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Assessments of radioactivity concentration of natural radionuclides and radiological hazard indices in sediment samples from the East coast of Tamilnadu, India with statistical approach

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ABSTRACT

This paper reports on the distribution of three natural radionuclides ^{238}U, ^{232}Th and ^{40}K in coastal sediments from Pattipulam to Devanampattinam along the East coast of Tamilnadu to establish baseline data for future environmental monitoring. Sediment samples were collected by a Peterson grab samples from 10 m water depth parallel to the shore line. Concentration of natural radionuclides were determined using a NaI(Tl) detector based γ-spectrometry. The mean activity concentration is ⩽2.21, 14.29 and 360.23 Bq kg^{-1} for ^{238}U, ^{232}Th and ^{40}K, respectively. The average activity of ^{232}Th, ^{238}U and ^{40}K is lower when compared to the world average value. Radiological hazard parameters were estimated based on the activity concentrations of ^{238}U, ^{232}Th and ^{40}K to find out any radiation hazard associated with the sediments. The radiological hazard parameters such as radium equivalent activity (Ra_{eq}), absorbed gamma dose rates in air (D_R), the annual gonadal dose equivalent (AGDE), annual effective dose equivalent (AEDE), external hazard index (H_{ex}) internal hazard index (H_{in}), activity utilization index (AUI) and excess lifetime cancer (ELCR) associated with the radionuclides were calculated and compared with internationally approved values and the recommended safety limits. Pearson correlation, principal component analysis (PCA) and hierarchical cluster analysis (HCA) have been applied in order to recognize and classify radiological parameters in sediments collected at 22 sites on East coast of Tamilnadu. The values of radiation hazard parameters were comparable to the world averages and below the recommended values. Therefore, coastal sediments do not to pose any significant radiological health risk to the people living in nearby areas along East coast of Tamilnadu. The data obtained in this study will serve as a baseline data in natural radionuclide concentration in sediments along the coastal East coast of Tamilnadu.

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1. Introduction

Radioactivity is common in rocks, soil, beach sand, sediment and riverbed soil, in rivers and oceans, and even in our building materials and houses. Naturally occurring radioactive materials generally contain primordial radionuclides, left over since the creation of the earth (UNSCEAR, 1982). The naturally existing radionuclides like ^{238}U, ^{232}Th and ^{40}K are present everywhere in the Earth's crust. Radium-226 (^{226}Ra, uranium series progeny), Radium-228 (^{228}Ra, thorium series progeny) and potassium-40 (^{40}K) are of most concern due to theirs high solubility and mobility. The knowledge of the concentrations and distributions of these radionuclides are of interest since it provides useful information in the monitoring of environmental contamination by natural radioactivity (Yii et al., 2009). The activity of natural radionuclides in soil and sediment depends mainly on the types of rocks from which they originate. These radionuclides pose exposure risks externally due to their γ-ray emissions and internally due to radon and its progeny (UNSCEAR, 1988).

Hence, humans should be aware of their natural environment with regard to the radiation effects due to the naturally occurring and induced radioactive elements. The study of the distribution of primordial radionuclides allows the understanding of the

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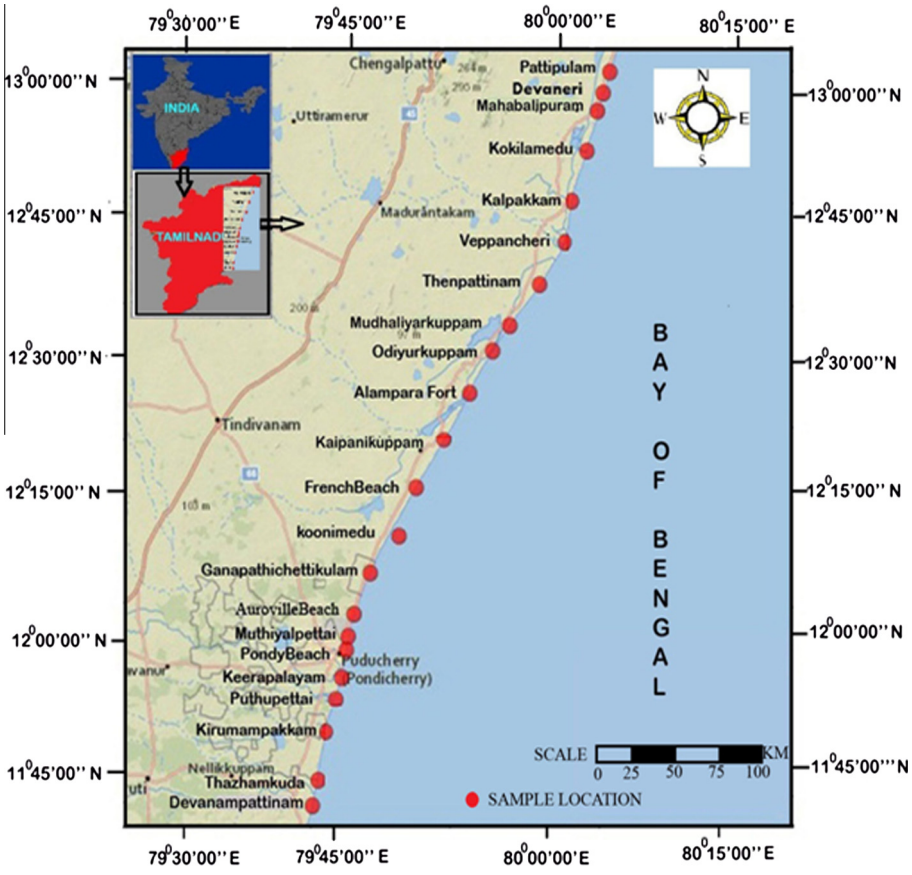

Fig. 1. Location Map.

Table 1
Latitude and longitude of Locations.

S. No.	Sample ID	Latitude (N)	Longitude (E)	Locations
1	PPM	12°40′51.27″N	80°15′19.35″E	Pattipulam
2	DVN	12°39′19.32″N	80°14′49.68″E	Devaneri
3	MAM	12°37′55.53″N	80°14′13.14″E	Mahabalipuram
4	KKM	12°34′56.33″N	80°13′22.37″E	Kokilamedu
5	KPM	12°30′57.52″N	80°11′50.57″E	Kalpakkam
6	VPC	12°27′58.97″N	80°11′16.29″E	Veppancheri
7	TPM	12°24′42.28″N	80°9′48.29″E	Thenpattinam
8	MKM	12°21′26.51″N	80°6′52.67″E	Mudaliyarkuppam
9	OKM	12°19′35.89″N	80°5′44.70″E	Odiyurkuppam
10	APT	12°16′19.80″N	80°3′16.00″E	Alampara fort
11	KPK	12°12′42.65″N	80°1′32.40″E	Kaipanikuppam
12	FBH	12°9′2.75″N	79°59′11.44″E	French beach
13	KMU	12°4′59.37″N	79°55′53.55″E	Koonimedu
14	GCM	12°2′45.84″N	79°56′46.86″E	Ganapathichettikulam
15	ABH	11°59′51.98″N	79°55′31.39″E	Auroville beach
16	MPT	11°57′43.22″N	79°52′42.65″E	Muthiyalpet
17	PBH	11°56′38.16″N	79°52′17.45″E	Pondy beach
18	KEP	11°54′23.61″N	79°51′49.37″E	Keerapalayam
19	PPT	11°52′45.44″N	79°51′19.75″E	Puthupettai
20	KIP	11°50′23.50″N	79°51′54.44″E	Kirumampakkam
21	TKA	11°46′28.21″N	79°49′31.03″E	Thazhankuda
22	DPM	11°44′41.37″N	79°49′23.01″E	Dhevanampattinam

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 (Alam et al., 1999; Singh et al., 2005). Knowledge about the distribution of radioactivity present in natural materials enables one to assess any possible radiological hazard to mankind by the use of such materials.

The knowledge of the concentrations and distributions of the radionuclides is of interest, since it provides useful information in the monitoring of environmental radioactivity. The concentration of radionuclides in marine sediments can provide very useful information on the source, transport mechanisms and environmental fate of radionuclides. This information is required for successful long-term marine environmental radiation monitoring and assessment. Obtaining activity concentrations of natural radionuclides are useful not only for the above-mentioned reasons, but also for radiation risk assessment. Hence the estimation of radiation hazard parameters in marine sediments can reflect the health hazards due to natural radiation from nearby terrestrial areas as well as the hazards to people who handle these sediments. To address these problems, assessment of radioactivity concentration in the marine environment is essential. Natural radioactivity measurements in coastal sediments in different parts of the world were reported by many authors (Akram et al., 2006; Mohanty et al., 2004; Alatise et al., 2008; Amekudzie et al., 2011; Tari et al., 2013).

Therefore, the measurement of natural radioactivity due to gamma rays from the coastal areas should be regularly examined. This paper reports the activity concentrations of natural radionuclides ^{238}U, ^{232}Th and ^{40}K, for coastal sediments from Pattipulam to Devanampattinam along East coast of Tamilnadu, India and to provide useful information for estimation of the radiation exposures of human being and in monitoring of environmental radioactivity at that area.

The objective of this paper is to evaluate the radiological hazards due to natural radioactivity associated with coastal sediments by calculating radium equivalent activity (Ra_{eq}), absorbed dose rate (D_R), annual effective dose equivalent (AEDE), annual gonadal dose equivalent (AGDE), activity utilization index (AUI), excess

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