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The Use of Lichens in Atmospheric Trace Element Deposition Studies in Slovenia

By

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Summary

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In 1992, a monitoring survey on a national scale was carried out using *Hypogymnia physodes* as a biomonitor for trace element air pollution. The primary aim was to analyse epiphytic lichens to gain information about the levels of elements in the atmosphere and to identify significant pollution sources. The geographical concentration patterns of the trace elements obtained from the lichen data were mapped and compared with the Index of Atmospheric Purity (IAP) calculated on the basis of data from lichen thalli type mapping, obtained on a more dense bioindication grid in 1991.

The results obtained showed good agreement between the mapping of sulphur and trace elements with the status of lichen vegetation. The most exposed regions with elevated trace element levels and lower values of IAP were in the north-western Alpine part of Slovenia which coincides with high precipitation, and in the east of Slovenia, where many local pollution sources are situated.

Introduction

Determination of atmospheric pollution generally requires a wide network of sampling stations and the use of technical equipment to collect and measure air particulate matter and deposition. Usually such monitoring programmes over large areas are expensive and sometimes impossible because of the lack of basic services (electricity), especially at remote places (PUCKETT 1988). Therefore an alternative method using biomonitors such as lichens, mosses, tree bark or pine needles can be

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applied (MARKERT 1993). In many respects, lichens posses optimal characteristics for biomonitoring trace elements and radionuclides (PUCKETT 1988, MARKERT 1993).

The air in Slovenia is considered to be rather polluted, based on results for classical air pollutants available from the national ambient air monitoring programme (HRČEK & al. 1992). Polluted air is manifested as forest damage. One of the methods for investigating the reasons for forest decline is the use of lichen distribution mapping, the so-called IAP method, which was pioneered by DE SLOOVER & LEBLANC 1968. This method assigns numerical values to phyto-ociological characteristics of lichens at each site and then, through a mathematical formula, reduces these to a single IAP value for each site. The IAP values are then mapped. This method has also been used by BATIČ 1992 on a 4 x 4 km bioindication grid of Slovenia. However, this approach gives us only information that the air is polluted, but nothing can be said about the origin and type of pollutants.

The aim of the present paper is to present some of the results of our monitoring survey on a national scale using epiphytic lichens to monitor trace element air pollution and to compare the results with the IAP calculated on the basis of data from lichen thalli type mapping.

Materials and Methods

Sampling and sample preparation

Hypogymnia physodes L.(Nyl.) was used as the monitoring organism because it is one of the most tolerant epiphytic lichens to SO_2 and is also often used as a biomonitoring species in Slovenia (JERAN & al. 1993, 1995, 1996) as well as elsewhere (HERZIG & al. 1989). The lichen material was collected in the period from September to November 1992 at 86 sampling locations of the 16 x 16 km bioindication grid which has previously been introduced for some systematic studies connected with forest decline (BATIČ 1992). A detailed description of the sampling procedure has been given elsewhere (JERAN & al. 1995, 1996).

In the laboratory lichens were moistened with distilled water and then the adhering bark particles removed. After freeze drying, the samples were frozen in liquid nitrogen, then crushed and ground in a zirconia mortar with a ZrO_2 ball in a Fritch vibration micro-pulverizer. About 100-200 mg of dry lichen powder was then used to press tablets for instrumental neutron activation analysis (INAA).

Analysis

The lichens were analysed for metals and other trace elements using k_0-INAA (SIMONITS & al. 1975, SMODIŠ 1992). The lichen tablets were irradiated for 20 hours in the TRIGA Mark II reactor of the J. Stefan Institute, at a thermal neutron fluence rate of 1.1×10^{16} m^{-2} s^{-1}. Gamma spectrometric measurements were carried out with HPGe detectors connected to a Canberra 90 multichannel analyser. The details of the measurement procedures, including quality assessment of the method applied are given elsewhere (SMODIŠ 1992, SMODIŠ & al. 1992). Sulphur and lead were determined using X-ray fluorescence spectrometry (XRF).

Factor analysis

The data set of 28 element concentrations obtained for lichen samples collected at 86 stations of the national biomonitoring grid was subjected to Monte Carlo assisted target transformation factor analysis (TTFA) (KUIK & al. 1993a,b) performed at the Department of Radiochemistry of the Interfaculty Reactor Institute (IRI), Delft University of Technology, The Netherlands (JERAN & al. 1996).

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Results and Discussion

By applying non-destructive multielemental k_0-INAA it is usually possible to determine about 30 - 40 elements in lichens.

One way of presenting results for the element composition of epiphytic lichens collected on the national scale is by graphical mapping of the geographical isocontours of each element so that insight into the levels of each particular element is possible. In Fig.1a the example of sulphur distribution is given. The elemental concentrations were divided into 7 classes according to the percentile values and mapped.

It is interesting to compare the geographical sulphur concentration pattern (Fig.1a) as obtained from the results of lichen analysis on the 16x16 km bioindication grid with the distribution of IAP values (Fig.1b) calculated on the basis of a lichen inventory on 4x4 km plots performed in 1991 (BATIČ 1992). As can be seen from the two Figs., the most exposed regions with elevated levels of sulphur and some other elements such as, Cd, Cr, Fe, Mo, Sb, Se, Sr, Th, U, W, Zn and lower values of IAP are in the north-western Alpine part of Slovenia which coincides with high precipitation, and in the east of Slovenia, where many local pollution sources are situated.

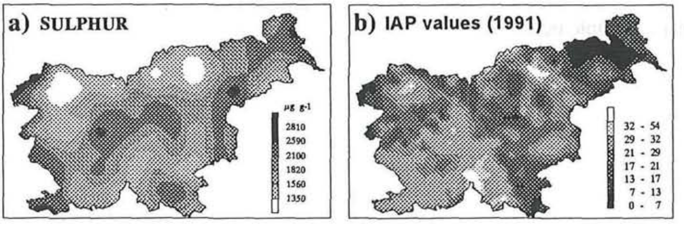

Fig. 1. a: The geographical concentration pattern of sulphur obtained from lichen data on the national scale, divided into 7 classes according to percentile values (10, 30, 30, 50, 70, 90, 95 %). b: Lichen map of Slovenia based on the IAP values as obtained from observing lichen vegetation on 4x4 km plots in 1991, on different types of trees. The IAP values have a span between 0-54, (where the value 0 means a plot without lichens and very polluted air and the value 54 means very rich lichen vegetation and very clean air) and are divided into 7 classes according to the percentile values (10, 30, 50, 70, 90, 95%).

Knowing that the sources of elements that cause elevated levels in lichens are both natural (crustal material, marine aerosols) and anthropogenic (industry, traffic, etc.), there are at least two ways of identifying the contributions of elements from different source terms; (i) by calculating the enrichment factor (EF) for each individual element, and (ii) by applying multivariate statistical techniques to the data set (SLOOF & WOLTERBEEK 1991, KUIK & al. 1993b, NASH III & GRIES 1995, JERAN & al. 1996).

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Application of Monte Carlo-assisted FA to 28 elements in *H. physodes* resulted in 9 factors which were assigned to crustal material, the steel industry, a contribution from the marine aerosol elements, the metallurgical industry, to coal burning processes, as well as to some other mining and industrial activities (JERAN & al. 1996). By plotting the factor values it is possible to obtain insight into atmospheric pollution in the territory of Slovenia, to compare the results with IAP values, and perhaps eventually identify the factors causing forest degradation.

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