Data Article

Data on natural radioactivity and associated radiation hazards in coastal sediment of Chennai Coast, Tamilnadu, India using gamma ray spectrometry

M. Tholkappian\(^a\), Durai Ganesh\(^b\), E. Devanesan\(^c\), N. Harikrishnan\(^b\), J. Prince Prakash Jebakumar\(^d\), R. Ravisankar\(^b,\)\(^*\)

\(^a\) Department of Physics, Sri Vari College of Education, Then Arasampattu, Tiruvannamalai 606611, Tamilnadu, India
\(^b\) Post Graduate and Research Department of Physics, Government Arts College, Tiruvannamalai 606603, Tamilnadu, India
\(^c\) Department of Physics, Divya Arts & Science College, Tiruvannamalai 606801, Tamilnadu, India
\(^d\) Coastal and Environmental Engineering, National Institute of Ocean Technology, Pallikaranai, Chennai 600100, Tamilnadu, India

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**A B S T R A C T**

This article contains data on the activity concentration of natural radionuclides in coastal sediment samples collected from Pulicat Lake to Vadanemmeli, East coast of Tamil Nadu using NaI(Tl) detector based \(\gamma\)-spectrometry. As marine sediments are found to be the repository of many radioactive pollutants, studied the objectives like (i) determine natural radionuclide activity concentrations in sediment samples in and around Chennai coast (ii) evaluate the radiological hazards due to natural radioactivity associated with coastal sediments and (iii) identify areas which may be radiological hazardous for the public along the study area. The average activity concentration of \(^{238}\text{U}\), \(^{232}\text{Th}\) and \(^{40}\text{K}\) in the present study is lower than world median value. The radiological hazard indices such as External hazard index \((H_{ex})\) and Gamma representative level index, \((I_{\gamma})\) were evaluated to assess radiation.
The simulated results show sediments do not pose any significant radiation hazards due to concentration of natural radionuclides.

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### Specifications Table

| Subject area | Physics |
|--------------|---------|
| More specific subject area | Radioactivity and Radiation Hazards |
| Type of data | Table |
| How data was acquired | NaI (Tl) detector (Scionix make) based gamma spectrometer of 3’’ dia × 3’’ thick housed inside 15 cm thick Pb shielding with graded lining |
| Data format | Raw data |
| Experimental factors | The sediment samples were collected from Pulicat Lake to Vadanemmeli of Chennai Coast along the Bay of Bengal Coastline in Southeastern India using a Peterson grab sampler during the pre-monsoon condition. The grab sampler collects the samples at 10 cm below the seabed in all sampling points. The collected samples were immediately transferred to polythene bags in order to avoid the sediment samples contact with the metallic dredge and the top sediment layer was scooped with an acid washed plastic spatula. Samples were stored in plastic bags and kept in refrigeration at 4 °C until analysis. Then the samples were air dried at 105 °C for 24 h to a constant weight and sieved through 250 μm mesh. Sediment samples were subjected to gamma spectral analysis with a counting time of 20,000 s. The concentrations of various radionuclides of interest were determined in Bq kg⁻¹ using the count spectra. The activity concentrations of ²³⁸U, ²³²Th and ⁴⁰K in sediment were determined using NaI(Tl) detector. The measurement for the natural radioactive elements ⁴⁰K, uranium and thorium, the gamma energies selected are 1460 keV for ⁴⁰K, 1763 keV (from daughter product ²¹⁴Bi) for uranium and 2614 keV (from daughter product ²⁰⁸Tl) for thorium. The detection limit of NaI (Tl) detector system for ⁴⁰K, ²³⁸U and ²³²Th are 8.50, 2.21 and 2.11 Bq kg⁻¹ respectively for a counting time of 20,000 s. |
| Data source location | Pulicat Lake to Vadanemmeli, East Coast of Tamilnadu, India |
| Data accessibility | Data is with this article. |

### Value of the data

- This data information provides the natural radioactivity concentration in the coastal sediment samples of Chennai Coast, Tamilnadu, India.
- Data can be used as a base-line data for radionuclide concentration levels in marine environments.
- The data can be useful for other researchers investigating the assessment of radiation hazards.
- Data provide baseline radiometric data on environmental radioactivity in the region for future epidemiological studies and environmental monitoring initiatives in the study area.
Table 1

Activity Concentration (Bq kg⁻¹), External Hazard Index (Hex) and Gamma Representative level index (Iγ) of Coastal sediment samples of Chennai Coast, Tamilnadu, India.

| S. No | Name of the Location | Sample ID | Activity Concentration | External Hazard Index (Hex) | Gamma Representative level index (Iγ) |
|-------|----------------------|-----------|------------------------|-----------------------------|-------------------------------------|
|       |                      |           | 238U Bq kg⁻¹ | 232Th Bq kg⁻¹ | 40K Bq kg⁻¹ | 238U Bq kg⁻¹ | 232Th Bq kg⁻¹ | 40K Bq kg⁻¹ |
| 1     | Pulicat Lake         | CPL       | 9.30               | 39.41          | 360.26     | 0.2528     | 0.6963 |
| 2     | Pulicat              | CPK       | 10.50              | 38.67          | 418.46     | 0.2653     | 0.7357 |
| 3     | Kattupalli           | CKP       | 2.21               | 10.98          | 390.51     | 0.1297     | 0.3849 |
| 4     | Powerstation         | CPS       | 2.21               | 14.96          | 372.54     | 0.1414     | 0.4127 |
| 5     | Nettukuppam          | CNK       | 2.21               | 2.11           | 412.09     | 0.0998     | 0.3106 |
| 6     | Ennore               | CEE       | 15.35              | 22.68          | 470.34     | 0.2272     | 0.6427 |
| 7     | Tiruchinnakuppam     | CTK       | 7.07               | 7.16           | 540.02     | 0.1591     | 0.4787 |
| 8     | Chennai Harbour      | CCH       | 10.04              | 35.70          | 445.85     | 0.2582     | 0.7212 |
| 9     | Chennai Port         | CPT       | 22.24              | 59.14          | 485.12     | 0.3902     | 1.0631 |
| 10    | Kasimedu-Tondiarpet  | CKU       | 7.09               | 30.39          | 428.69     | 0.2261     | 0.6370 |
| 11    | Neppiar Bridge       | CNB       | 11.10              | 30.94          | 416.12     | 0.2364     | 0.6608 |
| 12    | Marina Beach         | CMB       | 2.21               | 19.66          | 345.10     | 0.1539     | 0.4414 |
| 13    | Broken Beach         | CBB       | 12.04              | 41.98          | 427.33     | 0.2841     | 0.7850 |
| 14    | Besent Nagar         | CBN       | 6.48               | 17.72          | 413.87     | 0.1722     | 0.4963 |
| 15    | Thiruvanmiyur        | CTR       | 8.64               | 27.84          | 451.55     | 0.2251     | 0.6370 |
| 16    | Neelankarai          | CNI       | 2.21               | 11.54          | 473.13     | 0.1491     | 0.4456 |
| 17    | Chennai Golden Beach | CCG       | 2.21               | 11.54          | 439.77     | 0.1421     | 0.4233 |
| 18    | Panaiyur             | CPR       | 25.98              | 73.41          | 330.91     | 0.4235     | 1.1279 |
| 19    | Kanathursunami Area  | CKI       | 14.13              | 60.15          | 431.85     | 0.3611     | 0.9836 |
| 20    | Muttukkadu           | CMK       | 9.56               | 21.74          | 458.54     | 0.2054     | 0.5868 |
| 21    | Kovalam Beach        | CKB       | 9.29               | 24.23          | 419.10     | 0.2062     | 0.5836 |
| 22    | Vadanemmeli          | CVM       | 31.03              | 168.40         | 436.99     | 0.8274     | 2.1822 |
| **Average** |               |           | **10.14**         | **35.02**      | **425.82** | **0.2517** | **0.7016** |

1. Data

1.1. Activity concentrations of 238U, 232Th and 40K in the sediments

The activity concentrations of 238U, 232Th and 40K in sediment samples are given in Table 1. All values are given in Bq kg⁻¹ of dry weight. The range of activities and mean values (in brackets) for 238U, 232Th and 40K are ≤ 2.21 (BDL) – 10.14 (10.14), ≤ 2.11 (BDL) – 168.4 (35.02) and 330.91 – 540.02 (425.82) Bq kg⁻¹ respectively. The wide variations of the activity concentration values are due to the presence of physical, chemical and geochemical properties of sediment in marine environment [1,2]. The results show that the mean activity of 238U, 232Th and 40K are lower than the world average values (35 Bq kg⁻¹ for 238U, 30 Bq kg⁻¹ for 232Th and 400 Bq kg⁻¹ for 40K) [3]. Fig. 1 shows the variation of activity concentration with sampling locations.

1.2. Evaluation of radiological hazard effects

1.2.1. External hazard index (Hex)

The external hazard index (Hex) represents the external radiation exposure associated with gamma radiation from radionuclides of concern. This index can be evaluated using the following equation [4,5].

\[
H_{\text{ex}} = \frac{A_{U}}{370\text{Bq/kg}} + \frac{A_{Th}}{259\text{Bq/kg}} + \frac{A_{K}}{4810\text{Bq/kg}} \leq 1
\]  

(1)

where \(A_{U}\), \(A_{Th}\) and \(A_{K}\) are the specific activities of 238U, 232Th and 40K in Bq kg⁻¹ respectively. The value
of $H_{\text{ex}}$ must be lower than unity in order to keep the radiation hazard insignificant. Using the above formula $H_{\text{ex}}$ had been estimated and tabulated in Table 1. The $H_{\text{ex}}$ values ranged from 0.0998 (Nettukuppam) to 0.8274 (Vadanemmeli) with an average value of 0.2517, so the samples meet the condition $H_{\text{ex}} < 1$. This implies that activities involving the use of sediments samples are safe and do not attract any high levels of radiation exposure. Fig. 2 shows the locations and $H_{\text{ex}}$.

1.2.2. Gamma representative level index, ($I_{\gamma}$)

In order to examine whether the samples meet these limits of dose criteria, another radiation hazard index, the gamma representative level index ($I_{\gamma}$), is used to estimate the level of gamma radiation hazard associated with the natural radionuclides in specific investigated samples. It is used only as a screening tool for identifying materials that might become health concerns when used as construction materials [6]. The index was evaluated by the following equation [7]:

$$I_{\gamma} = \frac{A_{\text{U}}}{150} + \frac{A_{\text{Th}}}{100} + \frac{A_{\text{K}}}{1500}$$

(2)

where $A_{\text{U}}$, $A_{\text{Th}}$ and $A_{\text{K}}$ are the specific activities of $^{238}\text{U}$, $^{232}\text{Th}$ and $^{40}\text{K}$ (Bq kg$^{-1}$) in respectively. Values of $I_{\gamma} \leq 1$ correspond to an annual effective dose of less than or equal to 1 mSv, while $I_{\gamma} \leq 0.5$ corresponds to an annual effective dose less than or equal to 0.3 mSv [8]. The calculated values (Table 1) vary from 0.3106 (Nettukuppam) to 2.1822 (Vadanemmeli) with an average of 0.7016. The most of the studied locations did not exceed the recommended upper limit of unity indicating that the hazardous effects of these radiations are negligible. Fig. 3 shows the locations and gamma representative level index ($I_{\gamma}$).
2. Experimental design, materials and methods

2.1. Study area description

The study area, which spans from Pulicat Lake to Vadanemmeli of Chennai Coast, Tamil Nadu, India is located in one of the most populated regions of southeastern, India. The area is dominated by intensive industrial activities in which the discharge of their effluents into the river estuaries like Koratalliyar, Kosisthaliyar forms Ennore estuary surrounded by an major industrial corridor, Kuvam river loaded with Chennai city sewage, Adyar River forms Adyar estuary, Buckingham canal with untreated sewage traversing all these rivers has been going on for a long time. This coast is a very important environmental (comprises biosphere reserve at Pulicat Lake, Bird sanctuary, Mangroves in Ennore, Adyar and Kuvam estuaries, Muttukkaadu backwater), economical, commercial, agricultural and recreational location in southeastern India. This study was performed to determine the impacts of radiation hazard associated with sediments collected in and around Chennai coast along the East Coast of Tamil Nadu and to assess the radiation hazards due to concentration of natural radionuclides.
2.2. Sample collection and preparation

Totally 22 sediment samples were collected from Pulicat Lake to Vadanemmeli of Chennai coast along the Bay of Bengal Coastline in Southeastern Tamil Nadu, India using a Peterson grab sampler from 10 m water depths during the pre-monsoon season [9]. The sampling team initially approached to the beach by road and coastal craft hired from artisanal fishermen conveyed them to a sampling point after 45 min of sailing was utilized for sample collection. All sampling points were located parallel to the shoreline as shown in Fig. 4. The inter station spacing was maintained at 3 Knots for the study area.

The Peterson grab sampler is suitable for sampling nearshore seabed sediments particularly, in locations, where the sea bed is dominated by sandy, silt and/or gravelly sediments. This technique is the conventional method of sampling shallow sea bottom sediments [10–12]. The grab sampler collects the sediment samples at 25 cm below the seabed in all sampling points. From the grabbed samples, 10 cm thick sediment layer was scooped out from the middle of the grab to avoid metal contamination by the jaws of the grab.

Table 2 shows the geographic coordinates (latitudes and longitudes) of the various sampling locations. A handheld Global Positioning System (GPS) used for measuring the coordinates of the sampling points. Each sediment sample was carefully taken from the central portion of the craft and dredged with a plastic spatula previously washed with 2 M HCl and 2 M HNO₃ to avoid any contamination [13]. The samples were stored in plastic bags at 4°C. Generally sediments are refrigerated at < 6°C to determine the concentration of bioavailable metals using cooling box with ice or portable refrigerator. Hence, in 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.

Then the samples were air-dried at 105°C for 24 h to a constant weight and sieved through 250 μm mesh [9]. The homogenized sample was placed in a 250 g air tight PVC container to avoid radon or metal contamination.
thorn escaping from the container. The inner lid was placed and closed tightly with outer cap. Each sediment sample container was left for at least 5 weeks to reach secular equilibrium between radium and thorium, and their progenies [14].

2.3. Gamma spectrometric analysis

Sediment samples were subjected to gamma spectral analysis with a counting time of 20,000 s. A 3 × 3 NaI(Tl) detector was employed with adequate lead shielding which reduced the background by a factor of about 95%. The concentrations of various radionuclides of interest were determined in Bq kg⁻¹ using the count spectra. The energy calibration is required for various energies of radionuclides in the measurement of activity concentrations for the detector geometry size and selected samples. As the measurement is for the natural radioactive elements ⁴⁰K, uranium and thorium, the gamma energies selected are 1460 keV for ⁴⁰K, 1763 keV (from daughter product ²¹⁴Bi) for uranium and 2614 keV (from daughter product ²⁰⁸Tl) for thorium [15]. The detection limit of NaI(Tl) detector system for ⁴⁰K, ²³⁸U and ²³²Th are 8.50, 2.21 and 2.11 Bq kg⁻¹ respectively for a counting time of 20,000 seconds.

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Transparency document. Supplementary material

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