Extended abstract No. 339

ESTIMATION OF NICKEL DISTRIBUTION IN MIRE VEGETATION ON OLKILUOTO ISLAND

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SUMMARY

We estimated distribution of stable nickel (Ni) in mire vegetation on Olkiluoto Island which has been selected as a repository site for spent nuclear fuel disposal. The largest Ni pools were in living branches (28% of the inventory) and in below-ground parts of trees (23% of the inventory) when Olkiluoto based material was used. When supplemental data of Ni from the reference site was applied, the Ni distribution changed. The largest Ni pools were found in tree foliage, living branches and stem wood. As a conclusion, more site specific data of Ni on mires in Olkiluoto and on the selected reference mires would be needed.

KEY WORDS: biomass, element distribution, mires, nickel, safety assessment

INTRODUCTION

In Finland, Olkiluoto Island on the western coast has been selected as a repository site for spent nuclear fuel disposal. With approaching licensing steps (application for nuclear construction licence in 2012), the biosphere assessment demonstrating the long-term safety of the repository is developed into more and more site specific. Comprehensive studies concerning the biosphere characteristics of the site have been going on since 2002.

Mires are possible exposure pathways of people to the potential releases from a deep underground nuclear waste repository. Currently, there are only a few mires on the island. The existing mires are small and young. However, the properties of the future mire ecosystems surrounding Olkiluoto Island can be forecast and radionuclide transport models applied based on the properties of present mires, both on Olkiluoto Island and in a reference area (e.g. Haapanen *et al.*, 2010).

The most important radionuclides in transport models are long-lived ^{14}C, ^{36}Cl, ^{129}I, ^{93}Mo, ^{79}Se, ^{135}Cs, ^{59}Ni and ^{94}Nb. Due to low or non-existent concentrations of many of these nuclides in the environment and lack of data on radionuclide measurements, isotopic analogues are used in certain cases, e.g. Ni instead of ^{59}Ni. Ni, which is commonly referred to a heavy metal, is an essential micronutrient to plants, but it also is toxic at high concentration (Marchner, 1995). In this presentation we estimate distribution of stable Ni in mire vegetation on Olkiluoto Island.

MATERIAL AND METHODS

Mires in Olkiluoto

The relative area of mires in Olkiluoto is less than average density in Southwestern Finland (Saramäki and Korhonen, 2005). Since the area has been under active management, the proportion of undrained mires is also lower than in Southwestern Finland (Saramäki and Korhonen, 2005). The peat layers are shallow (Tamminen *et al.*, 2007), the hydrological conditions of drained mires are still changing, and the mires are small, which makes the estimation of mire coverage difficult. Estimates range from 4% (Rautio *et al.*, 2004) to 15% (Saramäki and Korhonen, 2005) of forest, scrub and waste land area. Despite the small amount of mires, the range of mire types is wide, and there are both forested and treeless mires, as well as seashore swamps (Miettinen and Haapanen, 2002). Eutrophic treeless reed-rush or sedge-herb swamps are common on the island. Close to the seashore, these swamps, which are usually small in area, were originally coves cut off from the sea by land uplift. Olkiluodonjärvi is the widest reed-rush swamp in the inland area (Miettinen and Haapanen, 2002). The mires are the least species-rich habitats in Olkiluoto. Typical species for mires were, for example, *Calamagrostis purpurea*, *Calla palustris*, *Equisetum sylvaticum*, and, above all white mosses (*Sphagnum* spp., Huhta and Korpela, 2006). Mires are described in more detail in Olkiluoto Biosphere Description 2009 (Haapanen *et al.*, 2009).

Due to the young, shallow peaty and intensively managed mires, drained and forested mire types are most prevalent in the presented data on the distribution of biomass and Ni of mire vegetation.

Biomass distribution

The monitoring of forests and mires on the island is based on a systematic grid with a density of 1 plot/ha (e.g. Tamminen *et al.*, 2007). The number of plots included in this grid was originally 560 but has decreased because of changes in land-use. Field measurement of the tree stand is based on the use of three concentric circular sample plots of fixed radius (3.09, 5.64 and 9.77 m, Saramäki and Korhonen, 2005). Trees were measured in accordance with the field manual of the National Forest Inventory (Saramäki and Korhonen, 2005). Biomass of different tree compartments were derived using Swedish models (Marklund, 1988), except for fine roots, whose biomass was calculated according to Helmisaari *et al.* (2007), and for leaves, the biomass of which was estimated using models by Repola (2008). The biomass of coarse roots and stumps of deciduous trees were estimated using the same models as for pine (Marklund, 1988).

Part of the measurement plots has been selected for further studies. In these sampling plots, the vegetation is assessed and the soil, needles, leaves and vegetation are sampled at intervals of 5-10 years in order to describe soil properties, vegetation composition and nutrient concentrations of plants and trees (Huhta and Korpela, 2006; Tamminen *et al.*, 2007). Biomass of other vegetation (below and above-ground, shrub-layer excluded) were derived from vegetation analysis (Huhta and Korpela, 2006) as described by Haapanen *et al.* (2007).

Nickel concentrations

Ni concentration was determined by wet digestion (HNO_3/H_2O_2) and analysed by ICP-AES. The results were expressed as concentration per weight of dry matter (drying at +105 °C). Ni was mainly determined for plant material collected from the Olkiluoto Island (Table 1). However, Ni concentrations in tree compartments were only analysed from trees growing in heath forests and groves, and consequently, these values were also used for trees growing on mires. In addition, Ni concentration was derived from other tree compartments or other tree species in cases original determinations were lacking. These exceptions were:

- no data for stem wood of birch; Ni concentration in black alder used instead
- data for dead branches of spruce and birch was used for other tree species
- Ni concentration in stumps was derived from corresponding values of stem wood and stem bark

For comparison, unpublished data for Ni concentrations of Scots pine, downy birch and understory vegetation from a reference site was used. This site, a drained pine mire (Ptkg II in Finnish classification), is located in Liesineva experimental area, western Finland.

Table 1. Mean concentration of Ni in different plant material. For tree compartments, values were weighted with the proportion of dry mass of different tree species (i.e. 0.15, 0.45, 0.3 and 0.1 for Scots pine, Norway spruce, birch and other deciduous, respectively). Ni concentration in below-ground parts of understory vegetation was assumed to be the same as in above-ground parts

Compartment	Ni, (mg $kg^{-1}{}_{dw}$)
Data source of Ni	Olkiluoto
Tree foliage	2.359
Living branches	1.418
Dead branches	2.366
Stem wood	0.415
Stem bark	0.837
Fine roots	3.910
Coarse roots	0.865
Stumps	0.626
Understory vegetation	2.416

RESULTS

Biomass and Ni distributions are presented in Table 2. Stem wood of trees contained 46% and living branches 20% of the total biomass of mire vegetation. Very small proportions of biomass were allocated to dead branches and understory vegetation. Contrary to biomass distribution, the largest Ni pools were in living branches (28% of the inventory) and in below-ground parts of trees (23% of the inventory) when Olkiluoto based material was used. Dead branches, stem bark of trees and understory vegetation had a minor share in Ni inventory (3, 6 and 5% of the inventory, respectively). When supplemental data of Ni from the reference site was applyid, Ni distribution changed. The largest Ni pools were found in tree foliage, living branches and stem wood (Table 2). The most notable difference in total Ni content of vegetation compartments was observed in tree roots and stumps.

Table 2. Distribution of biomass and Ni in the mire vegetation on the Olkiluoto Island. For comparison, Ni distribution is also presented when supplemental data from the reference site (Olkiluoto+Liesineva) was applied

Compartment	Biomass (g_{dw}/m^2)	Ni, (mg_{dw}/m^2)	Ni, (mg_{dw}/m^2)
Data source of Ni		Olkiluoto	Olkiluoto+Liesineva
Tree foliage	765	1.622	1.517
Living branches	1605	2.438	2.090
Dead branches	100	0.237	0.075
Stem wood	3700	1.612	1.615
Stem bark	494	0.484	0.400
Tree roots and stumps	1165	2.029	0.506
Understory vegetation	267	0.414	0.210

CONCLUSIONS

Ni distribution in the mire vegetation was estimated although available data was limited. There exists no Ni data for treeless mires, and the coverage of different mire types currently prevailing in Olkiluoto is not sufficient for the biosphere assessment in the material analysed thus far. Moreover, there are severe data gaps concerning Ni concentrations in different tree and understory species, and in their compartments as well. For example, total Ni content of tree roots and stumps was remarkable larger when Ni concentrations were derived from concentrations in stem wood and bark instead of using concentrations determined from stumps and roots. As a conclusion, more site specific data of Ni on mires in Olkiluoto and on the selected reference mires would be needed.

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