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Gamma-ray Spectrometric Analysis of Coastal Sediment Samples Along North East Coast of Tamilnadu

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Abstract : The concentration of natural gamma emitting ^{238}U, ^{232}Th and ^{40}K radionuclides in beach sediments along north east coast of Tamilnadu India has been carried out using sa NaI(Tl) gamma ray spectrometric technique with an aim of an evaluating radiation hazards to mankind, To assess the radiological hazards of coastal sediments, the absorbed and annual effective dose equivalence are calculated. The results of this study can be used as a baseline for future research.

Keywords : Beach sediments, Gamma ray spectrometry, Radiological Hazards

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1. Introduction

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 be aware of their natural environment with regard to the radiation health effects. 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. 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 [7]; in Kerala and Tamilnadu [5], in Kalpakkam [2] and in recent work in the coast of Orissa [4]. The main objective of this study was to determine natural radionuclide activity concentrations in sediment samples and to evaluate the radiological hazards due to natural radioactivity associated with beach sediments.

2. Materials and Methods

2.1. Study Area and Sample Collection

The present study area covers from Besant nagar to Aliyakuppam of Pondicherry city covering about 165 km stretch in north east coast of Tamil Nadu. Figure 1 shows the collected sample locations. Sediment samples were collected using Peterson grab at all the designated locations during low tide. The sediment samples were 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.

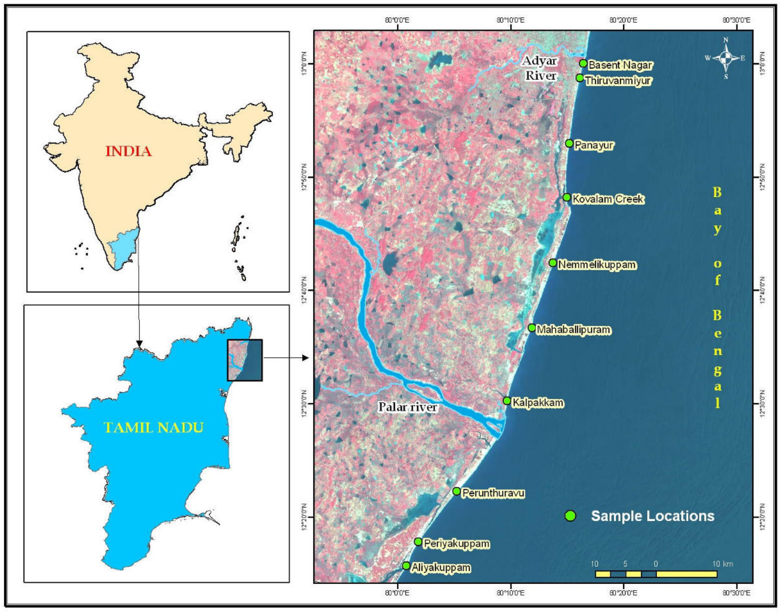


Figure 1. Sample collected locations of north east coast of Tamilnadu

2.2 Sample Preparation

The collected samples were dried in an oven at 100-110ºC for about 24h and sieved through a 2-mm mesh-size sieve to remove stone, pebbles and other macro-impurities. The homogenized sample was placed in a 250g airtight PVC container. The inner lid was placed in and closed tightly with outer cap. The container was sealed hermetically and externally using cellophane tape and kept aside for about a month to ensure equilibrium between ^{226}Ra and its daughter products before being taken for gamma ray spectrometric analysis [6].

2.3 Gamma Ray Spectrometric Analysis

All samples were subjected to gamma spectral analysis with a counting time of 10,000 secs. A 3" x 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 gamma-ray photo peaks corresponding to 1.46 MeV (^{40}K), 1.76 MeV (^{214}Bi) and 2.614 MeV (^{208}Tl) were considered in arriving at the activity of ^{40}K, ^{238}U and ^{232}Th in the samples. The detection limit of NaI(Tl) detector system for ^{40}K, ^{238}U and ^{232}Th are 8.5, 2.21 and 2.11 Bq kg^{-1} respectively for a counting time of 10, 000 secs.

3. Results and Discussions

3.1 Activity Concentrations of ^{238}U, ^{232}Th and ^{40}K in the Sediments

The activity concentrations of ^{238}U, ^{232}Th and ^{40}K sediment samples are given in Table -1. All values are given in Bq kg^{-1} of dry weight. The activities range and mean values (in brackets) for ^{238}U, ^{232}Th and ^{40}K are =2.21 – 104.6 (35.12), 24.35 – 2856.82 (713.16) and 250.9 – 560.4 (349.60) Bq kg^{-1}, respectively. The wide variations of the activity concentration values are due to their presence in the marine environment and their physical, chemical and geo-chemical properties [1, 3]. The results show that the mean activity of ^{238}U, ^{232}Th and ^{40}K is higher when compared with worldwide average value (35 Bq kg^{-1} for ^{238}U, 30 Bq kg^{-1} for ^{232}Th and 400 Bq kg^{-1} for ^{40}K) of this radionuclide in the sediment[7].

S.No	Location	Activity concentration (Bq/Kg)			Absorbed Dose Rate (DR) (nGy/h)	Annual Effective Dose Rate (mSv/y)
		^{238}U	^{232}Th	^{40}K		
1	Besant Nagar	33.58	259.14	260.5	197.97	0.244
2	Thiruvanmiyur	15.89	113.26	299.57	94.85	0.117
3	Payanurkuppam (AVM Studio)	30.24	461.57	317.03	333.72	0.410
4	Kovalam Creek (Estuary)	BDL	106.74	393.04	87.60	0.108
5	Nemilikuppam	104.6	2139.57	306.03	1482.78	1.824

6	Mahabalipuram	96.83	2856.82	560.43	1967.82	2.420
7	Kalpakkam	33.29	519.41	396.28	376.89	0.464
8	Periyakuppam	BDL	24.35	318.38	29.59	0.036
9	Perumthuravu	17.83	494.47	393.95	353.53	0.435
10	Marakanam (Estuary)	18.99	156.27	250.87	122.78	0.151
Average		**35.125**	**713.16**	**349.608**	**504.75**	**0.621**

Table-1 Activity concentration Absorbed dose rate(D_R), Annual effective dose rate (H_R)

The highest activity concentration of ^{238}U, ^{232}Th & ^{40}K was observed in Mahabalipuram. Figure 2 shows the variation of activity concentration at different sampling locations.

Figure 2 variation of activity concentration at different sampling locations

3.2. Absorbed Gamma Dose Rate (D_R)

The absorbed gamma dose rates due to gamma radiations in air at 1m above the ground surface for the uniform distribution of the naturally occurring radionuclides (^{238}U, ^{232}Th and ^{40}K) were calculated based on guidelines provided by UNSCEAR [7]. The conversion factors used to compute absorbed gamma dose rate (D_R) in air per unit activity concentration in Bq kg^{-1} (dry weight) corresponds to 0.462 nGy/h for ^{238}U, 0.604 nGy/h for ^{232}Th and 0.042 nGy/h for ^{40}K. Therefore D_R can be calculated as follows (UNSCEAR, 2000):

$$D_R\,(nGyh^{-1}) = 0.462A_U + 0.604\,A_{Th} + 0.0.42A_K \text{ ——————— } (1)$$

where A_U, A_{Th} and A_K are the activity concentrations of ^{238}U, ^{232}Th and ^{40}K in Bq kg^{-1}, respectively. The absorbed dose rate values ranged between 29.59 and 1967.82, with a mean value of 504.75 $nGyh^{-1}$. The estimated mean value of D_R in the studied samples is higher than the world average (populated-weighted) absorbed gamma dose rate of 84 $nGyh^{l}$. This may be due to monazite deposits and heavy minerals present in the study area. Figure 3 shows the variation of absorbed gamma dose rate with different locations.

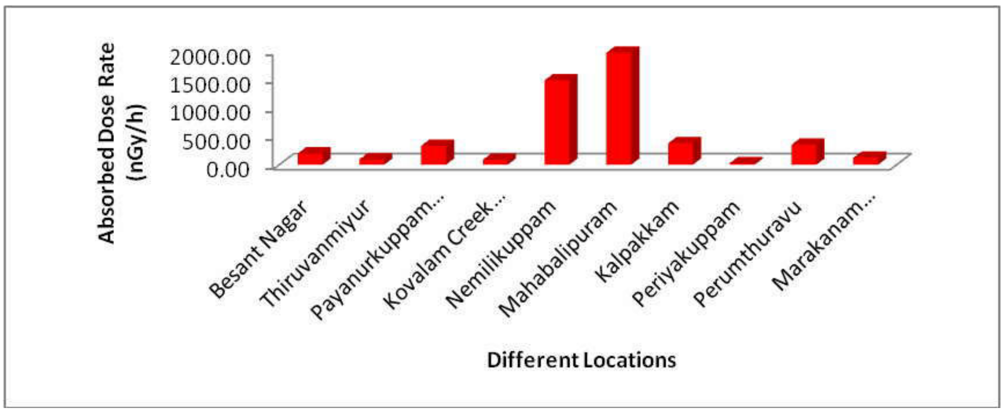


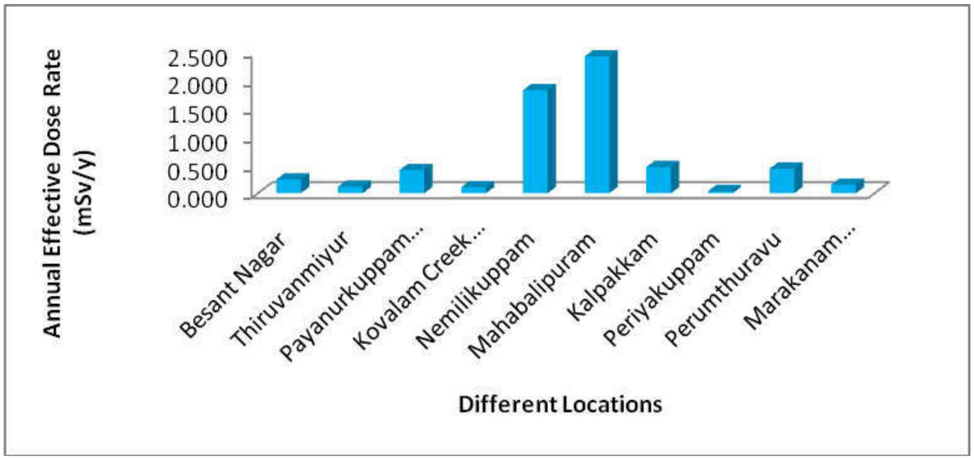
Figure 3. Variation of absorbed gamma dose rate with different locations.

3.3. Annual Effective Dose Rate (H_R)

The annual effective dose rate in mSv y^{1} was calculated by the following formula

$$H_R = D_R\,(nGyh^{-1}) \times 8760\,h \times 0.2 \times 0.7SvGy^{-1} \times 10^{-6} \text{ ——————— } (2)$$

The calculated AEDR values are ranged from 0.036 to 2.42 $mSvy^{1}$ with a mean value of 0.1621 $mSvy^{1}$, which is greater than the world average value of 0.07 $mSvy^{1}$ [7]. The highest value is observed at Mahabalipuram (2.42$mSvy^{1}$). Figure 4 shows the variation of indoor effective dose with different locations.



6.0. Conclusion

The activity concentrations of ^{238}U, ^{232}Th and ^{40}K in sediments collected different locations along the north east of Tamilnadu have been determined. The highest activity concentrations of ^{232}Th, ^{238}U and ^{40}K were observed in sediments from Mahabalipuram. The results of this study can be used as a baseline for future research and the data obtained in study may be useful for radiological mapping of the study area. It is recommended to determine the radioactivity concentrations in sediments of other parts of East Coast of Tamilnadu.

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