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Study of ^{7}Be activity concentration in rainfall as a function of sampling height

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Introduction:

Beryllium-7 (^{7}Be) has been used as a tracer in environmental studies since the 1950s for several purposes. The understanding of its genesis and transport in the atmosphere is very important and many works have been carried out in different parts of the world[1]. Zhang et al.[2] compiled a global data base of ^{7}Be deposition flux, with works published between 1955 and 2020. Based on these works, it can be concluded that there are few works performed in latitudes from 20° to 30°S, requiring greater efforts to understand its behavior in these environments. In addition, there is no standard height in the literature for the sampler's allocation, compromising the concentration comparison in different areas and at different heights. The objective of this work was to analyze, from the bibliometric mapping, the sampler installation heights and to verify whether the altimetric variation of sampling was statistically significant to change the ^{7}Be activity concentration. As a case study, ^{7}Be activity concentration was determined during the dry and wet seasons of 2021 and 2022 at four different heights and at ground level on IPEN campus, located in the city of São Paulo.

Methodology:

The database provided by Zhang et al.[2] is composed of 306 study areas, from which oceanic observations made at sea level were excluded. Thus, in the bibliometric analysis, 184 study areas were used, where the radionuclide deposition process and the sampler height indication were verified. For the present study, four 50 cm diameter conical malleable PVC samplers were made, fixed in a 23.5 m high water tank located at the Centro de Metrologia das Radiações - Instituto de Pesquisas Energéticas e Nucleares (CMR/IPEN). Each sampler was connected by a hose to 20 L capacity gallons. In the laboratory, the volume of the samples was measured, they were filtered and acidified with HNO_3 at pH 2, concentrated to 100 mL and later placed in high-density polypropylene bottles (F100) for measurement by high-resolution gamma-ray spectrometry. Rainfall samples were collected from July 2021 to March 2022. Measurements of ^{7}Be gamma transition of 477.6 keV were performed using a CANBERRA hyper pure germanium (HPGe) detector with a beryllium window, model GX 2520, associated to an electronic system. The results were organized in tables in MS Excel® 2021 and ANOVA and Kruskal-Wallis statistical tests were performed using PAST® 3.0 software.

Results:

The bibliometric analysis (Figure 1-A) confirms the initial hypothesis that there is no standard height for installing the samplers, since in most works this sampling parameter is not mentioned. The main atmospheric deposition mechanism studied is the total deposition (Figure 1-B), due to the lower production cost and easier operation of the samplers. Based on the analyzed articles, the altitude variation of 23.5 m (Figure 1-C) shows great representativeness of the sample universe (95%). The monthly rainfall (L) plus ^{7}Be activity concentration ranges and means (Bq L^{-1}) are shown in Table 1 and, in Figure 1, the mean values of ^{7}Be activity concentration for each sampling height in the dry and wet seasons. In August and September 2021, there was only one rainy event each month.

Figure 1 – A) Indication of the sampler's height in the bibliometric review; B) Types of atmospheric deposition studied; C) Schematic representation of the samplers showing the mean values of ^{7}Be activity concentration (Bq L^{-1}) for each sampling hight in the dry and wet seasons.

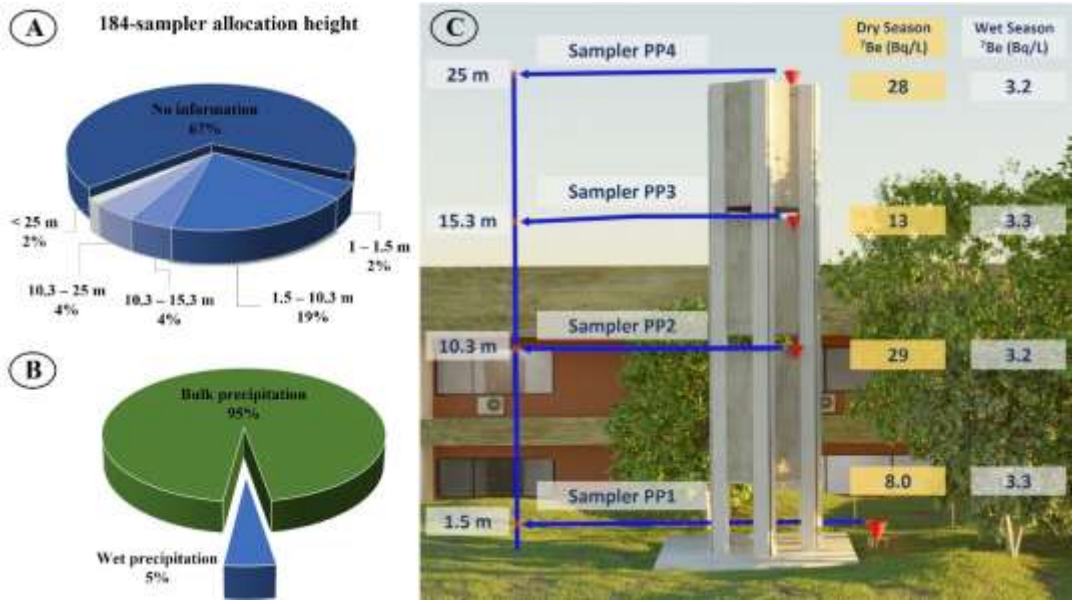

Table 1 – Monthly accumulated rainfall (L) and ^{7}Be activity concentration ranges and means.

Season/Month		Monthly rainfall (L)				^{7}Be (Bq/L) Activity concentration interval Monthly mean			
Season	**Month**	**PP1**	**PP2**	**PP3**	**PP4**	**PP1**	**PP2**	**PP3**	**PP4**
Dry	**Jul/21**	7.1	2.7	3.9	6.1	3.11–15.3 9.22	4.69–53 29	4.79–39 22	5.69–97 52
	Aug/21	6.3	3.1	3.7	5.1	6.67±0.49	**< 1,20	2.74±0.39	2.71±0.33
	Sep21	4.4	2.5	3.1	3.6	6.97±0.92	**< 7.40	5.87±1.05	6.66±0.97
Wet	**Dec/21**	44.2	32.7	36.5	32.4	1.61–5.23 3.17	1.36–4.28 2.45	0.97–3.80 2.04	1.21–5.71 2.88
	Jan/22	76.9	37.9	2.4*	70.2	3.24–4.19 3.58	5.53±0.34	5.73±0.79	1.4–4.95 3.08
	Feb/22	22.7	7.6	8.3*	20.4	2.11–3.96 3.03	**< 8,20	**< 1,38	3.41±0.5
	Mar/22	35.1	16.0	21.1	9.9*	1.96–5.64 3.44	**< 1.85	2.23–5.71 3.97	0.12–6.41 3.26

* sampling problems ** sample detection limit

Statistical tests were performed for three different scenarios: i) evaluation by season; ii) monthly analysis and; iii) analysis by collection. Only a statistically significant variation was found for the parameter volume collected among different seasons.

Conclusions:

The height of sample collection is a parameter that receives little attention in the literature. The results of the case study indicate that the variation of 23.5 m in height is not statistically relevant for the change in the ^{7}Be activity concentration. The results obtained corroborate with unpublished data for the study area and in the understanding of the dynamics of the ^{7}Be radionuclide in latitudes from 20° to 30°S.

References:

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