Determination of Natural Radioactivity Levels in Sediments: Caravelas River

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Abstract: Due to intensive human activity in the region and disorderly occupation, the Caravelas River estuary has not yet evaluated the contribution of natural radioactivity. In order to determine the natural radioactivity levels in sediments, the activities of ^{238}U, ^{232}Th and ^{40}K, were calculated using a gamma spectrometry system for measuring the concentration of radiation in samples. Results for ^{238}U, ^{232}Th and ^{40}K ranged from (18.03 to 191.51), (28.57 to 118.25) and (134.06 to 186.80) $Bq.kg^{-1}$, respectively, within of detection limits. The estimated uncertainty levels were less than 10% (k = 1).

Keywords: Natural Radioactivity; GammaSpectrometry; Caravelas River Estuary.

1. INTRODUCTION

Estuaries are bodies of water considered of paramount importance on primary productivity, due to high concentrations of nutrients, in addition to being the natural habitat of birds, mammals and fish, and spawning of environments many species of commercial value fish and migratory bird route [1; 9].

Due to growing population expansion of the coastal cities, these environments also have significant economic importance, because they are used as access routes to the interior of the continent, to the port activities, in the fishing industry, the extraction of sand, among others.

The disordered occupation, the use of the estuary as a receiver of natural, industrial effluents, the presence of pathogenic substances, in addition to the absence of proper management, endanger sustainable development of these environments [15;18].

Estuaries can be thought of as filters of chemicals transported by the rivers, which often arise from the mixing zone under a fairly modified [8].

The characteristics of estuarine sediments are of great interest for a number of reasons. If these deposits contain large concentrations of clay minerals, their influence on the chemistry of the estuarine environment by ion exchange is extremely important to the chemical exchange between the Mainland and the ocean.

Furthermore, the composition of these sediments reflectsthe initial mixture of continental runoff and ocean waters such that studies of these sediments can produce

reasonable information on the geochemical and physical processes that take place in this environment [10; 21].

Naturally occurring radionuclides are mentioned in the literature as Naturally Occurring Radioactive Material (NORM). Radionuclides with high concentration show the man the risk of ionizing radiation effect. Although the radionuclides are uniformly distributed in the Earth's crust, there are regions where are found high concentrations, as is the case of Guarapari (ES), Caetité (BA) and Poços de Caldas (MG) in Brazil.

The aimof this study is to determine the concentrations in activity (Radiometry) of ^{238}U, ^{232}Th and ^{40}K in sediments in the estuary of the river Caravelas (BA). This information will serve as benchmarks for an assessment of the environmental impact caused by any change that occurs in the natural sources of radioactivity [7; 16; 17].

2. AREA OF STUDY

The Caravelas River estuary (17° 43 ' S; 39° 15 ' W) is located in the extreme south of Bahia State, extending into the continent, where it forms the second largest mangrove forest complex in the Northeast region of Brazil, with an area of 66 km^2. This estuary is associated with the mouth of Peruípe River, through small winding channels and has a bar of entry of approximately 2 km.

According to their geographical location, the estuary of the river Caravelas is under Tropical wet climate type AF Köpen, with maximum average temperature of 25.5°C in the summer and an average minimum temperature of 21.5°C in winter. The average annual precipitation is 1750 mm. Figure 1 shows the location map of the area under study.

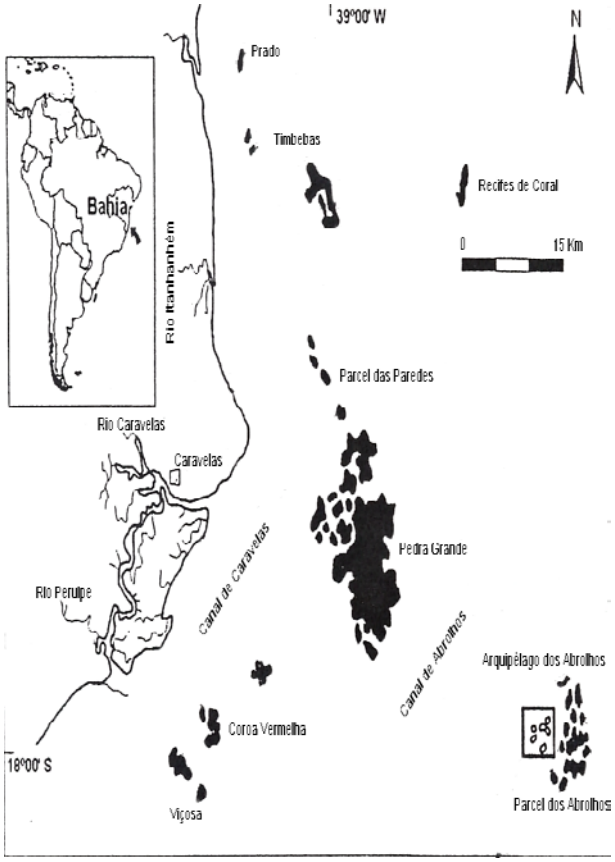

Figure 1: location of the Caravelas River estuary.

3. MATERIALS AND METHODS

Preliminarily the concentrations of ^{238}U, ^{232}Th and ^{40}K must be determined by a non-destructive technique by means of gamma spectrometry analysis, due to its high accuracy. For this, the samples must be homogenized to achieve an even distribution of the minerals present, standardizing the masses (weights) of each sample around 440 g, 60,000 count seconds and proper geometry. The samples were placed in polyethylene bottles of cylindrical shape with a diameter of 5.5 cm and 10.0 cm in height, closed and stored for 30 days to reach secular equilibrium between ^{238}U, ^{232}Th and its decay products [4; 14].

After the storage period, the samples were analyzed at a hiperpure germanium detector (HPGe) Canberra, branded with 2 ≤ keV

resolution (FWHM) in 1332 keV energy range and ≤ keV 1.20 to 122 keV. The extent of energy detector is between 12 keV and 3 MeV.

To construct the efficiency curve was used a standard cocktail with ^{60}Co (2002.243 Bq), ^{65}Zn (2571.467 Bq), ^{134}Cs (2390.962 Bq),^{137}Cs (2029.989 Bq) and ^{152}Eu (2846.799 Bq), with fixed values for the reference date. In turn, the value of which corresponds to the energy efficiency of the radionuclide of interest. The same sample is measured bottle empty (white) to serve as reference of the background radiation [4;5].

To obtain the values activities, we used the standard cocktail of radionuclides with respective energies according to Equation 1, based on the reference date of the standard. This standard was certified by the Institute of Radiation Protection and Dosimetry (IRD).

$$A = A_0 \, . e^{-\lambda . t} \qquad (1)$$

In that, **A** is the activity to be calculate; $\mathbf{A_0}$is the initial activity; and **λ** is the decay constant for each radionuclide.

At the end of the count of each sample for ^{238}U, ^{232}Th and ^{40}K, its concentrations are determined using the method of the area under the photopeak, i.e., the number of counts under the photopeak of interest, in Bq.kg^{-1}, by means of the Equation 2 [2; 3; 4; 5].

$$A = \frac{C}{\epsilon . t . I_\gamma . m} \qquad (2)$$

Where: **A** is the activity of radionuclide to be measured (Bq.kg^{-1}); **C** is the total area of the peak of radionuclide (counts); **ϵ** is the efficiency of the detector; **t** is the counting time (s); **Iγ** is the percentage of the radionuclide emissions considered in energy of interest; and **m** is the mass of the sample (kg).

4. RESULTS

Concentrations in activities of ^{238}U, ^{232}Th and ^{40}K in sediment samples of the Caravelas River estuary were determined and their data values in Bq.kg^{-1}. The amplitude (variation) and the average values (in parentheses) obtained here for ^{238}U, ^{232}Th, ^{40}K are [18,03-191.51 (113.36)], [28,57-118.25 (72.97)], [134,06-186.80 (155.98)], respectively, with combined uncertainty less than 10% for a 68% confidence level. The great variation of the values of concentrations in activities isdue to their presence in the marine environment as well as their physical, chemical and geochemical analysis [11; 12; 19].

These concentrations are quite superior for ^{238}U and ^{232}Th, about 2 times greater than the world average, respectively, about 50% lower than the world average value in relation to the ^{40}K compared to the world average values (35 Bq.kg^{-1} for ^{238}U, 30 Bq.kg^{-1} for ^{232}Th and 400 Bq.kg^{-1}for ^{40}K) for these radionuclides in sediments [20].

5. CONCLUSIONS

Concentrations in activities of ^{238}U, ^{232}Th and ^{40}K of sediments collected in the Caravelas River Estuary-BA were determined with precision using gamma spectrometry technique and standardized radioactive sources. From the values of activity concentration of these radionuclides could evaluate the potential radiological risks due to the effects of ionizing radiation.

Here one can consider that the average value of each parameter measured for ^{238}U and ^{232}Th are about 2 times larger than the global average values, respectively, while ^{40}K is below 50% in relation to the world average.

Therefore, this may mean that the potential risk to human health is directly associated with the sediment measured in the Estuary of the river Caravelas - BA.

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