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Studies on Radionuclides ^{226}Ra, ^{238}U, ^{228}Th and ^{40}K in River Sediment Samples of Kanyakumari District, Tamil Nadu, India

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Abstract

The activity concentration of natural radio nuclides such as ^{226}Ra, ^{238}U, ^{228}Th and ^{40}K were determined in river sediment samples collected from Kanyakumari district. The measurements were carried out using a 3" × 3" NaI Gamma spectrometry. The mean radionuclide activity concentrations obtained for each of the radio nuclides expressed in Bq/Kg are18.85, 8.71, 18.75 and 148.10 for ^{228}Ra, ^{238}U, ^{228}Th and ^{40}K respectively. The mean absorbed dose rate is 21.77 nGy/h^{-1}. The activity concentration was found to be less than the recommended level of international guide lines and would not pose any significant radiological impact on the environment.

Keywords: Distribution, river sediments, radio nuclides, impact, Kanyakumari district.

Introduction

There are many natural sources of radiation which have been present since the formation of earth. It is not surprising to know that for an average person, the naturally occurring sources contribute about four to five times as much to the exposure as the man made sources[1]. Environmental activity of ^{238}U and ^{232}Th concentration were studied in high background radiation area palong, Johr, Malaysia and their concentration in grass and water samples in the study area though insignificant the mosses were found to be possible bio-radiological indicators due to their high absorption of the heavy radioelements from the environment[2]. Ramsar, a northern coastal city of Iran, has high back ground radiation as well as over 50 hot springs with low and high radium contents, The average whole body dose received by population in these areas is about 5 times higher than the normal background radiation level[3]. The concentration of uranium and thorium in Earth's crust is in the range 1.1-10 ppm for uranium and 10 ppm for thorium. This corresponds to an activity concentration range of 13.5-123Bq/kg for ^{238}U and 39.4 Bq/kg for ^{232}Th [4-6]. Study on radionuclide in terrestrial ecosystem in the vicinity of western ghats in India revealed proportionate uptake of radioactivity to the concentration of the radionuclides in the soil. The radioactivity of beach sands of Manavalakurichi region along the south - west coast of India in Tamil Nadu has revealed the high potency of the monazite sands spanning across the Kadiapattinam estuary on the eastern side of Manavalakurichi[7]. The in situ radiometric surveys indicated that the beaches and immediate hinterlands in the west coast of southern Tamil Nadu have more radioactive when compared to the east coast[8]. According to UNSCEAR report, the greatest contribution to mankind's exposure comes from natural background radiation, and the worldwide average annual effective dose per capita is 2.4 mSv[9]. Natural background radiation based on the above scenario determined by the concentration of natural radio activity in river sediments, collected from kanyakumari district.

Material and Methods

Sample collection: Sediment samples were collected using a metallic crib and samples were collected at random. Samples were collected from the shore as well as from the interior up to 1m depth. After collection the samples were weighed and dried in a hot air oven at 80 – 90^0 C. The dried samples were sieved using a mechanical sieve and the sediment particles below > 63µ were taken for analysis. The sediments were stored in plastic container sealed and kept for one month for the equilibration of daughter products.

Radioactivity measurements: The radio nuclide activity concentration was measured using Gamma counting system. Cs^{137} and Co^{60} standard sources are used in the system. The concentrations of the various nuclides are determined using the count spectra. The peaks corresponding to 1.46Mev (^{40}K), 1.76Mev (^{214}Bi) and 2.614 Mev (^{208}Tl) energies are considered to arrive at the activity levels of ^{40}K, ^{238}U and ^{232}Th respectively. 300 grams of rock powder samples are placed on the NaI detector and measured for a period of 5000 s. Gamma activity were calculated using the given efficiency factor and formula:

^{228}Ac (930 Kev) = 4.5×10^{-3} CPS Bq^{-1}
^{40}K (1410 Kev) = 1.46×10^{-3} CPS Bq^{-1}
^{240}Bi (1700 Kev) = 7.6×10^{-3} CPS Bq^{-1}
^{208}Tl (2500 Kev) = 8.78×10^{-4} CPS Bq^{-1}

Net value = Sample net integral value – Back ground value

$$\gamma = \frac{\text{Net counts}}{T} \times \frac{100}{\text{Efficiency}} \times \frac{1}{\text{Sample weight}} \times 1000 \text{ Bq/kg}$$

Absorbed dose rate: Radionuclide activity concentration in river sediment is one of the major determinants of the natural back ground radiation. All exposure rates originate from radioactive sources in the river sediment and the activity concentration corresponds to total absorbed dose rate in air at 1m above the ground level on the basis of guide lines reported by UNSCEAR[10]. Therefore radioactivity content in river sediment can be used to estimate the external gamma radiation exposure or dose rate. The gamma radiation absorbed dose rate in air D_R (nGy h^{-1}) was calculated using the equation.

$$D_R = 0.462\ C_u + 0.621\ C_{Th} + 0.0417\ C_K \quad (1)$$

Where: C_{Th}, C_U and C_K are the average activity concentrations of ^{228}Th, ^{238}U and ^{40}K in Bq/Kg, respectively.

Results and Discussion

The radio nuclides (^{226}Ra, ^{228}Th, ^{238}U and ^{40}K) activity concentration in river sediment samples were shown in Table 1. The activity concentrations for ^{226} Ra ranged from 10.79 to 28.56 Bq/Kg with an average activity of 18.85 Bq/Kg. Similar pattern has been reported in Cauvery river sediments at Tiruchirapalli[11]. ^{228}Th ranged from 11.63 to 31.21 Bq/Kg with an average activity of 18.75 Bq/Kg. ^{238}U ranged from 5.07 to 16.01 Bq/Kg with an average activity of 8.71 Bq/Kg. The activity of ^{40}K has been recorded to vary in the range 111.42 – 151.13 Bq/Kg with an average activity of 148.10 Bq/Kg. The overall radionuclide activity has been recorded at Valliyar river sediment near Eraniel and in minimum at Sittar river sediment. The correlation between ^{228}Th and ^{238}U activity and also ^{226}Ra and ^{40}K activity in river sediments are shown in Figure 2 & 3.From the γ-absorbed dose rate of ^{228}Th, ^{238}U and ^{40}K in river sediment samples were calculated using equation (1) and the calculated values are mentioned in the table (1). The calculated γ - absorbed dose rate for river sediments varied from 13.68 to 37.72 nGy^{-1} with an average value of 21.77 nGy^{-1}. Which were much lower than the world average value of 55 nGy^{-1}[12].

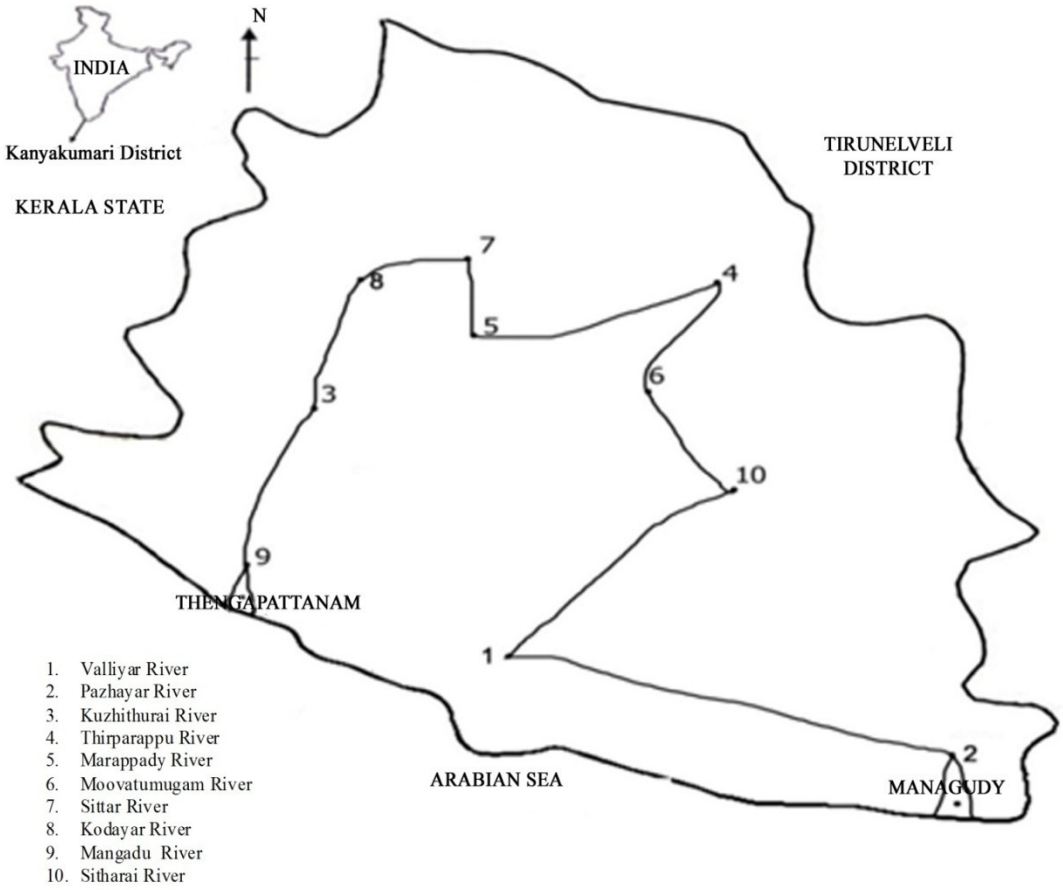

Figure-1
Map showing the study area and sampling locations

Table-1
Gamma activity concentration of river sediment samples and the activity ratio of ^{228}Th and ^{238}U (Bq/Kg), absorbed dose rate

S.No	Locations	^{226}Ra	^{228}Th	^{238}U	^{40}K	^{228}Th/^{238}U	Absorbed dose rate (nGy h^{-1})
1.	Valliyar	28.56	31.21	16.01	262.42	1.9	37.72
2.	Pazhayar	26.75	18.46	8.13	131.12	2.2	20.68
3.	Kuzhithurai	13.46	22.34	7.48	121.56	2.9	22.39
4.	Thirparappu	21.06	18.74	6.29	133.11	2.9	20.09
5.	Marappady	16.77	23.23	9.07	151.13	2.5	24.91
6.	Moovatumugam	20.58	18.55	7.99	133.98	2.3	20.79
7.	Sittar	10.79	11.96	5.07	111.42	2.3	13.68
8.	Kodayar	19.01	16.38	8.17	146.92	2.0	20.07
9.	Mangadu	18.70	15.07	8.48	142.45	1.7	19.21
10.	Sitharal	12.90	11.63	10.42	146.95	1.1	18.16

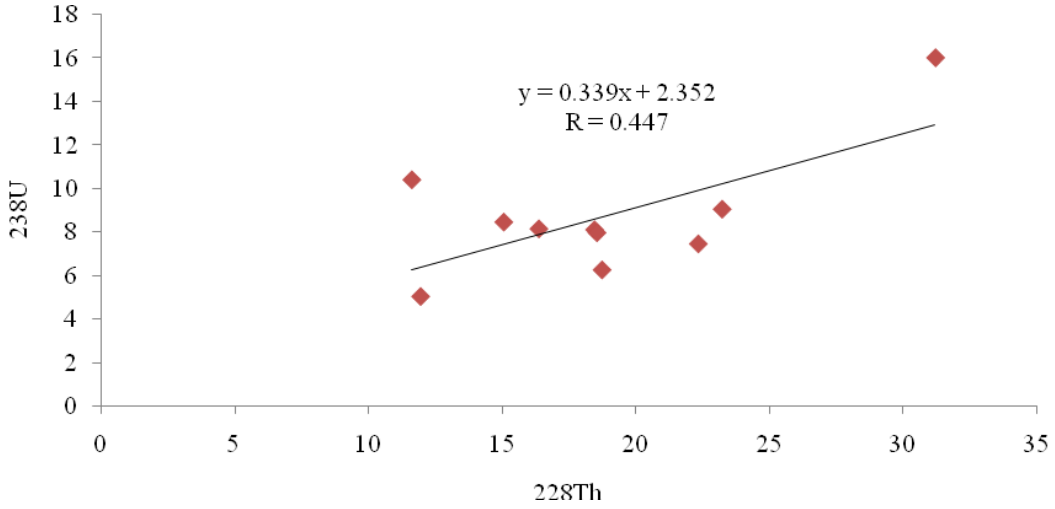

Figure- 2
Correlation between ^{238}U and ^{228}Th in river sediment samples (Bq/Kg)

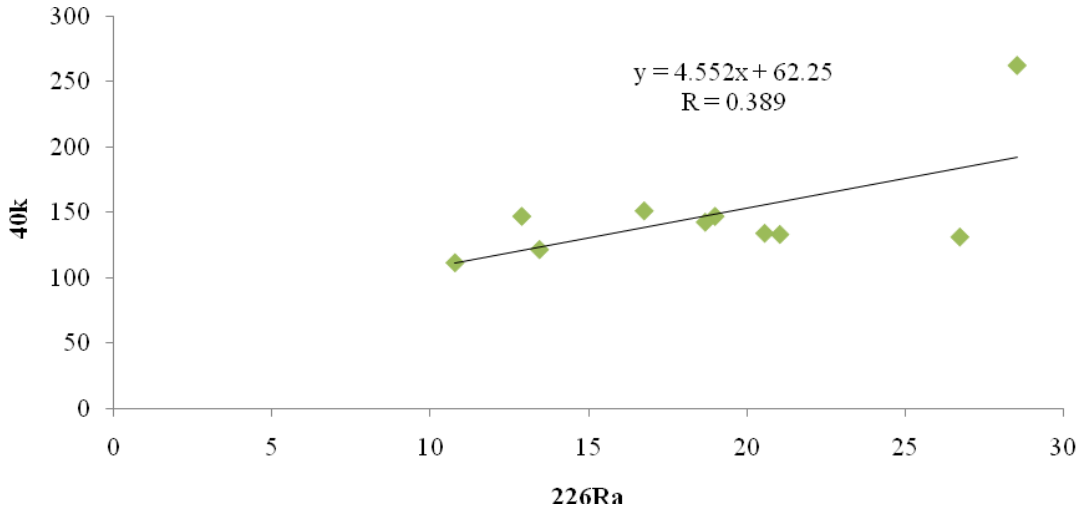

Figure-3
Correlation between ^{226}Ra and ^{40}K in river sediment samples (Bq/Kg)

Conclusion

Gamma ray spectroscopy is used for studying the natural radiation. The river sediments of natural radio nuclides (^{226}Ra, ^{228}Th, ^{238}U and ^{40}K) activity concentration are very low which reflect to the values of their hazard indices that are below limits. However the overall activity level of ^{226}Ra, ^{238}U, ^{228}Th and ^{40}K activities in kanyakumari district river sediments level is very lower than the world average values.

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