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Assessment of gamma radiation and associated radiation hazards in coastal sediments of south east coast of Tamilnadu, India with statistical approach

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ABSTRACT

Gamma spectroscopy was performed to determine the concentrations of ^{226}Ra, ^{232}Th and ^{40}K in sediment samples collected from Periyakalapet to Parangaipettai, East coast of Tamilnadu. The activity concentrations were determined by direct counting using a hyper pure germanium (HPGe) detector inter phased with a multi channel analyzer (MCA). The average activity concentrations of the corresponding nuclides were 30.81 Bq kg^{-1} for ^{226}Ra, 85.67 Bq kg^{-1} for ^{232}Th and 425.72 Bq kg^{-1} for ^{40}K. The average activity concentration of ^{232}Th and ^{40}K are slightly higher and ^{226}Ra is lower than world average values. The radiation hazard indices namely Radium Equivalent Activity (Ra_{eq}) Absorbed Gamma Dose Rate (D_R), Annual Effective Dose Rate (H_R), Representative Level Index (RLI), Annual Gonadal Dose Equivalent (AGDE), Internal Hazard Index (H_{in}) and External Hazard index (H_{ex}) are calculated and compared with the previously reported data. The extracted values are comparable to the recommended values and they all fall within the safety limits. Hence harmful radiation effects are not posed to the public and tourists going to the beaches for recreation or to the fishermen involved in their activities in the area as a result of the natural radioactivity of sediments. Multivariate Statistical analyses were carried out between the parameters obtained from the radioactivity to know the existing relations and to study the spatial distribution of radionuclides.

1. Introduction

Measurements of natural radioactivity in aquatic sedimentary environments have been of significant importance in studies related to marine pollution and sedimentary processes. The sediment plays an important role in aquatic ecosystems and so monitoring radiological studies might lead to better management and protection of marine resources (Matishov and Matishov, 2004).

The sources of radioactivity in the marine environment come mainly from atmospheric nuclear tests, discharges from nuclear and reprocessing plants, and accidental releases. Among the major long-lived radionuclides already present or introduced into seas, the most important are: the radionuclides of radium, thorium series, and ^{40}K for natural radioactivity, ^{137}Cs, ^{90}Sr and $^{239+240}$Pu for artificial radioactivity. These, depending on their biogeochemical properties, are transported from catchment areas to the marine medium and then undergo several complex natural processes, depending on quantity of particles, marine circulation and resuspension of sediments (IAEA, 1988). The distribution of both natural and artificial radionuclides within the seabed can provide information on transient and vertical sediment movement, accumulation and global radioactive inventory (Noureddine et al., 2003).

The present study attempts to determine natural (^{226}Ra, ^{232}Th & ^{40}K) radioactivity levels in sediments collected from Periyakalapet to Parangaipettai, East coast of Tamilnadu, India using HPGe gamma ray spectrometer system. In addition, the radiation hazard associated with the radionuclides in the sediment samples was computed and analysed with statistical approach.

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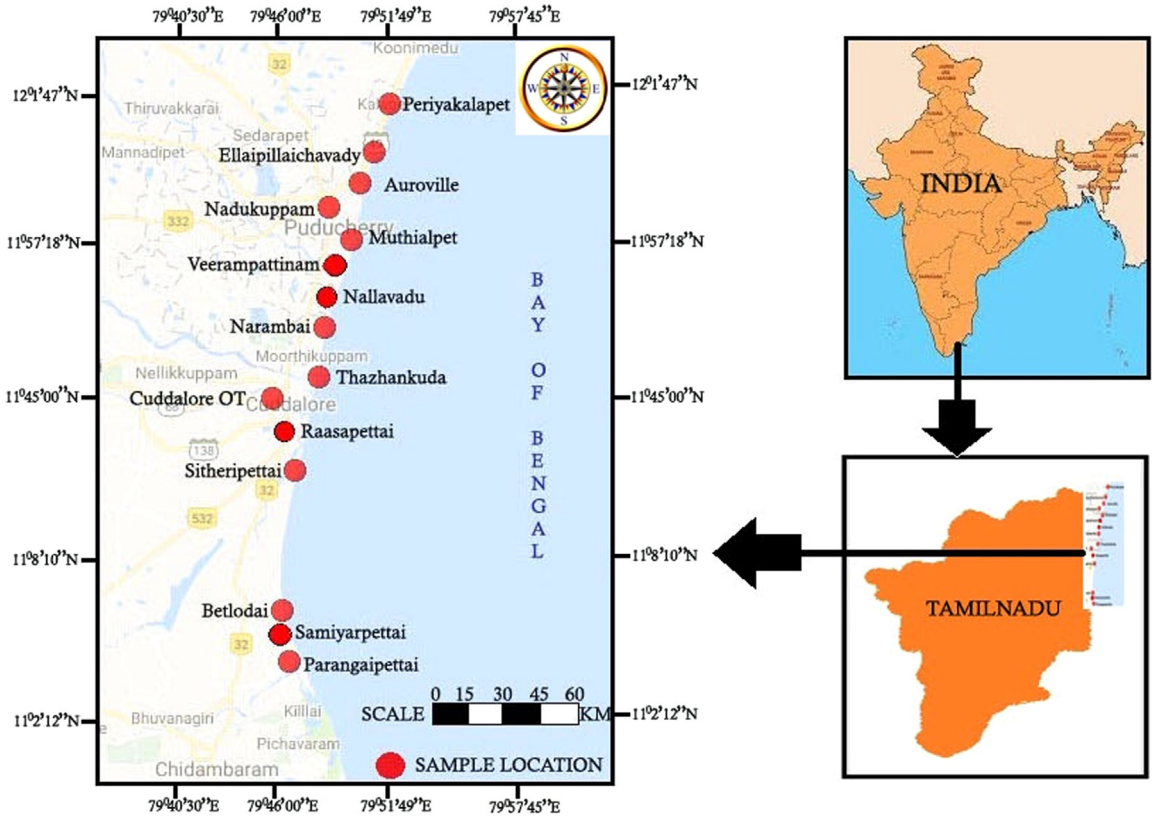

Fig. 1. Sediment samples collected in Periyakalapet to Parangaipettai coastal area, Tamilnadu.

2. Materials and methods

2.1. Study area and geological background

The present study area covers from Periyakalapet (N: 12° 1′ 46.6320" E: 79° 51' 49.0032") to Parangaipettai (N: 11° 30' 0.0000″ E: 79° 46' 0.0012"), East coast of Tamilnadu. Fig. 1 shows the sample collected locations and Table-1 gives the geographical information of the locations. This study area includes many anthropogenic activities like electronics and automation, mosaic tiles, plastic & cane baskets, soap factory etc. The area between Periyakalapet and Parangipettai consists of both depositional and erosional nature like deltaic alluvial plains, cheniers, paleo lagoonal plains and strandlines, coastal sand dunes, beaches, beach cliffs, paleo-barrier, paleotidal flats and mud flats, river mouth bars, abandoned river channels and natural levees.

Table-1
Latitude and Longitude of the Coastal Area of Tamilnadu.

S. No	Location ID	Name of the Location	Latitude (N)	Longitude (E)
1	PKP	Periyakalapet	12° 1' 46.6320"	79° 51' 49.0032"
2	EPC	Ellaipillaichavady	11° 55' 54.0228"	79° 48' 19.1268"
3	ARV	Auroville	11°59'2.8422"	79°50'55.5334"
4	NDK	Nadukuppam	11°58'1.7401"	79°38'35.5103"
5	MTP	Muthialpet	11° 57' 18.2556"	79° 50' 4.1712"
6	VMP	Veerampattinam	11° 54' 5.6160"	79° 49' 36.7428"
7	NVD	Nallavadu	11° 51' 27.6014"	79°34'27.46"
8	NRB	Narambai	11° 49' 3.2520"	79° 48' 0.9216"
9	TZK	Thazhankuda	11°46'14.2020"	79°47'40.5605"
10	COT	Cuddalore OT	11° 45' 0.0000"	79° 45' 0.0000"
11	RSP	Raasapettai	11° 40' 56.2692"	79° 46' 17.5008"
12	STP	Sitheripettai	10° 30' 31.6944"	77° 13' 17.7600"
13	BLD	Betlodai	11° 21' 45.2300"	79° 32' 21.8544"
14	SYP	Samiyarpettai	11° 32' 57.2100"	79° 45' 31.8744"
15	PGP	Parangaipettai	11° 30' 0.0000"	79° 46' 0.0012"

This region is also covered by sedimentary formations, ranging in age from cretaceous to recent.

The oldest sedimentary formations are the cretaceous sediments of Mesozoic era. The recent (Quarternary) formation in the region is represented by laterites and alluvium laterites occur as thin cap over the Cuddalore formation. There are three major rivers traversing the regions namely Gingee River, Ponnaiyar River and Vellar River before joining the Bay of Bengal. The major part of the plain comprises of gently sloping land with a chain of sand dunes extending all along the coast.

2.2. Sample collection and preparation

The sediment samples were collected from Periyakalapet to Parangaipettai, East coast of Tamilnadu using a Peterson grab sampler from a distance of 10 m parallel to the shoreline during the pre-monsoon period. South Indian rivers are seasonal and interference due to anthropogenic input alters the results. Hence, premonsoon season is selected to avoid riverine input. Systematic random sampling is a useful and flexible design for estimating the average pollutant concentration within grid cells, and is sometimes also referred to as stratified random sampling. The area of concern is subdivided using a square and then samples are collected from within each cell using the random selection procedures. Systematic random sampling allows for the isolation of cells that may require additional sampling and analysis. The samples were collected from 10 m water depths and sediment samples were collected using Peterson grab sampler capable of penetrating up to 1.2 cm on the seafloor present at 10 m water depths.

Then sediments were transferred to polythene bags and properly labeled at the sampling site itself, the present study samples were refrigerated at –4 °C using cooling box with ice and brought to laboratory. Then samples were air-dried and larger stone fragments or shells were removed by hand picking. Finally, samples were oven dried at 105 °C