*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**

# URANIUM AND THORIUM IN URBAN PARK SOILS OF SÃO PAULO

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## ABSTRACT

The Environmental Protection Agency of the State of São Paulo (CETESB) has reported the Quality Reference Value (VRQ) for soils in São Paulo, which is the concentration of a substance in the soil or groundwater which defines groundwater quality and clean soil, for several elements. Nevertheless, there is no information about U and Th concentrations. In the present paper, which is part of a main project that assesses metals in urban park soils of São Paulo city, the concentration of U and Th were determined in surface soil samples of fourteen city public parks. Instrumental Neutron Activation Analysis (INAA) was used for analysis. The U and Th range concentrations obtained were: 1.9 to 8.6 mg $kg^{-1}$ for U and 8.4 to 38.0 mg $kg^{-1}$ for Th. The U and Th range concentrations obtained are significantly higher compared to NASC values (2.7 mg $kg^{-1}$ for U and 12 mg $kg^{-1}$ for Th), but they are in the same order of magnitude of other studies reported in the literature. The uranium and thorium concentrations in São Paulo park soils may be attributed to lithology of São Paulo. On the other hand, high uranium concentrations (up to hundreds of ppm) have been reported in the literature in fertilizers containing phosphate, which may have contributed to the uranium levels in the park soils, due to the park garden maintenance.

## 1. INTRODUCTION

In recent years urban soils have received increased attention by scientists, leading to studies focused on their description and investigation all over the world, since they play an important role in maintaining the environmental quality. The Environmental Protection Agency of the State of São Paulo (CETESB) [1] has reported the Quality Reference Value (VRQ) for soils in São Paulo, which is the concentration of a substance in the soil or groundwater which defines groundwater quality and clean soil, for several elements. Nevertheless, there is no information about U and Th concentrations.

Uranium is the highest-numbered element found naturally in significant quantities in the Earth's crust. Significant concentrations of uranium occur in some substances such as phosphate rock deposits, and minerals such as lignite, and monazite sands. High uranium concentrations (up to hundreds of ppm) have been reported in the literature in fertilizers containing phosphate. Uranium presence is a consequence of the natural occurrence of this element in phosphate rocks usually employed as a source of phosphorous in phosphate fertilizer production. Soluble uranium salts are toxic and are readily excreted in the urine, although some accumulation in the kidney does occur in the case of chronic exposure. The

World Health Organization [2] has established a daily "tolerated intake" of soluble uranium salts for the general public of 0.5 µg/kg body weight (or 35 µg for a 70 kg adult). Thorium is surprisingly abundant in the Earth's crust, being almost as abundant as lead and three times more abundant than uranium. Since thorium oxide is highly insoluble, very little of this element circulates through the environment. Thorium is radioactive and can accumulate in the bones. Thus, it can cause bone cancer many years after exposure has taken place [3].

In the present paper, which is part of a main project that assesses metals in urban park soils of São Paulo city, the concentration of U and Th were determined in surface soil samples of fourteen city public parks. The objective of this study was to determine the U and Th levels in São Paulo park soils, as there is no available information concerning this, and furthermore, to compare the results with literature data of other locations.

## 2. MATERIALS AND METHODS

The metropolitan region of São Paulo has about 21 millions of inhabitants distributed in 7,944 km². Fourteen urban parks were studied in order to cover the whole city (Figure1): Cidade de Toronto, Guarapiranga, Chico Mendes, Carmo Raul Seixas Rodrigo Gáspari, Vila dos Remédios, Luz, Aclimação, Ibirapuera, Alfrdo Volpi, Trianon, Buenos Aires Raposo Tavares.

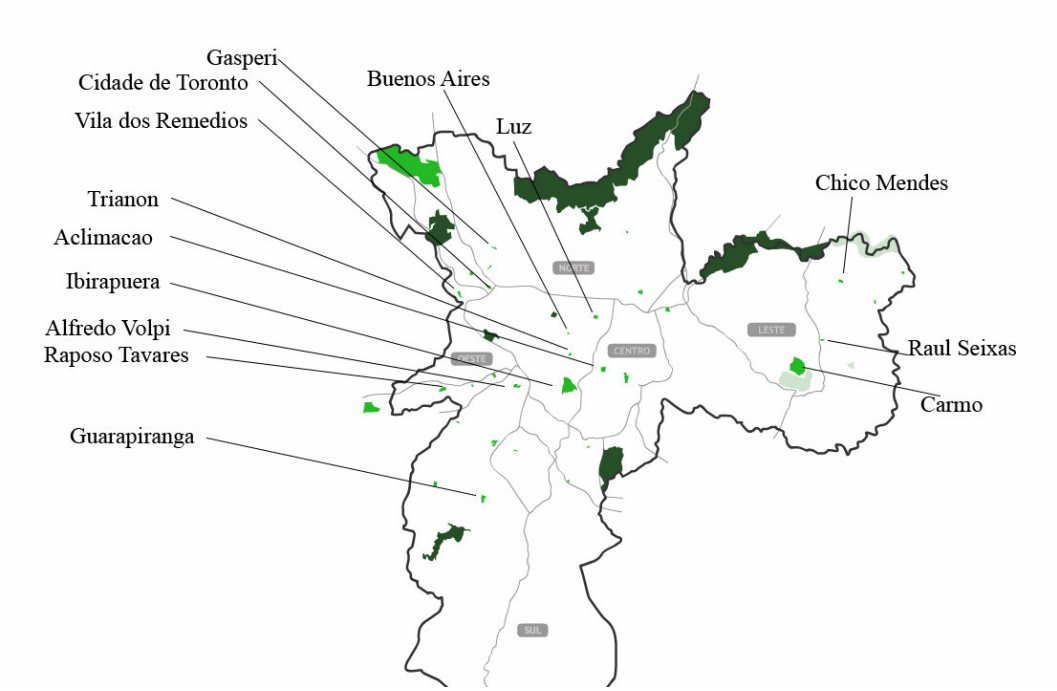


Figure 1: Urban Parks in São Paulo city

Top soil samples (0–20 cm) were collected, between October 2006 and April 2007, in lines across the parks at every 30 m. A polyethylene tube with 4 cm diameter was used to take the

samples. In the laboratory, the samples were dried at 40-50$^{o}$C and sieved through plastic-only sieves into <2 mm fraction. Before and after sieving, the samples were homogenized and quartered and then grinded in an agate mortar.

Instrumental Neutron Activation Analysis (INAA) was used for analysis. 100 mg of the sample were irradiated for 8 hours at a thermal neutron flux of 1013 n cm-2 s-1 at the IEA–R1 nuclear reactor of IPEN/CNEN–SP. To obtain the concentration of the elements of interest, the reference materials GS-N and BE-N (GIT-IWG) were irradiated with the samples. The gamma ray spectrometry was performed by using a GX20190 hyperpure Ge detector (FWHM of 1.9 keV for the 1.332 keV peak of $^{60}$Co) and associated electronics. Two series of countings were performed: the first one five days after irradiation and the second one 15 days after irradiation. The counting times varied from 1 to 2.5 hours. The gamma-ray spectra were processed by using the VISPECT gamma-ray software, which locates peak positions and calculates the energies and net areas. For quality control the reference material Soil7 (IAEA) was analyzed, giving results with accuracy and precision better than 10%.

## 3. RESULTS AND DISCUSSION

In Table 1, the U and Th range concentrations obtained in the 14 park soils analysed are shown and these data are compared with other soils values from Brazil and another countries reported in the literature.

The U and Th range concentrations obtained are significantly higher compared to NASC [4] values (2.7 mg kg-1 for U and 12 mg kg-1 for Th), but the values found in the present study showed the same range as indicated in the literature. The uranium and thorium concentrations in São Paulo park soils may be attributed to the geochemical composition of the parent rocks from São Paulo. On the other hand, the application of phosphate fertilizers for long periods of time causes accumulation of U in the surface soil of agricultural fields [5]. Phosphate fertilizers contain significant amounts of U as an impurity. In a paddy field in Japan the increase in soil U due to the application of calcium superphosphate fertilizer (600 kg ha$^{-1}$ year$^{-1}$ as mixed fertilizer) for 10 years was estimated to be 5.3% of the total U in the soil. Studies performed by de Souza & Ferreira [6] in samples of fertilizers highly commercialized in the State of São Paulo showed a range of concentration of 21.83 to 7.93 ppm of natural Uranium and 153.0 to 47.1 ppm of natural Thorium. Based on these data it is also suggested that the concentration of uranium may be due to the use of fertilizers in the parks for garden maintenance.

## CONCLUSIONS

The uranium and thorium concentrations in São Paulo urban park soils presented concentration levels in the range of those obtained in similar studies, which indicates natural origin. Nevertheless, a contribution of uranium coming from phosphate fertilizers may not be discarded.

Table1. Uranium and Thorium range concentrations (mg $kg^{-1}$) in São Paulo park soils compared with data reported in the literature

**3.**

| PARK | URANIUM | THORIUM |
|---|---|---|
| Cidade de Toronto | 2.8 – 4.5 | 13.4 – 23.2 |
| Guarapiranga | 4.3 - 8.6 | 16.9 – 24.0 |
| Chico Mendes | 2.4 – 4.3 | 14.5 – 26.6 |
| Carmo | 2.1 – 2.9 | 8.4 - 12.1 |
| Raul Seixas | 1.9 – 2.5 | 7.60 – 15.9 |
| Rodrigo Gáspari | 2.5 -4.1 | 15.7 – 20.8 |
| Vila dos Remédios | 5.6 – 3.7 | 23.6 – 38.0 |
| Luz | 3.6 – 7.2 | 34.3 – 21.0 |
| Aclimação | 3.8 – 5.6 | 24.2– 35.8 |
| Ibirapuera | 3.8 – 6.9 | 33.0 – 17.6 |
| Alfredo Volpi | 2.78 – 6.25 | 13.3 – 26.8 |
| Trianon | 6.0 – 4.8 | 17.7 – 28.8 |
| Buenos Aires | 5.6 – 4.1 | 27.8 – 22.7 |
| Raposo Tavares | 2.71 – 5.6 | 12.9 – 27.0 |
| Range | | |
| **Other studies** | | |
| Perez *et al*. [7] | 0.001 – 2.11 | 0.003 – 38.08 |
| De Souza & Ferreira [6] | 3.87 – 11.58 | 3.46 – 5.25 |
| Kucera *et al*. [8] | 1.8 – 3.20 | 8.0 – 15.50 |
| Yamaguchi *et al*. [5] | 0.08 – 14.00 | - |
| Sterckerman *et al*. [9] | 2.45 – 2.33 | 9.40 – 10.30 |

## ACKNOWLEDGMENTS

The authors acknowledge FAPESP for finantial support.

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