VNU Journal of Science: Mathematics – Physics, Vol. 33, No. 2 (2017) 53-58

Preliminary Results of PIXE Analysis of Mosses for Air Pollution Monitoring in Hanoi Using Pelletron Accelerator

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Received 17 April 2017
Revised 26 May 2017; Accepted 15 June 2017

Abstract: Air pollution is a major problem in many cities in Vietnam. The existence of heavy metals in dust particles in the air impacts negatively on human health. There are many different methods to collect dust in the air and analyse the heavy metals concentration. The method using mosses as a biological indicator for monitoring air pollution has been using widely around the world. This paper presents the preliminary results of using moss for analysis of heavy metals in the air in Hanoi by PIXE technique on Pelletron electrostatic accelerator of the VNU, University of Science (HUS).

Keywords: Moss, Pelletron, PIXE, Accelerator, Air pollution.

1. Introduction

Using biomonitor as air pollution indicators is emerging trend besides direct air analysis. This is especially when monitoring large areas [1]. The usefulness of moss in determining the concentrations of heavy metals in the air in different regions were discussed and demonstrated in several studies [2, 3]. Research-based pollution filter dust in the air is only in a short sampling period. Sampling in a large number of places and in long term by the technical equipments is very expensive. Biomonitoring is a cost effective and appropriate solution. Biomonitoring is defined as a method for assessing the several characteristics of the biosphere with the use of bio-organisms. Bioindicator or biological monitor [4] is used to call this organism. Biomonitor is organisms that provide quantitative information about the quality of environment [3, 5]. Therefore, this method requires proper organism. The sample can be collected in large areas or the sites where away from the laboratories. The major advantages of bioindicators are no requirement of using expensive sampling equipment in the long term, also they could be found easily. Especially, the heavy metal concentrations in organisms are higher than in other technical monitoring systems. This can improve the accuracy of measurements.

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https://doi.org/10.25073/2588-1124/vnumap.4204

Furthermore, most organisms reflect environmental conditions in average value during certain periods of time when pollution level rapidly changes with time, this average becomes important.

The key of using mosses as a biomonitor for air pollution analysis are their abilitis in nutrients absorption from wet and dry deposition through their leaves. They do not have true roots for uptake from substrates. The use of mosses as a biomonitor for air pollution analysis have become popular in the world such as in European countries since the early 1960s [5], in North America in 1996. In Wisconsin (USA), moss-bag technique was used to monitor heavy metal, sulfur and nitrogen using mesh bags containing Sphagnum russowii [6]. Similar studies were done in Romania, Russia and Bulgaria using Sphagnum girgensohnii with 36 elements investigated [7]. In 1990s, in most European countries [8], the moss species were used to obtain information about the deposition of heavy metals in the region, changes in deposition model, long-distance transmission of gas, and the local emission sources.

The aim of this study is to test the capability of the heavy metal analyzing method in mosses on the Pelletron accelerator in HUS. In the next phases, we can establish a standardized protocol for sampling, sample preparation, elemental analysis by PIXE method with many more samples and sites.

2. Material and method

2.1. Equipment

Analysis of the samples was done on the National Electrostatic Corporation Model 5SDH-2 Pelletron at HUS. This is a 1.7 million volt tandem electrostatic accelerator.

Figure 1. Model 5SDH-Pelletron accelerator, at Hanoi University of Science.

2.2. Sample preparation and processing

In this study, we chose Sphagnum moss as a biomonitor with suitable for monitoring heavy metal pollution [9] due to the high cation-exchange capacity of their cell walls [10]. Sphagnum moss samples were collected in the mountain (higher than 1000m at Ta Cu Ty commune, Bac Ha district, Lao Cai province. Sample processing procedure was shown in (fig. 2, 3, 4, 5) and given below:

- Washing mosses.
- Creating moss bag (weight 2 gram dry moss per a bag).
- Hanging samples at a place in a certain time.
- Transferring samples to laboratory.
- Sample processing before analysis.

Figure 2. Moss bag.

Figure 3. Sphagnum mosses.

Figure 4. Moss sample processing.

Figure 5. A moss bag hangs on the outdoor to monitor the air metal contents of the site.

2.3. PIXE method

The samples were analyzed by the PIXE technique using to determine the major or minor elements in a wide range of material samples. When the X-rays are detected by a high resolution detector, the well known Z-dependence of the X-ray energies, as well as the intensities of the X-rays lines, allow a straightforward determination of the target elements. PIXE technique has proved to be a sensitive analytical method of the chemical elements, especially convenient for analyzing multi-elements. The detection limit of this analytical technique is in the ppm range for all elements with a high Z number, because intense fluxes of charged particle obtained from tandem accelerator are readily available, the X-ray production yields for particles beam with energies in the MeV range are large and the background associated with the exciting radiation is rather low.

For our PIXE analyses we used a proton beam with max energy of 3.4 MeV, a thick target (standard and moss sample in the form of pellets) was placed in the center of the reaction chamber at an angle of 32.8° with respect to the incident beam. The beam transport tube of accelerator and reaction chamber was maintained in a high vacuum (10^{-7} Torr) during target irradiation. The characteristic X-ray spectra of samples were detected by X ray spectroscopy with a Silicon Drift Detector (SDD), coupled to a PC- based multichannel analyzer with energy resolution (FWHM) of 138 eV at X 5.9 keV Mn K X-ray and processed off-line using the GUPIX software. Concentrations of elements from samples were determined using known values of concentrations of the same elements from the reference samples.

3. Results and discussions

Details of the PIXE spectrum obtained during the bombardment of moss samples were represented in Figure 6. Peaks in the spectrum occur at energies indicative of characteristic X rays and the qualitative analysis is an easy task in PIXE due to the known dependence of X-ray energies with the atomic number of elements.

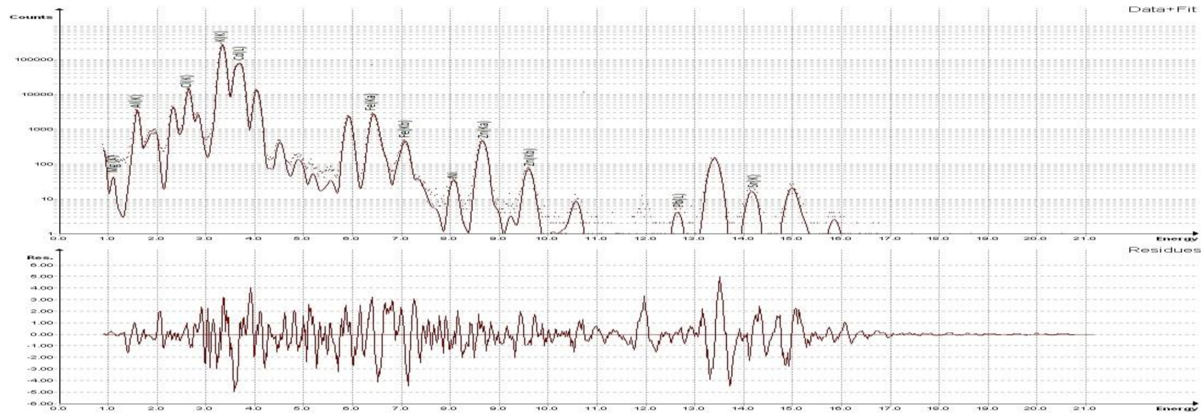

Figure 6. PIXE spectrum of a moss sample.

In this work, concentration of ten elements: Mg, Cl, K, Al, Fe, Cd, Zn, Sr, Pb, Ni have been determined in the moss samples hung in the different periods of time. The results are shown in Figure7.

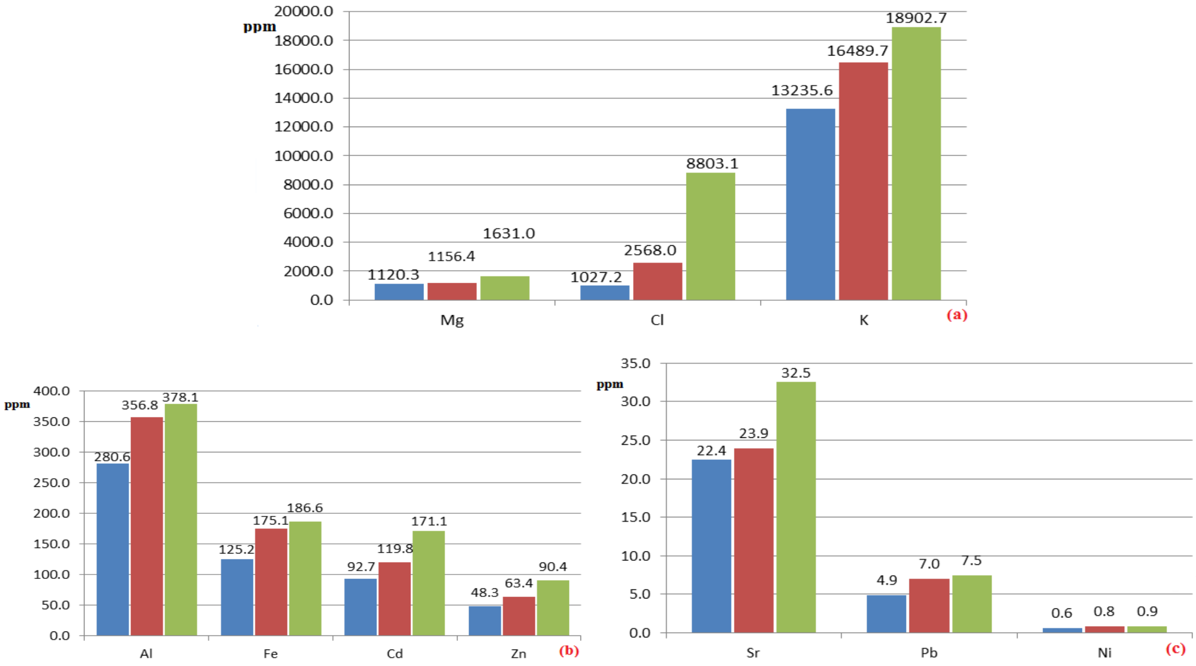

Figure 7. The results of heavy metal concentration in moss samples(a,b,c). The blue, red and green shape represents the concentration of sample collected on Sept. 03, 2016, 04/17/2016 and 06/13/2016, respectively.

Base on the analysis results illustrated in Figure 7, we have some comments:

- The concentration of elements which absorbed in the moss samples increase with time.

- The absorption of each element is different depending on many factors such as the number and type of free cation exchange sites, the age of the cells, their reaction desiccation, temperature, precipitation, pH, composition of the pollutants, and leaching. The concentration of Cl element significant increases in the 3rd measurements and reaching closely 243% compared to the previous measurements.

- The concentration of potassium is the highest and nikel has the lowest concentration in the same investgated area and reaching 13236 ppm and 0.6 ppm, respectively, in the first measurement.

- In the same moss sample, the concentration of 3 elements Mg, Cl, K are higher than 1000ppm. Meanwihile, the group of Zn, Pb and Ni having the lower concentration.

4. Conclusions

The study was implemented on moss species from Lao Cai province, the samples were hung at a family in Gia Lam District, Ha Noi. After some periods of time, they were colllected and brought to accelerator laboratory, Department of Nuclear Technology, Faculty of Physic, Hanoi University of Science with content:

- Checking the possiblity of using Sphagnum moss as bioindicator of atmospheric heavy metal pollution.

- Setting up sampling and analytical procedure.

- Determination of the heavy metals concentration of moss samples at the same hung place by PIXE method using 5SDH-2 Pelletron accelerator.

The results have confirmed the responsible ability of the sphagnum moss as bioindicator, the concentration of heavy metals increases with time hanging samples, concentrations of elemental chlorine is hight level and suddenly increase in third measurements. We hope that next studies about factors that affecting the chlorine levels, as well as hanging and measuring samples at different times may reveal the reason of higher chlorine concentration.

5. Perspectives

From the preliminary results about the responsible ability the sphagnum moss in the analysis of heavy metals in the air, in next phases, we need to evaluate some parameters:

- Analysis of the original moss samples to assess the background concentrations of heavy metals.

- Measure the moss samples at various periods of huning to assess the level of pollution, as well as evaluating the fluctuations of pollution in the region.

- Samples will be hanged at many places for making maps of air pollution, especially in industrial areas to having proper solution for environmental pollution problem.

- The presented PIXE technique is known for its sensitivity, accuracy, precision, sometimes quickly, requiring small amounts of material and the ability to perform multielemental analysis of a large number of samples, it is high potential in assessing the pollution level of a region.

Acknowledgments

This paper is completed with financial support from the project QG.10-15 of VNU.

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