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Evaluation of ^{40}K and ^{210}Pb levels in soil of the Caantiga biome in the desertification core in the semi-arid region of Brazil

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1. Introduction

The radionuclides resulting from the decay of the uranium and thorium series, and ^{40}K, are found naturally in nature, forming part of different soil compounds and participating in various biogeochemical processes [1]. Assessing radionuclides in soil is also crucial to understanding the potential radiological risks to human health in any region [2]. In Brazil, knowledge about the concentration of radionuclides in soil still needs to be improved, making it difficult to understand the radiological levels to which the population is exposed [3].

In the semi-arid region of Brazil, where the Caatinga biome is predominant and endemic, with high biodiversity, further studies on several fields and the distribution of radionuclides are still needed [4]. Even though this biome is severely affected by the misuse of natural resources and the increase in areas undergoing desertification, impacting regional biodiversity and soil quality [5].

Studies by Leal et al. (2020) [6] seek to understand the levels of radionuclides in the soils of the semi-arid region, specifically in Pernambuco. However, there is still a gap in the literature about information about the concentration of radionuclides in soils from the Caatinga biome, with emphasis on areas that occur in desertification nucleus. Carrying out this survey is crucial to understanding the behavior of natural radionuclides at these sites, and it also helps in studies comparing areas, serving as possible reference values.

Among the natural radionuclides, ^{210}Pb and ^{40}K stand out, the former being widely used in soil erosion studies and the latter for its ability to become available to plants [7]. In this context, this study aims to evaluate the levels of ^{210}Pb and ^{40}K in soils of the Caatinga biome in the desertification nucleus of the Brazilian semi-arid region. This research hypothesizes that radionuclide levels in the region may be higher than in other semi-arid areas and world reference values.

2. Methodology

2.1. Study Area

The study was carried out in two areas (one degraded and the other conserved) of the Caatinga biome, both located on the island of Assunção, Pernambuco, Northeast, Brazil, coordinates 8°30′51″ S, 39°18′36″ W (Fig. 1). The area is part of the Cabrobó desertification nucleus, with predominantly hyperxerophilic Caatinga vegetation, a typical semi-arid climate and predominantly Neosols, Planosols and Luvisols soils [8].

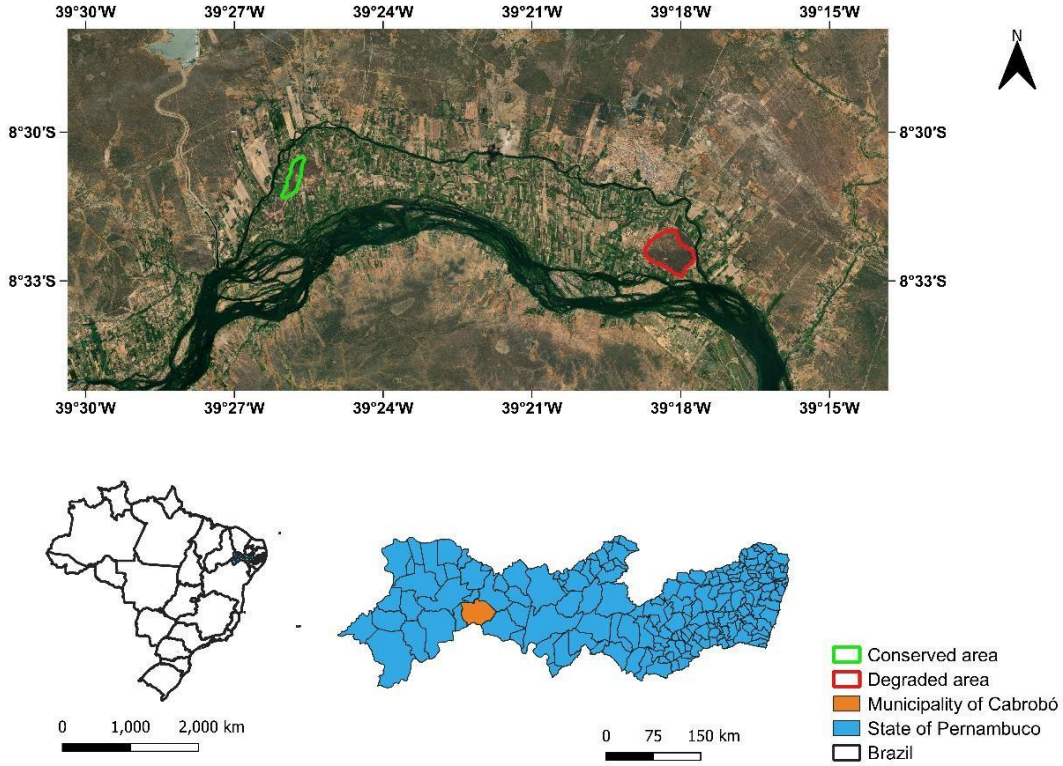

Figure 1: Location of soil sample collection areas

2.2. Collection and Analysis of Sample

To carry out the collection, plots (10m x 30m) were marked around the edges of the conserved and degraded areas. Samples were collected at 3 points per plot (beginning, middle and end), at 0 - 20 centimeters depth. The soil was dried in a forced circulation oven (60 ºC), crushed and sieved to obtain a uniform granulometry. Afterwards, each sample was placed in a Petri dish and sealed with silicone to maintain the secular equilibrium for 30 days.

In this study, the natural radionuclides ^{210}Pb and ^{40}K were determined by High Resolution Gamma Spectrometry with a hyperpure germanium detector (HPGe), Canberra (USA). The concentration was determined using the respective energies: 46 KeV (^{210}Pb) and 1460 KeV (^{40}K). The count duration per sample was 86,400 seconds, with the background count lasting 17,800 seconds. To guarantee the quality of the analytical procedure, the IAEA-327 reference material (radionuclides in soil) from the International Atomic Energy Agency was used- IAEA. The auto absorption resulting from the low energyof 210Pb, was corrected according to the Custhall et al., (1983) [9] proposal.

3. Results and Discussion

Table I shows the descriptive statistics of the results obtained. The conserved area reported a higher mean value of ^{210}Pb. Although, the mean value of ^{40}K was higher in the degraded area. This radionuclide has a high value than world average (400 Bq/Kg) [10]. This higher value may be related to the fact that the soils in the semi-arid region are poorly developed, and this radioisotope is not leached due to the low level of precipitation in the region [6]. The ^{210}Pb did not show anomalous values for the semi-arid region,as demonstrated in the studies carried out by Silva et al. (2009) [11], and this factor may be related to thetype of rock present in the study areas. Studies carried out in the semi-arid Agreste region of Pernambuco showed values of more than 195 Bq/Kg for ^{210}Pb, while in our study areas the average value was in the range of 50 to 70 Bq/Kg [11].

Table I: Descriptive statistics of the concentration of ^{210}Pb and ^{40}K in soil from the Caatinga biome inan area under desertification in the Brazilian semi-arid region

Areas	Redionuclideos	Average (Bq/Kg)	Coefficient of variation	Minimum	Maximum
Degraded	^{210}Pb	57.3	29.3	6.9	161
	^{40}K	1275.7	322.3	537.5	2318
Conserved	^{210}Pb	69.9	26.2	7.1	193.1
	^{40}K	426.6	203.6	10.2	1181.4

Fig. 2 shows the results of the Mann-Whitney U-test for comparing the areas concerning each radionuclide determined in the study. ^{210}Pb reported no significant difference, showing similar results. As this is the same region where the study areas are located, the concentration of the respective element may be influenced by the type of rock in the region, as discussed above. Still, a significant difference was observed for ^{40}K, with a higher concentration in the degraded area. This factor may be related not only tonatural soil issues, but also to the use of fertilizers, especially phosphates, which have a high content of the respective radionuclide [12]. The possible use of this input over a long period of time may have influenced the concentration of ^{40}K in the respective area. After a long period of use for agricultural activities, the area may have been abandoned and the native vegetation began to regenerate.

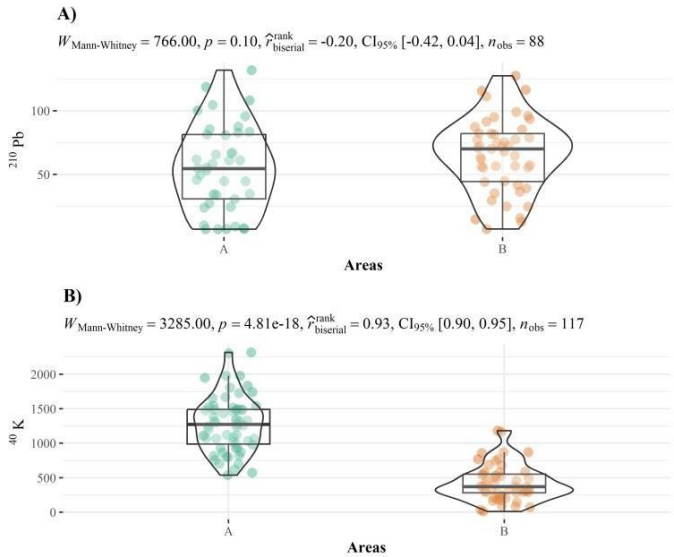

Figure 2: Mann-Whitney U-test to compare the concentration (Bq/Kg) of the radionuclides ^{210}Pb and ^{40}K determined in soil from degraded (A) and conserved (B) areas of the Caatinga biome in the desertification nucleus of the Brazilian semi-arid region.

The study was carried out for the state of Pernambuco showed a median value of 464 Bq/Kg for ^{40}K [6]. Nevertheless, in our study, a much higher median value was observed, especially for the degraded area (1275 Bq/Kg). The conserved area showed normality compared to the respective study carried out previously in the state, reporting a value of 370 Bq/Kg.

4. Conclusions

The results show that the ^{210}Pb values are within the normal range. However, the ^{40}K in the degraded area needs to be better studied, as its concentration is much higher than the reference values worldwide in the Brazilian semi-arid region and may have been influenced using agricultural inputs. Studies that seek to assess the soil in a stratified manner and the transfer factor to the plant are highly encouraged. The application of indices to assess the radiological risk of the respective radionuclides willbe addressed in future studies.

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