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Baseline Assessment of dose due to Natural Radionuclides in soils of coastal regions of Kanyakumari district in Tamil Nadu, India

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Abstract: *The natural radioactivity due to uranium, Thorium and potassium in soil contributes to the radiation dose received by human beings significantly. Gamma ray spectrometric measurements carried out for the natural radioactivity levels due to ^{226}Ra, ^{232}Th and ^{40}K in beach sand samples around the coast of Kanyakumari district were analyzed. For assessing the environmental radiological impact to public it is essential to evaluate the activity levels of these radionuclides. The absorbed dose rate due to natural radionuclides was also calculated and the results are reported in this paper. The total annual effective dose of the study area founds to vary between 0.94 mSv to 2.23 mSv. This study provides a baseline data of radioactivity background levels in the coastal regions of Kanyakumari district from Muttom to Midalam and will be useful to assess any changes in the radioactive background levels.*
Key words: *Natural radioactivity, radionuclides, dose*

I. Introduction

Radionuclides are found naturally in air, water and soil. Natural background radiation is of terrestrial and extra-terrestrial origin [1]. Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geographical and geological conditions and appear at different levels of the soils of each region in the world. There are few regions in the world known to be high background radiation areas due to local geology and geo chemical effects that cause enhanced levels of terrestrial radiation [2]. In the high background areas of the country such as Austria, Brazil, China, France, India and Iran the radiation levels were found to be high varying over an order of magnitude depending upon the site-specific terrestrial radioactivity[3]. In India there are quite a few monazite sand bearing placer deposits causing high background radiation along its long coastal line. Ullal in Karnataka, Kalppakkam in Tamil Nadu, coastal parts of Tamil Nadu and Kerala state and south western coast of India are known to be high back ground radiation areas [4]. One of the areas in the south west coast where high radiation level has been reported was from coastal regions of Kanyakumari district, in Tamil Nadu. Beach sand in these areas contains heavy minerals like ilmenite, rutile, zircon, monazite and sillimanite. ^{232}Th and ^{238}U are reported from these regions, caused mainly due to the monazite bearing black sands. Combinations of favorable factors like the hinterland geology, geomorphology, sub-tropical climate and intricate network of drainage aided by wind and coastal processes like waves and currents have influenced these formations [5]. Monazite sands are known to contain thorium with some extent of ^{238}U and ^{40}K. Since the radionuclides are not uniformly distributed the knowledge of their distribution in soil plays an important role in radiation protection and measurement. Also the radioactivity of soils is essential for understanding changes in the natural background [6]. In sense of lives, health and environmental pollution determination of the radioactivity concentration in sands is useful. Therefore an attempt is made in the present investigation to studies on the natural radioactivity content in the beach sands of coastal regions of Kanyakumari district.

II. Materials and Methods

2.1. Study Area and Sample collection

The area under study represents a part of south west coast of Tamil Nadu and is mainly the coastal stretch between Muttom to Midalam (Naturally High Background Radiation Area) in Kanyakumari district. The beach sands were collected from ten major sites namely Muttom, Kadiapattinam, Chinnavillai, Periavillai, Puthoor, Kottilpad, Colachel, Simoncolony, Kodimunai and Vaniakudi. Fig.1. represents map of the study area. The samples were collected in a polythene bag and brought to the laboratory.

2.2. Map of the sampling area

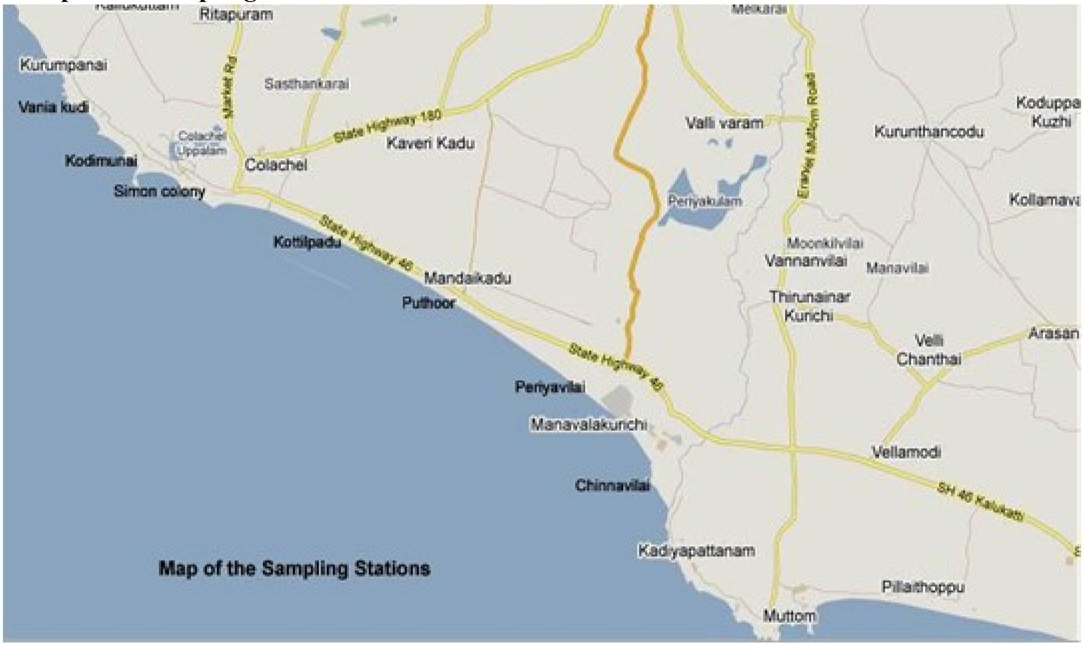

Fig. 1. Map of the Sampling stations

2.3. Sample processing and activity determination

Soil samples collected from various beaches were brought to the laboratory. Organic material roots, vegetation pebbles etc., if present were removed and the samples were initially sun dried by spreading them in a tray. Samples were later dried in an oven at 110^0c for complete removal of moisture for 24hours. These samples were filled in plastic containers. Sample containers were filled with 300-500gm of the samples for uniformity and sealed with adhesive tapes to make them air tight depending on the density of the sample. These sample containers were stored for a period of one month before Gamma spectrometric analysis so as allow the establishment of secular equilibrium between ^{226}Ra, ^{232}Th and their daughter products. Estimation of ^{226}Ra, ^{232}Th and ^{40}K in the sand samples were carried out by using high resolution Gamma ray spectrometry comprising a high purity NaI(Tl) detector(Electronic Enterprises Pvt.Ltd, Mumbai). Samples were counted on a Canberra make vertically oriented NaI (Tl) having a relative efficiency of 24.8% and resolution of 1.95kev for13.32kev peak of ^{60}Co [7]. Efficiency calibration of the system is carried out by using secondary standard sources (RGU-1(400 µg/g of ^{238}U) and RGTh-1(800 µg/g of ^{232}Th) procured from IAEA. Estimation of natural radioactivity were carried by measuring the following Gamma energies viz., ^{226}Ra directly through the 186.2kev and indirectly by measuring the ^{214}Bi (609.3 kev, 1120.2kev and 1764.5kev) and ^{214}Pb(351.9kev) photo peaks. ^{232}Th is estimated through ^{228}Ac(911.2kev) ^{212}Pb(238.6kev) and ^{208}Tl(2614kev) photo peaks, and estimation of ^{40}K through the 1460.8kev photo peak ^{226}Ra and ^{232}Th were estimated by measuring different daughters that emit clear Gamma peaks of high intensity to confirm the attainment of radioactive secular equilibrium within the samples between ^{226}Ra and its daughters. All the samples were counted for 3000 seconds.

III. Results and Discussion

The average radioactivity content in the samples in Bq/kg is given in table 1.From the results it is evident that the overall high activity of ^{226}Ra is found in Chinnavillai (268 Bq/kg) and it is low at Puthoor (102 Bq/kg). Fig.2. gives the graphical representation of the concentration of various radionuclides in soils of the study area. The pattern of variation of ^{40}K shows that it is low at Colachel (64 Bq/kg) and high at Chinnavillai (98 Bq/kg). A high radioactivity content for ^{238}U is estimated at Chinnavillai (233 Bq/kg) and a lower content of (114 Bq/kg) is found at Kadiapattinam. The activity variation for ^{232}Th shows that Chinnavillai has the highest radioactivity concentration (2650 Bq/kg) and Puthoor has the lowest concentration of (1189 Bq/kg).

Table.1. Average activity in Bq/kg

Sampling sites	Average activity in Bq/kg			
	^{226}Ra	^{228}Ra	^{40}K	^{232}Th
Muttom	131	116	85	1480
Kadiapattinam	126	114	76	1327
Chinnavillai	268	233	98	2650
Periavillai	179	165	97	1875
Puthoor	102	89	68	1189
Kottilpad	157	136	72	1623
Colachel	135	116	64	1415
Simoncolony	138	127	77	1399
Kodimunai	159	134	84	1582
Vaniakudi	141	119	88	1474

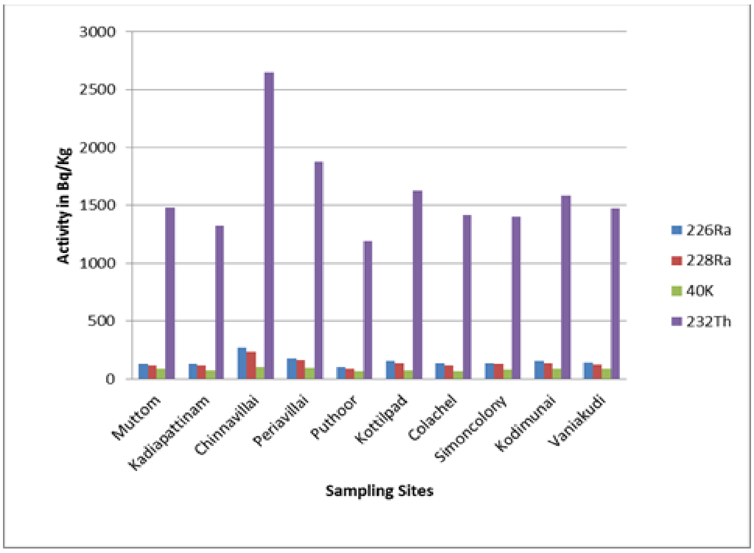

Fig. 2. Concentration of radioactive nuclides in soils of the study area

3.1. Absorbed dose

The absorbed dose rate (D) [8] due to gamma radiations in air at 1m above ground level for the uniform distribution of naturally occurring nuclides was calculated using equation (1):

$$D = 0.462\ C_{Ra} + 0.604\ C_{Th} + 0.0042\ C_k \qquad (1)$$

Where D is the absorbed dose rate in $nGyh^{-1}$ and C_{Ra}, C_{Th} and C_k are the activity concentrations of ^{226}Ra, ^{232} Th and ^{40}K in the soil samples in Bq/Kg.

3.2 Annual Effective Dose

To estimate the annual effective dose, two important factors must be taken into account (i) the conversion coefficient from the absorbed dose in air to the effective dose and (ii) the indoor occupancy factor. The former gives the equivalent dose in Svy^{-1} from absorbed dose in air Gyh^{-1}, while the latter gives the fraction of the time the individual is exposed to outdoor radiation. The first factor has been recommended by UNSCEAR, 2000 as 0.7 $SvGy^{-1}$ and the second factor as 0.2, which suggests that there is variation from absorbed dose in air to effective dose received by adults. The annual effective dose is calculated, taking into consideration that people in India, on an average, spend nearly 20% of their time outdoors. To estimate the annual effective dose rate, their conversion coefficient from absorbed dose in air to effective dose (0.7 $SvGy^{-1}$) and outdoor occupancy factor of (0.2) proposed by UNSCEAR, 2000 were used. The annual effective dose rate [9] in units of $mSvy^{-1}$ was calculated by using equation (2):

$$\text{Annual effective dose} = D \times (24 \times 365) \times 0.7 \times 0.2 \times 10^{-6}\ mSv \qquad (2)$$

Table 2. gives the absorbed dose and the annual effective dose from soil. The absorbed dose ranges from 768 to 1823 $nGyh^{-1}$. Fig.3. shows the graphical representation of the annual effective dose estimated from soils of the study area. To estimate the annual effective dose, the indoor occupancy factor and the conversion coefficient from the absorbed dose in air to effective dose must be taken into account. The annual effective dose ranges from 0.94 mSv to 2.23mSv.

Table.2. Absorbed dose and Annual Effective Dose in the study area

Sampling sites	Absorbed Dose($nGyh^{-1}$)	Annual Effective Dose (mSv)
Muttom	958.01	1.17
Kadiapattinam	862.9	1.05
Chinnavillai	1728.5	2.11
Periavillai	1823.2	2.23
Puthoor	768.1	0.94
Kottilpad	1055.8	1.29
Colachel	918.79	1.12
Simoncolony	911.98	1.11
Kodimunai	1032.14	1.26
Vaniakudi	959.13	1.17

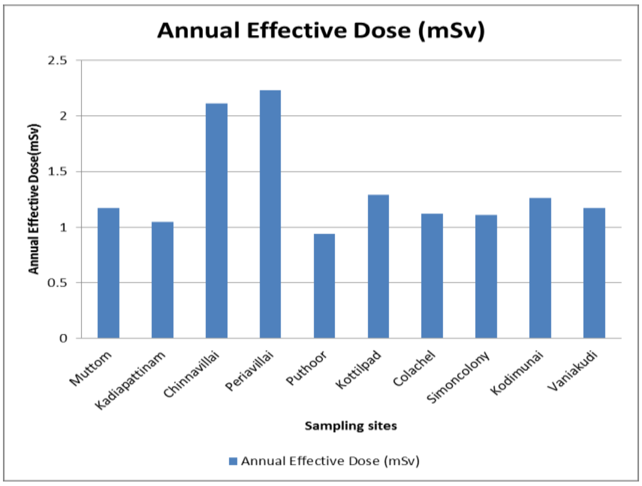

Fig. 3. Annual effective dose from soils of the study area

IV. Conclusion

Radiological assessment for the soil samples collected from the study area indicates that the concentration of radionuclides ranges from 102 to 268 Bq/Kg for ^{226}Ra, 114 to 233 Bq/Kg for ^{228}Ra, 1189 to 2650 Bq/Kg for ^{232}Th and 64 to 98 Bq/Kg for ^{40}K. The absorbed dose in air ranges from 768 nGy/h to 1823 nGy/h and the Annual effective dose lie between 0.94 mSv to 2.23 mSv. This enhanced level of radioactivity is due to monazite bearing black sand which is an orthophosphate of thorium, uranium and rare earths, present with a concentration varying from 0.3 to 5 % in the soils of this area. Beach sands in these areas contain heavy minerals like ilmenite, rutile, garnet, zircon, monazite, magnetite, sillmenite etc., Combination of favorable factors like the hinter land geology, coastal geomorphology, sub-tropical climate and intricate network of drainage aided by wind and coastal processes like waves and currents have influenced this formation.

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