

^{210}Po DETERMINATION IN ESTUARINE SEDIMENTS FROM BAIXADA SANTISTA, SP - BRAZIL

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ABSTRACT

The objective of the present work is to determine ^{210}Po activity concentration in estuarine sediments from Baixada Santista. The area comprehends nine cities in the Brazilian coast (Bertioga, Guarujá, Santos, São Vicente, Cubatão, Praia Grande, Mongaguá, Itanhaém and Peruíbe). It is one of the most important industrial areas in Brazil due to the large number of industries operating in Cubatão, such as steel, petrochemical and fertilizer industries. That, together with a large population, causes a negative impact on marine biota. The cores were obtained from São Vicente and Bertioga by extracting profiles up to 1 meter depth with a Piston core sampler. The samples were prepared and treated with both physical and chemical processes. The physical processes include drying, grinding and sieving. The chemical preparation consists of a series of acid digestion till total dissolution and destruction of organic matter. After the acid digestion, the samples were filtered and evaporated till dryness. The residue was then dissolved in HCl 6.25 M. Po was spontaneously deposited in mirror finished silver disc, for 2 hours at 90 °C and constant agitation. The disc was then counted in a surface barrier alpha detector for 200,000 seconds. Three cores were analyzed so far, two from São Vicente and one from Bertioga.

1. INTRODUCTION

There is an increasing interest in studying marine ecosystems and to determine and quantify contaminants that result from human activity. Among these contaminants, the fate of trace elements is important, especially when the marine food chain is considered [1], [2], [3]. Among trace elements, radionuclides are a source of concern due to problems of exposition and eco-toxicological effects [4].

The study of marine core samples provides information about the temporal elements deposition, allowing to establish natural concentration and to determine the level of contamination of the most recent layers [5], [6], [7], [8].

In relation to radionuclides, it is important to refer to those that occur naturally and can cause an increase of exposition (NORM- Naturally Occurring Radioactive Material); and those that are technologically enhanced (TENORM-Technologically Enhanced Naturally Occurring Radioactive Material), not only from nuclear facilities [9], [10].

Particularly ^{210}Po has a significant importance to eco-toxicology and radioprotection, since it accumulates throughout the food chain, and represents the largest dose contribution for marine life due to alpha emitters, according to Cheryl & Shannon quoted by Hernandez [11]. The element polonium (^{210}Po) is a wide spread natural occurring alpha emitter from the uranium (^{238}U) decay series. Polonium has 25 known radioisotopes, but only ^{208}Po , ^{209}Po and ^{210}Po have a half-life longer than a day, the last one have a half-life of $138,376 \pm 0,002$ days [12]. Po^{210} is the product of ^{222}Rn decay, which throughout a series of transformations forms Po^{210} and deposits in the sediment.

The amount of Po in sediments can vary according to the local lithology, granulometric fractions and organic matter.

The concentration of Po can be raised by natural processes such as volcanic eruptions, fires, soil dust re-suspension and sea salt migration. The sources of increase in concentration caused by human activity are: use of fossil fuels, effluent and industrial residues mainly from extraction and processing uranium, deposition of radium rich elements such as phosphogypsum [13].

1.1. Study Area

The study area comprehends nine cities in the Brazilian coast: Guarujá, Santos, São Vicente, Cubatão, Praia Grande, Mongaguá, Itanhaém e Peruíbe. Among these places it is important to point out those with great potential to cause direct influence on aquatic ecosystems, like: Santos with a population of 417,983 and an area of 725 km²; São Vicente with 303,551 inhabitants and 13.1 km² and Cubatão with 108,309 inhabitants and an area of 160 km² [14]. Furthermore, the main harbor of Brazil is located in Santos and in Cubatão there are a large number of industries operating, such as steel, petrochemical and fertilizer industries, with direct negative impact in the area.



Figure 1. Baixada santista

2. SAMPLING AND ANALYTHICAL METHODS

Samples were collected in May and June 2007, in locations chosen according to the levels of impact and to the diversity of environments (figure 2). The cores were obtained from São Vicente, Bertioga and Cubatão by extracting profiles up to 1 meter depth with a Piston core sampler. Table 1 indicates the sampling location, code attributed to the cores, sampling date and coordinates.

Table 1: Sampling location, sample identification, sampling date and coordinates

Sampling location	Sample identification	Sampling date	Coordinates
São Vicente	Rio Boturoca – BO3	23/05/2007	S 23° 55' 042''' W 46° 27' 596'''
	Largo de São Vicente – VI4	23/05/2007	S 23° 57' 144''' W 46° 25' 483'''
Bertioga	Rio Itapanhaú – RI6	29/05/2007	S 23° 51' 618''' W 46° 09' 471'''

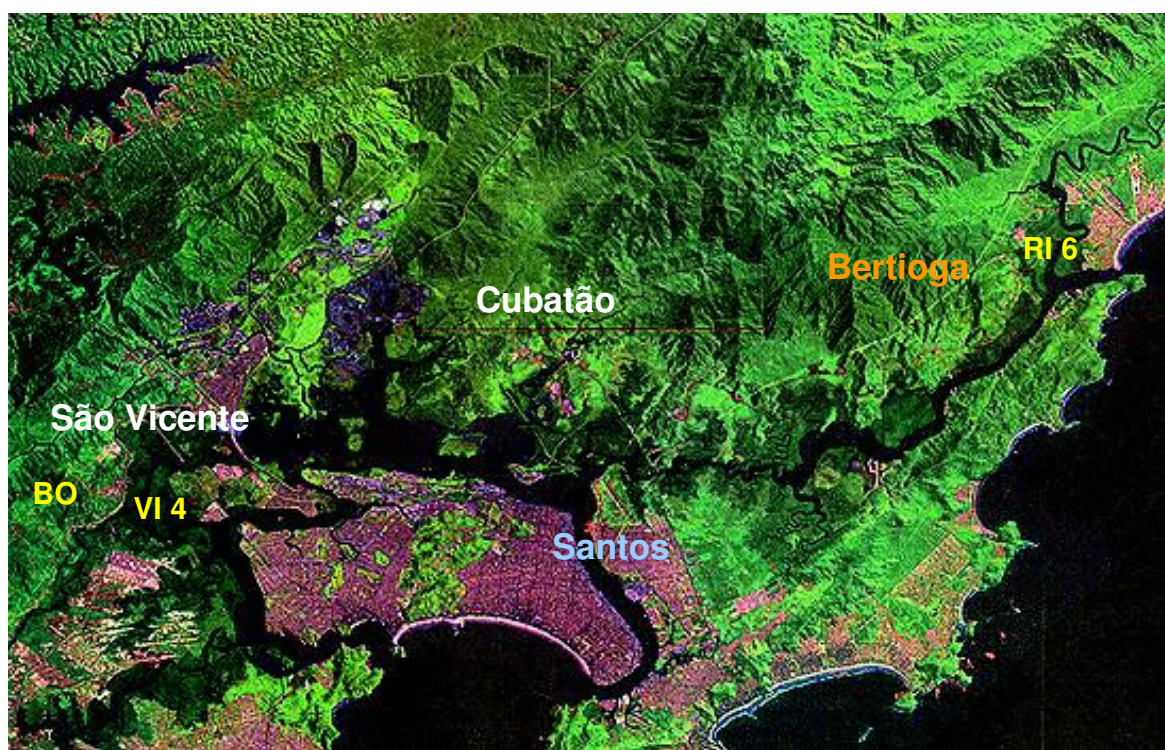


Figure 2. Sampling location

2.1. Pretreatment

The cores were sectioned in slices with 2 cm each and dried for 24 hours at 60 °C, to remove moisture without losing volatile elements. Subsequently samples were grinded, pulverized in a pestle, sieved and stored in a polyethylene flask.

2.2 Chemical treatment and polonium deposition

The chemical treatment for Po determination was adapted from Figgins [15]. Pretreated sediment was precisely weighted (approximately 0,5g) and 100 µg of ^{209}Po (with activity of 2.1715 Bq g^{-1}) was added as a tracer. Then the sediment with the tracer was submitted to acid digestion with a part of nitric acid and three parts of hydrochloric acid at 90°C till total dissolution.

The residue was separated in a *teflon* beaker and 1 ml of HF was added to dissolve silica. Both solutions were mixed together and then evaporated till near dryness with concentrated HCl for 3 times and 6.25 mol L^{-1} HCl was added. The solution was then filtered in a 0.1 micra Millipore paper filter. To proceed deposition 10ml hydroxylamine hydrochloride was added to eliminate Fe^{3+} and Cr^{6+} interference, 0.2 ml of Bi^{3+} (50mg de Bi^{3+} per ml) as hold-back carrier and 10 ml of 25% sodium citrate as complexing agent. De-ionized water was added to increase volume to 100 ml and the pH was adjusted to 1.5 with concentrated ammonium hydroxide or HCl, if necessary.

A silver disc was then submerged in the solution and let for deposition for 2 hours at 90°C and constant agitation. The disc was then counted in a surface barrier alpha detector for 200,000 seconds. The activity concentration was calculated as follows:

$$Ac = 2,1715 \cdot \frac{\text{Count.a}}{\text{Counta.b}} \cdot \frac{Ms}{Ma} \cdot 1000$$

where,

Ac = Activity concentration (Bq kg^{-1})

Count.a = counting rate in the region of the isotope of interest (cps)

Count.b = counting rate of the tracer (cps)

Ms = tracer weight (g)

Ma = sample weight (g)

2.1715 = activity of the tracer (Bq g^{-1})

3. RESULTS AND DISCUSSION

In the core BO3, collected in São Vicente, the activity concentration varied from $32 \pm 2 \text{ Bq kg}^{-1}$, in the deepest layer, to $101 \pm 5 \text{ Bq kg}^{-1}$, in the top layer (table 2 and figure 3). The analysis of this core showed a gradual decrease with depth. These results correlate well with the amount of fine fraction of the core (figure 3), except for the first 7 cm, where higher concentrations were found for ^{210}Po . The other two cores, VI4 (table 3 and figure 4) and RI6 (table 4 and figure 5) presented a small variation in the concentrations of ^{210}Po , from $18 \pm 2 \text{ Bq kg}^{-1}$ to $42 \pm 3 \text{ Bq kg}^{-1}$. These results also correlate well with the percentage of fine fraction observed in the same layers (figure 4 and 5), giving indication that the adsorption of elements is higher in the fine grain fraction [16]. The result of Po in these two cores can be considered the baseline for this radionuclide in the region studied.

The results obtained in this study for the activity concentration of Po in core sediments of Bertioga and Cubatão are within the range observed in the literature for preserved environments: 7.7 ± 0.5 to $60 \pm 2.3 \text{ Bq kg}^{-1}$, in the Antarctic region [17] and from 52 ± 1 to $118 \pm 3 \text{ Bq kg}^{-1}$ in the bay of Gazouet on the Algerian Coast [18]. Sirelkhatim *et al.* [1]

obtained lower concentrations for superficial sediments from the Red Sea in Sudan, ranging from 0.47 to 5.87 Bq kg⁻¹.

Table2: Activity concentration in BO3 core

Depth (cm)	Activity Concentration (Bq kg ⁻¹)
2	101 ± 5
5	82 ± 4
7	54 ± 3
13	39 ± 3
19	34 ± 3
25	37 ± 3
33	32 ± 2

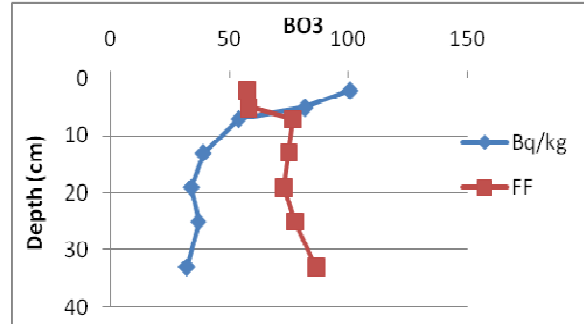


Figure 3: Variation of activity concentration of Po-210 (Bq kg⁻¹) and percentage of fine fraction (%) with depth

Table 3: Activity concentration in VI4 core

Depth (cm)	Activity Concentration (Bq kg ⁻¹)
2	35 ± 3
5	23 ± 2
7	28 ± 3
11	25 ± 2
19	27 ± 2
25	20 ± 2
33	24 ± 2
49	29 ± 2
51	21 ± 2

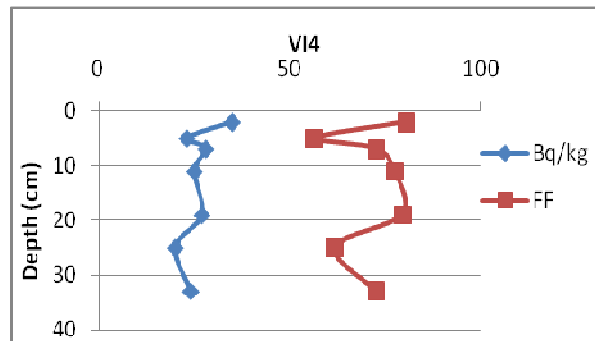


Figure 4: Activity concentration of Po-210 (Bq kg⁻¹) and percentage of fine fraction (%) with depth

Table 4: Activity concentration in RI6 core

RI6-01	21 ± 2
RI6-03	18 ± 2
RI6-05	36 ± 2
RI6-07	19 ± 2
RI6-15	24 ± 1
RI6-23	30 ± 4
RI6-31	42 ± 3

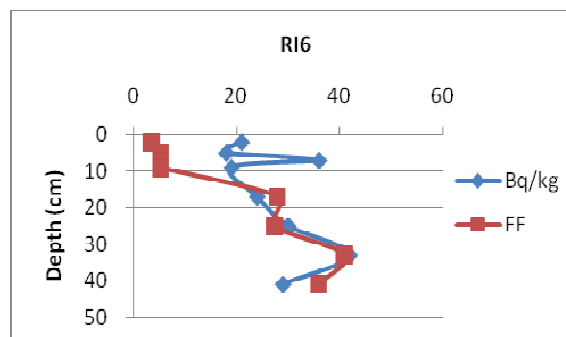


Figure 5: Activity concentration of Po-210 (Bq kg^{-1}) and percentage of fine fraction (%) with depth

4. CONCLUSIONS

The results obtained for the activity concentration of ^{210}Po presented good correlation with percentage of fine fraction, especially in cores VI4 and RI6. The highest values of activity concentration were found in superficial sediments of core BO3 possibly indicating contamination. The result of Po in the cores VI4 and RI6 can be considered as the baseline for this radionuclide in the region studied.

ACKNOWLEDGMENTS

Thanks to CETESB (Companhia de Tecnologia de Saneamento Ambiental) for the collaboration in the cores sampling, to FAPESP (Fundação de Amparo a Pesquisa do Estado de São Paulo) for financial support under contract 2006/05686-4, and to CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) for grant number 300835/95-7.

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