Preface: validation and application of plants as biomonitors of atmospheric trace element deposition

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Biographical notes: Borut Smodiš is a Senior Research Associate at the Jožef Stefan Institute, Ljubljana, Slovenia. He received a PhD in Chemical Sciences in 1991 from the University of Ljubljana. From 1996 to 2003, he was assigned with the International Atomic Energy Agency (IAEA), the Division of Human Health, as Nuclear Analytical Specialist and Health Environmental Toxicologist within the Nutritional and Health-Related Environmental Studies Section. During the assignment, he coordinated a number of research projects on studying human exposure to toxic elements. His main research interests include developments in nuclear analytical techniques (mainly neutron activation analysis), radiochemistry, application of radioactive tracers in studying environmental cycling of heavy metals and environmental monitoring of toxic elements and radionuclides.

1 Introduction

It is known that direct measurements of airborne pollutants (e.g. airborne particulate matter) on a large scale are extremely costly and labour-intensive; therefore, impractical and almost impossible. Biomonitoring, that is, continuous observation of an area with the help of bioindicators, is also an appropriate tool for assessing the levels of air pollution. In this context, a bioindicator is an organism (or part of it) that reveals the presence of a substance in its surroundings with observable and measurable changes (e.g. accumulation of pollutants), which can be distinguished from the effects of natural stress. Application of bioindicators has several advantages compared with the use of direct measurements of contaminants, related primarily to the ease of sampling, trace element accumulation and consequently facilitating the analysis and provision of measurement of integrated exposure over time. Simple and inexpensive sampling procedures allow a very large number of sites to be included in the same survey, permitting detailed geographical patterns to be drawn. Biomonitoring can be an effective tool for pollutant mapping and trend monitoring in real time and retrospective analysis. By application of appropriate statistical tools, information can also be obtained on the type and location of pollution sources as well as on the short-, medium- and long-range trans-boundary transport of environmental pollutants.

Mosses and lichens lack root systems, so they depend on surface absorption of nutrients; they have been shown to concentrate particulates and dissolved chemical species from dry and wet deposition. Therefore, they have been considered as the most appropriate bioindicators for studying atmospheric deposition of pollutants.

In Europe and several other developed countries, nuclear and related analytical techniques, such as neutron activation analysis, inductively coupled plasma mass spectrometry and X-ray fluorescence analysis, have been shown to be particularly appropriate for the analysis of such organisms. The use of these analytical techniques, as part of nuclear technology at large, comes within mandate of the International Atomic Energy Agency (IAEA) a specialised technical organisation within the United Nations Organisation family. Therefore, the IAEA initiated a Coordinated Research Project (CRP) on 'Validation and application of plants as biomonitors of trace element atmospheric pollution, analysed by nuclear and related techniques' in 1998. The responsible IAEA organisational unit was the Nutritional and Health-related Environmental Studies Section of the Division of Human Health, from the Department of Nuclear Sciences and Applications. The CRP consisted of 14 participating institutions, partly financially supported by the IAEA, from the same number of countries worldwide.

The objective of the five-year project was to identify suitable bioindicators of atmospheric trace element pollution for local and/or regional application (e.g. moss and/or lichen); whenever possible these bioindicators should be validated for general environmental monitoring. The project was coordinated by the IAEA staff, and the progress discussed during three research coordination meetings held at Vienna and Lisbon. The participants carried out their own investigations according to the agreed plans. The group consisted of several well-recognised teams in biomonitoring research as well as several newcomers still paving their way into more profound scientific work. Therefore, an important outcome of the CRP was knowledge transfer and exchange of experience among the group. The participants addressed the following key research areas:

- *Quantification*: assessment of a quantitative relationship between the elemental content of the bioindicator species and the (wet or bulk) deposition or the atmospheric concentrations.
- *Time resolution*: assessment of the element accumulation rate in the bioindicator to permit estimates of the time needed for the monitor to reflect new elemental atmospheric/deposition conditions.
- *Geographical resolution*: resolution strength of the bioindicator in a spatial sense. This means that local variability in bioindicator responses, survey design (grid density) and spatial variability in deposition and atmospheric concentrations should be considered simultaneously.
- *Survey*: assessment of geographical differences and/or time trends in deposition and/or atmospheric concentrations by the determination of the elemental content of the sampled bioindicator species.
- *Mapping*: graphical representation of the bioindicator-based results, mostly referred to cases where local and/or regional surveys are carried out.
- *Impact*: assessment of the changes in bioindicator parameters as a result of ambient and/or internal conditions. This means that selected physiological/biochemical parameters are quantified in relationship with the varying extent of deposition and/or atmospheric concentrations. Furthermore, changes in selected parameter values are determined in order to get insight into the consequences: changed values may lead to changed relationships between monitor and deposition and/or atmospheric concentrations.

Although the participants harmonised and validated their sample collection, preparation and analysis procedures, it was concluded that, owing to diverse meteorological and other environmental conditions in different parts of the world (e.g. temperature, amount of dust in air, amount of precipitation), the possibility of harmonising operating procedures is limited. Similarly, there is no bioindicator species available on a global scale. Nevertheless, several epiphytic species from the genus *Tillandsia* (the Bromeliaceae family) were identified as appropriate regional bioindicators for the tropical and subtropical parts of Latin America and the Caribbean countries.

This Special Issue of the *International Journal of Environment and Pollution* contains a selection of six interesting national CRP contributions of sound scientific value. These papers include contributions on various methodological aspects and case studies carried out within the framework of the CRP, as well as some interesting prospects for future work, addressing one or more above-mentioned research areas. It is hoped that the issue will be of interest to the journal readers, in particular to those who are involved in investigations concerned with biomonitoring trace element deposition from the atmosphere.