



25. november 2022

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Ferskvandsmonitoring ved Greenland Ruby rubinmine ved Aappaluttoq i 2022

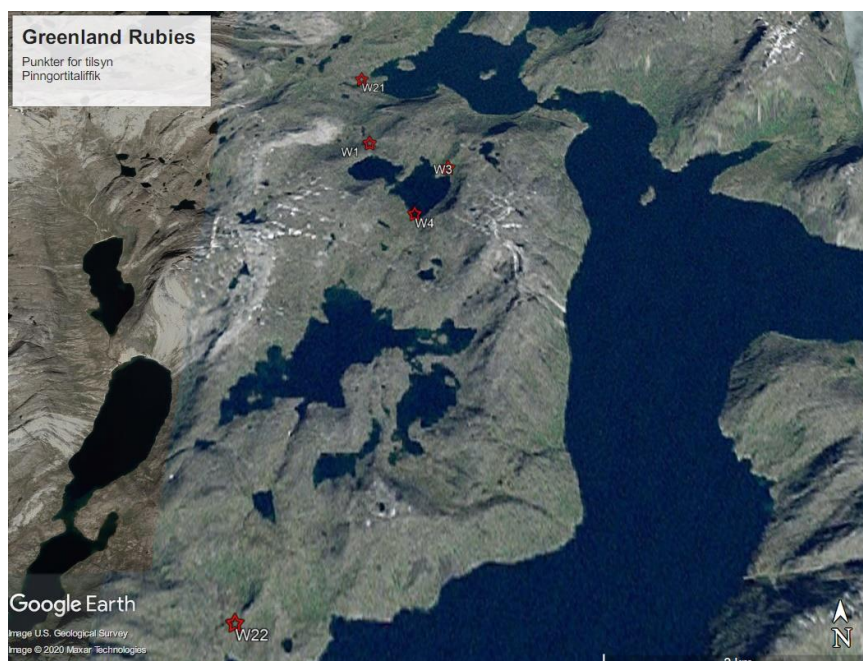
Dette notat præsenterer resultaterne af myndighedernes ferskvandsmonitoring ved Greenland Ruby rubinmine ved Aappaluttoq i 2022. Programmet blev gennemført d. 9. september.

Minen, dvs. selve bruddet, er anlagt på en tidligere halvø midt i søen Ukkaata Qaava. Søen modtager især vand fra to tilløb til det sydøstlige bassin, mens afløbet sker fra det nordvestlige bassin. Vandstanden i søen blev i løbet af årene 2015 og 2016 sænket 10 meter, og søen er nu opdelt i to adskilte bassiner, forbundet af en gravet kanal. I det sydøstlige bassin deponeres tailings og waste-rock fra minen, mens det nordvestlige bassin fungerer som en slags klaringsbassin, hvorfra vandet løber til fjorden Tasiusaa via en ca. tre kilometer lang elv forbi sprængstoflager og mine-camp.

Lokaliteter

Der blev udtaget vandprøver ved 5 lokaliteter:

- W3 og W4 i de to tilløb til søens sydøstlige bassin
- W1 i elven ca. 200 meter nedstrøms udløbet fra søens nordvestre bassin
- W21 i elven nedstrøms sprængstoflager og camp og ca. 300 meter opstrøms udløbet i fjorden
- W22 i en elv ca. 8 km sydvest for minen (= referencestation).



Figur 1 Oversigt over prøvestationer.

Metode

Vandprøverne blev udtaget efter retningslinjerne i DCE's indsamlingsinstruks, og der blev både indsamlet ufiltrerede prøver og prøver filtreret gennem et 0.45 µm nylonfilter. Grønlands vandkvalitetskriterier er baseret på filtrerede prøver. Forskellen mellem de filtrerede og ufiltrerede prøver giver et mål for mængden af suspenderet partikulært stof.

Både filtrerede og ufiltrerede vandprøver blev analyseret på DCE's akkrediterede laboratorium i Roskilde.

Resultater

Resultaterne fra 2022 er vist i Figur 2, side 3-**Error! Bookmark not defined.**, (filtrerede prøver) og Figur 3, side 4-5, (ufiltrerede prøver) sammen med resultaterne fra de samme lokaliteter i 2015, 2017, 2018, 2019, 2020 og 2021. Figurerne viser resultaterne for de metaller, for hvilke der er etableret grønlandske vandkvalitetskriterier. Kriterieværdierne er angivet på figurerne.

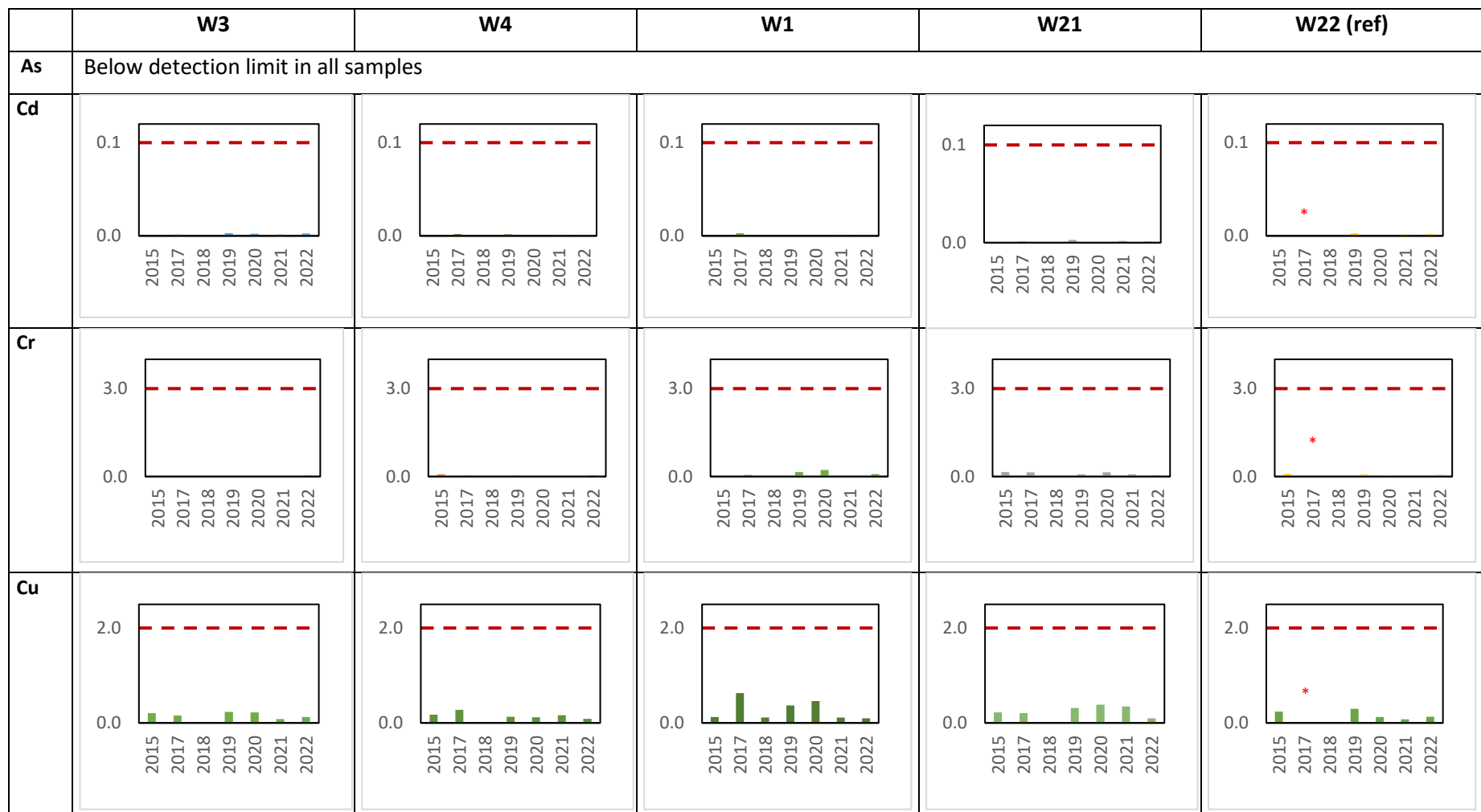
Der sker en berigning med en lang række stoffer, bl.a. Aluminium (Al), Titanium (Ti), Krom (Cr), Mangan (Mn), Jern (Fe), Nikkel (Ni), Kobber (Cu) og Bly (Pb), i den opløste (filtrerede) fraktion ved vandets passage gennem søen, og for de fleste stoffer en endnu stærkere berigning i den partikulære fraktion. Berigningen af den opløste fraktion skyldes givetvis især udledning af tailings bestående af frisk knust materiale, mens dele af den partikulære fraktion også kan stamme fra den stærke erosion af søbredden, der er opstået som følge af vandstandssænkningen.

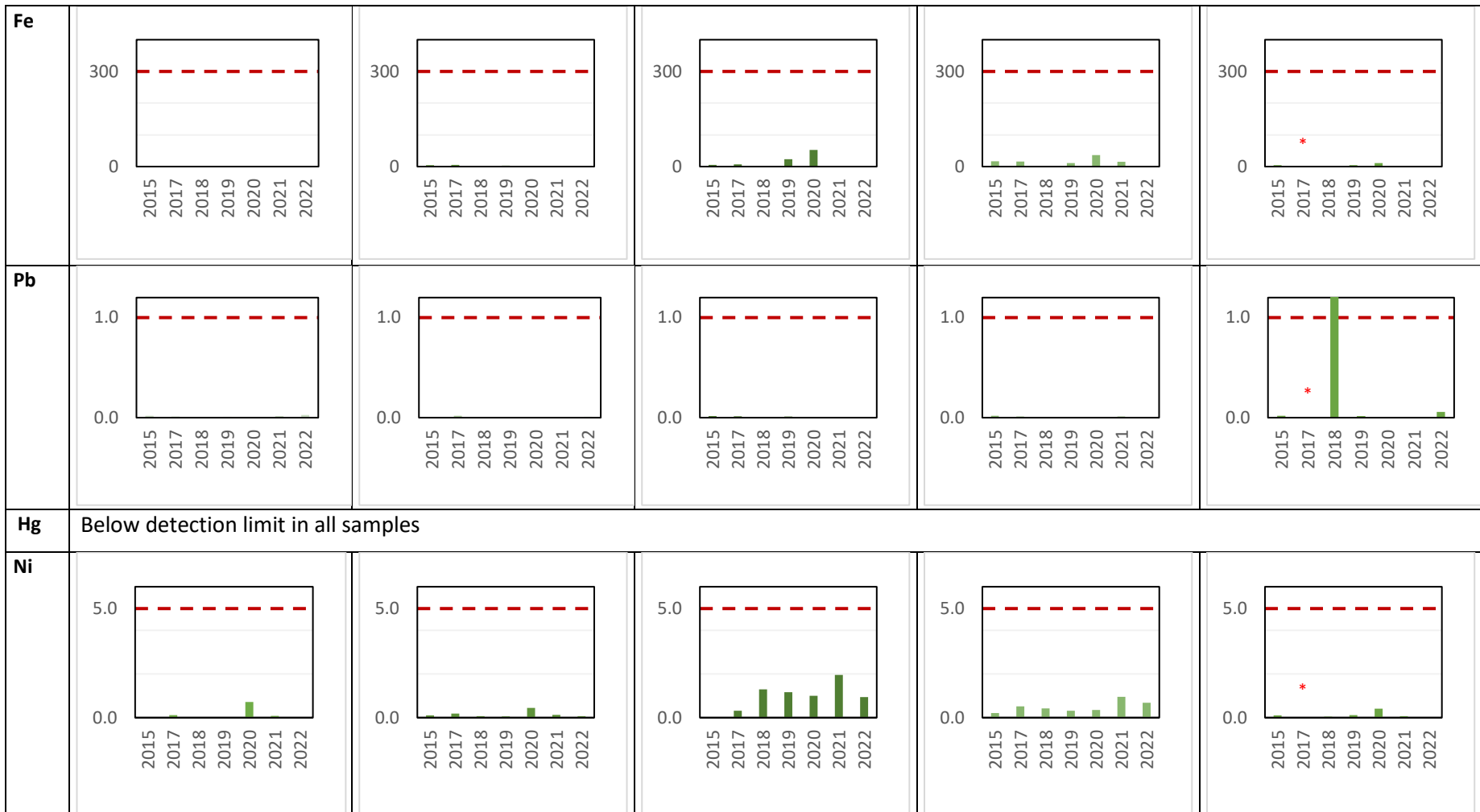
Ingen af stofferne i den opløste fraktion i 2022 optræder i koncentrationer, der overskrider vandkvalitetskriterierne fastsat af de grønlandske myndigheder. Koncentrationerne i afløbet fra søen (W1 og W21) er for de fleste af de målte stoffer, både i den opløste og partikulære fraktion, på niveau eller lavere end værdierne fra 2021.

Grænseværdierne gælder, som nævnt, kun for den opløste fraktion og er kun fastsat for de vigtigste og for de mest almindelige metaller.

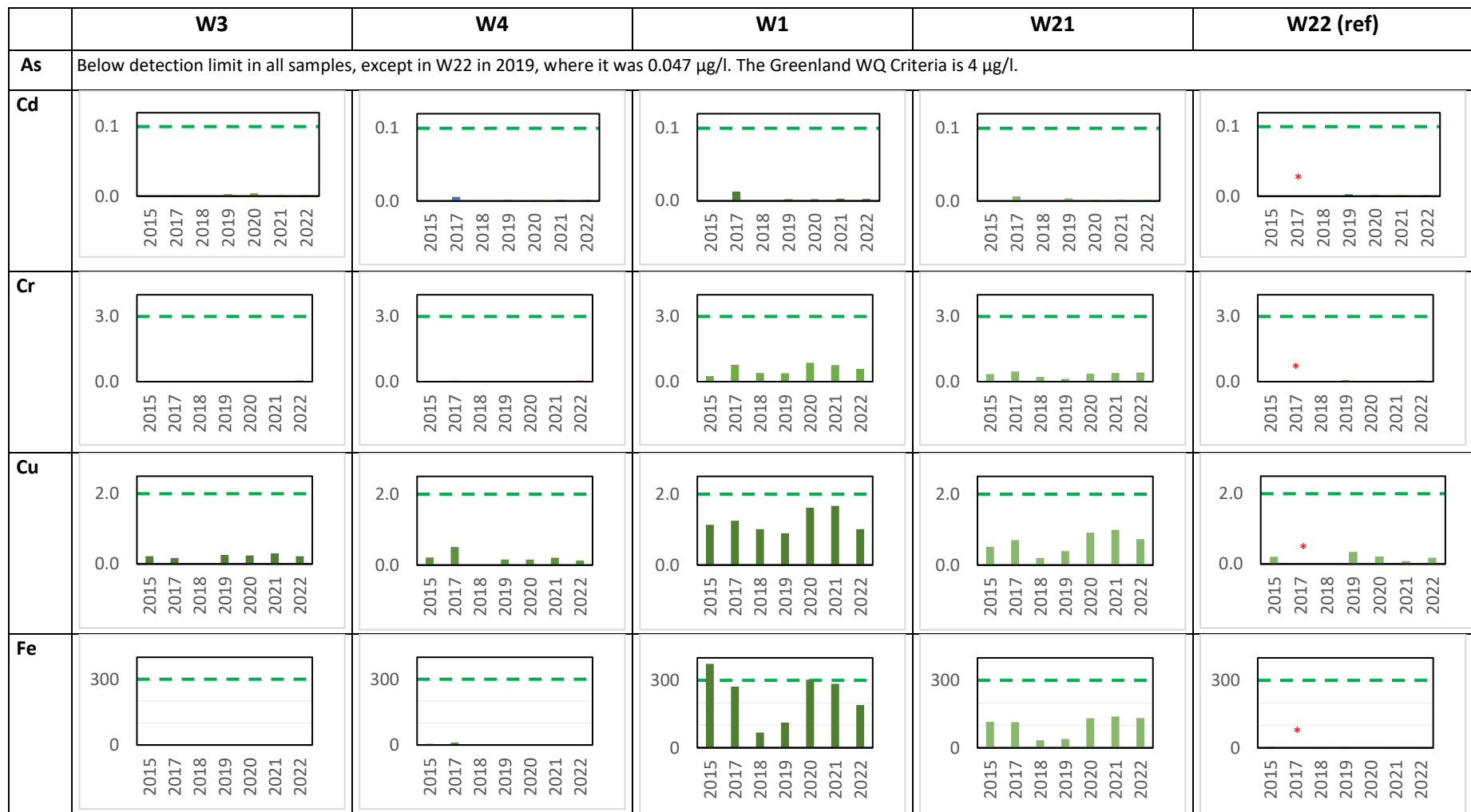
I forbindelse med udarbejdelsen af dette års monitoringsrapport bemærkede vi, at værdier for kobber i 2017 beklageligvis viser værdier for nikkel. Data for kobber i vandprøverne har i sig selv ikke været forkerte, men er altså ikke blevet afbildet. Det er nu rettet (også bagud i tid), således at figurerne herunder viser de korrekte værdier for kobber.

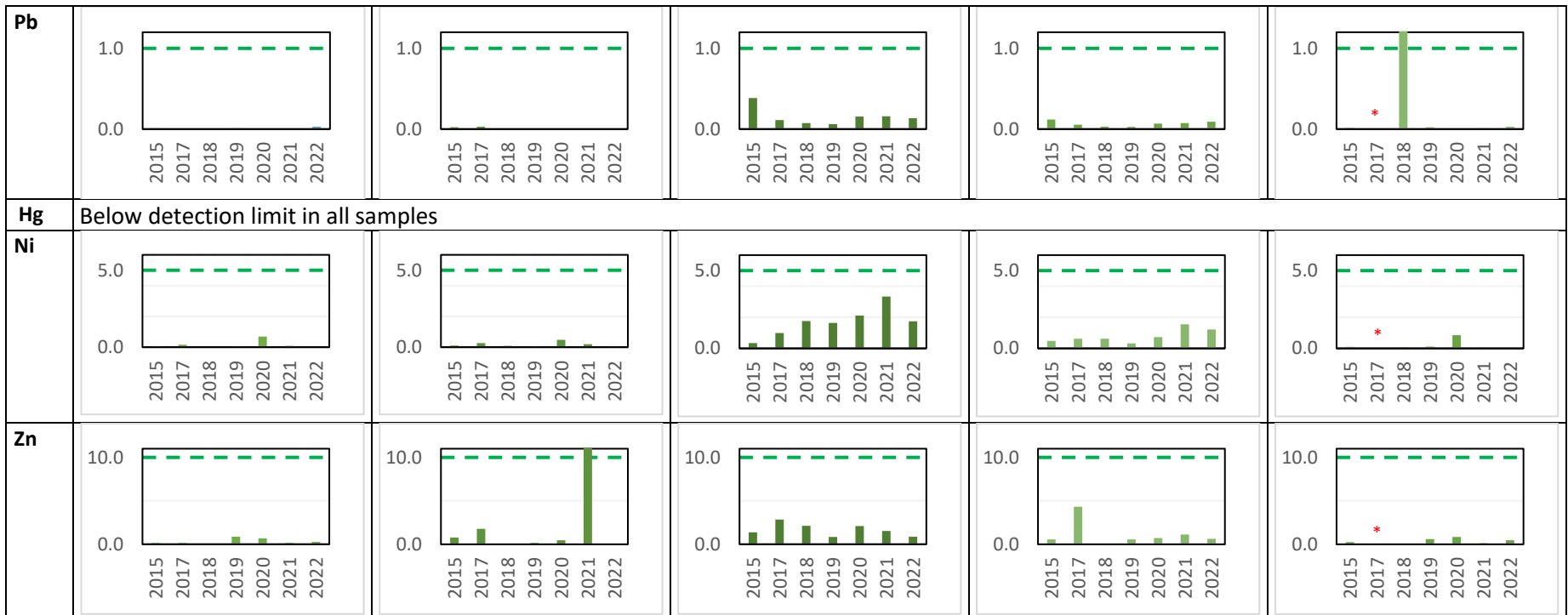
Figur 2. Indholdet af udvalgte metaller i filtrerede vandprøver i 2015, 2017, 2018, 2019, 2020, 2021 og 2022. Det grønlandske vandkvalitetskriterie er markeret med rødt. Koncentrationerne er angivet i $\mu\text{g}/\text{l}$. Markeringen * betyder at værdien mangler.





Figur 3. Indholdet af udvalgte metaller i ufiltrerede vandprøver. Der er ingen vandkvalitetskriterier for ufiltrerede prøver, men kriteriet for filtrerede prøver er markeret med grønt. Vandprøverne er taget i slutningen af august eller starten af september. Koncentrationerne er angivet i µg/l. Markeringen * betyder at værdien mangler.





Bilag 1

Testrapport 2022-1108 fra DCE, Aarhus Universitet, Ferskvandsprøver fra rubinminen, Sydgrønland 2022.

Analyseresultater og detektionsgrænser for samtlige 61 analyserede grundstoffer.

Test report no. 1108

Water samples from the Aappaluttoq Ruby Mine, Southwest Greenland in 2022

Customer: The Environmental Agency for Mineral Resource Activities, Nuuk (EAMRA)

Sample collection:

Sampling place: Near the Aappaluttoq Ruby Mine, Southwest Greenland

Sampling time: September 2022

Sample type: Freshwater

Sampling performed by: Greenland Institute of Natural Resources (GINR).

Sampling methods: Standard DCE methods

Uncertainty in sampling: Not evaluated here

Analyses:

Analyses performed by: University of Aarhus, Institute for Bioscience
National Centre for Environment and Energy (DCE)
Frederiksborgvej 399
4000 Roskilde

Date of analyses: October 2022

Analytical methods: Freshwater samples were acidified with 1 ml/l Merck Suprapure nitric acid and analysed for elemental composition (c. 60 elements) by ICP-MS (Agilent 7900).

Uncertainty of measurement: The laboratory is accredited by the Danish accreditation body DANAK to analyses of freshwater for the elements in listed in Appendix 1 with the specified detection limits and measurement uncertainties. The detection limits during the day of analyses (3 SD on blank samples) were determined based on measurements of a series of

blank samples treated in the same way as the samples. Blank values were subtracted from the sample values. The detection limits during the day of analyses are shown in the tables and it is indicated with a '<DL' if measured values were below the detection limit.

Notes: For quality assessment/quality control (QA/QC), a certified freshwater reference material (SLRS-6) was analysed along with the freshwater samples. The reference material was analysed with satisfactory results and the results are provided in the report after the sample results.

Data in this report has also been sent in an excel file.

Contact person: Jens Søndergaard (DCE)

Appendixes: Appendix 1. Uncertainty of measurements.

The results represent only samples that have been analyzed.

Element concentrations in freshwater samples

Results are given in µg/l. The detection limit (DL) of the analyses is determined as 3 standard deviations on blank values measured during the analyses. Non-accredited elements are marked with a * in the table. <DL= below the detection limit. The values for the Greenland Water Quality Criteria for mining activities (GWQC) are shown for reference.

ID no.	Project	Site	Comment	Li	Be	Na	Mg	Al	P	K	Ca*	Sc*
DL				0.002	0.002	0.836	0.058	0.300	2.986	10.083	0.654	0.002
Greenland Water Quality Criteria (for filtered samples)										20.000		
64651	Ruby	St. 22	Filtered	0.124	<DL	1383.229	165.349	13.599	<DL	186.492	464.624	<DL
64652	Ruby	St. 22	Filtered	0.122	<DL	1341.421	164.012	3.764	<DL	178.353	453.277	<DL
64654	Ruby	St. 3	Filtered	0.063	<DL	956.542	101.436	5.494	<DL	114.097	270.345	<DL
64655	Ruby	St. 3	Filtered	0.055	<DL	931.337	98.809	6.127	<DL	111.818	258.811	<DL
64658	Ruby	St. 4	Filtered	0.213	<DL	1306.577	169.780	6.546	<DL	238.779	1313.792	<DL
64659	Ruby	St. 4	Filtered	0.213	<DL	1343.661	167.336	6.835	<DL	298.045	1279.764	0.002
64661	Ruby	St. 1	Filtered	0.505	<DL	1419.411	645.414	4.988	<DL	1200.147	2329.382	0.003
64662	Ruby	St. 1	Filtered	0.526	<DL	1480.020	673.966	5.160	<DL	1286.463	2410.081	0.003
64664	Ruby	St. 21	Filtered	0.415	<DL	1498.155	543.605	6.724	<DL	974.577	2024.467	<DL
64665	Ruby	St. 21	Filtered	0.441	<DL	1445.593	520.126	6.173	<DL	908.610	1929.980	<DL
64653 Ufiltr.	Ruby	St. 22	Unfiltered	0.123	<DL	1426.011	172.824	16.499	<DL	191.855	493.936	<DL
64656 Ufiltr.	Ruby	St. 3	Unfiltered	0.058	<DL	924.705	97.472	10.114	<DL	110.885	260.402	<DL
64660 Ufiltr.	Ruby	St. 4	Unfiltered	0.210	<DL	1254.768	165.044	13.834	<DL	221.839	1258.460	0.002
64663 Ufiltr.	Ruby	St. 1	Unfiltered	0.836	<DL	1484.429	789.755	285.510	5.074	1312.167	2451.770	0.023
64666 Ufiltr.	Ruby	St. 21	Unfiltered	0.584	<DL	1415.467	587.890	205.565	3.564	934.649	1915.471	0.020

Continued:

Ti*	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga*	As	Se	Rb	Sr	Y*
0.008	0.011	0.037	0.008	0.078	0.001	0.050	0.024	0.144	0.002	0.042	0.007	0.002	0.002	0.000
		3.000		300.000		5.000	2.000	10.000		4.000				
0.065	0.012	0.055	0.101	0.854	0.005	<DL	0.171	0.350	0.003	<DL	0.017	0.375	2.174	0.010
0.036	0.018	<DL	0.123	0.236	0.004	<DL	0.091	0.325	<DL	<DL	0.012	0.352	2.130	0.002
0.016	<DL	0.043	0.159	0.290	0.016	<DL	0.117	0.292	<DL	<DL	0.007	0.194	2.001	0.005
0.027	0.014	<DL	0.151	0.391	0.017	<DL	0.130	0.241	<DL	<DL	0.009	0.182	1.963	0.005
0.014	0.092	0.038	0.047	0.185	0.008	0.061	0.048	<DL	0.003	<DL	0.012	0.357	4.695	0.003
0.027	0.087	0.040	0.044	0.417	0.006	0.066	0.126	0.146	0.004	<DL	0.013	0.351	4.588	0.004
0.013	0.076	0.109	0.575	0.343	0.005	0.925	0.091	<DL	0.008	<DL	0.041	3.545	8.106	0.004
<DL	0.108	0.062	0.585	0.369	0.005	0.952	0.099	<DL	0.006	<DL	0.038	3.883	8.538	0.004
0.026	0.077	0.058	0.533	0.558	0.010	0.691	0.091	<DL	0.004	<DL	0.026	2.956	6.874	0.005
0.026	0.080	0.047	0.503	0.442	0.009	0.672	0.101	<DL	0.009	<DL	0.022	2.748	6.593	0.005
0.202	0.017	0.063	0.324	2.929	0.008	<DL	0.180	0.482	<DL	<DL	0.020	0.370	2.260	0.011
0.086	<DL	0.053	0.161	1.017	0.017	<DL	0.221	0.270	<DL	<DL	0.017	0.184	1.889	0.008
0.107	0.098	0.058	0.161	2.696	0.011	0.076	0.124	<DL	0.003	<DL	0.023	0.324	4.416	0.009
12.825	0.508	0.583	3.649	190.839	0.132	1.738	1.011	0.886	0.129	<DL	0.036	4.441	8.897	0.077
9.491	0.349	0.417	2.455	132.760	0.089	1.224	0.729	0.631	0.079	<DL	0.031	3.154	6.845	0.054

Continued:

Zr*	Nb*	Mo*	Ru*	Pd*	Ag*	Cd	Sb	Te*	Cs	Ba	La*	Ce*	Pr*	Nd*
0.001	0.006	0.005	0.001	0.000	0.001	0.000	0.031	0.007	0.001	0.002	0.000	0.000	0.000	0.000
						0.100								
0.004	<DL	0.086	<DL	0.000	<DL	0.002	<DL	<DL	0.003	0.527	0.066	0.049	0.015	0.048
0.002	<DL	0.005	<DL	<DL	<DL	0.001	<DL	<DL	0.002	0.547	0.019	0.012	0.004	0.012
0.001	<DL	<DL	<DL	0.000	<DL	0.002	<DL	<DL	0.002	1.166	0.019	0.026	0.003	0.013
0.003	<DL	<DL	<DL	0.000	<DL	0.003	<DL	<DL	0.002	1.077	0.021	0.030	0.004	0.012
0.003	<DL	0.061	<DL	<DL	<DL	0.001	<DL	<DL	0.002	0.945	0.008	0.006	0.001	0.006
0.003	<DL	0.154	<DL	<DL	<DL	0.001	<DL	<DL	0.003	0.832	0.016	0.013	0.003	0.012
0.003	<DL	0.607	<DL	0.001	<DL	0.001	<DL	<DL	0.017	1.279	0.047	0.046	0.010	0.030
0.004	<DL	0.602	<DL	0.001	<DL	0.001	<DL	0.007	0.018	1.337	0.026	0.027	0.006	0.023
0.002	<DL	0.548	<DL	<DL	<DL	0.001	<DL	<DL	0.015	1.230	0.040	0.040	0.008	0.027
0.002	<DL	0.543	<DL	<DL	<DL	0.001	<DL	<DL	0.015	1.195	0.034	0.038	0.007	0.024
0.005	<DL	0.085	<DL	<DL	<DL	0.001	<DL	<DL	0.003	0.571	0.088	0.064	0.018	0.064
0.004	<DL	0.013	<DL	<DL	<DL	0.002	<DL	<DL	0.002	1.067	0.037	0.058	0.008	0.028
0.006	<DL	0.341	<DL	0.001	<DL	0.001	<DL	<DL	0.003	0.796	0.051	0.047	0.011	0.037
0.024	0.008	0.368	<DL	0.000	<DL	0.003	<DL	0.011	0.067	4.833	0.987	1.421	0.197	0.649
0.022	0.008	0.412	<DL	<DL	<DL	0.002	<DL	<DL	0.048	3.385	0.688	0.954	0.136	0.440

Continued:

Sm*	Eu*	Gd*	Tb*	Dy*	Ho*	Er*	Tm*	Yb*	Lu*	Hf*	Ta*	W*	Re*
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.005	0.000
0.008	0.001	0.003	0.000	0.002	0.000	0.001	0.000	0.000	<DL	0.000	<DL	<DL	<DL
0.002	0.000	0.001	0.000	0.001	0.000	0.000	<DL	0.000	<DL	<DL	<DL	<DL	<DL
0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.000	<DL	<DL	<DL	<DL	<DL
0.001	0.000	0.001	0.000	0.001	0.000	0.001	<DL	0.000	<DL	<DL	<DL	<DL	<DL
0.001	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	<DL	<DL	<DL	<DL	<DL
0.001	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	<DL	<DL	<DL	<DL
0.003	0.000	0.003	0.000	0.000	0.000	0.000	<DL	0.000	<DL	<DL	<DL	0.135	<DL
0.003	0.000	0.001	0.000	0.001	0.000	0.000	<DL	0.000	<DL	<DL	<DL	0.139	<DL
0.004	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	<DL	<DL	<DL	0.089	<DL
0.002	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	<DL	<DL	<DL	0.091	<DL
0.007	0.001	0.005	0.000	0.002	0.000	0.001	0.000	0.001	<DL	<DL	<DL	<DL	0.000
0.003	0.001	0.002	0.000	0.001	0.000	0.001	0.000	0.001	0.000	<DL	<DL	<DL	0.000
0.005	0.001	0.004	0.000	0.002	0.000	0.001	0.000	0.001	0.000	<DL	<DL	<DL	<DL
0.078	0.009	0.042	0.005	0.018	0.002	0.006	0.001	0.005	0.001	0.001	<DL	0.041	0.000
0.056	0.006	0.029	0.003	0.012	0.002	0.005	0.001	0.003	0.001	0.000	<DL	0.037	0.000

Continued:

Pt*	Au*	Hg*	Tl*	Pb	Bi*	Th*	U*
0.002	0.005	0.004	0.002	0.005	0.001	0.000	0.000
		0.050		1.000			
<DL	<DL	<DL	<DL	0.096	<DL	0.002	0.022
<DL	<DL	<DL	<DL	0.020	<DL	0.000	0.004
<DL	<DL	<DL	<DL	0.022	<DL	0.000	0.000
<DL	<DL	<DL	<DL	0.032	<DL	0.000	0.001
<DL	<DL	<DL	<DL	<DL	<DL	0.000	0.008
<DL	<DL	<DL	<DL	0.009	<DL	0.001	0.014
<DL	<DL	<DL	<DL	0.004	<DL	0.000	0.040
<DL	<DL	<DL	0.004	<DL	<DL	0.000	0.010
<DL	<DL	<DL	0.004	<DL	<DL	0.000	0.009
<DL	<DL	<DL	0.003	<DL	<DL	0.000	0.017
<DL	<DL	<DL	<DL	0.031	<DL	0.001	0.032
<DL	<DL	<DL	<DL	0.032	<DL	0.001	0.004
<DL	<DL	<DL	<DL	0.007	<DL	0.001	0.115
<DL	<DL	<DL	0.007	0.135	0.004	0.041	0.212
<DL	<DL	<DL	0.005	0.091	0.002	0.037	0.196

Measured element concentrations in certified reference material (SLRS-6) analysed along with the samples (for QA/QC)

Results are given in µg/l. The detection limit (DL) of the analyses is determined as 3 standard deviations on blank values measured during the analyses. Non-accredited elements are marked with a * in the table. <DL= below the detection limit. ND=Not determined. Numbers in brackets are information/reference values only (i.e. not certified values).

ID no.	Project	Site	Comment	Li	Be	Na	Mg	Al	P	K	Ca*	Sc*
DL				0.002	0.002	0.836	0.058	0.300	2.986	10.083	0.654	0.002
SLRS-6				0.496	0.007	2430.637	1937.778	30.320	4.088	604.788	7712.945	0.018
SLRS-6				0.532	0.005	2454.113	1978.270	30.592	<DL	587.467	7614.292	0.014
SLRS-6				0.510	0.006	2468.577	1952.853	30.882	<DL	602.823	7732.751	0.016
SLRS-6				0.522	0.006	2520.225	2017.097	32.124	<DL	624.173	7918.798	0.017
SLRS-6				0.517	0.006	2526.816	2015.485	31.283	4.525	634.426	7987.687	0.015
SLRS-6				0.492	0.005	2527.508	2019.054	32.010	3.112	632.296	7897.965	0.016
Certificate value				ND	(0.0066)	2760.000	2133.000	33.800	ND	651.000	8760.000	ND
Certificate uncertainty (2 SD)				ND	(0.0022)	220.000	58.000	2.200	ND	54.000	200.000	ND

Continued:

Ti*	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga*	As	Se	Rb	Sr	Y*
0.008	0.011	0.037	0.008	0.078	0.001	0.050	0.024	0.144	0.002	0.042	0.007	0.002	0.002	0.000
0.475	0.319	0.253	1.992	78.512	0.049	0.515	22.757	1.856	0.015	0.478	0.092	1.320	37.134	0.118
0.495	0.308	0.256	1.924	77.998	0.046	0.501	22.388	1.637	0.015	0.470	0.082	1.310	37.519	0.116
0.466	0.319	0.265	1.952	76.850	0.049	0.493	22.014	1.639	0.017	0.504	0.085	1.293	37.174	0.121
0.487	0.337	0.229	1.983	78.390	0.049	0.497	22.359	1.633	0.020	0.490	0.101	1.314	37.725	0.122
0.492	0.310	0.293	1.998	78.552	0.049	0.491	22.157	1.617	0.016	0.514	0.066	1.319	38.020	0.121
0.538	0.328	0.254	1.982	78.651	0.049	0.485	21.989	1.657	0.014	0.500	0.066	1.319	37.569	0.120
ND	0.351	0.252	2.120	84.300	(0.053)	0.616	23.900	1.760	ND	0.570	ND	ND	40.660	ND
ND	0.006	0.012	0.100	3.600	(0.012)	0.022	1.800	0.120	ND	0.080	ND	ND	0.320	ND

Continued:

Zr*	Nb*	Mo*	Ru*	Pd*	Ag*	Cd	Sb	Te*	Cs	Ba	La*	Ce*	Pr*	Nd*
0.001	0.006	0.005	0.001	0.000	0.001	0.000	0.031	0.007	0.001	0.002	0.000	0.000	0.000	0.000
0.039	<DL	0.170	<DL	0.001	<DL	0.007	0.304	<DL	0.004	13.107	0.215	0.261	0.051	0.192
0.040	<DL	0.169	<DL	0.001	<DL	0.010	0.306	<DL	0.005	13.199	0.217	0.263	0.050	0.197
0.039	<DL	0.176	<DL	0.001	<DL	0.008	0.297	<DL	0.005	13.022	0.216	0.259	0.050	0.200
0.046	<DL	0.188	<DL	0.001	<DL	0.010	0.297	<DL	0.005	13.382	0.218	0.267	0.052	0.201
0.044	<DL	0.189	<DL	0.001	<DL	0.008	0.297	0.011	0.004	13.388	0.216	0.259	0.052	0.194
0.047	<DL	0.190	<DL	0.001	<DL	0.007	0.294	<DL	0.004	13.123	0.213	0.257	0.049	0.196
ND	ND	0.215	ND	ND	ND	0.006	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	0.018	ND	ND	ND	0.001	ND	ND	ND	ND	ND	ND	ND	ND

Continued:

Sm*	Eu*	Gd*	Tb*	Dy*	Ho*	Er*	Tm*	Yb*	Lu*	Hf*	Ta*	W*	Re*
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.005	0.000
0.032	0.006	0.025	0.003	0.016	0.004	0.011	0.001	0.009	0.001	0.001	<DL	0.008	0.014
0.035	0.007	0.024	0.003	0.018	0.004	0.012	0.001	0.011	0.002	0.002	<DL	0.009	0.013
0.035	0.006	0.026	0.003	0.018	0.004	0.011	0.001	0.011	0.002	0.001	<DL	0.009	0.014
0.036	0.006	0.026	0.003	0.020	0.004	0.011	0.001	0.009	0.001	0.002	<DL	0.008	0.014
0.031	0.006	0.027	0.004	0.017	0.004	0.010	0.002	0.010	0.001	0.002	<DL	0.015	0.014
0.035	0.006	0.028	0.003	0.017	0.004	0.010	0.001	0.010	0.002	0.001	<DL	0.011	0.014
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

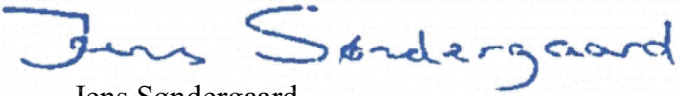
Continued:

Pt*	Au*	Hg*	Tl*	Pb	Bi*	Th*	U*
0.002	0.005	0.004	0.002	0.005	0.001	0.000	0.000
<DL	<DL	<DL	0.003	0.153	0.002	0.014	0.067
0.004	<DL	<DL	0.007	0.151	0.001	0.016	0.068
0.004	<DL	<DL	0.004	0.150	0.001	0.014	0.065
0.004	<DL	<DL	0.005	0.148	0.001	0.014	0.068
0.003	<DL	<DL	0.004	0.149	0.001	0.011	0.069
0.002	<DL	<DL	0.004	0.147	0.001	0.011	0.066
ND	ND	ND	ND	0.170	ND	ND	0.070
ND	ND	ND	ND	0.026	ND	ND	0.003

Responsible for the report:

Date: 17 October 2022

Signature:



Jens Søndergaard

Position: Senior Researcher/Head of Laboratory

Appendix 1. Uncertainty of measurements

Accredited detection limits and uncertainties for ICP-MS analyses of freshwater:

Expanded uncertainty, $k=2$ (95% confidence), in $\mu\text{g/l}$.

Parameter	Detection limit (DL)	Lower uncertainty U_{abs}	Upper uncertainty U_{rel} (%)
Li	1.0	0.67	15
Be	0.2	0.1	5
Na	55	37	10
Mg	10	6.7	10
Al	10	6.7	10
P	15	10	15
K	25	17	10
V	0.2	0.13	5
Cr	0.2	0.13	5
Mn	2.5	1.7	15
Fe	10	6.7	5
Co	0.2	0.1	10
Ni	0.5	0.3	10
Cu	0.8	0.5	10
Zn	10	6.7	15
As	1.0	0.67	20
Se	0.5	0.3	10
Sr	0.5	0.3	5
Mo	2.0	1.3	15
Cd	0.1	0.07	10
Sb	2.0	1.3	10
Cs	0.1	0.07	10
Ba	1.0	0.67	5
Pb	0.3	0.2	10

Calculation of uncertainties:

Detection limit (DL): The lowest result that is significant different from zero.

The total uncertainty (U_c) can be calculated from the formula:

$$U_c = \sqrt{U_{abs}^2 + U_{rel}^2 C^2} ;$$

U_{abs} = Lower uncertainty: The absolute uncertainty dominating at the lower measuring level (here set to 2/3 DL).

U_{rel} = Upper uncertainty: The relative uncertainty for samples with a high concentration.

C = Concentration.

Example:

The calculated total uncertainty U_c of a sample with a concentration of 5.1 mg/kg with $U_{abs} = 0.2$ and $U_{rel} = 24\%$ based on the formula gives:

$$U_{5,1} = U_c = \sqrt{0.2^2 + \left(\frac{24\%}{100\%}\right)^2 5.1^2} = 1.2$$

This means that there is a 95% probability that the true result is between 3.9 and 6.3.