Determination of heavy metals in the bioindicator plant Tradescantia pallida var. Purpurea

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Abstract

Background: There is an interest in developing cheaper and effective methodologies for air pollution monitoring. Thus, biological materials such as plants and animals accumulators of metals have been studied for use in biomonitoring of air pollution. The plant chosen for biomonitoring in the present study was the Tradescantia pallida var. Purpurea (T. pallida). The harmful effects of environmental pollution have been already evidenced by micronucleus assays using the species T. pallida. Three Brazilian studies identified accumulation in leaves of T. pallida of important elements for air pollution biomonitoring using neutron activation analysis. Here, a new methodology using atomic emission spectroscopy with inductively coupled plasma was evaluated.

Methods: Two samples of T. pallida were collected from different sampling points in the city of Sao Paulo. The two plant samples were analyzed by atomic emission spectroscopy with inductively coupled plasma to determine the concentrations of the heavy metals cadmium, lead, lithium, nickel, zinc, cobalt and manganese in the leaves of the species T. pallida.

Results: Making a comparison between concentrations of elements found in the two samples, Mn and Zn appeared in greater quantity in sample 1 (the collection point was a sidewalk next to an avenue with intense traffic of cars - metropolitan region Sao Paulo) than in sample 2 (residential neighborhood - metropolitan region Sao Paulo). Most of the concentrations of the elements were similar and appeared above the detection level of the device (ICP-AES) Spectro Ciros CCD.

Conclusions: All metals were detected in the dry biomass of the plants which brings more elements to the study of this species as a bioindicator of environmental pollution. Here we can not say if the metals were absorbed by the roots or by aerial parts, but establish the levels of these metals in such kind of plant with this methodology can be useful for further studies.

Keywords: Tradescantia pallida, heavy metals, environmental pollution
waste are causes of increased level of such metals.

Methods
Two samples of *T. pallida* were collected from different sampling points in the city of São Paulo in the month of March 2012. The first collection point was a sidewalk next to an avenue with intense car traffic (sample 1) (Latitude: -23.539354 Longitude: -46.728159). (15 different plants collected). The second collection point was a sidewalk in a residential neighborhood (Latitude: -23.5612609 Longitude: -46.7469433) (sample 2) (15 plants collected). For analysis of these leaves they were washed with deionized water to remove possible dust particles deposited and drying was done in a stove with forced air circulation, an average temperature of 40 oC for approximately 2 days. The samples of leaves were ground and mixed. These samples in powder form were stored in plastic pots which were stored in a desiccator (10g of biomass for each group of plants). The methodology used in the digestion of plant samples was based on the method 3052 - Microwave Assisted Acid Digestion of Siliceous and Organically Based Matrices (U.S. EPA 1996).

The two plant samples were analyzed by atomic emission spectroscopy with inductively coupled plasma (ICP-AES) Spectro Ciros CCD in Central Analytical Laboratory at the Institute of Chemistry of the University of São Paulo. The atomic emission spectrometry is a technique used for quantitative determination of metals in higher concentration levels (percentage) and traces (μg/L to μg/L) in a wide variety of samples, such as geological and environmental samples, water, steels and alloys, plants and food. This technique is a quick method for a high sensitivity for the determination of metals, which can detect very low concentrations. The fundamental principle of atomic emission spectrometry is the ionization of the elements to be analyzed by Inductively coupled plasma of argon sustained by a magnetic field that is generated by a radio frequency coil. Plasma samples pass through a nebuliser system and are transported in aerosol form. The samples undergo a series of physical-chemical processes: desolvation, vaporization and atomization.

Results
Making a comparison between concentrations of elements found in the two samples, Mn and Zn appeared in greater quantity in sample 1. Most of the elements dosages of biomass was similar and appeared above the level of detection of the device (ICP-AES) Spectro Ciros CCD. in Table 1 we see the results of measurements of metals in the two samples. With only two plant samples, that generated two homogenized biomass of the fifteen plants collected in each different region, it was not possible to analyze whether there is a statistical difference between the two samples. In our study the average of two samples of manganese was 173,3 ppm (standard deviation of 44,8ppm). The average of two samples of zinc was 62,8 (standard deviation of 1,10ppm).

Discussion
In a study that examined the uptake of metals by plants (sunflowers, oats and grass-Bahiaagrass), grown in soils with different levels of heavy metals (Cd element varying from 1.9 to 22.1 mg kg⁻¹), the concentrations of Cd were 1.32 till 43.50 mg kg⁻¹ (sunflower), 0.00 till 67.92 mg kg⁻¹ (oat) and 0.40 till 37.25 mg kg⁻¹ (gram-Bahiaagrass). The highest levels of Cd in the aerial parts of these plants occurred when grown in soil with 22.1 mg kg⁻¹. The uptake by the roots and translocation of the element to the aerial parts of plants occurred according to the quantity of the element in the soil [6]. In our dosages found in both groups of plants were 0.008 mg kg⁻¹ (converted value).

Cobalt is an element found in soils, rocks, water, plants and animals in trace quantities. In analysis by neutron activation in leaves of *T. pallida*, there was variation in the dosages of the element in the three regions to which the plants were exposed: Jabaquara (metropolitan region of São Paulo - region of industries) 90 ng g⁻¹ (SD ± 2), University of São Paulo (metropolitan region São Paulo - wooded campus) 83 ng g⁻¹ (SD ± 1), North Caucaia (region considered slightly polluted - control) 48 ng g⁻¹ (SD ± 3) [7]. In a study in Santo André city (Brazil), using neutron activation analysis, it was identified in *T. pallida* an evident accumulation in leaves of important elements for air pollution biomonitoring, such as: Ba, Ce, Co, Cr, Cs, La, Rb, Sr, Sc and Zn. In this study, no relation between the concentrations of metals in the leaves inserted in the inflorescences and the frequency of micronuclei was observed. However, the metal concentrations could discriminate specific sites, contributing to the mapping of polluted sources in each region studied [8]. Our dosages in both groups of plants were less than 0.02 mg kg⁻¹ (converted value).

Plants absorb several elements that appear not to play a role in their metabolism, namely arsenic (As), chromium (Cr), cobalt (Co), fluorine (F), iodine (I), lead (Pb), lithium (Li) and selenium (Se). The study of Magalhães [9] showed that the absorption of lithium per radish, lettuce and watercress increases due to the amount of lithium present in the experimental solutions in which the plants are placed.
Lithium dosed in watercress increased from 37 till 1216 ppm, when the experimental solution of lithium grew from 0.1 till 2.0 mM. In radish, lithium increased from 17 till 1008 ppm and in lettuce 11 till 508 ppm [9]. In our plant samples Li values were less than 0.002 mg kg\(^{-1}\) (converted value).

Manganese acts on the basal metabolism of plants (photosynthesis and transfer of phosphate), stabilizing the structure of the chloroplast and nucleic acid synthesis. In a study by short irradiation technique of neutron activation analysis in samples of leaves of \(T.\ pallida\) Mn was dosed 132-314 (in μg g\(^{-1}\)) for plants grown in regions with different levels of pollution [10]. In this study the region with the highest metered quantity of manganese in samples of leaves of \(T.\ pallida\) was an area with a lot of traffic from vehicles and factories (Jabaquara - metropolitan region of Sao Paulo). Using the artifice of incorporating the dosages of manganese from this study (analysis by neutron activation) with our results, grouping seven dosages of manganese from different regions of the State of Sao Paulo we get an average of 166.2 mg kg\(^{-1}\) (standard deviation of 83.7mg kg\(^{-1}\)). The dosage of the region considered slightly polluted of the study by neutron activation was 132,4 μg g\(^{-1}\) with a relative standard deviation ±6,1 (in five determinations). In our sample 2 the dosage of Mn was 141,71ppm (residential neighborhood). The dosage of the region considered polluted of Sao Paulo by neutron activation was 314,0 (SD ± 14,6 in six determinations). In our sample 1 (from an avenue with intense car traffic) the dosage was 205,06ppm. There is an apprehension that industrial emissions of Mn in the use of Mn-containing compounds as fuel additives may increase the population risk of Parkinson’s disease-like disorders. A canadian study suggested that exposure to ambient Mn advances the age of diagnosis of Parkinson’s disease, coherent with the hypothesis that exposure to Mn adds to the usual loss of neurons attributable to the aging process [11].

In the study by Andrade [6], plants sunflowers, oats and grass-Bahiagrass, grown in soils with different levels of nickel (16.5 till 38.4 mg kg\(^{-1}\)) the quantities of the element found in the aerial parts of plants were: 0.11 till 10.74 mg kg\(^{-1}\) (Sunflower), 0.73 till 52.70 mg kg\(^{-1}\) (black oats) and 2.83 till 11.88 mg kg\(^{-1}\) (Grass-Bahiagrass). The highest levels of Ni in aerial parts of these plants occurred when grown in soil with 11.88 mg kg\(^{-1}\). Our plant samples values were 0.01 ppm (Ni). Nickel, according with Dixon [12], is considered a functional plant nutrient and the appropriate level of the element in the tissues is 0.05 mg kg\(^{-1}\) by the author.

In the study with plants (sunflowers, oats and grass-Bahiagrass) grown in soils with different levels of Pb (234.8 till 9678.2 mg kg\(^{-1}\)) the quantities of the element found in the aerial parts of plants were: 4.94 till 213.93 mg kg\(^{-1}\) (Sunflower), 1.19 till 130.25 mg kg\(^{-1}\) (black oats) and from 1.32 till 171.10 mg kg\(^{-1}\) (Grass-Bahiagrass). The highest levels of Pb in the aerial parts of these plants occurred when grown in soil with 9678.2 mg kg\(^{-1}\) [6]. Our dosages of the two groups of plants were 0.01 ppm.

With respect to zinc in analysis by neutron activation, a variation in the dosages of the element in the three regions to which the plants were exposed was noted: Jabaquara (region of industries) 193 mg g\(^{-1}\) (SD ±6), University of Sao Paulo (wooded campus in Sao Paulo city) 63 mg g\(^{-1}\) (SD ±4), North Caucaia (region considered slightly polluted) 56 mg g\(^{-1}\) (SD ±4) [7]. In our study, in the sample 1 we got (63,63 ppm) and in the sample 2 (62,04 ppm). Zn average of two samples was 62,8 (SD ± 1,10ppm). Airborne concentrations of zinc in suspended particulate matter is higher in industrial areas and brass industries are mainly responsible for this. In a study conducted in India observed maximum concentrations of Zn at industrial site and minimum at residential site [13]. The concentration of Zn was also higher in urban than rural regions in another study [14]. A study conducted in Sao Paulo employing Tillandsia usneoides L. as biomonitor found Zn and Co highest contents related to industrial zones and associated to the presence of anthropogenic emission sources [15]. Zn was evidentally accumulated in leaves of \(T.\ pallida\) from the industrial areas of Santo Andre city, being considered indicator of emissions from the petrochemical pole in another study [8]. Among the particulate matter with aerodynamic diameter less than 2.5 μm (PM2.5) constituents, Zn showed the most significant associations with the increase in tumor necrosis factor alpha (TNF-α), a circulatory biomarker associated with activation of systemic inflammation and hypercoagulability and increased plasma homocysteine, mechanisms through which air pollution may influence the cardiovascular system [16].

Conclusions
All metals were detected in the dry biomass of \(T.\ pallida\) plants which brings more elements to the study of this species as a bioindicator of environmental pollution. Here we cannot say if the metals were absorbed by the roots or by aerial parts, but establish the levels of these metals in such kind of plant with this methodology can be useful for further studies. Analyze other elements of interest from the point of environmental pollution as well as the analysis of this species grown in soils with the same composition and in places exposed to different levels of air pollution could bring more elements to the study of \(T.\ pallida\) as a potential bioindicator plant. We can assume that \(T.\ pallida\) absorbs more zinc and manganese from the environment depending on the level of air pollution in the region, however, this remains to be demonstrated with specific methodology.

Competing interests
The author declare that he has no competing interests.

Author contribution
Thiago Paes de Barros de Luccia wrote and
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