

Seasonal variation of ^{210}Pb concentration measured in rainfall in São Paulo – Brazil

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Introduction

The natural radionuclide ^{210}Pb ($T_{1/2} = 22.3$ y) has been widely used as tracer of soil erosion, transport processes in watershed and as chronometers in the environment. It is present in the atmosphere as decay products of the gas ^{222}Rn . The radionuclide ^{222}Rn is replenished in the atmosphere by emanation from the surface of the earth where it is produced by decay of ^{226}Ra in geological materials. ^{210}Pb returns to the earth as dry fallout or is washed out in rain. As ^{222}Rn is a noble gas that emanates predominantly from the Earth's continental crust, the activity of ^{210}Pb in the air is longitudinal dependant, and its activity will decrease with elevation from the Earth's surface due to a decrease in the activity of ^{222}Rn (Peck and Smith, 2000, Winkler and Rosner, 2000, Martin, 2003, Piliposian and Appleby, 2003).

^{210}Pb is scavenged by aerosols and subsequently removed from the atmosphere, primarily by precipitation. In areas where the amount of rainfall is low, the dry fallout can be a significant component of the bulk depositional flux while in areas where there is a relatively higher amount of rainfall, the wet fallout is the major component (>90%) of the bulk depositional flux. In general, the amount of rainfall controls the seasonal variations of the depositional fluxes of ^{210}Pb , while precipitation-normalized depositional fluxes during spring are higher in the middle latitudes (Baskaran, 1995; Dueñas et al., 2001. McNeary and Baskaran, 2003, 2007).

From measurements of the activities of ^{210}Pb in rainfall, it is possible to estimate its annual flux that is useful in understanding sediment chronology. The behavior of ^{210}Pb provides knowledge on the behavior of other chemical species in atmospheric aerosols and knowledge of site-specific atmospheric fluxes is also crucial to studies of the impact of atmospherically delivered pollutants on terrestrial ecosystems. This isotope has also been used to determine aerosol residence time and removal rates of aerosols.

There is limited data on the depositional fluxes of ^{210}Pb in the precipitation in Brazil and South America as well, compared with data from Northern Hemisphere (Baskaran 1993, 1995, Beks et al, 1998, Caillet et al, 2001, Likuku, 2006, McNeary and Baskaran, 2003, 2007). The aim of this paper is to present preliminary results of ^{210}Pb concentrations in rainfall collected at São Paulo city, Brazil (Figure 1 a) to provide the baseline data for the bulk depositional fluxes of ^{210}Pb . For a period of three years, from 2003 to 2005, rainfall samples were collected and measured and the resulting seasonal ^{210}Pb data were correlated to seasons and precipitation.

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Materials and methods

Site Description

The sampling site is located at IPEN – Instituto de Pesquisas Energéticas e Nucleares, which is approximately 10 km west from downtown São Paulo (Figure 1b). São Paulo city is situated on a plateau in the southeast of Brazil, at latitude 23°32'S and longitude 46°37'W, having an average altitude of 760 m above sea level. Climate in the area is temperate tropical with dry period in winter and rainy in summer. The annual average temperature is 19.1°C, showing minimum and maximum of 15.3°C and 24.9°C, respectively. The annual rainfall in the city, for the studied period, averaged from 887 mm to 1160 mm with a mean value of 1016 mm. The winds in IPEN campus are predominantly from the SSE sector.

Sampling

In the framework of an environmental radiological monitoring program carried out at IPEN facilities, due to their routine liquid and gaseous effluents releases, rainfall samples are collected monthly at four points using a Ville de Paris pluviometer (Figure 1c). ^{210}Pb concentration was determined monthly in rainfall samples collected during the period from 2003 to 2005.

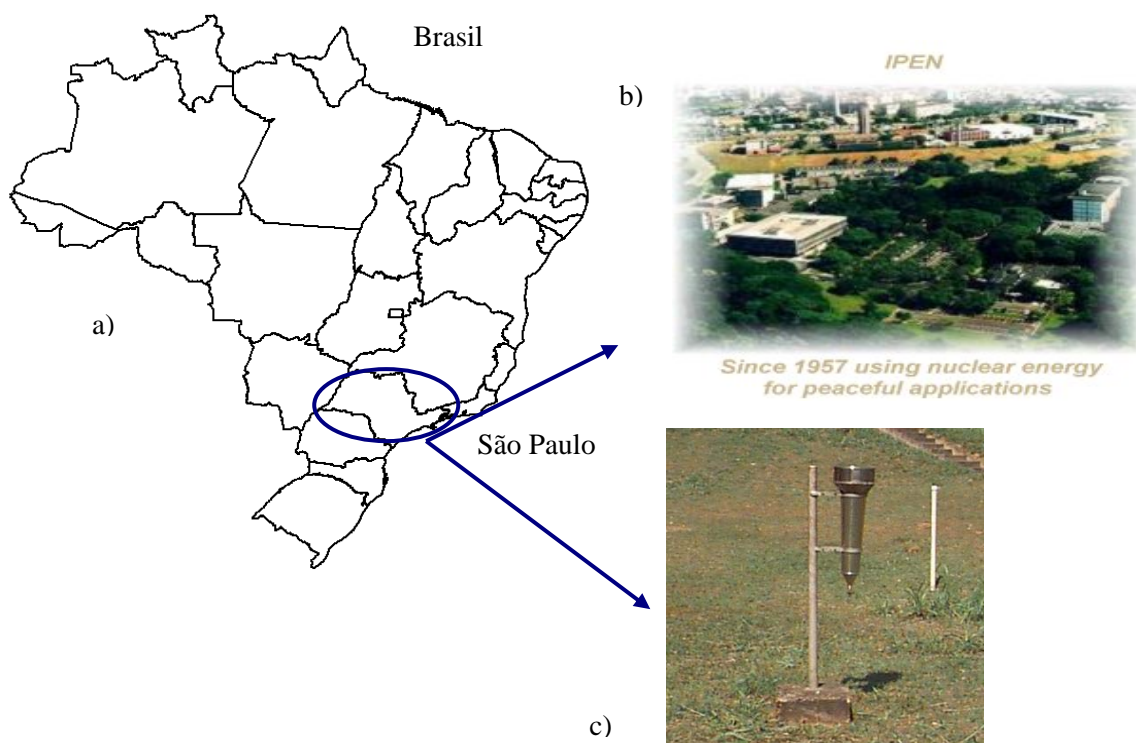


Figure 1.- a) Brasil and São Paulo map, b) IPEN, c) Ville de Paris Pluviometer

^{210}Pb determination

The rainfall samples were filtered and acidified with HNO_3 to $\text{pH} < 2$ and evaporated in hot plate to 1.0 L. ^{210}Pb concentration was determined using a radiochemical procedure that consists of an initial precipitation of Pb with 3M H_2SO_4 , dissolution of the precipitate with

nitrilo-tri-acetic acid at basic pH, and precipitation of $^{210}\text{PbCrO}_4$ with 30% sodium chromate. The ^{210}Pb concentration was determined through its decay product, ^{210}Bi , by measuring the gross beta activity of the $^{210}\text{PbCrO}_4$ precipitate. The chemical yields were determined by gravimetric analysis. ^{210}Pb concentration was measured in a low background gas flow proportional detector.

Results and Discussion

Figure 2 shows the monthly rainfall average for the studied period, from 2003 to 2005. The rainiest months are January and December, in the summer time.

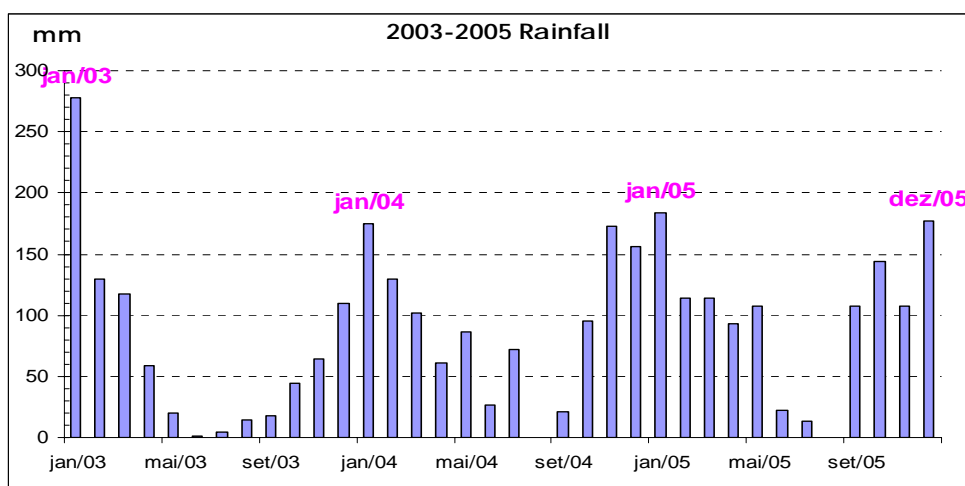


Figure 2.- Annual rainfall in São Paulo city, for the studied period, 2003-2005.

The concentrations of ^{210}Pb in rainfall measured monthly are showed in figure 3, and the values ranged from $17 \pm 2 \text{ mBqL}^{-1}$ to $626 \pm 30 \text{ mBq L}^{-1}$. ^{210}Pb concentrations show an inverse correlation with the amount of precipitation and seasons, presenting lower values in summer and spring and higher values in winter and fall (Figure 4).

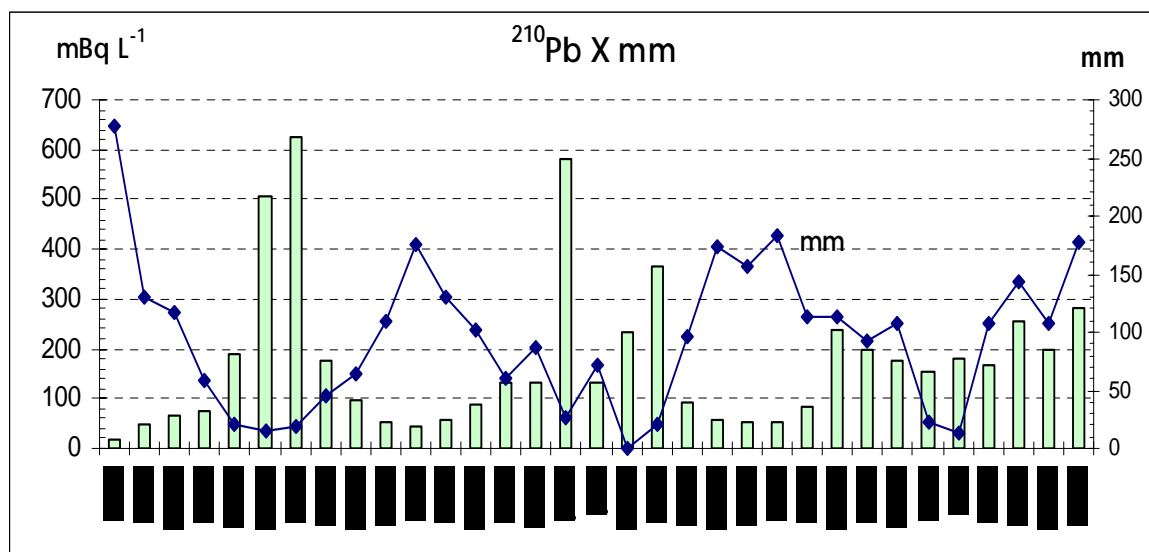


Figure 3.- ^{210}Pb in mBqL^{-1} concentrations X mm of monthly rainfall average

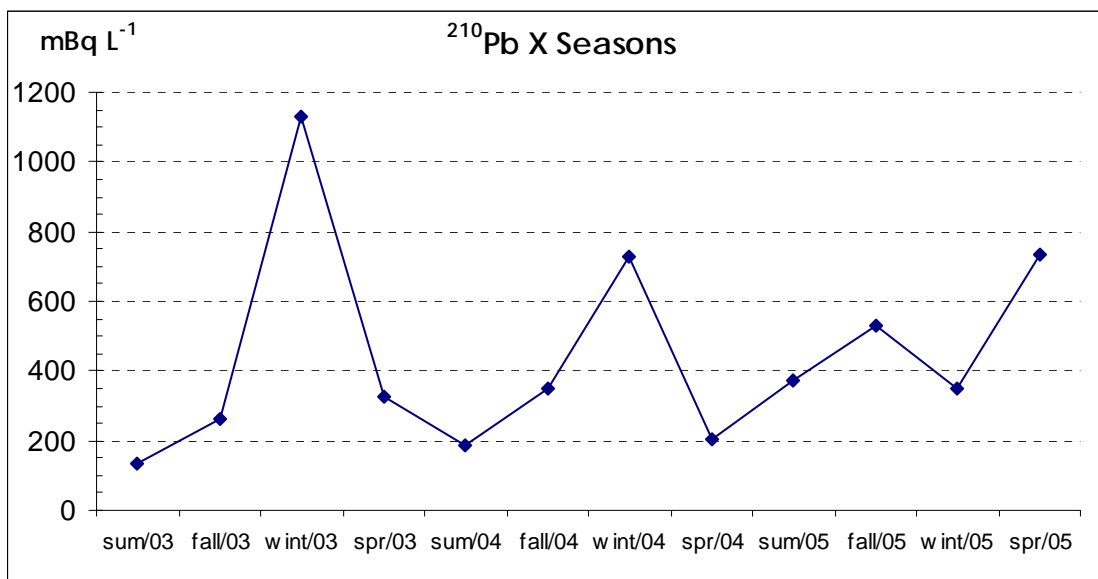


Figure 4 – Seasonal ^{210}Pb in mBqL^{-1} concentration in rainfall of São Paulo, from 2003 to 2005. Win=Winter, Spr= Spring, Sum= Summer and Fal=Fall

The values obtained for ^{210}Pb fluxes measured monthly ranged from 2.8 to 7.3 mBq m^{-2} , and they presented in figures 5, 6 and 7.

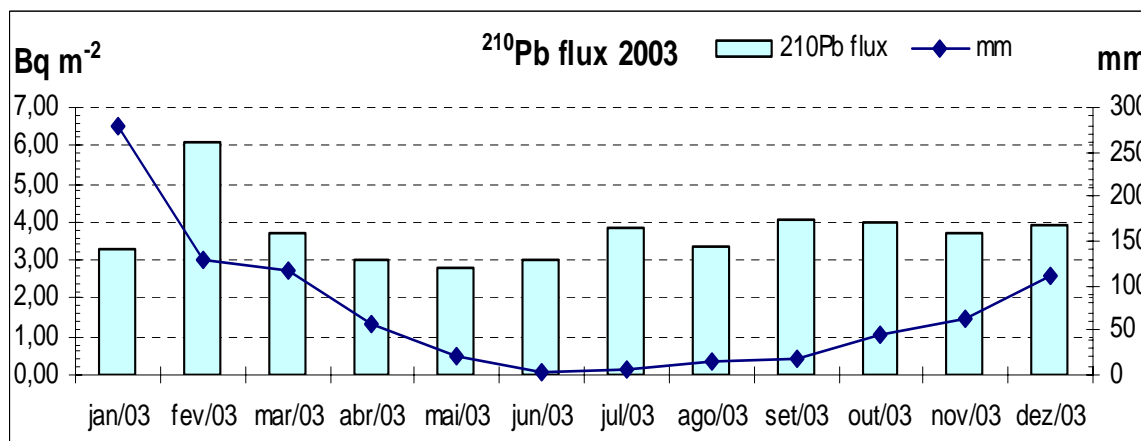


Figure 5 – ^{210}Pb flux in Bqm^{-2} X mm for 2003

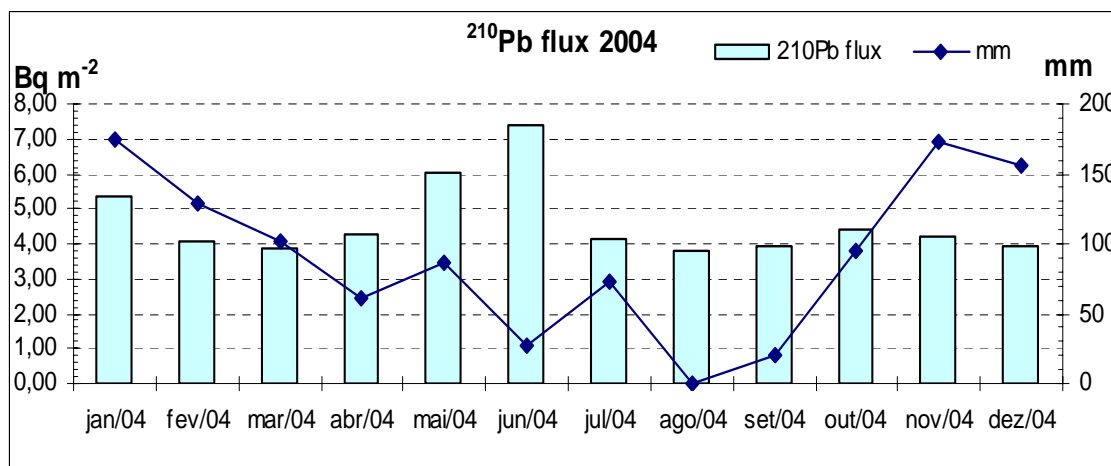


Figure 6 – ^{210}Pb flux in Bqm^{-2} X mm for 2004

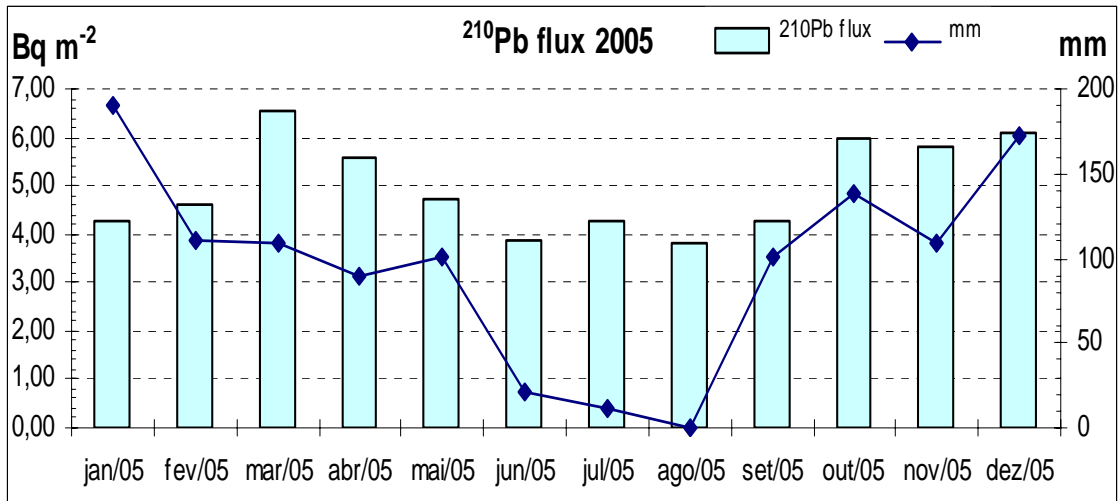


Figure 7 – ^{210}Pb flux in Bq m^{-2} X mm for 2005

The ^{210}Pb flux values also show an inverse correlation with the amount of precipitation, presenting higher values in dry months and lower values in rainy months (Figure 8).

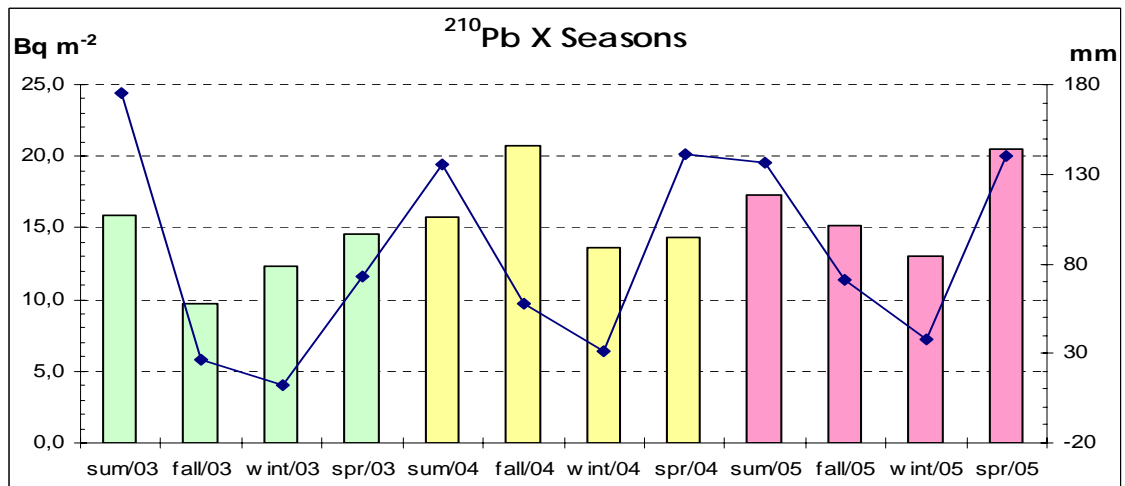


Figure 8 – Seasonal ^{210}Pb flux in rainfall in São Paulo, from 2003 to 2005. Win=Winter, Spr= Spring, Sum= Summer and Fal=Fall.

Conclusions

Direct measurements of the ^{210}Pb deposition in rainfall samples at São Paulo city, during a period of 36 months, from January 2003 to December 2005, gave a mean analyzed flux of $52 \pm 6 \text{ Bq m}^{-2} \text{ y}^{-1}$. ^{210}Pb concentrations in mBq L^{-1} displayed clearly correlation with precipitation, presenting higher values in winter time due to the small volumes of rainfall.

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