INTERSPECIES CALIBRATION OF HEAVY-METAL CONCENTRATIONS IN NINE MOSSES AND LICHENS: -APPLICABILITY TO DEPOSITION MEASUREMENTS

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Abstract. The study describes a method for including nine alternative moss and lichen species in heavy-metal air-pollution surveys based on concentrations in one of the species. Iron, Cu, Zn, Pb, Ni and Cd concentrations have been measured in Dicranum polysetum, Hylocomium splendens, Hypnum cupressiforme, Pleurozium schreberi, Pohlia nutans, Cladonia rangiferina, Hypogymnia physodes, Pseudevernia furfuracea and Usnea filipendula from 57 sites in coniferous woodland surrounding a brass foundry in Sweden.

Concentrations vary decidedly between species. The mosses frequently show higher concentrations than the lichens. The use of different monitor species in a deposition survey without interspecies calibration is not advised. Calibration factors for concentrations in different species can be calculated from the mean concentrations in each species. With the help of the factors, concentrations in a species not found in a certain site can be estimated from concentrations measured in any of the other species sampled.

The applicability of the reported calibration factors to surveys in other regions is discussed. Where these factors are not applicable, local calibration factors for indicator species of interest can be set up using the method presented.

1. Introduction

Mosses and lichens are known as efficient accumulators of heavy metals. Since they lack roots, these life forms depend largely on atmospheric deposition for their supply of mineral elements. In recent years they have been widely used as indicators of heavy-metal deposition (Rühling and Tyler, 1968; Herrmann, 1976; Tomassini et al., 1976). As a rule only one species has been used per study. Many authors have determined the metal concentrations in different species but, apart from a few studies (Nieboer et al., 1972; Steinnes, 1977; Grodzińska, 1978), few data have been published on the accumulation efficiency of different species. It is quite clear, however, that the metal concentrations can vary considerably between species in the same site. With no quantitative information on these differences it has hitherto not been possible to use alternative species in a survey. This is unfortunate as it is often difficult to find material in each sample site if the survey is restricted to one sample species.

The aim of this study is to develop a method that makes it possible to include samples of nine alternative moss and lichen species in a survey of heavy-metal pollution based on metal concentrations in one of the species. This is achieved by setting up calibration factors for concentrations in the different species. With
the help of these factors the concentration that would appear in a species not found in a certain sample site can be estimated from an actual concentration measured in any one of the other eight species.

2. Material and Methods

Material was sampled in the surroundings of a brass foundry in the village of Gusum, SE Sweden. The study area comprises a sparsely inhabited area of coniferous (*Pinus sylvestris* L. and *Picea abies* (L.) Karst.) woodland with an acid, low-nutrient siliceous moraine soil. Bare bedrock is widespread. *Vaccinium myrtillus* L., *V. vitis-idaea* L. and *Deschampsia flexuosa* (L.) Trin. characterize the field layer. The mean annual precipitation is 550 to 600 mm. There are no other industries in the area, but the foundry emits considerable amounts of Cu and Zn and some Pb, Cd and Ni but only a little SO₂.

The Zn concentration in epiphytic *Hypogymnia physodes* (L.) Nyl. (on *Pinus* trunks) ranges from >1600 μg g⁻¹ dry wt near the foundry to about 100 μg g⁻¹ at a distance of 7 km. Many plant species, especially mosses and lichens, are lacking in the vicinity of the foundry and at the border of occurrence of living *Pleurozium schreberi* (Brid.) Mitt., 1.5 to 2 km from the foundry, copper levels reach about 100 μg g⁻¹, whereas 10 to 15 μg g⁻¹ is a typical level at a distance of 7 km.

A computer was used to randomize 180 sample sites at 0 to 7 km from the foundry in such a way that 45 sites were randomly distributed within each of four sectors of the compass. The site density was made to increase gradually towards the center of the investigation area. Wherever possible the following species were sampled: the mosses *Dicranum polysetum* Sw., *Hylocomium splendens* (Hedw.) B.S.G., *Hypnum cupressiforme* Hedw., *Pleurozium schreberi* and *Pohlia nutans* (Hedw.) Lindb. and the lichens *Cladonia rangiferina* (L.) Wigg., *Hypogymnia physodes*, *Pseudevernia furfuracea* (L.) Zopf and *Usnea filipendula* Stirt.

Many of the 180 sites were disregarded in this study as one or more of the 9 species were lacking. The remaining 57 sites can be designated moderately polluted, since no complete sample set was obtained closer to the foundry than 1.6 km. The sample sites were situated more than 170 m from any main road.

*Pohlia* was sampled on rocks or large stones. For the other mosses, these substrates, as well as stumps and logs, were avoided and samples were taken on the ground. In most sites *Hypnum*, unlike the other mosses, was collected partly on sloping rocks due to shortage of material on level ground. *Cladonia* was sampled from organic substrate on rocks, *Pseudevernia* from branches and trunks of *Pinus sylvestris*, *Usnea* from branches and trunks of *P. sylvestris* and *Picea abies* and, finally, *Hypogymnia* from *Pinus* trunks. The field work was done from 17 July to 16 October 1974 and from 15 July to 21 August 1975.