Computational Assessment of Dose due to Primordial 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 1.86 mSv to 2.67 mSv. This study provides a baseline data of radioactivity background levels in some Naturally High Background Radiation Areas along the coastal regions of Kanyakumari district and will be useful to assess any changes in the radioactive background levels.***

Keywords: Natural radioactivity, radionuclides, dose

1. Introduction

Terrestrial sources contribute about 84% of the total radiation from natural sources to which an individual is exposed. It is an accumulated effect arising from a number of materials around us such as rock, soil, water, food and from within human body. It is obvious that people living in areas with large concentrations of radionuclides might be getting more than the average annual dose of radiation. Such areas are in Brazil, Sweeden, France and coastal areas of Kerala and Tamil Nadu[4]. Similarly, there are active regions rich in granite in France, with a high uranium and thorium content and alumshale, and in Sweeden, with high uranium and radium concentrations which also provide larger doses of radiation. 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.

2. Literature Survey

Menon et al., explains the naturally occurring radionuclides present in soil include ^{228}Ra, ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K . Khan et al., gives the knowledge of their distribution in soil and rocks plays an important role in radiation protection and measurement. Uosif.M and Tahir.A provides the assessment of radiation doses from natural radioactive sources is of particular importance as it is the largest contributor to the external dose of the world population. The world is naturally radioactive and around 90% of the human radiation exposure arises from natural sources such as cosmic radiation exposure to radon gas and terrestrial radiation. United Nations Scientific Committee on the effects of Atomic Radiation (UNSCEAR),Sources Effects and Risks of Ionizing Radiation Reported to the General Assembly, United Nations, New York, that In India, there are quite a few monazite sand bearing placer deposits causing natural high background radiation areas along its long coastal line.

Aswathanarayana.U explains Ilmenite rich beach sand deposits occur in the coastal stretches of Kerala, Tamil Nadu, Andhra Pradesh, Orissa and Maharastra which contain monazite bearing black sands. Several publications are available regarding the beach placers in India. Mir Azam Ali gave a brief account of the placer deposits of the Ratnagiri district, Maharastra. ^{232}Th and ^{238}U are reported from these regions, caused mainly due to the monazite bearing black sands. Sankaran et al., reported ^{238}U and ^{238}Th content of the rocks around this region varied from 1 to 3 ppm with a mean of 2ppm and from 5 to 15 ppm with a mean of 10 ppm respectively, while the ^{40}K content varied from 0.2 to 1%. Extensive work has been carried out by various research groups such as Lekshmi et al., Khanna.D et al., Iyengar M.A.R et al., Maniyan C.G. et al., to measure the radioactivity levels and geo-chemical characterization in the soil and sand samples around the beaches at various locations in India.

3. Materials and Methods

3.1. 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 (Naturally High Background Radiation Area) in Kanyakumari district. The beach sands were collected from five major sites namely Enayam, Midalam, Melmidalam, Thengapattinam and Puthenthurai. Fig.1. represents map of the study area. The samples were collected in a polythene bag and brought to the laboratory.

Figure 1: Map of the Sampling stations

3.2 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^{0}c 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, ^{232Th} 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.

4. 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 Puthenthurai (458 Bq/kg) and it is low at Enayam (269 Bq/kg). The pattern of variation of ^{40}K shows that it is low at Enayam (77 Bq/kg) and high at Thengapattinam(108 Bq/kg). A high radioactivity content for ^{238}U is estimated at Puthenthurai (427 Bq/kg) and a lower content of (237 Bq/kg) is found at Enayam. The activity variation for ^{232}Th shows that Puthenthurai has the highest radioactivity concentration (3250 Bq/kg) and Enayam has the lowest concentration of (2302 Bq/kg).

Table 1: Average radioactivity in Bq/kg

Sampling sites	*Average activity in Bq/kg*			
	^{226}Ra	*^{228}Ra*	*^{40}K*	*^{232}Th*
Enayam	269	237	77	2302
Midalam	320	289	87	2836
Melmidalam	362	351	83	2919
Thengapattinam	359	324	108	2750
Puthenthurai	458	427	68	1189

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):

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

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.

4.1 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):

Annual effective dose = D x (24 x 365) x 0.7 x 0.2 x 10^{-6} mSv………(2)

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

Sampling sites	*Absorbed Dose($nGyh^{-1}$)*	*Annual Effective Dose (mSv)*
Enayam	1517.92	1.86
Midalam	1864.43	2.28
Melmidalam	1933.80	2.37
Thengapattinam	1831.39	2.24
Puthenthurai	2178.75	2.67

Table 2. gives the absorbed dose and the annual effective dose from soil. The absorbed dose ranges from 1517.92 to 2178.75 $nGyh^{-1}$. 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 1.86 mSv to 2.67mSv.

5. Conclusion

Radiological assessment for the soil samples collected from the study area indicates that the concentration of radionuclides ranges from 269 to 458 Bq/Kg for ^{226}Ra, 237 to 427 Bq/Kg for ^{228}Ra, 2302 to 3250 Bq/Kg for ^{232}Th and 77 to 108 Bq/Kg for ^{40}K. The absorbed dose in air ranges from 1517.92 nGy/h to 2178.75 nGy/h and the Annual effective dose lie between 1.86 mSv to 2.67 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. The highest level of dose 2.67 mSv is estimated at Enayam this is due to the fact that 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.

6. Future Scope

The dose due to drinking water and air can be further estimated and from this the total dose due to air , water and soil to general public in the area can be determined

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Author Profile

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