural Resources (GINR) for the Environmental Agency for Mineral Resource Activities (EAMRA), Government of Greenland. The report presents the results from the authority environmental monitoring by DCE/GINR on behalf of EAMRA in 2025.

Keywords: Qaqortorsuaq Anorthosite Mine, Environmental Monitoring, Greenland, Mining

Front page photo: The tailings lake at Qaqortorsuaq Anorthosite Mine (White Mountain), 2025. Photo by J. Fritt-Rasmussen

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Preface

This environmental monitoring report for the Qaqortorsuaq Anorthosite Mine (White Mountain) is prepared by DCE – Danish Centre for Environment and Energy, Aarhus University, and Greenland Institute of Natural Resources (GINR) for the Environmental Agency for Mineral Resource Activities (EAMRA), Government of Greenland. The report presents the results from the authority environmental monitoring by DCE/GINR on behalf of EAMRA in 2025.

Sammenfatning

Denne miljømoniteringsrapport for Qaqortorsuaq Anorthosit Minen (White Mountain) er udarbejdet af DCE - Nationalt Center for Miljø og Energi, Aarhus Universitet, og Grønlands Naturinstitut (GN) for Miljøstyrelsen for Råstofområdet (MR), Naalakkersuisut.

Qaqortorsuaq Anorthosit Minen ligger i den centrale del af Vestgrønland ved Kangerlussuaq-fjorden. Minen har været i drift siden 2019 og den årlige produktion nærmede sig 40% af det maximale ved udgangen af i 2024 (Niras and BioApp 2025).

Myndighedsmiljømonitering blev gennemført i 2018, 2019, 2023-25 af DCE/GN på vegne af MR. Resultaterne fra moniteringen i 2018, 2019 og 2023 kan findes i Fritt-Rasmussen et al. (2024) og resultaterne fra moniteringen i 2024 kan findes i Fritt-Rasmussen et al. (2025). Resultaterne fra moniteringen i 2025 præsenteres i denne rapport.

Miljømoniteringen i 2025 omfattede prøvetagning af ferskvand, snekruslav, blåmuslinger og blæretang på udvalgte moniteringsstationer, og prøverne blev analyseret for mere end 60 forskellige grundstoffer[1]. Resultaterne sammenholdes med koncentrationer målt i baggrundsprøver indsamlet i 2012 og 2013 (før mineaktiviteter blev påbegyndt), for at vise mulige ændringer i forbindelse med mineaktiviteterne. Moniteringsdataene analyseres også for rumlige og tidsmæssige tendenser for at påvise mulig spredning af grundstoffer fra punktkilder samt ændringer i koncentrationsniveauer siden myndighedsmoniteringen blev påbegyndt. Desuden blev der i 2025 indsamlet ferskvand og jord til pH målinger.

I snekruslav var Al-koncentrationerne forhøjede i forhold til baggrundsmålingerne i de fleste af prøverne, især tæt på procesanlægget (L2 og L4) og ved tailingssøen (L17). Ved tailingssøen er koncentrationen af Al steget løbende fra den første monitering i 2018 og frem til 2025. Der blev også fundet forhøjede koncentrationer af Al udenfor støv-bufferzonerne. Al-koncentrationerne faldt med afstanden til punktkilder, hvilket indikerer spredning og aflejring af Al-holdigt støv.

I blæretang var koncentrationerne af aluminium (Al) og jern (Fe) højere end baggrundsniveauerne på alle tre moniteringsstationer. Koncentrationerne af disse grundstoffer er 18 og 21 gange højere for hhv. Al og Fe i 2025 i forhold til 2024 på station M1, som ligger nærmest procesanlægget.

I blåmuslinger var ingen af de analyserede grundstoffers[2] koncentrationer forhøjede sammenlignet med baggrundsprøver, bortset fra kobber (Cu), dog kun med 0.6 mg/kg tørvægt (baggrundsniveau +2SD: 26 mg/kg tørvægt versus den målte værdi i 2025: 26.6 mg/kg tørvægt).

[1] De følgende grundstoffer er præsenteret i rapporten: **Al**, As, **Ca**, Cd, Cr, **Cu**, **Fe**, Hg, **Mg**, Ni, Pb and Zn. Listen omfatter grundstoffer, som det er anbefalet at følge jf. VVM guidelines for ferskvand (Anon 2015). Grundstoffer skrevet med **fed**, er særligt relevante for dette mineprojekt fordi de udgør størstedelen af det brudte materiale eller forekommer naturligt i høj koncentration i området.

I ferskvandssystemet blev kobber (Cu) fundet i koncentrationer, der oversteg de grønlandske vandkvalitetskriterier (Greenland Water Quality Criteria, GWQC). Det afspejler imidlertid et naturligt højt Cu-indhold i området, som fremgår af de tilsvarende høje baggrundsniveauer. Der er ingen tegn på, at mineaktiviteterne har medført stigninger i Cu-koncentrationerne, idet stationen opstrøms for vejen og tailingssøen (F7) også havde forhøjet koncentration af kobber. Aluminium blev fundet i koncentrationer over baggrundsniveauet i ferskvandsprøverne indsamlet ved udløbet af søen, hvor tailings deponeres (Lake A outlet), og i udløbet fra Lake B (F30). Det indikerer, at aluminiumholdig tailings spredes, og at Al i et vist omfang frigives fra tailings. Aluminiumkoncentrationerne i ferskvand ved tailings-søens udløb var 2-4 gange højere end i 2023. GWQC inkluderer ikke Al, men vandkvalitetskriterier fra Australien/New Zealand angiver en grænseværdi på 55 µg/l for opløst Al (i ferskvand med pH > 6,5). Selvom Al-koncentrationen er ca. 3 gange højere end dette ved udløbet af Lake A, og koncentrationen er forhøjet ved udløbet af Lake B, så er koncentrationen af Al ikke forhøjet i forhold til baggrundsniveauerne i ferskvandsprøven taget længere nede i ferskvandssystemet (F20).

DCE/GINR vurderer, at selvom spredning af grundstoffer som fx Al kan måles i snekruslav, tang og ferskvand ved Qaqortorsuaq Anorthosite Mine, så har koncentrationerne målt i miljøprøverne ikke en væsentlig indvirkning på miljøet i området. Dog anbefaler DCE/GINR, at selskabet har et stærkt fokus på støvbegrænsende tiltag, og at miljøovervågningen, der udføres af myndighederne, fortsættes årligt for at følge udviklingen af mineaktiviteterne, som forventes at stige i fremtiden.

Summary

This environmental monitoring report for the Qaqortorsuaq Anorthosite Mine (White Mountain) is prepared by DCE – Danish Centre for Environment and Energy, Aarhus University, and Greenland Institute of Natural Resources (GINR) for the Environmental Agency for Mineral Resource Activities (EAMRA), Government of Greenland.

The Qaqortorsuaq Anorthosite Mine (White Mountain) is located in the central part of West Greenland by the Kangerlussuaq Fjord. The mine has been operational since 2019 with an annual production reaching approx. 40 % of maximum annual extraction quota by 2024 (Niras and BioApp 2025).

Authority environmental monitoring was conducted in 2018, 2019, 2023-25 by DCE/GINR on behalf of EAMRA. The monitoring results from 2018, 2019 and 2023 were reported in Fritt-Rasmussen et al. (2024), the results from 2024 were reported in Fritt-Rasmussen et al. (2025), while the monitoring results from 2025 are presented in the current report.

The environmental monitoring in 2025 included sampling of freshwater, crinkled snow lichen, blue mussels and bladderwrack at selected monitoring stations. The samples were analysed for 60+ elements[1]. The results are compared to concentrations measured in pre-mining baseline samples from 2012 and 2013 to detect possible changes related to the mining activities. The monitoring data are also analysed for spatial and temporal trends to detect possible dispersal of elements from point sources and changes in concentration levels over the time span of the monitoring dataset. In 2525, soil and freshwater samples were also analysed for pH.

2025 monitoring results show that Aluminium (Al) concentrations in crinkled snow lichens were elevated compared to the baseline measurements at most sampling stations, and particularly in areas close to the processing plant (L2 and L4) and the tailings lake (L17). At the tailings lake, the concentration of Al in lichens has consistently increased from the first monitoring in 2018 to 2025. Elevated concentrations of Al in lichens outside the designated dust mitigation buffer zones were found at most of the sampling stations. Aluminium concentrations decreased with increasing distance to the mine-related point sources showing a typical dispersion gradient.

In bladderwrack, the concentrations of aluminium and iron (Fe) were above baseline levels at all three marine monitoring stations. The concentrations of these elements have increased 18 and 21 times (for Al and Fe, respectively) from 2024 to 2025 at station M1 closest to the processing plant.

[1] The following elements were selected for presentation in the main report: **Al**, As, **Ca**, Cd, Cr, **Cu**, **Fe**, Hg, **Mg**, Ni, Pb and Zn. This list comprises elements recommended for analysis in the general EIA guideline for freshwater (Anon 2015), and the elements in bold font are of particular relevance for the current mining project, because they are main constituents of the mined mineral or occur naturally in elevated concentrations in the area.

None of the selected elements[1] analysed in blue mussels were elevated compared to baseline samples, except copper (Cu). The copper concentration was though, only elevated by 0.6 mg/kg dry weight (baseline +2SD (standard deviations): 26 mg/kg dry wt. vs. measured in 2025: 26.6 mg/kg dry wt.).

In the freshwater system, Cu was the only element found in concentrations exceeding the Greenland Water Quality Criteria (GWQC). However, this reflects a natural high freshwater Cu concentration in the Qaqortorsuaq area, which is evident from the similarly high baseline levels. There is no indication that the mining activities have caused an increase in Cu concentrations, as the station (F7) upstream of the road and the tailings lake also showed an elevated concentration. Aluminium was found in concentrations above the baseline levels in the freshwater samples collected at the outlet of the tailings lake (Lake A outlet) as well as in the samples from the outlet of Lake B (F30), indicating dispersion of Al-containing tailings as well as some dissolution of Al from the tailings. The Al concentrations in freshwater from Lake A outlet was 2-4 times higher than in 2023, but slightly lower than in 2024. The GWQC does not include Al, but water quality guidelines from Australia/New Zealand have a value of 55 ug/l for dissolved Al (in freshwater with pH above 6.5). Though the Al concentration is approx. 3 times higher than this at the outlet of Lake A, and the concentration is elevated at the outlet of Lake B, the freshwater sample taken further down the freshwater system (F20) did not have Al concentrations above baseline levels.

In conclusion, DCE/GINR asses that although dispersion of some elements, such as Al, can be measured in lichens, seaweed and freshwater at the Qaqortorsuaq Anorthosite Mine, the concentrations measured are not considered to have a significant impact on the environment in the area. However, DCE/GINR recommend that the company has a strong focus on dust mitigation measures and that the environmental monitoring done by the authorities is continued annually to follow the development of mining activities, which are expected to increase in the future.

Eqikkaaneq

Avatangiisinik mississuineq pillugu nalunaarusiaq una piiaaffik Qaqortorsuaq Anorthosit Minen (White Mountain) sinnerlugu suliaavoq suliarinnittuuppullu DCE-Nationalt Center for Miljø og Energi, Aarhus Universitet aamma Pinngortitaleriffik, Aatsitassaqarnermut Aqutsisoqarfik, Namminersorlutik Oqartussat sinnerlugit.

Qaqortorsuaq Anorthosit Minen Kalaallit Nunaata Kitaata qiterpasissuani Kangerlussuup kangerluaniippoq. Piiaaffillu 2019imiit ingerlanneqalerpoq, ukiumoortumillu piiagassat ukioq 2024 naalermat 40 %-it missaanniissimapput.

Pisortat MR sinnerlugu avatangiisinik mississuineri 2018imi, 2019imi aamma 2023-25imi ingerlanneqarput, 2024mi inernerit Fritt-Rasmussen et al.-imi (2025) atuarneqarsinnaapput. 2025mi inernerit nalunaarummi uani saqqummiunneqarput.

Avatangiisinik mississuilluni nakkutilliinerni imeq, orsuaasat, uillut qeqqussallu aalajangersimasut mississugassatut tigusiffigineqarsimapput, taakkulu grundstoffit assigiinngitsut 60init ikinnerunngitsut pillugit mississuiffigineqarput. Mississukkat inerneri (aatsitassarsiornerit suli aallartinneqannginnerani) 2012imi aamma 2013imi najoqqutaralugu mississugassatut tigusiffigineqarsimasut akuinut naleqqersuunneqarsimapput, aatsitassarsiornermi sutigut sunnerneqarsimanersut paasiniarlugu. Nakkutilliilluni mississukkat paasissutissartaat aamma mississorneqartarput qanoq annertussuseqarneri piffissallu nikinneri malillugit siaruaassimaneri amerlassusiilu mississuiffiusut nalaanni allanngortoqarnersoq paasiniarlugu. Taakku saniatigut imermik tarajoqanngitsumik issumillu pH-mik uuttortagassamik 2025mi tigusisoqarpoq.

Orsuaasani Al, tassalu aluminium, najoqqutaralugu mississugassatut tigusimasanit amerlanerpaani qaffasinneruvoq, pingaartumik piiaaffimmut qaninnerusumi (L2 og L4) kiisalu tatsip eqqaaffigineqartup (L17) eqqaani. Tatsip eqqaaffigineqartup eqqaani Al 2018mi mississueqqaarnerminngaanniit malittuinnarmik 2025p tungaanut qaffakkaluttuinnarsimavoq. Nunap immikkoortuata mississuiffigineqartup avataa Al-imik qaffasissumik aamma nassaarfiuvoq. Tatsip eqqaaffigineqartup eqqaa ungasilliartortillugu Al milliartortarpoq, tamatumalu paasinarsisippaa pujoralannik al-itaqartunik siaruiaattoqarlunilu katersuuttoqarnera.

Qeqqussani aluminium (Al) aamma saviminissaq (Fe) mississuiffigineqartuni pingasuni tamani najoqqutaralugu mississugassatut tiguneqareersimasunut naleqqiukkaanni annertunerulersimapput. Grundstoffit taakku tamarmik piiaaffimmut qaninnerpaami station M1imi 2024minngaanniit 2025mut 18eriaamminngaanniit 21riaammut qaffassimapput (Al-imut aamma Fe-mut tunngatillugu).

Uillut mississuiffigineranni grundstoffit taakku marluk qaffariaateqarsimanerannik ersittoqanngilaq, kanngussak eqqaassanngikkaanni (Cu), panerluni oqimaassuseq 0.6 mg/kg angusimammagu (najoqqutassami qaffasissuseq +2SD: 26 mg/kg dry wt. illuatungaani 2025mi uuttortarneqartoq: 26.6 mg/kg tørvægt).

Imeq kanngussammik Kalaallit Nunaanni imermut pitsaassusissamut piumasaqaat (Greenland Water Quality Criteria (GWQC) qaangerlugu akoqalersimavoq. Nunap ilaani Cu-mik nunap nammineq pianik peqartoq misissukkat takutippaat, kiisalu najoqqutassani qaffasissutsini qaffasinnerat aamma takuneqarsinnaavoq. Aatsitassarsiornerit nassataannik Cu-ni qaffariaateqartoqartarneranik takussutissaqanngilaq, stationi aatsitassarsiorfiup tungaanut aqqusinermiittoq taserlu eqqaaffigineqartoq (F7) tamarmik kangussaqarnerat qaffariaateqarsimammat. Aluminium najoqqutassaq qaffasissuseq qaangerlugu tatsimi eqqaaffigineqartumi imermi misissugassatut tigusani nassaarineqarpoq, tamatuma nalaani eqqakkat katersorneqarput, (Lake A outlet) aamma Lake B (F30) akoqarpoq. Taamaannerata paasinarsisippaa eqqakkat aluminiumitallit siaruaattut kiisalu Al eqqakkanit aalajangersimasumik annertussusilik aniatinneqartoq.

Tatsimi eqqaaffiusumi imermi aluminium 2023mut naleqqiullugu 2-4riaammik qaffasinneruvoq. GWQCip Al ilanngutinngilaa, imermulli pitsaassusissamut piumasaqaatit Australien/New Zealandiminngaanneersoq Al imerpalasunngorsimasumi killissaa 55 µg/l-imiitippaat (imermi tarajoqanngitsumi pH > 6,5-ilimmi). Lake Ami Al pingasoriaammik qaffasinnerugaluartoq kiisalu Lake Bmi qaffassimagaluartoq Al imermi tarajoqanngitsumi itinerusumi (F2) misissugassatut tigusami qaffassimanngilaq.

Ataatsimut isigalugu DCE/GINR naliliivoq Qaqortorsuaq Anorthosite Minenimi grundstoffip Al-ip orsuaasani, qeqqussani imermilu tarajoqanngitsumi siaruaassimanera uuttortarneqarsinnaagaluartoq avatangiisimi misissukkani tigusani uuttortakkat nunap ilaani avatangiisimut annerusumik sunniuteqanngitsut. Taamaakkaluartoq DCE/GINRip innersuussutigaa pujoralaap siammarnissaanut killilersuummik suliffeqarfik annertuumik sammisaqangaatsiassasoq kiisalu avatangiisinik nakkutiginninneq, oqartussanit ingerlanneqartoq, ukiumoortumik ingerlanneqartassasoq. Taamaaliornikkut aatsitassarsiornerit ineriartornerat ukiuni tulliuttuni annertusiartortutut naatsorsuutigineqartoq malittarineqarsinnaaniassammat.

1 Introduction

The Qaqortorsuaq Anorthosite Mine (White Mountain) is located in the central part of West Greenland by the Kangerlussuaq Fjord (Figure 1). It is an open pit mine, and blasting and primary crushing of material take place at the pit. The material is transported by a haul road to the processing plant for grinding and magnetic separation. The processing plant is located close to the coast and the harbour. The final product is shipped out through the Kangerlussuaq fjord. Tailings are deposited in a freshwater lake (Lake A, tailings lake) (Figure 2). The mine has been operational since 2019 with an annual production reaching approx. 40 % of maximum annual extraction quota by 2024 (Niras and BioApp 2025).

The main environmental focus is the potential dust dispersion from the pit, the processing plant, and the road, and dust dispersal as well as element and particle discharge from the tailings deposition in Lake A. The White Mountain anorthosite has high contents of aluminium (30%), silica (50%) and calcium (15%), and low contents of iron (EIA 2015). A natural high Cu concentration is found within the license area. This is reflected in most of the baseline water samples from the lakes and rivers (EIA 2015).

The authority environmental monitoring was conducted by DCE/GINR on behalf of the Environmental Agency for Mineral Resource Activities (EAMRA), Government of Greenland in 2018, 2019, and 2023-2025. The results from the monitoring 2018, 2019 and 2023 were reported in Fritt-Rasmussen et al. (2024). The results from the 2024 monitoring are included in Fritt-Rasmussen et al. (2025). The results from the 2025 monitoring are presented in the current report.

1.1 The environmental effects of anorthosite mining

The environmental effects of anorthosite mining are mainly related to dust dispersion. This includes the chemical composition of the dust and the related effects as well as the physical effects of dust in both the terrestrial and limnic systems. Aluminium (Al) is one of the most common elements on earth, but it has little or no known biological function (Gensemer & Playle, 1999). The Al concentrations in the environment vary naturally depending on the geological setting. The potential toxicity of Al relates largely to the pH of both water and soil. At low pH, Al can become toxic to aquatic organisms (Gensemer & Playle, 1999), and to vegetation in acidic soils (Rahman et al. 2024).

In freshwater

Setting threshold values for Al in freshwater ecosystems is difficult and relies on site-specific water chemistry. In freshwater ecosystems, Al can become toxic to organisms at low pH (Gensemer & Playle, 1999). A high hardness of the freshwater, as well as high content of dissolved organic carbon (DOC), make Al less bioavailable to aquatic organisms (Gensemer & Playle, 1999).

A guideline from British Columbia, Canada, sums up different water quality guidelines in Canada, USA and Australia/New Zealand (B.C. Ministry of Water, Land, and Resource Stewardship 2023). The guidelines include values for total (corresponding to unfiltered samples) and dissolved (corresponding to filtered samples) Al. The Greenland Water Quality Criteria (GWQC) refers to filtered samples, and comparable criteria from the Canadian overview are the values from Australia/New Zealand for dissolved Al, where chronic impacts on freshwater organisms occur at Al concentrations of 0.8 µg/L in water with pH < 6.5, and at 55 µg/L in water with pH > 6.5.

In terrestrial environments

When Al is soluble it can be taken up from soil and bioaccumulated in plants. The toxicity of aluminium is related to the amount of soluble Al in the soil, as acidic soil conditions (pH < 5.5) can increase Al solubility (US EPA, 2003), leading to potential toxicity for plants and soil organisms (Rahman et al. 2024). The US EPA (2023) concludes that measuring soil pH and using a pH screening level of 5.5 can be used to assesses, if soluble Al may be present (US EPA, 2003; Rahman et al. 2024).

Aside from being the vector for Al transport to the surroundings, dust itself can also both directly and indirectly affect vegetation. It can reduce plant cover, alter plant communities, and increase metal concentrations in vegetation (Watkinson et al. 2021). If dust coats the leaves, the stomata (pores in the epidermis of leaves responsible for gas exchange such as CO_2 uptake during photosynthesis) may close, resulting in physiological changes and ultimately in reduced plant growth or death (Kameswaran et al., 2019). If the soil is acidic, then dust rich in Al can also affect e.g., root growth negatively and thus reduces plant growth (Ofoe et al. 2023).

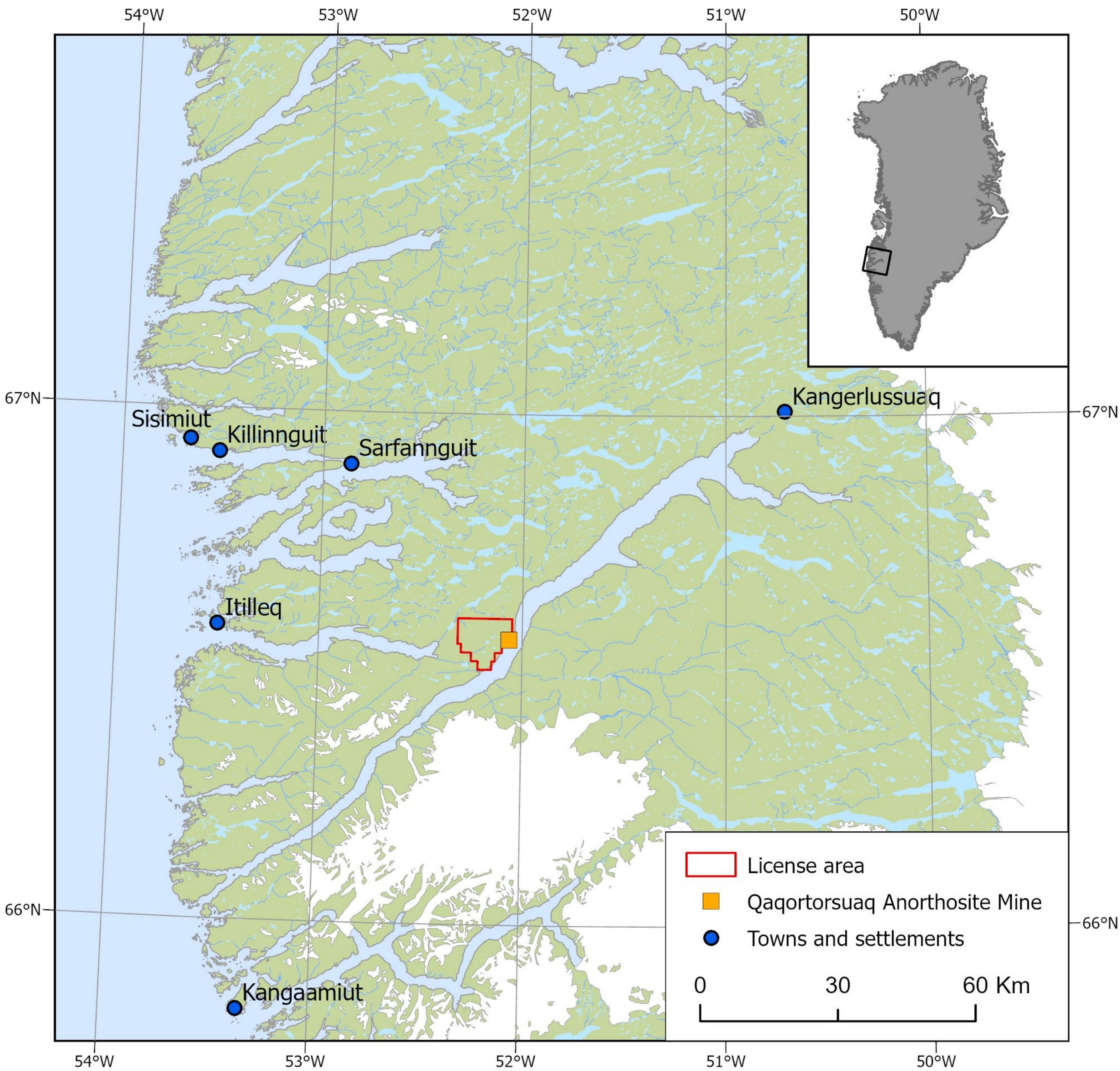


Figure 1. Map showing the location of the Qaqortorsuaq (White Mountain) Anorthosite Mine.

2 Environmental monitoring sampling

The environmental monitoring at White Mountain involves both monitoring by authorities and compliance control by the company.

The company's compliance control is designed to detect exceedance of guideline values at mining point sources, e.g. freshwater samples from the tailings lake freshwater system and dust deposition rates (obtained using Bergerhoff dust samplers) near the pit, processing plant, road, etc.

The authority environmental monitoring program is designed to monitor changes in element levels in the surrounding area caused by the mining activities. The program is adaptive and can be changed if the activities change or if the authority monitoring or the company's compliance control indicate circumstances that require closer attention.

A preliminary plan for both authority monitoring and compliance control by the company is detailed in a 2017 Hudson document, which was reviewed and commented on by DCE/GINR (Hudson A/S 2017). The monitoring carried out by DCE/GINR in 2018, 2019 and 2023 adheres to this preliminary plan. The authorities' environmental monitoring in 2024 and 2025 was adapted based on the monitoring results of previous years.

The authority monitoring programme at White Mountain is focused on three species of the biota: crinkled snow lichen (*Flavocetraria nivalis*), blue mussel (*Mytilus edulis*) and bladderwrack (*Fucus vesiculosus*). Along with freshwater samples, the biota samples are analysed for 60+ elements (see Section 3.3). The three species were selected because they are well-suited as monitoring organisms of mining contamination in terrestrial and marine environments and are widely distributed in Greenland. Since the 1970'ies they have been used in monitoring programs at many mine sites in Greenland (e.g., Johansen et al. 2008; Bach et al. 2014; Bach and Larsen 2016). Bladderwrack and blue mussels are sessile and can accumulate elements from the surrounding seawater. They thus reflect the seawater quality over longer time spans. Bladderwrack growth tips are used as proxies for the year-to-year contamination (reflecting the element accumulation during the growing season), whereas blue mussels accumulate elements during their lifespan of 10-15 years (Theisen 1973). The element accumulation in seaweed is considered only to reflect the dissolved elements in the seawater (Rainbow 1995), whereas blue mussels can accumulate elements in both the dissolved and particulate form (Rigét et al. 1997; Søndergaard et al. 2011). Blue mussels are internationally well-established monitoring organisms due to their role as suspension feeders, concentrating contaminants in their tissue as a result of filtration of large volumes of water.

Crinkled snow lichen is the preferred species for terrestrial monitoring in Greenland as it is found in most parts of the country (Søndergaard et al. 2020). Lichens are used as a monitoring organism for dust deposition due to their large surface area, lack of roots – and thus no elemental uptake from the ground – and their long lifespan. Their ability to accumulate dust and air pollutants from mining activities have been reported in several studies and with continuous pollution, element concentrations in lichens have been shown to increase with exposure time (e.g., Naeth and Wilkinson 2008; Søndergaard et al. 2011; Søndergaard et al. 2013; Søndergaard et al. 2020).

Element concentrations in filtered freshwater samples are proxies for the dissolved elements (here defined as particles that can pass through a 0.45 µm filter), whereas unfiltered freshwater samples also contain elements from particles in suspension.

Sampling was conducted according to the protocol detailed in Bach et al. (2022). In addition, soil and freshwater were sampled for pH measurements.

Appendix 1 contains a list of sample stations and coordinates for the 2025 monitoring. Appendix 2 contains an overview of all the monitoring samples included in this monitoring report. All results are included in Appendix 3-6.

2.1 Environmental monitoring programme 2025

For a complete overview of all sampling stations in 2025, see the map in Figure 2.

Lichens: The previous authority monitoring of crinkled snow lichen, *Flavocetraria nivalis*, showed that aluminium (Al) and iron (Fe) concentrations were elevated compared to baseline levels at some stations, particularly in areas close to the processing plant and the tailings lake and outside the designated dust mitigation buffer zones close to the processing plant (Fritt-Rasmussen et al. 2024, 2025). Therefore, an adapted lichen sampling program was implemented in 2024 to track concentrations of relevant elements in lichens along gradients from the three main dust sources: the road, the tailings deposit and the processing plant (Figure 2). The same monitoring stations were included in the 2025 monitoring. The lichen sampling was supplemented with pH measurements of soil collected at the same sampling sites. Thus, 23 lichen samples were analysed for element concentrations, and pH was measured in 23 soil samples.

Freshwater: Samples were collected at F7 (upstream station), Lake A outlet, F20, and F31 (Figure 2). As several element concentrations were above the baseline levels in the freshwater samples collected at the outlet of the tailings-lake (Lake A outlet) in 2024, a new station at the outlet of Lake B (F30) was also sampled. One filtered and one unfiltered sample were collected at each station for a total of 10 samples for element analysis. pH was also measured at all five stations.

Seaweed: Bladderwrack, *Fucus vesiculosus*, was collected at M1, M1A and M3A (Figure 2). Bladderwrack growth tips were collected along a 20 m stretch of the coast at each station. The 3 samples were analysed for element concentrations. M2 and M3 were not visited in 2025. If, at any point in time, results from the marine stations closer to the point sources reveal elevated concentrations of elements of concern, the two stations may be re-introduced in the environmental monitoring.

Blue mussels: Previous monitoring showed that none of the selected elements analysed in blue mussels, *Mytilus edulis,* were found in elevated concentrations compared to baseline samples. Therefore, as time available at the mine site did not allow mussel sampling at all three stations, blue mussels were only collected at M1A and M3A (M1 was not sampled). A total of 3 samples (one depurated and two non-depurated) of blue mussels from one size group (4.0-4.9 cm) were analysed for element concentrations.

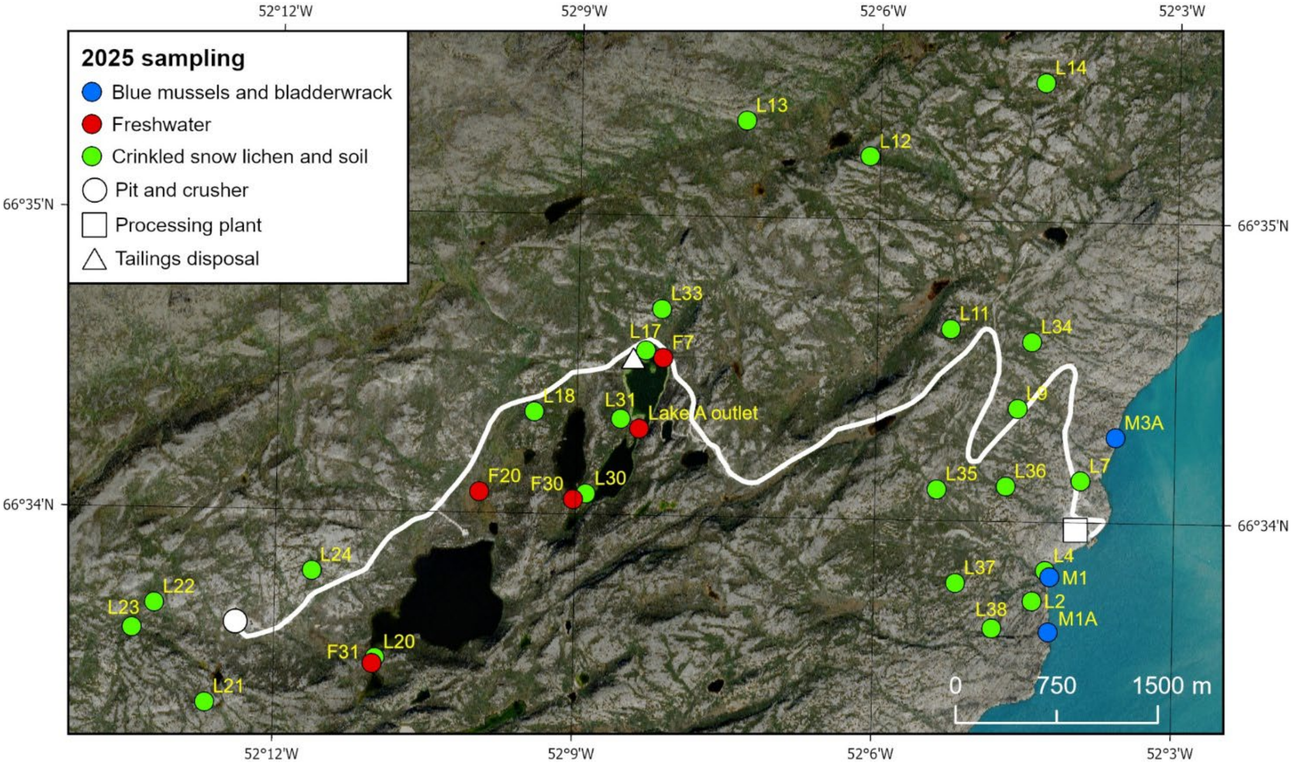


Figure 2. Overview of authority environmental sampling locations in 2025.

3 Analytical methods

All samples were analysed for chemical composition at the environmental trace element laboratory at Department of Ecoscience, Aarhus University in Roskilde, Denmark. The laboratory is ISO 17025 accredited by the Danish Accreditation Fund DANAK (Accreditation no. 411). The accreditation includes trace element analyses of biological material, sediment/soil, freshwater and seawater.

3.1 Sample preparation

Lichen samples were sorted by hand using plastic tweezers, and only fresh-looking yellow parts were selected and freeze-dried. Bladderwrack tips and blue mussel soft parts were also freeze-dried before being homogenised in an agate mortar.

Subsequently, 300 mg sub-samples of freeze-dried lichens, bladderwrack and mussels were digested in a mixture of 4 ml concentrated Merck Suprapure nitric acid and 4 ml Milli-Q water in Teflon bombs in an Anton Paar Multiwave 7000 Microwave Oven (following the DS259 method). Finally, the solution was diluted to 60 grams in total with Milli-Q water and stored in polyethylene bottles until analysis.

Freshwater samples (both filtered and unfiltered) were stored cool in 15 ml polyethylene vials. Prior to analysis, 30 µl of concentrated Merck Suprapure nitric acid was added to the samples, and the acidified samples were left for a minimum of 24 hours prior to analyses.

3.2 Chemical analyses

All samples were analysed for element composition by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) using an Agilent 7900 ICP-MS. The ICP-MS measures 61 elements as a standard.

The 61 elements measured in the samples were: lithium (Li), beryllium (Be), sodium (Na), magnesium (Mg), aluminium (Al), phosphorus (P), potassium (K), calcium (Ca), scandium (Sc), titanium (Ti), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), gallium (Ga), arsenic (As), selenium (Se), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), molybdenum (Mo), ruthenium (Ru), palladium (Pd), silver (Ag), cadmium (Cd), antimony (Sb), tellurium (Te), caesium (Cs), barium (Ba), lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), lutetium (Lu), hafnium (Hf), tantalum (Ta), wolfram (W), rhenium (Re), platinum (Pt), gold (Au), mercury (Hg), thallium (Tl), lead (Pb), bismuth (Bi), thorium (Th) and uranium (U)) using the following elements as internal standards: germanium (Ge), rhodium (Rh), indium (In) and iridium (Ir).

Detection limits (DL) for the measured elements on the day of analysis were determined based on measurements of blank solutions and calculated as three times the standard deviation on these. Blank solutions are the digestion solutions alone without the samples, treated in the Teflon bombs and diluted in the same way as the samples. At least one blank solution was prepared for every series of digestions.

In addition to the blank solution, one duplicate sample (same sample but two different digestions) and at least one sample of Certified Reference Material (CRM) were analysed per series of digestion. The duplicate sample was analysed to check the repeatability of the measurements, and the CRMs were analysed to check the accuracy. The CRMs used were DORM-5, TORT-3, DOLT-5 and SLRS-6 (https://nrc-digital-repository.canada.ca/).

The quality of the methods is checked by participation in the international QUASIMEME laboratory inter-calibration programme twice a year.

3.3 pH measurements

Soil and freshwater samples were measured for pH.

Soil

pH in soil samples was measured in a laboratory at Department of Ecoscience, Aarhus University, Roskilde, Denmark. Measurements followed the UN Standard operating procedure for soil pH determination (FAO, 2021). The soil was freeze-dried and sifted through a 2 mm sieve. Soil was weighed to a 50 mL vial and added H_2O (Milli-Q). The samples were placed at a shaking table for 2-3 hours. After settling for 18 hours, pH was measured.

Freshwater

pH in freshwater samples was measured both in the field and in the laboratory at Department of Ecoscience, Aarhus University, Roskilde, Denmark. In the field and in the lab, the measurements were made using a pre-calibrated WTW 3410 multimetre with a pH SenTix 940 probe. A sample was collected in a 2 L acid-washed plastic vial. The pH-probe was rinsed in Milli-Q water prior to being inserted in the sample. The pH reading was done after 5 minutes.

3.4 Data analyses

The element concentrations in the environmental baseline samples from 2012 and 2013 (pre-construction phase) are essential to evaluate the impact of the mine project on the environment. The impact analysis is primarily based on a comparison between concentrations of selected elements in the baseline samples and the monitoring samples from 2025. Where relevant, results from the environmental monitoring in 2018, 2019, 2023 (Fritt-Rasmussen et al. 2024) and 2024 (Fritt-Rasmussen et al. 2025) are also included. The following elements were selected for presentation in the main text of this report: **Al**, As, **Ca**, Cd, Cr, **Cu**, **Fe**, Hg, **Mg**, Ni, Pb and Zn. This list comprises elements recommended for analysis in the general EIA guideline for freshwater (Anon. 2015), and the elements in bold font are of particular relevance for the current mining project, because they are main constituents of the mined mineral or occur naturally in elevated concentrations in the area. In the assessment, values are flagged as elevated if they are higher than mean +2SD (two times the standard deviation) of the baseline measurements of the sample type in question (see results in chapter 4).

When preparing the current report, it was assessed that the calculation of element baseline concentrations for the Qaqortorsuaq anorthosite project (based on samples collected in 2012-13) could be improved as a result of ongoing quality control of data in the Mineral Resources Environmental Database (MRED). This has resulted in updated baseline values (mean+2SD) for some of the selected elements (Table 1). Appendix 8 provides updated baseline values for all elements, sample types and systems, including a detailed description of the calculations.

Table 1. New (from 2025 and onwards) and old (prior to 2025) baseline concentrations for selected elements in crinkled snow lichen, bladderwrack, blue mussel, freshwater (filtered) and freshwater (unfiltered). The unit is mg/kg dry weight for lichen, bladderwrack and blue mussel samples, and µg/L for freshwater. [a]Mg and Ca are highly abundant in seawater and therefore not included as part of the selected elements for the marine samples

	Lichen		Bladderwrack		Blue mussel		Freshwater filtered		Freshwater unfiltered	
	New	Old	New	Old	New	Old	New	Old	New	Old
Al	859	840	309	103	1539	1539	54	106	190	118
As	0.33	0.34	30	107	19	19	0.14	0.12	0.13	0.33
Ca[a]	21141	21214	-	-	-	-	25664	25738	25398	21866
Cd	0.25	0.24	1.05	3.23	5	5	0.02	0.03	0.03	0.04
Cr	3.08	3.17	0.86	12	7	7.02	0.36	0.5	0.6	0.4
Cu	7.53	7.87	17	21	26	26	8.87	9.68	11.69	10.32
Fe	1244	1282	260	105	1799	1799	180	193	289	230
Hg	0.25	0.26	0	0.16	0.24	0.24	0.02	0.02	0.03	0.03
Mg[a]	2587	2479	-	-	-	-	14457	13797	14602	9068
Ni	5	5	2.69	4.21	12	11.59	4.03	6.62	5.07	7.3
Pb	3	3	0.09	0.17	5.8	5.81	0.11	0.11	0.19	0.19
Zn	36	37	16	32	111	111	2.32	2.25	6.66	4.7

4 Results

The full dataset with concentrations of all elements across all sample types in 2025 is given in Appendix 3-6.

4.1 Crinkled snow lichens

The results of selected element concentrations in crinkled snow lichen are shown in Table 2 together with updated pre-mining baseline values. The full dataset is given in Appendix 3. The concentrations of Al are elevated compared to baseline levels at all stations, except the three stations north of the site (reference stations), two stations near the road and one in the terrain near Lake B (Table 2, Figure 4).

Near Lake A (tailings lake), the concentration of Al in lichens has increased from 2018 to 2025 (L17 in Figure 3). At the processing plant, the general trend is also an increase in Al concentrations from 2018 to 2025 (L2 and L4 in Figure 3).

A map of the Al concentration in the lichen samples is given in Figure 4. The main mining point sources and buffer zones (according to the permit) are also indicated on the map. In 2024, elevated concentrations of Al in lichen were only found outside the dust mitigation buffer zones at two stations near the processing plant. In 2025, elevated concentrations of Al in lichen were found outside the dust mitigation zone at most stations, except the three stations north of the site (reference stations), one stations near the road and one in the terrain near Lake B (Figure 4). The Al concentration decreased with increasing distance from the processing plant, indicating dispersion from this source via windborne dust (Table 2). For comparison, maps of the Al concentration in lichens for all monitoring years (2018, 2019, 2023, 2024 and 2025) are given in Appendix 7.

The elevated concentrations around the tailings lake (L17, L31 and L33) are likely a result of tailings being placed on the lakeshore and not below the thermocline in the lake as required in the company's permit. Since 2023, the company has been in a process to implement a facility to pump the tailings below the thermocline in Lake A. The facility was not (and had not been) in operation in August 2025, when DCE/GINR did the environmental monitoring on behalf of the authorities. Further, it remains unclear what the mining company's intentions are regarding the tailings already deposited at the lakeshore.

Table 2. Selected elements (mg/kg dry weight) measured in crinkled snow lichen (*Flavocetraria nivalis*) from different monitoring stations in 2025. Blue values are elevated compared to baseline samples from 2012 and 2013, representing the pre-mining concentration levels of the area. Values are flagged as elevated, if they are higher than mean +2SD of the baseline samples.

ID		Element (mg kg-1 dry weight)											
		Al	**As**	**Ca**	**Cd**	**Cr**	**Cu**	**Fe**	**Hg**	**Mg**	**Ni**	**Pb**	**Zn**
Baseline 2012-2013 (n=39)	Min	24	0.1	500	0.037	0.05	0.1	27	0.025	88	0.05	0.05	0.5
	Max	840	0.56	27000	0.23	3.2	13	1500	0.31	2300	6.5	6.3	38
	Mean	471	0.141	11469	0.139	1.598	3.00	623	0.125	1654	2.43	0.732	21.31
	SD	194	0.096	4836	0.055	0.742	2.27	311	0.062	467	1.33	0.949	7.56
	Mean +2SD	859	0.33	21141	0.25	3.08	7.53	1244	0.25	2587	5.08	2.63	36
Process plant, camp and harbor	L2	2207	0.06	15438	0.02	1.37	1.55	563	0.03	1122	1.24	0.29	12.0
	L2	2323	0.04	17639	0.03	0.92	1.43	426	0.03	1115	0.97	0.30	10.7
	L4	3534	0.03	26643	0.04	0.78	1.54	383	0.02	909	1.09	0.48	11.3
	L37	1033	0.03	9394	0.04	1.60	1.61	607	0.03	1044	1.27	0.24	13.2
	L37	912	0.02	10416	0.04	1.18	1.23	452	0.03	1001	1.01	0.25	12.3
	L38	1396	0.03	12799	0.03	1.08	1.67	422	0.03	812	0.92	0.23	8.8
Road	L7	4994	0.05	14337	0.03	2.43	3.27	1016	0.03	1033	2.53	0.42	22.0
	L9	1948	0.03	8530	0.04	3.12	2.40	1172	0.03	1065	2.09	0.39	13.3
	L11	905	0.02	8175	0.04	1.71	1.95	672	0.03	1246	1.33	0.23	20.0
	L18	741	0.03	9587	0.05	1.22	1.99	414	0.03	1535	1.47	0.17	18.9
	L34	1954	0.06	9757	0.04	5.21	4.04	2064	0.04	1647	3.76	0.48	17.5
	L35	801	0.02	6181	0.02	1.69	1.40	583	0.04	993	1.10	0.22	16.3
	L36	1431	0.03	10319	0.05	3.02	3.78	1214	0.03	1073	2.24	0.33	12.3
Terrain north of site	L12	400	0.01	5642	0.04	0.98	0.94	340	0.03	1319	1.16	0.13	13.1
	L13	405	0.02	5474	0.05	0.91	1.81	347	0.04	1374	2.12	0.14	27.1
	L14	854	0.03	12250	0.03	5.28	3.41	1266	0.02	1418	4.83	0.24	10.9
Tailings lake	L17	3208	0.03	19520	0.04	0.50	1.45	257	0.04	893	0.93	0.22	15.7
	L30	452	0.02	5821	0.05	0.95	1.29	374	0.04	1190	0.86	0.15	14.7
	L30	524	0.02	6253	0.05	1.16	1.34	444	0.03	1167	1.03	0.16	16.5
	L31	1141	0.02	7282	0.06	1.27	1.61	523	0.04	1535	1.34	0.20	21.1
	L33	1052	0.02	10903	0.05	0.79	1.50	322	0.03	1439	0.98	0.15	25.3
Pit	L20	1292	0.09	18509	0.08	2.91	4.84	1165	0.04	1267	3.88	0.42	15.0
	L21	1239	0.02	15424	0.08	1.08	1.49	458	0.03	1155	1.24	0.27	15.6
	L22	1585	0.01	9180	0.05	0.77	1.20	296	0.03	1033	0.87	0.18	20.2
	L23	1311	0.03	10413	0.02	0.92	1.15	327	0.03	786	0.80	0.18	11.3
	L24	1513	0.02	12955	0.07	1.32	1.27	536	0.03	822	1.22	0.35	13.6

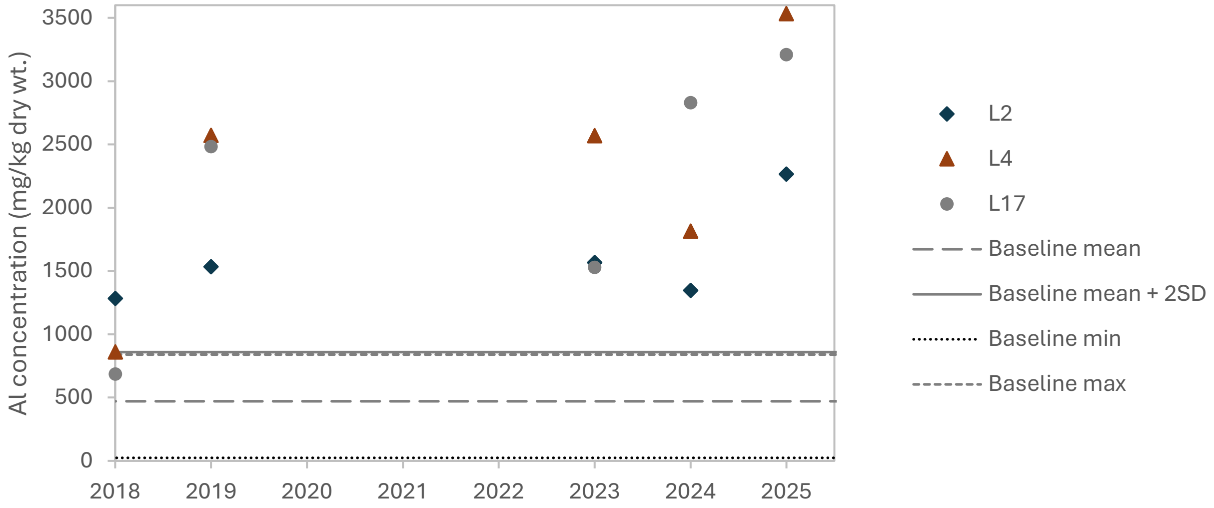


Figure 3. Concentrations of aluminium (Al) in crinkled snow lichen (*Flavocetraria nivalis*) samples close to the tailings lake (L17) and the processing plant (L2 and L4) in 2025. The mean baseline level, mean baseline level plus 2SD (standard deviations), and minimum and maximum baseline values for the entire area are also shown. Note that the baseline maximum incidentally coincides with the baseline mean +2SD.

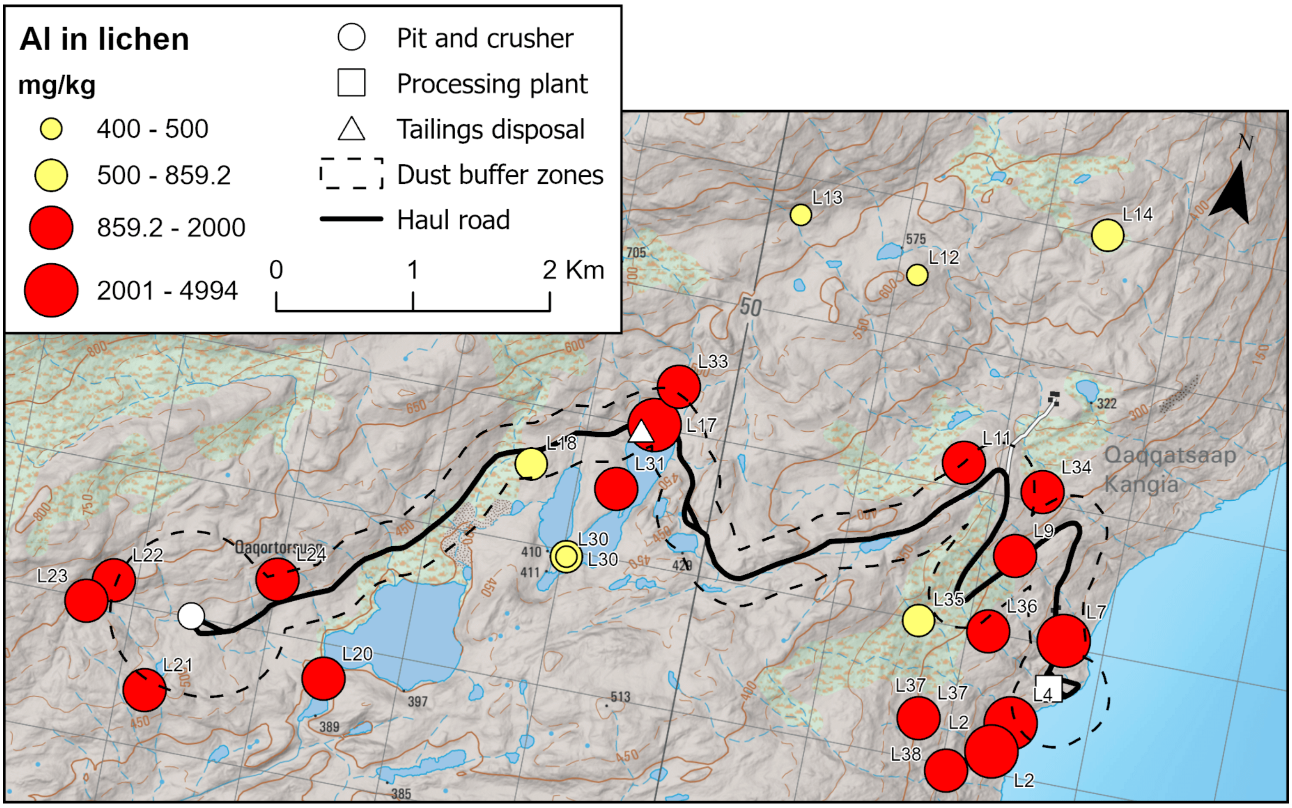


Figure 4. Concentrations of aluminium (Al) in crinkled snow lichen (*Flavocetraria nivalis*) samples in 2025. Concentrations above baseline +2SD (859.2 mg/kg dry weight) are shown as red circles and concentrations below baseline +2SD as yellow circles. The dotted line indicates the buffer zone outside where the dust deposition and dust concentration shall comply with threshold values in the permit. The buffer zones are: 500 m from crusher and open pit, 200 m from roads and 300 m from port.

4.2 Bladderwrack

Bladderwrack analyses results for selected elements (see section 3.4) are shown in Table 3, and the full dataset is given in Appendix 4. Al, Fe, Cr, Ni and Pb are above baseline mean plus 2SD at all three stations (Table 3). From 2024 to 2025, the concentrations of Al and Fe has increased 18 and 21 times, respectively, at the monitoring station closest to the processing plant (M1, Figure 5), i.e. Al has increased from 153 mg/kg dry wt. in 2024 to 2847 mg/kg dry wt. in 2025, and Fe has increased from 151 mg/kg dry wt. in 2024 to 3244 mg/kg dry wt. in 2025. For the 2026 authority monitoring, special attention will be given to the monitoring of bladderwrack.

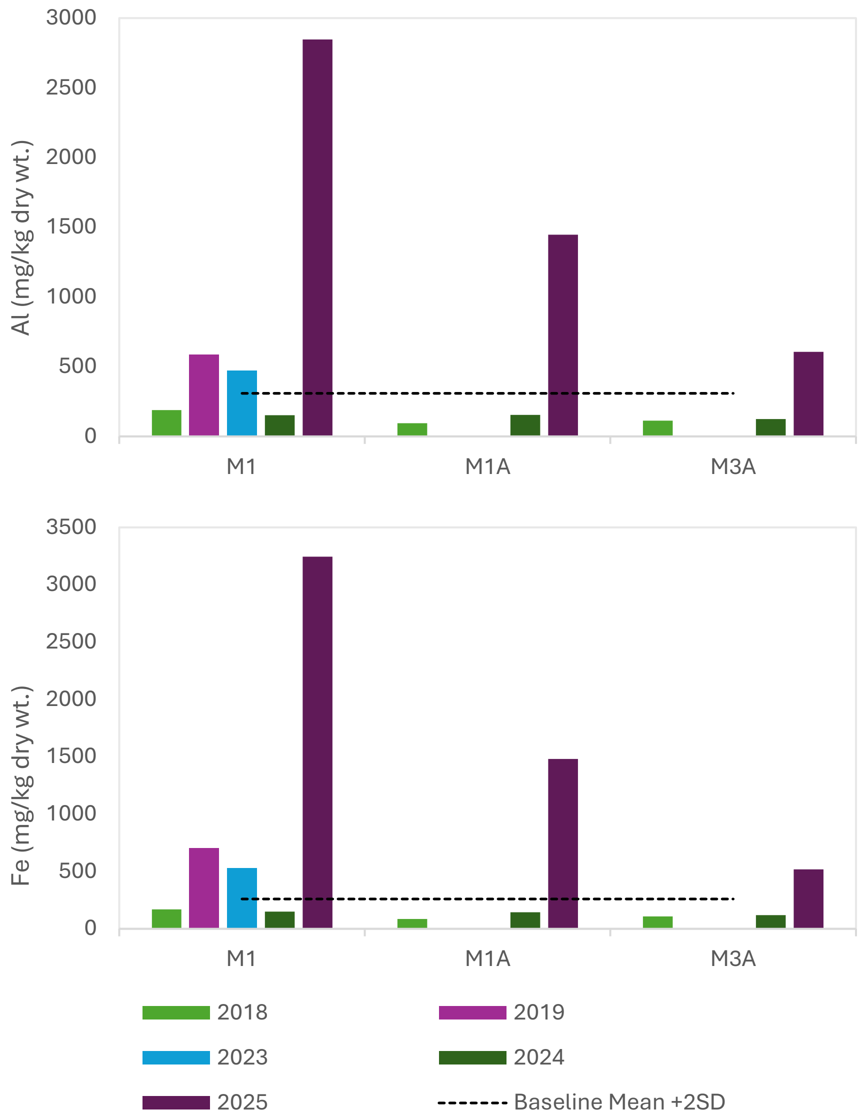


Figure 5. Concentrations of aluminium (Al, upper graph) and iron (Fe, lower graph) in bladderwrack (*Fucus vesiculosus*) samples at the monitoring stations M1, M1A and M3A. Baseline mean +2SD is shown as a horizontal black dashed line.

Table 3. Selected elements (mg/kg dry weight) measured in bladderwrack (*Fucus vesiculosus*) at different monitoring stations in 2025. Blue values are elevated compared to baseline samples from 2013, representing the pre-mining concentration levels of the area. Values are flagged as elevated if they are higher than mean +2SD of the baseline level.

ID	Year	Distance plant (km)	Samples *n*		Al	As	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
All baseline samples - pre-mining	2018		6	Mean	132	25	0.79	0.40	14.78	121	0.0022	1.72	0.051	12.4
				SD	88	3	0.13	0.23	1.05	70	0.0000	0.48	0.02	1.5
				Mean +2SD	309	30	1.05	0.86	16.89	260	0.0022	2.69	0.09	15.3
				Min	72	22	0.59	0.23	13.73	82	0.0022	1.22	0.03	10.4
				Max	305	29	0.99	0.85	16.09	257	0.0022	2.58	0.08	14.2
M1	2025	0.4	1		2847	23	0.94	10.98	17.51	3244	0.00	9.73	0.43	16.5
M1A	2025	0.8	2	Mean	1447	24	0.88	5.24	15.96	1480	<LOD	6.18	0.22	13.8
M3A	2025	0.8	1		607	22	1.08	1.94	14.40	519	<LOD	3.19	0.11	11.2

Element (mg/kg dry wt.): Al–Zn

4.3 Blue mussel

Selected results of element analyses of blue mussels are shown in Table 4, and the full dataset is given in Appendix 5. None of the selected elements are measured in elevated concentrations compared to the baseline samples, except Cu. The concentration of Cu was though, only elevated by 0.6 mg/kg dry weight compared to the baseline +2SD value (baseline value: 26 mg/kg dry wt. vs. measured in 2025: 26.6 mg/kg dry wt.).

The concentration of Al in the mussels sampled closest to the processing plant (station M1) shows an increase from 2019 to 2023, and a decrease from 2023 to 2025 (Figure 6).

Table 4. Selected elements (mg/kg dry weight) measured in blue mussels (*Mytilus edulis*) at different monitoring stations in 2025. Concentrations in baseline samples, reflecting the pre-mining level of the area, are also given. Blue values are elevated compared to baseline samples (values are flagged as elevated if higher than mean+2SD of the baseline samples). Dep. = depurated mussels, non-dep.= non-depurated mussels.

ID		Shell length (cm)	Distance plant (km)	Samples *n*		Al	As	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
Baseline 2013	Non-dep.			9	Mean + 2SD	1539	19	5.0	7.0	26	1799	0.24	12	5.8	111
					Min	490	14	2.9	2.6	15	540	0.069	5.9	0.48	85
					Max	1500	19	4.8	6.2	25	1500	0.23	11	6.6	110
					Mean	901	16	3.6	4.5	19	1066	0.1	8.3	1.6	94
					SD	319	1.7	0.7	1.3	3.0	367	0.05	1.6	2.1	8.5
M1	Dep.	4.0-4.9	0.4	1		206	11.7	4.28	1.60	15.1	227	0.041	6.78	0.448	54.9
	Non-dep.	4.0-4.9		1		456	12.3	3.86	2.66	12.1	507	0.044	8.91	0.345	57.3
M3A	Non-dep.	4.0-4.9	0.8	1		608	12.4	3.38	3.17	26.6	731	0.049	6.95	0.363	57.1

Elements (mg/kg dry wt.): Al–Zn

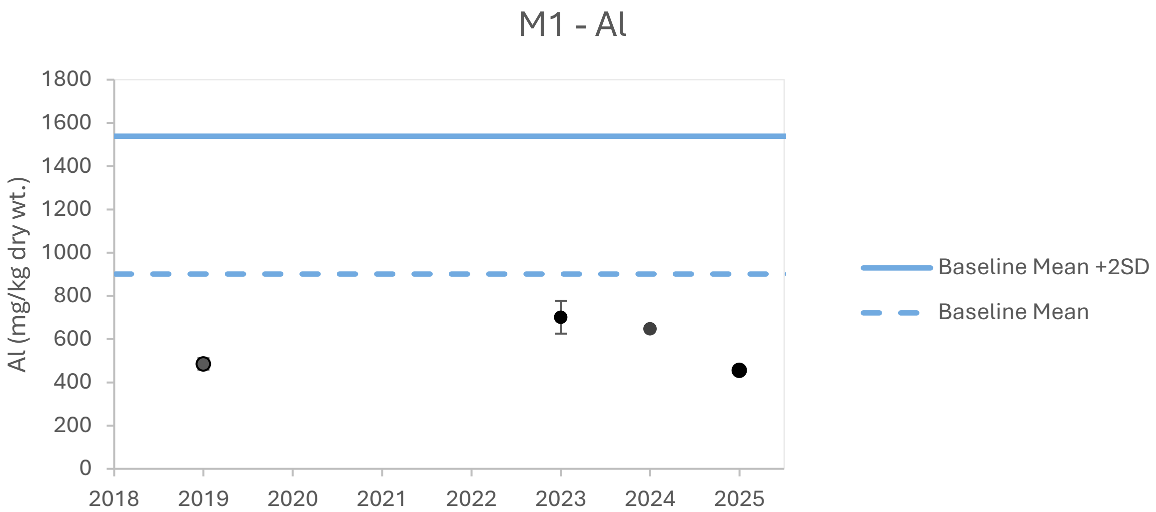


Figure 6. Concentrations of aluminium (Al) in non-depurated blue mussel (*Mytilus edulis*) samples collected close to the processing plant (Station M1) in 2019, 2023, 2024 and 2025. The mean baseline level and mean baseline level +2SD are also shown.

4.4 Freshwater

Concentrations of all element measurements in the freshwater samples are given in Appendix 6 for both filtered and unfiltered samples. In Table 5, concentrations of the selected elements in filtered and unfiltered freshwater samples are presented. Data on pre-mining baseline samples (mean and mean+2SD) and Greenland Water Quality Criteria (GWQC) for mining activities are also provided.

The baseline samples revealed a natural high concentration of Cu in the freshwater system. This is also reflected in the monitoring samples that have elevated concentrations compared to the GWQC. The concentrations are not elevated, when compared to the baseline levels. The highest Cu concentrations are found in the sample taken at the inlet of Lake A (F7).

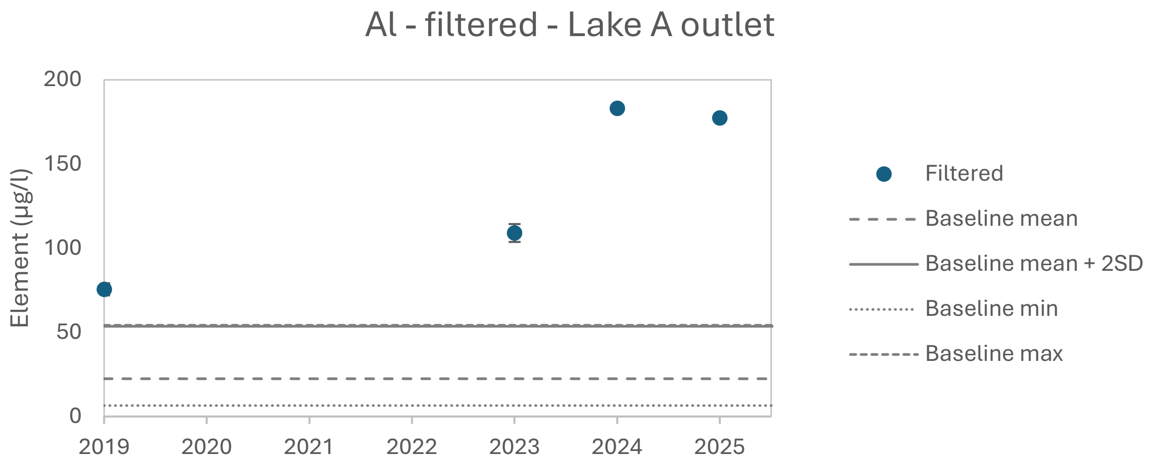
Aluminium is found in elevated concentrations compared to baseline levels in the samples taken at the outlet from the tailings deposition lake (Lake A) and the outlet from Lake B (F30) (Table 5). The elevated levels found here reflect the current tailings deposition activities. The Al concentrations in freshwater at the "Lake A outlet" station is 2-5 times higher than in 2023 (Figure 7). This likely reflects that tailings have been deposited on the northern shore of Lake A, from where the tailings enter the lake. The magnitudes of the increases above baseline levels are 8 times and 75 times for filtered and unfiltered samples, respectively, documenting that the increase in Al concentration primarily stems from particles (>0.45 µm) in suspension. The Al concentration at station F30 (outlet of Lake B) downstream from Lake A also exceed baseline levels in both filtered and unfiltered samples. This indicates that the current handling of tailings slowly results in the dispersal of tailings further down the freshwater system.

Aluminium is not included in the GWQC, and setting a guideline value is challenging, because the toxicity of Al relies heavily on the local chemical setting, including water pH. A guideline from British Columbia in Canada has compiled guideline values from several countries (B.C. Ministry of Water, Land, and Resource Stewardship 2023) and states a value of 55 µg/l for dissolved Al in freshwater with a pH above 6.5. The pH values in freshwater measured as part of the 2025 monitoring effort were all above 7.3 (Table 6). The Al concentration is approx. 3 times higher at the outlet of Lake A (177 µg/L), and approx. 1.5 times higher at station F30 (89 µg/L) than the Canadian guideline value. The freshwater samples taken further down the freshwater system do not have Al concentrations above baseline levels and the Canadian guideline value.

Concentrations of selected elements (µg/l) measured in freshwater samples (filtered and unfiltered) at different monitoring stations in 2025. Blue values are elevated compared to baseline samples (values are flagged as elevated if higher than mean +2SD of the baseline samples). Underlined values are above the Greenland Water Quality Criteria (GWQC) for mining activities. Measurements below instrument detection limit are marked with <LOD.

Table 5. Concentrations of selected elements (µg/l) measured in freshwater samples (filtered and unfiltered) at different monitoring stations in 2025. Blue values are elevated compared to baseline samples (values are flagged as elevated if higher than mean +2SD of the baseline samples). Underlined values are above the Greenland Water Quality Criteria (GWQC) for mining activities. Measurements below instrument detection limit are marked with <LOD.

				Elements (µg/l)											
				Al	**As**	**Ca**	**Cd**	**Cr**	**Cu**	**Fe**	**Hg**	**Mg**	**Ni**	**Pb**	**Zn**
GWQC	**Filtered**				**4**		**0.1**	**3**	**2**	**300**	**0.05**		**5**	**1**	**10**
Baseline	Filtered (n=12)	2012 + 2013	Mean +2SD	53.6	0.14	25664	0.02	0.36	8.87	180	0.02	14457	4.03	0.11	2.32
			Min	6.5	0.01	5449	0.00	0.08	3.01	4	0.00	1722	1.32	0.00	0.27
			Max	54.2	0.18	24362	0.02	0.37	8.43	217	0.02	18390	3.95	0.12	2.42
			Mean	22.4	0.05	13825	0.01	0.19	5.11	60	0.01	5500	2.43	0.04	1.01
			SD	15.6	0.04	5920	0.01	0.08	1.88	60	0.01	4479	0.80	0.03	0.65
	UnFiltered (n=12)	2012 + 2013	Mean +2SD	189.7	0.13	25398	0.03	0.60	11.69	289	0.03	14602	5.07	0.19	6.66
			Min	9.1	0.00	5733	0.00	0.06	3.63	5	0.001	1710	1.54	0.00	0.21
			Max	232.3	0.16	24393	0.03	0.74	11.40	293	0.03	18660	5.70	0.22	8.13
			Mean	58.4	0.04	13885	0.01	0.27	6.44	115	0.01	5533	2.74	0.07	2.30
			SD	65.7	0.04	5756	0.01	0.17	2.62	87	0.01	4535	1.17	0.06	2.18
2025	Filtered	F7		24	<LOD	7080	0.001	0.22	4.79	15.08	<LOD	3345	2.95	<LOD	0.52
		Lake A outlet		177	<LOD	16828	0.001	0.09	3.45	7.31	<LOD	3243	1.77	<LOD	<LOD
		F30		89	<LOD	15276	0.001	0.10	2.92	10.56	<LOD	3338	1.96	<LOD	1.21
		F20		29	<LOD	8525	0.001	0.20	3.33	26.14	<LOD	2666	1.94	<LOD	<LOD
		F31		24	<LOD	6219	0.001	0.19	3.24	18.25	<LOD	2081	1.95	<LOD	1.34
	Unfiltered	F7		31	<LOD	7117	0.001	0.24	5.04	21.10	<LOD	3332	2.97	<LOD	<LOD
		Lake A outlet		4433	<LOD	19675	0.002	0.17	3.91	74.86	<LOD	3303	1.96	0.071	1.11
		F30		944	<LOD	15958	0.001	0.14	3.19	27.38	<LOD	3395	2.04	0.016	1.07
		F20		46	<LOD	8585	0.001	0.21	3.61	36.75	<LOD	2653	2.44	<LOD	<LOD
		F31		30	<LOD	6266	0.001	0.20	4.00	26.69	<LOD	2110	1.84	0.010	2.42



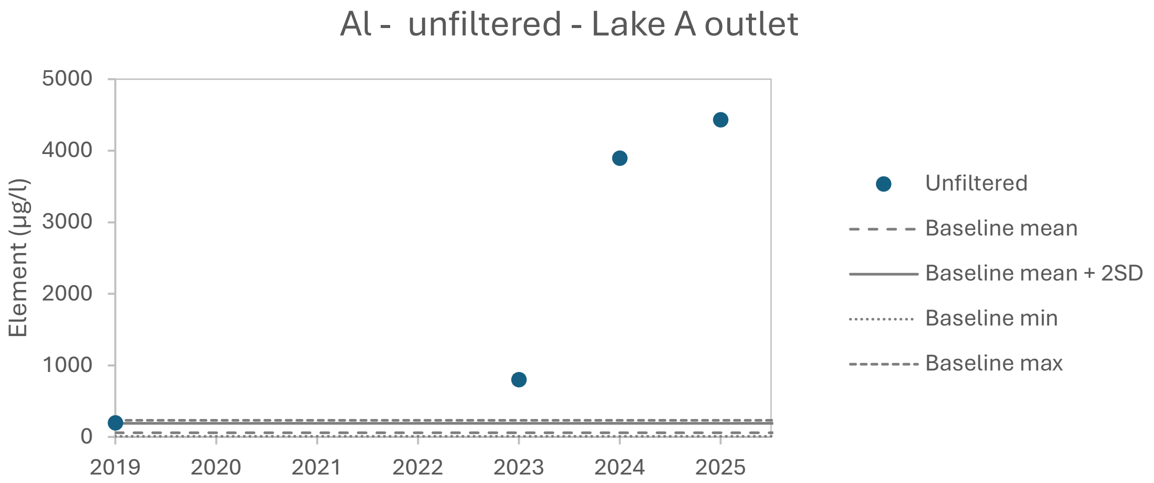


Figure 7. Concentrations of aluminium (Al) in filtered (top) and unfiltered (bottom) freshwater from the outlet of Lake A in 2019, 2023, 2024 and 2025. The mean baseline level, mean baseline level +2SD and minimum and maximum baseline values are shown.

Table 6. pH values in freshwater samples measured in the field and at the laboratory at Aarhus University, Roskilde, Denmark.

Station name	Field pH measurement	Laboratory pH measurement
F7	7.6	7.4
F Lake A	8.0	7.7
F30	7.8	7.7
F20	7.3	7.3
F31	7.4	7.4

4.5 pH in soil

Average pH in the soil samples is 6.3 (range: 5.5-8.3; Table 7), which is slightly acidic. Soils in Greenland are generally considered highly acidic with pH values below 5.5. At three of the sampling stations (L11, L20 and L21) the pH was 5.5 which is likely a reflection of local conditions.

Plants are susceptible to toxic effects of aluminium in the soil, but only in soils where pH is less than 5.5. In acidic soils (pH < 5.5), Al becomes soluble for uptake and bioaccumulation in the plants. As the pH in the collected soil samples has a mean value of 6.3, aluminium is not considered soluble to plants and as such has no environmental effects (US EPA, 2003; Rahman et al. 2024).

Table 7. pH measurements in soil (H_2O solution) in samples collected at the lichen stations. The three stations (L11, L20 and L21) with pH = 5.5 are marked in grey.

Station name	pH (soil in H_20-solution)
L2	6.7
L4	6.3
L7	6.9
L9	7.1
L11	5.5
L12	5.7
L13	6.5
L14	6.5
L17	5.9
L18	6.0
L20	5.5
L21	5.5
L22	5.8
L23	7.6
L24	5.6
L30	6.2
L31	5.8
L33	6.2
L34	8.2
L35	6.6
L36	6.7
L37	5.7
L38	6.5

5 Conclusions

The authority's environmental monitoring in 2025 documents elevated concentrations (compared to the baseline mean +2SD) of a few elements, mainly aluminium (Al), in crinkled snow lichen, bladderwrack and freshwater samples at most of the sampling stations. Al is a primary constituent of the mined anorthosite, and therefore the increases in concentrations over time, and the increases in concentrations towards point sources such as the processing plant, pit and roads, document a spread of elements to the surroundings from the mining activities. The temporal and spatial trends are particularly clear for crinkled snow lichen, indicating that dust dispersion is a main vector for the spread of elements. Elevated concentrations of Al in lichen are found outside the designated dust mitigation buffer zones at all stations, except the three stations north of the site (reference stations), one stations near the road and one in the terrain near Lake B.

Thus, DCE/GINR recommend that extra focus on dust monitoring and mitigation by the company is continued. DCE/GINR recommend that dust mitigation e.g., water spraying of the roads are implemented. Further, DCE/GINR recommend that attention is given to get the tailings plant in operation so that tailings can be deposited below the thermocline in Lake A in compliance with the terms in the license agreement. The increased concentrations of Al in freshwater samples at the outlet of Lake A (the tailings lake) and Lake B (F30) are assessed as being a result of the tailings disposal at the lake shoreline (Figure 8). DCE/GINR recommend that the tailings at the lake shoreline is removed and deposited below the thermocline in Lake A in compliance with the license agreement. DCE/GINR further recommend that the monitoring of the freshwater system is continued.

The 18- and 21-fold increases in Al and Fe respectively in the bladderwrack samples were unexpected. As the element concentrations in blue mussels were not above the baseline values at any of the monitored stations, there is no clear explanation of the elevated concentrations in the bladderwrack samples. DCE/GINR recommend that the marine monitoring is continued at M1, M1A and M3A to follow this development.

Figure 8. Tailings deposited on lake shore at Lake A. From there it disperses to the lake and the surroundings on land.
Photo: Katrine Raundrup.

DCE/GINR recommend that the development of element concentrations is monitored annually at the same stations and at the same time of year. Further, DCE/GINR recommend that the monitoring program continues to be adaptive to changes in the mining activities e.g., increased production. The current monitoring data further underline the significance of the company maintaining a comprehensive dust mitigation program.

For the 2026 authority environmental monitoring, DCE/GINR recommend:

- That environmental monitoring by the authorities is continued, and that sampling is conducted during the same period as in 2023-2025. Specifically for bladderwrack, where the growth tips of the year are collected, it is important that the collection is performed at the end of the growing season. Thus, sampling of bladderwrack is conducted in August/early September.
- That monitoring by the authorities of crinkled snow lichen is continued at the same stations as in 2025, and that the lichen sampling is supplemented with pH measurements of the soil.
- That the mining company (and their environmental consultants) rely on Bergerhoff dust collection samplers for the compliance control and omit lichens collected in the same areas as the authority's environmental monitoring stations to avoid unnecessary duplication of the monitoring work and depletion of the lichen reserve at the stations. The Bergerhoff samplers have the advantage of giving a quicker indication of increases in dust levels and element concentrations, as well as providing a measure of absolute dust deposition rates, but often with limited spatial coverage. In contrast, the lichens provide a relative measure of the long-term dust deposition and increases in element concentrations, potentially covering a much larger area.
- That monitoring of freshwater by the authorities is continued at the same locations as in 2025. That pH is also measured in the freshwater samples. That a reference station is included >200 upstream from F7.
- That monitoring of bladderwrack and blue mussels by the authorities are continued at the three marine stations used in 2025 (M1, M1A and M3A).

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Appendix 1 Monitoring stations

The stations sampled during the 2025 authority environmental monitoring, including station names, sample types and coordinates (decimal degrees, datum: WGS84).

Station ID	Sample type	Latitude	Longitude
F7	Fresh water	66.57052	-52.13578
F Lake A Outlet	Fresh water	66.56581	-52.13956
F20	Fresh water	66.56142	-52.16612
F30	Fresh water	66.56101	-52.15047
F31	Fresh water	66.54983	-52.18358
L2	Crinkled snow lichen/Soil	66.55475	-52.07350
L4	Crinkled snow lichen/Soil	66.55678	-52.07142
L7	Crinkled snow lichen/Soil	66.56278	-52.06567
L9	Crinkled snow lichen/Soil	66.56756	-52.07642
L11	Crinkled snow lichen/Soil	66.57280	-52.08780
L12	Crinkled snow lichen/Soil	66.58420	-52.10170
L13	Crinkled snow lichen/Soil	66.58643	-52.12245
L14	Crinkled snow lichen/Soil	66.58930	-52.07250
L17	Crinkled snow lichen/Soil	66.57101	-52.13871
L18	Crinkled snow lichen/Soil	66.56681	-52.15715
L20	Crinkled snow lichen/Soil	66.55025	-52.18310
L21	Crinkled snow lichen/Soil	66.54708	-52.21143
L22	Crinkled snow lichen/Soil	66.55367	-52.22010
L23	Crinkled snow lichen/Soil	66.55198	-52.22375
L24	Crinkled snow lichen/Soil	66.55597	-52.19389
L30	Crinkled snow lichen/Soil	66.56139	-52.14830
L31	Crinkled snow lichen/Soil	66.56641	-52.14268
L33	Crinkled snow lichen/Soil	66.57380	-52.13612
L34	Crinkled snow lichen/Soil	66.57201	-52.07414
L35	Crinkled snow lichen/Soil	66.56211	-52.08965
L36	Crinkled snow lichen/Soil	66.56237	-52.07815
L37	Crinkled snow lichen/Soil	66.55588	-52.08632
L38	Crinkled snow lichen/Soil	66.55289	-52.08013
M1	Blue mussel/Bladderwrack	66.55635	-52.07058
M1A	Bladder wrack	66.55269	-52.07072
M3A	Blue mussel/Bladderwrack	66.56569	-52.05994

Appendix 2 All monitoring samples

Information on all 2025 monitoring samples included in the monitoring report. [a]size class non-depurated. [b]size class deputrated, [c]filtered to <0.45 um using Whatman PES filter.

Station name	Sample ID	Sample type	Additional information	Latitude	Longitude	Methods	Unit
M1	67726	Bladder wrack		66.55635	-52.07058	ICP-MS	mg/kg
M1A	67727	Bladder wrack		66.55269	-52.07072	ICP-MS	mg/kg
M3A	67852	Bladder wrack		66.56569	-52.05994	ICP-MS	mg/kg
M1	67854	Blue mussel	4.0-4.9 cm[b]	66.55635	-52.07058	ICP-MS	mg/kg
M1	67725	Blue mussel	4.0-4.9 cm[a]	66.55635	-52.07058	ICP-MS	mg/kg
M3A	67853	Blue mussel	4.0-4.9 cm[a]	66.56569	-52.05994	ICP-MS	mg/kg
L2	67704	Crinkled snow lichen		66.55475	-52.07350	ICP-MS	mg/kg
L4	67706	Crinkled snow lichen		66.55678	-52.07142	ICP-MS	mg/kg
L7	67750	Crinkled snow lichen		66.56278	-52.06567	ICP-MS	mg/kg
L9	67723	Crinkled snow lichen		66.56756	-52.07642	ICP-MS	mg/kg
L11	67746	Crinkled snow lichen		66.57280	-52.08780	ICP-MS	mg/kg
L12	67738	Crinkled snow lichen		66.58420	-52.10170	ICP-MS	mg/kg
L13	67740	Crinkled snow lichen		66.58643	-52.12245	ICP-MS	mg/kg
L14	67742	Crinkled snow lichen		66.58930	-52.07250	ICP-MS	mg/kg
L17	67728	Crinkled snow lichen		66.57101	-52.13871	ICP-MS	mg/kg
L18	67730	Crinkled snow lichen		66.56681	-52.15715	ICP-MS	mg/kg
L20	67855	Crinkled snow lichen		66.55025	-52.18310	ICP-MS	mg/kg
L21	67857	Crinkled snow lichen		66.54708	-52.21143	ICP-MS	mg/kg
L22	67859	Crinkled snow lichen		66.55367	-52.22010	ICP-MS	mg/kg
L23	67861	Crinkled snow lichen		66.55198	-52.22375	ICP-MS	mg/kg
L24	67863	Crinkled snow lichen		66.55597	-52.19389	ICP-MS	mg/kg
L30	67732	Crinkled snow lichen		66.56139	-52.14830	ICP-MS	mg/kg
L31	67734	Crinkled snow lichen		66.56641	-52.14268	ICP-MS	mg/kg
L33	67744	Crinkled snow lichen		66.57380	-52.13612	ICP-MS	mg/kg
L34	67748	Crinkled snow lichen		66.57201	-52.07414	ICP-MS	mg/kg
L35	67708	Crinkled snow lichen		66.56211	-52.08965	ICP-MS	mg/kg
L36	67709	Crinkled snow lichen		66.56237	-52.07815	ICP-MS	mg/kg
L37	67711	Crinkled snow lichen		66.55588	-52.08632	ICP-MS	mg/kg
L38	67713	Crinkled snow lichen		66.55289	-52.08013	ICP-MS	mg/kg
F7	67721	Fresh water	Unfiltered + pH	66.57052	-52.13578	ICP-MS	ug/L
F7	67722	Fresh water	Filtered[c]	66.57052	-52.13578	ICP-MS	ug/L
F Lake A Outlet	67717	Fresh water	Unfiltered + pH	66.56581	-52.13956	ICP-MS	ug/L
F Lake A Outlet	67718	Fresh water	Filtered[c]	66.56581	-52.13956	ICP-MS	ug/L
F20	67715	Fresh water	Unfiltered + pH	66.56142	-52.16612	ICP-MS	ug/L
F20	67716	Fresh water	Filtered[c]	66.56142	-52.16612	ICP-MS	ug/L
F30	67719	Fresh water	Unfiltered + pH	66.56101	-52.15047	ICP-MS	ug/L
F30	67720	Fresh water	Filtered[c]	66.56101	-52.15047	ICP-MS	ug/L
F31	67865	Fresh water	Unfiltered + pH	66.54983	-52.18358	ICP-MS	ug/L
F31	67866	Fresh water	Filtered[c]	66.54983	-52.18358	ICP-MS	ug/L
L2	67705	Sediment		66.55475	-52.07350	FAO (2021)	pH
L4	67707	Sediment		66.55678	-52.07142	FAO (2021)	pH
L7	67851	Sediment		66.56278	-52.06567	FAO (2021)	pH
L9	67724	Sediment		66.56756	-52.07642	FAO (2021)	pH
L11	67747	Sediment		66.57280	-52.08780	FAO (2021)	pH
L12	67739	Sediment		66.58420	-52.10170	FAO (2021)	pH
L13	67741	Sediment		66.58643	-52.12245	FAO (2021)	pH
L14	67743	Sediment		66.58930	-52.07250	FAO (2021)	pH
L17	67729	Sediment		66.57101	-52.13871	FAO (2021)	pH

L18	67731	Sediment	66.56681	-52.15715	FAO (2021)	pH
L20	67856	Sediment	66.55025	-52.18310	FAO (2021)	pH
L21	67858	Sediment	66.54708	-52.21143	FAO (2021)	pH
L22	67860	Sediment	66.55367	-52.22010	FAO (2021)	pH
L23	67862	Sediment	66.55198	-52.22375	FAO (2021)	pH
L24	67864	Sediment	66.55597	-52.19389	FAO (2021)	pH
L30	67733	Sediment	66.56139	-52.14830	FAO (2021)	pH
L31	67735	Sediment	66.56641	-52.14268	FAO (2021)	pH
L33	67745	Sediment	66.57380	-52.13612	FAO (2021)	pH
L34	67749	Sediment	66.57201	-52.07414	FAO (2021)	pH
L35	67736	Sediment	66.56211	-52.08965	FAO (2021)	pH
L36	67710	Sediment	66.56237	-52.07815	FAO (2021)	pH
L37	67712	Sediment	66.55588	-52.08632	FAO (2021)	pH
L38	67714	Sediment	66.55289	-52.08013	FAO (2021)	pH

Appendix 3 Crinkled snow lichen samples

Element analyses results (concentrations in mg/kg dry weight) for lichen samples from monitoring in 2025. Blue values indicate values higher than mean +2SD of baseline samples. Note that baseline values are not available for all elements. Measurements below instrument detection limit are marked with <LOD (limit of detection).

Station ID Element (mg/kg dry wt.)	Mean baseline (2012 + 2013) + 2SD	L2	L2	L4	L7	L9	L11	L12	L13	L14	L17	L18	L20	L21
Ag	**0.08**	0.001	0.001	0.000	0.001	0.001	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.000
Al	**859**	2207	2323	3534	4994	1948	905	400	405	854	3208	741	1292	1239
As	**0.33**	0.056	0.037	0.034	0.049	0.027	0.020	0.007	0.022	0.033	0.034	0.029	0.087	0.021
Au	**0.50**	0.007	0.007	0.005	0.001	0.002	0.006	0.003	0.010	0.004	0.002	0.022	0.006	0.006
Ba	**104**	25.7	23.9	28.6	28.7	28.2	40.3	29.2	30.8	36.5	24.5	40.5	55.6	49.2
Be		0.006	0.005	0.006	0.011	0.011	0.007	0.004	0.004	0.011	0.006	0.004	0.013	0.007
Bi	**25**	0.008	0.007	0.019	0.010	0.005	0.003	0.001	0.002	0.003	0.010	0.007	0.005	0.005
Ca	**21141**	15438	17639	26643	14337	8530	8175	5642	5474	12250	19520	9587	18509	15424
Cd	**0.25**	0.023	0.027	0.042	0.031	0.038	0.043	0.036	0.046	0.030	0.036	0.047	0.082	0.085
Ce	**10**	5.055	4.321	7.244	6.896	9.270	8.185	1.849	1.933	7.591	3.607	2.489	17.662	5.084
Co	**2.31**	0.350	0.292	0.312	0.696	0.869	0.494	0.298	0.491	1.340	0.265	0.425	1.301	0.367
Cr	**3.08**	1.375	0.920	0.782	2.432	3.116	1.710	0.981	0.907	5.277	0.499	1.216	2.910	1.078
Cs		0.039	0.032	0.039	0.056	0.031	0.025	0.012	0.013	0.031	0.039	0.013	0.049	0.027
Cu	**7.53**	1.546	1.427	1.544	3.272	2.404	1.950	0.940	1.809	3.406	1.446	1.992	4.838	1.488
Dy		0.132	0.097	0.097	0.131	0.195	0.110	0.050	0.053	0.182	0.051	0.060	0.224	0.094
Er		0.067	0.049	0.045	0.066	0.098	0.053	0.025	0.026	0.091	0.023	0.030	0.106	0.044
Eu		0.068	0.051	0.065	0.073	0.097	0.063	0.023	0.029	0.083	0.038	0.029	0.129	0.050
Fe	**1244**	563	426	383	1016	1172	672	340	347	1266	257	414	1165	458
Ga		0.467	0.440	0.628	0.905	0.636	0.413	0.159	0.165	0.493	0.494	0.210	0.766	0.342
Gd		0.246	0.185	0.219	0.251	0.362	0.240	0.089	0.109	0.326	0.120	0.105	0.494	0.187
Hf		0.006	0.003	0.002	0.008	0.014	0.009	0.005	0.005	0.017	<LOD	0.003	0.015	0.007
Hg	**0.25**	0.026	0.028	0.022	0.026	0.032	0.033	0.034	0.037	0.022	0.035	0.032	0.035	0.026
Ho		0.024	0.018	0.017	0.024	0.036	0.020	0.009	0.009	0.035	0.009	0.011	0.041	0.017
K	**3480**	1704	1770	1779	2139	1978	2225	1685	2043	1752	1894	2186	1793	1636
La	**5.97**	3.374	2.605	3.995	3.671	4.647	4.732	1.151	1.692	3.878	2.182	1.360	10.893	3.096
Li		0.219	0.164	0.232	0.533	0.430	0.182	0.051	0.066	0.391	0.255	0.161	0.454	0.166
Lu		0.007	0.005	0.005	0.007	0.010	0.005	0.003	0.003	0.010	0.002	0.003	0.011	0.004
Mg	**2587**	1122	1115	909	1033	1065	1246	1319	1374	1418	893	1535	1267	1155
Mn	**112**	23.0	20.3	28.6	40.7	47.2	42.7	47.2	42.7	46.3	24.1	44.8	43.9	42.2
Mo	**0.14**	0.073	0.069	0.083	0.115	0.066	0.048	0.031	0.048	0.084	0.062	0.041	0.105	0.045
Na	**1344**	872	858	896	1081	528	697	417	424	767	828	652	757	699
Nb		0.062	0.045	0.033	0.077	0.119	0.090	0.062	0.067	0.122	0.022	0.064	0.124	0.076
Nd	**3.47**	2.342	1.800	2.559	2.487	3.340	2.852	0.812	1.139	2.959	1.431	0.983	6.188	1.949
Ni	**5.08**	1.244	0.966	1.086	2.532	2.091	1.329	1.160	2.115	4.833	0.931	1.472	3.879	1.241
P	**1058**	551	618	775	709	818	949	802	894	597	688	955	694	568
Pb	**2.63**	0.292	0.301	0.479	0.418	0.389	0.234	0.130	0.135	0.243	0.218	0.169	0.423	0.274
Pd		0.004	0.004	0.004	0.003	0.003	0.002	0.002	0.003	0.003	0.002	0.003	0.004	0.003
Pr		0.672	0.519	0.757	0.720	0.950	0.867	0.233	0.325	0.836	0.424	0.281	1.876	0.577
Pt		<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Rb		1.716	1.410	1.598	3.058	1.553	3.541	1.058	1.052	2.134	1.466	1.384	4.148	2.706
Re		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	<LOD	0.000	0.000
Ru		<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Sb	**0.13**	0.004	0.003	0.008	0.006	0.003	0.006	<LOD	0.004	0.003	0.002	0.005	0.003	0.002
Sc	**0.25**	0.233	0.169	0.166	0.342	0.437	0.275	0.146	0.138	0.492	0.097	0.164	0.444	0.184
Se	**2.69**	0.080	0.083	0.062	0.069	0.067	0.061	0.046	0.044	0.065	0.056	0.060	0.104	0.062
Sm	**0.50**	0.351	0.261	0.345	0.363	0.500	0.373	0.120	0.159	0.448	0.190	0.147	0.752	0.268
Sr	**105**	61.2	67.4	94.3	54.8	49.9	34.0	24.8	30.9	37.2	56.7	48.3	71.3	48.7
Ta		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Tb		0.027	0.020	0.022	0.028	0.041	0.025	0.010	0.011	0.037	0.012	0.012	0.050	0.020
Te		0.002	0.001	<LOD	0.001	0.001	0.001	0.001	0.001	0.002	<LOD	0.003	<LOD	0.001
Th	**0.25**	0.320	0.286	0.515	0.434	0.327	0.217	0.072	0.057	0.282	0.321	0.094	0.323	0.146
Ti	**99**	52.5	38.6	31.7	86.6	106.1	62.0	32.1	32.8	103.0	21.3	38.0	110.2	45.2
Tl	**0.05**	0.001	<LOD	<LOD	0.005	0.003	0.001	<LOD	0.001	0.005	<LOD	<LOD	0.008	0.001
Tm		0.009	0.006	0.006	0.009	0.012	0.007	0.003	0.003	0.012	0.003	0.004	0.013	0.005
U	**0.05**	0.064	0.043	0.031	0.079	0.025	0.017	0.008	0.018	0.026	0.013	0.010	0.035	0.016
V	**3.71**	1.375	1.046	0.821	2.340	3.032	1.858	0.935	0.954	3.306	0.542	1.111	2.951	1.207
W	**3.81**	0.171	0.215	0.336	0.138	0.031	0.014	0.006	0.005	0.007	0.502	0.013	0.010	0.010
Y	**0.75**	0.746	0.554	0.515	0.709	1.050	0.559	0.262	0.270	0.972	0.260	0.315	1.192	0.509
Yb		0.050	0.038	0.032	0.052	0.074	0.040	0.020	0.019	0.071	0.016	0.023	0.081	0.032
Zn		12.03	10.68	11.34	22.01	13.25	19.97	13.12	27.12	10.91	15.72	18.95	15.00	15.64
Zr	**36**	0.288	0.192	0.132	0.375	0.545	0.355	0.206	0.189	0.643	<LOD	0.118	0.579	0.241

Station ID Element (mg/kg dry wt.)	Mean baseline (2012 + 2013) + 2SD	L22	L23	L24	L30	L30	L31	L33	L34	L35	L36	L37	L37	L38
Ag	**0.08**	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.000	0.000
Al	**840**	1585	1311	1513	452	524	1141	1052	1954	801	1431	1033	912	1396
As	**0.34**	0.014	0.026	0.019	0.022	0.018	0.020	0.024	0.057	0.025	0.031	0.029	0.022	0.030
Au	**0.50**	0.003	0.003	0.003	0.005	0.004	0.010	0.009	0.004	0.003	0.003	0.003	0.002	0.004
Ba	**109**	36.6	23.5	35.6	29.6	27.4	41.4	26.9	43.5	16.5	19.7	30.6	31.9	15.0
Be		0.005	0.005	0.007	0.005	0.005	0.006	0.004	0.019	0.007	0.012	0.007	0.005	0.006
Bi	**25**	0.006	0.006	0.005	0.002	0.006	0.003	0.002	0.005	0.002	0.004	0.003	0.003	0.003
Ca	**21214**	9180	10413	12955	5821	6253	7282	10903	9757	6181	10319	9394	10416	12799
Cd	**0.24**	0.045	0.023	0.071	0.053	0.046	0.056	0.048	0.045	0.024	0.050	0.036	0.042	0.029
Ce	**11**	1.851	2.548	4.913	1.786	2.421	2.475	1.649	12.499	3.570	7.743	4.211	4.463	3.665
Co	**2.41**	0.273	0.325	0.387	0.345	0.418	0.472	0.229	1.477	0.475	0.953	0.413	0.329	0.309
Cr	**3.17**	0.771	0.917	1.317	0.947	1.156	1.274	0.786	5.211	1.688	3.019	1.602	1.176	1.083
Cs		0.016	0.018	0.043	0.011	0.012	0.023	0.017	0.052	0.018	0.030	0.022	0.020	0.019
Cu	**7.87**	1.199	1.151	1.273	1.287	1.338	1.609	1.497	4.043	1.405	3.785	1.614	1.231	1.670
Dy		0.041	0.061	0.102	0.050	0.060	0.066	0.041	0.288	0.090	0.194	0.097	0.100	0.109
Er		0.021	0.029	0.049	0.026	0.032	0.033	0.022	0.144	0.044	0.097	0.049	0.050	0.052
Eu		0.021	0.030	0.051	0.022	0.028	0.030	0.020	0.136	0.039	0.087	0.045	0.047	0.055
Fe	**1282**	296	327	536	374	444	523	322	2064	583	1214	607	452	422
Ga		0.274	0.268	0.387	0.154	0.191	0.282	0.206	0.844	0.280	0.555	0.321	0.297	0.342
Gd		0.075	0.111	0.191	0.083	0.107	0.110	0.075	0.513	0.154	0.335	0.172	0.183	0.205
Hf		0.001	0.002	0.006	0.005	0.007	0.007	0.003	0.029	0.010	0.017	0.008	0.006	0.004
Hg	**0.26**	0.032	0.033	0.033	0.040	0.034	0.040	0.030	0.040	0.035	0.031	0.031	0.030	0.028
Ho		0.008	0.011	0.019	0.010	0.012	0.012	0.008	0.054	0.017	0.036	0.018	0.018	0.020
K	**3368**	1890	1880	1742	2003	1898	2070	2043	2294	1754	1845	1718	1646	1682
La	**6.38**	0.956	1.453	2.700	0.892	1.303	1.336	0.888	6.723	1.846	3.991	2.251	2.451	2.870
Li		0.159	0.126	0.182	0.088	0.142	0.162	0.112	0.542	0.159	0.314	0.167	0.141	0.154
Lu		0.002	0.003	0.005	0.003	0.003	0.004	0.002	0.016	0.005	0.010	0.005	0.005	0.005
Mg	**2479**	1033	786	822	1190	1167	1535	1439	1647	993	1073	1044	1001	812
Mn	**112**	49.2	29.1	37.2	42.3	41.2	72.1	33.3	69.3	43.9	45.3	35.9	31.5	19.2
Mo	**0.15**	0.040	0.050	0.050	0.033	0.043	0.035	0.040	0.085	0.057	0.084	0.050	0.043	0.083
Na	**1270**	700	553	605	481	546	743	624	681	429	506	544	521	530
Nb		0.044	0.054	0.074	0.064	0.069	0.084	0.049	0.191	0.074	0.126	0.082	0.064	0.051
Nd	**3.58**	0.693	1.039	1.837	0.707	0.971	0.990	0.647	4.603	1.341	2.877	1.568	1.685	1.979
Ni	**4.67**	0.870	0.800	1.220	0.862	1.026	1.335	0.984	3.755	1.104	2.239	1.268	1.011	0.916
P	**1102**	776	952	723	762	777	996	724	980	870	820	762	692	565
Pb	**3.43**	0.177	0.176	0.352	0.146	0.162	0.204	0.155	0.477	0.215	0.334	0.241	0.246	0.233
Pd		0.001	0.002	0.001	0.002	0.002	0.002	0.003	0.004	0.002	0.003	0.002	0.003	0.003
Pr		0.198	0.296	0.533	0.197	0.275	0.278	0.184	1.308	0.380	0.813	0.448	0.482	0.573
Pt		<LOD	<LOD	<LOD	0.000	0.000	<LOD	<LOD	<LOD	<LOD	0.000	<LOD	<LOD	<LOD
Rb		2.216	1.138	3.867	1.131	1.217	3.647	1.144	3.049	1.363	1.821	1.961	1.864	0.983
Re		<LOD	<LOD	<LOD	0.000	0.000	0.000	0.000	0.000	<LOD	0.000	<LOD	<LOD	0.000
Ru		<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Sb		0.004	0.002	0.002	0.002	0.003	0.004	0.004	0.003	0.002	0.003	0.003	0.003	0.003
Sc	**0.25**	0.119	0.135	0.219	0.154	0.179	0.212	0.129	0.776	0.229	0.447	0.244	0.189	0.186
Se	**2.55**	0.051	0.055	0.067	0.053	0.053	0.053	0.048	0.092	0.053	0.090	0.062	0.058	0.072
Sm	**0.50**	0.103	0.157	0.268	0.113	0.148	0.152	0.100	0.697	0.210	0.440	0.235	0.252	0.285
Sr	**105**	22.0	45.4	31.6	33.2	32.3	23.3	44.4	59.3	36.3	63.6	51.7	58.2	51.1
Ta		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Tb		0.009	0.012	0.021	0.010	0.012	0.013	0.009	0.058	0.018	0.039	0.020	0.021	0.023
Te		0.001	0.001	0.001	<LOD	<LOD	0.001	0.001	0.003	0.002	0.001	0.001	0.001	0.001
Th	**0.25**	0.090	0.133	0.179	0.086	0.111	0.099	0.089	0.600	0.124	0.303	0.138	0.132	0.207
Ti	**101**	27.1	31.7	52.5	33.7	40.1	50.2	29.2	171.2	55.2	106.2	56.8	46.2	39.7
Tl	**0.05**	<LOD	<LOD	<LOD	0.001	0.001	<LOD	0.001	0.008	<LOD	0.004	0.001	<LOD	<LOD
Tm		0.003	0.004	0.006	0.004	0.004	0.004	0.003	0.019	0.006	0.013	0.006	0.006	0.007
U	**0.05**	0.009	0.011	0.021	0.011	0.012	0.013	0.009	0.038	0.013	0.049	0.019	0.018	0.037
V	**3.78**	0.781	0.871	1.440	1.014	1.224	1.480	0.844	5.450	1.617	3.279	1.663	1.251	1.112
W	**3.94**	0.009	0.010	0.011	0.010	0.011	0.047	0.038	0.024	0.016	0.029	0.031	0.034	0.084
Y	**0.69**	0.216	0.315	0.550	0.254	0.316	0.349	0.217	1.538	0.465	1.026	0.520	0.538	0.599
Yb		0.016	0.022	0.037	0.021	0.025	0.026	0.016	0.115	0.033	0.076	0.038	0.037	0.038
Zn		20.20	11.33	13.57	14.70	16.50	21.08	25.28	17.53	16.31	12.25	13.22	12.27	8.81
Zr	**37**	0.061	0.093	0.233	0.199	0.239	0.276	0.122	1.251	0.354	0.650	0.308	0.244	0.210

Appendix 4 Bladderwrack samples

Element analyses results (concentration in mg/kg dry weight) for bladderwrack samples from monitoring in 2025. Blue values are higher than mean +2SD of baseline samples. Note that baseline values are not available for all elements. Measurements below instrument detection limit are marked with <LOD.

		Bladderwrack growth tips			
Element	**Mean baseline (2013) + 2SD**	**M1**	**M1A**	**M1A**	**M3A**
Distance to plant (km)		**0.4**	**0.4**	**0.4**	**0.8**
Ag	0.066	0.014	0.029	0.028	0.020
Al	309	2847	1361	1533	607
As	30	23.35	23.57	23.74	22.36
Au	0.003	0.005	0.006	0.003	0.003
Ba	121	420	431	418	402
Be	0.005	0.035	0.016	0.018	0.007
Bi	0.001	0.003	0.001	0.001	0.000
Ca	11998	14626	15173	14939	14267
Cd	1.048	0.941	0.871	0.887	1.083
Ce	1.149	7.666	4.471	4.873	2.388
Co	2.234	3.387	3.179	3.260	2.491
Cr	0.856	10.98	4.90	5.58	1.94
Cs	0.034	0.176	0.092	0.106	0.058
Cu	17	17.51	15.71	16.21	14.40
Dy	0.027	0.151	0.076	0.083	0.036
Er	0.014	0.075	0.037	0.041	0.017
Eu	0.077	0.076	0.049	0.051	0.031
Fe	260	3244	1392	1567	519
Ga	0.111	1.135	0.545	0.601	0.252
Gd	0.090	0.270	0.152	0.164	0.082
Hf	0.005	0.034	0.012	0.013	0.002
Hg	0.002	0.002	<LOD	<LOD	<LOD
Ho	0.005	0.028	0.014	0.015	0.007
K	27378	21114	23154	23682	20623
La	1.186	4.391	2.887	3.079	1.850
Li	0.636	2.370	1.182	1.235	0.652
Lu	0.002	0.009	0.004	0.005	0.002
Mg	8752	9622	9321	9427	8459
Mn	66	90.69	65.06	67.77	40.03
Mo	0.149	0.145	0.139	0.168	0.125
Na	27802	12329	18518	18805	16833
Nb	0.046	0.398	0.231	0.256	0.095
Nd	0.647	2.689	1.630	1.757	0.961
Ni	2.688	9.727	5.963	6.405	3.191
P	1666	1399	1628	1697	1655
Pb	0.085	0.431	0.211	0.232	0.107
Pd	0.733	0.038	0.038	0.037	0.038
Pr	0.180	0.790	0.466	0.504	0.278
Pt	0.002	0.001	<LOD	<LOD	<LOD

Rb		17.05	14.72	15.32	12.18
Re	0.056	0.013	0.015	0.015	0.013
Ru	0.004	0.000	0.000	0.000	0.000
Sb	0.012	0.003	0.006	0.004	0.003
Sc	0.143	0.873	0.400	0.455	0.156
Se	0.054	0.050	0.041	0.040	0.040
Sm	0.080	0.390	0.218	0.237	0.118
Sr		1177	1228	1178	1230
Ta	0.001	0.001	0.000	0.000	0.001
Tb	0.007	0.032	0.016	0.017	0.008
Te	0.003	0.005	0.001	0.002	0.002
Th	0.061	0.663	0.304	0.341	0.123
Ti	22	300	134	154	50
Tl	0.015	0.070	0.049	0.050	0.034
Tm	0.002	0.010	0.005	0.005	0.002
U	0.409	0.534	0.640	0.641	0.519
V	0.619	7.138	3.270	3.663	1.254
W	0.009	0.024	0.025	0.018	0.009
Y	0.177	0.825	0.442	0.490	0.217
Yb	0.011	0.061	0.028	0.032	0.013
Zn	15	16.51	13.59	14.07	11.23
Zr	0.308	1.227	0.513	0.582	0.179

Appendix 5 Blue mussel samples

Element analyses results (concentration mg/kg dry weight) for blue mussel samples from the monitoring in 2025. Blue values indicate values higher than mean +2SD of baseline samples. Note the baseline samples were not depurated. Note that baseline values are not available for all elements. Measurements below instrument detection limit are marked with <LOD.

	Mean baseline (2013)	Depurated	Non-depurated	
Station ID	**+ 2SD**	**M1**	**M1**	**M3A**
Distance from plant (km)		**0.4**	**0.4**	**0.8**
Mussels shell length (cm)		**4.0-4.9**	**4.0-4.9**	**4.0-4.9**
Element (mg/kg dry wt.)				
Ag	0.08	0.018	0.005	0.064
Al	1538	206	456	608
As	18.98	11.67	12.27	12.35
Au	0.50	0.009	0.011	0.010
Ba	15.72	3.598	5.887	7.642
Be		0.005	0.006	0.008
Bi	25.00	0.001	0.002	0.002
Ca	9148	2253	2908	2085
Cd	5.00	4.280	3.858	3.375
Ce	16.48	12.083	13.591	9.796
Co	3.33	1.512	1.948	1.741
Cr	7.02	1.600	2.656	3.166
Cs		0.025	0.030	0.040
Cu	25	15.09	12.11	26.59
Dy		0.089	0.102	0.090
Er		0.042	0.049	0.044
Eu		0.057	0.064	0.054
Fe	1799	227	507	731
Ga		0.360	0.465	0.445
Gd		0.274	0.309	0.246
Hf		<LOD	0.002	0.003
Hg	0.24	0.041	0.044	0.049
Ho		0.016	0.018	0.017
K	15080	7830	7887	8372
La	22.84	14.87	16.29	11.11
Li		0.217	0.346	0.527
Lu		0.005	0.005	0.005
Mg	4033	1838	1979	2329
Mn	42.25	6.917	11.314	13.305
Mo	0.65	0.465	0.489	0.545
Na	21034	8028	8484	10049
Nb		0.019	0.065	0.092
Nd	6.17	4.483	4.966	3.556
Ni	11.59	6.777	8.912	6.948
P	12090	13324	12135	13323
Pb	5.81	0.448	0.345	0.363
Pd		0.003	0.003	0.003
Pr		1.500	1.654	1.166
Pt		<LOD	<LOD	<LOD
Rb		3.670	4.007	4.685
Re		0.000	0.000	0.000
Ru		<LOD	<LOD	<LOD
Sb		0.004	0.006	0.005
Sc	0.25	0.176	0.236	0.299
Se	10.34	3.384	3.646	3.896
Sm	0.50	0.408	0.460	0.358
Sr	75.17	26.47	26.38	24.21
Ta		0.001	0.001	0.001
Tb		0.023	0.026	0.022
Te		0.004	0.002	0.001
Th	0.25	0.080	0.127	0.171
Ti	133	9.88	36.69	58.23
Tl	0.05	0.005	0.016	0.020
Tm		0.005	0.006	0.005
U	0.43	0.604	0.628	0.549
V	5.12	0.632	1.323	1.848
W	2.50	0.014	0.017	0.018
Y	0.50	0.668	0.728	0.619
Yb		0.029	0.035	0.033
Zn	111	54.89	57.27	57.10
Zr		0.104	0.168	0.191

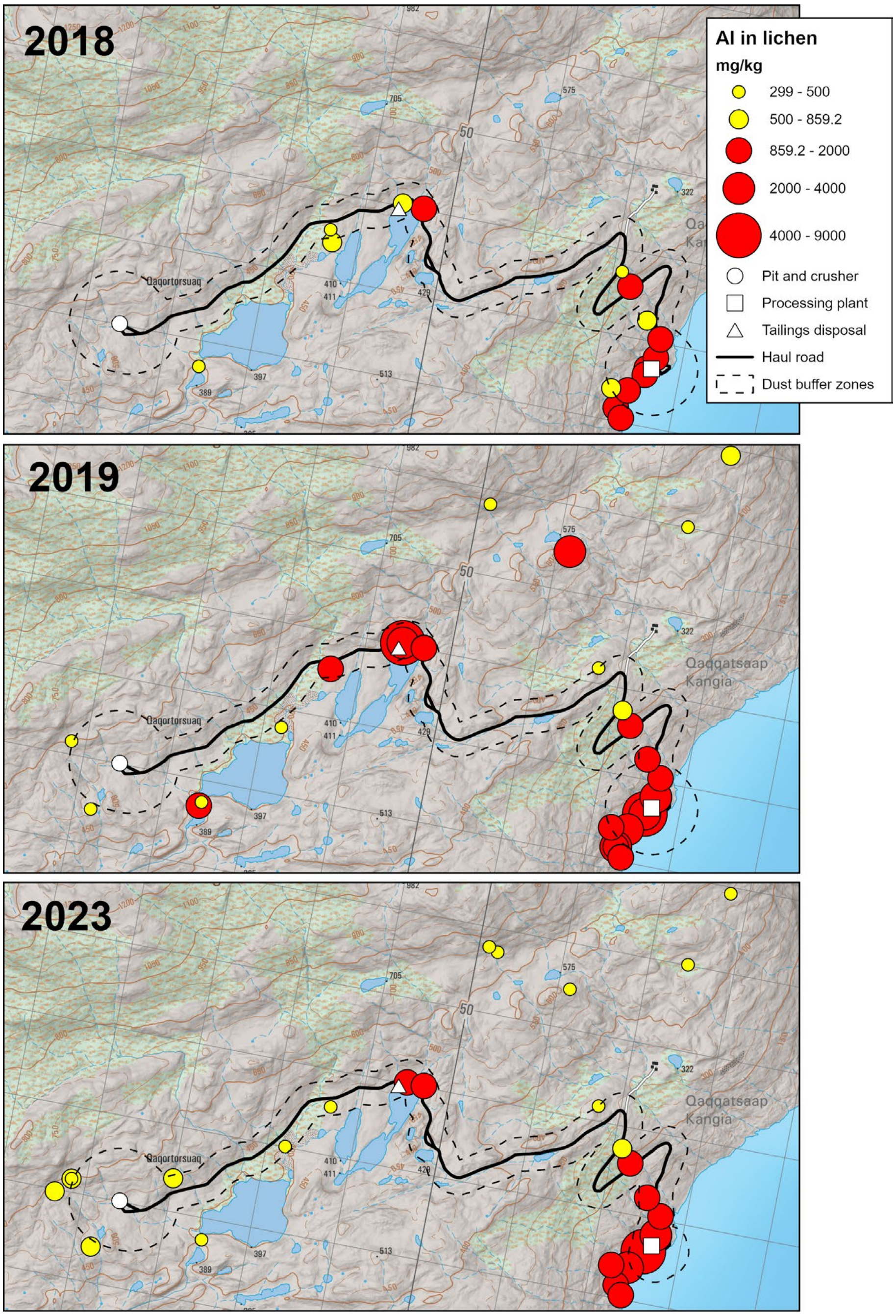
Appendix 6 Freshwater samples

Element analysis results (µg/l) for unfiltered and filtered freshwater samples from monitoring in 2025. Blue values are higher than mean +2SD of baseline samples. Measurements below instrument detection limit are marked with <LOD.

	Unfiltered						Filtered					
	Mean baseline (2012+ 2013) + 2SD	**F7**	**Lake A outlet**	**F20**	**F30**	**F31**	**Mean baseline (2012+ 2013) + 2SD**	**F7**	**Lake A outlet**	**F20**	**F30**	**F31**
Ag	0.01	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	<LOD	0.001	<LOD
Al	190	31	4433	46	944	30	54	24	177	29	89	24
As	0.13	<LOD	<LOD	<LOD	<LOD	<LOD	0.14	<LOD	<LOD	<LOD	<LOD	<LOD
Au	0.01	<LOD	<LOD	<LOD	<LOD	<LOD	0.02	<LOD	<LOD	<LOD	<LOD	<LOD
Ba	52	27.6	6.9	17.6	8.3	17.4	49	26.9	2.0	17.3	6.7	17.1
Be	0.02	<LOD	0.005	<LOD	<LOD	<LOD	0.02	<LOD	<LOD	0.001	<LOD	<LOD
Bi	0.0043	<LOD	0.006	<LOD	0.001	<LOD	0.0010	<LOD	0.001	<LOD	<LOD	<LOD
Ca	25398	7117	19675	8585	15958	6266	25664	7080	16828	8525	15276	6219
Cd	0.03	0.001	0.002	0.001	0.001	0.001	0.02	0.001	0.001	0.001	0.001	0.001
Ce	2.78	0.376	0.610	0.413	0.325	0.378	0.85	0.322	0.132	0.348	0.194	0.327
Co	0.44	0.066	0.482	0.061	0.154	0.044	0.33	0.069	0.272	0.052	0.088	0.037
Cr	0.60	0.237	0.175	0.213	0.141	0.203	0.36	0.215	0.095	0.203	0.104	0.185
Cs	0.01	<LOD	<LOD	<LOD	<LOD	<LOD	0.01	<LOD	<LOD	<LOD	<LOD	<LOD
Cu	12	5.042	3.908	3.605	3.189	4.000	8.87	4.792	3.451	3.328	2.919	3.239
Dy	0.07	0.016	0.008	0.013	0.007	0.013	0.02	0.015	0.004	0.012	0.005	0.012
Er	0.03	0.009	0.003	0.007	0.004	0.007	0.01	0.008	0.002	0.006	0.003	0.006
Eu	0.04	0.012	0.007	0.009	0.006	0.009	0.02	0.012	0.003	0.008	0.003	0.008
Fe	289	21.10	74.86	36.75	27.38	26.69	180	15.08	7.31	26.14	10.56	18.25
Ga	0.09	0.021	0.624	0.028	0.198	0.020	0.03	0.020	0.202	0.025	0.102	0.018
Gd	0.17	0.040	0.023	0.030	0.018	0.030	0.05	0.033	0.010	0.024	0.012	0.029
Hf	0.01	0.003	0.002	0.003	<LOD	0.003	0.01	0.003	<LOD	0.003	<LOD	0.002
Hg	0.03	<LOD	<LOD	<LOD	<LOD	<LOD	0.02	<LOD	<LOD	<LOD	<LOD	<LOD
Ho	0.01	0.003	0.001	0.003	0.001	0.002	0.00	0.003	0.001	0.002	0.001	0.002
K	4998	1839	1340	1474	1569	1375	4597	1851	1236	1449	1515	1351
La	2.57	0.588	0.453	0.450	0.340	0.484	0.82	0.530	0.152	0.394	0.235	0.432
Li	1.48	0.149	0.361	0.149	0.244	0.076	1.34	0.154	0.312	0.043	0.140	0.096
Lu	0.00	0.001	0.000	0.001	0.001	0.001	0.00	0.001	0.000	0.001	0.000	0.001
Mg	14602	3332	3303	2653	3395	2110	14457	3345	3243	2666	3338	2081
Mn	30	0.241	4.370	1.076	1.177	0.532	39	0.173	1.173	0.690	0.558	0.327
Mo	0.41	0.234	0.504	0.183	0.391	0.105	0.52	0.236	0.514	0.167	0.377	0.114
Na	90397	2460	4417	2860	3876	2588	86906	2452	4085	2842	3772	2562
Nb	0.01	<LOD	<LOD	<LOD	<LOD	<LOD	0.01	<LOD	<LOD	<LOD	<LOD	<LOD
Nd	1.66	0.433	0.331	0.337	0.242	0.342	0.59	0.393	0.116	0.291	0.174	0.310
Ni	5.07	2.967	1.956	2.442	2.042	1.841	4.03	2.952	1.768	1.942	1.963	1.950
P	33	<LOD	<LOD	<LOD	<LOD	<LOD	14.10	<LOD	<LOD	<LOD	<LOD	<LOD
Pb	0.19	<LOD	0.071	<LOD	0.016	0.010	0.11	<LOD	<LOD	<LOD	<LOD	<LOD
Pd	0.01	0.002	0.002	0.001	0.001	0.001	0.01	0.002	0.001	0.001	0.001	0.001
Pr	0.47	0.125	0.092	0.091	0.070	0.100	0.16	0.111	0.031	0.085	0.047	0.089
Pt	0.01	<LOD	<LOD	<LOD	<LOD	<LOD	0.01	<LOD	<LOD	<LOD	<LOD	<LOD
Rb	2.20	0.774	0.768	0.803	0.823	0.881	2.02	0.777	0.622	0.810	0.783	0.872
Re	0.01	0.000	0.001	0.000	0.001	0.000	0.00	0.000	0.001	0.000	0.001	0.000
Ru	0.00	<LOD	<LOD	<LOD	<LOD	<LOD	0.00	<LOD	<LOD	<LOD	<LOD	<LOD
Sb	0.19	<LOD	<LOD	<LOD	<LOD	<LOD	0.07	<LOD	<LOD	<LOD	<LOD	<LOD
Sc	0.12	0.039	0.044	0.039	0.021	0.033	0.11	0.040	0.018	0.035	0.015	0.036
Se	0.27	<LOD	<LOD	<LOD	<LOD	<LOD	0.37	<LOD	<LOD	<LOD	<LOD	<LOD
Sm	0.20	0.056	0.040	0.046	0.029	0.048	0.07	0.054	0.019	0.040	0.022	0.040
Sr	213	52.60	37.02	36.86	39.58	29.67	211	52.22	29.89	36.65	38.04	29.23
Ta	0.00	<LOD	<LOD	<LOD	<LOD	<LOD	0.00	<LOD	<LOD	<LOD	<LOD	<LOD
Tb	0.02	0.004	0.002	0.003	0.002	0.003	0.01	0.003	0.001	0.003	0.001	0.003
Te	0.02	<LOD	<LOD	<LOD	<LOD	<LOD	0.00	<LOD	<LOD	<LOD	<LOD	<LOD
Th	0.06	0.026	0.054	0.028	0.023	0.025	0.04	0.029	0.010	0.029	0.013	0.027
Ti	6.45	0.556	2.563	0.384	0.679	0.294	0.63	0.308	0.134	0.217	0.092	0.143
Tl	0.04	<LOD	<LOD	<LOD	<LOD	<LOD	0.04	<LOD	<LOD	<LOD	<LOD	<LOD
Tm	0.00	0.001	0.000	0.001	0.000	0.001	0.00	0.001	0.000	0.001	0.000	0.001
U	0.19	0.024	0.101	0.024	0.056	0.022	0.19	0.024	0.098	0.022	0.055	0.021
V	1.83	0.186	0.361	0.161	0.186	0.129	0.47	0.163	0.290	0.158	0.178	0.123
W	0.01	<LOD	4.469	0.341	2.662	<LOD	0.04	0.041	4.724	0.337	2.653	0.038
Y	0.29	0.098	0.042	0.071	0.040	0.080	0.11	0.087	0.022	0.069	0.030	0.072
Yb	0.02	0.008	0.003	0.006	0.002	0.006	0.01	0.005	0.002	0.005	0.002	0.005
Zn	6.66	<LOD	1.113	<LOD	1.075	2.422	2.32	0.524	<LOD	<LOD	1.211	1.345
Zr	0.23	0.117	0.068	0.107	0.064	0.094	0.23	0.109	0.052	0.100	0.052	0.088

Appendix 7 Maps of aluminium concentrations in lichens over time

Visualisation of the aluminium concentration in lichens at each sampling station during each of the monitoring years (2018, 2019, 2023, 2024 and 2025) on a comparable scale. Concentrations above mean+2SD of baseline samples (859.2 mg/kg dry weight) are shown as red circles and concentrations below as yellow circles.



Appendix 8 Updated element baseline values for the Qaqortorsuaq anorthosite mine project

Introduction

When preparing the present report, it was assessed that the calculation of element baseline concentrations for the Qaqortorsuaq anorthosite project (based on samples collected in 2012-13) could be improved as a result of ongoing quality control of data in the Mineral Resources Environmental Database (MRED). It was found that:

- **Crinkled snow lichen** collection and analysis in 2013 not only included samples from the lichen stations that formed part of the baseline sampling program but also included samples from 10 orchid monitoring sites (WM 1-10). As the latter also reflect baseline conditions in the area, the calculation of element baseline concentrations for crinkled snow lichen can be improved by including these ten extra samples (minus one outlier[1])
- The **crinkled snow lichen** reference station L13 (sample-ID: 49288) is located in Kangerlussuaq, not in the license area, and is therefore excluded from the calculation of the element baseline concentrations.
- Some analysis results from **freshwater samples** were not included in the original calculation of element baseline concentrations as information on filtering status was missing. This missing information has been retrieved, which means that the sample size can be improved.
- **Freshwater samples** from St. 30 and St. 41 are located in a freshwater system by the old camp northeast of the present camp. The two stations are not part of the freshwater system in which tailings are deposited and from which the other baseline and monitoring samples derive. Thus, three different baseline values for filtered and unfiltered freshwater samples are now calculated: one for all freshwater samples (to maximize sample size), one for freshwater samples from the tailings system, and one for freshwater samples from the stream by the old camp.
- The baseline sampling of **blue mussels** included samples from both Kangerlussuaq fjord (M1-3) and Itinneq inlet (M4). As these are two very different marine systems, three different baseline values are now calculated: one for all blue mussel samples (to maximize sample size), one for blue mussel samples from Kangerlussuaq, and one for blue mussel samples from Itinneq. Further, baseline values are calculated both for individual size classes and pooled across size classes (to maximize sample size).

[1] Sample-ID 49294 from orchid monitoring site WM 6 is a marked outlier. The Al concentration in the sample is 2200 mg/kg dry weight, which is far outside the range of the other 39 baseline samples (mean: 470.9 mg/kg dry weight, SD: 194.1 mg/kg dry weight; see Table 3). Sample-ID 49294 is therefore excluded from the element baseline calculations.

- All analysed **bladder wrack samples** included in the calculations of element baseline concentrations were from station M4 located in Itinneq inlet (no bladder wrack samples from Kangerlussuaq fjord from 2012-13 were analyzed as part of the baseline). As Kangerlussuaq and Itinneq are very different marine systems, it was decided to include bladder wrack samples from Kangerlussuaq fjord from 2018 as part of the baseline (mining activities in 2018 were still limited). Thus, three different baseline values are now calculated: one for all bladder wrack samples (to maximize sample size), one for bladder wrack samples from Kangerlussuaq 2018, and one for bladder wrack samples from Itinneq.

In this appendix, we present re-calculated baseline values according to the above refinements. The baseline values are calculated based on all ICP-MS analysed samples from the baseline campaigns in 2012-13, plus analysed bladder wrack samples from 2018. The total sample size is 92 (Table A8.1).

Calculation method

Following DCE standards, element baseline values are calculated as mean plus two standard deviations (mean+2SD) in mg/kg dry weight for biota samples and µg/l for filtered and unfiltered freshwater samples. Concentrations below limit of detection (LOD) are included as 0.5*LOD (halfway between 0 and LOD). Duplicate measurements of the same sample-ID (part of the ICP-MS quality control procedure) are averaged prior to calculation of the baseline concentrations. Thus, sample size (n) refers to the number of samples, not the number of measurements.

As the calculation of a baseline value depends on estimation of mean and standard deviation (SD), baseline values cannot be calculated when n<2 (not possible to estimate SD).

Further, baseline values are not meaningful if all measurements of a particular element for a particular sample type are below LOD. In this case, all values (and their mean) will be 0.5*LOD (see above) and SD=0, resulting in a baseline value of 0.5*LOD. Thus, when using the baseline values, it is important to pay attention to the ratio between the number of samples (n) and the number of samples with measurements below limit of detection (n<LOD). If these two numbers are the same, all measurements are below LOD, and the baseline value is not directly meaningful.

Which baseline value to use?

With several different baseline values for a specific sample type and element, it becomes important to choose the most relevant one, when assessing measurements of monitoring samples. Ideally, we want to compare monitoring samples with baseline concentrations based on the largest possible sample size, and the greatest similarity in environmental setting. E.g., when assessing a measurement on a blue mussel monitoring sample from St. M1 in Kangerlussuaq fjord, it would be ideal to compare it to a baseline concentration based only on samples from Kangerlussuaq, and not on samples from Itinneq inlet, which is part of a different marine system. Further, if the monitoring sample is of blue mussels only of the size class 2.0-2.9 cm, it would be even better to compare it to a baseline concentration based only on blue mussels from Kangerlussuaq of the size class 2.0-2.9 cm. However, there is a trade-off between sample size and similarity of environmental setting/sample type (see

Table A8.2). Thus, the total number of blue mussel baseline samples is 12, whereas there are only 3 baseline samples of blue mussels from Kangerlussuaq fjord in the size class 2.0-2.9 cm, making the latter a rather uncertain basis for a baseline value.

In selecting a baseline value for a certain sample type, our guiding principle is that we choose the highest possible level of generality (to increase sample size), where the measurements of the constituent samples are still homogeneous. Thus, we pool samples if the measurements are not significantly different. However, we may also choose to compare monitoring samples to several different baseline concentrations with explicit reference to their type.

Table A8.1: Samples included in the updated calculation of element baseline concentrations for the Qaqortorsuaq anorthosite mine project (n=92). Several different types of baselines were calculated, and the table shows which specific samples were included in which baselines.

Sample information					Baseline type																						
ID	Sample type	Subsample	Collection date	Station	Lichen	Freshwater_ Unfiltered_All	Freshwater Filtered_All	Freshwater_Unfiltered TailingsSystem	Freshwater_Filtered TailingsSystem	Freshwater_Unfiltered OldCampSystem	Freshwater_Filtered OldCampSystem	Bluemussels_All	Bluemussels 2.0to2.9cm_All	Bluemussels 4.0to4.9cm_All	Bluemussels 6.0to6.9cm_All	Bluemussels Kangerlussuaq	Bluemussels Itinneq_inlet	Bluemussels_2.0to2.9cm Kangerlussuaq	Bluemussels_4.0to4.9cm Kangerlussuaq	Bluemussels_6.0to6.9cm Kangerlussuaq	Bluemussels_2.0to2.9cm Itinneq_inlet	Bluemussels_4.0to4.9cm Itinneq_inlet	Bluemussels_6.0to6.9cm Itinneq_inlet	Bladderwrack_All	Bladderwrack Kangerlussuaq	Bladderwrack Itinneq_inlet	ShorthornSculpin_All
62419	Bladderwrack		20180919	St M1																				1	1		
62420	Bladderwrack		20180919	St M1																				1	1		
62421	Bladderwrack		20180919	St M2																				1	1		
62422	Bladderwrack		20180919	St M2																				1	1		
62423	Bladderwrack		20180919	St M3																				1	1		
62424	Bladderwrack		20180919	St M3																				1	1		
49262	Bladderwrack		20130702	St M4																				1		1	
49263	Bladderwrack		20130702	St M4																				1		1	
49227	Blue mussel	2.0-2.9 cm	20130628	St M1								1	1			1		1									
49250	Blue mussel	2.0-2.9 cm	20130701	St M2								1	1			1		1									
49247	Blue mussel	2.0-2.9 cm	20130630	St M3								1	1			1		1									
49259	Blue mussel	2.0-2.9 cm	20130702	St M4								1	1				1				1						
49226	Blue mussel	4.0-4.9 cm	20130628	St M1								1		1		1			1								
49251	Blue mussel	4.0-4.9 cm	20130701	St M2								1		1		1			1								
49248	Blue mussel	4.0-4.9 cm	20130630	St M3								1		1		1			1								
49260	Blue mussel	4.0-4.9 cm	20130702	St M4								1		1			1					1					
49225	Blue mussel	6.0-6.9 cm	20130629	St M1								1			1	1				1							
49252	Blue mussel	6.0-6.9 cm	20130701	St M2								1			1	1				1							
49249	Blue mussel	6.0-6.9 cm	20130630	St M3								1			1	1				1							
49261	Blue mussel	6.0-6.9 cm	20130702	St M4								1			1		1						1				
48210	Freshwater	Filtered	20120730	St 20			1		1																		
49202	Freshwater	Filtered	20130530	St 20			1		1																		
46450	Freshwater	Filtered	20130902	St 21			1		1																		

48218	Freshwater	Filtered	20120731	St 21			1		1																		
49204	Freshwater	Filtered	20130530	St 21			1		1																		
46433	Freshwater	Filtered	20130901	St 22			1		1																		
48214	Freshwater	Filtered	20120731	St 22			1		1																		
49206	Freshwater	Filtered	20130530	St 22			1		1																		
46408	Freshwater	Filtered	20130830	St 23			1		1																		
48221	Freshwater	Filtered	20120801	St 23			1		1																		
46498	Freshwater	Filtered	20130904	St 30			1				1																
48305	Freshwater	Filtered	20120808	St 30			1				1																
49214	Freshwater	Filtered	20130530	St 30			1				1																
46453	Freshwater	Filtered	20130902	St 31			1		1																		
49219	Freshwater	Filtered	20130530	St 41			1				1																
46469	Freshwater	Filtered	20130903	WM 7			1		1																		
48211	Freshwater	Unfiltered	20120730	St 20		1		1																			
49201	Freshwater	Unfiltered	20130530	St 20		1		1																			
46449	Freshwater	Unfiltered	20130902	St 21		1		1																			
48217	Freshwater	Unfiltered	20120731	St 21		1		1																			
49203	Freshwater	Unfiltered	20130530	St 21		1		1																			
46432	Freshwater	Unfiltered	20130901	St 22		1		1																			
48215	Freshwater	Unfiltered	20120731	St 22		1		1																			
49205	Freshwater	Unfiltered	20130530	St 22		1		1																			
46409	Freshwater	Unfiltered	20130830	St 23		1		1																			
48220	Freshwater	Unfiltered	20120801	St 23		1		1																			
46497	Freshwater	Unfiltered	20130904	St 30		1				1																	
48304	Freshwater	Unfiltered	20120808	St 30		1				1																	
49213	Freshwater	Unfiltered	20130530	St 30		1				1																	
46452	Freshwater	Unfiltered	20130902	St 31		1		1																			
49219	Freshwater	Unfiltered	20130530	St 41		1				1																	
46468	Freshwater	Unfiltered	20130903	WM 7		1		1																			
48323	Lichen		20120720	1	1																						
48324	Lichen		20120720	2	1																						
48325	Lichen		20120720	3	1																						
48326	Lichen		20120720	4	1																						
48327	Lichen		20120722	5	1																						
48328	Lichen		20120720	6	1																						

49276	Lichen		20130703	L 1	1																						
49285	Lichen		20130703	L 10	1																						
49286	Lichen		20130703	L 11	1																						
49287	Lichen		20130703	L 12	1																						
49277	Lichen		20130703	L 2	1																						
49278	Lichen		20130703	L 3	1																						
49279	Lichen		20130703	L 4	1																						
49280	Lichen		20130703	L 5	1																						
49281	Lichen		20130703	L 6	1																						
49282	Lichen		20130703	L 7	1																						
49283	Lichen		20130703	L 8	1																						
49284	Lichen		20130703	L 9	1																						
49264	Lichen		20130703	LN 1	1																						
49273	Lichen		20130703	LN 10	1																						
49274	Lichen		20130703	LN 11	1																						
49275	Lichen		20130703	LN 12	1																						
49265	Lichen		20130703	LN 2	1																						
49266	Lichen		20130703	LN 3	1																						
49267	Lichen		20130703	LN 4	1																						
49268	Lichen		20130703	LN 5	1																						
49269	Lichen		20130703	LN 6	1																						
49270	Lichen		20130703	LN 7	1																						
49271	Lichen		20130703	LN 8	1																						
49272	Lichen		20130703	LN 9	1																						
49289	Lichen		20130703	WM 1	1																						
49298	Lichen		20130703	WM 10	1																						
49290	Lichen		20130703	WM 2	1																						
49291	Lichen		20130703	WM 3	1																						
49292	Lichen		20130703	WM 4	1																						
49293	Lichen		20130703	WM 5	1																						
49295	Lichen		20130703	WM 7	1																						
49296	Lichen		20130703	WM 8	1																						
49297	Lichen		20130703	WM 9	1																						
49233	Sculpin	Liver	20130629	St M1																							1

Table A8.2: List of the different types of baseline values calculated, and the sample sizes (n) on which they are based. Blue colour marks the baselines used for assessing the 2025 monitoring data in the present report.

Baseline type	**n**
Lichen	39
Freshwater_Unfiltered_All	16
Freshwater_Filtered_All	16
Freshwater_Unfiltered_TailingsSystem	12
Freshwater_Filtered_TailingsSystem	12
Freshwater_Unfiltered_OldCampSystem	4
Freshwater_Filtered_OldCampSystem	4
Bluemussels_All	12
Bluemussels_2.0to2.9cm_All	4
Bluemussels_4.0to4.9cm_All	4
Bluemussels_6.0to6.9cm_All	4
Bluemussels_Kangerlussuaq	9
Bluemussels_Itinneq_inlet	3
Bluemussels_2.0to2.9cm_Kangerlussuaq	3
Bluemussels_4.0to4.9cm_Kangerlussuaq	3
Bluemussels_6.0to6.9cm_Kangerlussuaq	3
Bluemussels_2.0to2.9cm_Itinneq_inlet	1
Bluemussels_4.0to4.9cm_Itinneq_inlet	1
Bluemussels_6.0to6.9cm_Itinneq_inlet	1
Bladderwrack_All	8
Bladderwrack_Kangerlussuaq	6
Bladderwrack_Itinneq_inlet	2
ShorthornSculpin_All	1

Table A8.3: Element baseline concentrations in mg/kg dry weight for biota samples and µg/l for freshwater samples. The baseline values are calculated as mean+2SD. Baseline values are only given if sample size (n) is greater than one. Baseline values are not meaningful, if the number of measurements below limit of detection (n<LOD) equals sample size (n) (all measurements are below sample size). Table A8.3 contains 1090 rows and thus can be forwarded upon request.

Element baseline concentrations in mg/kg dry weight for biota samples and µg/l for freshwater samples
Table A8.3 contains 1090 rows and thus can be forwarded upon request.

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This environmental monitoring report for the Qaqortorsuaq Anorthosite Mine (White Mountain) is prepared by DCE – Danish Centre for Environment and Energy, Aarhus University, and Greenland Institute of Natural Resources (GINR) for the Environmental Agency for Mineral Resource Activities (EAMRA), Government of Greenland. The report presents the results from the authority environmental monitoring by DCE/GINR on behalf of EAMRA in 2025.

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