

METALS IN SOILS ADJACENT TO AVENUES OF HIGHLY DENSE TRAFFIC OF SÃO PAULO CITY, BRAZIL

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ABSTRACT

São Paulo is the largest city in Brazil with about 19 millions of inhabitants in the metropolitan area, more than 8 million motor vehicles and strong industrial activity at the metropolitan region, which are responsible for increasing pollution in the region. Nevertheless, there is little information on metal contents in the metropolitan region soils, which would be very useful as a fingerprint of the environmental pollution. The present study aimed to determine As, Ba, Co, Cr, Sb and Zn concentrations in soils adjacent to avenues of highly dense traffic downtown São Paulo city: Consolação/Rebouças Avenues; 23 de Maio Avenue and Tiradentes Avenue, to assess their possible sources and potential environmental impact. The analytical technique employed was Instrumental Neutron Activation Analysis (INAA). The results show metal concentration levels higher than the values reference values for soils of São Paulo, according to the Environmental Protection Agency of the State São Paulo (CETESB) guidelines. As, Ba and Zn showed concentration levels above the Intervention Values in some points, indicating direct or indirect potential risks to human health. The traffic related element Ba, Sb and Zn presented concentrations above the Prevention Values in points with high density traffic and may be associated to vehicular emissions.

1. INTRODUCTION

Urban environment pollution is a key issue in almost every metropolitan area in the world; economical and populational growth, heavy traffic and industrial emissions lead to contamination of air, water and soil, with an impact on the health of the population [1]. Metals are often used as pollution trackers and, although they occur naturally in soils, their contents are generally increased in the urban environment due to anthropogenic activities.

In recent years, urban soils have been recognized as an important source of human toxic metal intake, due to the presence of potentially toxic metals in high concentrations - this effect being even more important for children, which are more susceptible than adults [2].

São Paulo, with 20 million inhabitants distributed over 8000 km² in the metropolitan area, a huge industrial park and approximately one vehicle for every two inhabitants, shows severe pollution problems. In the last years, some studies have been made on the concentration of metals in soils of public parks [3,4], but little is known about the soils that surround the city's most important traffic corridors.

This study presents the results obtained for the concentration levels of six potentially toxic elements (As, Ba, Co, Cr, Sb and Zn) in soils taken from the vicinities of three of the most important traffic arteries of the São Paulo city: 23 de Maio, Consolação/Rebouças and Tiradentes (Fig.1)

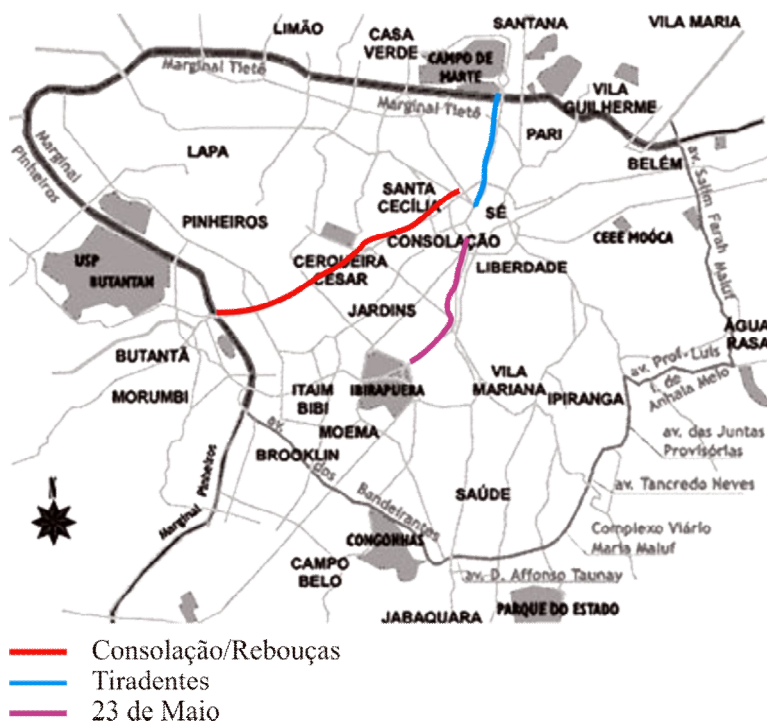


Figure 1. Map of the São Paulo city showing the location of the three corridors studied.

2. INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS (INAA)

INAA is an analytical method to perform qualitative and quantitative multi-elemental analysis, providing detection limits of part per billion or better for many elements. The neutron activation analysis technique consists in irradiating a sample with neutrons, which will interact with the nuclei of the elements in the sample, mainly via (n,γ) reactions, forming radioactive nuclides that, as part of their natural decay, will emit characteristic gamma rays. The analysis of these gamma-rays allows the identification and quantification of the elements present in the original sample. In INAA, the samples are irradiated together with reference materials with well-known concentrations of the elements under study, so that the concentrations of the elements in the samples are calculated directly from the comparison of the results obtained for the reference materials.

3. MATERIALS AND METHODS

Topsoil samples (depth 0-5 cm) were taken from three points along each the 23 de Maio, Tiradentes and Consolação/Rebouças avenues; in each point, four samples were acquired and labeled A, B, C and D, according to the distribution shown in Fig.2. The points were numbered from 1 to 3, with 1 being the closest to the city center and 3 the most distant. The samples were collected using a polyethylene tube with 4 cm diameter and stored in plastic bags; later they were dried at 40-50°C and sieved through plastic-only sieves into fractions lower than 2 mm – before and after sieving, the samples were homogenized, quartered and grinded in an agate mortar.

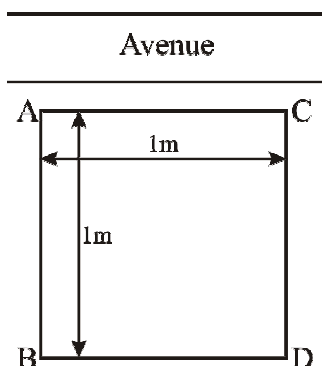


Figure 2. Sampling scheme for each of the collected points.

For the analysis process, approximately 100 mg of each sample was placed in a pre-cleaned inert plastic bag and weighted; samples were then placed inside an aluminum vessel, together with the standard reference materials Soil 7 (IAEA), GS-N and BE-N (GIT-IWG), and irradiated for 8 hours under a thermal neutron flux of $10^{12} \text{ n.cm}^{-2} \text{ s}^{-1}$ in the IEA-R1 nuclear reactor. The samples were then counted twice using an HPGe detector; the first counting series was performed after 7 days of the irradiation and the second one 15 days after irradiation; the counting times varied from 1 to 2 hours, and the gamma-ray spectra were processed using the VISPECT software in order to obtain the gamma peak areas.

4. RESULTS AND DISCUSSION

The results obtained for each of the sampling points are presented in Table 1, together with the guiding values determined by CETESB, the Environmental Protection Agency of the State of São Paulo [5].

Table 1. Concentration values of metals in the sampling points compared to the guiding values for soil as determined by the Environmental Protection Agency of the State of São Paulo - CETESB [5] ($\mu\text{g}\cdot\text{g}^{-1}$).

	Point		As	Ba	Co	Cr	Sb	Zn
23 de Maio	1	Mean	15.5	250.3	4.1	85.2	3.6	275.1
		Median	15.8	251.5	4.2	83.6	3.6	279.7
		Range	13.0-17.6	198.9-299.3	3.5-4.5	80.9-92.6	3.3-4.0	239.2-301.8
	2	Mean	17.0	278.2	3.9	80.0	3.9	320.5
		Median	17.0	259.5	3.8	82.2	3.6	313.8
		Range	13.5-20.5	195.5-398.1	3.5-4.7	61.9-93.8	2.7-5.5	193.7-460.6
	3	Mean	8.4	423.4	4.1	61.3	5.9	491.0
		Median	7.9	435.2	4.2	64.9	5.8	491.1
		Range	5.8-12.1	351.2-472.1	3.8-4.4	48.2-67.1	5.3-6.8	482.8-499.1
Consolação / Rebouças	1	Mean	15.6	288.3	4.3	86.3	4.2	357.6
		Median	15.3	284.7	4.2	83.5	4.2	368.5
		Range	13.85-18.03	241.9-342.0	3.9-4.9	80.3-98.1	3.7-4.8	297.0-396.2
	2	Mean	16.9	326.1	3.4	70.6	3.0	222.6
		Median	17.1	325.8	3.2	66.6	2.8	216.7
		Range	15.07-18.18	277.6-375.2	3.0-4.2	66.0-83.2	2.4-4.0	161.6-295.3
	3	Mean	15.3	140.8	2.7	59.6	1.4	64.7
		Median	14.7	148.6	2.7	59.5	1.4	60.6
		Range	11.59-20.34	105.5-160.4	2.5-2.9	51.6-67.9	1.0-1.8	58.4-79.2
Tiradentes	1	Mean	8.7	284.9	3.0	54.6	2.6	182.9
		Median	8.8	272.3	3.1	54.0	2.5	184.1
		Range	7.82-9.42	220.1-374.7	2.7-3.3	47.2-63.4	1.8-3.6	144.9-218.6
	2	Mean	14.2	324.5	4.3	83.5	2.5	268.7
		Median	14.3	339.9	4.3	80.1	2.6	260.4
		Range	12.11-16.06	244.3-373.8	4.0-4.9	71.3-102.4	2.2-2.8	220.6-333.5
	3	Mean	3.5	231.3	2.4	23.1	1.3	111.5
		Median	3.5	217.2	2.4	23.1	1.4	117.1
		Range	3.34-3.67	185.3-305.5	2.2-2.5	20.6-25.4	1.1-1.4	89.6-122.1
Quality Reference Value			3.5	75	13	40	0.5	60
Prevention Value			15	150	25	75	2.0	300
Intervention Value			35	300	35	150	5.0	450

The concentration results for Co in all sampled points were below the Quality Reference Value (VRQ), indicating that there is no contamination of this element; all the results for Cr and some of the results for As in the 3rd point of the Av. Tiradentes were also below the VRQ.

Values between the Prevention Value (VP) and the Intervention Value (VI) were found for As in the 1st and 2nd points of Av. 23 de Maio, in all 3 points sampled in the Consolação/Rebouças corridor and in some of the samples taken from the 2nd point in the Av. Tiradentes. For Cr, values between VP and VI were found in all samples of the 1st points of Av. 23 de Maio and Consolação/Rebouças and for the 2nd point of Av. Tiradentes and in some of the samples from the 2nd points in Av. 23 de Maio and Consolação/Rebouças. These results may be attributed to anthropogenic activities, since this element is used in several products, including pesticides and fertilizers.

For Zn, most values were between VRQ and VP; in some samples of the 2nd point in Tiradentes and in all samples from the 1st points in Av. 23 de Maio and Consolação/Rebouças, the values found were between VP and VI; in one of the samples from the 2nd point of the Av. 23 de Maio and in all samples from the 3rd point of the same avenue, though, the results for Zn were above the Intervention Value, indicating a highly contaminated environment.

For Sb, only the results from the 3rd points from Av. Tiradentes and Consolação/Rebouças were below the Prevention Value; as for Zn, some of the samples from the 2nd point and all the samples from the 3rd point in Av. 23 de Maio showed results above the Intervention Value.

Zn and Sb are considered traffic related elements, and may be associated to vehicular sources (Zn is used in lubricant oils). Zn accumulation in particulate matter is due to the wear and tear of certain automobile materials and parts during driving.

For Ba, though, the situation was a lot worse, with only some of the samples from the 3rd point of Consolação/Rebouças below the Prevention Value. Moreover, values above the Intervention Value were found for some of the samples from the 2nd point of Av. 23 de Maio, the 1st point of Consolação/Rebouças and the 3rd point of Av. Tiradentes; for most of the samples from the 2nd points from Consolação/Rebouças and Tiradentes; and for all the samples from the 3rd point of Av. 23 de Maio. Barium may be associated to the natural lithology of São Paulo, which may indicate natural origin. On the other hand, organometallic compounds containing barium have been used to reduce diesel smoke and 85-95% of the metal is emitted as particulates in the vehicle exhausts. These results indicate an almost widespread contamination of Ba, which may have severe prejudicial effects on the environment and on the population's health.

5. CONCLUSIONS

The results obtained showed an almost widespread contamination of Ba; dangerously high concentrations of Zn and Sb, above the Intervention Value defined by CETESB, were also found in some points along Av. 23 de Maio; concentrations above the Prevention Value were also found for As and Cr. It should be noted, also, that for none of the points sampled in this work the results for all elements were better than the Quality Reference Value, once again indicating the poor quality condition of the soils along these highly dense traffic avenues in São Paulo.

ACKNOWLEDGMENTS

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