

CHEMICAL ELEMENT COMPOSITION OF ATMOSPHERIC BROMELIADS FOR ACTIVE BIOMONITORING OF THE SUGARCANE CULTIVATION IMPACTS

**Thiago O. Santos^{1,2}, Crescencio A. Silva Filho², Mitiko Saiki³, Frederico A. Genezini³,
Elvis J. França², Clovis A. Hazin^{1,2} and Eliane Valentim²**

¹ Universidade Federal de Pernambuco – UFPE – Departamento de Energia Nuclear
Av. Professor Luiz Freire, 1000
50740-540 Recife, PE
thiago_cbufpe@yahoo.com.br

² Centro Regional de Ciências Nucleares (CRCN / CNEN – PE)
Av. Professor Luiz Freire 200
50740-540 Recife, PE
valentim@cnen.gov.br, candrade@cnen.gov.br, ejfranca@cnen.gov.br, chazin@cnen.gov.br

³ Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
mitiko@ipen.br, fredzini@ipen.br

ABSTRACT

The Ecologic Reserve of Gurjaú - ERG is inserted into the south portion of the Metropolitan Region of Recife, precisely in the limits of the municipalities of Jaboatão dos Guararapes, Cabo de Santo Agostinho and Moreno. This conservation unit is situated among the sugarcane processing plants of Salvador, São Braz, São João and Roças Velhas, being the last one the oldest in the Pernambuco State. In the ERG's boundaries, there are diverse anthropogenic activities such as the inappropriate application of pesticides and chemical fertilizers and sugarcane burning before harvesting, which increase the availability of numerous particles and gases for the atmosphere. Here, this study focused on the evaluation of air quality of the ERG's ecosystem using as biomonitor the atmospheric epiphyte *Tillandsia recurvata* by means of the analysis of chemical element composition of leaves after 150 days of exposure. The quantification of chemical elements was carried out by means of the neutron activation analysis using high resolution gamma-ray spectrometry to determine Br, Co, Cr, Fe, Se and Zn in *Tillandsia* leaves. First information on the use of the active biomonitoring was, therefore, provided to assess the main chemical elements associated to the sugarcane burning in the Pernambuco State.

1. INTRODUCTION

The Atlantic Forest is one of the hottest hotspots of the world. Biodiversity conservation is actually demanded for sustainable development mainly in urban areas such as the Metropolitan Region of Recife. The Ecologic Reserve of Gurjaú - ERG is a representative area of such biome and situated among the sugarcane processing plants of Salvador, São Braz, São João and Roças Velhas, being the last one the oldest in the Pernambuco State. The reserve was created in 1987 with a total area of about 1,100 ha, in which 400 ha represents the forested areas. Of course, some anthropogenic activities may contribute indiscriminately to harm the environment. Among them, sugarcane burning, pesticides and fertilizers are the most important sources of pollution for this ecosystem [1].

Sugarcane is one of the main cultures in Brazil since the sixteenth century. However, during the beginning of National Alcohol Program (PROÁLCOOL) in 1975, there was a great expansion in terms of cultivated area. This program was developed by the Brazilian government to stimulate the production of ethanol, used as fuel for automobiles. Currently, Brazil is the largest producer of cane sugar in the world with an estimated cultivated area of about 8 million ha and an intended production of 625,000 million tons of sugarcane for sugar (43%) and ethanol (57%) production for 2010/2011 [2].

In the Pernambuco State, Northeast Region, Brazil, sugarcane cultivation is widespread, especially in the Atlantic Forest original areas because of the most appropriated climate and soil conditions for cultivation. During the harvesting, burning is necessary to facilitate and protect workers from poisonous animals like snakes and scorpions. Sugarcane burning also increases up to 10 times the manual harvesting [3].

Sugarcane burning is responsible for the releasing of numerous particles and gases into the atmosphere. It is known that some of the compounds released by the burning process are carcinogenic, mutagenic and responsible for endocrine disorders [4]. The presence of very small particles may cause a significant impact on the health of exposed populations and the environment [4]. Monitoring of contaminants released into the environment is utmost relevant because the needs for estimating the main risks associated with such exposure. Several studies have documented the harmful effects caused to the environment, thereby, population, exposed to the particles produced during the burning of sugar cane [5,6,7].

Despite the use of instruments for particle monitoring, the genus *Tillandsia* of epiphytic bromeliads is recognized as biomonitor, thereby, highly sensitive, to air pollutants. These organisms are able to accumulate metals in tissues because of the exclusive dependence on the atmosphere to uptake nutrients and water [8]. Here, this study aimed at the evaluation of air quality of the ERG's ecosystem using as biomonitor the atmospheric epiphyte *Tillandsia recurvata* by means of the analysis of chemical element composition of leaves after 150 days of exposure. The quantification of chemical elements was carried out by means of the neutron activation analysis using high resolution gamma-ray spectrometry to determine six chemical elements in *Tillandsia* leaves. First information on the use of the active biomonitoring was, therefore, provided to evaluate the main chemical elements associated to the sugarcane burning in the Pernambuco State.

2. MATERIALS AND METHODS

2.1. Study area

The Reserva Ecológica de Gurjaú – ERG (coordinates: 273647.76 m E; 9090147.21 m S) is inserted into the south portion of the Metropolitan Region of Recife, precisely in the limits of the municipalities of Jaboatão dos Guararapes, Cabo de Santo Agostinho and Moreno (Figure 1). The climate is considered hot and humid according to the Köppen classification with annual rainfall of 1,900 mm (Autumn-Winter) [9]. For comparison, biomonitoring was also carried out in the Horto Florestal de Dois Irmãos (coordinates: 285521.93 m E;

9114737.16 m S), a conservation unit without direct influence of sugarcane burning (Figure 1).

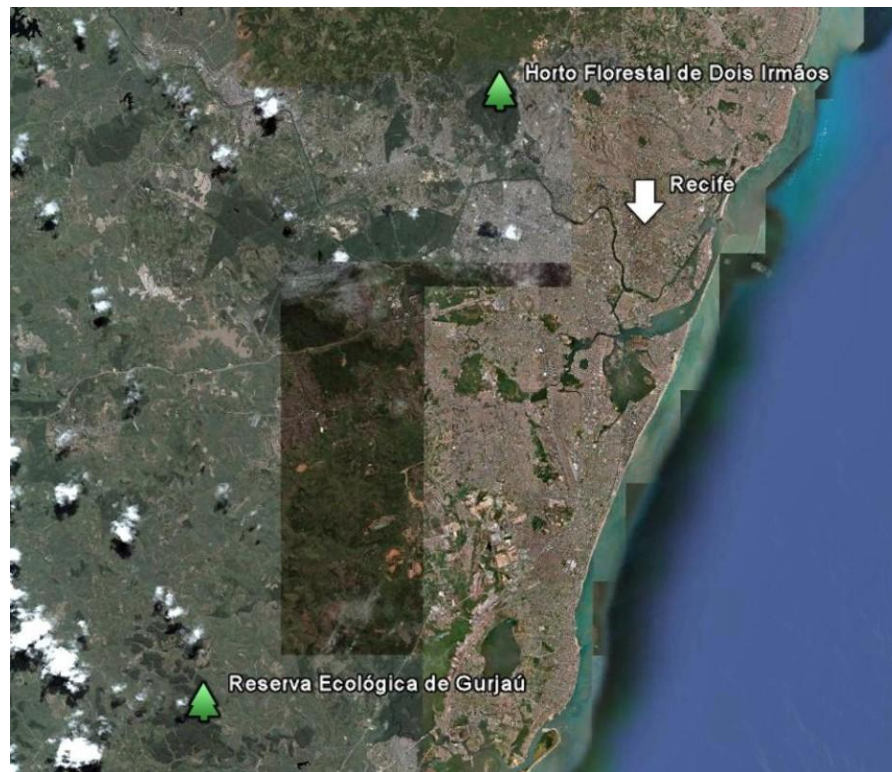


Figure 1. Localization of the conservation units in the Metropolitan Region of Recife, Pernambuco State, Brazil. Source: Google Earth (2011).

2.2. Sampling and experimental design

The transplants of the atmospheric bromeliad *Tillandsia recurvata* were collected on the rural area of the Municipality of Garanhuns, Pernambuco State, Brazil, an area far away from potential sources of air pollutants. Before transplantation, each biomonitor was cleaned to remove any interfering material. Experimental unit consisted of 12 g transferred to nylon mesh bags (2 mm) to allow the organism contact with the surrounding atmosphere. Samples were simultaneously transplanted to the Ecological Reserve of Gurjaú and the Horto Florestal de Dois Irmãos in order to compare the concentration of chemical elements in exposed organisms. The exposure period was six months (from September to February).

2.3. Sample preparation

After the exposure period, samples of the epiphyte *Tillandsia recurvate* were dried, milled in mortar and sieved to achieve maximum particle size of 1 mm. Test portions of approximately 200 mg of samples were directly weighed in polyethylene bags, sealed and, together, the standards and reference materials, conducted to chemical analysis.

2.4. Instrumental Neutron Activation Analysis – INAA, relative method

Aliquots of 50 µL of standard solutions of Br, Co, Cr, Fe, Se and Zn were pipetted on filter paper Whatman No. 42 using an automatic calibrated pipette. Filters were dried in a desiccator at room temperature. For quality of the analytical protocol, test portions of 200 mg of reference materials (IAEA 336 Trace Elements in Lichen; IAEA 392 Trace Elements in Algae) produced by International Agency of Atomic Energy. All samples, standards and reference materials were irradiated with a flux of 10^{13} neutrons per square centimeter for 16 hours at the IEA-R1 Nuclear Research Reactor of the Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN). High resolution gamma-ray spectrometry was utilized to quantify Br, Co, Cr, Fe, Se and Zn in *Tillandsia* samples.

2.5. Statistical analysis

Accumulation factor of chemical element concentrations analyzed in *Tillandsia recurvata* samples was estimated to compare the degree of pollution of the monitored sites according to the following equation:

$$FEE = \frac{(CEA - CEC)}{CEC} \times 100 \quad (1)$$

in which,

- FEE = Accumulation factor for the chemical element;
- CEA = Concentration of chemical element E in the sample,
- CEC = Concentration of chemical element E in the control sample.

3. RESULTS AND DISCUSSION

Table 1 shows the results of Br, Co, Cr, Fe, Se and Zn in *Tillandsia* samples from the control site (Garanhuns, Pernambuco State, Brazil), the Horto Florestal de Dois Irmãos and the Reserva Ecológica de Gurjaú. The estimated accumulation factors of chemical element concentrations analyzed by neutron activation analysis in samples of *Tillandsia recurvata* exposed at sites of monitoring compared to that place unpolluted can be shown in Figure 2.

Table 1. Concentration of chemical element and analytical uncertainties (mg kg⁻¹) in *Tillandsia recurvata* exposed to different atmospheric sources

Element	Control sample (Garanhuns)	Horto Florestal de Dois Irmãos	Reserva Ecológica de Gurjaú
Br	13.5 ± 0.3	14.50 ± 0.10	11.7 ± 0.2
Co	2.19 ± 0.03	2.18 ± 0.03	2.96 ± 0.034
Cr	13.60 ± 0.07	22.75 ± 0.12	118.29 ± 0.12
Fe	5560 ± 30	4960 ± 30	6710 ± 40
Se	0.798 ± 0.017	0.720 ± 0.015	2.681 ± 0.007
Zn	140.9 ± 0.6	268.0 ± 1.1	309.6 ± 1.3

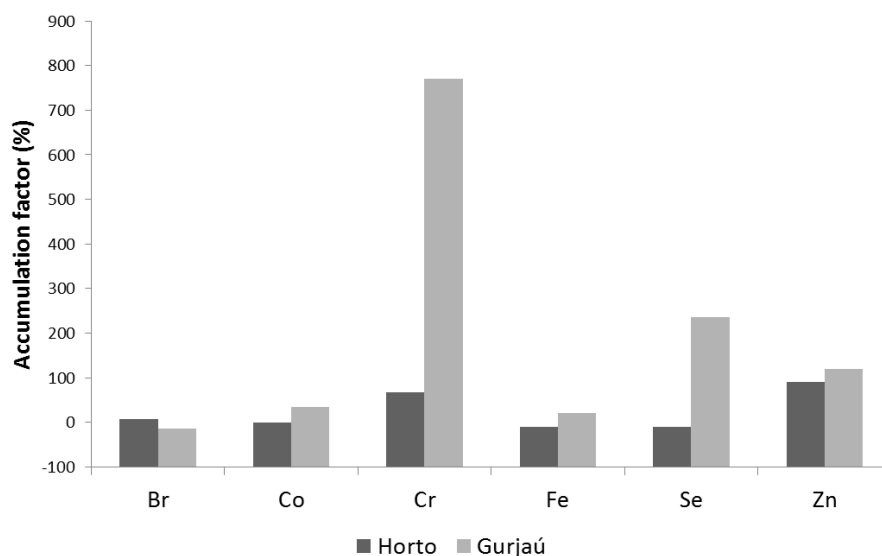


Figure 2. Accumulation factor of the concentration of elements analyzed by neutron activation analysis in samples of *Tillandsia recurvata*

With exception of Br, the other chemical elements presented higher accumulation factors (FE) in the samples exposed in the Reserva Ecológica de Gurjaú (Figure 2). Cr, Se and Zn showed the highest percentages of accumulation in this conservation unit, while for Cr and Zn the EF values were higher in *Tillandsia* exposed in the Horto Florestal de Dois Irmãos.

Among the investigated chemical elements, the highest FE percentage (770%) was observed for Cr in samples exposed in Gurjaú. This phenomenon was not so intense for samples exposed at the Horto (67%). Since atmospheric sources of Cr are not only industrial processes, but also combustion, including the burning of forests [10], such increasing of chemical element concentration was related to the effect of sugarcane burning on the biomonitors. Coal combustion, Cu-Pb smelter industry, wastewater and some phosphate fertilizers can be a potential source of selenium for the ecosystem [11]. This last source may be responsible for the increasing in 236% of the selenium concentration found in samples exposed in Gurjaú. The presence of cobalt in the atmosphere can be associated to the mining activities, combustion of coal and use of fertilizers [11]. Likewise, this last anthropogenic activity can explain the enrichment of Co (35%) in leaves of *Tillandsia* exposed in Gurjaú.

The chemical elements Fe and Zn have showed slight difference between monitored areas. Iron increasing was attributed to the influence of earth particulate adhered to the biological material. Zinc is an element of great physiological importance to plants as a constituent of several enzymes [12]. However, samples exposed in both areas were able to accumulate this chemical element in leaves compared to the background, thereby corroborating impacts on Zn distribution associated to anthropogenic impacts.

4. CONCLUSIONS

Biomonitoring using the epiphyte *Tillandsia recurvata* was successfully employed for assessing air pollution from sugarcane burning and agricultural activities in the Reserva Ecológica de Gurjaú. Effects on chemical element distribution in biomonitor were associated to the anthropogenic activities, mainly because of the highest accumulation factors compared to the control samples. First results for active biomonitoring of air pollution were provided for the Pernambuco State, Brazil.

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