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Assessment of natural radionuclide distribution in shore sediment samples collected from the North Dune beach, Henties Bay, Namibia

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ABSTRACT

The activity concentrations of ^{238}U, ^{232}Th and ^{40}K were determined using gamma spectrometry (HPGe detector) and their radiological hazards are presented in this study for shore sediment samples from the North Dune beach of Henties Bay, Namibia. The activity concentrations were found to range from 25.32 ± 1.24 Bq.kg^{-1} to 232.33 ± 0.62 Bq.kg^{-1} with an average value of 175.59 ± 0.92 Bq.kg $^{-1}$ for ^{238}U, BDL to 77.99 ± 45 Bq.kg^{-1} with an average value of 40.17 ± 27 Bq.kg^{-1} for ^{232}Th and 222.39 ± 8 Bq.kg^{-1} to 482.16 ± 10 Bq.kg $^{-1}$ with an average value of 349.66 ± 8 Bq.kg^{-1} for ^{40}K. In order to assess the radiological hazard of the shore sediment samples, the radiological hazard indices such as absorbed dose rates (ADR), radium equivalent (R_{eq}) annual effective dose equivalent (AEDE), the hazard indices (H_{ex} and H_{in}), and the excess lifetime cancer risk (ELCR) were calculated. The values obtained in the present study were compared with world acceptable limits and it was found that the average values of radium equivalent (Req) and external hazard index (Hex) were below the world allowable limits. However, the average values of absorbed dose rates (ADR), annual effective dose equivalent (AEDE) (outdoor and indoor), internal hazard index (H_{in}) and excess lifetime cancer risk (ELCR) exceeded the world acceptable limits.

1. Introduction

Human populations are exposed to varying levels of ionizing radiation from numerous sources in the environment. These sources include cosmic rays and natural radioactive sources in air, drinking water and food (National Council on Radiation Protection, 1975; United Nations Scientific Committee on Effects of Atomic Radiation, 1998). Knowledge of the levels of natural radionuclides and their distribution in the environment is of great interest in several fields of environmental sciences. The naturally occurring radioactive materials (NORMs) are relatively and uniformly distributed in the seas and oceans. Human activities have however, released additional amounts of NORMs into the environment. Among these activities are; mining and milling of mineral ores, ore processing and enrichment, nuclear fuel fabrication and the handling of fuel cycle tail end products (Ramasamy, Senthil, Meenakshisundaram, & Gajendran, 2009). Also the discharge and deposition into the sea of low level waste from the nuclear industry has become a worrisome source of contamination in most marine coastal environments.

Shore sediments not only consist of organic and inorganic compounds but also radionuclides. The reason for this is that most of the radioactivity deposited on surface sediments is washed by rains and drained through rivers to the oceans. Part of the ground deposited activity is absorbed in the soils and percolates with the underground waters to the oceans. Radioactive materials reaching the ocean become part of the marine ecosystem (Akram, Riffat, Qureshi, & Solaija, 2006). The NORMs present in soil and sediment include ^{238}U, ^{232}Th and ^{40}K. Gamma radiation emitted from these radioisotopes, also referred to as terrestrial background radiation, constitutes the main source of irradiation to human

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populations (Mulwa, Maina, & Patel, 2013). To mitigate these problems, assessment of the concentration of radioisotopes in the marine environment is of importance. Sediments have been widely used as environmental indicator and their ability to trace contamination sources and monitor contaminants is widely recognized (Amekudzie et al., 2011). It is therefore, necessary to quantify the distribution of radioactive materials in shore sediments in order to assess the radiological impacts of the detected radionuclides on human populations.

Over the years, the coastline of the Erongo Region of Namibia has experienced an increase in industrial establishments, tourism, transport and urbanization for socio-economic purposes. The region is also home to six active uranium mines, where commercial exploitation of uranium has been taking place for export purposes.

Little is known about the concentrations of NORMs in the shore sediments of the North Dune Henties Bay beach which lies on the coastline of the Erongo Region of Namibia. This paper reports on measurements of specific activity concentrations of natural radioactivity of ^{238}U, ^{232}Th and ^{40}K, from shore beach sediment samples in Henties Bay. The objective of this present study was to evaluate the radiological hazards occasioned by natural radioactivity associated with beach sediments by calculating the absorbed dose rate, annual effective dose rate, external hazard index, internal hazard index, radium equivalent and excess lifetime cancer risk.

2. Materials and methods

2.1. Study area

Henties Bay is a coastal town situated in the Erongo Region of Western Namibia as shown in Fig. 1. It lies on longitude 14°30′19″E and latitude 22°55′27″S. The town is one of Namibia's best-known and most popular holiday destinations located 70 km north of Swakopmund where uranium ore is mined for commercial purposes. The climate of the town is characterised by aridity. Some prominent features of the climate include: very low rainfall of about 15 mm at the coastline, coastal fog, and the southerly and south-westerly winds that sometimes occasion the mobility of entire desert surface and tailings (von Oertzen, 2008).

2.2. Sample collection and preparation

In order to evaluate the concentration of natural radioactivity in the beaches of Henties Bay, shore sediment samples were collected from 20 randomly chosen points in October 2013. The GPS coordinates of these points were marked and designated to be representative of the concentrations of natural radioactive materials at the shore of the beach (Table 1). The sampling points were carefully chosen to represent areas where human population are involved in various activities. At each location, shore sediment samples were taken from approximately 7 to 10 m away from high tide at a depth of 20 cm by using a hand scooper. After each sample was cleared of debris, it was well packed into a plastic bag and labelled according to the geographical coordinates of the sampling point. The samples were oven-dried at 115 °C to ensure complete eradication of moisture and passed through a 2 mm sieve. An amount of 100 g of each shore sample was then placed in a radon-tight container of 10 cm diameter. Each vessel was weighted and sealed for 30 days to allow secular equilibrium to be attained between ^{238}U and ^{232}Th with their respective progeny (Onjefu et al., 2016).

2.3. Sample counting and measurements

2.3.1. Activity measurements

On attainment of secular equilibrium, the samples were counted

Fig. 1. Map of Namibia showing the location of Henties Bay.