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Measurement of natural radioactivity in Brazilian beach sands

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Abstract

The distribution of natural radionuclide γ-ray activities and their respective annual effective dose rates, produced by ^{40}K, ^{226}Ra and ^{232}Th, were determined for sand samples collected along the coast of four Brazilian States: São Paulo (SP), Rio de Janeiro (RJ), Espírito Santo (ES) and Bahia (BA). For some specific beaches, the values of the annual effective dose rates or γ-ray radiation hazard indices exceed the average worldwide exposure of 2.4 mSv y^{-1} due to natural sources and the limits proposed by Organization for Economic Co-operation and Development for building materials. The average values of the radium equivalent activities were evaluated and found to be 696 Bq kg^{-1} in Mambucaba (RJ), 1621 Bq kg^{-1} in Buena (RJ), 2289 Bq kg^{-1} in Anchieta (ES), 10 205 Bq kg^{-1} in Meaipe (ES), 83 425 Bq kg^{-1} in Guarapari (ES), 531 Bq kg^{-1} in Vitória (ES), 2026 Bq kg^{-1} in Serra (ES), 3240 Bq kg^{-1} in São Mateus (ES), 3075 Bq kg^{-1} in Porto Seguro (BA) and 1841 Bq kg^{-1} in Itacaré (BA). These values are above the limit of 370 Bq kg^{-1} recommended for the safe use of building materials for dwellings by OECD.

Keywords: Coastal sands; γ-ray spectrometry; ^{40}K, ^{226}Ra and ^{232}Th concentrations; Annual effective dose rate; Radiation hazards indexes

1. Introduction

Beach sands are mineral deposits formed through weathering and erosion of either igneous or metamorphic rocks. Among the rock constituent minerals are some natural radionuclides that contribute to ionizing radiation exposure on Earth. Natural radioactivity in soils comes from U and Th series and natural K.

The study of the distribution of primordial radionuclides allows the understanding of the radiological implication of these elements due to the γ-ray exposure of the body and irradiation of lung tissue from inhalation of radon and its daughters (Alam et al., 1999; Singh et al., 2005). In particular, it also is important to assess the radiation hazards arising due to the use of soil or sand samples in the construction of dwellings. Therefore, the assessment of gamma radiation dose from natural sources is of particular importance as natural radiation is the largest contributor to the external dose of the world population (UNSCEAR, 1993, 2000). These dose rates vary depending upon the concentration of the natural radionuclides, ^{238}U, ^{232}Th, their daughter products and ^{40}K, present in soil, sands and rocks, which in turn depend upon the local geology of each region in the world. In certain beaches of Brazil there are areas

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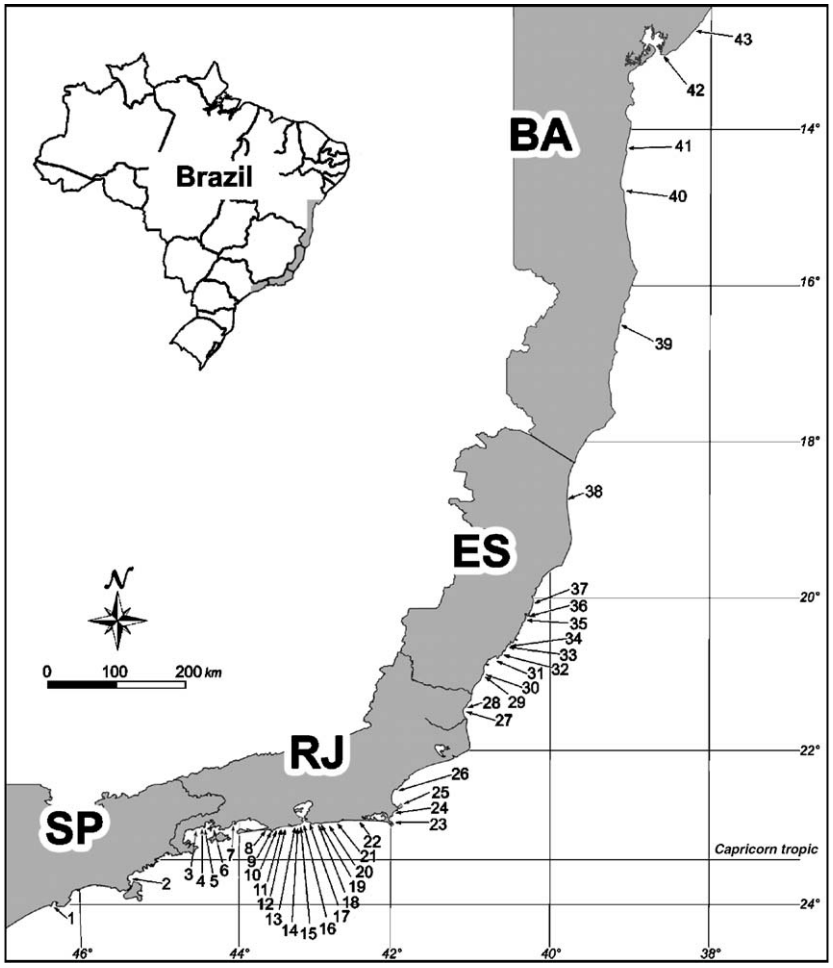

Fig. 1. Geographic location of the tourist resorts of four Brazilian States where the beach sand samples were collected. The sampling locations are indicated by their number (see Table 1).

well-known for their high background radiation. These areas are directly connected with the occurrence of heavy-mineral deposits. The Areia Preta beach in Guarapari (Espírito Santo State) is a famous example, visited by tourists for its black radioactive sand, looking for sea swimming and treatment of rheumatoid. Thus, it is important to verify the extent of this anomalous behavior along the Atlantic coast of Brazil, since there are several heavy-mineral deposits in beaches and sandy laces in the coasts of North Rio de Janeiro, the Espírito Santo and the South Bahia States.

Using HPGe and NaI γ-ray spectrometers to determine the concentration of natural radionuclides in an extensive selection of the Atlantic coasts of Brazil, beach sands were collected in order to evaluate the radiation hazard in these areas. The annual effective dose rates, radium equivalent activities and external hazard indices were evaluated and compared to the limits proposed by United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 1993) and Organization for Economic Co-operation and Development (OECD, 1979; Beretka and Mathew, 1985), respectively.

2. Material and methods

2.1. Sample collection and preparation

Superficial beach sand samples of 43 different coastal zones were collected, covering about 2000 km along four Brazilian States: São Paulo (SP), Rio de Janeiro (RJ), Espírito Santo (ES) and Bahia (BA). The region studied is the coastline between northern coast of Bahia State (12°40′S and 38°05′W), and the southern coast of São Paulo (24°10′S and 46°30′W). Fig. 1 shows the tourist resort locations at the four Brazilian States where the sand samples were collected. The resort localizations are indicated by their number (see Table 1). Some resorts were