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Metal pollution around Norwegian industries studied by analysis of naturally growing moss samples

2015 survey

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ABSTRACT

On request from the Norwegian Environment Agency, a survey of atmospheric deposition of heavy metals around industrial enterprises in Norway has been carried out. The participation was voluntary and 22 industries located at 17 different sites financed their own participation. The survey is based on analysis of samples of naturally growing moss collected around the enterprises during the summer of 2015 and includes 57 different elements. For a majority of the sites this survey is a follow-up of corresponding surveys carried out in 2000, 2005, and 2010. In general the results show that deposition of heavy metals close to the industries depends closely on the industrial processes used as well as the local topographic and meteorological conditions. The results are evaluated relative to corresponding background levels in moss in parts of Norway with low impact of air pollution. Like in previous surveys, the generally most polluted industrial location is Mo i Rana, followed by Odda. At most sites only minor general improvement is observed since the previous survey in 2010.

NORWEGIAN TITLE

Tungmetallforurensing rundt norske industrier studert ved analyse av moseprøver. Undersøkelse i 2015.

KEYWORDS

Metals | Survey | Moss samples

ABSTRACT (in Norwegian)

Etter oppdrag fra Miljødirektoratet, er atmosfærisk nedfall av tungmetaller undersøkt rundt aktuelle industrianlegg i Norge. 22 industribedrifter på 17 forskjellige steder ønsket å delta og har finansiert sin egen deltakelse. Undersøkelsen er basert på prøver av naturlig voksende mose innsamlet rundt de enkelte bedrifter sommeren 2015 og omfatter 57 grunnstoffer. I et flertall av tilfellene dreier det seg om gjentakelse av tilsvarende undersøkelser i 2000, 2005 og 2010. Resultatene viser at nedfall av metaller i nærområdet til disse bedriftene avhenger sterkt av de prosesser bedriften arbeider med så vel som de lokale topografiske og meteorologiske forhold. Grad av forurensning er vurdert i forhold til verdier fra moseprøver tatt i strøk av Norge lite utsatt for luftforurensning. Det generelt mest forurensede industristedet er som tidligere Mo i Rana, etterfulgt av Odda. På de fleste stedene er det kun små til moderate endringer å spore fra tidligere undersøkelser.

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Summary

On request from the Norwegian Environmental Agency a survey of atmospheric deposition of heavy metals was carried out around industrial enterprises in Norway. Participation was voluntary and 20 industries at 15 locations financed their own participation. The survey is based on analysis of moss samples collected locally around each enterprise during the summer of 2015, and includes 58 elements. The present survey is for most locations a repetition of corresponding surveys executed in 2000, 2005, and 2010. The results show that deposition of heavy metals close to the companies strongly depends on the processes used by the enterprises as well as the local topographic- and meteorological conditions. The results are evaluated in relation to median values from a nationwide moss survey in Norway 2015, covering 230 background sites. Temporal trends are presented for Mn and Zn in Sauda, Ni and Bi in Årdal and Cd in Odda. Mean values from the 3 apparently most influenced sites at each location are shown together with mean values from previous surveys.

Metal pollution around Norwegian industries studied by analysis of naturally growing moss samples: 2015 survey 2015 survey

1 Introduction

The moss biomonitoring technique, first employed in Sweden (Rühling and Tyler, 1973) is particularly well suited in territories where mosses are frequent and grow on a humic soil substrate. Since 1977, moss samples have been collected all over Norway every five years according to a regular network to serve as monitors of atmospheric deposition of heavy metals (Steinnes et al., 2009, 2016), and are also employed in coordinated deposition surveys on the European level (Harmens et al.). The moss species preferentially used in Norway for this purpose is *Hylocomium splendens*. This moss is characterized by a well-defined annual growth, which allows definition of the time period it was exposed to atmospheric deposition.

The primary use of this approach in Norway is for studies of metal deposition over large territories (*e.g*. Steinnes, 1980, Steinnes et al., 1992a, Berg et al., 1994; 1997). A first attempt to use this approach for monitoring of metal deposition in detail around a local industry was carried out at Mo i Rana (Steinnes et al. 1992b). Based on the experience from this work, a more extensive monitoring of metal deposition at 11 sites in Norway was carried out in 2000 (SFT 2001). This monitoring involving a gradually increasing number of sites and industries, was followed up in 2005 (Steinnes et al., 2007) and 2010 (Steinnes et al., 2011). The work described in the present report is a further extension of previous work, with additional industries and sites, based on moss sampling in 2015. Totally 22 industries listed below, distributed among 17 geographical locations, participated in the 2015 survey. The industries financed their own participation.

Eramet Porsgrunn, Porsgrunn
Glencore nikkelverk, Kristiansand S
Elkem Carbon, Kristiansand S
Alcoa Lista, Lista
Eramet Kvinesdal, Kvinesdal
Hydro Aluminium, Karmøy
Eramet Sauda, Sauda
Sør-Norge Aluminium, Husnes
Boliden, Odda
TiZir Titanium, Odda
Elkem AS, Bjølvefossen
Hydro Aluminium, Høyanger
Nystar, Høyanger
Hydro Aluminium, Årdal
Hydro Aluminium, Sunndal
Wacker Chemicals, Hemne
Elkem Thamshavn, Orkanger
Alcoa Mosjøen, Mosjøen
Glencore Manganese Norway, Mo i Rana
Fesil, Mo i Rana

Celsa Armeringsstål, Mo i Rana
Finnfjord, Finnsnes

Figure 1: Map showing all locations where moss were sampled in 2015.

Since the first national survey of metal deposition at industrial sites in Norway, the number of participants has varied somewhat, as shown in Table 1. The number of sites varied from 11 in 2000, via 7 in 2005 and 14 in 2010, to 17 in 2015.

Table 1: Sites where the moss monitoring method has been employed in Norway to monitor metal deposition around local industries.

ID	Location	2000	2005	2010	2015
Por	Porsgrunn	X		X	X
Krs	Kristiansand S		X	X	X
Lis	Lista	X		X	X
Kvi	Kvinesdal	X		X	X
Sau	Sauda	X	X	X	X
Kar	Karmøy			X	X
Hus	Husnes			X	X
Odd	Odda	X	X	X	X
Ålv	Ålvik				X
Høy	Høyanger	X		X	X
Ård	Årdal	X	X	X	X
Sun	Sunndal	X	X	X	X
Hem	Hemne				X
Ork	Orkanger				X
Msj	Mosjøen	X		X	X
MiR	Mo i Rana	X	X	X	X
Fin	Finnsnes	X			X

2 Experimental

2.1 Sampling

Samples of the moss species *Hylocomium splendens* were collected during the period May – August 2015 around the participating industries. The sampling sites were selected in order to reflect in a best possible way the local deposition pattern considering local topography and prevailing wind directions, in most cases at 1-10 km distance from the plant. At sites previously studied the sampling sites were as far as possible the same as before. The sampling network employed at each of the locations is shown on maps in Figs. 2, 3, 8-11, 13, 15, 19, 20, 23, 26-30 and 34.

2.2 Analysis

The moss samples were dried at room temperature and extraneous material was removed by hand. Segments of the moss plants corresponding to the last 3 years´ growth were selected for chemical analysis. Digestion of moss samples was performed with a microwave technique system (UltraCLAVE, Milestone, Italy). Dry moss (0.5-0.6 g) was accurately weighed and HNO_3 (5 ml, s.p) was added. The samples were digested according to a 65 minutes long temperature programme, with stepwise heating to 250 °C and a holding time of 30 minutes at 250 °C. After cooling, the digests were quantitatively transferred to polypropylene tubes and diluted to 50 ml with deionized water.

For determination of metals, aliquots of 1.0 ml and 0.1 ml, respectively, were diluted to 10 ml. A high resolution inductively coupled plasma mass spectrometer (ICP-HRMS), ELEMENT2 from Thermo Scientific, Bremen, was used for determination of metals. All calibration standards, blank samples and reference materials contained 1%(v/v) HNO_3 (s.p) and 1 ng ml^{-1} rhenium as internal standard.

For determination of Hg , aliquots of 25 ml were diluted to 50 ml and added 5 ml BrCl for stabilisation. A cold-vapour atomic fluorescence spectrophotometer (CV-AFS), Tekran, Canada, was used for determination of mercury.

To assess the accuracy of the results a certified reference material traceable to NIST (1566b) were used. In addition, moss reference samples M-2 and M-3 prepared and distributed by the Finnish Forest Research were analysed. Calibration curves for all elements reported, including elements not certified in the CRMs, were verified using multi-element standards from Certipur.

2.3 Uncertainty

To minimize or eliminate uncertainty sources in the fieldwork, the principles as described in "Heavy metals, Nitrogen and POPs in European mosses: survey 2015, Monitoring manual (UNECE ICP-Vegetation, 2015)", were followed. Measurement uncertainties are calculated from CRM and reference moss samples M-2 and M-3. The uncertainties listed in table 1 include laboratory bias, uncertainty in CRM values, laboratory reproducibility and have coverage factor of 2.

Table 2: Estimated uncertainties in the determination of elements

Element	Uncertainty (%)	Element	Uncertainty (%)	Element	Uncertainty (%)
Be	18	Co	14	Cd	7
B	16	Ni	17	Sb	10
Na	20	Cu	10	Cs	13
Mg	20	Zn	20	Ba	12
Al	20	Ga	23	La	20
S	10	Ge	25	Ce	15
K	11	As	15	Sm	30
Ca	24	Se	20	Hg	10
Sc	30	Rb	17	Tl	11
V	19	Sr	11	Pb	18
Cr	30	Y	20	Bi	14
Mn	13	Mo	20	Th	18
Fe	20	Ag	10	U	10

2.4 Trend analysis

The statistical method used for detecting and estimating trends, is the nonparametric Mann-Kendall test and Sen's method (Gilbert, 1987). The Mann-Kendall test is used to discover monotonic decreasing or increasing trend in data sets and the variables do not need to

conform to any particular distribution. To achieve the lowest level of confidence (□= 0.1), the test requires at least four values. The present survey is the fourth moss-survey carried out around Norwegian industries. Some industries have participated in all four surveys, which facilitates trend analysis at the lowest level of significance. The locations where trends are studied are Mo i Rana, Sauda, Odda, Sunndal, and Årdal.
Sen's method is a non-parametrical method that is used to estimate the slope of an existing linear trend. This method requires minimum 10 values to calculate confidence interval for the slope estimate. Hence, the present data set is too limited and does not fulfil the presumptions this method requires. Even so, the slope during the time period is shown, but it is emphasized that the uncertainty in these slopes are high.

3 Results

Results for concentrations of 57 elements in moss samples collected at 17 industrial sites in Norway during the summer of 2015 are listed in Tables 3, 5, 7, 9, 11, 12, 14, 16, 18, 20, 22, 24, 26, 27, 29, 30,and 32. Values exceeding background level in moss by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Elements such as Cu, Mn and Zn are essential nutrients in plants and occur naturally in relatively high concentration in moss. For these elements values exceeding background level with a factor of 5 and 10, indicate obvious and substantial pollution, respectively. Deposition of mercury poses a special case where any increase should be considered as undesirable. Thus, values of mercury exceeding background levels with a factor of 3 and 10 indicate obvious and substantial pollution respectively.
Background levels are based on mean values for moss samples in a region of Norway little affected by air pollution as evident from the simultaneous nationwide survey (National Moss survey 2015). These background levels are presented in Table A2.
Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at each geographical location, are listed in Tables 4, 6, 8, 10, 13, 15, 17, 19, 21, 23, 25, 28, 29, and 33. These results are basis for discussion in chapter 4 . The selected elements are those exceeding the criteria for obvious or substantial pollution. In addition, corresponding values from previous surveys involving the same local sampling sites are presented. The colouring codes are similar to those used in Table 3. Mean values exceeding criteria for obvious or substantial pollution were not found at Karmøy or Hemne. Hence, there are no tables for these two locations.
Time trends of elements showing significant changes in concentration at given locations are shown in Figs. 12, 14 and 22.

4 Discussion

The discussion is divided and the results are first discussed according to location, and then for each element.

4.1 Location

In the following the results for each geographical location are discussed on the basis of the character of industries in question and the contamination levels observed, and maps are shown demonstrating the local distribution of the most important pollutant elements at each site. At most sites, sampling was carried out a five sites surrounding the industries.

4.1.1 Porsgrunn

The sampling sites at Porsgrunn are shown in Figure 2. The area is relatively densely inhabited and several minor sources may contribute to the general metal pollution. Some of the results indicate moderate pollution at one or more site, but no metals reach seriously high levels at any of the sites.

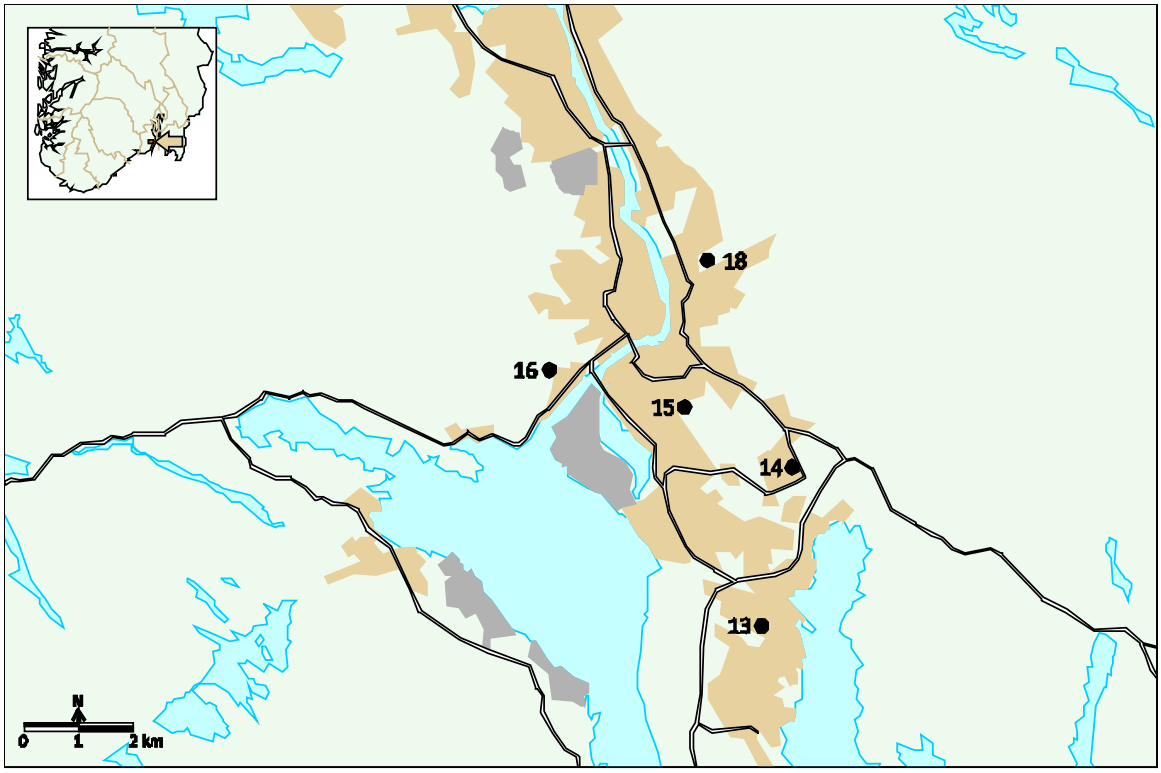

Figure 2: Sampling sites – Porsgrunn

Table 3: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Porsgrunn

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Por 15-13	0.57	0.07	8.5	244	7.7	26	0.81	0.40	0.008	0.07	0.31	0.39	0.03	0.23	29	1.8
Por 15-14	0.50	0.05	5.9	229	13	14	0.78	0.35	0.003	0.06	0.29	0.24	0.02	0.27	25	1.6
Por 15-15	3.2	0.24	23	216	11	52	3.2	0.25	0.014	0.12	0.21	0.20	0.05	0.54	38	6.0
Por 15-16	0.12	0.02	6.0	200	9.3	42	0.51	0.13	0.011	0.02	0.08	0.10	<0.02	0.13	23	2.0
Por 15-18	0.45	0.06	4.8	159	28	17	0.85	0.27	0.006	0.06	0.25	0.16	0.05	0.31	38	1.4
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Por 15-13	3.2	0.31	1.1	0.20	0.091	0.30	0.04	0.14	0.03	0.10	0.008	0.074	0.010	0.05	0.018	0.039
Por 15-14	3.3	0.31	1.2	0.22	0.066	0.21	0.05	0.14	0.03	0.11	0.008	0.076	0.011	0.06	0.011	0.019
Por 15-15	12	1.4	5.0	0.86	0.230	1.2	0.19	0.60	0.11	0.46	0.041	0.317	0.043	0.12	0.003	0.007
Por 15-16	3.2	0.33	1.2	0.17	0.082	0.28	0.04	0.09	0.02	0.07	0.004	0.034	0.004	0.02	0.020	0.032
Por 15-18	3.1	0.28	1.1	0.19	0.104	0.22	0.04	0.16	0.03	0.11	0.011	0.085	0.011	0.04	0.004	0.008
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Por 15-13	0.16	4.9	0.13	0.23	0.08	1276	870	1375	5060	0.19	46	2.4	2.9	377	707	0.57
Por 15-14	0.36	5.9	0.09	0.28	0.09	1378	849	1328	4538	0.20	62	2.4	2.4	749	834	0.54
Por 15-15	0.08	5.8	0.28	0.93	0.35	2567	3270	1379	10153	0.65	125	6.8	5.8	833	2231	1.6
Por 15-16	0.02	1.3	0.01	0.05	0.06	1233	470	972	3393	0.05	26	1.0	1.2	1209	197	0.36
Por 15-18	0.10	5.5	0.08	0.27	0.08	1775	1017	1183	5200	0.21	73	2.4	2.0	1004	837	0.68
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Por 15-13	2.1	12	49	0.26	0.81	3480	0.03	0.34	0.35	0.104						
Por 15-14	2.1	13	60	0.31	0.76	3569	0.04	0.33	0.25	0.029						
Por 15-15	4.4	13	48	1.2	1.3	3575	0.07	0.89	0.42	0.084						
Por 15-16	1.1	3.2	36	0.13	0.23	5612	0.01	0.07	0.10	0.049						
Por 15-18	2.0	9.1	59	0.38	1.0	6295	0.04	0.31	0.32	0.064						

Table 4: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Porsgrunn	13,15,18	2015					3.2	6.0							
		2010					4.7	8.0							
		2000					2.1	3.7							
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
		2015													
		2010													
		2000													

4.1.2 Kristiansand

The sampling sites in Kristiansand are shown in Figure 3. The main source of atmospheric metal pollution in this city is a copper-nickel smelter. In addition to the major metals Ni (Figure 4) and Cu Figure 5) this source is most probably responsible for high relative levels of Co, Ag (Figure 6), and Te (Figure 7). In 2015 five more sampling sites were added to the previous ones in order to distinguish any metal pollution from Elkem Carbon, an additional participant in the survey, but no evident metal contribution from this enterprise was observed.

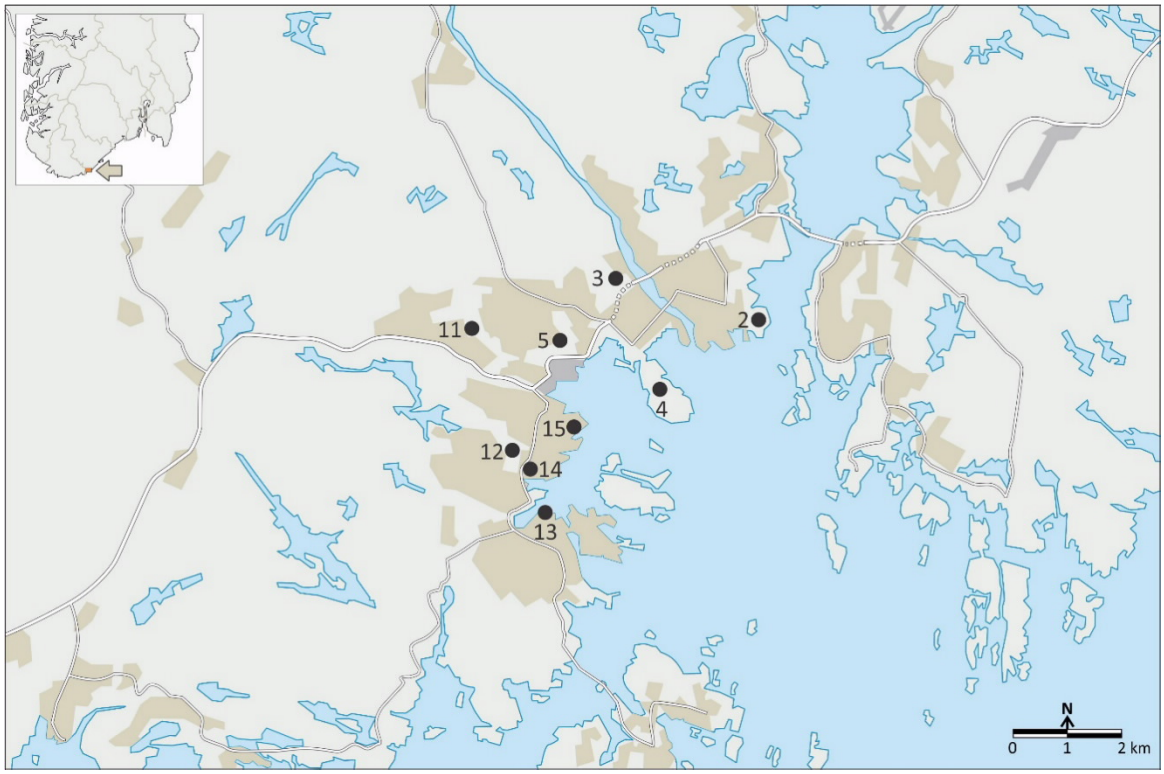

Figure 3: Sampling sites - Kristiansand

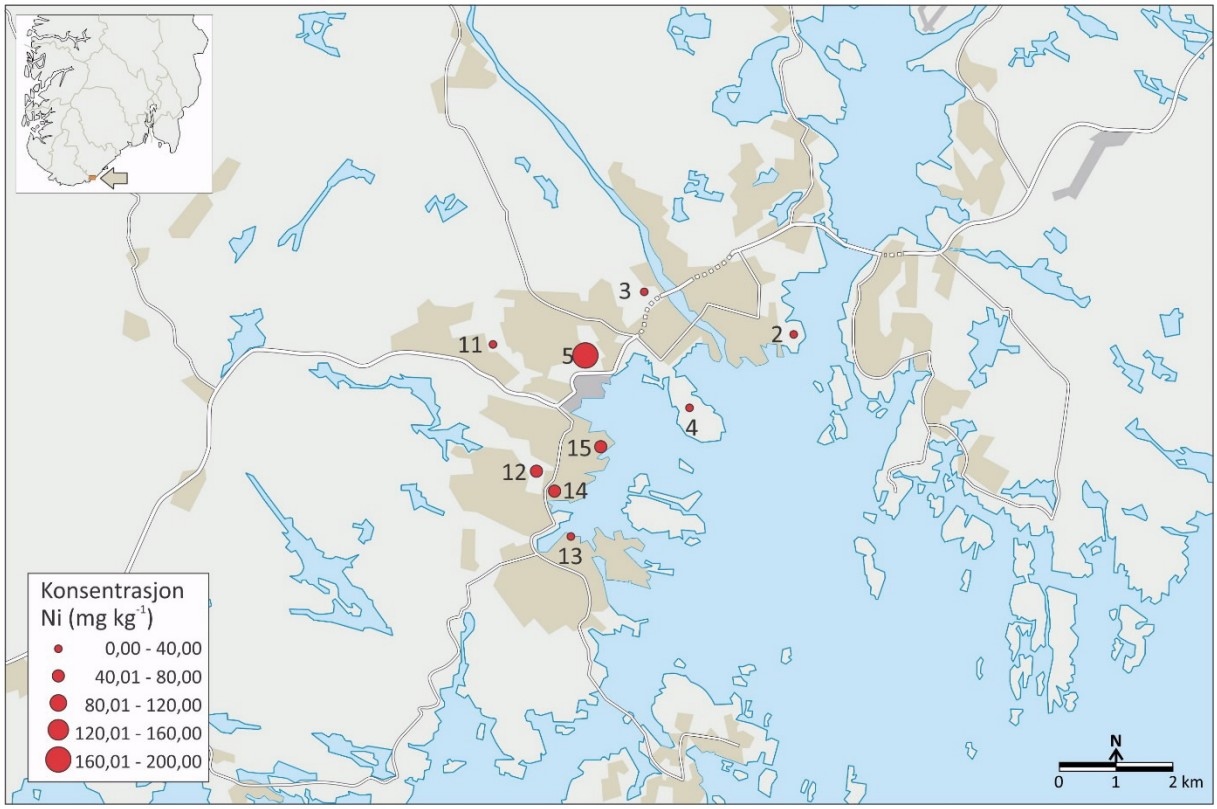

Figure 4: Concentration of Nickel in moss samples – Kristiansand

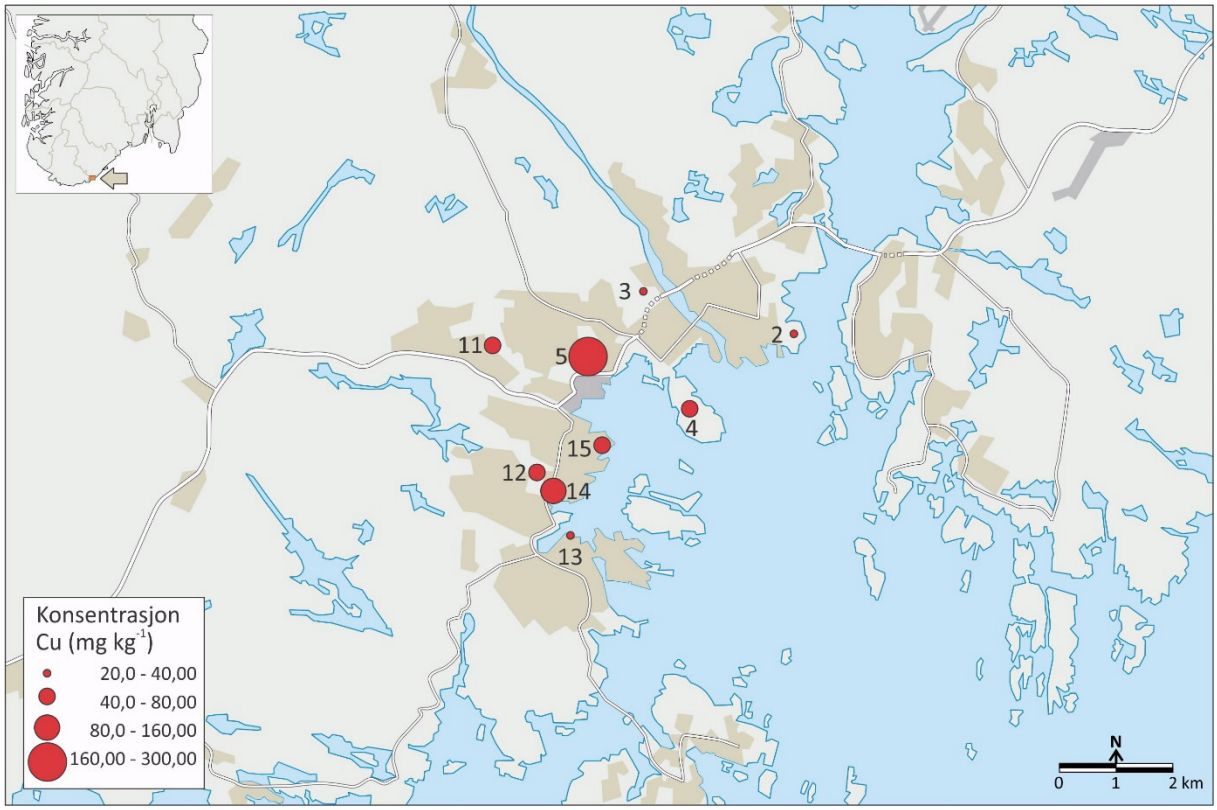

Figure 5: Concentration of Copper in moss samples - Kristiansand

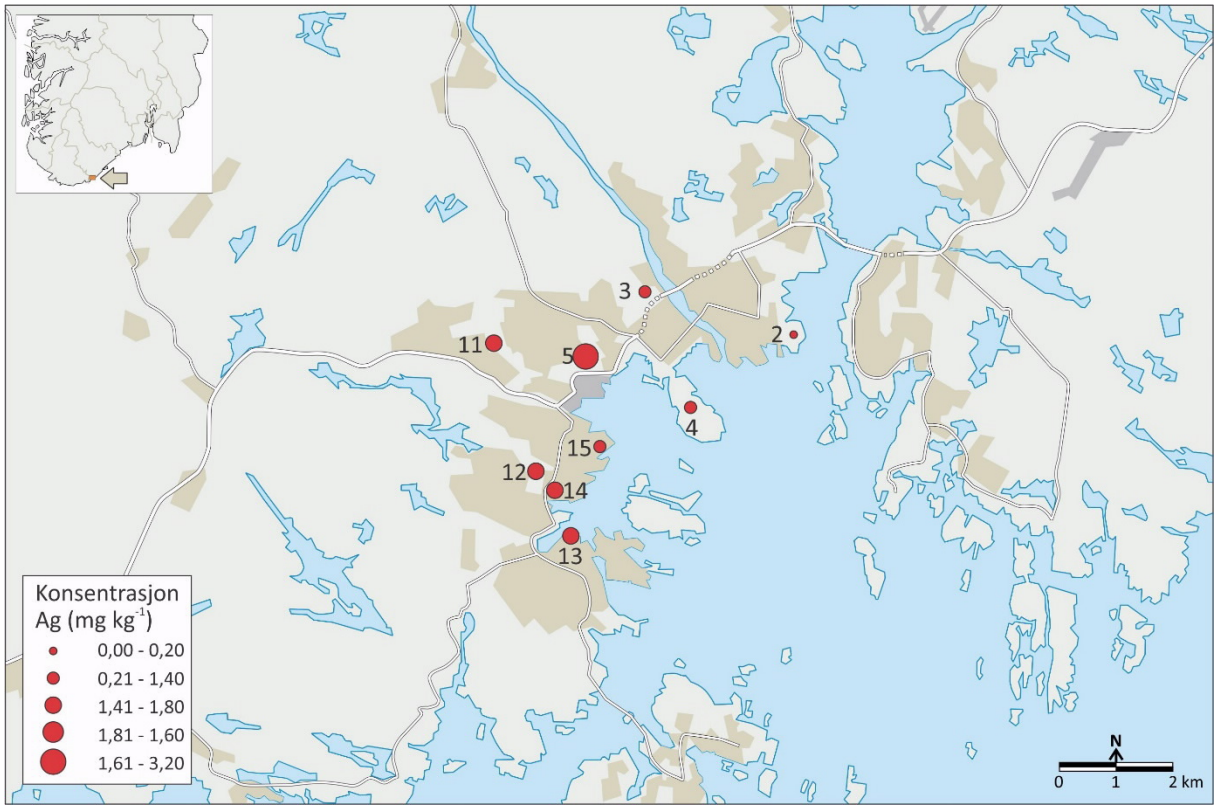

Figure 6: Concentration of Silver in moss samples – Kristiansand

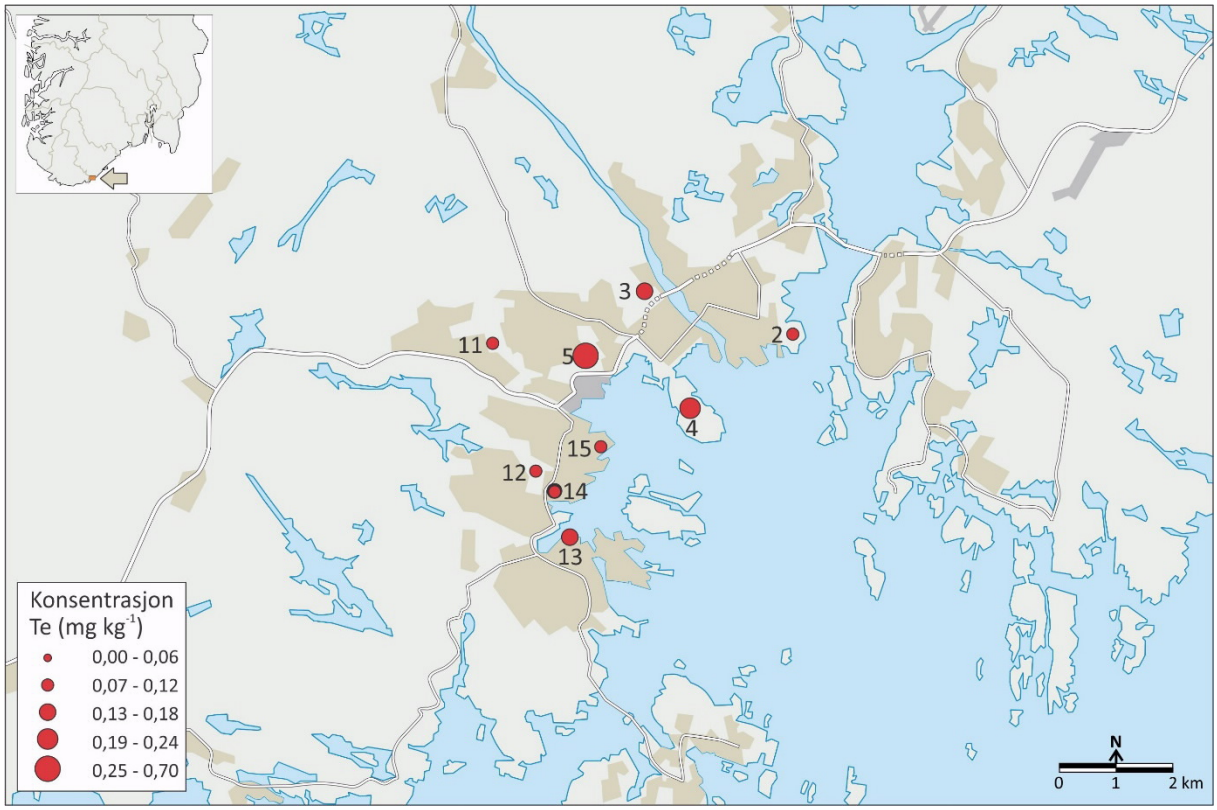

Figure 7: Concentration of Tellurium in moss samples – Kristiansand

Table 5: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Kristiansand

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Krs 15-02	0.29	0.02	5.8	306	14	17	0.57	0.14	0.007	0.17	0.47	0.14	0.07	0.20	28	0.77
Krs 15-03	0.34	0.03	3.7	205	21	10	0.76	0.16	0.006	0.29	0.35	0.28	0.13	0.27	21	0.77
Krs 15-04	0.66	0.04	11	293	21	17	1.2	0.24	0.010	0.30	0.23	0.26	0.20	0.24	37	1.6
Krs 15-05	1.6	0.14	7.5	246	25	27	7.0	0.04	0.043	3.9	0.40	0.11	0.61	0.36	68	12
Krs 15-11	0.50	0.03	3.3	294	17	16	1.1	0.19	0.010	0.46	0.27	0.44	0.12	0.30	29	1.4
Krs 15-12	0.44	0.03	2.0	199	16	11	1.0	0.18	0.009	0.45	0.16	0.28	0.09	0.29	29	1.3
Krs 15-13	0.26	0.02	2.1	597	17	15	0.66	0.21	0.009	0.41	0.34	0.65	0.15	1.2	20	0.6
Krs 15-14	0.39	0.03	2.7	219	26	15	0.82	0.16	0.013	0.59	0.20	0.28	0.12	0.41	29	1.1
Krs 15-15	0.44	0.04	1.9	149	25	10	1.2	0.14	0.011	0.40	0.21	0.39	0.09	0.39	25	2.6
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Krs 15-02	1.6	0.16	0.61	0.11	0.06	0.14	0.03	0.10	0.02	0.07	0.007	0.054	0.007	0.02	0.005	0.012
Krs 15-03	1.6	0.17	0.68	0.13	0.06	0.15	0.03	0.13	0.03	0.09	0.009	0.074	0.010	0.03	0.007	0.015
Krs 15-04	3.5	0.36	1.4	0.25	0.10	0.31	0.06	0.20	0.04	0.15	0.014	0.116	0.016	0.04	0.007	0.019
Krs 15-05	25	2.9	12	2.2	0.39	2.5	0.46	1.5	0.269	1.1	0.088	0.673	0.089	0.08	0.010	0.081
Krs 15-11	3.3	0.33	1.3	0.25	0.092	0.29	0.05	0.21	0.04	0.15	0.014	0.109	0.015	0.04	0.008	0.025
Krs 15-12	3.1	0.33	1.3	0.24	0.089	0.28	0.05	0.18	0.03	0.14	0.012	0.097	0.013	0.04	0.008	0.025
Krs 15-13	1.3	0.13	0.52	0.10	0.063	0.12	0.03	0.08	0.02	0.05	0.005	0.041	0.007	0.03	0.008	0.027
Krs 15-14	2.4	0.25	0.96	0.18	0.081	0.20	0.04	0.14	0.03	0.11	0.010	0.083	0.011	0.03	0.006	0.031
Krs 15-15	4.5	0.62	2.4	0.42	0.089	0.52	0.08	0.23	0.04	0.16	0.012	0.105	0.014	0.03	0.010	0.034

Kristiansand cont.

	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Krs 15-02	0.05	4.4	0.11	0.24	0.19	1741	724	1191	5264	0.15	42	1.7	0.96	229	544	2.0
Krs 15-03	0.19	5.1	0.27	0.36	0.21	1443	850	1277	3028	0.22	61	2.8	1.5	343	818	1.2
Krs 15-04	0.09	5.5	0.31	0.65	0.30	1742	965	1029	3990	0.33	99	4.1	1.9	210	1349	3.3
Krs 15-05	0.09	13	1.6	3.6	1.3	2546	2182	1583	10016	1.2	175	6.5	4.9	130	2670	17
Krs 15-11	0.10	5.3	0.34	0.47	0.19	1914	1348	1325	3722	0.40	89	4.4	2.6	358	1534	3.0
Krs 15-12	0.08	7.6	0.25	0.35	0.19	1167	937	1184	3072	0.29	72	4.9	2.1	293	1096	2.9
Krs 15-13	0.07	19	0.35	0.18	0.08	1597	685	1071	2457	0.14	36	2.4	4.8	148	1721	1.5
Krs 15-14	0.08	7.7	0.36	0.28	0.14	1511	921	1389	3404	0.24	64	3.8	1.7	462	969	4.1
Krs 15-15	0.06	23	0.36	0.31	0.16	920	945	1625	3220	0.22	54	9.7	2.6	186	1000	2.4
	Ni	**Cu**	**Zn**	**Ga**	**Mo**	**K**	**Ge**	**As**	**Se**	**Hg**						
Krs 15-02	17	25	88	0.23	0.47	5912	0.03	0.27	0.47	0.073						
Krs 15-03	13	23	46	0.31	0.47	4877	0.03	0.41	0.82	0.074						
Krs 15-04	38	47	57	0.43	0.61	6545	0.04	0.56	0.83	0.054						
Krs 15-05	187	288	99	1.0	0.97	6333	0.12	3.6	11	0.147						
Krs 15-11	23	48	62	0.52	0.70	6063	0.05	0.55	1.1	0.071						
Krs 15-12	47	59	39	0.61	0.71	5246	0.07	0.97	1.3	0.066						
Krs 15-13	12	33	106	0.27	1.4	5011	0.03	0.52	1.9	0.059						
Krs 15-14	71	83	38	0.41	0.68	6101	0.06	1.0	1.1	0.085						
Krs 15-15	48	74	43	1.1	0.95	4551	0.18	1.4	1.1							

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Table 6: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Kristiansand	4, 5, 11	2015	1.6		0.27	0.31	4.9	10.4	8.7	0.70	1.7	0.63			
		2010	1.6		0.47	0.40	1.7	3.2	10.7	0.62	0.54	0.37			
		2005	0.7		0.42	0.96	0.68	1.9	12.5	0.23	0.24	0.15			
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
		2015			7.8	83	128				1.6				
		2010			5.4	74	110				1.3				
		2005			3.8	105	62				1.0				

4.1.3 Lista

The aluminium smelter at Lista (Figure 8) is situated in a flat terrain with a generally high wind exposure. This may partly explain the low deposition of most metals in its surroundings. Only Ga, a very likely contribution from an aluminium smelter, is deposited at distinctly higher levels near the smelter.

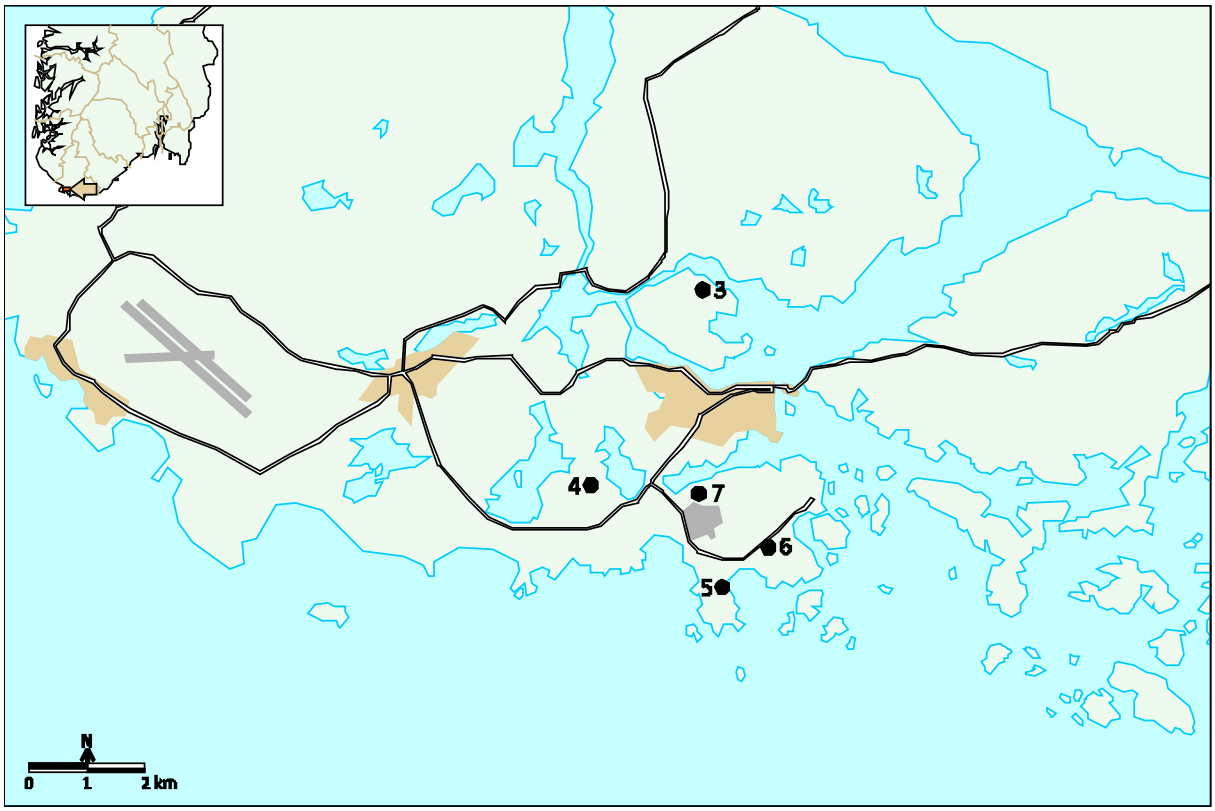

Figure 8: Sampling sites – Lista

Table 7: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Lista

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Lis 15-03	0.16	0.06	1.2	287	7.4	17	1.80	0.06	0.005	0.03	0.22	0.15	<0.02	0.11	18	2.1
Lis 15-04	0.26	0.03	2.9	342	5.2	26	0.64	0.09	0.007	0.04	0.20	**0.25**	<0.02	0.08	30	0.86
Lis 15-05	0.24	0.03	3.6	531	4.4	34	1.6	0.12	0.009	0.03	0.78	0.09	<0.02	0.06	34	1.9
Lis 15-06	0.12	0.02	5.6	484	10	23	0.41	0.06	0.007	0.02	0.16	0.11	<0.02	0.06	16	0.45
Lis 15-07	0.27	0.04	3.4	489	5.4	23	1.1	0.10	0.007	0.04	0.17	**0.23**	0.02	0.06	28	1.4
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Lis 15-03	2.3	0.34	1.3	0.23	0.060	0.32	0.06	0.21	0.04	0.15	0.012	0.091	0.012	0.02	0.019	0.042
Lis 15-04	2.0	0.22	0.90	0.17	0.079	0.19	0.04	0.13	0.02	0.09	0.008	0.060	0.008	0.02	0.003	0.006
Lis 15-05	3.8	0.47	**1.8**	0.36	0.097	**0.40**	0.08	0.28	**0.05**	0.19	0.018	0.135	0.018	0.03	0.003	0.006
Lis 15-06	1.0	0.12	0.53	0.10	0.040	0.11	0.02	0.08	0.01	0.05	0.004	0.036	0.005	0.02	0.007	0.010
Lis 15-07	3.5	0.36	1.5	0.28	0.087	0.31	0.06	0.20	0.04	0.14	0.012	0.091	0.013	0.03	*0.038*	0.007
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Lis 15-03	0.04	4.4	0.06	0.08	0.03	1617	678	862	1904	0.10	26	1.9	0.79	143	404	0.38
Lis 15-04	0.12	5.2	0.08	0.17	0.04	1767	1970	944	3164	0.17	35	2.4	1.1	128	742	0.40
Lis 15-05	0.04	5.4	0.05	0.37	0.06	2207	775	1052	3623	0.19	48	1.9	0.85	298	747	1.1
Lis 15-06	0.02	3.3	0.06	0.06	0.02	1954	1071	954	2583	0.09	26	1.5	0.66	284	363	0.36
Lis 15-07	0.03	**7.3**	**0.16**	0.20	0.06	1775	4242	1171	2346	0.20	39	3.8	1.7	229	1120	0.80
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Lis 15-03	1.3	5.1	42	0.26	0.43	3886	0.02	0.13	0.52	0.045						
Lis 15-04	1.7	6.5	59	0.81	0.78	3597	0.04	0.23	0.48	0.059						
Lis 15-05	1.5	5.3	**171**	0.40	0.44	5150	0.04	0.19	0.45	0.080						
Lis 15-06	1.9	5.1	77	**1.1**	0.43	5826	0.02	0.13	0.43	0.080						
Lis 15-07	5.5	12	95	**3.6**	**2.0**	4376	0.04	0.39	0.52	0.111						

Table 8: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Lista	4,5,7	2015													
		2010													
		2000													
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
		2015							1.7						
		2010							1.3						
		2000							nd						

4.1.4 Kvinesdal

The only significant industrial source at Kvinesdal is a manganese production facility, and the sampling sites (Figure 9) are all located within relatively short distance from the smelter. Except for Mn the metal deposition is generally low.

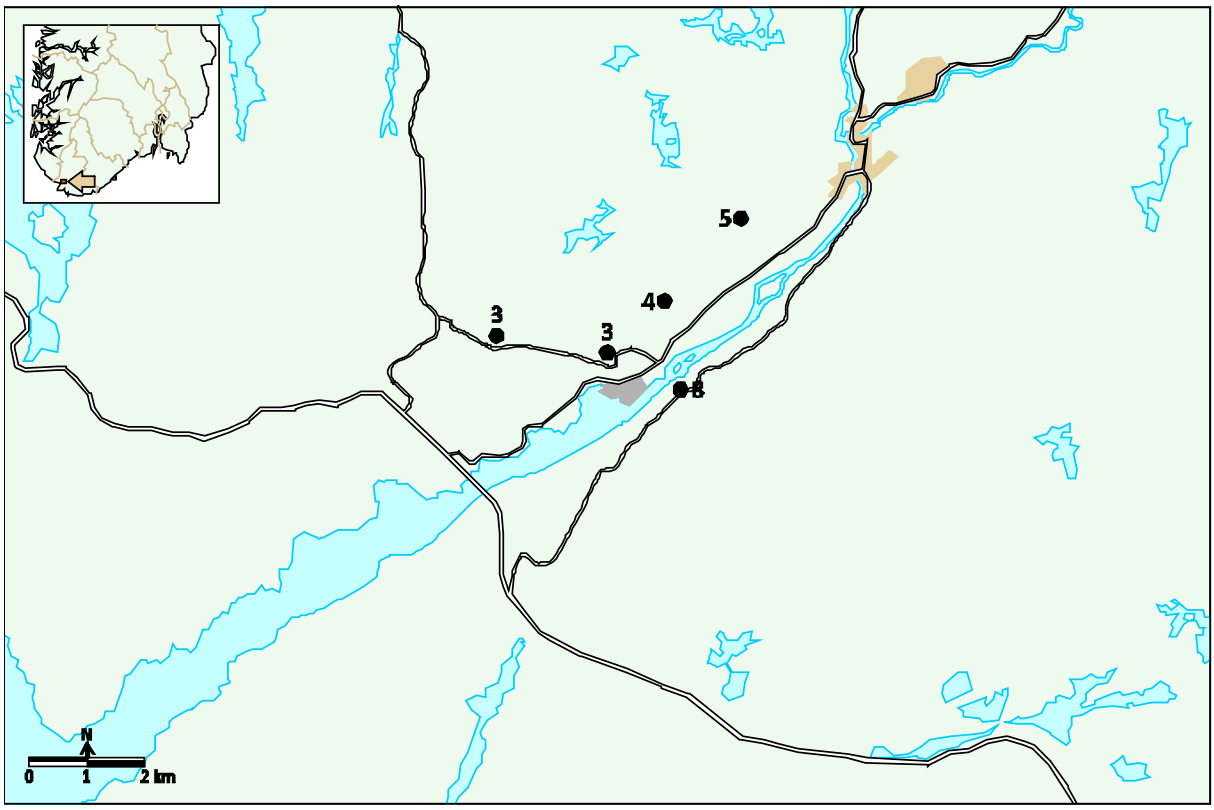

Figure 9: Sampling sites – Kvinesdal

Table 9: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Kvinesdal

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Kvi 15-02	0.19	0.02	2.9	235	19	17	0.30	0.06	0.005	0.03	0.12	0.15	<0.02	0.18	30	0.48
Kvi 15-03	0.28	0.05	3.9	264	8.4	21	0.62	0.06	0.006	0.06	0.24	0.19	<0.02	0.26	53	0.84
Kvi 15-04	0.23	0.05	1.9	220	12	23	0.43	0.07	0.006	0.06	0.15	0.15	0.03	0.73	59	0.74
Kvi 15-05	0.26	0.04	3.0	401	29	17	0.58	0.12	0.005	0.03	0.08	0.09	<0.02	0.14	32	1.5
Kvi 15-08	0.20	0.03	4.2	354	7.7	21	0.28	0.05	0.005	0.05	0.21	0.14	<0.02	0.15	35	0.51
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Kvi 15-02	0.98	0.10	0.40	0.08	0.064	0.09	0.02	0.05	0.01	0.04	0.002	0.025	0.003	0.02	0.006	0.009
Kvi 15-03	2.1	0.20	0.79	0.15	0.121	0.16	0.03	0.11	0.02	0.08	0.006	0.052	0.007	0.05	0.014	0.029
Kvi 15-04	1.6	0.15	0.57	0.11	0.125	0.13	0.02	0.08	0.01	0.05	0.004	0.037	0.005	0.04	0.010	0.019
Kvi 15-05	3.3	0.30	1.1	0.19	0.081	0.22	0.04	0.12	0.02	0.09	0.007	0.058	0.008	0.03	0.004	0.008
Kvi 15-08	1.1	0.11	0.42	0.08	0.074	0.08	0.02	0.06	0.01	0.04	0.002	0.024	0.003	0.02	0.005	0.009
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Kvi 15-02	0.05	4.5	0.04	0.11	0.03	1581	569	959	2444	0.11	23	1.6	0.74	350	424	0.22
Kvi 15-03	0.07	5.4	0.07	0.18	0.05	1464	1142	915	3210	0.27	37	2.1	1.6	1220	619	0.70
Kvi 15-04	0.12	5.8	0.07	0.14	0.05	1625	950	827	2789	0.21	32	1.8	1.6	1119	439	0.62
Kvi 15-05	0.03	2.1	0.02	0.43	0.09	1664	893	857	2625	0.18	44	1.6	1.2	512	567	0.34
Kvi 15-08	0.15	4.2	0.05	0.13	0.03	1546	746	1060	3077	0.13	28	1.9	0.88	601	422	0.41
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Kvi 15-02	1.2	6.1	35	0.17	0.37	4672	0.03	0.20	0.58	0.106						
Kvi 15-03	1.7	6.9	52	0.24	0.84	2707	0.02	0.32	0.70	0.143						
Kvi 15-04	1.8	5.7	33	0.20	0.75	2792	0.02	0.33	0.71	0.090						
Kvi 15-05	1.1	4.5	30	0.26	0.62	5181	0.02	0.16	0.42	0.055						
Kvi 15-08	1.3	5.4	51	0.20	0.45	2993	0.02	0.21	0.57	0.095						

Table 10: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Kvinesdal	3,4,5														
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			950												
			1500												
			720												

4.1.5 Karmøy

The sampling sites at this aluminium smelter (Figure 10) are all located in a flat and wind exposed terrain, and the results show that deposition of metals in its neighbourhood is generally limited.

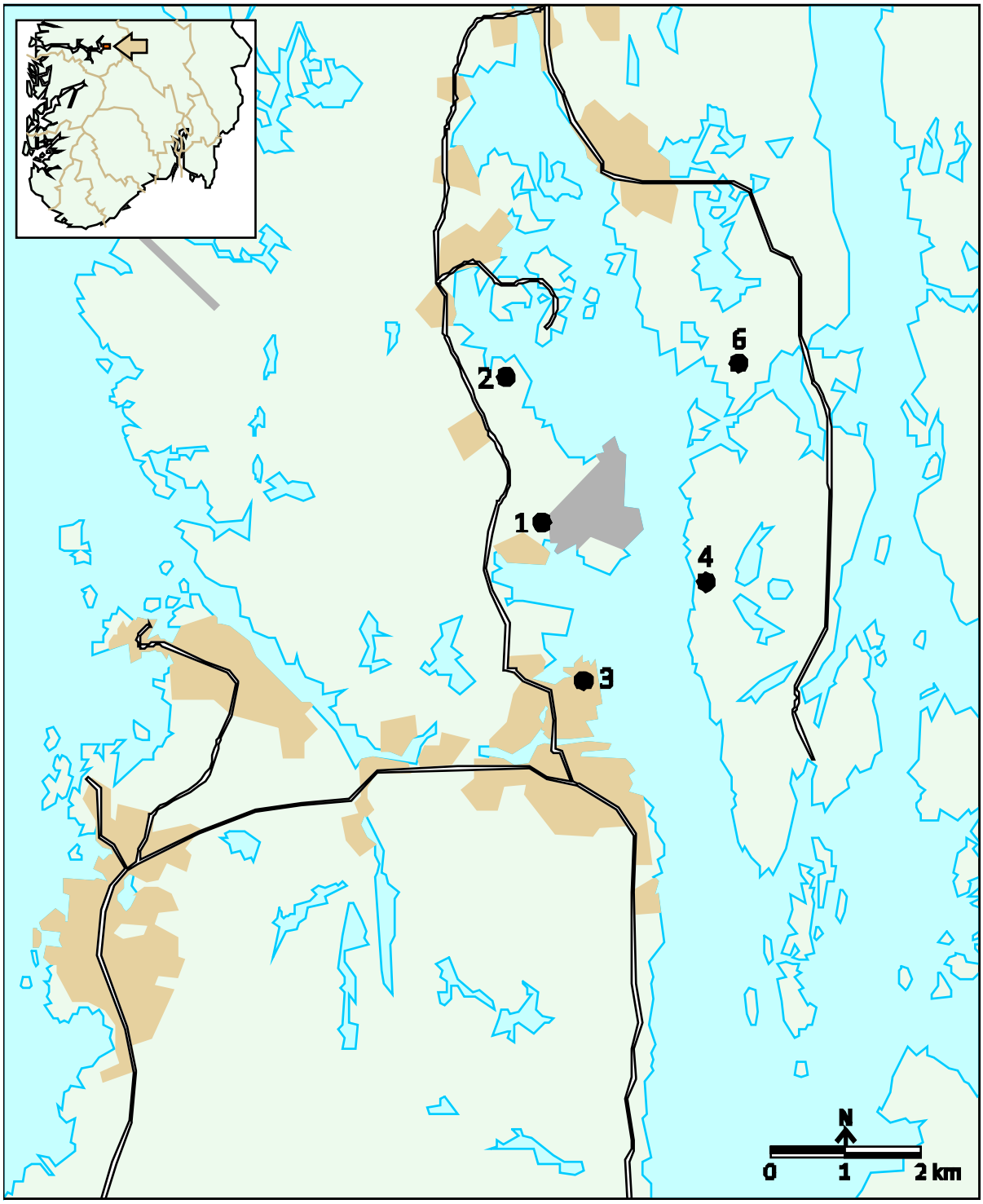

Figure 10: Sampling sites - Karmøy

Table 11: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Karmøy

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Kar 15-01	0.22	0.04	5.0	355	5.6	19	0.46	0.07	0.006	0.02	0.08	0.13	0.02	0.29	22	0.53
Kar 15-02	0.40	0.06	6.2	995	3.4	47	1.3	0.01	0.015	0.03	0.19	0.03	0.04	0.11	31	2.9
Kar 15-03	0.11	0.02	2.2	737	5.6	15	0.17	0.05	0.004	0.02	0.09	0.10	<0.02	0.10	9.0	0.20
Kar 15-04	0.55	0.04	6.5	577	7.3	24	0.39	0.13	0.006	0.02	0.12	0.10	0.04	0.13	21	0.60
Kar 15-06	0.16	0.02	3.1	397	11	20	0.21	0.07	0.005	0.02	0.10	0.09	0.04	0.22	28	0.32
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Kar 15-01	1.2	0.13	0.51	0.10	0.05	0.11	0.02	0.09	0.02	0.06	0.005	0.043	0.006	0.03	0.004	0.007
Kar 15-02	4.0	0.47	1.74	0.28	0.12	0.33	0.06	0.21	0.04	0.15	0.012	0.098	0.013	0.03	0.005	0.009
Kar 15-03	0.41	0.04	0.18	0.03	0.02	0.04	0.01	0.03	0.01	0.02	0.001	0.014	0.002	0.01	0.003	0.005
Kar 15-04	1.8	0.13	0.48	0.09	0.05	0.10	0.02	0.07	0.01	0.05	0.004	0.037	0.005	0.02	0.003	0.115
Kar 15-06	0.66	0.07	0.29	0.05	0.05	0.06	0.01	0.04	0.01	0.03	0.002	0.018	0.003	0.02	0.003	0.005
	Tl	Pb	Bi	Th	U	M	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Kar 15-01	0.13	2.6	0.06	0.13	0.04	1643	2255	879	2382	0.20	64	3.3	2.1	188	695	0.43
Kar 15-02	0.03	5.3	**0.19**	0.12	0.14	2230	3204	1381	3788	0.53	91	7.8	2.7	164	1635	1.3
Kar 15-03	0.03	2.0	0.02	0.05	0.03	1828	732	894	2197	0.10	26	1.3	0.77	186	419	0.30
Kar 15-04	0.02	1.7	0.04	0.16	0.06	2125	3623	808	2248	0.27	87	3.2	3.55	382	924	0.77
Kar 15-06	0.05	1.9	0.03	0.10	0.03	1647	1214	749	2098	0.10	28	1.3	0.74	145	353	0.18
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Kar 15-01	5.1	6.3	54	0.52	0.75	3387	0.02	0.23	0.57	0.050						
Kar 15-02	12	70	171	0.90	0.68	4767	0.04	0.48	0.56	0.066						
Kar 15-03	2.0	6.5	97	0.16	0.91	6105	0.01	0.21	0.28	0.054						
Kar 15-04	5.5	4.5	43	0.76	0.43	3635	0.02	0.34	0.35	0.100						
Kar 15-06	1.8	4.8	29	0.26	0.37	3504	0.05	0.13	0.43	0.058						

4.1.6 Sauda

The Sauda ferromanganese plant (Figure 11) is located next to a small town in a narrow valley. The deposition of Mn in the neighbourhood of the enterprise is high, but has declined regularly since 2000 as shown in figure 12. A similar decline is observed for several other metals, including Zn, and present levels are generally low.

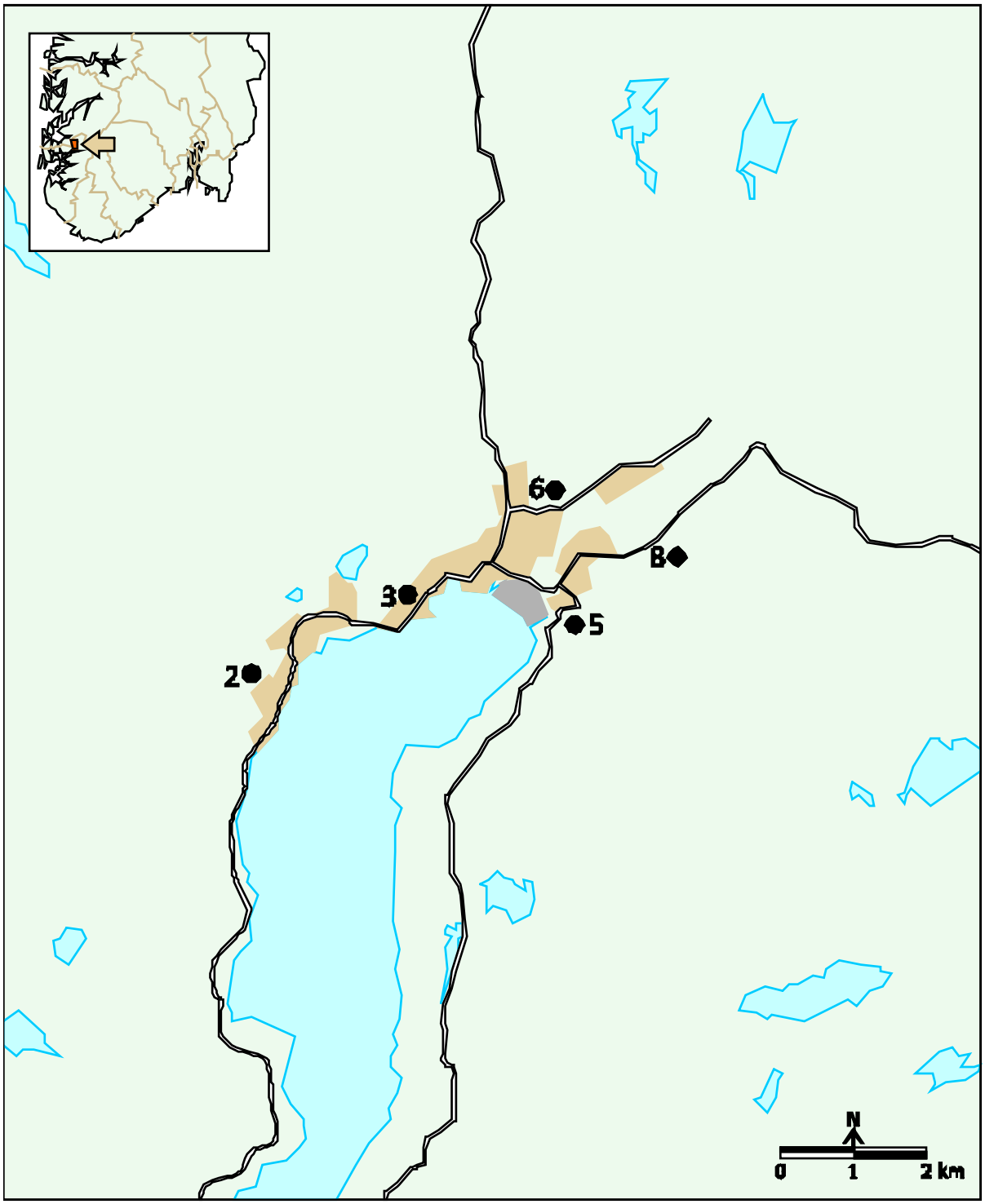

Figure 11: Sampling sites - Sauda

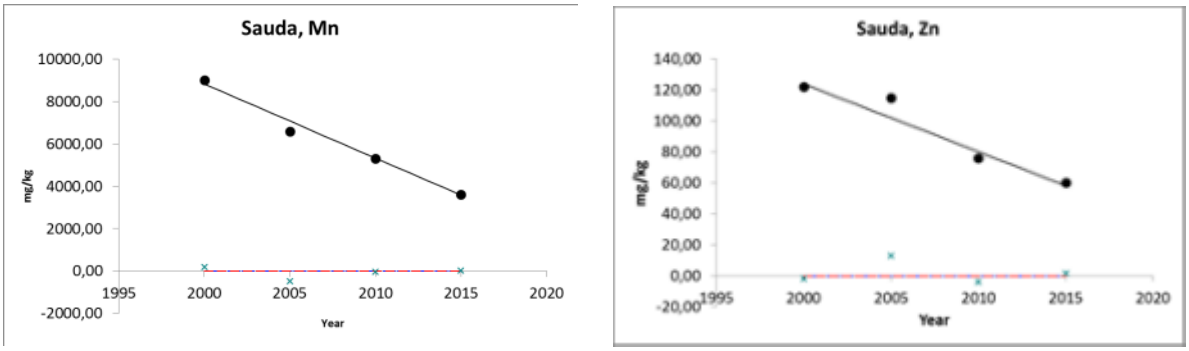

Figure 12 : Trends in mean concentrations of Mn and Zn from the three apparently most contaminated sampling sites, using Mann-Kendall test. The level of significance is 0.1.

Table 12: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Sauda

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Sau 15-02	0.22	0.02	2.5	330	10	12	0.30	0.11	< 0.001	0.04	0.29	0.11	0.01	0.18	15	0.42
Sau 15-03	0.26	0.03	2.0	202	13	17	0.36	0.12	0.007	0.04	0.31	0.14	0.03	0.75	41	0.46
Sau 15-05	0.35	0.06	5.1	305	4.1	17	0.55	0.12	0.008	0.07	0.48	0.13	0.05	0.20	98	0.77
Sau 15-06	0.29	0.04	2.2	218	11	17	0.41	0.10	0.007	0.05	0.34	0.12	0.03	0.47	47	0.57
Sau 15-08	0.27	0.04	2.0	238	6.1	18	0.40	0.10	0.007	0.05	0.27	0.14	0.02	0.44	41	0.51
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Sau 15-02	0.86	0.10	0.39	0.07	0.031	0.09	0.02	0.05	0.01	0.04	0.002	0.028	0.003	0.02	0.005	0.010
Sau 15-03	1.0	0.12	0.50	0.09	0.104	0.12	0.02	0.07	0.01	0.06	0.004	0.036	0.005	0.02	0.008	0.017
Sau 15-05	1.9	0.16	0.68	0.14	0.239	0.18	0.04	0.11	0.02	0.09	0.007	0.058	0.008	0.04	0.008	0.017
Sau 15-06	1.2	0.13	0.56	0.11	0.133	0.15	0.03	0.08	0.02	0.07	0.005	0.044	0.006	0.02	0.005	0.013
Sau 15-08	1.1	0.12	0.52	0.10	0.110	0.14	0.03	0.07	0.01	0.06	0.004	0.040	0.006	0.03	0.006	0.014
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Sau 15-02	0.26	6.4	0.04	0.09	0.04	1224	629	1159	1936	0.15	40	1.6	1.3	707	491	0.49
Sau 15-03	0.12	7.5	0.08	0.13	0.04	1259	712	1063	2147	0.19	50	2.0	3.9	3126	672	1.2
Sau 15-05	0.12	6.1	0.07	0.17	0.05	1506	866	1032	2377	0.23	51	2.2	9.7	6890	1053	5.2
Sau 15-06	0.07	6.1	0.06	0.13	0.04	1567	681	1026	2498	0.17	48	1.7	5.4	2622	669	1.6
Sau 15-08	0.04	7.2	0.07	0.12	0.04	1749	606	893	2376	0.19	44	2.0	5.2	1311	711	1.4
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Sau 15-02	1.2	6.0	35	0.19	0.41	2736	0.02	0.24	0.48	0.070						
Sau 15-03	2.9	5.7	36	0.23	0.57	2548	0.03	0.41	0.56	0.088						
Sau 15-05	6.9	7.4	56	0.26	0.93	2146	0.03	0.60	0.42	0.103						
Sau 15-06	4.1	6.4	58	0.20	0.75	3037	0.12	0.47	0.69	0.069						
Sau 15-08	3.6	4.2	67	0.19	0.53	1958	0.03	0.32	0.47	0.089						

Table 13: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Sauda	5,6,8	2015		0.36		0.034									
		2010		0.35		0.048									
		2005		0.51		0.043									
		2000		0.66		nd									
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
		2015	3300		2.7	4.9		60							
		2010	5300		5.0	6.1		76							
		2005	6600		4.7	13.1		115							
		2000	9000		3.1	8.5		122							

4.1.7 Husnes

The main source of metal deposition at Husnes (Figure 13) is an aluminium smelter. Generally the metal deposition is low, but like in 2010 moderate levels of Ni, Sb, and Te are observed near the source.

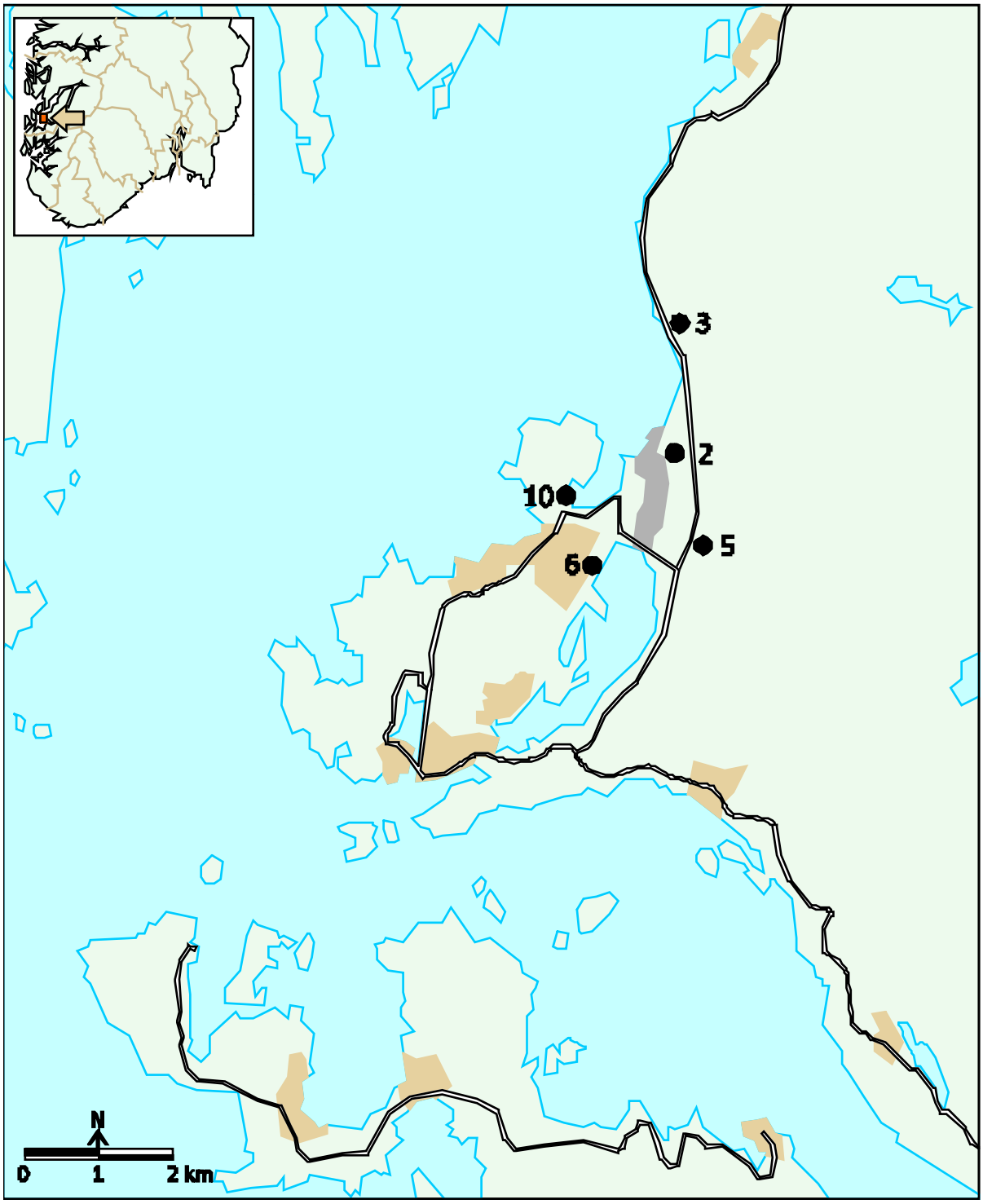

Figure 13: Sampling sites - Husnes

Table 14: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Husnes

Location	Li7	Be9	B11	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Hus 15-02	0.27	0.05	2.9	373	7.2	15	0.37	0.11	0.005	0.04	0.13	0.69	0.12	0.14	21	0.46
Hus 15-03	0.20	0.04	3.5	334	12	14	0.35	0.08	0.004	0.03	0.14	0.28	0.07	0.13	20	0.40
Hus 15-05	0.12	0.04	2.8	217	8.7	24	0.21	0.07	0.006	0.11	0.37	0.30	0.12	0.07	31	0.54
Hus 15-07	0.19	0.02	2.2	264	9.6	17	0.49	0.13	0.004	0.03	0.18	0.25	0.04	0.17	27	0.54
Hus 15-10	0.21	0.03	4.8	384	12	34	0.31	0.09	0.009	0.02	0.18	0.23	0.02	0.11	26	0.40
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Hus 15-02	0.91	0.10	0.38	0.07	0.04	0.08	0.02	0.05	0.01	0.04	0.003	0.031	0.004	0.03	0.003	0.006
Hus 15-03	0.78	0.08	0.35	0.07	0.05	0.08	0.01	0.06	0.01	0.04	0.004	0.031	0.005	0.02	0.005	0.009
Hus 15-05	0.82	0.08	0.29	0.05	0.06	0.06	0.01	0.03	0.01	0.02	0.001	0.015	0.002	0.02	0.007	0.012
Hus 15-07	1.2	0.13	0.53	0.11	0.06	0.10	0.02	0.09	0.02	0.06	0.008	0.051	0.009	0.03	0.013	0.036
Hus 15-10	0.80	0.09	0.34	0.07	0.06	0.07	0.01	0.05	0.01	0.04	0.003	0.029	0.004	0.02	0.003	0.006
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Hus 15-02	0.09	5.0	0.18	0.12	0.05	1166	4008	1048	2258	0.14	36	3.5	1.4	292	726	0.55
Hus 15-03	0.11	2.2	0.06	0.08	0.03	1304	1889	1013	2848	0.14	32	2.1	0.69	517	463	0.37
Hus 15-05	0.02	3.0	0.07	0.05	0.02	1695	1973	868	3446	0.06	18	1.7	0.54	164	262	0.54
Hus 15-07	0.10	2.1	0.08	0.13	0.06	1104	1423	979	3610	0.16	49	1.9	0.84	174	549	0.28
Hus 15-10	0.02	2.3	0.10	0.08	0.04	1909	1379	912	3995	0.10	29	1.6	0.63	217	333	0.76
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Hus 15-02	33	8.1	47	1.3	1.7	2705	0.03	0.95	0.78	0.076						
Hus 15-03	14	6.9	52	0.61	0.44	3119	0.02	0.38	0.23	0.073						
Hus 15-05	17	5.8	64	0.55	0.41	3792	0.02	0.36	0.66	0.066						
Hus 15-07	7.7	4.8	32	0.49	0.52	3725	0.02	0.31	0.46	0.081						
Hus 15-10	11.7	5.2	39	0.46	0.29	4165	0.03	0.24	0.42	0.080						

Table 15: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Husnes	2,3,5	2015			0.42	0.10									
		2010			0.56	0.07									
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
		2015				22									
		2010				25									

4.1.8 Odda

Two main sources of metal pollution are located at Odda around 5 km apart: a zinc smelter at Eitrheim, and a titanium production facility at Tyssedal, and 10 sampling sites were employed (Figure 15). Odda is still one of the most polluted sites in this survey, particularly with respect to Ti (Figure 16), Zn (Figure 17), and Cd (Figure 18). To assess the relative contribution from the two industries to the deposition of these metals the three sites most closely situated to each plant were especially assessed (Table 17). Considering these differences however it is still difficult to distinguish the relative contributions. Ti is clearly higher around Tyssedal, whereas Zn and Cd are not much different between these two groups of sites. As for time trends the Ti deposition has decreased from 2010 to 2015, whereas levels of Zn and Cd did not change much since 2010. If levels of Cd from all previous moss surveys are included, a slightly decreasing trend is observed. In addition to the elements already mentioned, moderate to high deposition is observed at Odda for V, Fe, Hg, Tl, Pb and Bi.

Figure 14: Trends in mean concentrations of Cd from the three apparently most contaminated sampling sites, using Mann-Kendall test. The level of significance is 0.1.

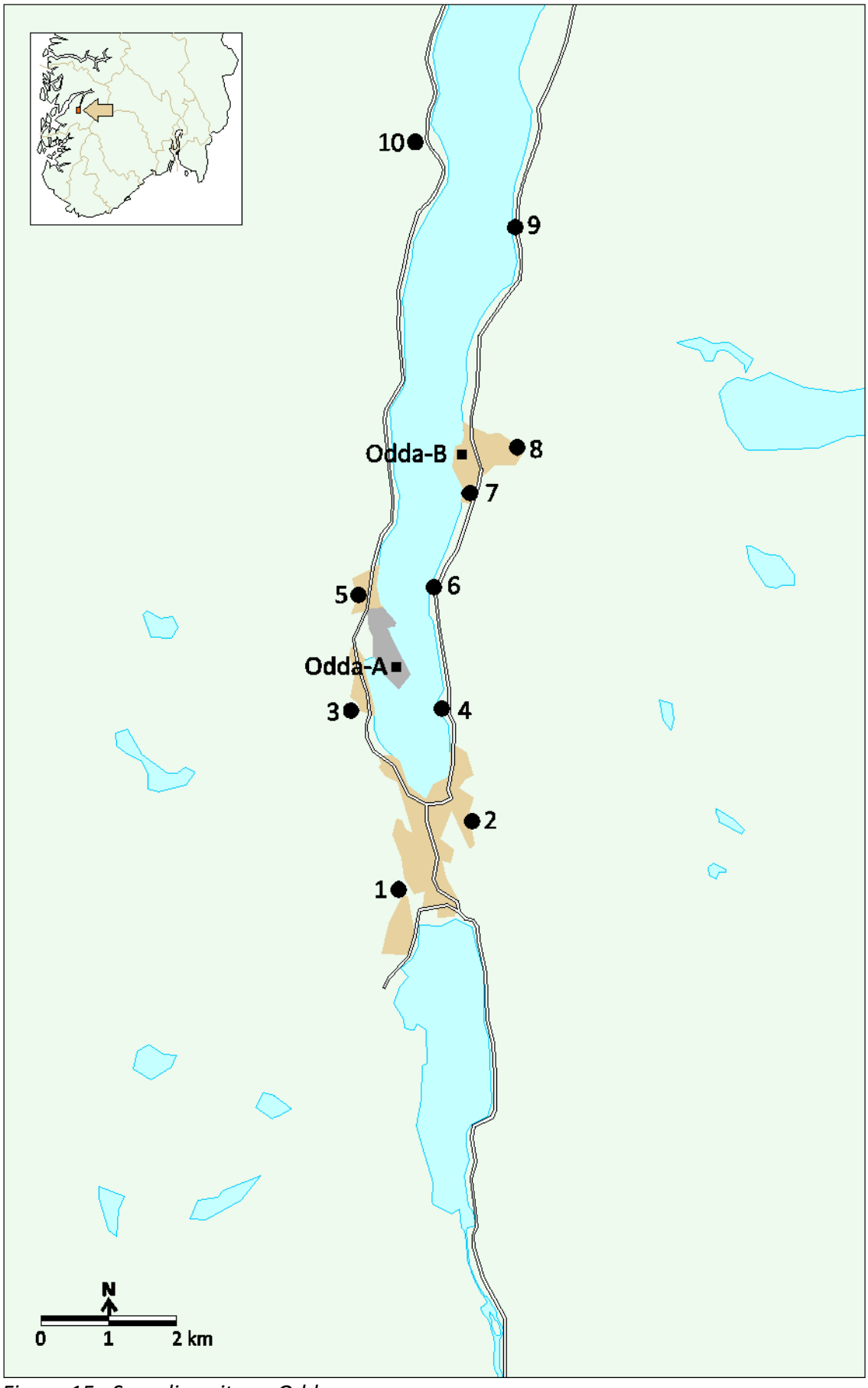

Figure 15: Sampling sites – Odda

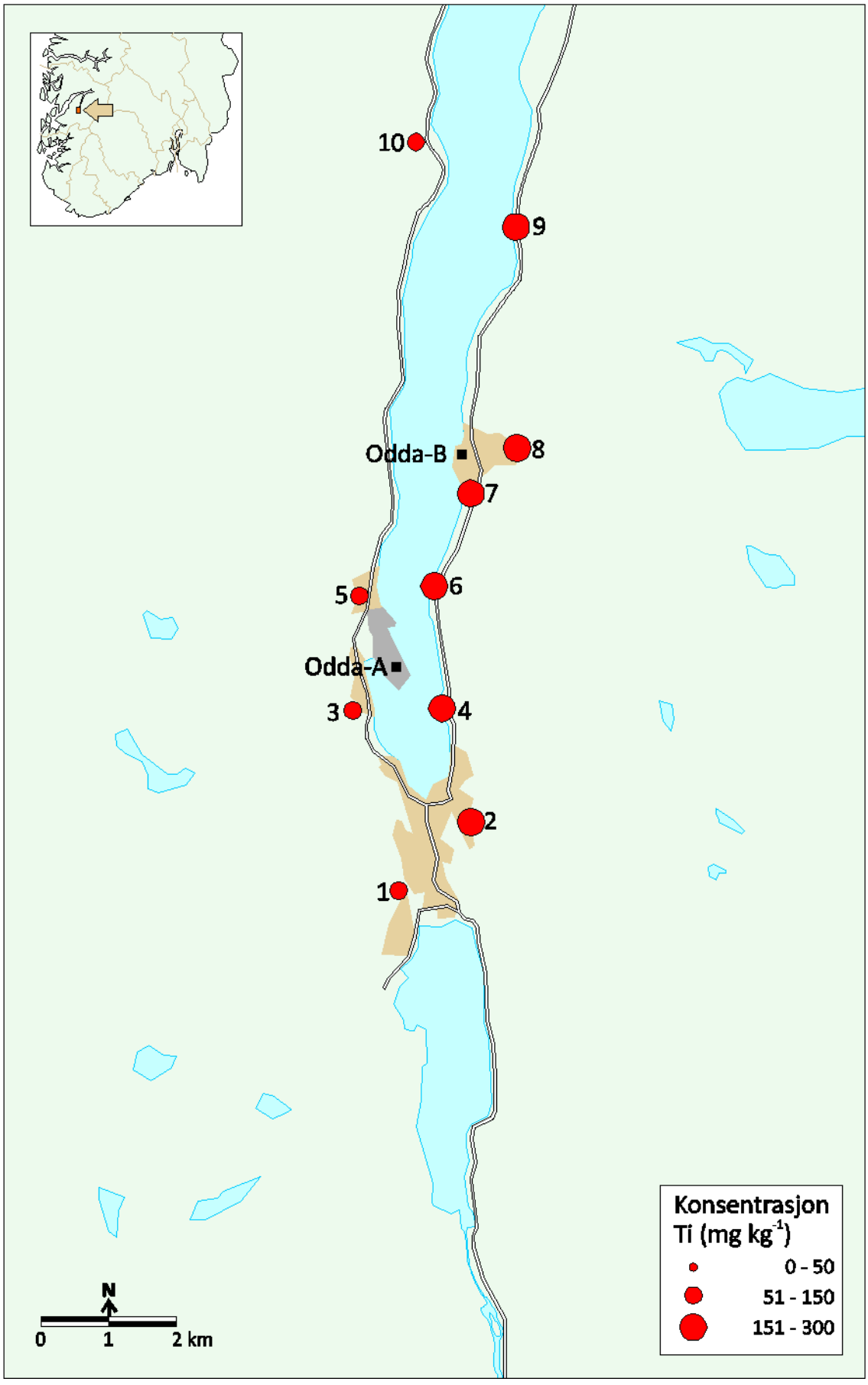

Figure 16: Concentration of Titanium in moss samples – Odda

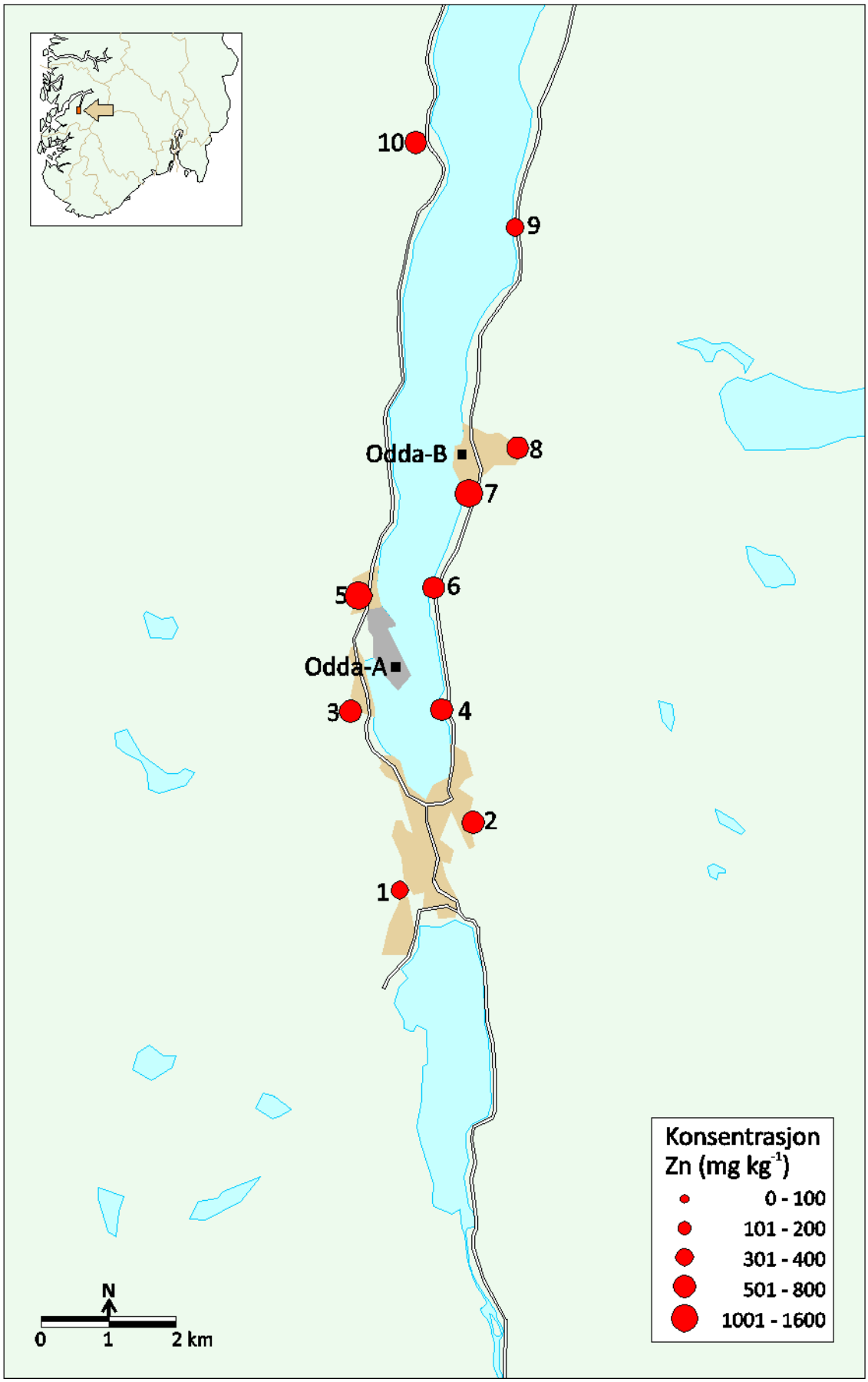

Figure 17: Concentration of Zinc in moss samples – Odda

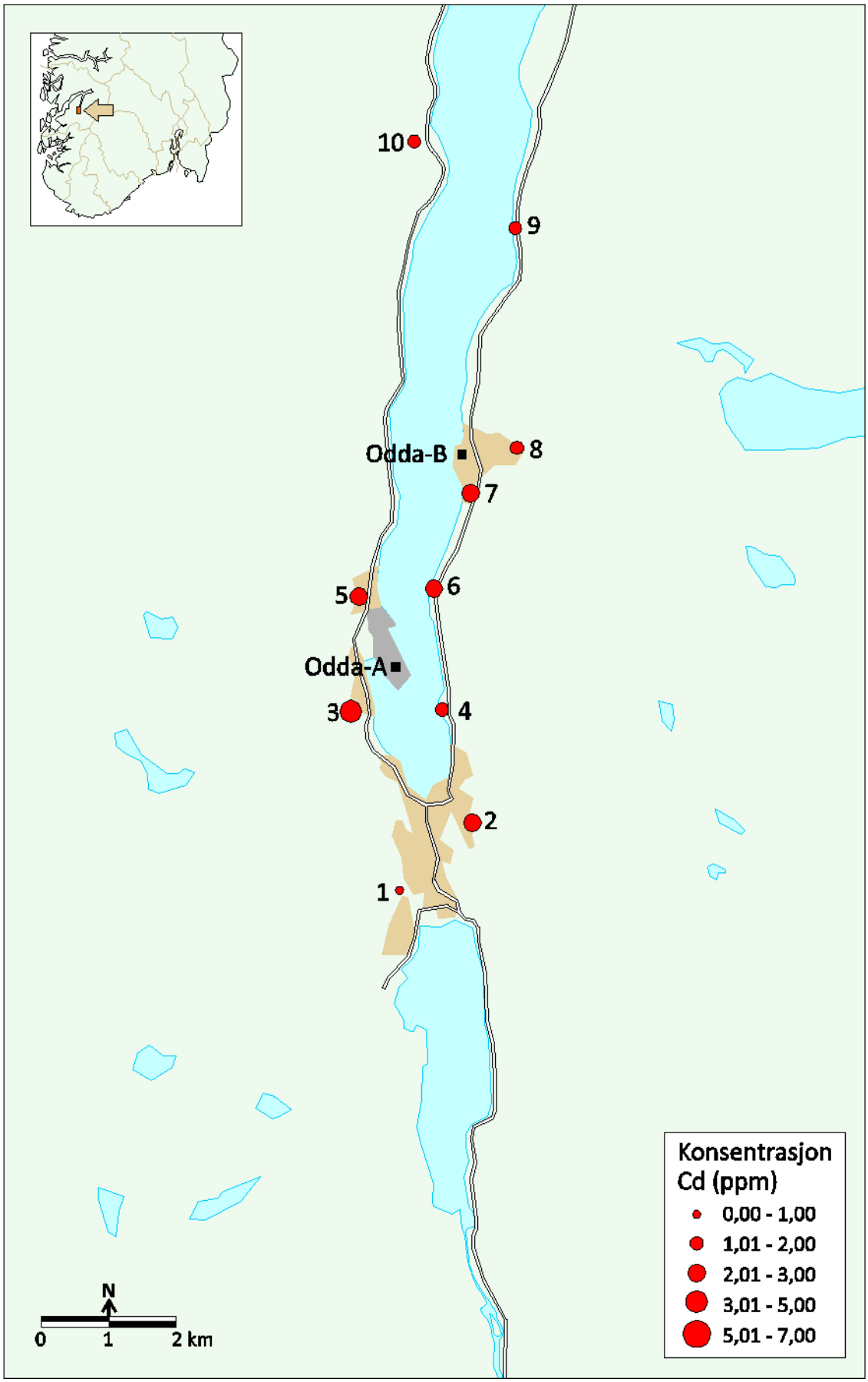

Figure 18: Concentration of Cadmium in moss samples – Odda

Table 16: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Odda

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Odd 15-01	0.10	0.01	2.2	168	17.6	5.7	0.12	0.03	0.003	0.07	0.99	0.09	<0.02	0.70	28	0.17
Odd 15-02	0.44	0.05	11	314	8.8	16	0.78	0.03	0.006	0.18	2.7	0.15	<0.02	0.15	55	1.2
Odd 15-03	0.18	0.02	1.6	214	38	10	0.22	0.02	0.004	0.16	3.3	0.22	<0.02	0.23	39	0.29
Odd 15-04	0.24	0.03	2.6	382	11	15	0.66	0.02	0.005	0.11	2.0	0.09	<0.02	0.10	25	0.69
Odd 15-05	0.73	0.05	1.4	202	11	15	0.98	0.02	0.005	0.14	2.8	0.09	<0.02	0.18	32	0.93
Odd 15-06	0.83	0.05	4.2	289	6.0	18	1.6	0.03	0.005	0.14	2.7	0.04	<0.02	0.25	41	1.9
Odd 15-07	0.38	0.06	6.0	271	9.5	20	0.62	0.01	0.007	0.12	2.9	0.03	<0.02	0.24	32	0.92
Odd 15-08	0.26	0.05	2.1	159	31	17	0.53	0.01	0.005	0.09	1.5	<0.01	<0.02	4.9	54	1.4
Odd 15-09	0.38	0.03	4.3	310	6.6	28	0.49	0.02	0.009	0.08	1.2	0.08	<0.02	0.13	56	0.69
Odd 15-10	0.14	0.02	3.4	201	11	7	0.20	0.01	0.002	0.09	1.4	<0.01	<0.02	0.29	14	0.26
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Odd 15-01	0.31	0.03	0.13	0.02	0.051	0.03	0.01	0.02	0.00	0.01	0.000	0.009	0.001	0.02	0.003	0.006
Odd 15-02	2.2	0.25	0.96	0.18	0.130	0.22	0.04	0.13	0.03	0.09	0.008	0.066	0.009	0.03	0.004	0.008
Odd 15-03	0.53	0.06	0.23	0.04	0.078	0.05	0.01	0.04	0.01	0.03	0.002	0.018	0.003	0.02	0.007	0.012
Odd 15-04	1.3	0.15	0.59	0.11	0.059	0.13	0.03	0.10	0.02	0.07	0.006	0.049	0.007	0.03	0.007	0.014
Odd 15-05	2.3	0.22	0.90	0.18	0.088	0.20	0.04	0.17	0.03	0.12	0.013	0.095	0.013	0.03	0.007	0.043
Odd 15-06	3.9	0.42	1.6	0.30	0.118	0.30	0.06	0.25	0.05	0.18	0.016	0.154	0.018	0.04	0.007	0.014
Odd 15-07	1.8	0.18	0.72	0.13	0.091	0.16	0.03	0.10	0.02	0.08	0.009	0.056	0.010	0.02	0.005	0.012
Odd 15-08	2.0	0.18	0.68	0.12	0.126	0.18	0.03	0.09	0.02	0.07	0.007	0.048	0.008	0.03	0.002	0.007
Odd 15-09	1.3	0.13	0.55	0.11	0.131	0.13	0.02	0.08	0.02	0.06	0.007	0.046	0.009	0.03	0.002	0.007
Odd 15-10	0.49	0.05	0.21	0.04	0.031	0.05	0.01	0.03	0.01	0.02	0.003	0.019	0.005	0.02	0.003	0.007

Odda cont.

Location	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Odd 15-01	0.23	15	0.09	0.05	0.03	954	321	905	3586	0.06	102	1.2	0.71	359	351	0.13
Odd 15-02	0.34	36	0.29	0.25	0.12	1578	870	1265	5660	0.25	212	3.9	2.2	208	1376	0.79
Odd 15-03	0.26	50	0.21	0.08	0.04	1129	515	1310	2979	0.09	117	1.6	1.0	442	539	0.25
Odd 15-04	0.12	36	0.30	0.20	0.09	1339	732	1036	4619	0.20	190	3.3	2.1	63	1192	0.55
Odd 15-05	0.17	44	0.21	0.23	0.10	1478	1358	970	3310	0.51	189	4.3	2.2	103	1603	0.72
Odd 15-06	0.14	50	0.34	0.37	0.14	1749	1431	1199	6756	0.63	261	6.6	4.8	73	2904	1.1
Odd 15-07	0.28	67	0.79	0.35	0.08	1365	709	1148	4348	0.26	257	9.0	7.0	88	3897	1.5
Odd 15-08	0.52	28	0.33	0.17	0.10	1230	656	804	4143	0.21	284	5.3	3.4	131	2286	0.80
Odd 15-09	0.10	23	0.27	0.16	0.06	1372	692	917	5771	0.21	185	3.3	2.2	53	1277	0.64
Odd 15-10	0.21	17	0.13	0.07	0.03	951	546	1065	2806	0.16	137	2.8	1.6	438	921	0.39
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Odd 15-01	0.55	4.9	241	0.09	0.18	3811	0.01	0.38	0.20	0.097						
Odd 15-02	1.7	9.3	774	0.32	0.41	4615	0.06	1.1	0.32	0.207						
Odd 15-03	0.81	8.3	701	0.15	0.27	4595	0.04	0.81	0.27							
Odd 15-04	1.6	9.5	682	0.27	0.32	4047	0.03	0.73	0.41	0.168						
Odd 15-05	1.8	8.1	844	0.56	0.35	4135	0.07	1.1	0.46	0.215						
Odd 15-06	2.6	13	738	0.69	0.45	4830	0.07	1.2	0.43	0.364						
Odd 15-07	3.9	9.1	1183	0.42	0.37	5507	0.06	0.88	0.74	0.175						
Odd 15-08	2.0	6.9	557	0.34	0.33	3395	0.08	0.43	0.49	0.109						
Odd 15-09	2.1	6.7	347	0.28	0.28	4331	0.03	0.47	0.19	0.122						
Odd 15-10	1.0	7.8	414	0.20	0.20	3555	0.03	0.61	0.28	0.138						

Table 17: Mean values of selected elements for the three samples apparently exposed to the highest

metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Odda-A	2,3,4,	2015	0.15	2.7									170	3.0	1.8
		2010	0.18	2.7									320	4.5	3.0
		2005	0.24	3.5									230	2.4	1.7
		2000	nd	4.3									180	2.0	1.3
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
		2015		1040				610			0.90				
		2010		1530				540			0.62				
		2005		800				1270			0.91				
		2000		nd				1230			1.31				
Location	**Site**	**Year**	Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Odda-B	7,8,9	2015	0.10	1.9									270	6.9	4.2
		2010	0.21	2.4									1010	10.7	7.3
		2005	0.14	2.4									370	6.6	4.2
		2000	nd	2.2									210	3.7	2.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
		2015		2500				690			0.60				
		2010		4300				730			0.65				
		2005		3200				950			0.55				
		2000		3200				820			1.30				

4.1.9 Ålvik

The present industry at Ålvik (Figure 19) deals with ferrosilicon production. Except for moderate levels of La and Ce the levels of all elements in moss samples are low around this industry. A slightly elevated level of Cr may be associated with general contamination of the site from a previous ferrochrome smelter.

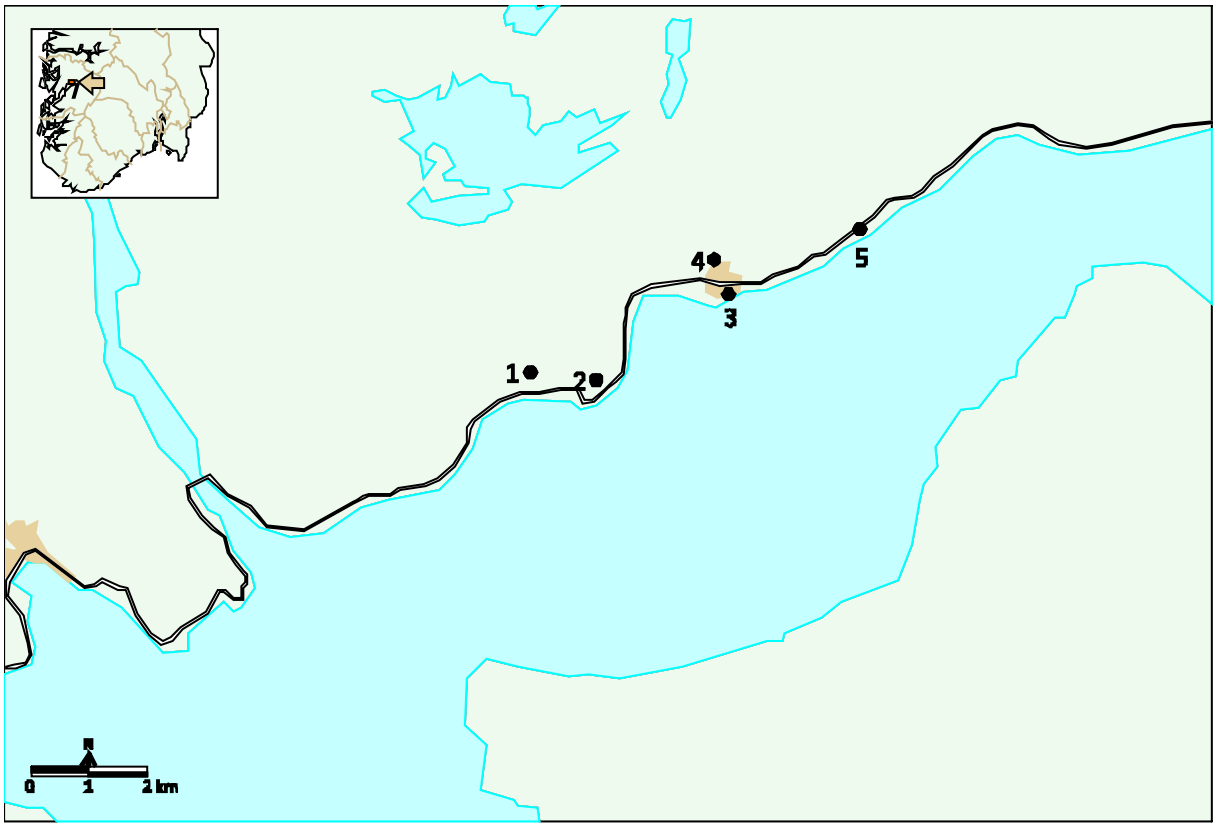

Figure 19: Sampling sites - Ålvik

Table 18: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Ålvik

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Ålv 15-01	0.13	0.02	1.6	344	6.9	16	0.17	0.07	0.004	0.02	0.15	0.09	<0.02	0.06	25	1.6
Ålv 15-02	0.21	0.03	5.8	386	30	11	0.33	0.13	0.003	0.03	0.13	0.11	<0.02	0.28	22	4.8
Ålv 15-03	0.40	0.03	4.1	231	6.3	17	0.48	0.26	0.005	0.05	0.18	0.15	<0.02	0.12	38	24
Ålv 15-04	0.46	0.03	4.6	192	13	18	0.25	0.23	0.005	0.05	0.24	0.15	<0.02	0.16	37	16
Ålv 15-05	0.21	0.02	2.2	261	13	16	0.22	0.13	0.004	0.03	0.19	0.13	<0.02	0.47	32	4.2
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Ålv 15-01	2.2	0.07	0.27	0.05	0.057	0.07	0.01	0.03	0.01	0.02	0.003	0.018	0.005	0.01	0.005	0.011
Ålv 15-02	6.0	0.14	0.49	0.08	0.058	0.12	0.02	0.06	0.01	0.05	0.005	0.033	0.007	0.02	0.004	0.010
Ålv 15-03	28	0.24	0.82	0.12	0.088	0.30	0.03	0.08	0.02	0.07	0.007	0.052	0.009	0.04	0.004	0.092
Ålv 15-04	19	0.17	0.56	0.07	0.083	0.21	0.02	0.04	0.01	0.04	0.004	0.028	0.006	0.03	0.004	0.010
Ålv 15-05	5.2	0.09	0.34	0.06	0.073	0.09	0.01	0.04	0.01	0.03	0.004	0.023	0.005	0.02	0.001	0.005
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Ålv 15-01	0.02	2.0	0.04	0.05	0.02	1280	426	824	2200	0.09	28	1.1	3.9	230	394	0.15
Ålv 15-02	0.04	2.4	0.03	0.09	0.04	1574	731	1122	2282	0.16	49	1.7	5.6	232	726	0.39
Ålv 15-03	0.03	3.7	0.07	0.15	0.09	1904	812	695	3703	0.18	55	2.5	18	53	1272	0.48
Ålv 15-04	0.04	3.8	0.08	0.10	0.07	1480	676	1434	4430	0.11	32	1.8	22	454	1427	0.50
Ålv 15-05	0.07	2.6	0.05	0.08	0.16	1379	483	743	2939	0.10	37	1.4	5.3	227	651	0.35
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Ålv 15-01	1.7	6.3	33	0.16	0.26	2983	0.05	0.13	0.54	0.042						
Ålv 15-02	3.4	7.2	49	0.26	0.37	5742	0.03	0.19	0.66	0.045						
Ålv 15-03	4.8	7.7	54	0.43	0.78	2536	0.09	0.32	0.57	0.046						
Ålv 15-04	6.6	11	52	0.42	1.1	6618	0.17	0.29	0.63	0.051						
Ålv 15-05	3.7	6.2	53	0.22	0.39	3418	0.28	0.19	0.44	0.038						

Table 19: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Ålvik	2,3,4	2015													15
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
		2015													

4.1.10 Høyanger

Metal deposition at Høyanger (Figure 20) is generally low to moderate. Still distinctly elevated high levels of Hg, probably related to a previous local accidental release, are down to about 40% of the 2010 level (Figure 21). Moderately elevated levels of Ni, Sb and Bi are noted.

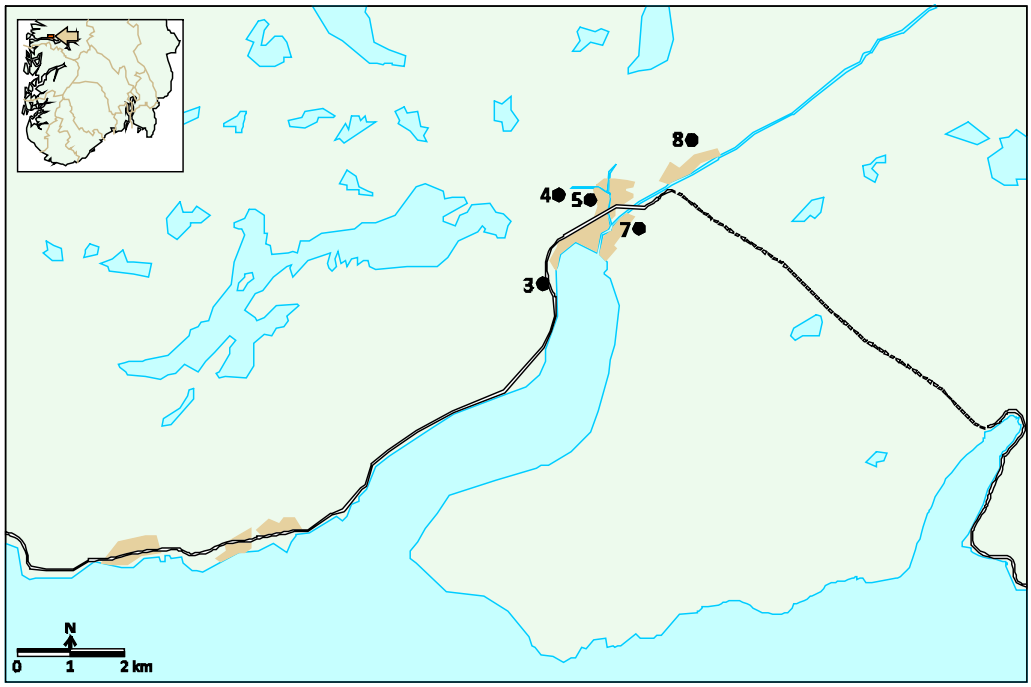

Figure 20: Sampling sites - Høyanger

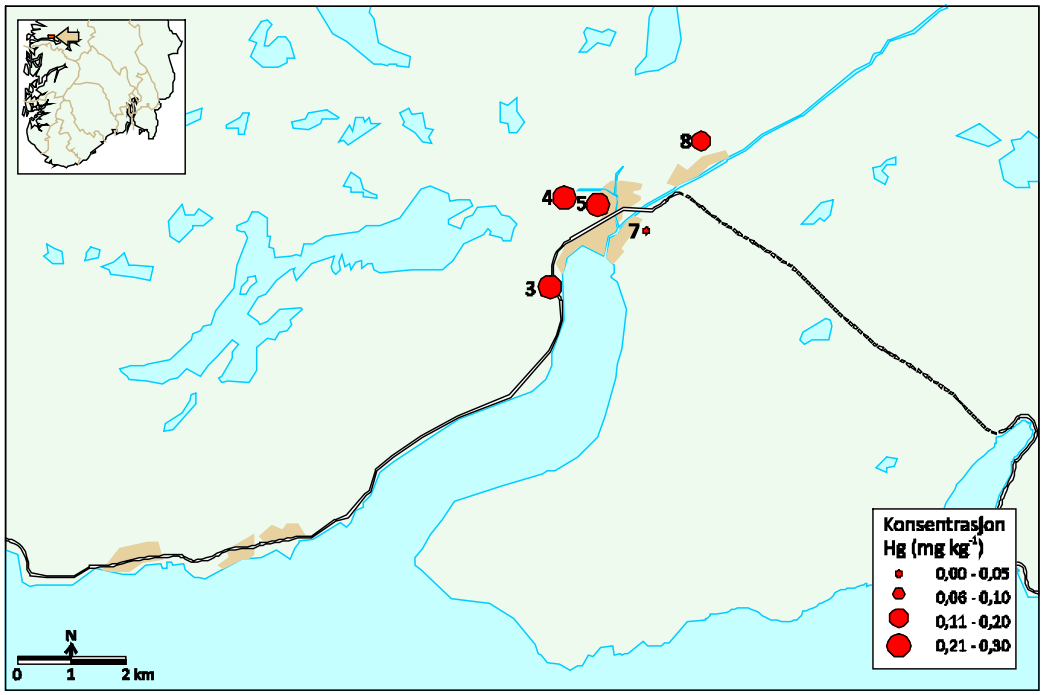

Figure 21: Concentration of Mercury in moss samples - Høyanger

Table 20: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Høyanger

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Høy 15-03	0.07	0.03	1.9	218	15	14	0.10	0.06	0.004	0.06	0.13	0.46	0.06	0.04	22	0.24
Høy 15-04	0.18	0.04	3.5	164	9.5	22	0.39	0.15	0.006	0.06	0.15	0.30	0.04	0.31	46	0.74
Høy 15-05	0.23	0.05	1.4	286	23	17	0.54	0.16	0.004	0.06	0.17	0.76	0.11	0.43	48	0.86
Høy 15-07	0.11	0.03	1.4	357	8.0	18	0.30	0.13	0.004	0.04	0.19	0.24	0.04	0.04	30	0.81
Høy 15-08	0.09	0.03	2.7	204	16	31	0.11	0.05	0.008	0.03	0.11	0.39	0.05	0.07	53	0.33
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Høy 15-03	0.35	0.04	0.15	0.02	0.04	0.03	0.01	0.01	0.01	0.01	0.002	0.007	0.003	0.01	0.002	0.006
Høy 15-04	1.5	0.15	0.59	0.10	0.11	0.11	0.02	0.07	0.02	0.06	0.006	0.041	0.007	0.02	0.003	0.008
Høy 15-05	1.7	0.17	0.74	0.14	0.11	0.15	0.03	0.09	0.02	0.07	0.008	0.056	0.010	0.03	0.003	0.008
Høy 15-07	1.4	0.15	0.58	0.09	0.07	0.12	0.02	0.05	0.01	0.04	0.005	0.030	0.006	0.02	0.002	0.006
Høy 15-08	0.40	0.04	0.17	0.03	0.10	0.03	0.01	0.02	0.01	0.01	0.002	0.009	0.003	0.01	0.010	0.026
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Høy 15-03	0.02	8.6	0.12	0.03	0.02	998	1515	1051	2195	0.03	14	1.7	1.1	183	282	0.42
Høy 15-04	0.05	6.2	0.10	0.16	0.05	1301	1448	831	4160	0.16	57	2.3	1.8	477	790	0.46
Høy 15-05	0.05	8.6	0.27	0.17	0.06	894	2875	1069	2805	0.18	70	3.5	2.0	247	913	0.70
Høy 15-07	0.02	6.5	0.10	0.09	0.04	905	988	804	2404	0.09	37	1.4	1.1	48	477	0.50
Høy 15-08	0.04	4.1	0.13	0.03	0.02	891	1347	1264	3390	0.04	17	1.5	0.61	227	280	0.42
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Høy 15-03	15	6.7	71	0.71	0.59	4636	0.02	0.51	0.46	0.234						
Høy 15-04	8.1	6.4	99	0.64	0.39	3559	0.03	0.37	0.50	0.280						
Høy 15-05	24	8.0	67	1.5	0.58	5328	0.04	0.76	0.92	0.217						
Høy 15-07	6.5	6.1	75	0.43	0.39	3986	0.02	0.22	0.38	0.055						
Høy 15-08	11	5.4	96	0.76	0.74	4736	0.01	0.40	0.46	0.157						

Table 21: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Høyanger	3,4,5	2015			0.51	0.07			7.8	0.16					
		2010			0.87	0.18			20.5	0.25					
		2000			0.31	nd			5.0	0.50					
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
		2015				16			1.0			0.25			
		2010				19			0.9			0.56			
		2000				18			7.0			0.05			

4.1.11 Årdal

The Årdal aluminium smelter (Figure 23) is located in a narrow valley between high mountains, and the small town of Øvre Årdal is considerably exposed to deposition of several metals presumably related to activities at the nearby smelter, e.g. V (Figure 24), Ni (Figure 25), Ga, Sb, and Bi. The levels of these elements are similar as corresponding data from 2010. Looking at time trends for 2000-2015, a slightly increasing trend for Ni and a small decreasing trend for Bi are observed (Figure 22).

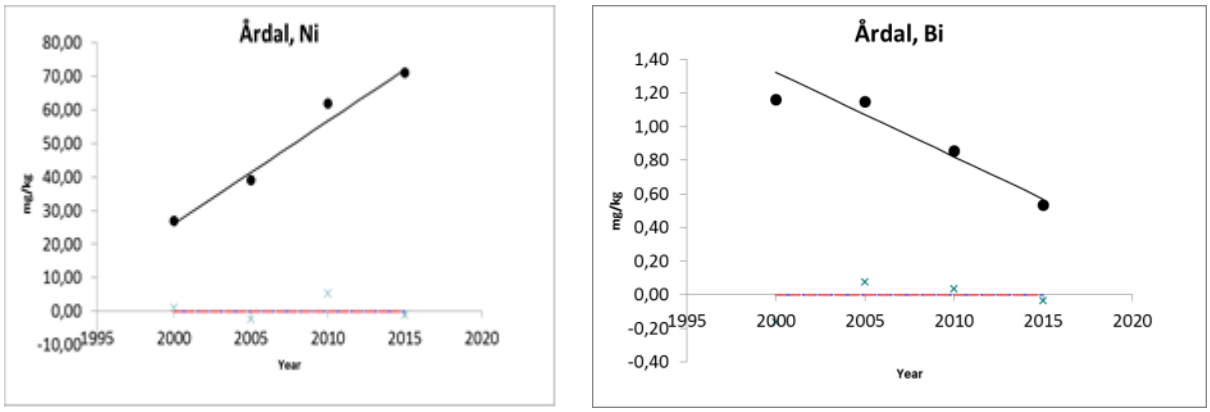

Figure 22: Trends in mean concentrations of Ni and Bi from the three apparently most contaminated sampling sites, using Mann-Kendall test. The level of significance is 0.1.

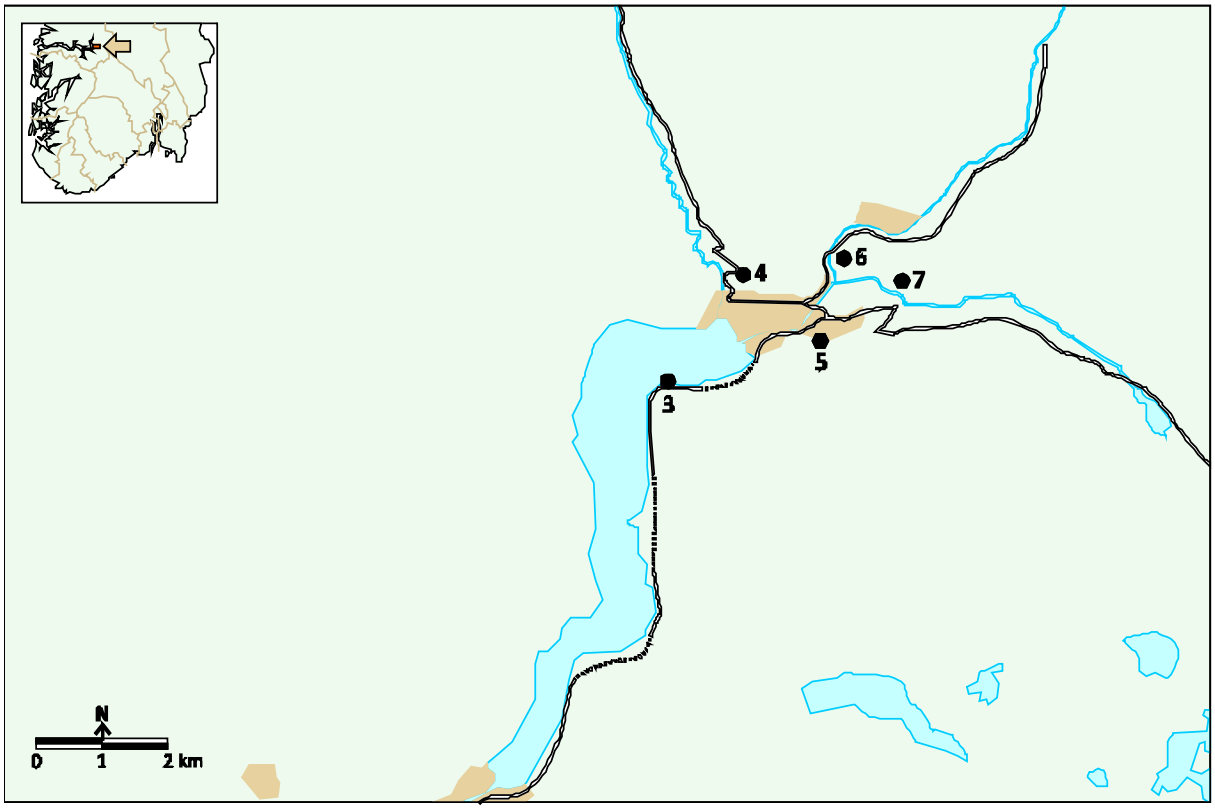

Figure 23: Sampling sites – Årdal

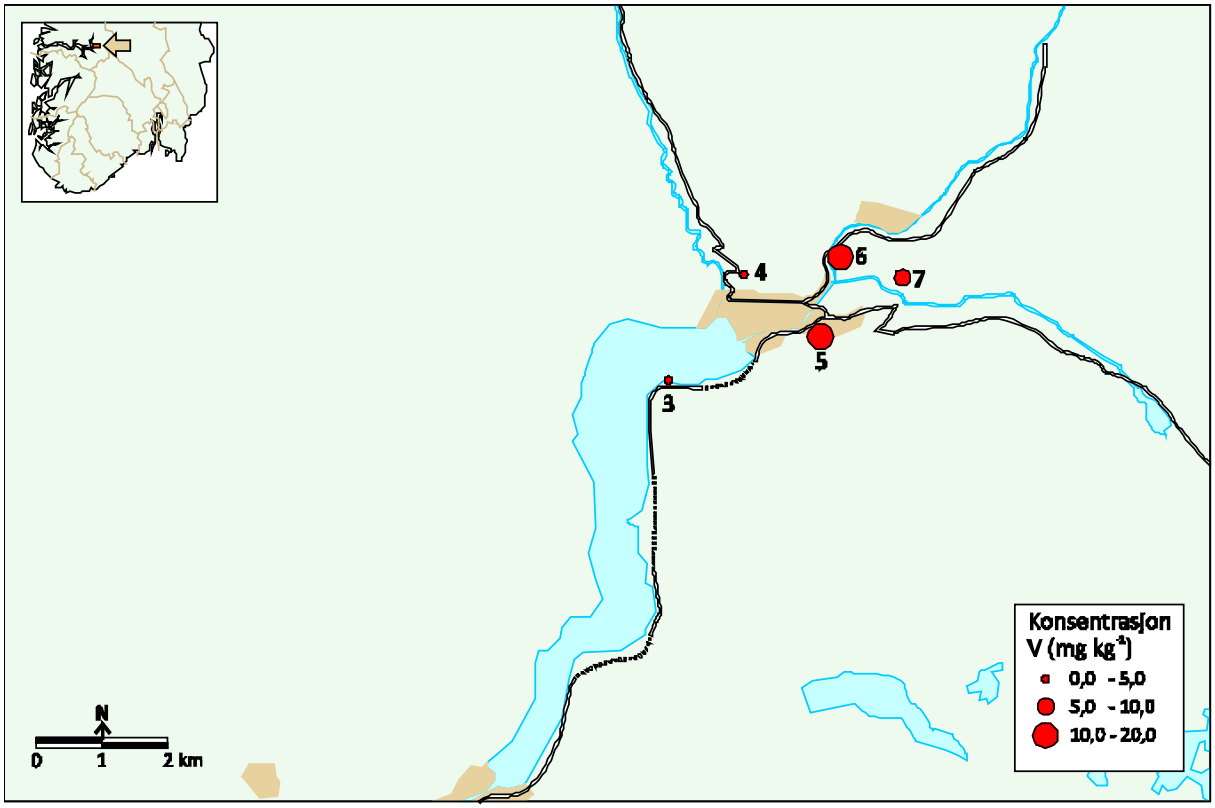

Figure 24: Concentration of Vanadium in moss samples – Årdal

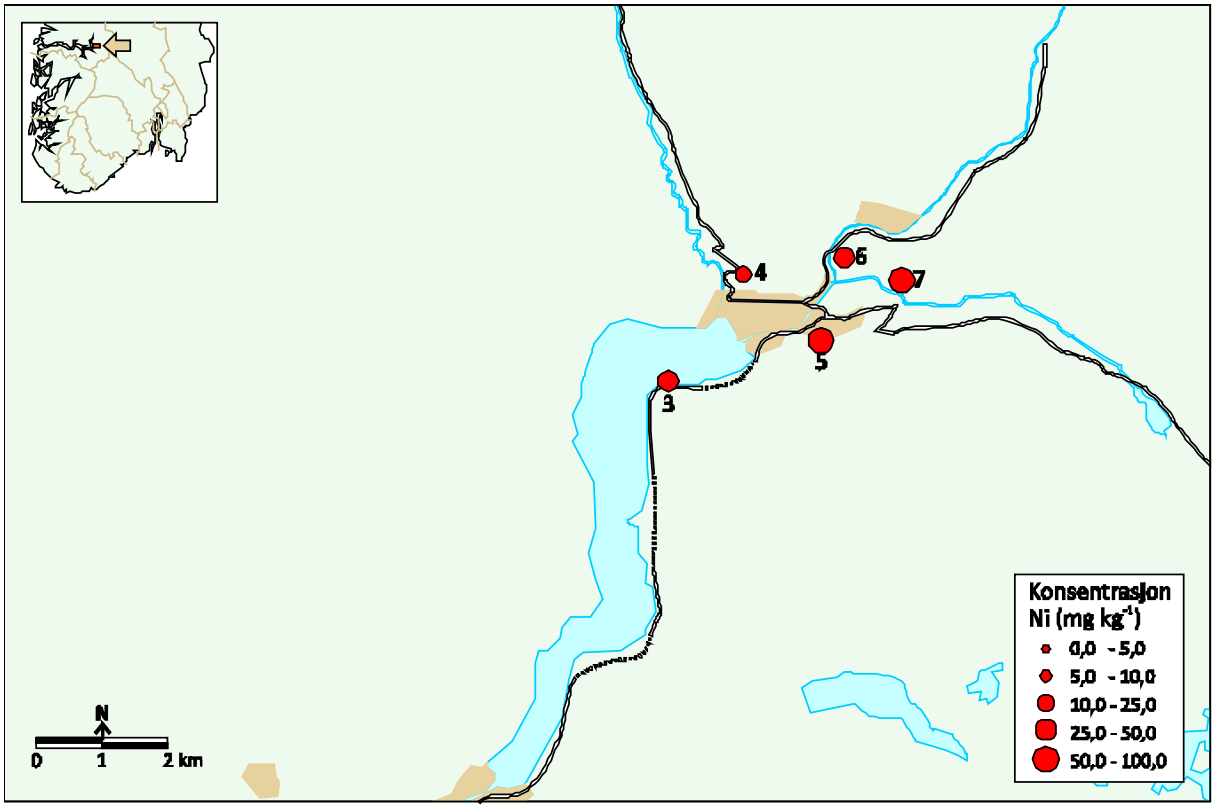

Figure 25: Concentration of Nickel in moss samples - Årdal

Table 22: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Årdal

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Ård 15-03	0.29	0.05	2.1	217	8.1	30	0.44	0.15	0.007	0.03	0.09	0.84	0.06	0.09	57	0.79
Ård 15-04	0.16	0.04	2.9	151	6.0	31	0.25	0.09	0.008	0.02	0.11	0.45	0.05	0.07	47	0.48
Ård 15-05	1.1	0.17	8.2	356	6.4	47	1.7	0.06	0.012	0.05	0.58	0.68	0.17	0.11	78	3.8
Ård 15-06	0.91	0.10	4.2	309	5.8	43	1.7	0.05	0.012	0.04	0.09	0.26	0.09	0.08	127	4.2
Ård 15-07	0.21	0.11	3.2	252	9.1	24	0.18	0.07	0.006	0.03	0.24	2.0	0.24	0.06	50	0.36
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Ård 15-03	1.7	0.17	0.73	0.12	0.133	0.14	0.03	0.08	0.02	0.06	0.007	0.045	0.008	0.03	0.005	0.018
Ård 15-04	0.94	0.10	0.40	0.07	0.099	0.09	0.02	0.04	0.01	0.03	0.004	0.025	0.006	0.02	0.002	0.006
Ård 15-05	7.4	0.87	3.5	0.58	0.255	0.65	0.11	0.31	0.06	0.25	0.021	0.157	0.023	0.05	0.003	0.008
Ård 15-06	7.9	0.92	3.7	0.58	0.373	0.70	0.11	0.31	0.06	0.26	0.021	0.160	0.024	0.04	0.002	0.007
Ård 15-07	0.56	0.06	0.23	0.04	0.101	0.05	0.01	0.02	0.01	0.02	0.003	0.016	0.004	0.03	0.003	0.009
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Ård 15-03	0.02	2.3	0.23	0.12	0.05	1026	3713	865	3283	0.23	73	4.6	1.2	162	1096	1.2
Ård 15-04	0.02	1.6	0.16	0.08	0.03	1200	1984	958	3547	0.12	38	2.2	0.60	199	482	0.97
Ård 15-05	0.03	6.4	0.58	0.30	0.13	2052	9344	1203	6228	0.92	233	16	5.4	175	3749	2.7
Ård 15-06	0.02	3.1	0.28	0.31	0.07	2245	4714	819	5868	1.1	264	17	9.4	182	4812	2.8
Ård 15-07	0.02	3.4	0.74	0.04	0.02	1094	8855	1170	3458	0.08	30	6.1	0.89	570	519	1.5
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Ård 15-03	37	6.3	49	1.4	0.71	4256	0.03	0.75	0.21	0.037						
Ård 15-04	18	4.0	33	0.78	0.28	4014	0.01	0.37	0.26	0.036						
Ård 15-05	80	14	112	3.8	0.70	5649	0.06	1.92	0.33	0.046						
Ård 15-06	34	22	30	1.9	0.92	4782	0.07	0.74	0.38	0.033						
Ård 15-07	99	7.3	61	3.4	0.83	4760	0.04	1.7	0.44	0.044						

Table 23 Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	Site	Year	Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Årdal	5,6,7	2015			0.9	0.17				0.53			190	13	
		2010			2.1	0.20				0.86				14	
		2005			0.7	0.04				1.13				11	
		2000			1.0	nd				1.16				13	
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
		2015		3000	2.3	71			3.0						
		2010				62			3.5						
		2005				39			9.9						
		2000				27			7.4						

4.1.12 Sunndal

The sampling sites located around the Sunndal aluminium smelter are shown in Figure 26. In addition to the major metal Al moderately elevated levels are observed for Ti, V, Ni, Ga and Bi. These levels have stayed relatively constant since 2000.

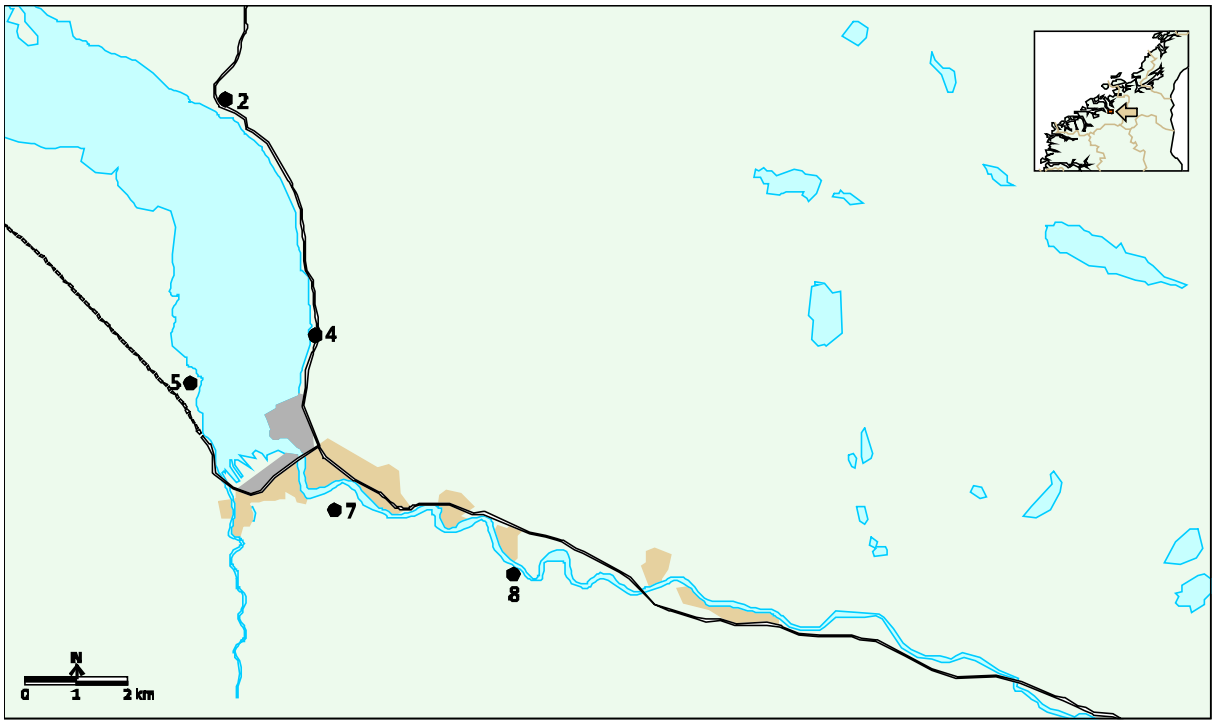

Figure 26: Sampling sites - Sunndal

Table 24: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Sunndal

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Sun 15-02	0.38	0.04	3.4	359	9.5	33	0.65	0.22	0.011	0.02	0.04	0.10	0.04	0.14	30	2.1
Sun 15-04	1.8	0.14	17	339	8.9	52	1.8	0.19	0.013	0.04	0.08	0.35	0.07	0.24	60	4.0
Sun 15-05	0.40	0.03	3.9	169	10	19	0.61	0.26	0.006	0.02	0.06	0.08	0.03	0.61	37	1.4
Sun 15-07	0.53	0.07	5.9	241	14	19	0.58	0.34	0.006	0.05	0.12	0.50	0.05	0.23	32	1.3
Sun 15-08	0.13	0.03	1.8	192	19	14	0.15	0.07	0.005	0.01	0.04	0.20	0.02	0.20	13	0.33
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Sun 15-02	3.7	0.37	1.4	0.25	0.120	0.41	0.07	0.13	0.03	0.13	0.008	0.077	0.010	0.02	0.004	0.011
Sun 15-04	7.8	0.92	3.3	0.52	0.220	0.61	0.10	0.29	0.06	0.24	0.020	0.163	0.023	0.05	0.004	0.007
Sun 15-05	2.9	0.29	1.1	0.18	0.100	0.26	0.04	0.11	0.02	0.09	0.007	0.064	0.009	0.02	0.006	0.012
Sun 15-07	2.8	0.27	1.0	0.18	0.097	0.23	0.04	0.10	0.02	0.08	0.006	0.057	0.008	0.04	0.017	0.036
Sun 15-08	0.61	0.06	0.28	0.05	0.038	0.07	0.01	0.03	0.01	0.03	0.002	0.017	0.003	0.01	0.008	0.023
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Sun 15-02	0.02	0.82	0.02	0.31	0.09	2050	1988	851	3307	0.29	88	2.7	1.8	171	844	0.49
Sun 15-04	0.04	2.2	0.14	0.69	0.21	3067	7666	969	5787	0.79	288	9.1	3.8	190	2606	1.6
Sun 15-05	0.22	1.0	0.04	0.25	0.08	1537	1088	698	3536	0.29	93	2.8	1.8	493	883	0.58
Sun 15-07	0.13	2.4	0.16	0.25	0.09	1268	5139	947	3385	0.36	115	4.9	2.5	253	1129	0.77
Sun 15-08	0.02	0.92	0.10	0.08	0.03	981	2591	999	3076	0.10	54	1.5	0.72	133	357	0.26
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Sun 15-02	4.5	5.2	22	0.51	0.36	5326	0.03	0.12	0.30	0.027						
Sun 15-04	16	8.6	137	1.9	1.1	4562	0.06	0.55	0.26	0.082						
Sun 15-05	2.7	4.3	62	0.35	0.23	2890	0.02	0.12	0.22	0.031						
Sun 15-07	17	6.1	34	1.3	0.51	4031	0.02	0.42	0.30	0.060						
Sun 15-08	7.8	3.2	22	0.68	0.22	4311	0.01	0.25	0.26	0.085						

Table 25: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	Site	Year	Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Sunndal	4,5,7	2015								0.12				5.6	
		2010								0.18				4.6	
		2005								0.10				3.3	
		2000								0.17				4.2	
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
		2015				12									
		2010				13									
		2005				39									
		2000				8									

4.1.13 Hemne

Monitoring of metal deposition around the silicon refinery at Hemne (Figure27) was carried out for the first time in 2015. The levels of most elements studied are generally low. Occationally elevated levels are observed for a few elements.

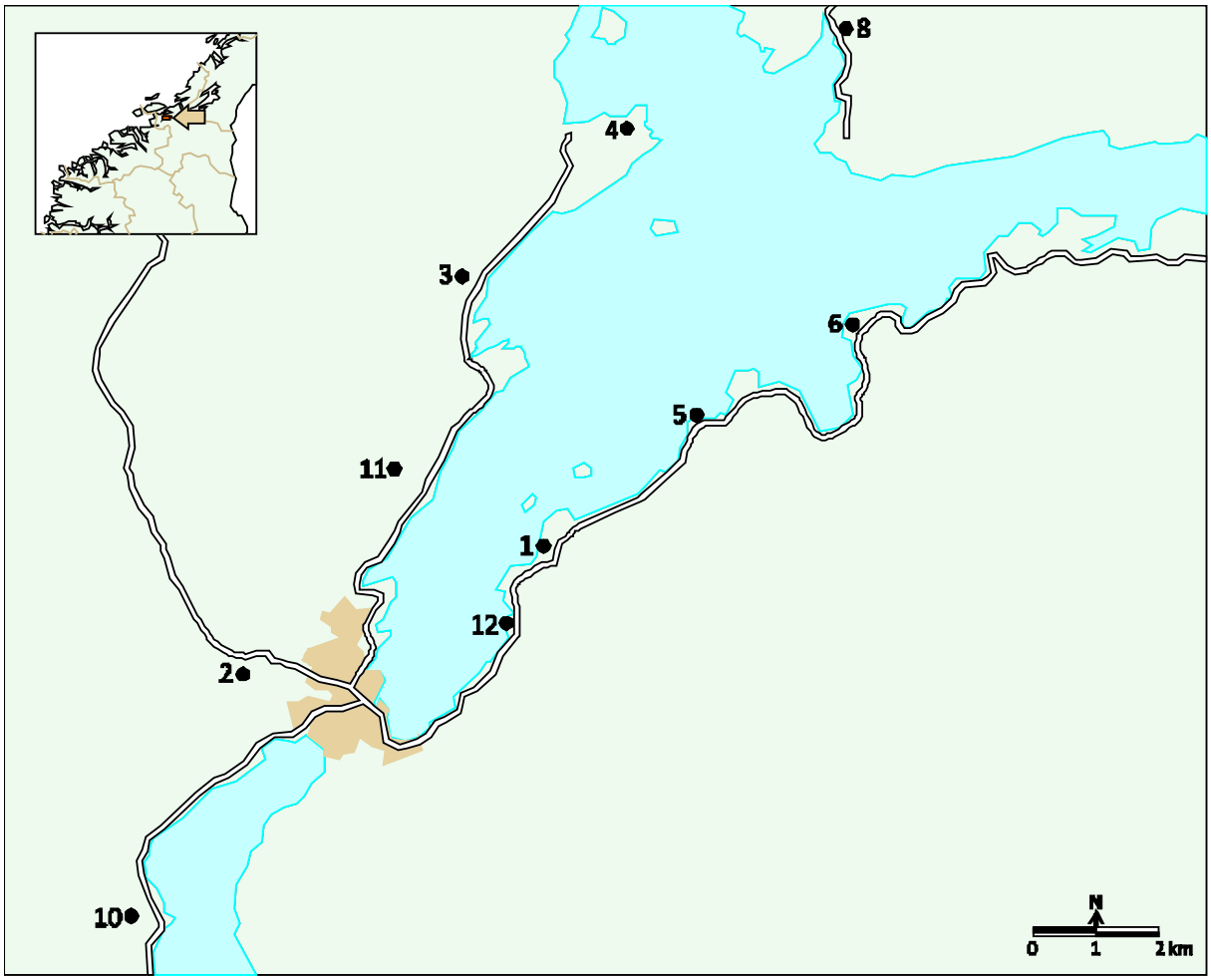

Figure 27: Sampling sites - Hemne

Table 26: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Hemne

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Hem 15-01	0.52	0.03	21	825	5.2	35	0.60	0.06	0.008	0.04	0.09	0.08	<0.02	0.16	47	0.95
Hem 15-02	0.12	0.02	5.0	465	5.7	18	0.20	0.06	0.004	0.04	0.02	0.03	0.02	0.12	32	0.32
Hem 15-03	0.07	0.01	1.2	291	8.3	16	0.08	0.04	0.004	0.01	0.04	0.03	<0.02	0.09	26	0.26
Hem 15-04	0.10	0.01	6.3	533	11	22	0.17	0.05	0.005	0.01	0.07	0.03	<0.02	0.15	36	0.45
Hem 15-05	0.09	0.01	5.4	808	5.9	15	0.08	0.04	0.004	0.02	0.06	0.03	<0.02	0.06	8.6	0.18
Hem 15-06	0.08	0.01	1.8	553	4.6	12	0.06	0.03	0.003	0.08	0.03	0.02	<0.02	0.11	19	0.10
Hem 15-08	0.13	0.01	2.8	500	6.5	21	0.15	0.07	0.005	0.02	0.04	0.02	<0.02	0.19	23	0.31
Hem 15-10	0.09	0.01	9.5	359	4.6	34	0.07	0.03	0.008	0.01	0.08	0.02	<0.02	0.04	18	0.11
Hem 15-11	0.07	0.01	6.3	461	9.5	16	0.06	0.03	0.004	0.01	0.03	0.02	<0.02	0.20	14	0.09
Hem 15-12	0.13	0.01	22	964	18	35	0.10	0.04	0.007	0.02	0.09	0.03	<0.02	0.16	22	0.15
	Ce	**Pr**	**Nd**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu**	**Hf**	**Ir**	**Pt**
Hem 15-01	2.0	0.20	0.82	0.15	0.120	0.17	0.03	0.12	0.02	0.08	0.010	0.064	0.011	0.03	0.003	0.007
Hem 15-02	0.64	0.07	0.27	0.05	0.052	0.05	0.01	0.03	0.01	0.02	<0.001	0.017	0.001	0.01	0.065	0.004
Hem 15-03	0.38	0.04	0.13	0.02	0.048	0.03	0.01	0.01	0.01	0.01	0.002	0.006	0.003	0.01	0.001	0.005
Hem 15-04	0.70	0.07	0.25	0.04	0.072	0.05	0.01	0.03	0.01	0.02	0.003	0.012	0.004	0.01	0.003	0.009
Hem 15-05	0.36	0.04	0.15	0.02	0.019	0.03	0.01	0.01	0.01	0.01	0.002	0.009	0.003	0.01	0.003	0.006
Hem 15-06	0.20	0.02	0.08	0.01	0.031	0.02	0.01	0.01	0.00	0.01	0.002	0.006	0.003	0.01	0.007	0.024
Hem 15-08	0.61	0.06	0.21	0.03	0.036	0.05	0.01	0.02	0.01	0.02	<0.001	0.012	0.000	0.01	0.002	0.004
Hem 15-10	0.21	0.02	0.09	0.01	0.027	0.02	0.00	0.01	0.00	0.01	<0.001	0.002	<0.001	0.01	0.004	0.009
Hem 15-11	0.17	0.02	0.07	0.01	0.020	0.02	0.00	0.01	0.00	0.00	<0.001	<0.001	<0.001	0.01	0.017	0.027
Hem 15-12	0.30	0.03	0.13	0.02	0.037	0.02	0.00	0.01	0.00	0.01	<0.001	0.006	<0.001	0.01	0.005	0.011

Hemne cont.

	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Hem 15-01	0.03	2.2	0.08	0.23	0.07	2203	1301	937	5390	0.50	111	4.3	5.6	106	1369	1.1
Hem 15-02	0.01	0.43	<0.003	0.07	0.02	1417	575	657	2662	0.12	26	0.97	1.3	236	321	0.17
Hem 15-03	0.01	0.48	0.02	0.03	0.02	1082	244	649	3416	0.05	14	0.59	0.44	360	151	0.13
Hem 15-04	0.01	0.62	0.02	0.04	0.02	1450	349	753	3391	0.07	21	0.82	0.59	445	232	0.80
Hem 15-05	0.02	0.48	0.02	0.04	0.02	1151	297	875	2608	0.06	15	0.67	0.43	332	197	0.14
Hem 15-06	0.04	0.46	0.01	0.03	0.02	971	256	732	2750	0.04	14	0.57	0.37	409	149	0.07
Hem 15-08	0.01	0.53	<0.003	0.06	0.02	1642	468	794	2937	0.08	23	0.70	0.37	674	227	0.25
Hem 15-10	0.003	0.30	<0.003	0.02	0.01	2051	251	760	4063	0.06	15	0.55	0.45	265	155	0.26
Hem 15-11	0.01	0.36	<0.003	0.02	0.01	1713	212	759	2938	0.04	12	0.49	0.35	127	126	0.09
Hem 15-12	0.01	0.48	<0.003	0.03	0.02	2999	304	985	3329	0.08	21	0.76	0.67	201	222	0.49

	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg
Hem 15-01	2.7	5.7	49	0.45	0.62	3725	0.07	0.19	0.38	0.108
Hem 15-02	1.2	3.5	12	0.13	0.13	3833	0.02	0.06	0.15	0.047
Hem 15-03	0.97	2.2	17	0.09	0.17	3295	0.01	0.05	0.25	0.040
Hem 15-04	1.3	3.0	44	0.11	0.13	4778	0.02	0.07	0.24	0.067
Hem 15-05	0.46	2.7	37	0.10	0.16	4604	0.02	0.06	0.16	0.045
Hem 15-06	0.52	2.2	17	0.08	0.12	3631	0.01	0.08	0.28	0.035
Hem 15-08	0.68	2.9	28	0.13	0.07	3199	0.01	0.06	0.19	0.050
Hem 15-10	1.00	2.5	31	0.08	0.06	4111	0.01	0.04	0.14	0.033
Hem 15-11	0.87	2.5	14	0.07	0.06	3891	0.01	0.05	0.18	0.053
Hem 15-12	0.97	3.4	52	0.10	0.27	5522	0.02	0.07	0.09	0.059

4.1.14 Orkanger

Monitoring of metal deposition around the silicon industry at Orkanger (Figure 28) was carried out for the first time in 2015. Except for moderate levels of V, the deposition of the metals studied are relatively low.

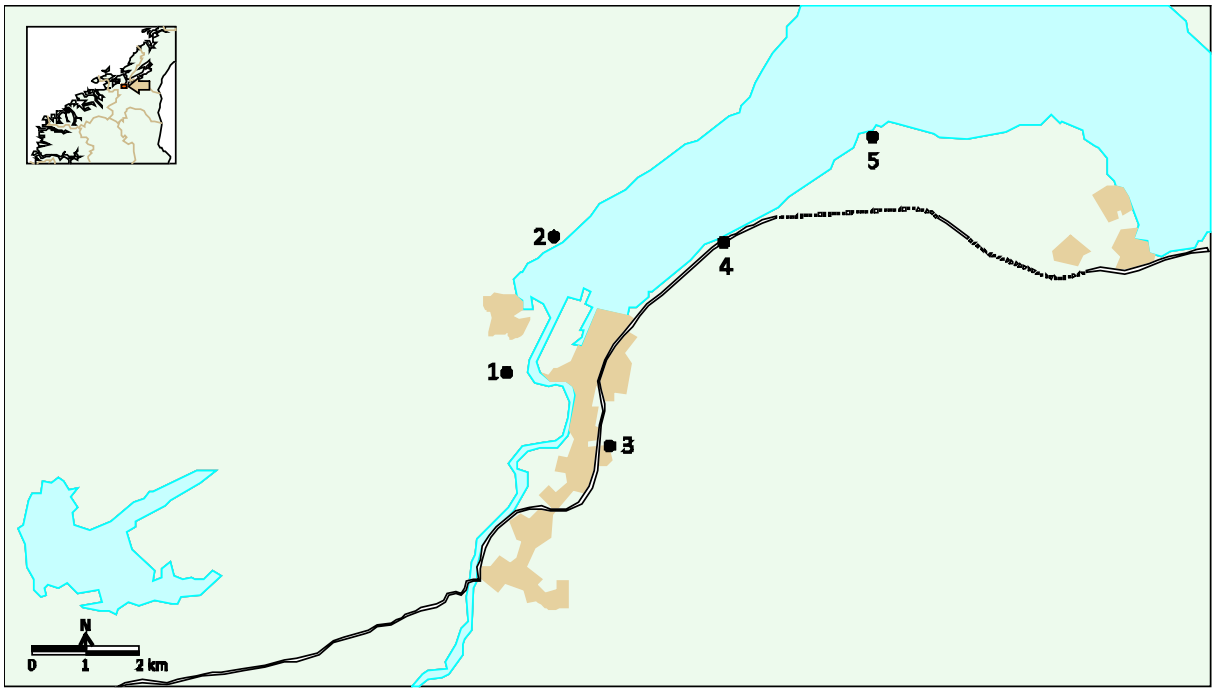

Figure 28: Sampling sites - Orkanger

Table *27: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.*

Orkanger

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Ork 15-01	0.76	0.05	15	452	15	30	1.1	0.10	0.011	0.05	0.17	0.19	<0.02	0.13	28	0.78
Ork 15-02	0.35	0.02	8.3	417	10	27	0.35	0.08	0.010	0.04	0.15	0.15	<0.02	0.09	33	0.38
Ork 15-03	0.20	0.02	5.4	237	14	15	0.24	0.06	0.007	0.03	0.16	0.05	<0.02	0.21	29	0.23
Ork 15-04	0.78	0.04	4.7	343	11	17	0.93	0.09	0.008	0.06	0.09	**0.32**	<0.02	0.30	40	0.79
Ork 15-05	0.55	0.03	3.0	252	3.6	20	0.91	0.07	0.008	0.04	**0.88**	0.16	<0.02	0.07	27	0.68
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Ork 15-01	1.6	0.19	0.85	0.20	0.113	0.22	0.05	0.21	0.04	0.15	**0.016**	0.130	0.018	0.04	0.004	0.009
Ork 15-02	0.78	0.08	0.32	0.07	0.089	0.09	0.02	0.06	0.01	0.05	0.004	0.038	0.006	0.02	0.004	0.010
Ork 15-03	0.52	0.06	0.23	0.05	0.072	0.06	0.01	0.04	0.01	0.04	0.003	0.028	0.004	0.01	0.003	0.007
Ork 15-04	1.9	0.21	0.90	0.20	0.146	0.23	0.05	0.18	0.03	0.14	0.014	0.107	0.015	0.05	0.007	0.016
Ork 15-05	1.5	0.17	0.75	0.17	0.104	0.21	0.05	0.17	0.03	0.13	0.013	0.105	0.015	0.04	0.004	0.012
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Ork 15-01	0.03	4.3	0.02	0.21	0.06	3587	2074	1161	6500	**1.4**	177	**11**	**6.1**	344	**3124**	2.0
Ork 15-02	0.02	4.9	0.02	0.09	0.03	2506	854	1108	4301	0.35	73	3.2	2.9	885	1060	0.71
Ork 15-03	0.02	0.83	<0.003	0.08	0.02	2818	657	959	4517	0.33	52	2.6	1.5	223	722	0.82
Ork 15-04	0.08	3.1	0.05	0.25	0.08	1970	1970	1131	3294	0.92	152	**7.9**	5.6	151	2577	1.1
Ork 15-05	0.04	2.1	0.03	0.18	0.05	1918	1545	767	4763	0.81	161	**6.1**	3.7	110	1844	1.0
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Ork 15-01	4.5	11	64	0.71	0.99	6264	0.06	0.20	0.26	0.073						
Ork 15-02	3.0	8.4	107	0.28	0.61	5561	0.04	0.20	0.27	0.073						
Ork 15-03	2.6	4.7	46	0.19	0.25	4554	0.02	0.11	0.14	0.054						
Ork 15-04	3.6	13	58	0.62	0.62	4091	0.07	0.35	0.32	0.098						
Ork 15-05	3.2	8.0	56	0.50	0.43	3536	0.06	0.31	0.16	0.022						

Table 28: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	**Ag**	**Cd**	**Sb**	**Te**	**La**	**Ce**	**Pb**	**Bi**	**Th**	**U**	**Ti**	**V**	**Cr**
Orkanger	2015													8,3	
			Mn	**Fe**	**Co**	**Ni**	**Cu**	**Zn**	**Ga**	**Mo**	**As**	**Hg**	**Nb**	**Ba**	

4.1.15 Mosjøen

The sampling sites located around the Mosjøen aluminium smelter are shown in Figure 29. The data are generally low to moderate. Except for moderate levels of Bi the values are low at all sites.

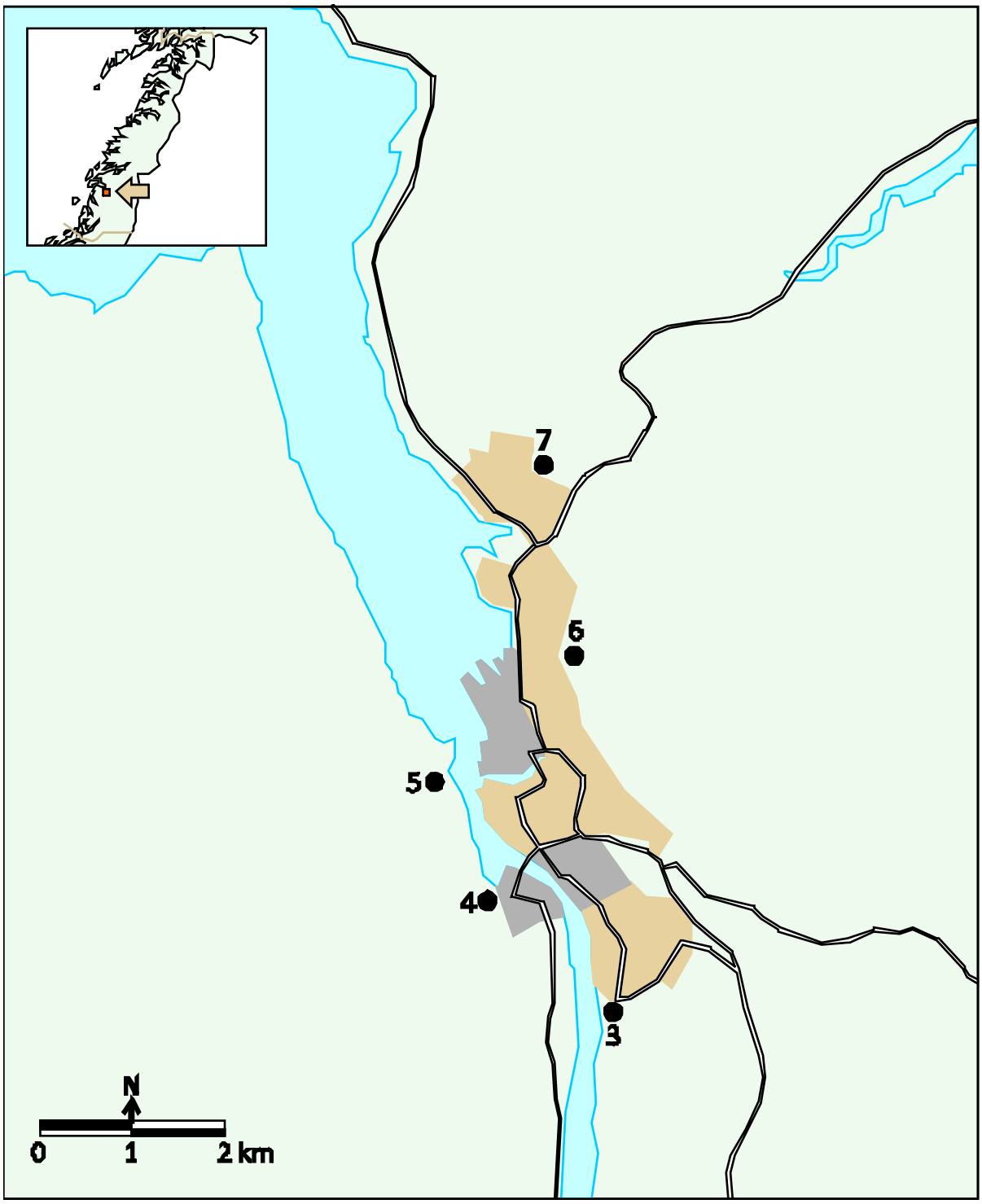

Figure 29: Sampling sites – Mosjøen

Table 29: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Mosjøen

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Msj 15-03	0.39	0.03	4.2	399	8.4	23	0.48	0.11	0.007	0.03	0.10	0.08	0.04	0.18	36	0.55
Msj 15-04	0.19	0.02	5.4	339	5.8	29	0.37	0.08	0.007	0.02	0.09	0.07	0.03	0.11	25	0.90
Msj 15-05	0.35	0.04	2.9	415	8.5	26	0.45	0.12	0.006	0.03	0.07	0.10	0.04	0.10	29	0.48
Msj 15-06	0.23	0.03	3.4	337	3.9	20	0.30	0.07	0.007	0.03	0.11	0.12	0.05	0.11	22	0.31
Msj 15-07	0.32	0.03	5.3	344	5.3	27	0.59	0.10	0.009	0.03	0.11	0.08	0.05	0.19	27	0.71
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
Msj 15-03	1.3	0.14	0.59	0.12	0.087	0.12	0.02	0.09	0.02	0.06	0.006	0.047	0.006	0.03	0.008	0.014
Msj 15-04	1.2	0.17	0.64	0.11	0.068	0.15	0.02	0.07	0.01	0.05	0.003	0.031	0.004	0.02	0.006	0.013
Msj 15-05	1.1	0.13	0.52	0.11	0.068	0.12	0.02	0.08	0.02	0.06	0.005	0.044	0.006	0.03	0.013	0.025
Msj 15-06	0.78	0.09	0.41	0.08	0.067	0.10	0.02	0.06	0.01	0.05	0.004	0.035	0.005	0.03	0.007	0.015
Msj 15-07	1.8	0.19	0.84	0.18	0.097	0.21	0.04	0.13	0.03	0.11	0.009	0.074	0.010	0.04	0.006	0.014
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Msj 15-03	0.03	1.4	**0.21**	0.11	0.04	2155	1551	871	2714	0.32	76	3.6	1.6	271	987	0.69
Msj 15-04	0.03	1.2	**0.21**	0.05	0.03	1543	1196	643	4527	0.15	51	1.9	0.70	127	466	0.50
Msj 15-05	0.03	2.6	**0.23**	0.09	0.04	1853	1601	885	2716	0.29	84	3.5	1.2	107	870	0.50
Msj 15-06	0.02	1.8	**0.41**	0.09	0.03	1836	2121	781	3748	0.21	67	2.8	0.75	255	730	0.32
Msj 15-07	0.03	3.2	**0.30**	0.14	0.04	2028	1693	837	3934	0.38	126	4.2	1.2	179	1091	0.91
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Msj 15-03	4.6	7.8	46	0.43	0.34	4262	0.03	0.31	0.55	0.054						
Msj 15-04	5.5	3.9	66	0.30	0.23	3346	0.03	0.17	0.44	0.032						
Msj 15-05	4.2	3.3	24	0.45	0.35	4997	0.03	0.20	0.38	0.051						
Msj 15-06	5.3	3.8	40	0.49	0.24	3014	0.02	0.22	0.33	0.051						
Msj 15-07	3.9	3.5	29	0.50	0.32	3731	0.03	0.29	0.49	0.070						

Table 29: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	**Ag**	**Cd**	**Sb**	**Te**	**La**	**Ce**	**Pb**	**Bi**	**Th**	**U**	**Ti**	**V**	**Cr**
Mosjøen	4,5,7	2015				0.04				0.25					
		2010				0.3				0.35					
		2000				n.d				0.03					
			Mn	**Fe**	**Co**	**Ni**	**Cu**	**Zn**	**Ga**	**Mo**	**As**	**Hg**	**Nb**	**Ba**	
		2015													
		2010													
		2000													

4.1.16 Mo i Rana

In previous surveys Mo i Rana (Figure 30) has consistently shown as the generally most polluted industrial site in Norway with respect to metals, and this situation persists in 2015. Levels of most elements are among the highest in this survey, such as Mn (Figure 31), Fe (Figure 32), and Zn (Figure 33). The three industries presumably sharing the responsibility for this situation are a manganese alloy plant, a ferrosilicon plant, and a facility for production of metal reinforcing products from scrap metal. As the smelter units are located a short distance from each other it is difficult to distinguish emissions of metals from each source. In addition, waste dumps located within the industrial area may release dust adding to the air pollution.

Following the classification employed in this report "moderate pollution" is evident for a total of 21 elements, and five of those metals (V, Cr, Mn, Zn, and Pb) are present as "serious pollutants" in some cases. The levels of most of these elements has been relatively constant since 2005. An exception is Cr, where a substantial reduction was observed over the period 2000-2010, but the 2015 level is similar to that observed in 2010.

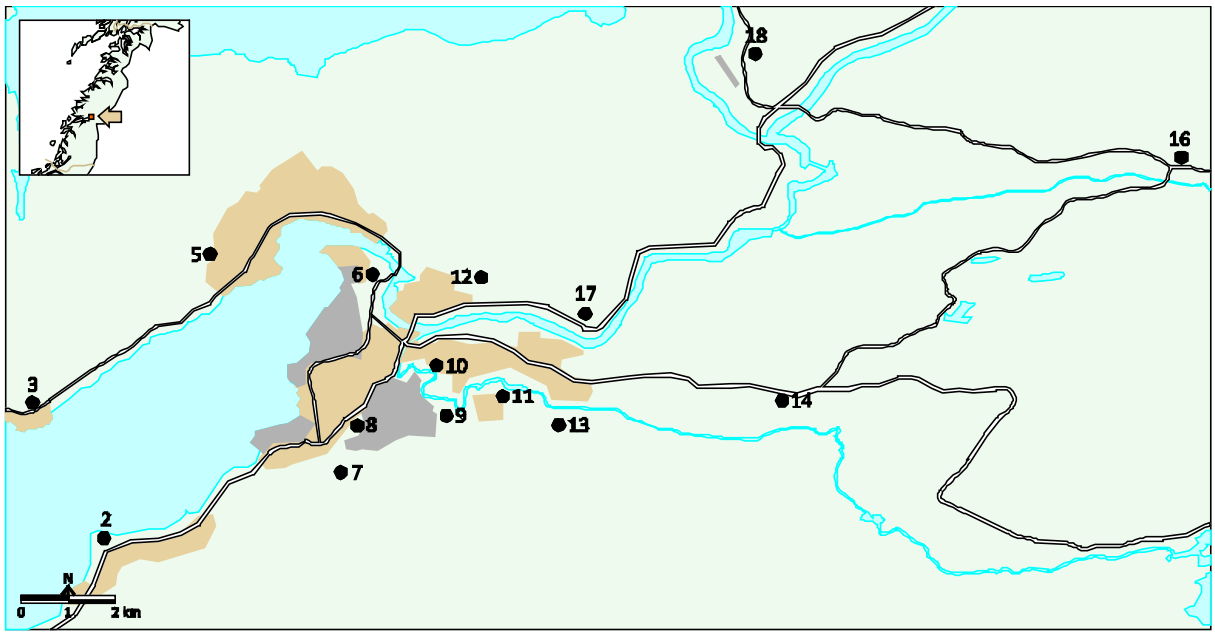

Figure 30: Sampling sites - Mo i Rana

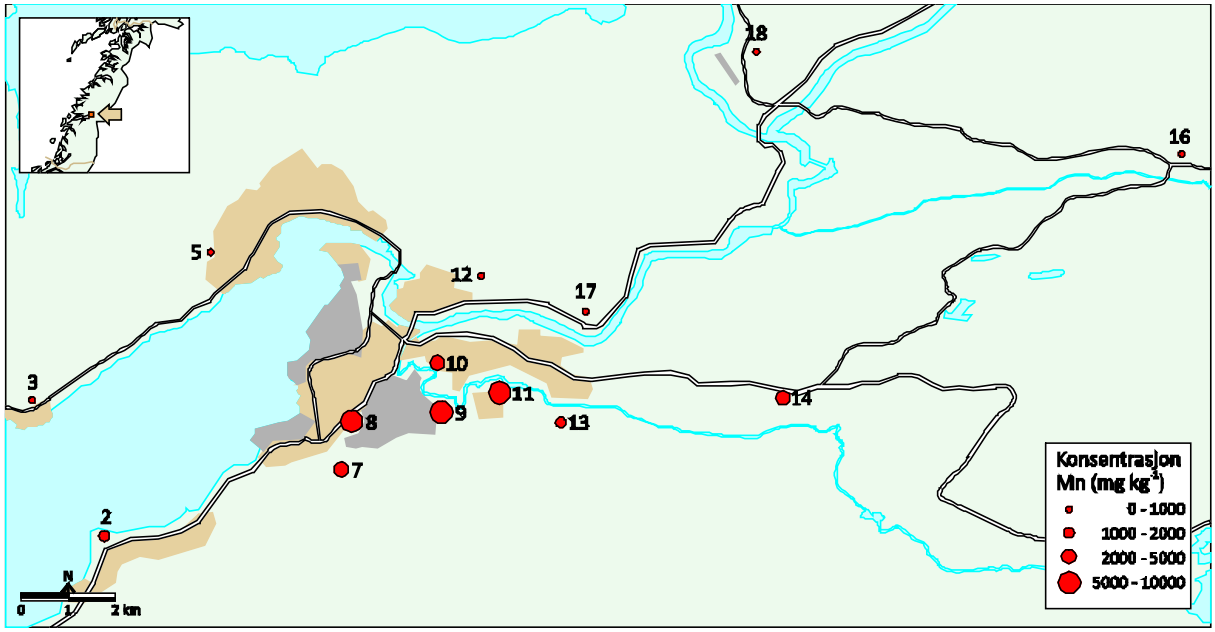

Figure 31: Concentration of Manganese in moss samples- Mo i Rana

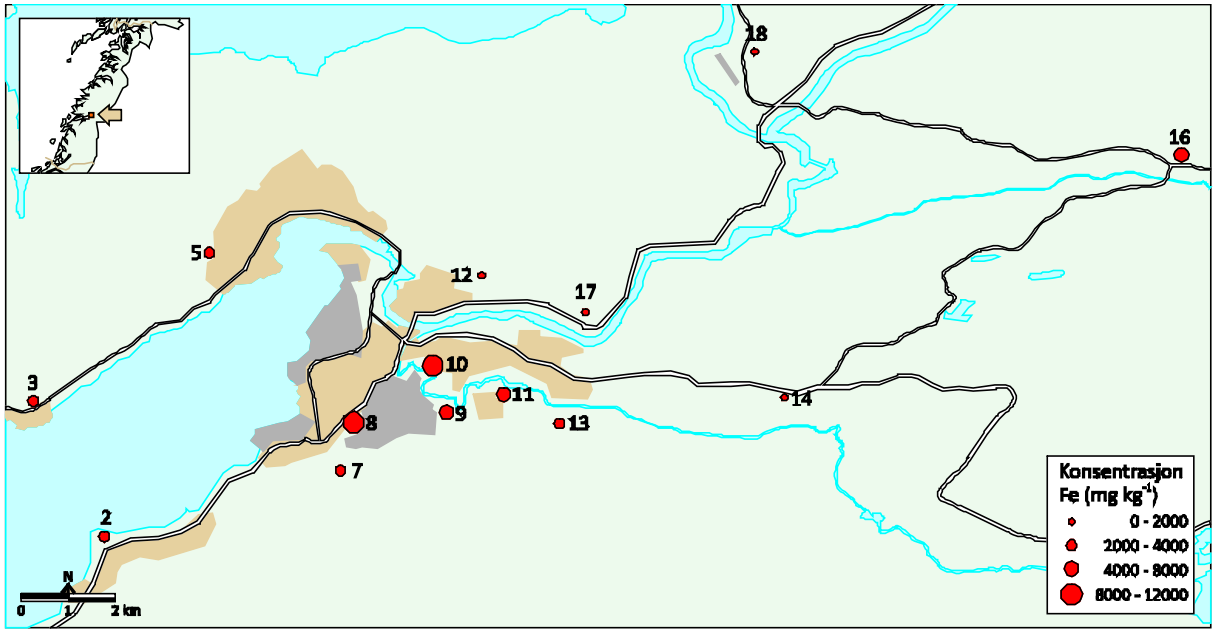

Figure 32: Concentration of Iron in moss samples - Mo i Rana

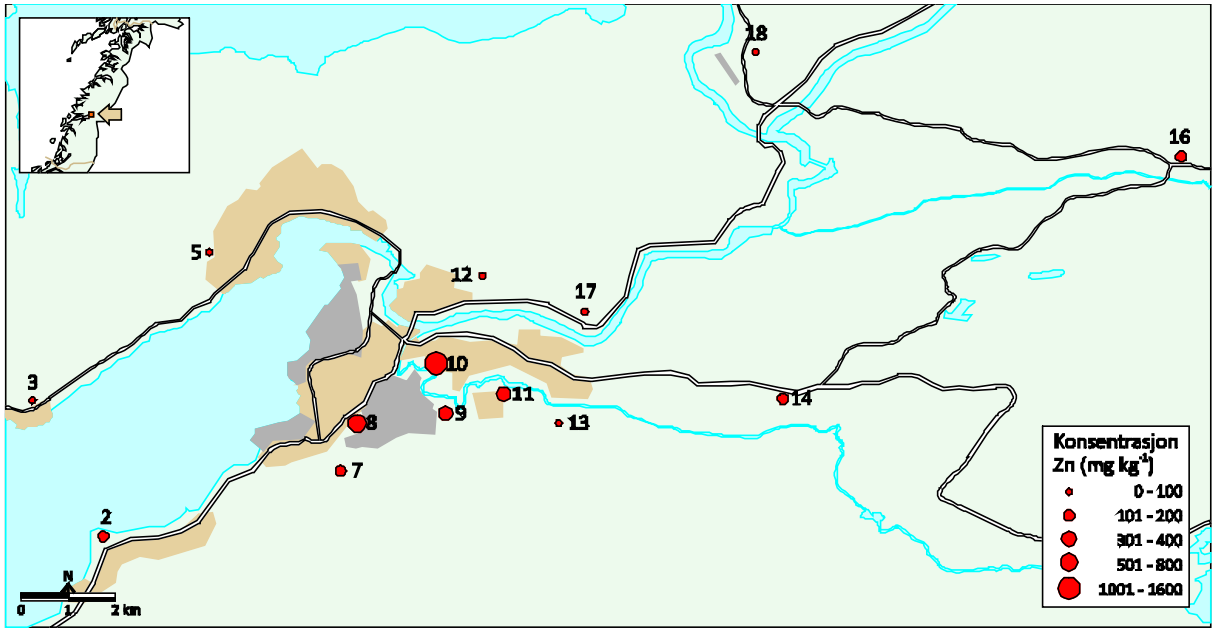

Figure 33: Concentration of Zinc in moss samples - Mo i Rana

Table 30: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Mo i Rana

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
MiR 15-02	0.83	0.09	22	348	8.5	32	1.1	0.48	0.009	0.08	0.27	0.15	0.04	0.22	105	2.0
MiR 15-03	0.85	0.07	9.6	360	11	25	0.97	0.37	0.009	0.11	0.17	0.14	0.05	0.29	54	1.6
MiR 15-05	0.68	0.06	12	296	10	24	0.65	0.40	0.009	0.10	0.12	0.16	0.05	0.42	55	0.97
MiR 15-07	0.51	0.11	10.0	277	4.5	21	0.87	0.71	0.008	0.18	0.32	0.25	0.09	0.24	133	1.1
MiR 15-08	4.0	0.52	49	250	11	77	6.2	0.12	0.026	0.28	1.3	0.16	0.05	0.61	658	8.9
MiR 15-09	1.0	0.26	29	158	12	42	2.8	0.37	0.014	0.17	0.74	0.12	0.08	0.48	290	4.0
MiR 15-10	1.4	0.14	48	226	13	40	1.4	0.63	0.016	0.39	1.8	0.26	0.09	0.28	159	3.0
MiR 15-11	1.3	0.29	31	263	8.8	33	2.9	0.52	0.010	0.14	0.70	0.14	0.06	0.48	288	4.2
MiR 15-12	0.36	0.04	9.1	264	11	30	0.45	0.49	0.010	0.06	0.24	0.10	0.06	0.22	64	0.76
MiR 15-13	0.33	0.07	5.2	242	6.4	22	0.73	1.4	0.008	0.08	0.18	0.12	0.13	0.20	82	1.0
MiR 15-14	0.37	0.04	7.1	248	17.0	19	0.44	0.70	0.007	0.10	0.25	0.11	0.08	0.50	92	0.83
MiR 15-16	2.7	0.15	14	340	19.1	40	4.5	0.12	0.012	0.22	0.31	0.05	0.06	0.44	62	6.7
MiR 15-17	0.35	0.02	3.3	153	29.0	24	0.34	0.20	0.008	0.07	0.20	0.06	0.03	2.6	88	0.31
MiR 15-18	0.23	0.04	1.7	228	52.2	27	0.31	0.16	0.009	0.09	0.11	0.09	0.03	2.5	28	0.56

Mo i Rana cont.

Location	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ir	Pt
MiR 15-02	4.1	0.44	1.7	0.29	0.247	0.37	0.06	0.20	0.04	0.15	0.013	0.107	0.015	0.02	0.007	0.015
MiR 15-03	3.4	0.34	1.4	0.25	0.172	0.33	0.07	0.16	0.03	0.15	0.012	0.099	0.014	0.04	0.020	0.007
MiR 15-05	1.9	0.21	0.80	0.16	0.149	0.23	0.04	0.11	0.02	0.10	0.008	0.068	0.010	0.03	0.002	0.007
MiR 15-07	3.2	0.28	1.2	0.22	0.353	0.29	0.06	0.16	0.03	0.13	0.011	0.091	0.012	0.09	0.005	0.013
MiR 15-08	21	2.4	9.4	1.625	1.881	2.23	0.44	1.18	0.21	0.95	0.080	0.655	0.087	0.08	0.013	0.035
MiR 15-09	10	0.89	3.6	0.72	0.873	0.99	0.19	0.54	0.10	0.44	0.038	0.302	0.041	0.05	0.036	0.066
MiR 15-10	5.2	0.64	2.7	0.41	0.444	0.61	0.11	0.30	0.05	0.25	0.018	0.164	0.025	0.03	0.006	0.014
MiR 15-11	12	1.1	4.1	0.73	0.680	0.91	0.16	0.55	0.10	0.39	0.038	0.281	0.039	0.03	0.006	0.012
MiR 15-12	1.6	0.16	0.73	0.13	0.168	0.17	0.03	0.09	0.02	0.08	0.006	0.050	0.007	0.03	0.007	0.015
MiR 15-13	2.3	0.23	0.92	0.17	0.220	0.24	0.04	0.12	0.03	0.11	0.009	0.073	0.010	0.04	0.006	0.013
MiR 15-14	1.7	0.17	0.70	0.13	0.242	0.18	0.03	0.08	0.02	0.07	0.006	0.050	0.007	0.04	0.007	0.016
MiR 15-16	14	1.9	7.6	1.3	0.380	1.8	0.34	0.94	0.17	0.78	0.065	0.565	0.075	0.15	0.008	0.018
MiR 15-17	0.60	0.06	0.29	0.06	0.211	0.07	0.02	0.06	0.01	0.05	0.005	0.038	0.005	0.02	0.004	0.010
MiR 15-18	1.3	0.13	0.51	0.09	0.079	0.13	0.02	0.06	0.01	0.05	0.003	0.033	0.005	0.02	0.004	0.010

Mo i Rana cont.

Location	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
MiR 15-02	0.10	12	0.08	0.41	0.13	2772	1957	1013	5795	0.65	94	9.1	81	1939	3134	1.5
MiR 15-03	0.15	12	0.05	0.39	0.10	2632	1578	1278	4700	0.57	108	6.6	49	748	3528	1.2
MiR 15-05	0.07	15	0.04	0.24	0.05	2731	1241	981	5142	0.36	68	4.1	25	866	2700	0.63
MiR 15-07	0.06	20	0.09	0.30	0.10	2032	1741	888	4794	0.64	92	5.6	102	2166	2921	1.1
MiR 15-08	0.13	59	0.33	2.2	1.2	4352	6870	917	15290	3.5	150	26	220	8356	10021	4.8
MiR 15-09	0.17	22	0.15	0.90	0.30	2012	3632	1005	8544	1.4	198	13	207	9525	4159	3.7
MiR 15-10	0.09	104	0.50	0.68	0.23	4430	4117	1351	16745	0.50	157	46	356	4255	11867	1.6
MiR 15-11	0.22	25	0.21	0.99	0.32	2494	4194	1335	7470	1.7	221	20	210	7934	6611	3.7
MiR 15-12	0.03	7.2	0.05	0.22	0.05	2328	919	955	5947	0.23	52	2.5	14	757	1714	0.51
MiR 15-13	0.14	12	0.06	0.22	0.08	1587	1451	848	5513	0.42	86	5.2	69	1597	2234	0.73
MiR 15-14	0.32	13	0.04	0.18	0.05	1658	1047	1376	6124	0.26	69	3.4	62	2224	1634	0.75
MiR 15-16	0.08	15	0.10	2.7	0.32	3300	4492	838	10003	1.5	308	13	41	846	5784	2.4
MiR 15-17	0.06	9.8	0.05	0.07	0.02	2309	715	1068	4262	0.35	56	3.7	9.7	939	1114	0.51
MiR 15-18	0.03	5.7	0.03	0.17	0.03	1883	658	674	3128	0.12	41	1.3	1.7	221	579	0.21

Mo i Rana cont.

Location	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
MiR 15-02	4.5	13	172	0.51	1.5	4337	0.04	0.37	0.37	0.143						
MiR 15-03	3.0	11	96	0.53	0.97	4345	0.06	0.31	0.31	0.209						
MiR 15-05	2.1	7.6	82	0.36	0.67	4451	0.05	0.33	0.41	0.115						
MiR 15-07	5.3	12	167	0.28	1.6	3296	0.04	0.44	0.42	0.129						
MiR 15-08	20	52	689	0.94	3.5	3445	0.10	1.1	0.43	0.175						
MiR 15-09	9.8	18	213	0.59	3.2	4171	0.07	1.0	0.47	0.269						
MiR 15-10	13	40	929	1.3	5.2	4773	0.12	0.80	0.40	0.554						
MiR 15-11	9.9	24	263	0.59	3.0	3544	0.07	1.1	0.53	0.209						
MiR 15-12	1.9	5.9	70	0.26	0.62	3699	0.03	0.16	0.40	0.080						
MiR 15-13	2.8	6.9	99	0.27	0.94	4004	0.04	0.30	0.45	0.103						
MiR 15-14	2.6	7.4	144	0.30	0.63	4402	0.03	0.20	0.46	0.173						
MiR 15-16	5.4	11	141	1.6	1.3	4293	0.09	1.7	0.28	0.109						
MiR 15-17	1.9	4.7	94	0.25	0.32	4659	0.04	0.15	0.30	0.051						
MiR 15-18	0.88	3.8	53	0.17	0.23	4739	0.02	0.16	0.40	0.028						

Table 31: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	**Ag**	**Cd**	**Sb**	**Te**	**La**	**Ce**	**Pb**	**Bi**	**Th**	**U**	**Ti**	**V**	**Cr**
Mo i Rana	8,9,10	2015		1.30	0.95	0.07	5.3	12.0	62	0.33	1.23	0.57	399	28	260
		2010		1.49	0.95	0.38	6.9	17.2	80	0.49	1.58	0.70	417	30	330
		2005		2.62	0.60	0.16	4.1	10.8	153	0.34	1.01	0.33	296	27	1200
		2000		1.26	0.3	nd	3.3	6.8	115	0.36	0.82	nd	403	59	9700
			Mn	**Fe**	**Co**	**Ni**	**Cu**	**Zn**	**Ga**	**Mo**	**As**	**Hg**	**Nb**	**Ba**	
		2015	7400	9500	3.4	14	37	610			1.1		0.4	370	
		2010	9000	11000	6.0	24	42	710			1.7		6.4	490	
		2005	11200	12200	8.3	120	63	1100			3.0		2.15	250	
		2000	1900	17300	10.0	60	60	1110			3.4		1.25	90	

4.1.17 Finnsnes

Like in the only previous assessment in 2000 the metal deposition around the Finnfjord ferrosilicon plant (Figure 34) appears to be low in general. Moderate levels of V are observed at some sites.

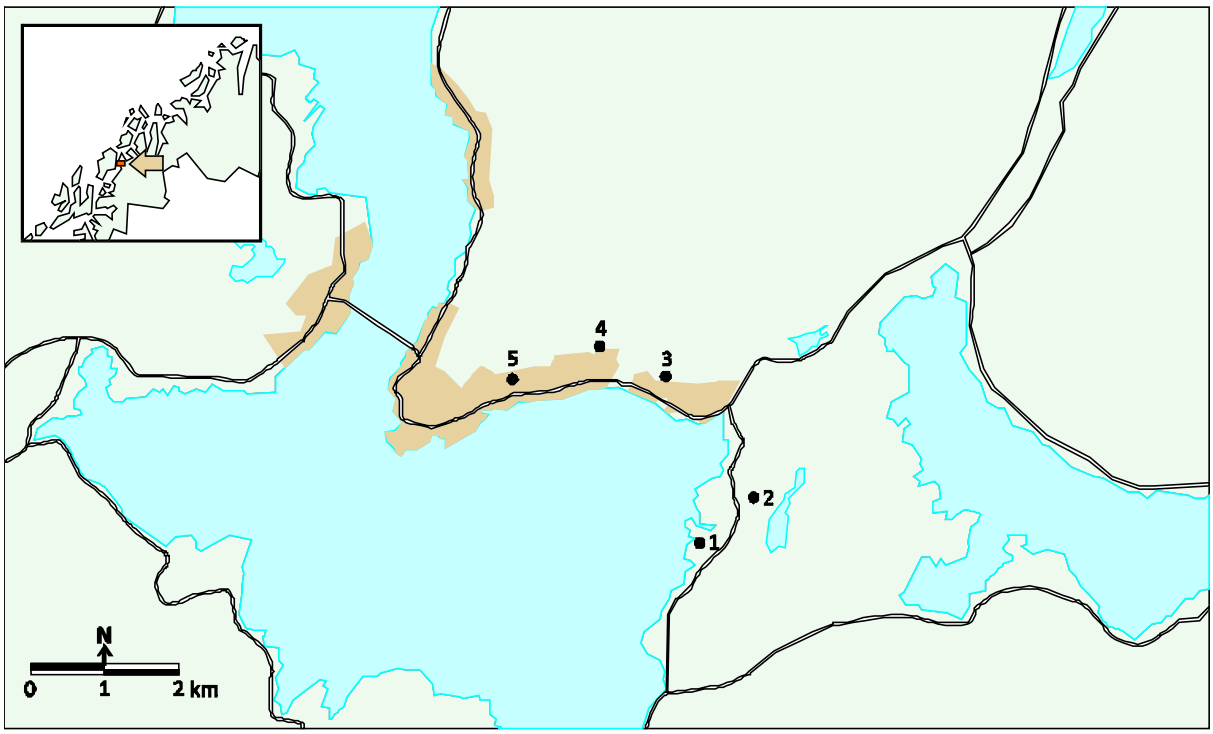

Figure 34: Sampling sites – Finnsnes

Table 32: Concentrations of 57 elements in all 2015 moss samples (mg kg^{-1}). Values exceeding background level by a factor of 10 or more indicate obvious pollution, and these values are marked in blue print. Values exceeding background level by a factor of 50 or more indicate substantial pollution, and these values are marked in red print. Background values are listed in table A2.

Finnsnes

Location	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
Fin 15-01	0.30	0.03	8.9	213	15	18	0.24	0.07	0.008	0.02	0.06	0.20	<0.02	0.26	52	0.39
Fin 15-02	0.39	0.03	6.3	170	16	22	0.19	0.05	0.008	0.02	0.05	0.10	<0.02	0.18	17	0.28
Fin 15-03	0.87	0.05	30	348	19	27	0.91	0.13	0.010	0.04	0.13	0.12	0.02	0.36	57	1.3
Fin 15-04	0.52	0.04	5.2	185	10	24	0.61	0.11	0.009	0.03	0.06	0.05	<0.02	0.38	26	0.79
Fin 15-05	1.5	0.07	15	255	11	34	1.4	0.02	0.011	0.05	0.29	0.04	<0.02	0.28	44	2.3
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf1	Ir	Pt
Fin 15-01	0.77	0.09	0.35	0.07	0.13	0.10	0.02	0.04	0.01	0.04	0.003	0.026	0.004	0.01	0.009	0.021
Fin 15-02	0.55	0.06	0.25	0.05	0.05	0.07	0.01	0.03	0.01	0.03	0.002	0.020	0.003	0.01	0.004	0.011
Fin 15-03	2.9	0.31	1.2	0.24	0.18	0.34	0.06	0.17	0.03	0.15	0.012	0.100	0.014	0.03	0.012	0.026
Fin 15-04	1.6	0.19	0.76	0.15	0.09	0.19	0.04	0.11	0.02	0.09	0.007	0.062	0.009	0.02	0.010	0.021
Fin 15-05	4.6	0.52	2.2	0.41	0.19	**0.59**	0.11	0.27	0.05	0.24	0.019	0.159	0.021	0.03	0.002	0.006
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Fin 15-01	0.02	1.4	<0.003	0.07	0.02	2815	712	941	5558	0.19	37	1.7	2.8	333	602	0.39
Fin 15-02	0.03	1.0	<0.003	0.05	0.02	2115	473	886	3794	0.13	24	1.4	1.7	188	684	0.23
Fin 15-03	0.03	1.5	0.01	0.34	0.07	3523	2075	1246	8941	0.72	161	6.7	4.5	375	1938	1.3
Fin 15-04	0.20	0.83	0.01	0.19	0.04	2162	1055	713	5760	0.40	86	3.2	2.4	249	1099	0.60
Fin 15-05	0.06	1.6	0.04	**0.57**	0.11	3525	2653	1049	8634	1.1	179	9.6	**7.8**	197	**3069**	1.9
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
Fin 15-01	1.64	6.4	30	0.19	0.30	4500	0.04	0.33	0.37	0.038						
Fin 15-02	1.87	4.8	38	0.23	0.27	4335	0.10	0.22	0.33	0.031						
Fin 15-03	3.40	9.1	113	0.59	0.39	5262	0.05	0.31	0.19	0.097						
Fin 15-04	1.67	4.1	25	0.32	0.20	3565	0.03	0.15	0.22	0.023						
Fin 15-05	4.71	8.9	71	0.94	0.76	4672	0.08	0.39	0.31	0.040						

Table 33: Mean values of selected elements for the three samples apparently exposed to the highest metal pollutant levels at the given sampling site.

Location			Ag	Cd	Sb	Te	La	Ce	Pb	Bi	Th	U	Ti	V	Cr
Background levels			0.01	0.05	0.02	0.01	0.25	0.45	0.7	0.01	0.05	0.02	25	0.5	0.6
			Mn	Fe	Co	Ni	Cu	Zn	Ga	Mo	As	Hg	Nb	Ba	
			200	300	0.2	1	3.5	30	0.1	0.1	0.1	0.05	0.1	20	
Location	**Site**	**Year**	**Ag**	**Cd**	**Sb**	**Te**	**La**	**Ce**	**Pb**	**Bi**	**Th**	**U**	**Ti**	**V**	**Cr**
Finnsnes	2,3,4	2015												6.3	
		2000												0.9	
			Mn	**Fe**	**Co**	**Ni**	**Cu**	**Zn**	**Ga**	**Mo**	**As**	**Hg**	**Nb**	**Ba**	
		2015													
		2000													
		2010													
		2000													

4.2 Discussion according to element

In the corresponding report from 2010 (Steinnes et al., 2011) the results were discussed for each element individually. In the following an updated version is presented considering the 2015 results in particular. The classification of pollution level follows the terms used in all the tables in this report.

4.2.1. Beryllium

Beryllium pollution previously observed from the Karmøy, Høyanger, Årdal, and Sunndal aluminium smelters had been substantially reduced in 2015. In the present survey obvious Be pollution is observed only at Mo i Rana.

4.2.2. Vanadium

Obvious V pollution is evident only at Mo i Rana. At other sites obvious V pollution is observed only occasionally.

4.2.4. Chromium

Obvious Cr pollution is still evident at Mo i Rana. At the other sites obvious pollution is observed only occasionally.

4.2.5. Manganese

Obvious Mn pollution is evident at Mo i Rana, and to a lesser extent at Sauda. No appreciable problem is observed elsewhere.

4.2.6. Iron

Like in previous surveys the highest deposition is observed at Mo i Rana, followed by Årdal.

4.2.7. Cobalt

The highest Co deposition is observed in Kristiansand, associated with the copper-nickel smelter.

4.2.8. Nickel

Obvious Ni pollution is evident at Årdal and Kristiansand, at the same general levels as in 2010. Appreciable Ni deposition is also observed at Høyanger, Sunndal, and Mo i Rana.

4.2.9. Copper

Obvious Cu pollution is evident in Kristiansand, similar to 2010. Appreciable deposition is also observed at Mo i Rana.

4.2.10. Zinc

Obvious Zn pollution is observed at Mo i Rana and Odda. In the latter case the distribution among sites indicates contributions from the Zn smelter as well as the Ti refinery.

4.2.11. Gallium

Deposition of Ga is generally low, with a few occasionally elevated values near some aluminium smelters.

4.2.12. Arsenic

Slightly elevated As levels are evident at several sites, at levels similar to the 2010 survey. The 2015 deposition at Sauda is considerably less than in 2010.

4.2.13. Molybdenum

Mo deposition is generally low, with an exception for Mo i Rana.

4.2.14. Cadmium

Obvious Cd pollution is observed at Odda, at the same general level as in 2010. In a similar way as discussed above for Zn there seems to be more than one source of Cd pollution.

4.2.15. Tellurium

Tellurium is regarded as a very toxic element. Although the deposition of Te at the present sites is low in absolute terms, it is considerably enriched many places relative to background level. This is particularly the case at the metal works at Kristiansand, Årdal, and Høyanger, where the 2015 levels are very similar to those from 2010.

4.2.16. Mercury

Levels of Hg are somewhat elevated at Høyanger, Mo i Rana, and Odda. At the remaining sites the 2015 values are at background level.

4.2.17. Thallium

Levels are generally low. Like in 2010 Odda and Mo i Rana show the highest values.

4.2.18. Lead

The 2015 levels are generally similar to those from 2010, with the highest level in Mo i Rana followed by Odda. As leaded gasoline no longer contributes to the Pb deposition in Norway these emissions are most probably from the local industries.

4.2.19. Bismuth

Obvious pollution is observed at Kristiansand, Odda, and Årdal, followed by somewhat lower levels at Mosjøen and Husnes. In most cases the 2015 values do not differ much from those observed in 2010.

4.2.20. Aluminium

The deposition of Al among the sites is similar in 2015 as in 2010, with a general tendency to higher levels at the aluminium smelters. The Al deposition varies by a factor of 10 among the sites in the following approximate order: Sunndal > Årdal > Mo i Rana > Lista > Husnes > remaining sites.

4.2.21. Other elements

Results for the other elements such as Li, B, Na, Rb, Sr, Y, Nb, Rh, Ag, Cs, Ba, REE, Hf, Ir, Pt, Th, U, Mg, S, Ca, Sc, Ti, Ga, Ge, Se elements indicate that they may not be associated with air pollution to any significant extent.

5 Concluding remarks

Monitoring of atmospheric deposition of heavy metals using moss is a well-established technique. Even so, some limitations should be taken into account when interpreting the data presented in this report. These data give total deposition since contribution from wet- and dry-deposition using this technique is not separated. These data gives neither information of which size fractions of particles the different metals mainly are associated to, nor information of physical- or chemical form of the metals deposited. Hence, conclusions regarding health risks and environmental consequences should not be drawn solely based on the results presented in this report.

Mo i Rana is still the most polluted industrial site in this survey, with 17 metals considered as "obvious pollution" and V, Cr, Mn, Zn and Pb at levels classified as "substantial pollution". Also Odda is among the most contaminated locations, especially in respect to Zn, Ti and Cd, where the two latter metals are at the highest levels in this survey. Slightly decreasing trends are observed for Cd in Odda, Mn and Zn in Sauda and a slightly increasing trend for Ni in Årdal. The lowest levels where found in Hemne, Mosjøen and Finnsnes. Overall, there is little change in concentration levels for most elements at the different locations since last survey in 2010.

6 References

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Appendix A

Tables

Table A1: List of sampling sites with corresponding coordinates given as decimal degrees.

Sampling site	N. Latitude	E. Longitude	Sampling site	Latitude	Longitude
Por 15-13	59.0941	9.6847	Odd 15-01	60.0585	6.5368
Por 15-14	59.1191	9.6963	Odd 15-02	60.0645	6.5579
Por 15-15	59.1295	9.6566	Odd 15-03	60.0833	6.5200
Por 15-16	59.1308	9.6138	Odd 15-04	60.0828	6.5499
Por 15-18	59.1214	9.6646	Odd 15-05	60.0999	6.5248
Krs 15-02	58.1468	8.0335	Odd 15-06	60.1002	6.5498
Krs 15-03	58.1549	7.9896	Odd 15-07	60.1139	6.5612
Krs 15-04	58.0873	8.0023	Odd 15-08	60.1176	6.5773
Krs 15-05	58.1429	7.9746	Odd 15-09	60.1489	6.5700
Krs 15-11	58.1435	7.9453	Odd 15-10	60.1586	6.5438
Krs 15-12	58.1238	7.9633	Ålv 15-01	60.4157	6.3986
Krs 15-13	58.1144	7.9673	Ålv 15-02	60.4240	6.4033
Krs 15-14	58.1266	7.9571	Ålv 15-03	60.4296	6.4314
Krs 15-15	58.1290	7.9771	Ålv 15-04	60.4357	6.4311
LIS 15-03	58.1114	6.7845	Ålv 15-05	60.4323	6.4467
LIS 15-04	58.0794	6.7491	Ård 15-03	61.2995	7.7685
LIS 15-05	58.0628	6.7911	Ård 15-04	61.3146	7.8242
LIS 15-06	58.0692	6.8030	Ård 15-05	61.3059	7.8126
LIS 15-07	58.0773	6.7818	Ård 15-06	61.3163	7.8202
Kvi 15-02	58.2849	6.8461	Ård 15-07	61.3135	7.8373
Kvi 15-03	58.2811	6.8880	Hem 15-01	63.3140	9.1408
Kvi 15-04	58.2904	6.9049	Hem 15-02	63.2936	9.0450
Kvi 15-05	58.3025	6.9333	Hem 15-03	63.3527	9.1176
Kvi 15-08	58.2761	6.9084	Hem 15-04	63.3761	9.1705
Kar 15-01	59.3106	5.3017	Hem 15-05	63.3323	9.1902
Kar 15-02	59.3296	5.2905	Hem 15-06	63.3459	9.2418
Kar 15-03	59.2929	5.3096	Hem 15-08	63.3894	9.2374
Kar 15-04	59.3049	5.3389	Hem 15-10	63.2601	9.0030
Kar 15-06	59.3305	5.3482	Hem 15-11	63.3228	9.0896
			Hem 15-12	63.3039	9.1288

Background levels in moss

Table A2: Background levels

	Li	Be	B	Na	Rb	Sr	Y	Nb	Rh	Ag	Cd	Sb	Te	Cs	Ba	La
mg/kg	0.1	0.02	2	200	5	15	0.2	0.1	0.004	0.01	0.05	0.02	0.01	0.1	20	0.25
	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf1	Ir	Pt
mg/kg	0.45	0.06	0.15	0.04	0.03	0.04	0.01	0.03	0.005	0.02	0.001	0.015	0.001	0.01	0.003	0.01
	Tl	Pb	Bi	Th	U	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
mg/kg	0.02	0.7	0.01	0.05	0.02	1200	500	700	2500	0.1	25	0.5	0.6	200	300	0.2
	Ni	Cu	Zn	Ga	Mo	K	Ge	As	Se	Hg						
mg/kg	1	3.5	30	0.1	0.1	3000	0.02	0.1	0.2	0.05						

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