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Analysis of *Tradescantia pallida* plant exposed in different sites for biomonitoring purposes

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Comparisons were made between the results obtained for elements accumulated by *Tradescantia pallida* plant exposed in sites with different pollution levels: Cerqueira César and Congonhas districts, considered polluted areas of São Paulo city, and Caucaia do Alto county, considered a non polluted site. Statistical test applied to the results indicated that plant samples from polluted areas presented higher concentrations of Ba, Ce, Cr, Co, Fe, La, Sb and Sc than those found for ones from a non-polluted site. Discriminant analysis applied to the results obtained revealed three groups of results corresponding to sites with different levels of pollution.

Introduction

In the past years, applications of biological materials for monitoring toxic element from air pollution have increased a lot and a great variety of plants and animal tissues have been analyzed.

Therefore, some higher plants, lichens and mosses are recognized as indicators of atmospheric pollution and their use as biomonitors has showed advantages over the conventional methods, which measure pollutants directly. Generally, biological monitoring has a low cost and manpower, presents ease sampling and allows obtaining relative information on air quality of wide geographical regions.

Besides the use of plants for biomonitoring atmospheric pollutants of big cities, like São Paulo city is of great interest. In São Paulo, there is a serious pollution problem however, data on element pollutant levels are very scarce and there is no systematic evaluation of these data.

Among several plant species that can be studied for biomonitoring, *Tradescantia pallida* (Rose) D.R. Hunt. cv. *purpurea* from *Commelinaceae* family was chosen to be used in this study due to its availability, ease of sampling and cultivation and tolerance. This is an ornamental plant found in gardens and along avenues and streets even though they are places with high levels of pollution.

Recently *Tradescantia* plants have become widely acknowledged for the detection of genotoxic effects of heavy metal ions by micronucleus assay and it is suggested for biomonitoring metal-contaminated soils.[1] *Tradescantia*-micronucleus bioassay has also been carried out to detect genotoxicity of pollution levels of rivers,[2] urban and industrial areas[3–6] as well as to monitor and test mutagenicity of air contaminated by radioisotopes around power plants after nuclear accidents.[7]

However, *Tradescantia* plants have not been studied for biomonitoring elements from atmospheric pollution. In our previous works,[8] a protocol for *T. pallida* sample collection and treatment was defined and effects of leaf age and its cleaning on their elemental concentrations have also been studied.

The purpose of this study was to determine the content of elements accumulated in leaves of *T. pallida* plant exposed in three sites of different levels of pollution in order to evaluate the relative air quality of each of these areas. The three sites chosen for this study were Cerqueira César and Congonhas, considered polluted sites of São Paulo city, and Caucaia do Alto, considered a non-polluted control site.

Instrumental neutron activation analysis (INAA) was used for multielemental determination in leaves of *T. pallida* in the present work.

Experimental

Exposure sites

The following sites were chosen for biomonitoring studies: Cerqueira César and Congonhas districts, considered polluted areas of São Paulo city, and Caucaia do Alto county, considered a non-polluted site situated about 50 km from São Paulo downtown. Samples from Caucaia do Alto were kept in a green house. The sites of Cerqueira César and Congonhas were chosen because they are located within the areas known as polluted in São Paulo city.

The city of São Paulo, Capital of São Paulo State, is located at an altitude of 715–900 meters, with annual precipitation of about 1300 mm and temperature ranging

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from 15 to 23 °C, showing serious air pollution problems. In winter, that is the months from June to August, air pollution increases in São Paulo due to difficult dispersion of pollutants caused by low wind speeds and reduced rain precipitation. The city is also subjected to frequent thermal inversions. It covers about 5,000 km^2 of area with a population of roughly 18 million and it is an important industrialized economic center of Brazil with about 5.5 million vehicles.

Transplantation and collection of T. pallida samples

T. pallida plant was rooted in sixty vases containing soil from the same lot to avoid its composition to affect the elements accumulated by plant. Twenty vases were distributed in each chosen site and were kept there during six months before collection. The vases were placed 50 cm over the soil on wood platforms.

The leaf samples were collected in the third knot from the edge of the stems. This collection was carried out monthly during a period of about one year (from March 1999 to April 2000). The samples were cleaned using milli-Q water, freeze-dried and then ground for the analyses. In the drying process, there was a mean weight loss of about 94.7%.

Preparation of standards

Multielement standards were used for the INAA determinations. Stock solutions of elements were provided from Spex Certiprep Chemical or prepared by dissolving high purity metals, oxides or salts in high purity reagents or milli-Q water. Single or multielement solutions were prepared by using appropriate amounts of these stock solutions and were then pipetted onto sheets of Whatman No. 42 filter paper. After drying these sheets in a desiccator, they were placed in polyethylene bags that were heat sealed for irradiation with the samples.

Instrumental neutron activation analysis

The samples ranging in mass from 100–180 mg were weighed in polyethylene bags. Five-minute irradiations were carried out under a thermal neutron flux of $4 \cdot 10^{11}$ $n \cdot cm^{-2} \cdot s^{-1}$ for the determination of Ba, Cl, K, Mn, Na and Sr, using a pneumatic transfer system of the IEA-R1 nuclear reactor. Sixteen-hour irradiations, under thermal neutron flux of about 10^{12} $n \cdot cm^{-2} \cdot s^{-1}$, were carried out for As, Ba, Br, Ca, Ce, Co, Cr, Fe, K, La, Rb, Sb, Sc, Sr, Th and Zn determinations.

After adequate decay times, gamma-ray measurements were performed by a GX2020 hyperpure Ge detector which was coupled to Model 1510 Integrated Signal Processor and System 100 MCA Card, both by Canberra. The detector used had a resolution (FWHM) of 0.90 keV for 122 keV gamma-rays of ^{57}Co and 1.78 keV for 1332 keV gamma rays of ^{60}Co. Samples and standards were measured at least twice and the sample–to–detector distances of 3.0 and 0.5 cm were used for the first and second measurements, respectively. The gamma-ray spectra were processed using VISPECT software that evaluates peak areas (counting rates) and gamma-ray energies. The standard comparative method was used for calculating the elemental concentrations.

Certified reference materials IAEA 336 Lichen and NIST 1570 Peach Leaves were irradiated with the samples and analysed to control the quality of the results. The accuracy and the precision for most elements were, generally, found to be within 11%.

Results and discussion

Table 1 shows arithmetic mean values and standard deviations obtained for samples collected monthly. As it can be seen in this table, the elements Ca and K were found at percentage levels; Ba, Br, Cl, Fe, Mn, Na, Rb, Sr and Zn at $\mu g \cdot g^{-1}$ levels, and As, Ce, Co, Cr, Sb, La, Sc and Th at $\mu g \cdot kg^{-1}$ levels. To evaluate if there are significant differences among results obtained for samples collected on three sampling sites, analysis of variance (ANOVA) was applied (for $p<0.05$).

Statistical test applied to the results showed that samples from Cerqueira César and Congonhas presented higher concentrations of Ba, Ce, Co, Cr, Fe, La, Sb and Sc ($p<0.05$) when compared with those obtained for samples exposed in a clean place of Caucaia do Alto. Concentrations of As, Ca, Mn, Sr, Th and Zn showed the same magnitude for samples collected in the three sites. Samples from Caucaia do Alto presented the highest concentrations of Br, Cl, K, Na and Rb ($p<0.05$). High concentrations of these elements cannot be attributed to marine origin since Caucaia do Alto is located about 80 km far from the sea and plants of this site was kept in a green house. Further studies should be carried out in order to investigate the origin or the reason for these high concentrations. Besides samples from Congonhas presented higher concentrations of Ba, Ce, Cr, Fe, Sb and Sc than those from Cerqueira Cesar ($p<0.05$).

Table 1. Mean values of elemental concentrations obtained in *T. pallida* samples cultivated in the three sites of different levels of pollution

Element	Sampling sites		
	Caucaia do Alto	Cerqueira César	Congonhas
As, $\mu g \cdot kg^{-1}$	50.5 ± 16.7	64.9 ± 7.8	95.9 ± 7.9
Ba, $\mu g \cdot g^{-1}$	26.6 ± 2.4	151.1 ± 6.4	219.9 ± 11.1
Br, $\mu g \cdot g^{-1}$	60.1 ± 0.3	28.0 ± 0.1	24.3 ± 0.1
Ca, %	2.4 ± 0.1	2.9 ± 0.1	2.6 ± 0.1
Ce, $\mu g \cdot kg^{-1}$	278 ± 28	1029 ± 29	1304 ± 24
Cl, $\mu g \cdot g^{-1}$	33521 ± 856	6361 ± 164	8096 ± 208
Co, $\mu g \cdot kg^{-1}$	60.4 ± 2.1	216.5 ± 4.6	301.9 ± 5.4
Cr, $\mu g \cdot kg^{-1}$	31.4 ± 21.7	396.3 ± 22.7	931.2 ± 23.6
Fe, $\mu g \cdot g^{-1}$	65.7 ± 1.6	128.4 ± 2.2	213.4 ± 1.9
K, %	6.7 ± 0.3	3.9 ± 0.4	3.8 ± 0.4
La, $\mu g \cdot kg^{-1}$	97.0 ± 5.1	577.8 ± 4.5	709.6 ± 4.2
Mn, $\mu g \cdot g^{-1}$	102.2 ± 3.2	129.7 ± 2.9	109.7 ± 3.8
Na, $\mu g \cdot g^{-1}$	2818 ± 75	82.1 ± 10.1	109.7 ± 14.1
Rb, $\mu g \cdot g^{-1}$	51.2 ± 1.0	34.9 ± 0.6	15.9 ± 0.2
Sb, $\mu g \cdot kg^{-1}$	6.0 ± 1.7	115.2 ± 3.0	163.7 ± 2.9
Sc, $\mu g \cdot kg^{-1}$	5.2 ± 0.2	14.8 ± 0.3	30.9 ± 0.3
Sr, $\mu g \cdot g^{-1}$	232 ± 44	290 ± 29	292 ± 33
Th, $\mu g \cdot kg^{-1}$	41.0 ± 5.3	46.5 ± 3.1	54.9 ± 2.1
Zn, $\mu g \cdot g^{-1}$	124.1 ± 0.7	175.3 ± 0.9	121.5 ± 0.5

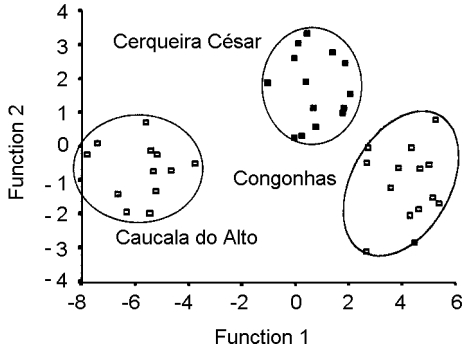

Fig. 1. Individual distribution of the measurements for the three groups of samples analyzed by applying the discriminant canonical functions

Discriminant analysis was also applied by using SPSS software for Windows version 9.0 (SPSS Inc.) to classify the samples according to their origins. Stepwise discriminant analysis selected Ba, Br, Ce, Cr, Rb, Sb, Sc and Zn to distinguish the groups. By applying these discriminant functions presented in Table 2, 100% of the cases were properly classified as shown in Table 3. A graphic representation of the distribution was obtained as presented in Fig. 1 that shows clearly three groups of results corresponding to the three sites of sample collection.

Table 2. Standardized canonical discriminant function coefficients obtained for the elements selected by stepwise procedures

Element	Function 1	Function 2
Ba	1.054	–0.304
Br	–1.120	–0.156
Ce	0.114	1.218
Cr	1.961	–1.327
Rb	0.345	1.193
Sb	0.478	0.438
Sc	–1.538	–0.173
Zn	–0.670	1.109

Table 3. Classification of the analytical results applying the discriminant function data given in Table 2

Actual group	*N**	Predicted group membership		
		Caucaia do Alto	Cerqueira César	Congonhas
Caucaia do Alto	12	12 (100%)	0 (0%)	0 (0%)
Cerqueira César	14	0 (0%)	14 (100%)	0 (0%)
Congonhas	14	0 (0%)	0 (0%)	14 (92.9%)

**N*: Number of samples.
Percentage of grouped cases and correctly classified: 100.0%.

Conclusions

This work can be considered as a preliminary investigation aimed at providing information on relative air quality of the São Paulo city area using *T. pallida* plant. Our results indicated high concentrations of the elements such as Ba, Ce, Co, Cr, Fe, La, Sb and Sc in *T. pallida* plant exposed in polluted sites. This fact suggests studies focusing on urban environment biomonitoring of São Paulo city to elucidate the origins of these elements.

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