STUDIA UNIVERSITATIS BABEŞ-BOLYAI, CHEMIA, XLVI, 1-2, 2001

BIOINDICATION OF ENVIRONMENTAL POLLUTION IN THE URBAN AND INDUSTRIAL AREAS

ANA-MARIA RUSU

Department of Chemistry, Babes-Bolyai University, Cluj-Napoca, Romania

ABSTRACT. Suitability of lichens mosses, fungi and tree leaves as accumulative indicators of trace element depositions in urban and industrial areas is discussed. The analysis of soils for the evaluation of the contamination level of an area is very important, but therefore the analysis of soils alone could be not sufficient. The use of different plant materials, due to their morphological characteristics, produces reliable results and can be done information about pollution at a very low cost comparatively to the traditional techniques. A short review of studies performed in the industrial area of Zlatna and Cluj-Napoca town with plant materials are given. The results obtained by plant materials and soil samples collected from the same areas provide a general overview on air pollution patterns within the investigated areas.

INTRODUCTION

The term “bioindicator” refer to the ability of an organism to indicate the presence/absence or high/low level of any factor in air pollution; where information is provided by the organism about pollutant gradients or changing pollution levels, the term “biomonitor” should be applied [1]. The terms are also used to differentiate between qualitative and quantitative, and further, monitoring can mean continuous observation, while indication can mean on-off measurements.

Vegetation may reveal the presence of man-made contaminated sites by measuring plant elemental contents. Source of contamination in which excessive concentrations of elements may be brought about are follows: 1. The exploration of mineral resources (mining activities, ore tailings, spoil tips; metal smelting, blast furnaces, smokes dusts); 2. Other industrial processes (electrolysis, cement, paint, tanning, plating, etc.); 3. Domestic and industrial waste disposal practices (landfills, sewage sludge, incinerators); 4. Energy supply (coal and petroleum burning, high tension lines, nuclear power plants); 5. Agriculture (Phosphate fertiliser, sewage sludge, pesticides); and 6. Traffic (leaded petrol, tyres, catalysts).

In general polluted air consist of a mixed gas-aerosol complex containing varying concentrations of SO_2, NO_x, O_3, and acid aerosols; notably in the vicinity of smelting operations, plants are subjected to fumes rich in SO_2 and other pollutants together with particulate matter.

The ideal accumulative bioindicator is a species, in which internal concentrations accurately reflect external concentrations, but in general it does not exist. Some demands must be fulfilled by an acceptable bioindicator. It should be:

- present in large amounts;
- widely distributed over the globe;
- easy to identify and to sample;
- analysable according to the standard analytical methods presently available.

The most widely used bioindicators of metal pollution in the industrial and urban areas are lichens, mosses, fungi and high plants. True mosses and lichens are useful indicators of pollution because not only are they long-lived and ubiquitous in all parts of the world from the tropics to the Arctic regions, but more importantly, they have no true root systems and obtain their nutrients (and pollutants) from the ambient air and water and not from the soil. It will be remembered that the fallout from recent Chernobyl disaster was measured largely by measuring the concentration of radionuclides in mosses and lichens from Fennoscardia and other parts of Europe [2.3]. Studies on lichens as biomonitors of metals and other elements were thoroughly reviewed by many authors [4-7]. As regards their suitability as bioindicators, and because there is a great similarity in many characteristics, mosses and lichens are often discussed together [8]. Because of the specific anatomical and physiological characteristics higher fungi are especially suitable for accumulating heavy metals from soil. In addition their intimate association with the soil and dead organic matter offer conditions for intensive exchange with the substrate [9]. Moreover it is very likely that heavy metal input to soil via deposition and litter fall is the main source of the heavy metal concentration found in fungi. In contrast to lichens, mosses and fungi, higher plants generally show a clear division into roots, shoots and leaves. The accumulation of heavy metals by higher plants represent both pathways of contamination, the accumulation of airborne heavy metals on the plant surfaces, and their uptake of heavy metal from soil [10-12]. Nevertheless it has been show in many studies that in polluted areas leaves can be regarded as accumulative monitors of many metal elements, because a great proportion of the elements deposited or intercepted is not imported into the leaf tissues but remains on the surface or in the wax cuticular.

This paper present a short review of studies performed in the industrial area of Zlatna and Cluj-Napoca town with plant materials. Moreover are presented the result of the deposition from atmosphere over industrial and urban areas, mainly due to the luck of suitable, sensitive and inexpensive techniques (using bioindicators) that permit simultaneous measurements usually at a large number of sampling sites. The present paper compares the contents of Cu, Pb and Zn in lichens, mosses, fungi, leaves and soils collected from two sampling sites from Zlatna (the lowest and the most polluted). Also, Cu, Pb and Zn concentrations determined in leaves collected from Zlatna and Cluj-Napoca are compared.

RESULTS AND DISCUSSION

Romania, like other countries in Europe and the World, is confronted with serious problems of environmental pollution as a consequence of intensive industrialisation. One ‘intensely polluted zone’ is the Zlatna region of central Transilvania. A cooper ore processing plant in the centre of Zlatna town produces acidic emission and large amount of metal particulates, both causing extreme environmental degradation throughout the locality. Previous studies [13] have indicated that concentration of pollutant elements in soils (Pb – 1800 μg/g; Cu – 600 μg/g; Zn – 500 μg/g) greatly exceed current Romanian Standards [14] maximum acceptable levels (Pb - 20 μg/g; Cu - 20 μg/g; Zn - 100 μg/g).

The location of the 7 studied sample sites and also, plants and soils sampling and sample preparation for analysis were described in detail elsewhere [13,15,16]. Flame atomic absorption spectrometer was employed for the metal elements determination.

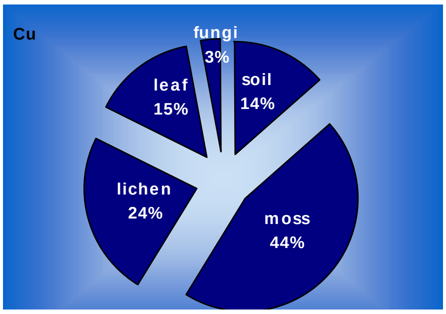
The Cu, Zn and Pb accumulation in lichens, mosses, fungi, leaves and soil at the two sites (Patringeni and Metes) from Zlatna town areas are shown in Fig. 1 and Fig. 2. In general, there are considerable differences in uptake and content of heavy metals between different plant materials. Considering the three elements Cu, Zn and Pb which were determined in all plant samples, the concentrations (μg/g d.w.) generally follow the order:

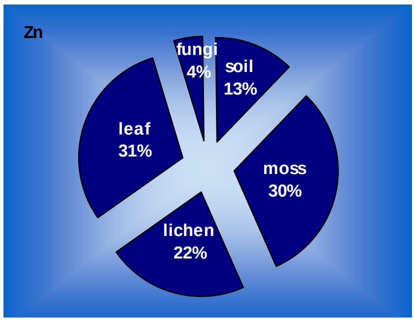
Cu - Patringeni: moss(2259)>lichen(1190)>leaf(761)>soil(687)>fungi(136)
- Metes: lichen(518)>moss(370)>leaf(349)>soil(106)>fungi(54)
Zn - Patringeni: leaf(1020)>moss(1019)>lichen(720)>soil(416)>fungi(143)
- Metes: leaf(638)>lichen(377)>moss(294)>soil(237)>fungi(120)
Pb - Patringeni : moss(3918)>lichen(2079)>soil(1833)>leaf(1679)>fungi(147)
- Metes: lichen(1087)>leaf(896)>moss(776)>soil(260)>fungi(73)

Cooper and Pb are higher in lichens and mosses, whereas Zn is higher in leaves. The soil and fungi samples have the lowest content of determined elements, except the very high Pb concentration measured in soil for the most polluted site investigated from Zlatna region. Also, the Cu, Zn and Pb concentration determined in all analysed samples decreases with distance from the pollutant source.

With regard to the present results no plant material can be considered to be an exact indicator of environmental heavy metal pollution. However, bioindicators could be useful for distinguishing between polluted and unpolluted areas and for determining sources of heavy metals emission. It may be concluded that many plants species can serve as indicator (accumulators), with different sensitivities to heavy metals and different abilities to accumulate them. Accumulation of heavy metals depends on the characteristics of the species in question as described above.

Undoubtedly urban pollution gives a serious contribution to global contamination of the environment. The extent and type and kind of this type of pollution depends on many factors among which are the number of inhabitants, their habits, types of energy sources, types and dimensions of the industrial zones, types and intensity of the motor-traffic and of course a lot of climatic factors.





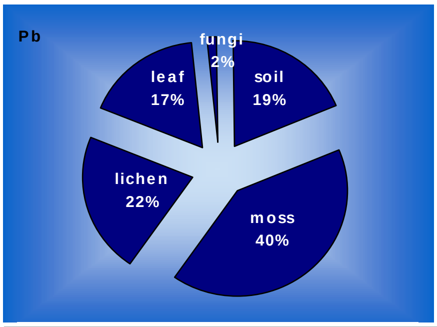
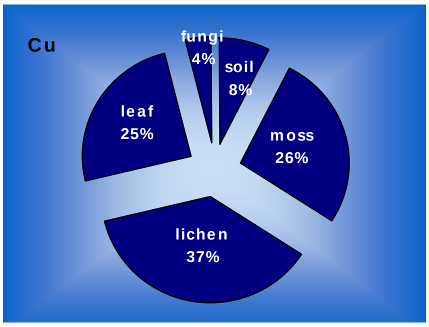
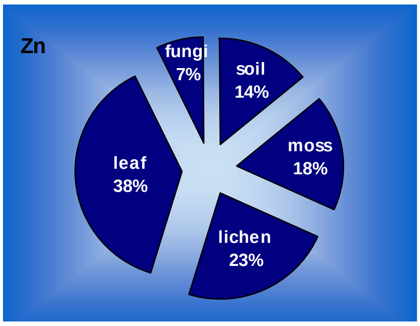


Fig. 1 Cu, Zn and Pb accumulation in lichens, mosses, fungi, leaves and soil in the most polluted site around Zlatna (Patringeni - 3.5 km SW close to the pollution sourse)





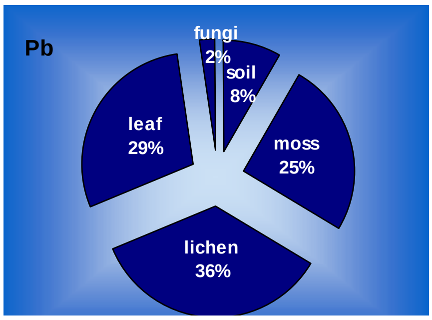


Fig. 2. Cu, Zn and Pb accumulation in lichens, mosses, fungi, leaves and soil collected in the most far studied site (Metes - 16 km WSW close to the pollution sourse).

Tilia cordata and *Acer Platanoides* leaves species has been used for passive monitoring of airborne heavy metal pollution in the urban area of Cluj-Napoca, Romania. By passive monitoring we have completed a general survey of the present heavy metal contamination within Cluj-Napoca in comparison with results from Zlatna (industrial) areas investigated in previous researches [15]. The metal concentrations in leaves samples show remarkable differences according to the different exposures to air pollution in Cluj-Napoca. Lead rises from 10 μg/g d.w. (dry weight) in slightly polluted areas, up to 104 μg/g d.w. next to main traffic roads. Cooper range from 7 μg/g d.w. up to 88 μg/g d.w., while Zn ranged from 31 μg/g d.w. to 154 μg/g d.w. For comparison has been analysed local control background leaf samples, collected from Botanical Garden, considered unpolluted area. The concentration of Pb, Cu and Zn were 2 μg/g d.w., 4 μg/g d.w., and 30μg/g d.w., respectively.

Comparative results of min. and max. Pb, Cu and Zn values measured in leaves collected from Zlatna industrial region and Cluj- Napoca urban areas are presented in Fig. 3. As show the fig. 3 the min. values for Pb, Cu and Zn measured in Zlatna are 90, 50 and 21 times higher than those determined in Cluj-Napoca; while the max. values measured in Zlatna are 16, 9 and 7 times higher than values determined in leaves collected in Cluj-Napoca for the same elements. Comparing the data for Pb, Cu and Zn found in the investigated industrial and urban areas with the control background leaf samples, collected from Botanical Garden, it is possible to draw conclusions about the pollution degree. In Zlatna the min. concentrations of Pb, Cu and Zn in leaves are approximately 450, 90 and 21 times higher than the control value; while in Cluj-Napoca the pollution degree for Pb and Cu is 5 and 2 times higher than in Botanical Garden, and the Zn concentration not exceed the control sample content. The max. values of Pb, Cu and Zn measured in leaves collected from Zlatna are 850, 192, and 34 times higher than those determined in Botanical Garden, while Pb, Cu and Zn max. concentration in leaves collected from Cluj-Napoca are 52, 22 and 5 times higher than in control samples.

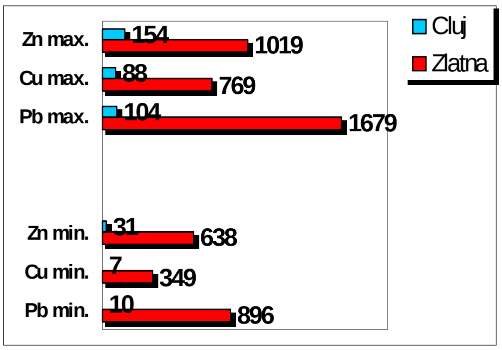


Fig. 3 Comparative results of min. and max. Pb, Cu and Zn values measured in leaf samples collected from Zlatna industrial region and Cluj- Napoca urban areas.

We concluded that Pb contamination in Zlatna is very high and in Cluj-Napoca relatively high. Also, Cu and Zn concentration exceed the normal admissible values in the main investigated areas.

REFERENCE

1. J.E. Sloof, M. De Bruin, H. Wolterbeek, in: *International Conference on Environmental Contamination, Venice Sept. 1988, Symposium proceedings:* Orio A.A. (ed.). Edinburgh, CEP Consultants Ltd.
2. J. Paatero, T. Jaakkola, A. Reponen, *Radiochim. Acta,* 1994, **64(2)**, 139-144.
3. I.G.Gokmen, M.Akgoz, A.Gokmen, *Fresenius'J.Anal.Chem.*, 1996, **355(5-6)**, 736-738.
4. P.W. James, in: *Air Pollution and Lichens*: B.W. Ferry, M.S. Baddeley, D.L Hawksworth, (eds.). London: The Athlone Press, 1973, 143-175.
5. Y. Tuominen, T. Jaakkola, in: *The Lichens:* V. Ahmadjian, M.E. Hale (eds.). New York: Academic Press, 1973, 185-223.
6. E. Niober, K.J. Puckett, D.H.S. Richardson, F.D. Tomassini, B. Grace, *International Conference of Heavy metals in the environment, Toronto, Ontario, Canada, Oct.1975, Symposium Proceedings,* Toronto, **Vol. 2**, 331-352.
7. E. Niober, D.H.S. Richardson, F.D. Tomassini, *The Bryologist,* 1978, **81**, 226-246.
8. K.J. Pucket, in: Lichens, Bryophytes and Air Quality. *Bibl. Lichenol* **30**, J. Cramer Verl., Berlin, 1988, 231-267.
9. A.R. Byrne, V.Ravnik, L.Kosta, *Sci.Total Environ.,* 1976, **6**, 65-78.
10. S. Halles, K. Debrock, J.M. Dumont, *Sci. Total Environ.,* 1979, **13**, 141-155.
11. R. Wittig, A. Terhorst, *Acta Biologica Benrodis,* 1988, **1** (2).
12. B. Mnkovska, *Biologia,* 1981, **36**, 489-496.
13. A.M. Rusu, W. Dubbin, N. Har, K. Bartok, W. O. Purvis, B. Williamson, *Studia Univ. Babes-Bolyai, Geologia,* 2000, **XLV (1)**, 105-113.
14. Monitorul Oficial al Romaniei (1997) IX, 303/I: 27.
15. A.M. Rusu, K. Bartok, W. Dubbin, W. O. Purvis, *Studia Univ. Babes-Bolyai, Chimia,* 2000, **XLV**, **1-2**, 241-250.
16. A.M. Rusu, K. Bartok, V. Din, W. O. Purvis, W. Dubbin, *Studia Univ. Babes-Bolyai, Chimia,* 2000, **XLV**, **1-2**, 251-259.