LOW-COST NATURAL MATERIALS USED IN MONITORING OF AIR QUALITY

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Abstract

In this paper has been studied the utilization of Sphagnum moss peat, natural moss peat and alkaline treated moss peat for the active biomonitoring of air quality from two different areas: Poiana Negrii and Poiana Stampei (Dorna Basin, Romania), during of September – October 2009. The following heavy metals: Pb, Cd, Cu, Mn and Fe, were used as indicators of the level of air pollution in studied areas. Accumulated heavy metals in the exposure sorbents were determined by graphite-furnance electrothermal atomic absorption spectrometry and used for the calculation of the enrichment factor (EF) in each case. The experimental results have show that the efficiency of studied natural materials in the retention of mentioned heavy metals from air depends by the nature of monitorized heavy metal, location and also by the exposure time. On the basis of obtained results, the efficiency of considered low-cost natural materials in active biomonitoring of air quality was considered.

1. Introduction

Air pollution represents an important issue in many parts of the world, especially in industrialized countries [1]. A large number of atmospheric pollutants are emitted from both natural and anthropogenic sources. Some of them are represented by the heavy metals that can exist in atmosphere as particles, causing the deterioration of air quality [2]. Aside from the environmental damage, human health is likely to be affected as the presence of heavy metals beyond a certain limit brings hazards to living organisms. For instance, the lead, cadmium and copper have been proved to cause kidney and liver damage, paralysis or chromic asthma [3]. From this reason the monitoring of air quality has a great importance.

In the last years, the most used method for the monitoring of air quality is active monitoring. The active monitoring is considered a relatively simple method, which offers a variety of information about the presence of some pollutants in air from certain region, during of well determined period of time. In addition, natural materials available in large quantities or waste products from industry or agriculture, generally named "low-cost" materials have been proven to be suitable for this purpose [4]. The Sphagnum peat moss and peat moss, in natural form or activated by chemical treatments are several examples of such materials which can be successfully used in the monitoring of air quality.

In this study, we have tested the possibility of utilization of three types of natural materials: Sphagnum peat moss, natural moss peat and alkaline treated moss peat, for the monitoring of air quality from two different areas: Poiana Negrii and Poiana Stampei (Dorna Basin, Romania), during of two months (September – October, 2009). The following heavy metals: Pb, Cd, Cu, Mn and

Fe, were used as indicators of the level of air pollution in studied areas. On the basis of obtained results, the efficiency of considered low-cost materials in active biomonitoring of air quality was evaluated. The obtained results indicate that the Sphagnum moss peat is a more effective biomonitor for studied heavy metals that the natural moss peat and alkaline treated moss peat, and this is due both to various functional groups and its high porosity.

2. Experimental

The sorbents samples (Sphagnum moss peat, natural moss peat and alkaline treated moss peat) were collected from Tinovu Mare Reservation (Romania). Before use, the straying components have been removed, and the obtained materials were washed, dried in air (4 hours at 75 °C), sieves and crushed to a particle size of 0.5 – 1.0 mm. The alkaline treated moss peat was obtained by treating the natural moss peat with 0.2 mol/L NaOH solution, according with the experimental procedure described by Bulgariu et al., 2011 [5]. Around 4.0 g of sorbents were placed in polyethylene bags and exposed in the monitoring points from studied area.

The sorbent samples (Sphagnum moss peat, natural moss peat and alkaline treated moss peat) were placed inside of Poiana Negrii and Poiana Stampei areas (Dorna Bazin), at a minimum distance of 250 – 300 m from any root and about 1 km from inhabited area and 5 km from dense populated area. All samples were suspended at a constant height of 2.0 m above ground, to avoid the influence of wind, and the exposure period was by 2 months (September – October 2009). At the end of each month, two samples from each sorbent have been collected and used for the analytical determination of heavy metals contents. The experimental values of heavy metals concentration (determined in duplicate) were then used for the calculation of enrichment factors (*EF*) according with the mathematical relation [6]:

$$EF = \frac{[M]_{after}}{[M]_{initial}} \qquad (1)$$

where: $[M]_{after}$ is the concentration of heavy metals after exposure period (μg/g of dry sorbent) and $[M]_{initial}$ is the concentration of heavy metals before exposure period (μg/g of dry sorbent).

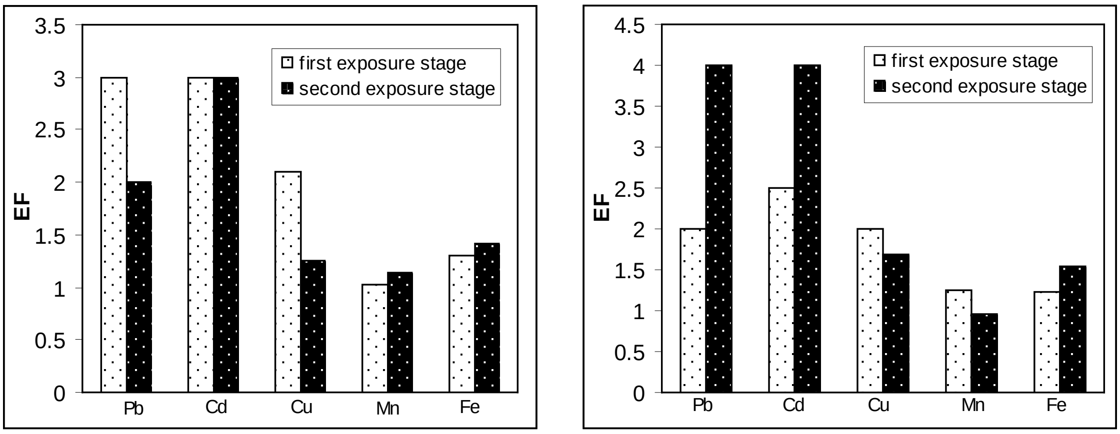
The concentrations of heavy metals in each sorbent sample, before and after each biomonitoring period (30 days) were determined by graphite-furnace electrothermal atomic absorption spectrometry (Vario 6.0 Atomic Absorption Spectrometer), using a prepared calibration graph. Five heavy metals (Pb, Cd, Cu, Mn and Fe) were monitories and determined by this method.

3. Results and discussion

The experimental results have been obtained for two sets of sorbents samples collected after two different period of exposure, from the location situated in the Poiana Negrii and Poiana Stampei areas. Figs. 1-3 show the ratio of the concentration of each studied heavy metal after each exposure period and in the control samples, prior to exposure, from both areas.

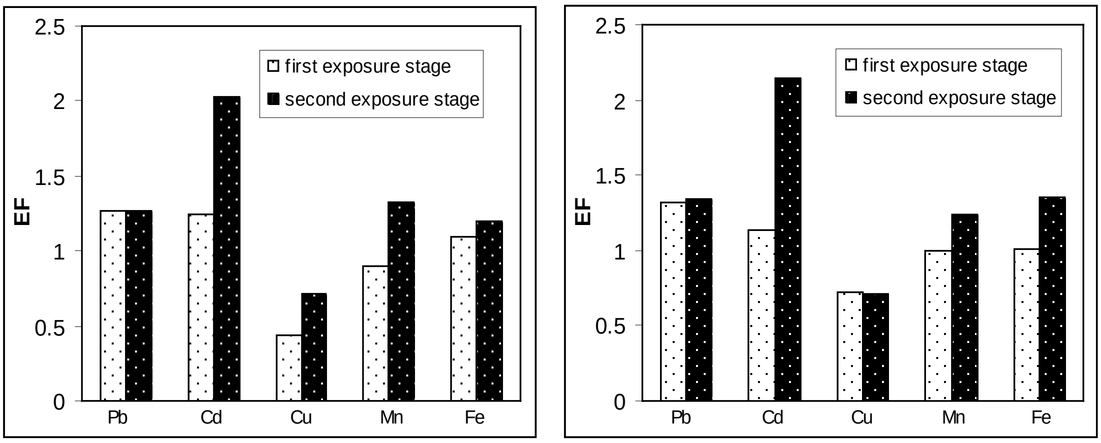
This ratio represents the enrichment factor (EF) and its values show the accumulation of certain heavy metal, during the exposure time [6]. This parameter can be used for to interpret the changes in the heavy metals content without assuming a linear or non-linear model describing the heavy metals accumulation and/or release, during of the time of exposure [7]. In function of EF value, the accumulation/loss of certain pollutant can be estimated on the basis of the following five categories [6, 8]: (a) EF = 0÷0.25 – sever loss; (b) EF = 0.25÷0.75 – loss; (c) EF = 0.75÷1.25 – normal tendency; (d) EF = 1.25÷1.75 – accumulation; and (e) EF > 1.75 – sever accumulation.

It can be observed from Fig. 1 that the Sphagnum moss peat has a sever accumulation tendency for Pb, Cd and Cu, an accumulation tendency for Fe and a normal behaviour for Mn, both in the first and second exposure periods. However, should be noted that in case of Poiana Negrii area, the values of EF ratio are higher after first exposure stage than after second exposure stage for Pb, Cd and Cu, and lower for Mn and Fe. In case of Poiana Stampei area, the values of EF are higher after first exposure stage for Cu, Mn and Fe, and lower for Pb and Cd.



(a) (b)

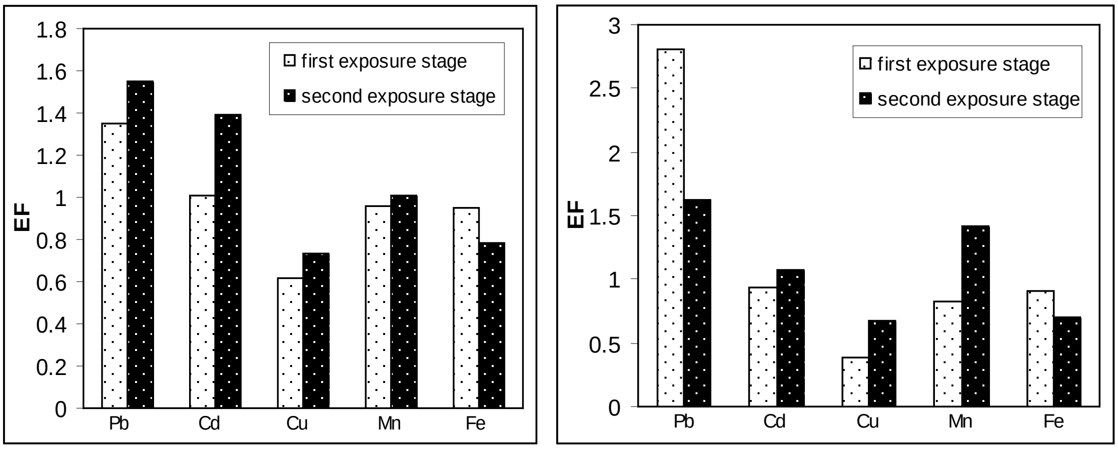
Fig. 1. The EF values for studied heavy metals when using the Sphagnum moss peat as a sorbent for biomonitoring: (a) Poiana Negrii; (b) Poiana Stampei.



(a) (b)

Fig. 2. The EF values for studied heavy metals when using the natural moss peat, as a sorbent for biomonitoring: (a) Poiana Negrii; (b) Poiana Stampei.

In case of natural moss peat, the EF values are lower than those obtained when using Sphagnum moss peat as sorbent. Thus, with exception of Cd, which has a sever accumulation tendency after second exposure stage, an accumulation tendency can be observed in case of Pb, Mn and Fe, or even a normal behaviour in case of Cu, in both studied areas. Also, for all studied heavy metals, the values of EF ratio are higher after second exposure stage than after first exposure stage, with exception of Cu from Poiana Stampei area.



(a) (b)

Fig. 3. The EF values for studied heavy metals when using the alkaline treated moss peat, as a sorbent for biomonitoring: (a) Poiana Negrii; (b) Poiana Stampei.

When alkaline treated moss peat is used for the biomonitoring of air, the obtained EF values indicate a sever accumulation only in case of Pb in Poiana Stampei area, while for all other studied heavy metals an accumulation tendency or even a normal behaviour should be noted. And in case of this sorbent, the EF values are higher after second exposure stage than after first exposure stage, with exception of Fe in both areas, and Pb in Poiana Stampei area.

On the basis of these experimental observations, it can be said that the Sphagnum moss peat is a more effective biomonitor for studied heavy metals that the natural moss peat and alkaline treated moss peat. This sorbent manifest a high affinity for heavy metals with toxic potential (Pb, Cd and Cu), than the other studied sorbents. This characteristic is determined both by the nature of functional groups from sorbent surface and by the porosity of this.

4. Conclusion

In this study, three types of low-cost natural materials (Sphagnum moss peat, natural moss peat and alkaline treated moss peat) were tested for the active biomonitoring of air quality from Poiana Negrii and Poiana Stampei areas. The biomonitoring study was performed during of two months (September – October 2009), and the sample were analyzed after each exposure period of 30 days, by graphite-furnace electrothermal atomic absorption spectrometry. The contents of five heavy metals (Pb, Cd, Cu, Mn and Fe) from the exposed and unexposed sorbents samples were used to calculate the enrichment factor (EF) values.

On the bases of the EF values can be observed that the Sphagnum moss peat has a severe accumulation tendency for Pb, Cd and Cu, an accumulation tendency for Fe and a normal behaviour for Mn. In case of natural moss peat and alkaline treated moss peat, the obtained values of the enrichment factor are lower. Also, some differences between heavy metals contents after first and second exposure period was observed.

The experimental results indicate that the Sphagnum moss peat is a more efficient biomonitor for studied heavy metals, that the natural moss peat and alkaline treated moss peat

5. Reference

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