PROCEEDINGS OF SCIENCE

^{7}Be content in rainfall and soil deposition in South American coastal ecosystems

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Beryllium-7 (^{7}Be) is a cosmogenic radionuclide that enters from the atmosphere, mainly by wet deposition, being widely used to explore environmental processes. With the aim of using beryllium as an environmental tracer, we are evaluating the ^{7}Be input through rainfalls, its soil deposition and vertical distribution in soil profile. In Niteroi City (Rio de Janeiro State, Brazil) the ^{7}Be content in rainfall and soil were evaluated. The ^{7}Be content in samples was determined by measuring its γ-emission at 477.6 Kev, using a special 55% efficiency high-purity germanium detector produced by Canberra. ^{7}Be activity concentration in rainfall ranged from 0.12 ± 0.15 Bq l^{-1} to 1.96 ± 0.23 Bq l^{-1} (Mean=0.58 Bq l^{-1}, SD=0.48 Bq l^{-1}). The magnitude of precipitation ranged from 2.8 to 40 mm. The ^{7}Be activity concentrations in Niteroi rains are lower than values reported from another sites. Differences in ^{7}Be content should be expected to occur in different environment, due to the effect that latitude and altitude can have on ^{7}Be atmospheric concentrations. ^{7}Be wet deposition ranged from 0.39 ± 0.49 Bq m^{-2} to 34.8 ± 4.9 Bq m^{-2}. The content and distribution of ^{7}Be in soil were analyzed for the months of February and April. ^{7}Be are presents at the first 2 cm depth and the activity concentration decrease exponentially, when depth increases. The total ^{7}Be content in soil were 190 Bq m^{-2} and 330 Bq m^{-2} for February and April, respectively. These results are expected because ^{7}Be are strongly retained in the first centimetres of soil and between February and April several rains have occurred, providing ^{7}Be to soil.

XXXIV edition of the Brazilian Workshop on Nuclear Physics,
Foz de Iguaçu, Parana state, Brasil
5-10 June 2011

[1] Speaker

PoS(XXXIV BWNP)064

1. Introduction

Research about input, circulation and accumulation of natural and anthropogenic radionuclides in terrestrial ecosystems allows examining sources, establishing time scales and elucidating several environmental processes.

^{7}Be is a cosmogenic radionuclide produced in the upper atmosphere and lower stratosphere by cosmic ray spallation of nitrogen and oxygen [1]. The nuclear reaction produces BeO or $Be(OH)_2$ which diffuse through the atmosphere until they attach to an atmospheric aerosol, and its deposition on the earth's surface depends on the production rate (cosmic-ray intensity) which varies with latitude, altitude and solar activity. Other factors include stratosphere–troposphere mixing, circulation and advection processes within the troposphere, and the efficiency with which it is removed from the troposphere [2]. So, ^{7}Be enters continuously into the ecosystem, principally through wet deposition.

The relatively short half-life of ^{7}Be (53 days), its reactivity, and its continuous and definable production rates, make it a potentially powerful tool for examining environmental processes and the number of investigations regarding the application of ^{7}Be as a tracer of environmental processes has increased notably in recent years. This radionuclide has been used in many fields; such as soil redistribution, sediment sources assessment, concentration in air, air mass transport, study of metal scavenging processes and others applications [2, 3, 4, 5, 6, 7, 8, 9, 10].

Potential correlations among ^{7}Be wet deposition, total precipitation and precipitation intensity have been extensively studied by different authors with divergent results [11, 12, 13]. With the aim of using beryllium as a tracer of environmental processes, we are evaluating the ^{7}Be input through rainfalls, its soil deposition and vertical distribution in soil profile.

2. Materials and methods

A rainfall collector was installed in coastal Brazil (S 22°54'; W 43°8'); at Niteroi City (Rio de Janeiro state). The altitude of the sampling site is 15 m above sea level. The average annual temperature is 23 ºC. Annual rainfall ranges from 1093 mm to 1207 mm. We collect samples from January to July of 2011.

2.1 Sampling procedures for rainfall collection

The rainwater was collected using a device constructed in metallic material associated to 20L plastic bottle. This device has a 0.5 m² of surface area, and allows collecting 500 ml of rainwater for each millimetre of rain fall; and the plastic bottle can accumulate the total rainfall. The rainwater collector was placed on the terrace of Instituto de Física (UFF); 1 m above the roof, to avoid contamination. The collector was washed with distilled water every day with the aim to avoid dry deposition.

The precipitation magnitude was determined by measuring the total volume of rain collected. From the total amount of rain collected, a sample of 1000 ml was taken and prepared on a Marinelli beaker.

Rainfall sampling was started in January 2011.

2.2 Sampling procedures for soil acquisition

For soil sampling, within on UFF campus, a land of 6.0 m^2 was prepared and surrounded, to avoid soil disturbances.

The soil samples were collected using plastic tubes of 9.6 cm diameter. The plastic tubes were driven into the soil and then, the soil profile were extracted without disturbance. In laboratory the soil profile was divided, using a slicer, in layers of different depth. The soil profile was sectioned in 9 layers: 0-2 mm; 2-4 mm; 4-6 mm; 6-8 mm; 8-10 mm; 10-12 mm; 12-14 mm; 14-16 mm; 16-21 mm. In each sampling time, 5 soil cylinders were taken, and the layers for a same deep interval homogenized, with the aim to obtain a mass sample needed to γ-spectrometry. The obtained soil samples were dried in stove (120ºC) to constant weigh, sieved through a 2 mm mesh and conditioned in Petri dish (6.4cm diameter x 1.4 cm height) for γ-spectrometry.

Soil samples were taken in February and April 2011.

2.3 ^{7}Be activity determinations

The ^{7}Be content in rainwater and soil samples was determined by measuring its γ-emission at 477.6 Kev. The γ-ray measurements were performed using a special 55 % efficiency high-purity germanium detector produced by Canberra.

For γ-counting, rainwater samples were placed in plastic Marinelli beakers (1000 ml) and soil samples were placed in filled Petri dish (34 g). Counting periods were typically one day. The errors on the activity concentrations arise from the statistical uncertainty in the peak areas and the uncertainty in the absolute efficiency of the gamma detector. The activity concentrations of ^{7}Be were corrected for decay to the time of sample collection.

3. Data analysis and results

From January 2011, 14 individual rain events were collected and analyzed by γ-spectrometry. ^{7}Be activity concentration ranged from 0.12 ± 0.15 Bq l^{-1} to 1.96 ± 0.23 Bq l^{-1} (Mean=0.58 Bq l^{-1}, SD=0.48 Bq l^{-1}). The amount of precipitation ranged from 2.8 to 40 mm (Fig 1). The mean activity concentrations in Niteroi rains are lower than values reported from other sites: 1.7 ± 0.53 Bq l^{-1} for Central Argentina [13] and 1.74 Bq l^{-1} for Switzerland [12]. Differences in ^{7}Be content should be expected to occur in different environment, due to the effect that latitude and altitude can have on ^{7}Be atmospheric concentrations. Nevertheless one Niteroi rain, of 17.8 mm, shows a higher ^{7}Be activity concentration (1.96 ± 0.23 Bq l^{-1}). A few rainfall data are still available, but variations in ^{7}Be content in rain have been described for other regions, and attributed to the reload time of the atmosphere.

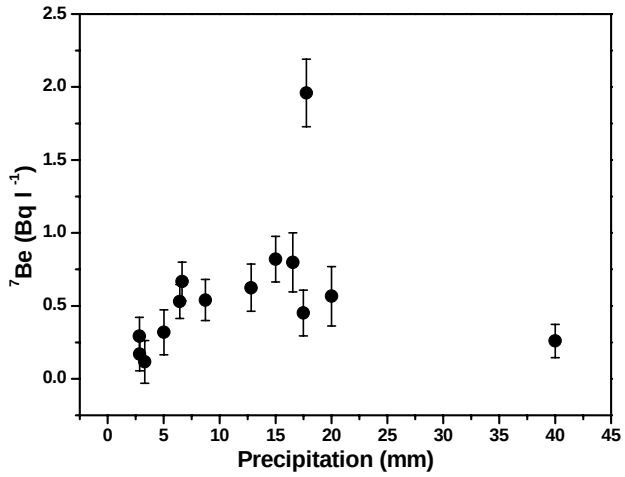

Figure 1. ^{7}Be activity concentration versus precipitation magnitude, in individual rain events. The error bars are the error in the activity concentration measurement.

^{7}Be wet deposition ranged from 0.39 ± 0.49 Bq m^{-2} to 34.8 ± 4.9 Bq m^{-2}. Figure 2 shows ^{7}Be wet deposition versus rainfall magnitude. For other regions a linear relationship between these two variables has been described. Although a few data are available, a good linear relationship can be obtained for rains with a magnitude lower to 20 mm. Nevertheless a rain of 17.8 mm shows a higher ^{7}Be content and in the other hand a rain of 40 mm shows a lower ^{7}Be content. The lower ^{7}Be content in 40 mm rain could be attributed to a washing of the atmosphere, as has been described for other regions [12]. These two rains could be indicating that for the region, the previous events and the event magnitude can affect the ^{7}Be content in rainfall. A large database is needed to understand the entry of ^{7}Be from atmosphere by rains, and the parameters that affect this input.

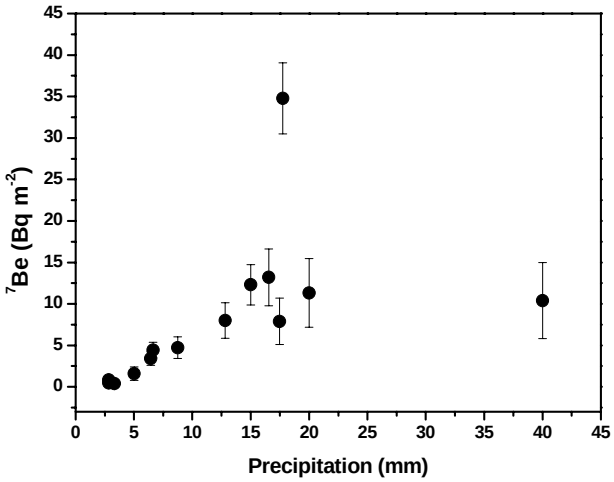

Figure 2. ^{7}Be wet deposition versus precipitation magnitude.

The content and distribution of ^{7}Be in soil were analyzed for the months of February and April. The ^{7}Be activity concentration values ranged from 2.9 ± 2.8 Bq kg^{-1} to 16.1 ± 3.3 Bq kg^{-1} in February and from 0.7 ± 14 Bq kg^{-1} to 25.2 ± 3.3 Bq kg^{-1} in April. ^{7}Be are presents at the first 2 cm deep and the activity concentration decrease exponentially, when depth increases. The total ^{7}Be content in soil were 190 Bq m^{-2} and 330 Bq m^{-2} for February and April, respectively. Figure 3 shows the change of ^{7}Be superficial activity density (Bq m^{-2}) in the soil profile for February (3.a) and April (3.b), showing the typical exponential decrease with the mass depth (kg m^{-2}).

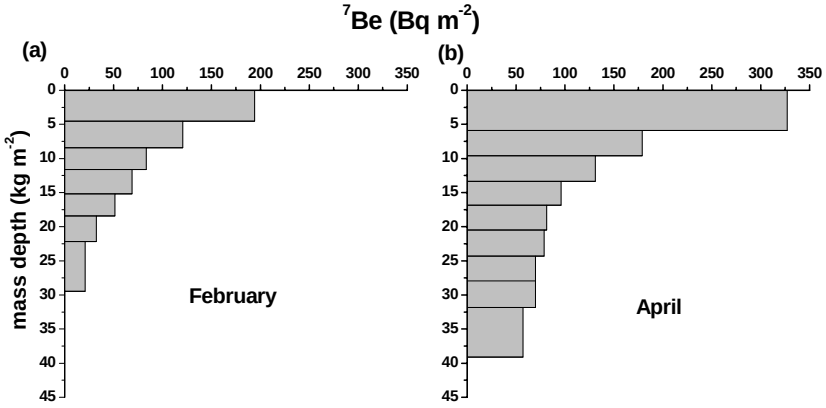

Figure 3. ^{7}Be superficial activity density as a function of mass depth, for February (a) and April (b).

The ^{7}Be content in soil in February (190 Bq m^{-2}) is lesser than in April (330 Bq m^{-2}), but the mass depth (and depth) not change between months. These results are expected because ^{7}Be is strongly retained in the first centimeters of soil and between February and April several rains have occurred, providing ^{7}Be to soil.

Acknowledgements

The authors would like to thank for the financial support to Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Consejo Nacional de Investigaciones Científicas y Técnicas (Conicet), Universidad Nacional de San Luis (UNSL) and Fundación Bunge y Born.

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