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BIOINDICATION OF SULPHUR DISTRIBUTION IN ESTONIA USING MOSSES

Abstract. Sulphur content in five widespread forest mosses — *Hypnum cupressiforme*, *Hylocomium splendens*, *Dicranum polysetum*, *Pleurozium schreberi*, and *Rhytidiadelphus triquetrus* — was studied to find out its accumulation in different species and its distribution on the territory of Estonia. It was detected that the value of plants as indicators was not the same: the best indicators were *H. splendens*, *P. schreberi*, and *R. triquetrus*.

The results enabled to draw up a bioindicational map of the sulphur content in mosses in Estonia. The map coincides with precipitation maps and the location of the main pollution sources.

The content of sulphates and soil pH were also studied. No considerable correlation with the content of sulphur in mosses was detected.

Key words: sulphur, air pollution, pH, indicator plant, *Hypnum cupressiforme*, *Hylocomium splendens*, *Dicranum polysetum*, *Pleurozium schreberi*, *Rhytidiadelphus triquetrus*, Estonia.

Introduction

Determination of the concentration of air pollutants in plants is a relatively new method of bioindication. This method has some advantages over the usual investigation of the occurrence, frequency, covering, and damages of species. These vegetational parameters depend not only on the state of the atmosphere, but also on local conditions (e.g. aridity) and they can be compared only in ecologically completely similar areas which are extremely difficult, if not impossible, to find. Investigation of the accumulation of elements does not require similarity in the subject areas: it depends only on the location of main pollution sources and on the climatic conditions (e.g. the direction of wind) (Laaksovirta, Olkkonen, 1979; Swieboda, Kalemba, 1981). This method sets out three conditions for plants as indicators:

1) they must accumulate air pollutants;

2) the content of elements in plants must depend on the distance from the emission source and the character of the distribution of pollutants;

3) natural content of the subject elements in these plants must be persistent under the given geochemical conditions (Laaksovirta, Olkkonen, 1977).

Among higher plants, the plants most suitable for such work are mosses (LeBlanc et al., 1974). As mosses have no roots, they get most of the nutrients (including sulphur) not from the soil, but from the air with the help of their leaves (Taoda, 1973; Roman, Volkmar, 1975). Air can penetrate freely due to the absence of impenetrable cuticle and adjustable stomata. Mosses have very quick metabolism. Rain water with pollutants dissolved in it is absorbed by the whole surface. And finally, mosses as perennial plants are active also in winter when pollution is especially high (Barkman, 1969).

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Materials and Methods

Sulphur content in the five most common forest mosses in Estonia — *H. cupressiforme*, *H. splendens*, *D. polysetum*, *P. schreberi*, and *R. triquetrus* — was determined. In addition, the content of sulphates and soil pH were determined. The material was collected from all parts of Estonia, for which the territory of the republic was divided into squares of 9×11 km. Moss samples were collected from 350 squares. The place for taking the samples was selected in coniferous forests at least 100 metres from the nearest road. Samples were collected in the summers of 1987—1989, and on Saaremaa Island in 1985 and 1989. Altogether more than 1000 moss samples and 136 soil samples were taken.

Sulphur content was determined in the whole plants, without separating living and dead parts of the plant. To do this, the material was ashed in Eschka powder and oxidized by HNO_3 into sulphates which were determined as $BaSO_4$.

The results were analysed by a computer, using correlation analyses.

Results and Discussion

The minimum sulphur content was quite similar in all five subject mosses (Table).

The minimum value may also be considered as the natural background in these mosses, therefore, the background sulphur content is practically the same in all the subject mosses. Differences appear when the impact of the pollution source is greater, which allows us to presume that the subject species do not accumulate sulphur to the same extent and, therefore, their behaviour as indicator plants may be different. For example, it seems that *D. polysetum* does not accumulate sulphur so well as the other four species. The average sulphur content in these species is almost the same. The strongest correlation, $r=0.84$, existed between *H. splendens* and *D. polysetum* sulphur contents, as well as between *H. splendens* and *P. schreberi* ($r=0.75$), *P. schreberi* and *R. triquetrus* ($r=0.81$), and *D. polysetum* and *P. schreberi* ($r=0.76$).

The weakest correlation with all the other species existed in the case of *H. cupressiforme* ($r=0.51-0.63$). Therefore, *H. cupressiforme* cannot be regarded as a better indicator than the other three species. In conclusion it could be said that our three most common forest mosses — *H. splendens*, *P. schreberi*, and *R. triquetrus* — are the best and the most easily available sulphur indicators.

Minimum, maximum, and corrected average sulphur content in mosses, mg/g

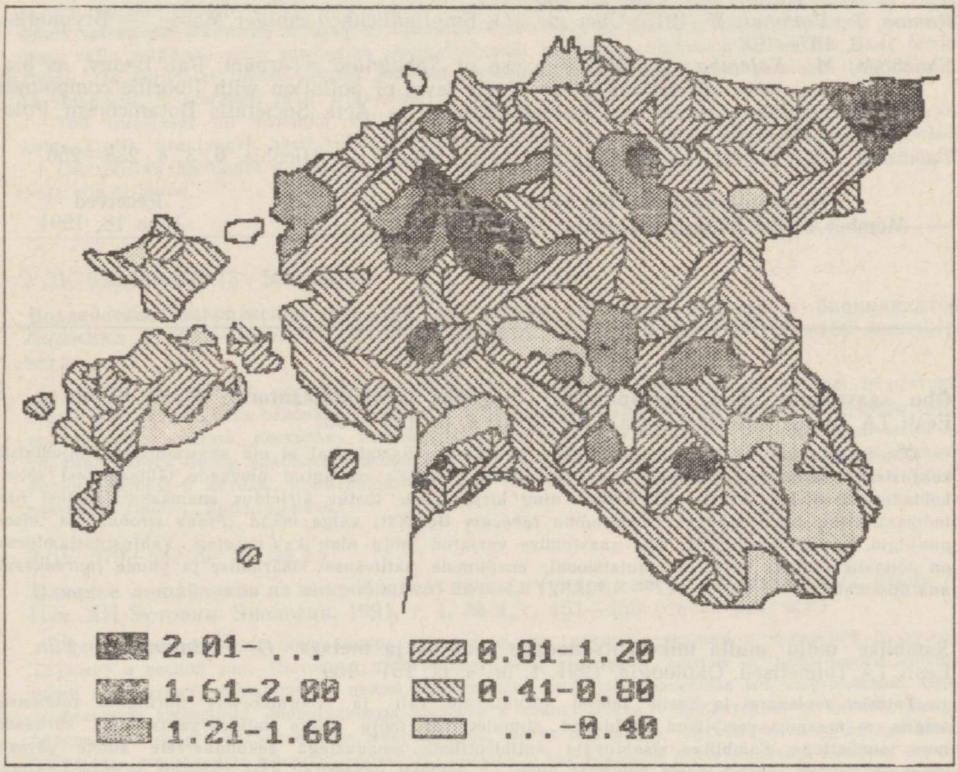
Species	Min.	Max.	Aver.
Hypnum cupressiforme Hedw.	0.10	2.26	0.73
Hylocomium splendens Br. Sch. et Gmb.	0.10	2.43	0.78
Dicranum polysetum Hedw.	0.12	1.76	0.67
Pleurozium schreberi Mitt.	0.10	2.68	0.74
Rhytidiadelphus triquetrus (Lindb.) Warnst.	0.10	3.25	0.78

As to the relation between sulphur content in *P. schreberi*, soil pH, and sulphate ion content, no statistically reliable correlation was detected. It is evident that the character of local pollution also plays a certain role here. For example, in North-East Estonia there is much fly ash which

increases soil pH. The results of the present investigation also indicate that the soils in North-East Estonia are not very acid. The highest acidity rate was detected between Rapla and Türi, Central Estonia, the uplands of Pandivere, Sakala, Otepää, and Haanja, which are the regions with the most abundant precipitation, and in the vicinity of Maardu, a centre of the chemical industry.

The greatest content of sulphates was found in North-East and Central Estonia, also in the vicinity of Tallinn, Tartu, and Pärnu. The content of sulphates was a little higher also in South-East Estonia.

The obtained results enabled us to draw up a map of the distribution of sulphur in Estonian mosses (Figure). The results coincide well with the map of precipitation (Agrometeoroloogiline . . ., 1987, 1988, 1989, 1990) and the location of the main pollution sources. The greatest concentrations of sulphur were detected in the impact regions of the Narva Power Plant and the Estonian Power Plant, on the uplands of Pandivere, Otepää, and Sakala, but also in Rapla County where maximum precipitation amounts have been registered. In general it could be noted that the content of sulphur in mosses is greater in North-West and Central Estonia where there is more precipitation. A front through the whole Estonia in the direction from north-west to south-east can be noticed. On the one hand, it could be explained by the impact of air-borne pollutants from the north-east which come down in the region of maximum precipitation. On the other hand, also sulphur compounds from Western Europe may be carried here.



Bioindicational map of Estonia on the basis of sulphur content in mosses, mg/g.

The present research shows that our three most common forest mosses — *H. splendens*, *P. schreberi*, and *R. triquetrus* — are good indicators for determining sulphur pollution in the air. Our further studies will concentrate on finding more exact relationships between sulphur content in mosses and the amount of precipitation.

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Õhu saastumise mõju metsapuudele: diagnoos ja bioindikaatorid. *D. F. Karnosky.* — Eesti TA Toimetised. Ökoloogia, 1991, **1**, nr. 4, lk. 145—150

Õhu saastumine on metsadele oluline stressifaktor. Samal ajal ei ole saastumisest põhjustatud kahjustused selgesti määratavad ega spetsiifilised. Artiklis on antud ülevaade tähtsamatest seisukohtadest saastekahjustuste määramisel ning kirjandusele toetuv kirjeldus enamkasutatavatest bioindikaatoritest, nagu tubakas (*Nicotiniana tabacum* Bel-W3), valge mänd (*Pinus strobus*) ja teised puuliigid, samuti samblikud. Õhu saastumise varjatud mõju ning ka varajasi kahjustusstaadiume on võimalik hinnata väävli akumulatsiooni, ensüümide aktiivsuse määramise ja puude juurdekasvu analüüsi kaudu.

Samblike mõju mulla mikrobotsönoosile tundras ja metsas. *O. Parinkina, T. Piin.* — Eesti TA Toimetised. Ökoloogia, 1991, **1**, nr. 4, lk. 151—159

Taimõri poolsaarel ja Eestis tehtud kõrvutavate väli- ja laboratoorsete uuringute tulemusel selgus, et maapinnasamblikud avaldavad stimuleerivat mõju mulla mikroorganismidele sarnaselt muu taimkattega. Samblikes sisalduvate antibiootiliste omadustega sekundaarsete ainete pärssiv mõju oli suurim sporogeensete bakterite puhul ja selgesti fikseeritav vaid vahetult sambliku talluse alumiste osadega seotud õhukeses mullakihis. Ükssama samblikuliik avaldab erinevates looduslikes vööndites ühesugust mõju mulla mikrobotsönoosile.