2009 International Nuclear Atlantic Conference - INAC 2009
Rio de Janeiro,RJ, Brazil, September27 to October 2, 2009
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: **978-85-99141-03-8**

ASSESSMENT OF AIR QUALITY IN MANGABEIRAS' PARK, BELO HORIZONTE, BRAZIL, USING EPIPHYTIC LICHENS AS BIOMONITOR

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ABSTRACT

Biomonitoring has been used as an alternative method to study the air pollution in several countries. The lichen, or lichenized fungi, is one of the most efficient on air pollution biomonitoring among the biomonitors. However, in Brazil, systematic use of lichens as biomonitors of environmental pollution is quite rare. In order to make an assessment of the air quality of the Mangabeiras' Park, this study was conducted by measuring the concentration of elements accumulated in the lichen thallus. This park, located in Belo Horizonte (Minas Gerais, Brazil), is the greatest green area in the city, and an apparent region of non polluted air.
During the development of the study, epiphytic lichens of several species were collected using a steel stainless knife, taking samples of similar sizes from 1.5 m from the soil. The lichens selection was based on morphological similarities, such as color and type of the thallus. The elemental concentration determination was carried out applying the neutron activation technique, k_0-standardization method, using the TRIGA MARK I IPR-R1 research reactor located at CDTN/CNEN.
The lichen samples presented expressive concentrations of Ba, Fe, K, Na and Zn. However, the presence of other characteristic soil elements from the region, such as As, Th and U, suggests the influence of the mining activity area, located in the surroundings.

1. INTRODUCTION

Nowadays, the use of lichens, or lichenized funghi, in the biomonitoring of atmospheric pollution is considered a significant and widespread tool when compared with the traditional methods of direct measurement of air contaminants [1]. However, in Brazil, despite the large number of lichen species already identified, this type of study is quite rare.

By definition, lichens are a symbiotic association between a fungus and an alga. It's a complex organism, which morphological and physiological characteristics - such as absence of stomata and cuticle, slow growing, environmental nutritional dependence, between others – that allow them to be used as excellent biomonitor of atmospheric pollution [2].

Belo Horizonte, located at the State of Minas Gerais, is the fifth most populated city of the country, being the Mangabeiras' Park, the greatest green area in the city. The Park area is positioned at the basis of the called "Serra do Curral", five kilometers away from the

downtown. From the earliest 60's until 1979, in this area, which belonged to a municipal mining company, extracting and processing of iron took place. The Mangabeiras' Park was opened in 1982, and actually it's, apparently, a region of non polluted air.

In order to make an assessment of the air quality of the Mangabeiras' Park in the last years, this study was conducted by measuring the concentration of elements accumulated in the thallus of lichen samples collected in the park.

2. MATERIALS AND METHODS

Initially studies were made about the distribution and presence of epiphytic lichens in the Mangabeiras' Park. Observing some morphological similarities, such as type of thallus and color, lichen samples of several species were selected in three different regions of the Park. The sampling sites (Fig.1) were always along the Park tracks, which have local traffic only. In order to have one idea of the elemental concentrations in each region, 6 to 8 samples of each region were grouped, forming one sample.

Figure 1. Satellite image of the Mangabeiras' Park area with the sampling sites marked. (Source: http://maps.google.com.br/)

2.1. Sampling and sample preparation

According to the procedure applied at the Nuclear and Energy Research Institute, IPEN – CNEN/SP [3, 4], lichen samples of several species were collected from *Tabebuia sp* trees using a stainless steel knife, 1.5 m high from de soil, observing the lichens' size between 0.3

cm and 0.9 cm of diameter. After being collected, all the samples were inserted into paper bags to avoid mould formation.

To remove extraneous materials, such as pieces of bark carried out during the collect, the samples were cleaned using stainless steel calipers (pertaining to a medical kit) and a 10x/20x loupe. After that, each sample was washed with 250 mL of deionized water to remove adhering particles. Then the samples were air dried at room temperature and inserted into polyethylene tubes, frozen under a temperature of -70 ºC and, then, lyophilized for 24 hours. The samples were weighted and inserted in irradiation vials.

2.2. Neutron Activation Analyses

Elemental concentration was carried out applying the neutron activation technique, k_0-standardization method, using the TRIGA MARK I IPR-R1 research reactor located at CDTN/CNEN, Belo Horizonte. The samples – around 100 mg each one - were irradiated simultaneously with neutron flux monitor Al-Au (0.1%) IRMM-530RA foil cut into 5 mm diameter and 0.1 mm thick. The irradiation was for eight hours in the carrousel IC-7, at 100 kW, under a thermal neutron flux of 6.35×10^{11} cm^{-2} s^{-1}. The parameters f and α in the IC-40 are (22.32 ± 0.2) and (-0.0022 ± 0.0002), respectively.

The gamma spectroscopy was performed on an HPGe detector with 50% efficiency and for the spectra analysis - peak area evaluation - the HyperLab program [5] was used. For the calculation of elemental concentrations a software package called KAYZERO/SOLCOI [6] was applied.

3. RESULTS

The Table 1 summarizes the results of the elemental concentration in lichen thallus and of the reference material analysis. The compounded lichen samples showed a range of 25 elements, being Ba, Ca, Fe, K, Na and Zn the ones with the most expressive concentrations. However, the Fe detached with the highest concentration in all samples. Results obtained for the lichen certified reference material IAEA 336 showed a good precision and a good agreement with the recommended values.

Table 1. Elemental concentration (mg kg^{-1}) in Mangabeiras' Park lichen samples and Reference material analysis

Element	Lichens' elemental concentration			Reference Material – IAEA 336	
	Sample 1 Region 1	Sample 2 Region 2	Sample 3 Region 3	Recommended Values	Experimental Values
As	4.8 ± 0.2	6.9 ± 0.2	3.4 ± 0.1	0.63 ± 0.08	0.71 ± 0.03
Au	0.016 ± 0.001	0.028 ± 0.001	0.014 ± 0.001	NR	0.0022 ± 0.0002
Ba	64 ± 10	68 ± 4	50 ± 4	6.4 ± 1.1	< 30
Br	7.8 ± 0.3	9.7 ± 0.3	10.6 ± 0.4	12.9 ± 1.7	12.5 ± 0.4
Ca	<2281	29750 ± 1398	14870 ± 848	NR	NR
Ce	5.9 ± 0.4	7.9 ± 0.4	4.4 ± 0.3	1.28 ± 0.17	1.22 ± 0.07
Co	1.6 ± 0.1	2.3 ± 0.1	1.2 ± 0.1	1.29 ± 0.05	0.30 ± 0.01
Cr	19 ± 1	25 ± 1	14 ± 1	1.06 ± 0.17*	3.3 ± 0.3
Cs	< 0.4	0.5 ± 0.1	0.4 ± 0.1	0.11 ± 0.013	0.12 ± 0.01
Eu	< 0.01	0.11 ± 0.01	< 0.01	NR	< 0.04
Fe	30550 ± 1082	34130 ± 1202	16470 ± 590	430 ± 50	445 ± 34
Hf	0.46 ± 0.04	0.65 ± 0.05	0.39 ± 0.07	NR	0.057 ± 0.005
K	1212 ± 44	1412 ± 55	908 ± 34	1840 ± 200	1950 ± 74
La	2.7 ± 0.1	< 1	2.0 ± 0.1	0.66 ± 0.1	0.64 ± 0.02
Na	43 ± 2	37 ± 1	27 ± 1	32 ± 4	39 ± 1
Nd	< 3	558 ± 25	< 3	0.6 ± 0.18*	< 3
Sb	0.57 ± 0.03	0.74 ± 0.03	0.34 ± 0.02	0.073 ± 0.01	< 0.03
Sc	1.12 ± 0.04	1.52 ± 0.05	0.75 ± 0.03	0.17 ± 0.03*	0.188 ± 0.007
Sm	0.39 ± 0.01	0.46 ± 0.02	0.25 ± 0.01	0.106 ± 0.014	0.095 ± 0.007
Ta	< 0.1	0.16 ± 0.02	< 0.1	NR	0.016 ± 0.002
Th	0.9 ± 0.1	1.35 ± 0.06	0.73 ± 0.05	0.14 ± 0.02	0.15 ± 0.01
U	0.38 ± 0.02	0.49 ± 0.02	0.25 ± 0.01	NR	< 0.03
W	0.66 ± 0.03	0.71 ± 0.03	1.11 ± 0.05	NR	< 0.11
Yb	0.22 ± 0.02	< 0.1	3 ± 1	0.037 ± 0.012*	< 0.05
Zn	58 ± 4	74 ±4	43 ± 3	30.4 ± 3.4	35 ± 2

* Information values; NR. Not Reported

4. DISCUSSION

Apart from being a preliminary study, the results were unexpected to an apparent area of non polluted air, because of the range and concentration of the elements determined. Therefore, discussions around the source of the elements are of great importance. To do so, comparisons with previous works were made, and the probable origin of some elements was speculated.

According to some authors [7, 8] the locations where the soil is exposed to wind erosion, windblown dust can represent an important source of elements to lichens. To identify the soil elements presented in the lichen samples, it is relevant to mention, the natural composition of the soil in this region, Iron Quadrangle [9]. Therefore, the mining activity, close to Mangabeiras' Park, may have contributed for the emissions of soil particles during excavation processes, for example, with Fe, As and Au, once iron ore occurs associated with As and Au [9]. Besides that, mechanisms of long-distance atmospheric transport of pollutants

could be eventually involved and responsible for carrying out elements to the sample sites [10].

It's also important to mention the presence of an iron mining company in the park area in the past. This fact may explain the high concentration of Fe in all lichen samples, possibly coming from soil.

The presence of Zn, Br and Ba suggests contamination of vehicular emissions [11, 12]. Maybe the sources of these elements are the emissions from the vehicles that cross the park (internal transportation) and others from a residential neighborhood very close to the park. It should be verified later.

The nuclear analytical method applied on elemental concentration determination, neutron activation technique, k_0-standardization method, was suitable on lichens analysis.

5. CONCLUSIONS

In this assessment of air quality of a non polluted area in Belo Horizonte, the sampling was made along the park tracks, where there is a daily traffic of vehicles. Applying the neutron activation analytical technique, a range of 25 elements was determined, being a large part, characteristic soil elements.

Knowing that the concentration of trace elements in lichen thalli may be directly correlated with environmental levels of these elements, the soil elements seem to be expressive in the air composition in the Park area. That allows the suggestion of influence of the mining activity area in the surroundings. Then, in this preliminary study, the results suggest that the soil is strongly contributing to the elemental composition of lichens.

It is important to emphasize that this is the first assessment of air using urban lichens. Next step of this work will comprise one choice of the lichen specie to be sampled. Soil matrix will also collect in order to verify the possible influence of this material on metal absorption.

This is an relevant study, not only because it is the first one being developed in this region using lichen as biomonitor, but also this work may give information about air quality during a period of time. The results will give insights to municipal environment institutions, supporting them in future actions.

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