STUK-A167 August 1999

A summary of chemical data from the EPORA project

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RADIATION AND NUCLEAR SAFETY AUTHORITY

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Keywords EPORA, boreal understorey ecosystems, copper, nickel

ABSTRACT

EPORA (Effects of Industrial Pollution on Distribution Dynamics of Radionuclides in Boreal Understorey Ecosystems) is part of the EU Nuclear Fission Safety Programme 1994-1998, and is co-ordinated by STUK. The main purpose of the project is to study the influence of strong chemical pollution on the turnover of long-lived artificial radionuclides in a northern boreal ecosystem, and its implication on the radiation exposure to local population. The study area is located in the Kola peninsula, Russia in the vicinity of the Monchegorsk copper-nickel smelter. The smelter has operated since 30's and has since then discharged large amounts of sulphur and heavy metals into its surroundings.The present report is a documentation of the chemical analyses of soils and vegetation performed in EPORA in order to characterize the ecological impact of the emissions from Monchegorsk at different distances from the smelter. It also contains a brief description of the methods used and a summary of the most prominent trends apparent from the data presented.

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TIIVISTELMÄ

Tutkimusprojekti EPORA (Effects of Industrial Pollution on the Distribution Dynamics of Radionuclides in Boreal Understorey Ecosystems eli Teollisten saasteiden vaikutus radionuklidien jakautumiseen ja kulkeutumiseen pohjoisten metsien aluskasvillisuuden muodostamassa kasvuympäristössä) on osa EU:n vuosien 1994-1998 ydinturvallisuuden tutkimusohjelmaa. Projektin päätarkoitus on tutkia kemiallisten saasteiden vaikutusta pitkäikäisten radioaktiivisten aineiden kulkeutumiseen pohjoisten metsien ekosysteemissä ja radioaktiivisten aineiden paikalliselle väestölle aiheuttaman säteilyannokseen. Tutkimus tehdään Kuolan niemimaalla sijaitsevan Montsegorskin nikkelikuparisulaton ympäristössä. Sulatto aloitti toimintansa jo 1930-luvulla ja on toimintansa aikana päästänyt ympäristöön suuria määriä happamoittavia ja raskasmetallisaasteita. Tässä julkaisussa esitetään EPORA-projektissa tehtyjen maaperän ja kasvillisuuden kemiallisten analyysien tulokset. Niiden avulla voidaan arvioida Montsegorskin sulaton päästöistä eri etäisyyksillä aiheutuvia ekologisia vaikutuksia. Julkaisussa kuvataan myös lyhyesti tutkimuksessa käytetyt menetelmät ja esitetään yhteenveto tulosten perusteella ekosysteemissä selkeimmin havaittavissa olevista muutoksista ja niiden kehityssuunnista.

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1 INTRODUCTION

The research project EPORA (Effects of Industrial Pollution on the Distribution Dynamics of Radionuclides in Boreal Understorey Ecosystems) is part of the EU Nuclear Fission Safety Programme 1994-1998. The main purpose of EPORA is to study the influence of strong chemical pollution on the turnover of artificial radionuclides (^{137}Cs, ^{90}Sr) in a northern boreal ecosystem, and subsequently to assess the significance of the findings to the radiation exposure of the population in such areas. The copper-nickel smelter complex at Monchegorsk, Russia was selected as study object for EPORA. This industry, which is located in the middle of the Kola peninsula about 120 km from the Finnish border, is known for its huge atmospheric emissions of chemical pollutants. These pollutants, the most important of which are SO_2 and the heavy metals nickel and copper, have had a strong impact on the surrounding forest ecosystems, and in areas close to Monchegorsk most of the natural forest is completely destroyed.

The main part of EPORA consists of studies of soil-plant systems along a gradient in the south-westerly direction from Monchegorsk. Four study areas in Russia at distances of 8 - 40 km and a reference area on the Finnish side of the border 152 km from the smelter complex were selected for this study, and appropriate samples of soil and understorey vegetation were collected from these areas during the period June-August 1997. At each site in Russia five different plots of 1.5 m x 1.0 m and in Finland of 1.0 m x 1.0 m were sampled. The soil type was iron-humus podzol on all sites, and the vegetation was spruce forest.

2 BRIEF DESCRIPTION OF SAMPLING AND CHEMICAL ANALYSES

2.1 Sampling

On each plot soil samples were taken from the humus (FH) layer, in the following denoted H, the eluvial horizon (E) and the illuvial horizon (B). In addition samples from the litter layer were collected. In most soil profiles the H, E, and B horizons were divided in two consecutive layers denoted 1 and 2. The sampling was done in a manner to allow calculation of chemical properties on an area basis as well as on a concentration basis.

Four plant species were sampled on all plots wherever present: the shrubs *Vaccinium myrtillus, Vaccinium vitis-idaea* and *Empetrum nigrum* and the grass *Deschampsia flexuosa.*
Pooled samples were prepared for all species from each site for analysis. In addition the frequency of *Empetrum nigrum* allowed separate samples to be analysed from each plot at the five sites.

A more detailed description of the sampling sites and the procedures used for field sampling is given elsewhere in report STUK-A166. After transportation to the STUK Rovaniemi laboratory the samples were dried and homogenised. All the vegetation and litter samples were dried at 105°C temperature in large drying ovens. The samples were separated with a Mylar film from the metallic trays or cages to avoid contamination. The large plant and litter samples were homogenized in a Palman mill, small plant samples in a Waring blendor homogenizer. The drying procedure of the litters from sites A and B was still going on at the end of 1997.
In conclusion there were 6 different soil samples collected: Two from the humuslayer (H1 and H2), two from the E-horizon (E1 and E2) and two from the B-horizon (B1 and B2). The soil samples were taken to the GTK laboratory in Rovaniemi to be dried at + 40°C and after that to be sieved with a mesh size of 2 mm.
The final samples were distributed to the participating laboratories for radioactivity measurements and chemical investigations. The purpose of the present report is to give a brief description of the chemical

analyses inherent in the EPORA project and to document the main results of the analyses.
The responsibilities of the institutions participating in the work described in this report has been as follows:

- STUK, in addition to managing the entire EPORA project, is responsible for the co-ordination of field work and sample preparation.

- Norwegian University of Science and Technology (NTNU) is responsible for Work Package 2 of EPORA, which includes the work necessary to produce the chemical data presented in this report. Practically all data shown in the following were produced at Department of Chemistry, NTNU.

- Kola Science Center has provided invaluable advice on the selection of study areas and has played an important role in the field work. The institute has studied ecological effects of chemical pollutants from the Monchegorsk industries for many years already (Lukina and Nikonov 1996), and experience from this work was essential for the selection of study areas on Russian territory.

2.2 Chemical analyses

The purpose of the work described here is to provide the chemical data necessary to characterise the pollution gradient from Monchegorsk and effects of the chemical pollutants on the soil chemistry and the nutrient supply to the understorey vegetation. The subjects considered necessary to study for this purpose were as follows:

- Nutrient elements (K, Ca, Mg, Mn), heavy metals (Cu, Ni, Zn) and stable Sr in plant material.

- Total (HNO_3-soluble) concentrations of Cu, Ni, and stable Sr in every layer of all soil profiles.

- Exchangeable (1 M NH_4NO_3) fractions of the above nutrient elements and heavy metals (Cu, Ni, Fe) in the same set of soil samples.

- Parameters relevant for the evaluation of soil acidification (cation exchange capacity, exchangeable acidity, base saturation, exchangeable Al) in all soil samples.

- Organic matter content in soils from surface horizons.

- Sequential extractions of selected soil samples to elucidate different binding forms of Ni, Cu, and Sr.

The work necessary to cover the first five subjects above is now completed, and the methods used and the results obtained are summarised in the following. Considering the last point, the experiments have been completed and the results are under evaluation, but are not included in this report.

3 PROCEDURES EMPLOYED IN THE LABORATORY WORK

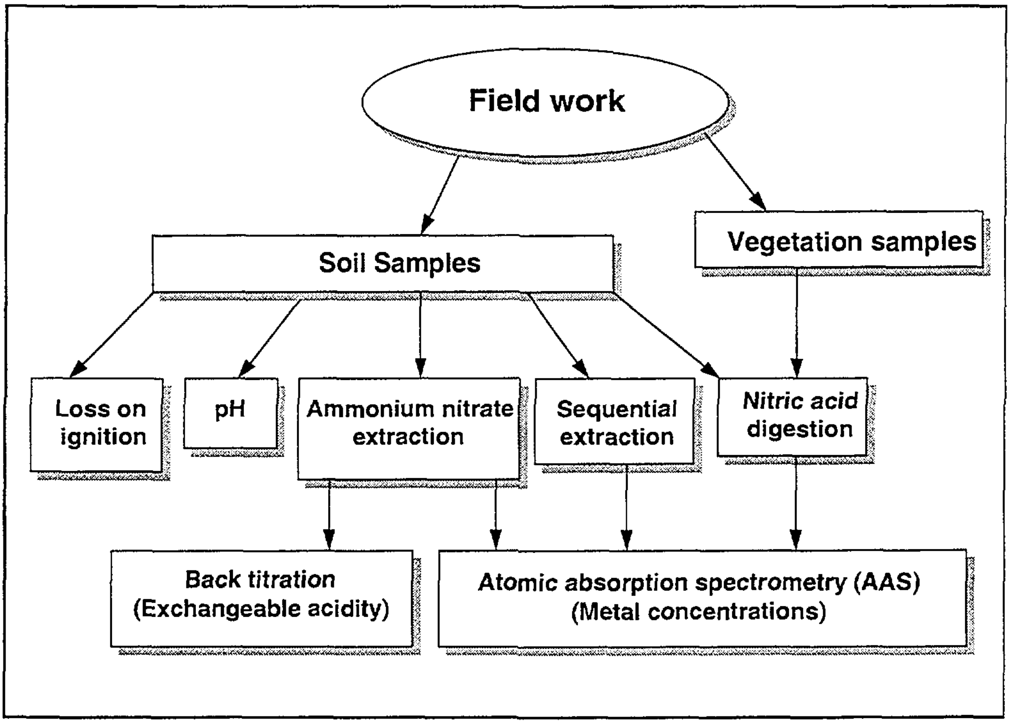


Figure 1. *Summary of laboratory procedures*

3.1 pH(H2O), pH(CaCl2) and LOI

2.5 g air-dried humus soil or 5.0 g air-dried mineral soil was shaken with 25 ml purified H_2O or 0.01 M $CaCl_2$ at 250 rpm for 15 min, and pH was measured in the supernatants after 1 hr of sedimentation.

Loss on ignition (LOI) in humus (O) and eluvial (E) horizons was determined for all sample plots, whereas LOI measurements in illuvial (B) horizons were performed on pooled samples from each site.

3.2 Sample digestion

Plant, litter and soil samples (2 g) were digested with HNO_3 (65%, 20 ml) at 80-90°C for 18 hrs. After cooling the sample solutions were filtered through S & S (Schleicher and Schuell) 604 filter papers and diluted to 50 ml in volumetric flasks. The plant samples were analysed with respect to Cu, Ni, Sr, K, Mg, Ca, Mn and Zn, whereas concentrations of Cu, Ni and Sr were determined in litter and soil samples. All samples were stored at room temperature.

3.3 Extraction

4.00 g of soil was shaken at 250 rpm with NH_4NO_3 (1M, 100 ml) for 2 hrs, and filtered through S &S 604. The filtrates were analysed with respect to Cu, Ni, Fe, Al, K, Mg, Ca, Mn and exchangeable acidity (EA). To avoid microbial growth, the samples were kept at +5°C for short term storage or -20°C for long term storage.

3.4 Analysis

Metal concentrations were determined by flame atomic absorption spectrophotometry (FAAS) using a Perkin-Elmer model 1100B. Air-acetylene flame was used in all analyses except for Sr and Al, where nitrous oxide-acetylene flame was applied. To prevent negative interferences in FAAS, 1 mg of La (as nitrate) per ml of sample was added prior to Ca, Mg, K, Sr, and Al determinations . For Sr determinations, 1 mg of K (as chloride) per ml sample was added in addition to La. Results for concentrations of the metals concerned in standard reference materials analysed simultaneously with the EPORA samples are shown in Table I.

Exchangeable acidity (EA) was determined by back-titrating the ammonium nitrate extracts with 0.05M NaOH to pH 7.00. Cation exchange capacity (CEC) and percent base saturation (B) were calculated using equations (1) and (2) respectively:

(1)	$CEC = \Sigma(K^+, Mg^{2+}, Ca^{2+}, Mn^{2+}, Ni^{2+}, EA)$ (meq/kg)
(2)	$B = \Sigma(K^+, Mg^{2+}, Ca^{2+}) \cdot 100 / CEC$ (%)

Table I. *Standard reference materials.*

Element	Sample	Certified value±SD (mg/kg)	Measured value±SD (mg/kg)	N
Copper	PN	3.0 ± 0.3	3.6 ± 0.2	9
	M3	3.76 ± 0.23	3.70 ± 0.06	4
	M2	68.7 ± 2.5	72.4 ± 0.9	4
	H3	6.88 ± 0.4	8.23 ± 0.13	4
	H2	401 ± 20	402 ± 12	4
Nickel	M2	16.3 ± 0.9	17.8 ± 0.4	4
	H3	3.00 ± 0.25	3.57 ± 0.11	4
	H2	90 ± 6	101 ± 2	4
Strontium	PN	4.8 ± 0.2	5.0 ± 0.2	9
	M2	5.31 ± 0.15	5.70 ± 0.14	4
	H3	24.8 ± 1.6	24.1 ± 0.4	4
	H2	28.6 ± 2.0	27.8 ± 0.6	4
Potassium	PN	3700 ± 200	3500 ± 100	6
	M3	4510 ± 280	4200 ± 30	2
	M2	6980 ± 350	7080 ± 120	2
	H3	820 ± 140	790 ± 40	2
	H2	930 ± 80	850 ± 70	2
Calcium	PN	4100 ± 200	4100 ± 400	5
	M3	1920 ± 70	2020	1
	M2	1910 ± 100	1950 ± 80	2
	H3	2510 ± 210	2570	1
	H2	1620 ± 70	1430 ± 200	2
Magnesium	M3	755 ± 77	796	1
	M2	826 ± 52	734 ± 55	2
	H3	550 ± 14	453 ± 9	2
	H2	564 ± 26	430 ± 44	2
Manganese	PN	675 ± 15	669 ± 24	6
	M3	535 ± 30	531	1
	M2	342 ± 17	338 ± 24	2
	H3	148 ± 5	151	1
	H2	51.5 ± 2.3	52.4 ± 0.9	2
Zinc	M3	25.4 ± 1.1	27.1	1
	M2	36.1 ± 1.2	39.0 ± 1.1	2
	H3	43.7 ± 2.5	47.2 ± 0.9	2
	H2	149 ± 6	155 ± 0	2

PN: Pine needles (National Institute of Standards and Technology)
M2, M3, H2, H3: cf. Steinnes et al. (1997)
N: Number of samples

3.5 Reproducibility

To assess the total variance associated with analyses and sample inhomogeneity, five sub-samples from different horizons of the soil profiles SRUSC3 and SRUSD5 (SRUSD1 for exchangeable acidity measurements) were treated as described in sections 3.2 and 3.3 respectively. The results from these tests are presented in Table II and Table III.

***Table II**. Reproducibility of nitric acid digestion*

Soil horizon	Element	Mean (mg/kg)	Range (mg/kg)	RSD (%)
L	Cu	1820	1720 - 1880	3.4
	Ni	1840	1720 - 1960	5.0
	Sr	18.6	18.3 - 19.2	2.0
Of	Cu	280	270 - 290	3.1
	Ni	550	530 - 580	3.7
	Sr	30	28 - 32	4.4
Oh	Cu	67	59 - 71	6.9
	Ni	194	181 - 200	4.0
	Sr	25	23 - 26	5.4
E1	Cu	24	22 - 29	11.9
	Ni	53	50 - 59	6.2
	Sr	5.0	4.2 - 5.9	11.8
E2	Cu	10.5	9.7 - 11.3	6.6
	Ni	23	22 - 25	5.2
	Sr	4.3	3.8 - 5.5	16.8
B1	Cu	11.2	10.6 - 11.7	3.4
	Ni	15.8	14.8 - 17.2	5.5
	Sr	3.2	2.1 - 3.6	19.1
B2	Cu	17.6	17.2 - 18.4	2.5
	Ni	19.1	18.2 - 19.9	3.2
	Sr	3.9	2.7 - 6.6	41

Table III. *Reproducibility of ammonium nitrate extraction.*

Soil horizon	Element/ Parameter	Mean (mg/kg)	Range (mg/kg)	RSD (%)
Of	Cu	27	24 - 30	8.1
	Ni	124	113 - 131	5.8
	Mn	260	250 - 270	3.8
	Fe	31	29 - 34	6.0
	K	1000	940 - 1050	4.8
	Mg	410	360 - 430	6.8
	Ca	2600	2400 - 2700	5.2
	Al	69	58 - 80	11.4
	EA[1)]	58.9	57.9 - 60.0	1.8
Oh	Ni	80	66 - 92	13.4
	Mn	131	108 - 153	15.4
	Fe	21	17.5 - 24	12.8
	K	650	560 - 690	7.6
	Mg	330	270 - 370	11.5
	Ca	1750	1440 - 2200	15.7
	Al	75	68 - 80	5.9
E1	Ni	1.6	1.4 - 1.9	13.4
	Mn	2.0	1.6 - 2.3	16.2
	Fe	4.5	3.8 - 5.3	11.9
	K	36	30 - 44	15.4
	Mg	12.1	9.5 - 16.1	24
	Ca	60	50 - 76	16.0
	Al	46	41 - 58	15.1
E2	Fe	8.1	7.7 - 8.7	4.8
	K	19.0	17.5 - 22	7.8
	Mg	5.8	5.6 - 6.2	4.4
	Ca	12	11 - 13	4.7
	Al	106	101 - 110	3.8
B1	Fe	51	37 - 68	24
	K	18.3	17.2 - 19.9	6.0
	Mg	6.4	6.2 - 6.9	4.9
	Ca	14	13 - 15	5.1
	Al	440	400 - 500	9.0
	EA[1)]	25.3	24.6 - 25.8	2.1
B2	Fe	35	29 - 43	16.7
	K	12.1	11.0 - 13.3	8.3
	Mg	2.7	2.4 - 3.1	10.2
	Ca	16	14 - 17	10
	Al	320	250 - 360	13.3

[1)] *Exchangeable acidity: meq / kg*

4 SUMMARY OF RESULTS

Complete data on Loss on ignition (LOI), pH, exchangeable acidity (EA), cation exchange capasity (CEC) and percent base saturation (B) are presented in **Table I.**

Total concentrations (HNO3 soluble) of Cu, Ni and Sr in litter and soil horizons from all plots at each sample site are presented in **Table II**.

Exchangeable (1M NH4NO3) concentrations of Cu, Ni, Fe, Mn, K, Mg, Ca and Al in soil horizons from all plots at each sample site are presented in **Table III.**

Total concentrations (HNO3 soluble) of K, Ca, Mg, Mn, Zn, Cu, Ni and Sr in plants and berries at all sample sites are shown in **Tables IV** and **V** respectively. Concentrations of the same metals in separate samples of *Empetrum nigrum* from all plots at all sites are presented in **Table VI.**

The chemical data of the EPORA project are summarized in the following graphical plots:

Figure 2: HNO_3-soluble metal concentrations in soil, based on table II.
Figure 3: Exchangeable (1M NH_4NO_3) concentrations of metal cations, based on table III.
Figure 4: Relative distribution of exchangeable cations, abstracted from tables I and III.
Figure 5: Absolute concentration of exchangeable cations, based on data from table III converted from mg/kg to meq/kg.
Figure 6: Metal concentrations in plant species, based on table IV

Concentrations below detection limits are replaced with a value corresponding to 1/2 MD and treated as "real" data in calculations of mean values (Standard error bars are not shown in such cases).

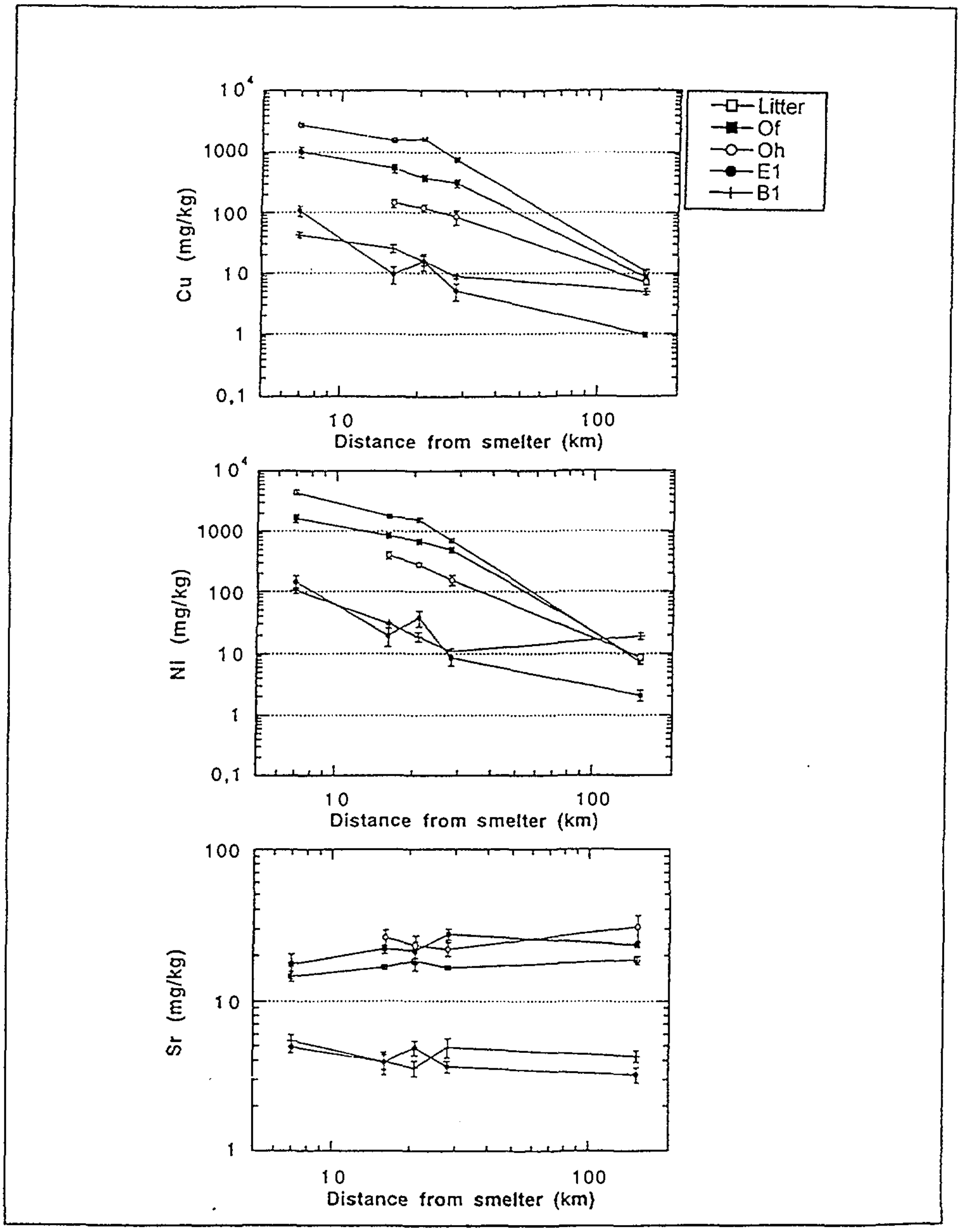


Figure 2. *Total (HNO_3 soluble) metal concentrations in selected soil horizons along the pollution gradient: mean values for each sample site with corresponding standard errors.*

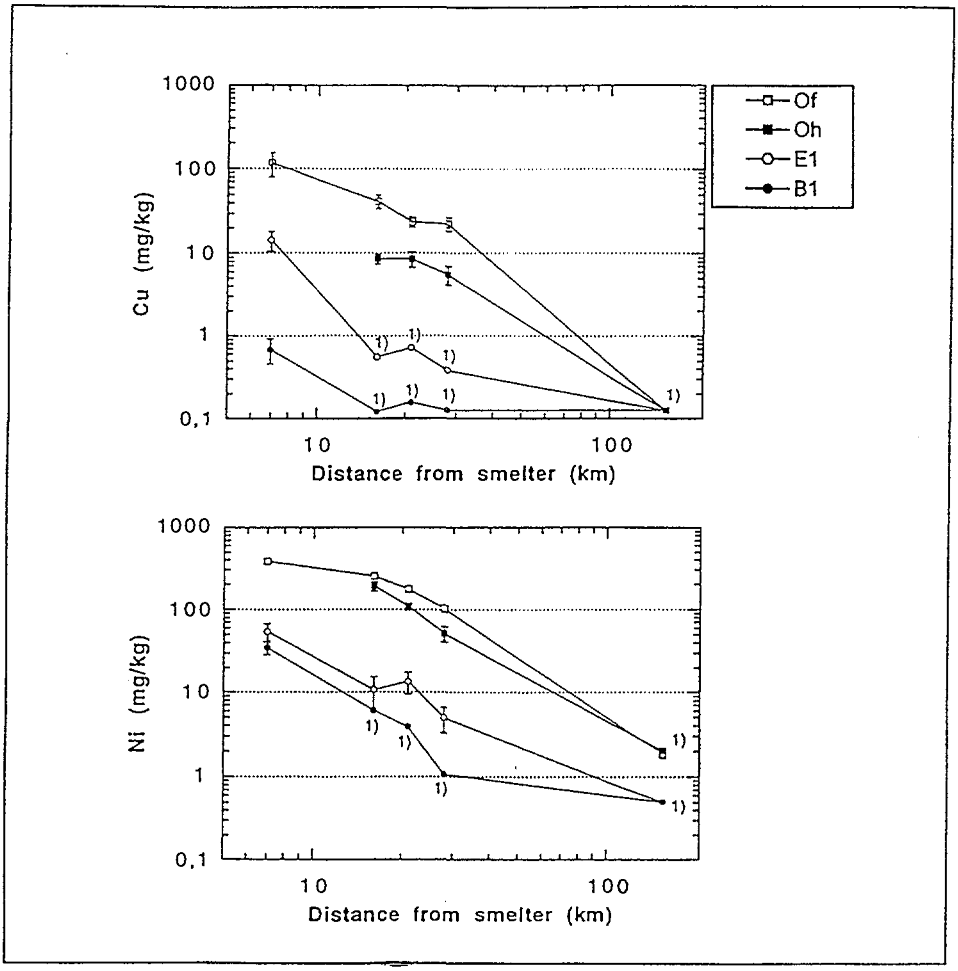


Figure 3a. *Exchangeable (1M NH_4NO_3) metal concentrations along the pollution gradient in selected soil horizons: mean values for each sample site with corresponding standard errors*

1)The metal concentration in one or more of the plots at the sample site is below detection limit.

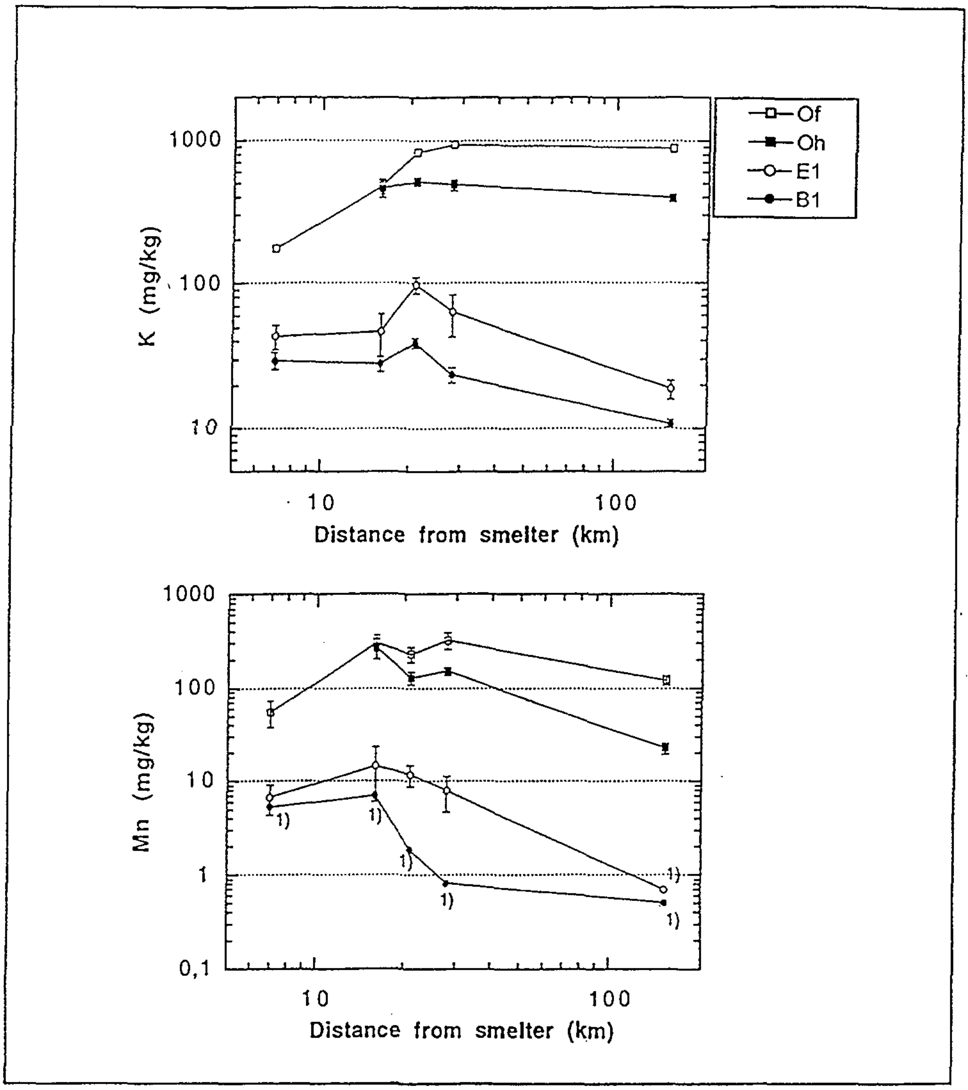


Figure 3b. *Exchangeable (1M NH_4NO_3) metal concentrations along the pollution gradient in selected soil horizons: mean values for each sample site with corresponding standard errors.*
[1)]The metal concentration in one or more of the plots at the sample site is below detection limit.

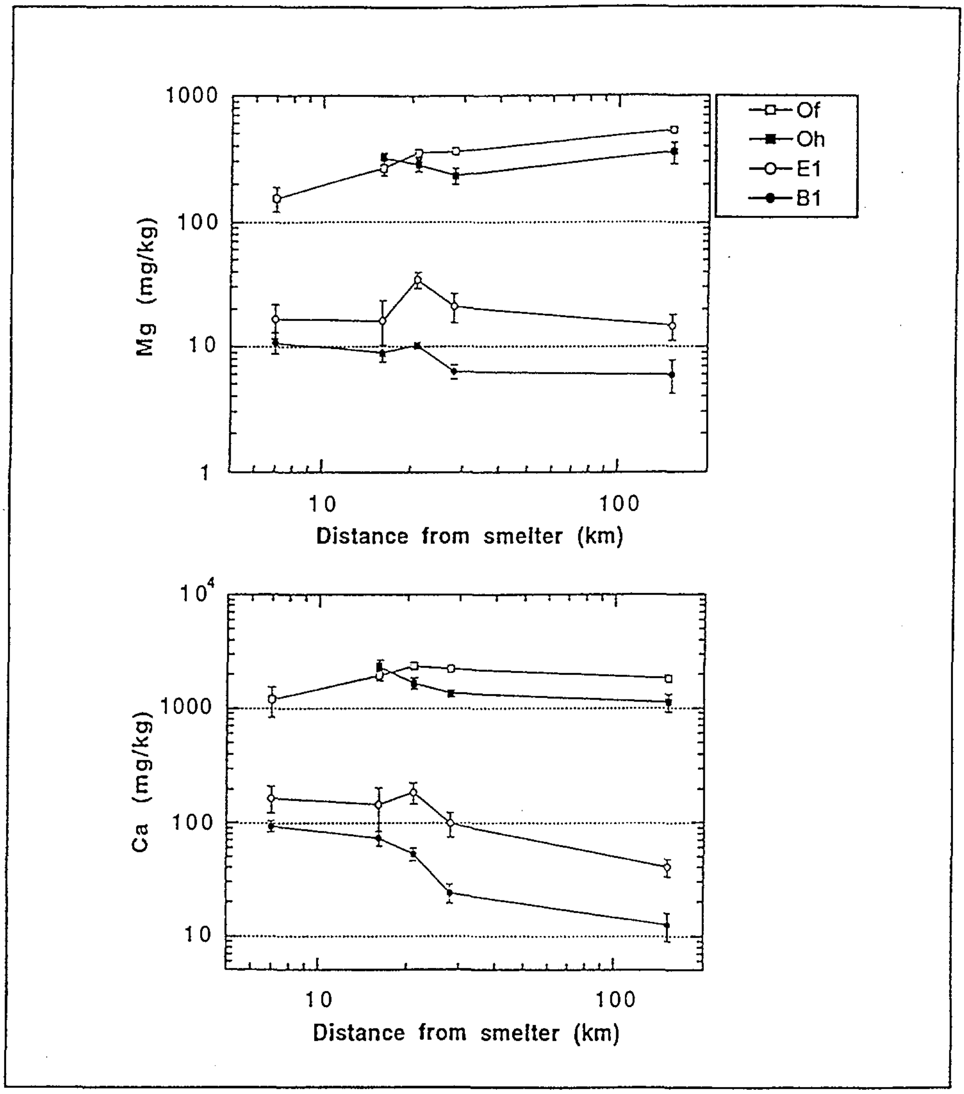


Figure 3c. *Exchangeable (1M NH_4NO_3) metal concentrations along the pollution gradient in selected soil horizons: mean values for each sample site with corresponding standard errors.*

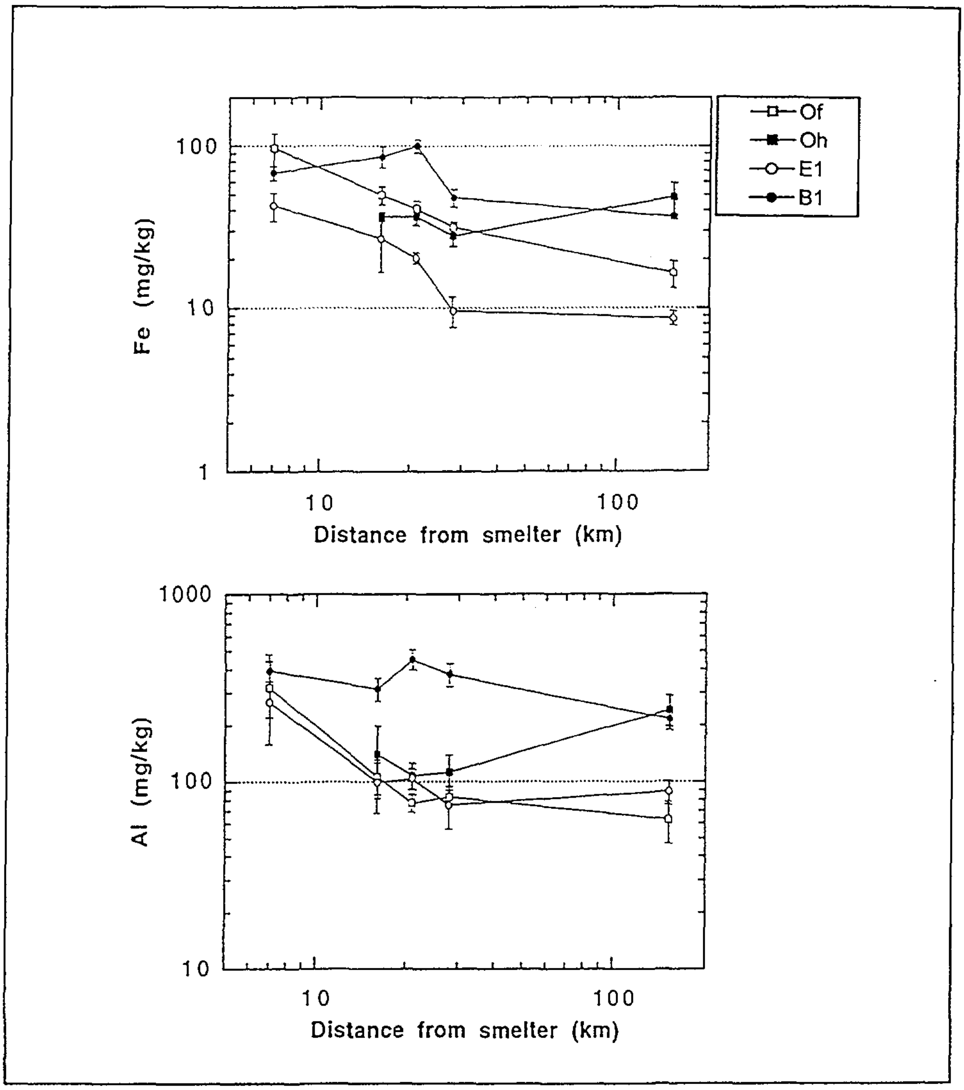


Figure 3d. *Exchangeable (1M NH_4NO_3) metal concentrations along the pollution gradient in selected soil horizons: mean values for each sample site with corresponding standard errors*

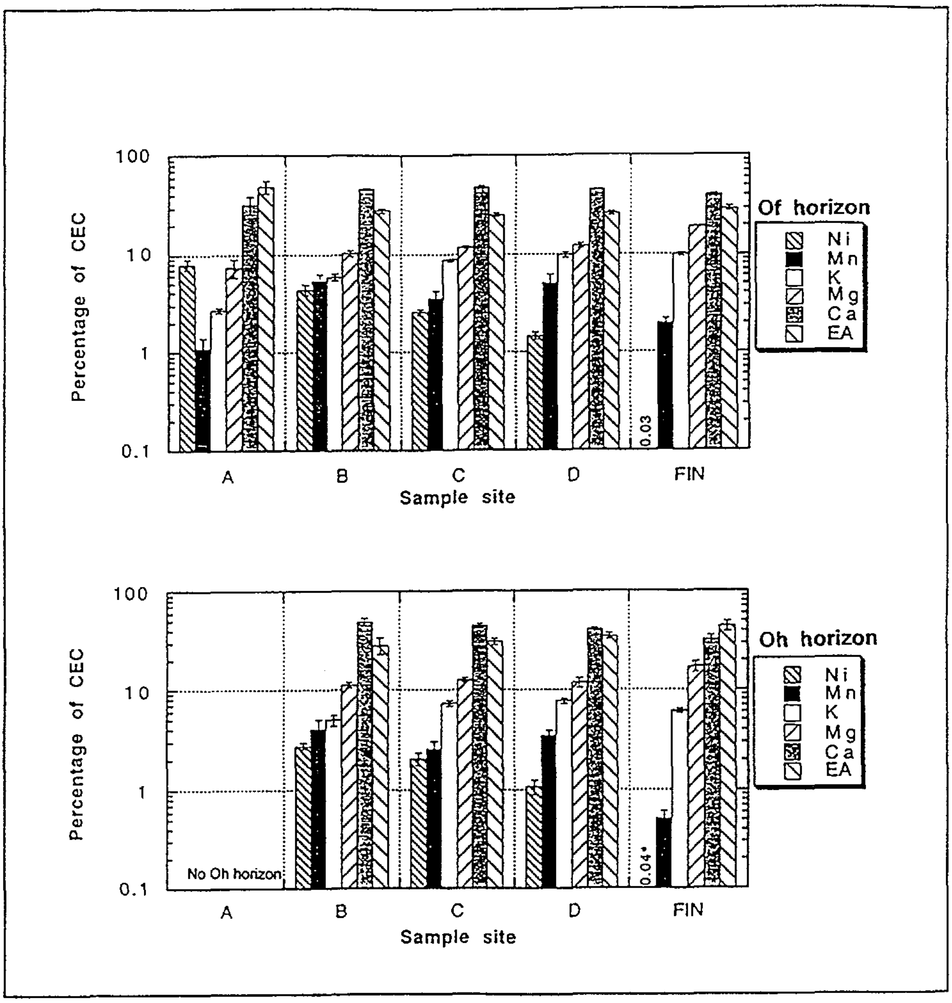


Figure 4a. *Exchangeable metals and acidity in humic horizons at all sample sites: mean values for each sample site with corresponding standard errors.*
**The metal concentration in one or more of the plots at the sample site is below detection limit*

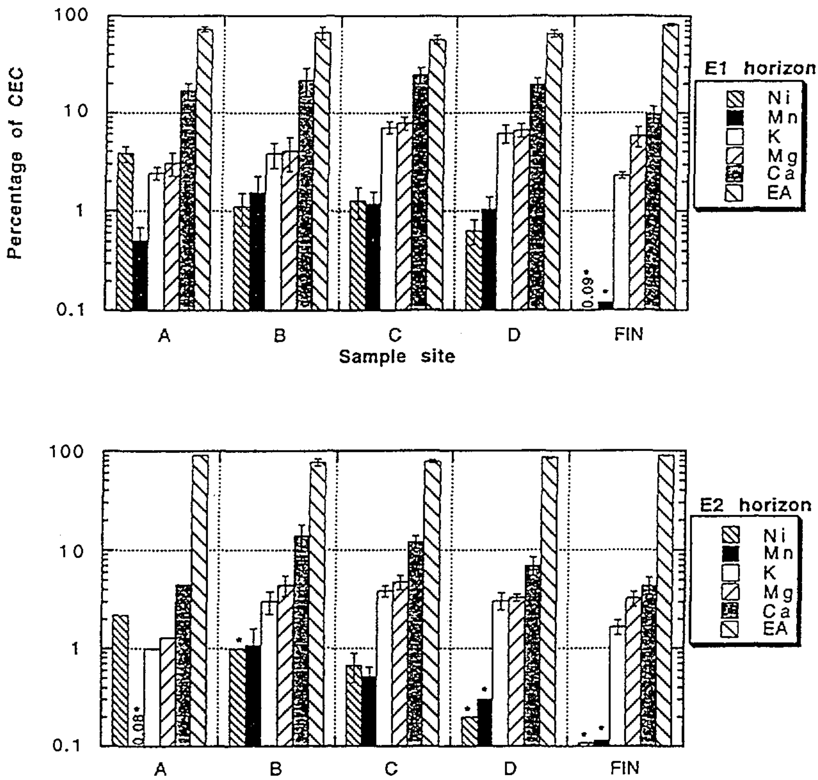


Figure 4b. *Exchangeable metals and acidity in eluvial horizons at all sample sites: mean values for each sample site with corresponding standard errors.*
**The metal concentration in one or more of the plots at the sample site is below detection limit.*

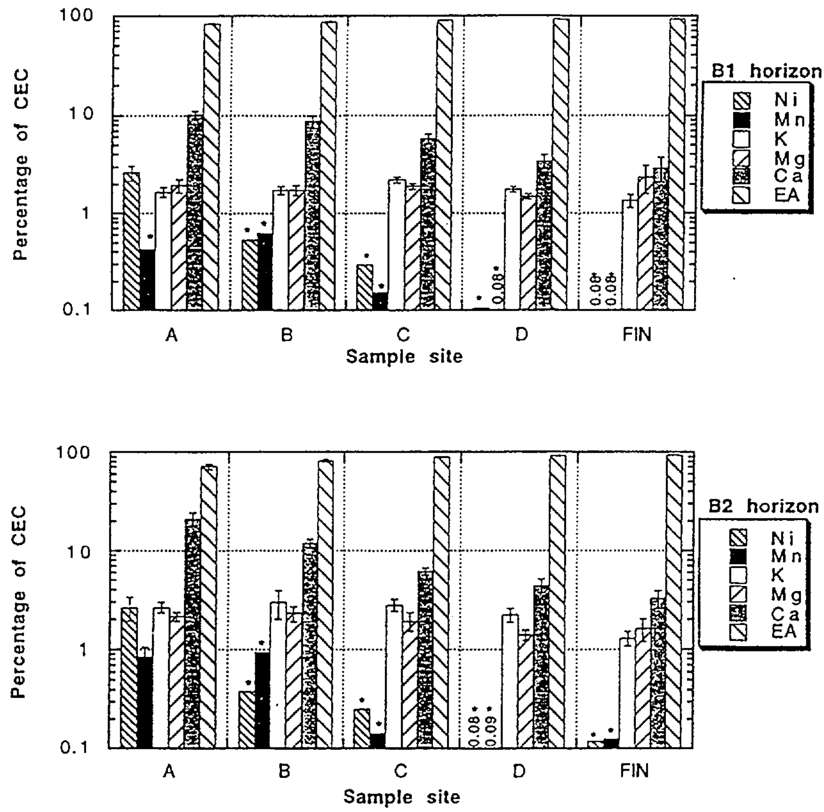


Figure 4c. *Exchangeable metals and acidity in illuvial horizons at all sample sites: mean values for each sample site with corresponding standard errors.*
**The metal concentration in one or more of the plots at the sample site is below detection limit.*

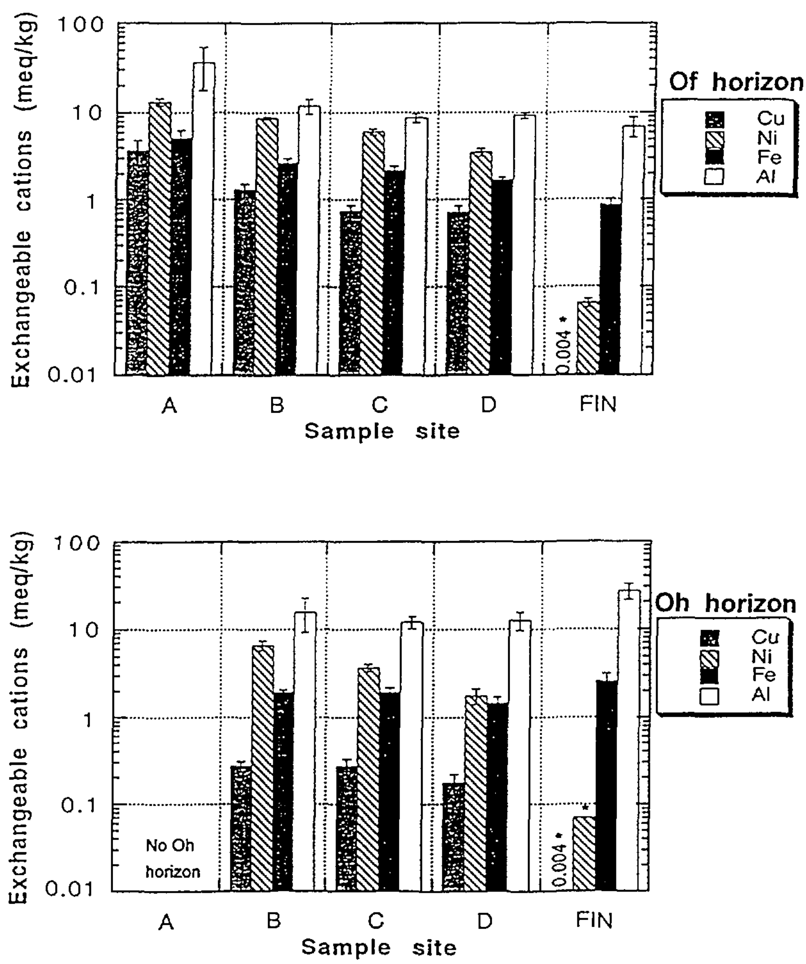
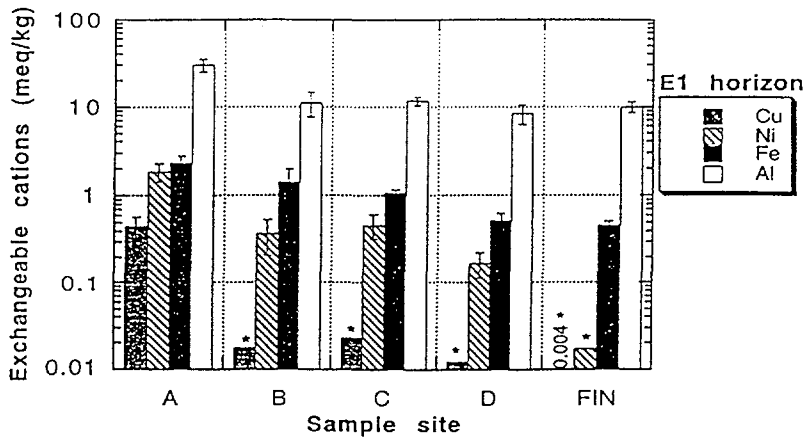


Figure 5a. *Exchangeable metals in humic horizons at all sample sites: mean values for each sample site with corresponding standard errors.*
**The metal concentration in one or more of the plots at the sample site is below detection limit*



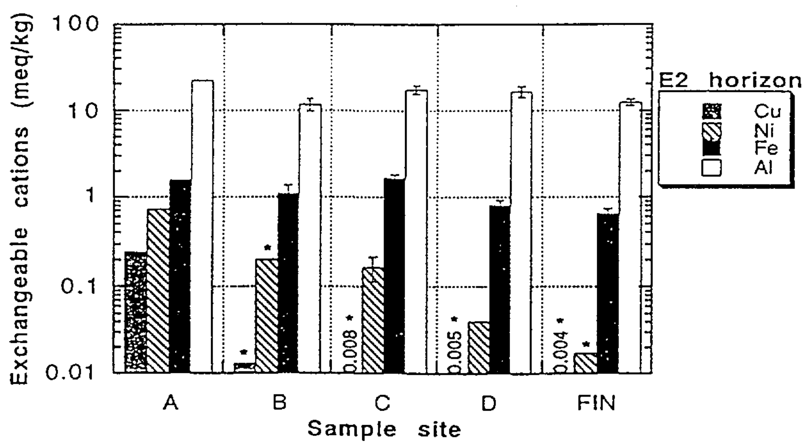


Figure 5b. *Exchangeable metals in eluvial horizons at all sample sites: mean values for each sample site with corresponding standard errors.*
**The metal concentration in one or more of the plots at the sample site is below detection limit.*

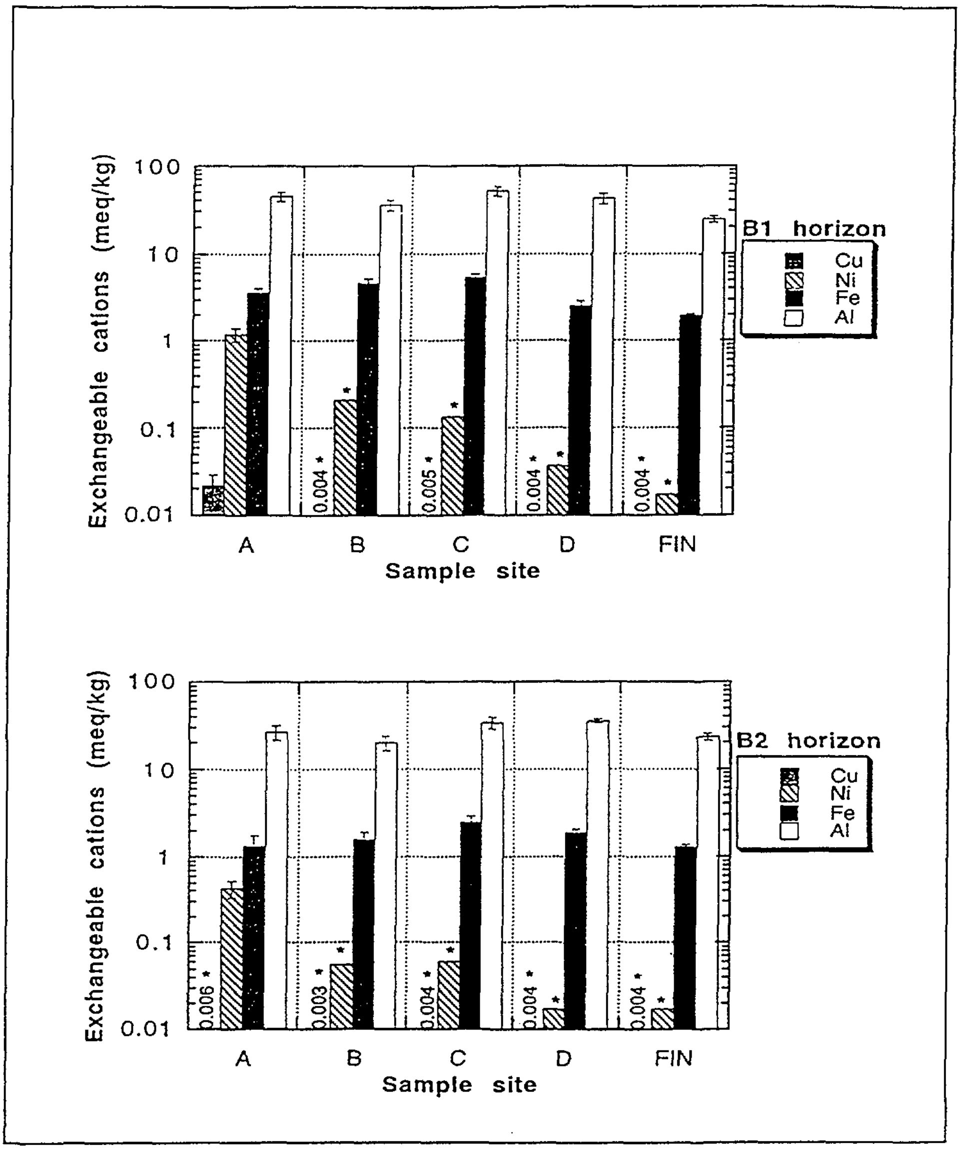


Figure 5c. *Exchangeable metals in illuvial horizons at all sample sites: mean values for each sample site with corresponding standard errors.*
**The metal concentration in one or more of the plots at the sample site is below detection limit.*

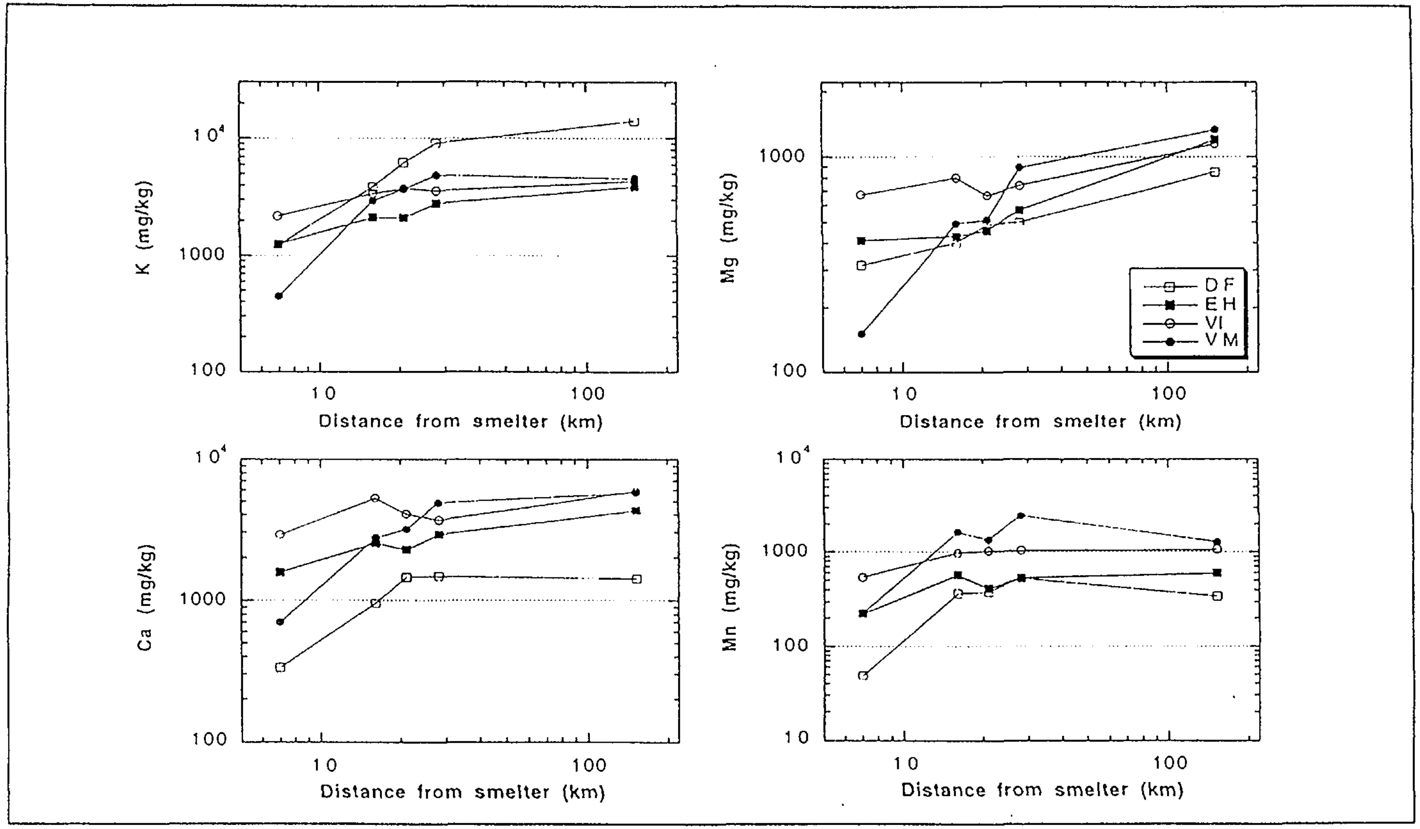


Figure 6a. *Concentrations of metals in plant species.*
(DF=Deschampsia flexuosa; EH=Empetrum nigrum; VI=Vaccinium vitis-idaea; VM=Vaccinum myrtillus)

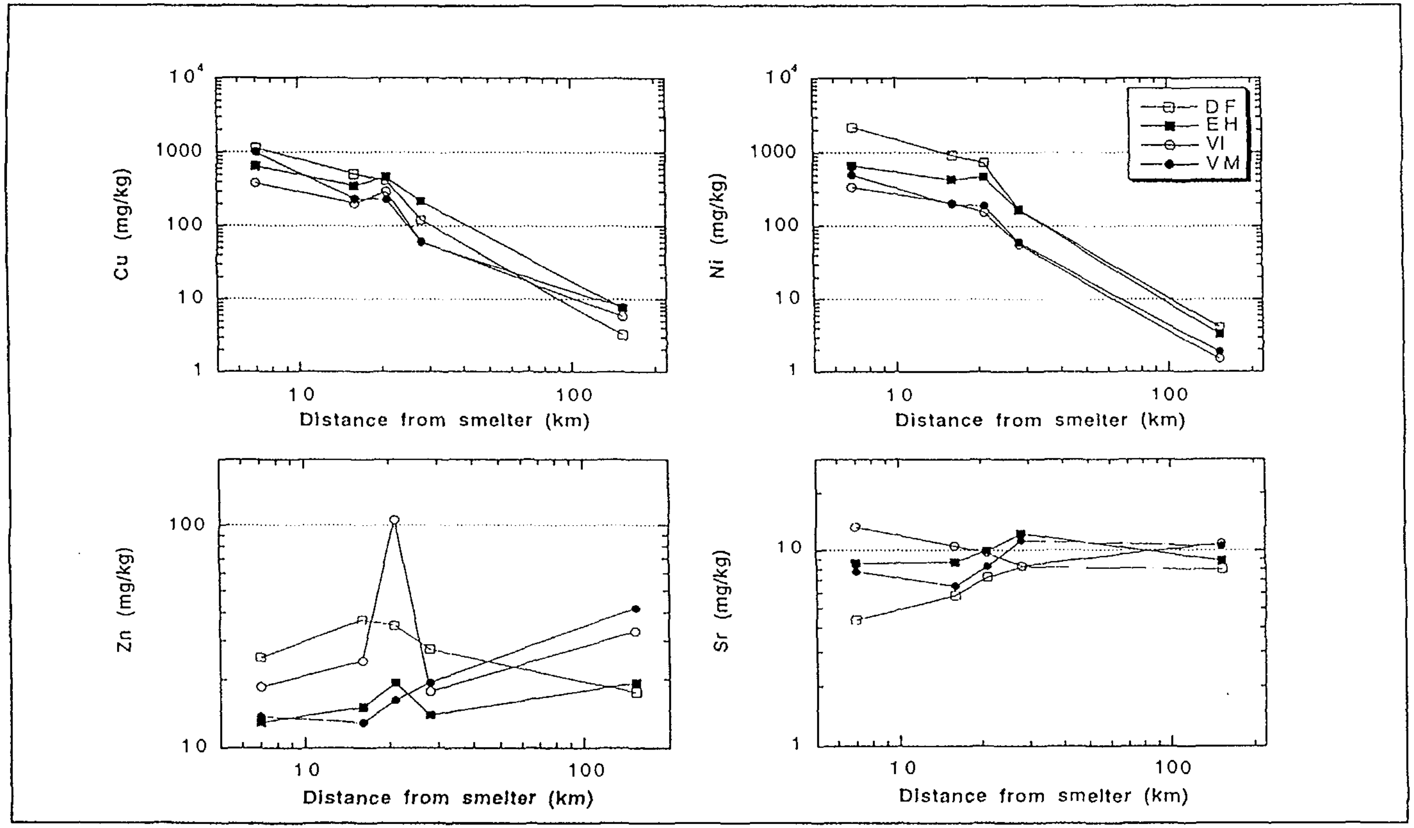


Figure 6b. *Concentrations of metals in plant species.*
(DF=Deschampsia flexuosa; EH=Empetrum nigrum; VI=Vaccinium vitis-idaea; VM=Vaccinum myrtillus)

5 SOME TYPICAL TRENDS OBSERVED

The main trends observed in soil chemistry and plant uptake along the pollution gradient may be briefly described as follows:

- Total concentrations of Ni and Cu in the humus layer increase regularly from about 10 ppm at the reference site to about 5000 ppm at the most polluted site A. Similar trends are observed for exchangeable fractions and plant concentrations of the same elements.

- Concentrations of exchangeable K, Ca, and Mg in the F-horizon (upper part of humus layer) of the soil decrease strongly with increased input of chemical pollutants. A similar strong decrease is not observed in the lower soil horizons. Plant contents generally follow the trends in the F-horizon, with the largest relative decrease observed for *Vaccinium myrtillus*.

- For stable Sr no clear trend is observed with distance from the smelter either in soil or plants.

- Only minor changes are observed in soil pH, cation exchange capacity, and exchangeable acidity with distance from the smelter. The vertical distribution of these properties in the soil is normal for podzols.

- Soil acidification at sites near the smelter, as evident from the base saturation, is less pronounced than what might have been expected considering the acidic emissions. This may be explained by the following two facts:

  1. The dry deposition of SO_2 from Monchegorsk is much more widespread than the deposition of particles, and the corresponding deposition gradient therefore much less steep than e.g. for metals. A major part of the SO_2 emitted from the smelter is distributed over rather large areas before oxidised to sulphate and deposited.

2. There are also considerable emissions of alkaline ash particles from the in-dustrial processes which may partly neutralize the effects of acidic deposition at sites near Monchegorsk.

- The main changes in the distribution of exchangeable cations in the humus layer is a higher content of Al, Fe, Ni, and Cu and a lower content of H^+ and base cations near Monchegorsk.

A more detailed scientific discussion of the chemical data and their relation to the radioecological situation will follow in subsequent publications.

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7 TABLES OF CHEMICAL DATA

Table 1a. Soil parameters describing sample site A (Monchegorsk, Russia)

Soil horizon	Plot	LOI (%)	PH (H_2O)	pH ($CaCl_2$)	EA (meq/kg)	CEC (meq/kg)	B (%)
Of	1	63.3	3.90	3.27	117	174	25
	2	70.5	3.75	2.89	73.4	235	62
	3	80.4	3.69	2.97	64.1	149	45
	4	53.1	3.77	2.98	75.4	122	29
	5	65.8	3.84	3.13	73.4	183	50
	Mean	**66.6**	**3.79**	**3.05**	**80.7**	**173**	**42**
	SD	**10.0**	**0.08**	**0.15**	**20.9**	**42**	**15**
Oh	1						
	2	70.9	3.73	2.94	62.0	190	56
	3	74.5	3.56	2.85	83.4	198	48
	4						
	5						
	Mean	-	-	-	-	-	-
	SD	-	-	-	-	-	-
E1	1	10.9	4.20	3.60	41.4	48.2	11.6
	2	16.1	4.26	3.28	34.1	51.9	28
	3	9.3	4.27	3.38	25.5	38.1	27
	4	6.5	4.00	3.26	25.1	31.0	16.7
	5	15.0	3.93	3.31	42.0	63.0	29
	Mean	**11.6**	**4.13**	**3.37**	**33.6**	**46.4**	**22**
	SD	**4.0**	**0.16**	**0.14**	**8.2**	**12.4**	**8**
E2	1	6.5	4.27	3.66	30.3	33.3	6.8
	2						
	3						
	4						
	5						
	Mean	-	-	-	-	-	-
	SD	-	-	-	-	-	-
B1	1	-	4.70	4.20	35.4	40.4	11.3
	2	-	4.74	4.03	35.1	43.6	14.7
	3	-	4.71	3.98	36.3	45.6	17.4
	4	-	4.43	3.93	34.5	40.4	11.4
	5	-	4.32	3.81	47.4	57.0	14.2
	Mean	**13.0**[2]	**4.58**	**3.99**	**37.7**	**45.4**	**13.8**
	SD	-	**0.19**	**0.14**	**5.4**	**6.9**	**2.5**
B2	1	-	5.20	4.65	9.4	14.2	28
	2	-	4.99	4.35	12.4	20.4	35
	3	-	4.70	4.37	9.4	12.6	23
	4	-	4.74	4.48	9.4	13.8	29
	5	-	4.56	4.16	23.8	27.7	13.2
	Mean	**8.8**[2]	**4.84**	**4.40**	**12.9**	**17.8**	**26**
	SD	-	**0.25**	**0.18**	**6.3**	**6.3**	**8**

[1] O, [2] Pooled samples

Table Ib. *Soil parameters describing sample site B (Vitta, Russia)*

Soil horizon	Plot	LOI (%)	pH (H_2O)	pH ($CaCl_2$)	EA (meq/kg)	CEC (meq/kg)	B (%)
	1	81.6	3.99	3.24	49.4	211	63
	2	94.4	3.90	2.89	73.5	238	62
Of	3	91.0	3.77	3.02	62.8	233	66
	4	86.7	3.84	3.09	57.8	221	65
	5	53.6	4.20	3.22	43.5	136	57
	Mean	**81.5**	**3.94**	**3.09**	**57.4**	**208**	**62**
	SD	**16.3**	**0.17**	**0.15**	**11.7**	**41**	**3**
	1	81.1	3.89	3.15	46.5	241	72
	2	78.3	3.62	2.98	82.5	187	52
Oh	3	90.6	3.72	2.98	63.9	259	69
	4	83.7	3.77	3.01	63.3	253	68
	5						
	Mean	**83.4**	**3.75**	**3.03**	**64.0**	**235**	**65**
	SD	**5.3**	**0.11**	**0.08**	**14.7**	**33**	**9**
	1	6.8	4.40	3.34	14.5	40.6	58
	2	6.6	4.19	3.32	43.6	47.7	8.1
E1	3	5.3	4.45	3.39	15.8	22.8	30
	4	11.0	4.27	3.23	17.6	31.0	39
	5	1.9	4.55	3.45	14.3	16.8	14.0
	Mean	**6.3**	**4.37**	**3.35**	**21.2**	**31.8**	**30**
	SD	**3.3**	**0.14**	**0.08**	**12.6**	**12.6**	**20**
	1	2.1	4.55	3.55	13.6	19.6	28
	2	2.1	4.46	3.66	19.4	21.1	7.2
E2	3	1.7	4.59	3.67	13.0	15.1	13.4
	4	4.0	4.32	3.39	22.3	27.3	17.8
	5	6.3	4.48	3.44	10.9	20.0	39
	Mean	**3.2**	**4.48**	**3.54**	**15.8**	**21**	**21**
	SD	**1.9**	**0.10**	**0.13**	**4.8**	**4**	**13**
	1	-	4.78	4.08	33.4	41.3	16.5
	2	-	4.81	4.25	29.0	33.7	13.8
B1	3	-	4.71	3.95	41.5	48.2	13.1
	4	-	4.45	3.69	58.6	64.2	8.2
	5	-	4.61	4.15	25.0	28.0	9.2
	Mean	**11.2** [2]	**4.67**	**4.02**	**37.5**	**43.1**	**12.1**
	SD	-	**0.15**	**0.22**	**13.3**	**14.0**	**3.4**
	1	-	5.07	4.40	17.5	21.4	15.8
	2	-	4.91	4.56	9.9	12.0	17.4
B2	3	-	4.66	4.01	22.8	25.8	11.1
	4	-	4.93	4.40	12.5	14.7	14.7
	5	-	4.81	4.68	2.4	3.3	26
	Mean	**7.5** [2]	**4.88**	**4.41**	**13.0**	**15.5**	**17.0**
	SD	-	**0.15**	**0.25**	**7.7**	**8.7**	**5.6**

[2] Pooled samples

***Table Ic.** Soil parameters describing sample site C (Kurka, Russia)*

Soil horizon	Plot	LOI (%)	pH (H_2O)	pH ($CaCl_2$)	EA (meq/kg)	CEC (meq/kg)	B (%)
Of	1	85.0	3.87	3.16	57.6	213	66
	2	93.8	3.79	3.16	63.0	242	67
	3	88.2	3.81	3.09	61.3	271	74
	4	93.1	3.74	3.09	60.3	268	70
	5	81.0	3.75	3.03	60.6	217	66
	Mean	**88.2**	**3.79**	**3.11**	**60.6**	**242**	**69**
	SD	**5.4**	**0.05**	**0.06**	**1.9**	**27**	**3**
Oh	1	59.6	3.87	3.12	49.6	157	61
	2	60.4	3.85	3.04	49.5	196	70
	3	58.6	3.89	3.08	55.3	151	60
	4	75.3	3.73	2.98	55.9	217	70
	5	65.5	3.78	2.95	68.1	194	61
	Mean	**63.9**	**3.82**	**3.03**	**55.7**	**183**	**65**
	SD	**6.9**	**0.07**	**0.07**	**7.6**	**28**	**5**
E1	1	15.4	4.04	3.08	35.5	55.7	34
	2	10.4	4.21	3.18	19.1	33.8	41
	3	12.8	4.28	3.30	9.9	28.5	60
	4	13.2	4.00	3.07	24.6	42.8	41
	5	5.3	4.14	3.20	17.3	22.8	24
	Mean	**11.4**	**4.13**	**3.17**	**21.3**	**36.7**	**40**
	SD	**3.9**	**0.12**	**0.09**	**9.5**	**12.9**	**13**
E2	1	5.6	4.23	3.30	21.0	25.8	17.2
	2	5.0	4.25	3.41	26.0	31.2	15.9
	3	6.4	4.30	3.48	15.5	23.1	31
	4	4.2	4.17	3.32	16.9	22.7	25
	5	3.8	4.22	3.40	19.3	22.8	15.3
	Mean	**5.0**	**4.23**	**3.38**	**19.7**	**25.1**	**21**
	SD	**1.0**	**0.05**	**0.07**	**4.1**	**3.6**	**7**
B1	1	-	4.29	3.55	49.4	53.9	7.9
	2	-	4.63	3.87	38.6	44.1	11.8
	3	-	4.43	3.86	33.0	36.9	9.8
	4	-	4.39	3.85	51.8	57.3	9.5
	5	-	4.48	4.06	33.0	36.8	10.4
	Mean	**11.6** [2]	**4.44**	**3.84**	**41.2**	**45.8**	**9.9**
	SD	-	**0.13**	**0.18**	**8.9**	**9.5**	**1.4**
B2	1	-	4.64	4.02	39.1	43.0	8.7
	2	-	4.91	4.30	21.8	24.2	9.8
	3	-	4.67	4.09	17.0	19.1	10.3
	4	-	4.52	4.26	22.1	24.8	10.6
	5	-	4.73	4.44	8.0	9.4	14.9
	Mean	**9.7** [2]	**4.69**	**4.22**	**21.6**	**24.1**	**10.9**
	SD	-	**0.14**	**0.17**	**11.3**	**12.2**	**2.4**

[2] Pooled samples

Table Id. *Soil parameters describing sample site D (Apatity, Russia)*

Soil horizon	Plot	LOI (%)	pH (H_2O)	pH ($CaCl_2$)	EA (meq/kg)	CEC (meq/kg)	B (%)
Of	1	92.1	3.89	3.14	58.9	240	66
	2	89.7	3.88	3.09	52.6	224	68
	3	96.0	3.53	2.84	79.0	260	67
	4	83.5	3.77	3.06	57.6	220	67
	5	91.9	3.75	3.00	66.9	270	70
	Mean	**90.6**	**3.76**	**3.03**	**63.0**	**243**	**68**
	SD	**4.6**	**0.15**	**0.12**	**10.3**	**22**	**1**
Oh	1	61.9	3.97	3.13	53.1	158	61
	2	55.6	3.87	3.05	45.6	148	63
	3	55.2	3.88	2.92	70.3	160	52
	4	50.2	3.88	3.30	50.1	145	62
	5	75.2	3.76	2.93	61.6	200	65
	Mean	**59.6**	**3.87**	**3.07**	**56.1**	**162**	**61**
	SD	**9.6**	**0.07**	**0.16**	**9.8**	**22**	**5**
E1	1	7.1	4.52	3.27	13.5	25.1	43
	2	8.0	4.28	3.24	18.8	35.3	44
	3	6.6	4.13	3.20	23.1	27.5	15.6
	4	5.1	4.24	3.24	18.0	24.0	24
	5	3.6	4.23	3.18	9.0	14.0	35
	Mean	**6.1**	**4.28**	**3.23**	**16.5**	**25.2**	**32**
	SD	**1.7**	**0.15**	**0.04**	**5.4**	**7.6**	**12**
E2	1	2.2	4.48	3.50	15.1	18.2	15.9
	2	3.5	4.37	3.34	18.6	23.4	19.6
	3	2.9	4.43	3.60	24.4	26.4	7.5
	4	2.2	4.26	3.54	15.9	18.0	11.1
	5	1.5	4.40	3.46	10.9	12.5	12.7
	Mean	**2.5**	**4.39**	**3.49**	**17.0**	**19.7**	**13.3**
	SD	**0.8**	**0.08**	**0.10**	**5.0**	**5.4**	**4.6**
B1	1	-	4.70	4.06	25.3	27.6	7.9
	2	-	4.63	3.88	38.0	41.7	8.6
	3	-	4.70	4.13	29.9	31.6	5.4
	4	-	4.47	3.96	38.0	40.4	5.9
	5	-	4.53	3.91	30.4	32.1	5.3
	Mean	**8.7**	**4.61**	**3.99**	**32.3**	**34.7**	**6.6**
	SD	-	**0.10**	**0.10**	**5.5**	**6.1**	**1.5**
B2	1	-	4.90	4.38	13.4	15.3	12.1
	2	-	4.86	4.12	26.9	29.4	8.4
	3	-	4.74	4.40	23.1	24.6	5.9
	4	-	4.65	4.15	20.2	22.0	8.2
	5	-	4.70	4.32	23.1	24.5	5.3
	Mean	**11.2**	**4.77**	**4.27**	**21.3**	**23.2**	**8.0**
	SD	-	**0.11**	**0.13**	**5.0**	**5.2**	**2.7**

[2] Pooled samples

Table Ie. *Soil parameters describing reference site REF (Naruska, Finland)*

Soil horizon	Plot	LOI (%)	pH (H_2O)	pH ($CaCl_2$)	EA (meq/kg)	CEC (meq/kg)	B (%)
Of	1	96.9	3.90	3.11	59.8	252	74
	2	93.6	3.63	2.99	71.9	215	64
	3	96.4	3.67	3.01	62.6	206	68
	4	92.6	3.73	3.06	62.6	243	72
	5	94.4	3.67	3.03	69.4	218	66
	Mean	**94.8**	**3.72**	**3.04**	**65.3**	**227**	**69**
	SD	**1.8**	**0.11**	**0.05**	**5.1**	**19**	**4**
Oh	1	69.8	3.67	2.94	72.5	183	60
	2	54.1	3.68	2.88	83.1	143	41
	3	78.4	3.71	2.97	64.5	215	70
	4	56.3	3.82	3.05	58.3	147	59
	5	59.2	3.76	2.94	81.3	154	47
	Mean	**63.6**	**3.73**	**2.96**	**71.9**	**168**	**55**
	SD	**10.3**	**0.06**	**0.06**	**10.7**	**31**	**11**
E1	1	3.0	4.18	3.22	13.0	17.0	23
	2	3.1	4.14	3.18	17.5	19.2	8.8
	3	3.8	4.18	3.20	14.0	18.7	25
	4	4.7	4.14	3.14	20.8	26.2	21
	5	3.1	4.06	3.25	20.3	23.1	12.0
	Mean	**3.5**	**4.14**	**3.20**	**17.1**	**20.8**	**17.9**
	SD	**0.7**	**0.05**	**0.04**	**3.5**	**3.7**	**7.1**
E2	1	1.3	4.29	3.57	12.5	14.3	12.3
	2	2.1	4.12	3.35	23.8	24.8	4.1
	3	1.3	4.32	3.50	13.0	14.7	11.1
	4	1.9	4.24	3.51	17.3	18.8	8.0
	5	1.6	4.23	3.61	9.1	10.3	11.0
	Mean	**1.6**	**4.24**	**3.51**	**15.1**	**16.6**	**9.3**
	SD	**0.4**	**0.08**	**0.10**	**5.6**	**5.5**	**3.3**
B1	1	-	4.41	3.65	21.1	23.0	7.8
	2	-	4.53	3.87	28.8	29.7	3.1
	3	-	4.30	3.70	17.4	19.7	11.8
	4	-	4.53	3.92	21.9	23.0	4.6
	5	-	4.58	4.07	14.1	15.0	5.6
	Mean	**3.3** [2]	**4.47**	**3.84**	**20.7**	**22.1**	**6.6**
	SD	-	**0.11**	**0.17**	**5.5**	**5.4**	**3.4**
B2	1	-	4.78	4.37	16.1	17.0	5.0
	2	-	4.75	4.46	13.0	13.9	6.0
	3	-	4.75	4.08	21.1	23.4	9.6
	4	-	4.69	4.33	11.3	12.0	6.2
	5	-	4.65	4.36	10.6	11.1	3.9
	Mean	**4.5** [2]	**4.72**	**4.32**	**14.4**	**15.5**	**6.1**
	SD	-	**0.05**	**0.14**	**4.3**	**5.0**	**2.2**

Pooled samples

Table IIa. HNO_3 *soluble metal concentrations in different soil horizons at sample site A.*[1] Oh 1/2

Soil horizon	Plot	Total Cu (mg/kg)	Total Cu (mg/m2)	Total Ni (mg/kg)	Total Ni (mg/m2)	Total Sr (mg/kg)	Total Sr (mg/m2)
L	1	3400	6200	6000	11100	16.5	30
	2	3100	8900	4300	12300	14.4	41
	3	2600	6800	3600	9600	12.6	33
	4	2300	3700	3600	5700	11.8	18.6
	5	2900	10600	4100	15000	17.9	65
	Mean	**2900**	**7200**	**4300**	**10700**	**14.6**	**38**
	SD	**400**	**2700**	**1000**	**3400**	**2.5**	**17**
Of	1	1180	4800	1660	6700	12.7	51
	2	330	1030	840	2600	28	85
	3	870	2700	1350	4200	14.7	46
	4	1640	5300	2500	8000	11.9	38
	5	1090	3800	1800	6400	21	75
	Mean	**1020**	**3500**	**1630**	**5600**	**17.6**	**59**
	SD	**480**	**1700**	**600**	**2200**	**6.7**	**20**
Oh[1]	1						
	2	670	2200	1300	4300	18.8	63
	3	1280	3000	1930	4600	16.9	40
	4						
	5						
	Mean	-	-	-	-	-	-
	SD	-	-	-	-	-	-
E1	1	45	340	58	440	4.5	34
	2	140	930	240	1560	6.4	42
	3	68	940	106	1470	4.4	60
	4	131	1500	110	1260	3.9	45
	5	152	1050	220	1500	5.5	38
	Mean	**107**	**950**	**145**	**1240**	**4.9**	**44**
	SD	**48**	**420**	**77**	**460**	**1.0**	**10**
E2	1	47	650	37	510	4.0	55
	2						
	3						
	4						
	5						
	Mean	-	-	-	-	-	-
	SD	-	-	-	-	-	-
B1	1	43	2900	70	4700	4.3	290
	2	28	1650	108	6400	5.4	320
	3	43	1950	121	5400	4.3	192
	4	40	2200	91	5000	6.7	370
	5	56	1790	130	4200	6.5	210
	Mean	**42**	**2100**	**104**	**5100**	**5.4**	**280**
	SD	**10**	**500**	**24**	**800**	**1.2**	**80**
B2	1	49	5000	126	13000	6.6	680
	2	34	2400	106	7700	7.6	550
	3	31	2800	80	7300	10.6	960
	4	34	2700	122	9700	7.1	560
	5	56	3200	95	5400	6.9	390
	Mean	**41**	**3200**	**106**	**8600**	**7.8**	**630**
	SD	**11**	**1000**	**19**	**2900**	**1.6**	**210**

***Table IIb**. HNO3 soluble metal concentrations in different soil horizons at sample site B.*

Soil horizon	Plot	Total Cu (mg/kg)	Total Cu (mg/m2)	Total Ni (mg/kg)	Total Ni (mg/m2)	Total Sr (mg/kg)	Total Sr (mg/m2)
L	1	1490	1740	1620	1900	16.9	20
	2	1400	2600	1680	3100	15.3	28
	3	1570	3800	1820	4300	15.3	36
	4	1830	3700	2100	4300	17.3	35
	5	1540	2700	1720	3000	19.1	34
	Mean	**1570**	**2900**	**1790**	**3300**	**16.8**	**31**
	SD	**160**	**800**	**190**	**1000**	**1.6**	**7**
Of	1	770	2400	1000	3100	19.6	60
	2	200	620	440	1370	22	70
	3	470	1660	820	2900	27	94
	4	570	1520	910	2400	23	62
	5	680	1650	1020	2500	18.4	45
	Mean	**540**	**1560**	**840**	**2400**	**22**	**66**
	SD	**220**	**620**	**240**	**700**	**3**	**18**
Oh	1	187	164	400	350	24	22
	2	80	181	220	510	17.9	41
	3	174	470	470	1290	32	87
	4	134	159	500	590	31	37
	5						
	Mean	**143**	**240**	**400**	**690**	**26**	**46**
	SD	**48**	**150**	**120**	**410**	**6**	**28**
E1	1	22	99	41	187	4.5	21
	2	9.0	78	10.9	94	3.2	28
	3	3.7	44	8.2	96	6.1	71
	4	7.0	64	28	250	3.2	29
	5	6.8	43	9.7	61	2.4	15.3
	Mean	**9.6**	**65**	**19.5**	**138**	**3.9**	**33**
	SD	**6.9**	**24**	**14.3**	**79**	**1.4**	**22**
E2	1	4.7	52	11.5	127	3.8	42
	2	5.3	200	5.5	210	4.8	185
	3	9.0	500	8.1	450	8.9	490
	4	4.3	50	8.3	97	2.4	28
	5	19.4	620	35	1100	3.1	98
	Mean	**8.6**	**280**	**13.6**	**400**	**4.6**	**169**
	SD	**6.4**	**260**	**12.0**	**420**	**2.6**	**191**
B1	1	24	250	35	370	2.8	30
	2	40	1050	32	830	2.8	74
	3	21	810	25	970	4.8	182
	4	17.3	560	26	840	4.6	148
	5	22	1030	34	1580	4.6	220
	Mean	**25**	**740**	**30**	**920**	**3.9**	**130**
	SD	**9**	**340**	**4**	**430**	**1.0**	**77**
B2	1	31	1380	33	1480	3.2	144
	2	54	4100	35	2600	3.2	240
	3	16.1	680	15.2	650	7.1	300
	4	27	1990	44	3300	5.7	420
	5	24	900	40	1520	4.9	187
	Mean	**30**	**1810**	**33**	**1920**	**4.8**	**260**
	SD	**15**	**1370**	**11**	**1050**	**1.7**	**110**

***Table IIc** HNO$_3$ soluble metal concentrations in different soil horizons at sample site C.*

Soil horizon	Plot	Total Cu (mg/kg)	Total Cu (mg/m2)	Total Ni (mg/kg)	Total Ni (mg/m2)	Total Sr (mg/kg)	Total Sr (mg/m2)
L	1	1380	1510	1200	1310	16.9	18.4
	2	1800	1740	1470	1420	18.2	17.6
	3	1820	2500	1840	2500	18.6	26
	4	1590	2200	1510	2100	16.9	24
	5	1710	2200	1720	2200	22	27
	Mean	**1660**	**2000**	**1550**	**1910**	**18.4**	**22**
	SD	**180**	**400**	**250**	**520**	**1.9**	**4**
Of	1	400	860	690	1470	22	47
	2	510	1320	940	2400	28	74
	3	280	710	550	1370	30	76
	4	450	1130	750	1900	26	66
	5	230	870	470	1770	27	99
	Mean	**380**	**980**	**680**	**1780**	**27**	**72**
	SD	**120**	**240**	**180**	**420**	**3**	**19**
Oh	1	164	177	330	360	18.5	20
	2	154	380	290	700	22	53
	3	67	120	194	350	25	44
	4	104	168	310	500	25	41
	5	118	210	280	500	26	45
	Mean	**121**	**210**	**280**	**480**	**23**	**41**
	SD	**39**	**100**	**50**	**140**	**3**	**12**
E1	1	29	240	65	530	5.8	48
	2	11.5	121	32	330	4.6	48
	3	24	210	53	460	5.0	44
	4	11.4	82	32	230	6.0	43
	5	2.4	17.0	4.5	32	2.8	20
	Mean	**15.7**	**134**	**37**	**320**	**4.9**	**41**
	SD	**10.8**	**91**	**23**	**200**	**1.3**	**12**
E2	1	5.8	76	12.2	159	2.1	27
	2	5.9	116	9.1	179	2.6	51
	3	10.5	152	23	340	4.3	62
	4	3.1	77	7.4	184	3.1	78
	5	2.2	51	3.4	79	2.6	60
	Mean	**5.5**	**94**	**11.1**	**188**	**2.9**	**56**
	SD	**3.2**	**40**	**7.6**	**94**	**0.8**	**19**
B1	1	13.2	570	18.9	810	4.2	183
	2	27	820	31	960	4.8	148
	3	11.2	400	15.8	560	3.2	112
	4	12.9	440	12.7	440	2.8	96
	5	16.5	490	16.3	480	2.8	84
	Mean	**16.1**	**540**	**19.0**	**650**	**3.6**	**125**
	SD	**6.2**	**170**	**7.2**	**230**	**0.9**	**41**
B2	1	24	1440	19.1	1160	4.3	260
	2	31	1920	36	2200	4.5	270
	3	17.6	1160	19.1	1260	3.9	260
	4	16.8	610	16.6	600	2.6	94
	5	33	1030	58	1820	2.1	65
	Mean	**24**	**1230**	**30**	**1410**	**3.5**	**191**
	SD	**7**	**490**	**18**	**630**	**1.1**	**103**

***Table IId**. HNO_3 soluble metal concentrations in different soil horizons at sample site.*

Soil horizon	Plot	Total Cu (mg/kg)	Total Cu (mg/m2)	Total Ni (mg/kg)	Total Ni (mg/m2)	Total Sr (mg/kg)	Total Sr (mg/m2)
L	1	600	350	560	330	16.9	9.9
	2	690	720	600	630	15.0	15.7
	3	640	520	750	610	18.2	14.8
	4	880	830	770	730	17.1	16.0
	5	950	750	820	640	16.1	12.6
	Mean	**750**	**630**	**700**	**590**	**16.7**	**13.8**
	SD	**160**	**190**	**110**	**150**	**1.2**	**2.5**
Of	1	500	960	700	1340	26	51
	2	270	730	500	1340	21	57
	3	260	1080	420	1790	35	148
	4	197	600	360	1090	25	77
	5	330	890	490	1300	30	79
	Mean	**310**	**850**	**490**	**1370**	**28**	**82**
	SD	**120**	**190**	**130**	**260**	**5**	**39**
Oh	1	116	270	170	390	21	48
	2	65	156	115	280	17.1	41
	3	3.7	17.4	77	360	23	106
	4	99	146	162	240	18.9	28
	5	143	175	250	300	30	37
	Mean	**85**	**152**	**154**	**310**	**22**	**52**
	SD	**54**	**89**	**64**	**60**	**5**	**31**
E1	1	8.8	126	11.4	163	3.3	48
	2	9.0	113	16.2	200	4.6	58
	3	2.4	35	5.0	74	3.9	59
	4	3.6	43	7.1	85	3.8	45
	5	1.58	27	3.6	60	2.6	43
	Mean	**5.1**	**69**	**8.6**	**117**	**3.6**	**51**
	SD	**3.6**	**47**	**5.1**	**63**	**0.8**	**7**
E2	1	3.6	161	4.2	187	6.9	310
	2	3.6	144	6.3	250	8.0	320
	3	2.8	45	3.7	59	2.7	43
	4	2.1	75	3.1	111	2.9	105
	5	2.6	130	2.0	101	2.0	97
	Mean	**3.0**	**111**	**3.9**	**142**	**4.5**	**174**
	SD	**0.7**	**49**	**1.6**	**76**	**2.7**	**129**
B1	1	8.7	420	10.6	510	6.0	290
	2	9.2	340	13.8	520	7.2	270
	3	10.7	220	13.6	280	4.0	83
	4	8.4	270	8.6	280	3.9	126
	5	6.8	250	7.1	260	3.4	127
	Mean	**8.8**	**300**	**10.8**	**370**	**4.9**	**179**
	SD	**1.4**	**80**	**3.0**	**130**	**1.6**	**94**
B2	1	14.3	840	13.4	790	4.6	270
	2	10.6	400	11.2	430	4.6	177
	3	14.9	250	14.1	240	2.3	38
	4	9.6	580	11.3	680	3.2	191
	5	10.4	890	11.6	1000	2.9	250
	Mean	**12.0**	**590**	**12.3**	**630**	**3.5**	**185**
	SD	**2.4**	**280**	**1.3**	**300**	**1.1**	**90**

***Table IIe.** HNO_3 soluble metal concentrations in different soil horizons at reference site REF Fnd).*

Soil horizon	Plot	Total Cu (mg/kg)	Total Cu (mg/m2)	Total Ni (mg/kg)	Total Ni (mg/m2)	Total Sr (mg/kg)	Total Sr (mg/m2)
L	1	11.0	6.8	6.9	4.3	22	13.8
	2	10.9	6.0	7.1	3.9	18.1	10.0
	3	10.3	5.2	6.4	3.2	16.8	8.5
	4	12.2	6.4	9.1	4.7	15.6	8.2
	5	9.6	4.0	6.4	2.7	21	8.7
	Mean	**10.8**	**5.7**	**7.2**	**3.8**	**18.7**	**9.8**
	SD	**1.0**	**1.1**	**1.1**	**0.8**	**2.8**	**2.3**
Of	1	8.2	26	8.4	27	24	77
	2	8.8	25	8.5	24	22	62
	3	6.9	46	5.8	39	26	177
	4	9.4	17.1	7.9	14.4	22	40
	5	9.9	19.4	10.0	20	23	46
	Mean	**8.6**	**27**	**8.1**	**25**	**24**	**80**
	SD	**1.2**	**12**	**1.5**	**9**	**2**	**56**
Oh	1	7.1	56	10.0	78	38	290
	2	7.3	22	8.8	26	21	64
	3	6.6	22	8.9	30	51	174
	4	5.0	12.1	5.5	13.5	22	53
	5	9.1	30	10.6	36	23	77
	Mean	**7.0**	**29**	**8.8**	**37**	**31**	**132**
	SD	**1.5**	**17**	**2.0**	**25**	**13**	**102**
E1	1	0.78	25	0.90	30	3.3	107
	2	1.35	31	3.5	81	4.5	103
	3	0.76	14.4	1.80	34	3.4	65
	4	0.95	21	2.2	48	2.4	53
	5	1.03	31	2.0	60	2.6	77
	Mean	**0.97**	**25**	**2.1**	**51**	**3.2**	**81**
	SD	**0.24**	**7**	**0.9**	**21**	**0.8**	**23**
E2	1	1.69	115	7.9	530	6.8	460
	2	1.66	39	5.8	135	4.9	115
	3	1.29	41	3.5	109	3.2	101
	4	1.23	38	6.4	196	2.4	72
	5	2.0	67	7.6	250	2.7	90
	Mean	**1.58**	**60**	**6.2**	**240**	**4.0**	**168**
	SD	**0.33**	**33**	**1.8**	**170**	**1.9**	**165**
B1	1	4.3	330	17.0	1310	5.7	440
	2	6.1	350	24	1350	4.3	240
	3	4.1	280	15.1	1030	3.7	250
	4	4.0	198	14.6	720	3.5	174
	5	6.6	530	27	2100	4.2	340
	Mean	**5.0**	**340**	**19**	**1310**	**4.3**	**290**
	SD	**1.2**	**120**	**5**	**530**	**0.9**	**100**
B2	1	6.3	820	22	2800	7.6	980
	2	7.7	470	29	1760	5.3	330
	3	5.6	430	20	1510	4.0	310
	4	5.0	390	19.3	1500	2.7	210
	5	7.3	460	25	1600	2.8	175
	Mean	**6.4**	**510**	**23**	**1840**	**4.5**	**400**
	SD	**1.1**	**170**	**4**	**560**	**2.0**	**330**

Table IIIa. *NH_4NO_3 extractable metals in different soil horizons at sample site A.* [1)] H1/2

Soil horizon	Plot	Cu (mg/kg)	Cu (mg/m2)	Ni (mg/kg)	Ni (mg/m2)	Mn (mg/kg)	Mn (mg/m2)	Fe (mg/kg)	Fe (mg/m2)
Of	1	108	430	370	1480	16.5	66	167	670
	2	26	80	320	980	111	340	59	181
	3	106	330	420	1330	74	230	62	193
	4	250	810	320	1030	17.9	58	130	420
	5	92	330	500	1770	58	200	67	240
	Mean	**116**	**400**	**390**	**1320**	**55**	**180**	**97**	**340**
	SD	**82**	**260**	**80**	**330**	**40**	**119**	**49**	**210**
Oh[1)]	1								
	2	72	240	500	1670	124	420	66	220
	3	156	370	490	1160	66	157	115	270
	4								
	5								
	Mean	-	-	-	-	-	-	-	-
	SD	-	-	-	-	-	-	-	-
E1	1	4.4	34	36	270	1.9	14	71	540
	2	11.0	72	87	580	14.6	96	34	220
	3	12.0	166	53	730	8.2	113	41	570
	4	27	310	18.6	210	1.5	17	19.6	220
	5	17.6	121	77	530	7.6	52	49	340
	Mean	**14.5**	**141**	**54**	**460**	**6.7**	**59**	**43**	**380**
	SD	**8.6**	**108**	**29**	**220**	**5.4**	**45**	**19**	**170**
E2	1	7.8	108	21	290	<1.4	-	30	410
	2								
	3								
	4								
	5								
	Mean	-	-	-	-	-	-	-	-
	SD	-	-	-	-	-	-	-	-
B1	1	0.33	22	14.2	960	<1.4	-	76	5100
	2	0.20	12	52	3100	8.9	530	69	4100
	3	1.50	67	32	1430	8.9	400	54	2400
	4	0.85	47	34	1870	4.5	240	53	2900
	5	0.55	18	42	1360	3.7	120	88	2800
	Mean	**0.69**	**33**	**35**	**1740**	-	-	**68**	**3500**
	SD	**0.52**	**23**	**14**	**820**	-	-	**15**	**1100**
B2	1	<0.18	-	21	2200	3.6	370	50	5200
	2	<0.18	-	16.7	1210	7.3	530	12.1	880
	3	<0.30	-	5.9	540	3.6	320	10.3	930
	4	<0.30	-	11.8	930	3.3	260	16.8	1330
	5	0.38	21	6.9	390	1.2	70	36	2000
	Mean	-	-	**12.4**	**1050**	**3.8**	**310**	**25**	**2100**
		-	-	**6.4**	**700**	**2.2**	**170**	**17**	**1800**

Table IIIa. continued

K		Mg		Ca		Al	
(mg/kg)	(mg/m2)	(mg/kg)	(mg/m2)	(mg/kg)	(mg/m2)	(mg/kg)	(mg/m2)
181	730	73	290	650	2600	960	3900
210	640	230	700	2500	7600	155	480
175	540	230	730	870	2700	105	330
145	470	81	260	490	1600	159	510
170	600	157	550	1470	5200	220	780
176	**600**	**154**	**510**	**1190**	**3900**	**320**	**1190**
22	**100**	**77**	**220**	**800**	**2400**	**360**	**1500**
197	660	194	650	1720	5800	163	550
220	520	180	430	1510	3600	174	410
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
26	195	10.2	78	82	620	390	3000
70	460	3.1	21	250	1620	210	1380
34	470	20	280	159	2200	200	2800
33	380	16.9	194	59	680	168	1920
54	370	33	220	280	1930	370	2500
43	**380**	**16.6**	**159**	**165**	**1410**	**270**	**2300**
18	**110**	**11.1**	**107**	**97**	**720**	**100**	**700**
12.8	177	5.2	72	30	420	197	2700
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
16.1	1090	3.8	260	77	5200	340	23000
33	1990	12.1	720	92	5500	280	16700
37	1640	13.6	610	117	5200	470	21000
25	1350	9.1	500	64	3500	350	19100
37	1180	15.2	490	118	3800	530	17100
29	**1450**	**10.8**	**520**	**94**	**4600**	**390**	**19400**
9	**370**	**4.5**	**170**	**24**	**900**	**100**	**2600**
14.6	1500	3.0	310	67	6900	150	15500
24	1750	6.3	460	121	8800	181	13100
16.5	1500	3.2	290	45	4100	200	18600
14.8	1170	4.6	360	64	5100	250	19600
15.5	880	5.2	300	57	3200	400	23000
17.1	**1360**	**4.5**	**340**	**71**	**5600**	**240**	**17900**
4.0	**340**	**1.4**	**70**	**29**	**2200**	**100**	**3800**

Table IIIb. *NH_4NO_3 extractable metals in different soil horizons at sample site B.*

Soil horizon	Plot	Cu (mg/kg)	Cu (mg/m²)	Ni (mg/kg)	Ni (mg/m²)	Mn (mg/kg)	Mn (mg/m²)	Fe (mg/kg)	Fe (mg/m²)
Of	1	51	155	280	870	520	1590	47	145
	2	16.4	52	230	710	270	850	29	90
	3	35	124	240	850	240	850	47	166
	4	44	115	260	680	320	840	58	154
	5	61	147	260	630	168	410	67	163
	Mean	**41**	**119**	**250**	**750**	**300**	**910**	**50**	**144**
	SD	**17**	**41**	**20**	**110**	**130**	**430**	**14**	**31**
Oh	1	11.2	9.8	188	165	420	370	32	28
	2	6.4	14.5	126	290	93	210	39	89
	3	10.0	27	210	580	280	770	34	92
	4	7.0	8.3	240	290	290	350	41	49
	5								
	Mean	**8.6**	**15.0**	**190**	**330**	**270**	**420**	**36**	**65**
	SD	**2.3**	**8.7**	**50**	**170**	**130**	**240**	**4**	**31**
E1	1	1.75	8.0	27	122	47	220	13.5	62
	2	0.23	1.9	4.4	38	2.5	21	63	540
	3	<0.18	-	3.2	37	3.8	44	11.3	132
	4	0.33	3.0	16.9	154	16.1	146	34	310
	5	0.40	2.5	3.1	20	3.4	22	10.8	69
	Mean	**-**	**-**	**10.9**	**74**	**14.6**	**90**	**27**	**220**
	SD	**-**	**-**	**10.6**	**60**	**19.2**	**88**	**23**	**210**
E2	1	<0.18	-	4.0	44	7.1	78	6.9	76
	2	0.20	7.7	2.4	92	1.4	54	36	1370
	3	<0.18	-	<1.3	-	1.6	90	10.3	570
	4	<0.18	-	3.3	38	3.2	38	29	340
	5	1.60	51	19.3	610	16.3	520	19.4	620
	Mean	**-**	**-**	**-**	**-**	**5.9**	**155**	**20**	**590**
	SD	**-**	**-**	**-**	**-**	**6.2**	**204**	**12**	**480**
B1	1	<0.18	-	10.3	109	20	210	62	660
	2	<0.18	-	<1.3	-	<1.4	-	64	1680
	3	<0.18	-	4.7	180	7.2	270	73	2800
	4	<0.18	-	5.8	188	2.8	90	126	4100
	5	0.25	12	9.0	420	4.4	210	104	4900
	Mean	**-**	**-**	**-**	**-**	**-**	**-**	**86**	**2800**
	SD	**-**	**-**	**-**	**-**	**-**	**-**	**28**	**1700**
B2	1	<0.18	-	4.6	200	9.2	410	29	1320
	2	<0.18	-	<1.3	-	<1.4	-	44	3300
	3	<0.18	-	1.6	67	4.9	210	31	1300
	4	<0.18	-	<1.3	-	1.5	110	36	2700
	5	<0.18	-	<1.3	-	1.7	65	8.2	310
	Mean	**-**	**-**	**-**	**-**	**-**	**-**	**30**	**1800**
	SD	**-**	**-**	**-**	**-**	**-**	**-**	**13**	**1220**

__Table IIIb__. continued

K		Mg		Ca		Al	
(mg/kg)	(mg/m²)	(mg/kg)	(mg/m²)	(mg/kg)	(mg/m²)	(mg/kg)	(mg/m²)
640	1970	250	760	1940	5900	67	200
490	1540	330	1050	2100	6700	179	560
470	1660	350	1250	2300	8000	74	260
510	1350	240	640	2200	5800	122	320
270	660	148	360	1180	2800	90	220
480	**1430**	**270**	**810**	**1940**	**5900**	**106**	**310**
130	**490**	**80**	**350**	**440**	**1900**	**46**	**150**
630	560	360	310	2500	2200	46	40
320	730	240	550	1370	3100	310	710
430	1170	380	1040	2700	7400	107	290
460	540	290	350	2700	3200	96	114
460	**750**	**320**	**560**	**2300**	**4000**	**141**	**290**
130	**290**	**60**	**330**	**600**	**2300**	**118**	**300**
70	320	44	200	360	1650	62	290
22	190	9.6	82	50	430	220	1900
34	400	17.5	200	89	1040	94	1100
93	850	3.1	28	191	1740	82	740
13.7	87	5.2	33	32	200	37	240
47	**370**	**15.9**	**110**	**145**	**1010**	**99**	**850**
34	**290**	**16.7**	**88**	**136**	**700**	**71**	**680**
22	250	11.2	124	82	900	65	720
9.8	380	5.0	191	17	670	146	5600
10.5	580	5.8	320	26	1400	95	5200
37	440	14.1	165	55	640	146	1710
45	1420	19.6	620	102	3200	76	2400
25	**610**	**11.1**	**280**	**56**	**1400**	**106**	**3100**
16	**470**	**6.1**	**200**	**36**	**1100**	**38**	**2200**
35	370	12.4	131	98	1000	270	2800
26	690	6.4	168	69	1800	460	12200
30	1150	10.1	380	94	3600	300	11200
34	1090	10.9	350	70	2200	350	11300
16.3	760	5.0	230	35	1600	200	9500
28	**810**	**9.0**	**250**	**73**	**2100**	**320**	**9400**
8	**320**	**3.1**	**110**	**25**	**900**	**100**	**3800**
16.0	720	5.0	230	51	2300	117	5200
11.8	890	3.3	250	31	2300	150	11300
12.6	530	5.4	230	42	1780	230	9600
14.3	1070	3.0	220	31	2300	290	22000
8.7	330	1.6	60	10	400	107	4100
12.7	**710**	**3.7**	**196**	**33**	**1820**	**178**	**10300**
2.7	**290**	**1.6**	**77**	**15**	**830**	**78**	**6900**

Table IIIc. *NH_4NO_3 extractable metals in different soil horizons at sample site B.*

Soil horizon	Plot	Cu (mg/kg)	Cu (mg/m²)	Ni (mg/kg)	Ni (mg/m²)	Mn (mg/kg)	Mn (mg/m²)	Fe (mg/kg)	Fe (mg/m²)
Of	1	31	67	157	340	260	550	51	110
	2	31	80	165	430	310	800	51	133
	3	15.2	38	159	400	96	240	28	69
	4	25	62	230	580	320	810	37	93
	5	16.8	63	177	660	171	640	36	136
	Mean	**24**	**62**	**178**	**480**	**230**	**610**	**41**	**108**
	SD	**8**	**15**	**30**	**140**	**100**	**230**	**10**	**28**
Oh	1	14.4	15.5	147	159	178	192	44	48
	2	10.8	26	99	240	151	370	44	107
	3	3.8	6.9	81	146	70	127	40	72
	4	5.9	9.6	114	184	153	250	20	33
	5	8.2	14.4	100	177	93	164	34	60
	Mean	**8.6**	**14.5**	**108**	**182**	**129**	**220**	**37**	**64**
	SD	**4.1**	**7.5**	**25**	**37**	**45**	**90**	**10**	**28**
E1	1	1.13	9.2	21	175	14.7	120	23	186
	2	<0.18	-	11.2	117	16.3	171	21	220
	3	2.1	17.9	24	210	17.9	156	22	195
	4	0.23	1.6	10.1	73	9.2	66	20	146
	5	<0.30	-	1.4	9.4	1.0	6.8	13.9	97
	Mean	-	-	**13.7**	**117**	**11.8**	**104**	**20**	**169**
	SD	-	-	**9.2**	**80**	**6.9**	**68**	**4**	**49**
E2	1	<0.18	-	6.4	83	4.1	52	27	360
	2	<0.18	-	3.0	59	3.9	77	39	760
	3	0.83	12	9.9	143	5.9	85	36	530
	4	<0.30	-	3.3	82	3.0	74	23	570
	5	<0.30	-	1.4	32	0.9	20	32	730
	Mean	-	-	**4.8**	**80**	**3.5**	**62**	**31**	**590**
	SD	-	-	**3.4**	**41**	**1.8**	**26**	**6**	**170**
B1	1	<0.18	-	6.0	260	2.6	113	114	4900
	2	<0.18	-	4.3	133	2.2	68	77	2400
	3	0.30	11	6.6	230	3.0	110	126	4500
	4	<0.30	-	2.3	79	1.1	38	102	3500
	5	<0.30	-	<0.8	-	<0.8	-	81	2400
	Mean	-	-	-	-	-	-	**100**	**3500**
	SD	-	-	-	-	-	-	**21**	**1200**
B2	1	<0.18	-	3.2	190	1.5	90	71	4300
	2	<0.18	-	1.7	100	<1.4	-	53	3200
	3	<0.30	-	3.1	200	1.5	99	47	3100
	4	<0.30	-	<0.8	-	<0.8	-	36	1310
	5	<0.30	-	<0.8	-	<0.8	-	23	720
	Mean	-	-	-	-	-	-	**46**	**2500**
	SD	-	-	-	-	-	-	**18**	**1500**

Table IIIc. continued

K		Mg		Ca		Al	
(mg/kg)	(mg/m²)	(mg/kg)	(mg/m²)	(mg/kg)	(mg/m²)	(mg/kg)	(mg/m²)
750	1600	280	610	1970	4200	78	167
940	2400	350	910	2200	5600	93	240
930	2300	420	1050	2900	7100	61	152
850	2100	380	970	2700	6800	54	137
670	2500	300	1120	2100	7700	99	370
830	**2200**	**350**	**930**	**2400**	**6300**	**77**	**210**
120	**400**	**60**	**200**	**400**	**1400**	**20**	**100**
510	550	220	230	1310	1410	113	123
630	1530	300	730	1940	4700	156	380
420	770	210	370	1250	2300	128	230
560	900	330	540	2200	3600	54	87
460	810	350	620	1570	2800	89	158
510	**910**	**280**	**500**	**1660**	**3000**	**108**	**196**
80	**370**	**70**	**200**	**410**	**1300**	**39**	**116**
124	1010	41	340	250	2000	141	1160
116	1210	46	480	141	1480	72	760
112	980	37	330	220	1960	85	740
79	570	29	210	260	1890	104	750
57	400	16.9	118	53	370	120	840
97	**830**	**34**	**290**	**186**	**1540**	**104**	**850**
28	**340**	**11**	**140**	**88**	**690**	**27**	**180**
38	500	10.5	135	52	670	97	1260
29	580	14.0	280	61	1210	172	3400
50	720	21	310	81	1170	164	2400
40	980	14.6	360	68	1670	141	3500
28	650	10.7	250	38	870	200	4600
37	**680**	**14.2**	**260**	**60**	**1120**	**155**	**3000**
9	**180**	**4.4**	**80**	**16**	**380**	**39**	**1300**
44	1890	12.2	530	43	1840	400	17100
36	1110	8.5	260	72	2200	320	9900
29	1010	10.2	360	41	1440	390	13800
45	1560	11.2	390	67	2300	640	22000
40	1200	9.2	270	41	1210	510	15100
39	**1360**	**10.3**	**360**	**53**	**1810**	**450**	**15600**
7	**360**	**1.5**	**110**	**16**	**480**	**130**	**4500**
33	2000	7.7	470	45	2800	470	29000
22	1330	3.4	210	31	1900	260	16100
23	1500	5.6	370	19	1220	260	17000
24	850	3.9	141	34	1230	340	12100
15.7	490	3.7	117	14	440	195	6100
23	**1240**	**4.8**	**260**	**29**	**1510**	**300**	**16000**
6	**590**	**1.8**	**150**	**13**	**870**	**110**	**8300**

Table IIId. *NH_4NO_3 extractable metals in different soil horizons at sample site D.*

Soil horizon	Plot	Cu		Ni		Mn		Fe	
		(mg/kg)	(mg/m^2)	(mg/kg)	(mg/m^2)	(mg/kg)	(mg/m^2)	(mg/kg)	(mg/m^2)
Of	1	37	70	134	260	470	900	39	75
	2	14.7	39	91	250	470	1260	24	64
	3	22	92	79	340	113	480	32	134
	4	13.4	41	87	260	310	930	32	97
	5	27	71	124	330	260	700	31	83
	Mean	**23**	**63**	**103**	**290**	**320**	**850**	**32**	**91**
	SD	**9**	**23**	**24**	**40**	**150**	**290**	**5**	**27**
Oh	1	7.3	16.7	70	161	152	350	27	62
	2	4.6	11.2	49	118	200	490	24	58
	3	0.65	3.0	23	107	164	760	44	200
	4	6.0	8.9	38	56	113	166	23	34
	5	9.0	11.0	80	98	131	159	21	25
	Mean	**5.5**	**10.1**	**52**	**108**	**152**	**380**	**28**	**77**
	SD	**3.2**	**4.9**	**23**	**38**	**34**	**250**	**9**	**73**
E1	1	0.75	11	8.7	125	12.7	182	9.6	137
	2	0.43	5.4	8.9	113	18.3	230	8.5	108
	3	<0.30	-	1.5	22	1.6	24	16.6	250
	4	0.45	5.4	4.0	47	5.3	63	9.1	108
	5	0.20	3.4	1.6	27	2.0	34	4.5	76
	Mean	-	-	**4.9**	**67**	**8.0**	**107**	**9.7**	**135**
	SD	-	-	**3.7**	**49**	**7.3**	**94**	**4.4**	**66**
E2	1	0.23	10	2.3	100	2.3	100	17.6	790
	2	<0.18	-	2.4	93	3.7	150	14.1	550
	3	<0.30	-	<0.8	-	<0.8	-	15.2	240
	4	<0.30	-	<0.8	-	1.1	40	20	730
	5	<0.30	-	<0.8	-	0.9	46	8.1	400
	Mean	-	-	-	-	-	-	**15.1**	**540**
	SD	-	-	-	-	-	-	**4.6**	**230**
B1	1	<0.18	-	1.6	79	<1.4	-	30	1440
	2	<0.18	-	2.6	96	1.8	67	48	1790
	3	<0.30	-	<0.8	-	<0.8	-	45	940
	4	<0.30	-	<0.8	-	0.9	29	67	2200
	5	<0.30	-	<0.8	-	<0.8	-	51	1880
	Mean	-	-	-	-	-	-	**48**	**1640**
	SD	-	-	-	-	-	-	**13**	**470**
B2	1	<0.18	-	<1.3	-	<1.4	-	33	1930
	2	<0.18	-	<1.3	-	<1.4	-	47	1770
	3	<0.30	-	<0.8	-	<0.8	-	32	540
	4	<0.30	-	<0.8	-	<0.8	-	30	1770
	5	<0.30	-	<0.8	-	0.9	76	35	3000
	Mean	-	-	-	-	-	-	**35**	**1810**
	SD	-	-	-	-	-	-	**7**	**880**

Table IIId. *Continued*

K		Mg		Ca		Al	
(mg/kg)	(mg/m²)	(mg/kg)	(mg/m²)	(mg/kg)	(mg/m²)	(mg/kg)	(mg/m²)
1000	1910	290	560	2200	4200	104	200
1000	2700	340	900	1960	5300	69	185
800	3400	430	1820	2400	10100	92	390
870	2600	330	990	1980	6000	81	240
1000	2700	410	1100	2600	7000	69	185
930	**2700**	**360**	**1070**	**2200**	**6500**	**83**	**240**
90	**500**	**60**	**460**	**300**	**2200**	**15**	**90**
480	1100	200	460	1370	3100	155	350
500	1220	290	690	1140	2800	69	167
360	1670	158	740	1230	5700	194	900
450	660	179	260	1260	1860	70	103
650	790	330	410	1750	2100	75	92
490	**1090**	**230**	**510**	**1350**	**3100**	**113**	**320**
100	**400**	**70**	**200**	**240**	**1500**	**58**	**340**
72	1020	24	350	141	2000	75	1080
138	1740	41	510	175	2200	49	620
23	340	11.1	166	56	840	149	2200
49	590	16.4	195	62	740	56	670
36	600	12.1	200	60	1010	46	780
63	**860**	**21**	**290**	**99**	**1360**	**75**	**1080**
45	**550**	**12**	**150**	**55**	**690**	**43**	**670**
16.5	740	6.9	310	38	1700	120	5400
46	1800	10.8	420	51	2000	123	4900
15.1	240	7.5	121	19	310	220	3600
19.4	690	7.4	260	18	640	162	5800
19.0	940	5.8	290	12	610	106	5200
23	**880**	**7.7**	**280**	**28**	**1100**	**147**	**5000**
13	**570**	**1.8**	**110**	**16**	**700**	**47**	**900**
20	980	4.3	210	26	1300	210	10000
33	1260	9.1	340	40	1500	350	13000
19.0	390	5.0	103	17	340	370	7600
28	900	7.1	230	22	710	530	17100
18.3	680	6.4	240	14	530	440	16500
24	**840**	**6.4**	**220**	**24**	**870**	**380**	**12800**
7	**330**	**1.9**	**80**	**10**	**490**	**120**	**4100**
20	1200	3.5	210	21	1200	290	16900
27	1030	5.4	200	27	1000	280	10700
18.2	310	4.0	67	13	230	330	5700
18.3	1100	3.5	210	21	1280	370	22000
12.1	1050	2.7	230	16	1340	320	28000
19.2	**940**	**3.8**	**184**	**20**	**1000**	**320**	**16600**
5.4	**360**	**1.0**	**66**	**5**	**500**	**30**	**8800**

Table IIIe. *NH_4NO_3 extractable metals in different soil horizons at reference site REF (Finland).*

Soil horizon	Plot	Cu		Ni		Mn		Fe	
		mg/kg	mg/m²	mg/kg	mg/m²	mg/kg	mg/m²	mg/kg	mg/m²
Of	1	<0.18	-	2.0	6.2	123	390	13.1	42
	2	<0.18	-	1.5	4.1	149	430	21	61
	3	<0.30	-	1.6	11	68	460	9.8	66
	4	<0.30	-	1.7	3.1	138	250	11.6	21
	5	<0.30	-	2.7	5.3	131	260	26	51
	Mean	-	-	**1.9**	**5.9**	**122**	**360**	**16.3**	**48**
	SD	-	-	**0.5**	**2.9**	**31**	**100**	**6.9**	**18**
Oh	1	<0.18	-	2.3	18	18.7	147	47	370
	2	<0.18	-	2.4	7.0	19.1	56	63	186
	3	<0.30	-	2.3	7.9	15.6	53	27	92
	4	<0.30	-	<0.8	-	34	83	25	60
	5	<0.30	-	2.9	9.6	25	84	81	270
	Mean	-	-	-	-	**22**	**84**	**49**	**200**
	SD	-	-	-	-	**7**	**37**	**24**	**130**
E1	1	<0.18	-	<1.3	-	<1.4	-	7.2	240
	2	<0.18	-	<1.3	-	<1.4	-	10.5	240
	3	<0.30	-	<0.8	-	<0.8	-	6.2	117
	4	<0.30	-	<0.8	-	1.4	31	9.2	210
	5	<0.30	-	<0.8	-	<0.8	-	10.3	310
	Mean	-	-	-	-	-	-	**8.7**	**220**
	SD	-	-	-	-	-	-	**1.9**	**70**
E2	1	<0.18	-	<1.3	-	<1.4	-	8.5	570
	2	<0.18	-	<1.3	-	<1.4	-	13.3	310
	3	<0.30	-	<0.8	-	<0.8	-	8.2	260
	4	<0.30	-	<0.8	-	<0.8	-	13.1	400
	5	<0.30	-	<0.8	-	<0.8	-	16.8	550
	Mean	-	-	-	-	-	-	**12.0**	**420**
	SD	-	-	-	-	-	-	**3.6**	**140**
B1	1	<0.18	-	<1.3	-	<1.4	-	42	3200
	2	<0.18	-	<1.3	-	<1.4	-	39	2200
	3	<0.30	-	<0.8	-	<0.8	-	32	2200
	4	<0.30	-	<0.8	-	<0.8	-	34	1700
	5	<0.30	-	<0.8	-	<0.8	-	35	2800
	Mean	-	-	-	-	-	-	**36**	**2400**
	SD	-	-	-	-	-	-	**4**	**600**
B2	1	<0.18	-	<1.3	-	<1.4	-	24	3100
	2	<0.18	-	<1.3	-	<1.4	-	24	1490
	3	<0.30	-	<0.8	-	<0.8	-	29	2300
	4	<0.30	-	<0.8	-	<0.8	-	21	1610
	5	<0.30	-	<0.8	-	<0.8	-	23	1430
	Mean	-	-	-	-	-	-	**24**	**1980**
	SD	-	-	-	-	-	-	**3**	**690**

Table IIIe. continued

K		Mg		Ca		Al	
mg/kg	mg/m²	mg/kg	mg/m²	mg/kg	mg/m²	mg/kg	mg/m²
1030	3300	590	1890	2300	7200	38	122
920	2600	480	1370	1500	4300	66	190
690	4600	490	3300	1660	11200	47	310
940	1710	590	1070	2100	3700	40	72
850	1670	490	970	1640	3200	123	240
890	**2800**	**530**	**1730**	**1820**	**5900**	**63**	**188**
130	**1200**	**60**	**960**	**320**	**3300**	**35**	**95**
450	3500	350	2700	1400	11000	164	1280
310	910	197	580	700	2100	270	800
440	1520	600	2100	1790	6100	165	560
390	960	380	920	920	2300	175	430
390	1310	260	880	810	2700	430	1440
400	**1650**	**360**	**1430**	**1120**	**4800**	**240**	**900**
60	**1090**	**150**	**910**	**460**	**3800**	**110**	**440**
14.7	480	12.2	400	52	1700	81	2600
16.3	370	5.5	125	17	380	57	1300
16.1	300	24	450	46	860	75	1420
30	670	22	480	57	1260	133	3000
17.3	520	10.3	310	30	890	97	2900
18.9	**470**	**14.6**	**350**	**40**	**1020**	**89**	**2200**
6.4	**140**	**7.7**	**140**	**17**	**490**	**29**	**800**
9.3	630	5.8	390	21	1400	105	7100
8.4	196	3.7	87	9.9	230	98	2300
9.3	290	8.2	260	14	450	85	2700
10.7	330	6.9	210	13	410	143	4400
10.7	360	5.2	172	8.7	290	126	4200
9.7	**360**	**6.0**	**220**	**13.4**	**560**	**111**	**4100**
1.0	**160**	**1.7**	**110**	**4.8**	**490**	**23**	**1900**
9.0	690	5.8	450	22	1700	198	15200
9.6	550	3.9	220	7.4	420	200	11600
11.2	770	12.9	880	20	1360	161	11000
12.5	620	4.5	220	7.3	360	260	13000
11.9	960	2.9	230	5.9	470	260	21000
10.8	**720**	**6.0**	**400**	**12.5**	**860**	**220**	**14300**
1.5	**160**	**4.0**	**280**	**7.7**	**620**	**40**	**4000**
4.8	620	1.8	230	12	1500	200	26000
6.6	410	2.2	136	9.6	590	136	8300
8.9	690	9.0	690	26	1980	220	17100
9.2	720	2.4	186	6.3	490	240	18500
6.7	430	1.4	89	2.8	180	240	15300
7.3	**570**	**3.4**	**270**	**11.2**	**950**	**210**	**17100**
1.8	**150**	**3.2**	**240**	**8.8**	**760**	**40**	**6400**

Table IV. *Metal concentrations in plant species from all sample sites*

Sample site	Plant species	K	Ca	Mg	Mn	Zn	Cu	Ni	Sr
					mg/kg				
A	*Deschampsia fl.*	1240	330	320	49	25	1150	2200	4.4
	Empetrum n.	1260	1580	410	220	12.9	650	660	8.5
	Vaccinium v-i.	2200	2900	670	540	18.6	390	340	13.2
	Vaccinium m.	450	700	151	230	13.7	1010	500	7.7
B	*Deschampsia fl.*	3900	960	400	370	37	520	930	5.8
	Empetrum n.	2100	2500	430	580	15.1	360	430	8.6
	Vaccinium v-i..	3400	5300	800	980	24	200	210	10.5
	Vaccinium m.	3000	2700	490	1610	12.9	240	197	6.5
C	*Deschampsia fl.*	6200	1450	480	380	35	420	730	7.2
	Empetrum n.	2100	2300	450	410	19.3	470	470	9.9
	Vaccinium v-i.	3800	4100	670	1030	106	300	155	9.6
	Vaccinium m.	3700	3100	510	1340	16.2	230	188	8.2
D	*Deschampsia fl.*	9000	1470	500	530	27	122	171	8.2
	Empetrum n.	2800	2900	570	530	14.0	220	164	12.2
	Vaccinium v-i.	3600	3700	740	1030	17.8	61	56	8.3
	Vaccinium m.	4800	4800	890	2400	19.3	59	60	11.2
REF	*Deschampsia fl.*[1]	13900	1410	850	340	17.6	3.2	4.1	8.0
	Empetrum n.[1]	3900	4300	1190	590	19.3	7.8	3.4	8.8
	Vaccinium v-i.[1]	4400	5900	1140	1070	33	5.8	1.5	10.8
	Vaccinium m.[1]	4600	5800	1330	1280	42	7.8	1.9	10.5
	Deschampsia fl.[2]	14000	1450	830	310	14.0	3.0	4.4	7.5
	Empetrum n.[2]	4100	4600	1160	560	20	7.7	4.8	8.5
	Vaccinium v-i.[2]	4400	5400	1080	1100	33	5.8	2.3	9.7
	Vaccinium m.[2]	4700	5600	1250	1240	43	7.6	3.0	9.6

[1]Sampled in June

[2]Sampled in August

Table V. *Metal concentrations in berries from all sample sites*

Sample site	Berries	K	Ca	Mg	Mn	Zn	Cu	Ni	Sr
					(mg/kg)				
A	Bilberry	8400	1620	600	350	9.4	12.0	20	2.2
	Crowberry	9800	680	370	20	6.9	51	68	2.6
B	Bilberry	8700	1800	640	550	8.5	7.6	11.7	2.4
	Crowberry	8400	690	360	67	8.4	17.1	24	2.5
C	Bilberry	8400	1770	640	470	9.0	6.7	7.4	2.1
	Crowberry	10900	570	370	40	7.3	14.0	13.7	1.8
D	Bilberry	7900	1710	670	660	10.5	6.1	6.9	2.2
	Crowberry	11100	680	390	78	9.9	12.4	11.0	2.4
REF	Bilberry								
	Crowberry	8100	560	400	60	7.8	6.1	1.8	2.2

Table VI. *Metal concentrations in <u>Empetrum nigrum</u> from all plots at each sample site*

Sample site	Plot	K	Ca	Mg	Mn	Zn	Cu	Ni	Sr
					mg/kg				
A	1	1110	1180	300	250	9.9	560	690	7.8
	2	1480	2200	460	300	19.6	820	1050	8.8
	3	1320	1620	440	280	15.7	600	800	11.5
	4	1320	1970	430	161	12.2	540	750	9.7
	5	1350	1390	370	108	14.8	980	970	9.2
	Mean	**1310**	**1660**	**400**	**220**	**14.4**	**700**	**850**	**9.4**
	SD	**130**	**410**	**60**	**80**	**3.7**	**190**	**150**	**1.4**
B	1	2300	2700	560	560	19.2	250	340	8.0
	2	2200	2400	430	370	14.9	450	640	8.9
	3	1880	3000	510	630	21	610	660	8.7
	4	2200	2100	340	500	13.6	400	420	7.3
	5	1920	3000	460	540	17.1	310	460	12.8
	Mean	**2100**	**2700**	**460**	**520**	**17.1**	**410**	**500**	**9.1**
	SD	**200**	**400**	**80**	**90**	**3.0**	**140**	**140**	**2.1**
C	1	2100	2200	460	350	19.0	380	430	9.6
	2	2200	2100	440	390	19.5	510	500	8.9
	3	2600	3000	450	370	15.2	370	390	9.9
	4	2300	1940	360	440	14.7	340	280	7.9
	5	1310	1480	450	290	22	510	460	8.8
	Mean	**2100**	**2100**	**430**	**370**	**18.1**	**420**	**410**	**9.0**
	SD	**500**	**500**	**40**	**60**	**3.1**	**80**	**80**	**0.8**
D	1	2900	2700	550	640	21	161	146	9.0
	2	2800	2800	580	590	14.6	153	164	9.0
	3	2700	3200	610	360	16.9	164	185	17.1
	4	2200	1840	390	390	12.8	240	181	13.7
	5	3300	3400	660	360	18.8	390	360	13.9
	Mean	**2800**	**2800**	**560**	**470**	**16.8**	**220**	**210**	**12.5**
	SD	**400**	**600**	**100**	**140**	**3.2**	**100**	**90**	**3.5**
REF	1	3100	3100	830	490	19.0	7.[illegible]	3.[illegible]	6.3
	2	2800	3800	830	750	21	7.[illegible]	3.[illegible]	8.8
	3	2600	3400	790	730	25	8.[illegible]	2.[illegible]	7.1
	4	2600	3000	750	650	23	7.[illegible]	3.[illegible]	7.4
	5	2700	3300	690	720	17.8	7.[illegible]	4.[illegible]	8.3
	Mean	**2700**	**3300**	**780**	**670**	**21**	**7.[illegible]**	**3.[illegible]**	**7.6**
	SD	**200**	**300**	**60**	**110**	**3**	**0.[illegible]**	**0.[illegible]**	**1.0**

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