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Measurements of natural gamma radiation in beach sediments of north east coast of Tamilnadu, India by gamma ray spectrometry with multivariate statistical approach

M. SureshGandhi [a], R. Ravisankar [b,*], A. Rajalakshmi [c], S. Sivakumar [d], A. Chandrasekaran [e], D. Pream Anand [f]

[a] Department of Geology, University of Madras, Guindy Campus, Chennai 600 025, Tamilnadu, India
[b] Post Graduate and Research Department of Physics, Government Arts College, Tiruvannamalai 606603, Tamilnadu, India
[c] Department of Physics, SSN College of Engineering, Kalavakkam, Chennai 603 110, Tamil Nadu, India
[d] Department of Physics, Mailam Engineering College, Mailam 604304, Tamilnadu, India
[e] Department of Physics, Global Institute of Engineering & Technology, Vellore 632509, Tamilnadu, India
[f] Department of Physics, ST. XAVIER'S College, Palayamkottai 627002, Tamilnadu, India

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ABSTRACT

The distribution of natural gamma ray emitting ^{238}U, ^{232}Th and ^{40}K radionuclides in beach sediments along north east coast of Tamilnadu, India has been carried out using a NaI(Tl) gamma ray spectrometric technique. The total average concentrations of radionuclides ^{238}U, ^{232}Th, and ^{40}K were 35.12, 713.16, and 349.60 Bq kg^{-1}, respectively. Correlations made among these radionuclides prove the existence of secular equilibrium in the investigated sediments. The total average absorbed dose rate in the study areas is found to be 504.75 $nGyh^{-1}$, whereas the annual effective dose rate has an average value of 0.62 $mSvy^{-1}$. The mean activity concentrations of measured radionuclides were compared with other literature values. The ratios between the detected radioisotopes have been calculated for spatial distribution of natural radionuclides in studied area. Also the radiological hazard of the natural radionuclides content, radium equivalent activity, external hazard index of the sediment samples in the area under consideration were calculated. Multivariate Statistical analyses (Pearson Correlation, Cluster and Factor analysis) were carried out between the parameters obtained from radioactivity to know the existing relations.

* *Corresponding author*. Tel.: +91 9443520354; fax: +91 4175 236553.
E-mail address: ravisankarphysics@gmail.com (R. Ravisankar).
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1. Introduction

All living organisms of the planet are exposed to natural radiation, which is mainly due to the activity concentration of primordial radionuclides ^{232}Th, ^{238}U and their product of decay, in addition to the other natural radionuclide ^{40}K present in the earths crust (UNSCEAR, 2000). Natural radioactivity is wide spread in the earth's environment and it exists in various geological formations like soils, rocks, plants, sand, water and air. Hence, humans should beware of their natural environment with regard to the radiation health effects. Some of the radiation health effects are chronic lung diseases, acute leucopoenia, anemia and necrosis of the mouth. Thorium exposure can cause lung, pancreas, hepatic, bone, kidney cancers and leukemia (Taskin et al., 2009). Therefore nowadays, human exposure to ionizing radiation is one of the scientific subjects that attracts public attention, since radiation of natural origin is responsible for most of the total radiation exposure of the human population. Many areas in the world such as Australia, Brazil, China, India, Iran, Japan, etc., possess high levels of natural radiation. In the recent years, studies on the high background radiation areas in the world have been of prime importance for risk estimation due to long term low-level whole body exposures to the public. The high radiation levels are due to the presence of large quantities of naturally occurring radioactive minerals in the rocks, soils, sediments, etc. (Singh, Shanker, Neelakandan, & Singh, 2007). Among the various geological formations, sediment plays a predominant role in aquatic radioecology and plays a role in accumulating and transporting contaminants within the geographic area. It is the basic indicator of radiological contamination in the environment (Suresh, Ramasamy, Meenakshisundaram, Venkatachalapathy, & Ponnusamy, 2011).

Sediment is a naturally occurring material that is broken down by processes of weathering and erosion, and is subsequently transported by the action of wind, water, or ice, and/or by the force of gravity acting on the particle itself. Sediments are most often transported by water (fluvial processes), wind (aeolian processes) and glaciers. Beach sands and river channel deposits are examples of fluvial transport and deposition, though sediment also often settles out of slow-moving or standing water in lakes and ocean dunes and loess are examples of aeolian transport and deposition. Glacial moraine deposits and till are ice-transported sediments. Seas, oceans and lakes accumulate sediment over time. The sediment could consist of terrigenous material, which originates on land, but may be deposited in either terrestrial, marine, or lacustrine (lake) environments; or of sediments (often biological) originating in the body of water. Terrigenous material is often supplied by nearby rivers and streams or reworked marine sediment (e.g. sand). In the mid-ocean, living organisms are primarily responsible for the sediment accumulation, their shells sinking to the ocean floor upon death. Deposited sediments are the source of sedimentary rocks, which can contain fossils of the inhabitants of the body of water that were, upon death, covered by accumulating sediment. Lake bed sediments that have not solidified into rock can be used to determine past climatic conditions.

Beach sediments 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 gamma-ray exposure of the body and irradiation of lung tissue from inhalation of radon and its daughters (Uosif, El-Taher, & Abbady, 2008). Radiological studies have been made in sediment beach locations, mainly in India, because along its coastline there are quite a few monazite sand bearing placer deposits causing natural high background radiation areas in Kerala (UNSCEAR, 2000) and Tamilnadu (Radhakrishna, Somashekarappa, Narayana, & Siddappa, 1993), in Kalpakkam (Kannan, Rajan, Iyengar, & Ramesh, 2002) and in recent work in the coast of Orissa (Mohanty, Sengupta, Das, Vijayan, & Saha, 2004). During the last few decades, the coastal environment of north east coast of Tamilnadu in India has experienced intense developments in industry, tourism, transport, urbanization and aquaculture. This paper reports the activity concentrations of natural radionuclides ^{238}U, ^{232}Th and ^{40}K, for beach sediments of north east coast of Tamilnadu, India.

The objective of this paper is to evaluate the radiological hazards due to natural radioactivity associated with beach sediments by calculating the radium equivalent activity (R_{eq}), absorbed dose rate (D_R), annual effective dose rate (AEDR) and External hazard index (H_{ex}). The data generated in this study may contribute to the natural radioactivity level database for this area and multivariate statistical techniques were applied to know the relationship between radionuclide and radiological parameters.

2. Materials and methods

2.1. Study area

The present study area covers from Besant Nagar (longitude 80.2668E and latitude13.0002N) to Aliyakuppam (longitude79.814722200E and latitude 11.890833300N) of Pondicherry city about 165 km. Fig. 1 shows the collected sample locations. The present study area covers many industries, most famous tourism place and nuclear power plant. The sample location were recorded in terms of degree - minute - second (Latitudinal and Longitudinal position) using hand-held Global Positioning System (GPS) (Model: GARMIN GPS-12) unit. Each location is separated by a distance of 10–15 km approximately.

2.2. Sample collection

Sediment samples were collected using Peterson grab at all the designated locations during low tide. The sediment sample was collected from a depth of 5 cm from the surface. Each sample has the weight of about 3 kg. The collected samples were air dried at room temperature in open air. The samples were placed in plastic pouches and transported to the laboratory.