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Natural Radioactivity Measurement in River Bed samples in and around Manaloorpet Riverbed Area, Tamilnadu, India

[1]R.Ravisankar, [2]A.Chandrasekaran, [3]P.Eswaran, [4]A.Rajalakashmi,
[5]P.Vijayagopal, [6]V.Meenakshisundaram

[1]Post Graduate and Research Department of Physics, Government Arts College, Thiruvanamalai-606603, Tamilnadu, India
[2]Global Institute of Engineering &Technology, Vellore-632509, Tamilnadu, India
[3]Department of Physics, VelTech (Owned by RS Trust), Avadai, Chennai-600062,Tamilnadu, India
[4]Department of Physics, SSN College of Engineering, Kalvakkam, Chennai-110, Tamilnadu, India.
[5,6] Radiation Safety Section, Radiological Safety Division. Indira Gandhi Centre for Atomic Research, Kalpakkam 603102, Tamilnadu, India.

ABSTRACT

The river bed samples in and around Manaloorpet area, Tamilnadu, India have been analyzed for natural radioactivity concentration to estimate the radioactivity levels in these area. The specific radioactivity concentration of Radium (R^{226}), Thorium (^{232}Th), and Potassium (^{40}K) have been determined by gamma ray spectrometry. The absorbed dose rates due to these radio nuclides were calculated and compared with world average values. The radium equivalent (Ra_{eq}) external hazards (H_{ex}) and internal radiation hazards (H_{in}) associated with natural radio nuclides were calculated. The Ra_{eq} value of present study is found to be lower than the limit of 370 Bq kg^{-1} and the value of H_{ex} and H_{in} are less than unity. These results indicate no radiological anomaly. The data presented in this study will serve as a base line survey for primordial radionuclide concentration in the study area.

Keywords: *Natural radioactivity, River bed samples, Gamma ray Spectrometer, External hazards, internal hazards.*

1. INTRODUCTION

The natural level of radioactivity in building material is one of the major causes of external exposure to gamma rays. The most source of external exposure is caused by the gamma rays emitted from the member of the uranium and thorium decay chains and ^{40}K occurring naturally in building materials. They are present in small quantities in the earth and in the building materials. Knowledge of radioactivity present in building materials enables one to assess any possible radiological hazard to mankind by use of such materials. The natural radioactivity studies of building materials have been reported by many workers [1-6]. Nationwide surveys have been carried out to determine the specific activity of building materials in many countries. In most of the countries the building materials such as sand, cement, cement plaster, cement brick, red-clay brick, gravel aggregate, lime/limestone and roof asbestos are the dominant materials for construction. In India, sand is used to mix with the cement for cement plaster in construction purposes. Generally, the collection of sand takes places in the river beds in India. The objective of the present study was to determine the specific radioactivity concentration of ^{226}Ra, ^{232}Th and ^{40}K in the riverbed samples (sand) collected from the Manaloorpet, Tamilnadu, India to assess any radiological hazard and to determine the indoor gamma radiation dose rate and the annual effective dose from the riverbed (sand) used in buildings.

2. MATERIALS AND METHODS

The gamma ray spectrometry method was employed to estimate the activity of ^{226}Ra, ^{232}Th and ^{40}K in the riverbed samples. The riverbed samples were collected at seven sampling points in Manaloorpet area of Tamilnadu, India. The distance between each sampling points is around 1km. The samples were powdered to obtain more or less the same grain size. The samples were transferred to a porcelain dish and oven dried at 110ºc. The samples were powdered and sieved through 150µm mesh, weighed and sealed in a 250ml plastic container, and kept for a month before counting by gamma ray spectrometry, in order to ensure that radioactive equilibrium was reached between ^{226}Ra, ^{222}Ra and its progeny [7]

Radiometric analyses of the samples were carried out using gamma ray spectrometer in the laboratory of Radiological Safety Division, Safety Group, at Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, Tamilnadu, India. NaI(TI) crystal detector of size 3"X3" along with 1K multi channel analyzer was used to record the gamma spectra. Standard sources of natural uranium (1997.56 Bq), natural thorium (1237.28 Bq) and KCl (5181.39 Bq), with a standard 250-ml container from International Atomic Energy Agency (IAEA) were used for calibrating the gamma ray spectrometer. The minimum detectable activity (MDA) limits were 13.25 Bq Kg^{-1} for ^{40}K, 8.5 Bq Kg^{-1} for ^{226}Ra and 1 Bq Kg^{-1} for ^{232}Th.

The gamma ray energies of 351.9keV (^{214}Pb), 609.3, 768.4, 1120.3, 1238.1 and 1764.5keV (^{214}Bi), 186.keV (^{226}Ra) were used to determine the concentration of the ^{238}U. Gamma ray energies 338.4keV (^{228}Ac), 538.3, 2614keV (^{208}Ti) and 911.1, 968.9 and 974.keV (^{228}Ac) were used to determine the concentration of ^{232}Th. The 1460.7keV gamma-ray of ^{40}K determined the concentration of ^{40}K using a computer program, after correcting for background and Compton scatter contributions and using efficiency factors obtained from standard samples for ^{232}Th, ^{226}Ra and ^{40}K.

3. RESULTS AND DISCUSSION

3.1 Activity concentration

The results of activity concentration (in Bq Kg^{-1}) of ^{232}Th, ^{226}Ra and ^{40}K in riverbed samples (sand) collected from the Manaloorpet area in table-1. It may be seen from Table -1 that the activity concentration of ^{232}Th varies from 2.54 Bq Kg^{-1} to 39.14 Bq Kg^{-1} and the activity concentration of ^{226}Ra varies from BDL to 10.68 Bq Kg^{-1}. The activity concentration of ^{40}K varies from 320.31 Bq Kg^{-1} to 394.53 Bq Kg^{-1} with an arithmetic mean of 356.49 Bq Kg^{-1}. The world average concentrations of ^{226}Ra, ^{232}Th `and ^{40}K are 40, 40 and 400 Bq Kg^{-1} respectively [8]. If one compares the activity of radionuclides of the present study with world average values, ^{226}Ra ^{232}Th and ^{40}K activity is found to be lower value. The average values of activity do not provide an exact indication of radiation hazard associated with the materials.

Table-1

Activity concentrations, radium equivalent and annual effective dose due to natural radionuclide in river bed samples of Manaloorpet, Tamilnadu, India

Sample Numbers	Activity concentration (Bq Kg^{-1})			Radium equivalent (Ra_{eq}) Bq Kg^{-1}	Annual radiation dose	Absorbed Dose Rate (nGy. h^{-1})	Annual effective dose (mSv)	Radiation Hazards	
	^{232}Th	^{226}Ra	^{40}K					H_{in}	H_{out}
S1	2.54	BDL	320.31	28.29	0.0763	28.41	0.149	0.076	0.076
S2	39.14	BDL	322.94	80.83	0.2176	68.88	0.362	0.2188	0.2188
S3	17.58	BDL	394.53	55.5	0.1497	50.90	0.267	0.1501	0.1501
S4	BDL	BDL	362.15	27.88	0.075	28.97	0.152	0.075	0.075
S5	3.4	BDL	366.15	33.05	0.0891	41.04	0.215	0.089	0.089
S6	22.04	10.68	372.38	70.86	0.1935	63.86	0.335	0.2205	0.191
S7	8.55	BDL	357	39.71	0.1071	28.56	0.150	0.1073	0.1073
Average	13.39	-	356.49	48.01	0.129	44.37	0.232	0.138	0.129

3.2 Radium equivalent activity (Ra_{eq})

Radiation hazards due to the specified radionuclides of ^{226}Ra, ^{232}Th and ^{40}K were assessed by two different indices. The most widely used radiation hazard index is called the radium equivalent activity. The radium equivalent formula is based on the estimation that 1 Bq Kg^{-1} of ^{226}Ra, 0.7 Bq Kg^{-1}of ^{232}Th and 13 Bq Kg^{-1} of ^{40}K produces the same gamma ray dose rates. It is calculated by the equation (1)

$$\mathbf{Ra_{eq} = A\,(Ra) + 1.43\,A\,(Th) + 0.077\,A\,(K) \ \ldots\ (1)}$$

where A(Ra), A(Th) and A(K) are the activities of ^{226}Ra, ^{232}Th and ^{40}K respectively in Bq Kg^{-1}. For the safe use of materials, the activity limit in terms of radium equivalent activity (concentration) is 370 Bq Kg^{-1}. The results of this study shows that the average value of Ra_{eq} obtained for the samples is 48.01 Bq Kg^{-1} and as such does not pose a radiological hazard when used for construction materials.

The annual radiation dose from building materials is based on the formula [4]

$$\frac{A_{Ra}}{340\ \text{Bq/Kg}} \quad \frac{A_{Th}}{260\text{Bq/Kg}} \quad \frac{A_{K}}{4810\ \text{Bq/Kg}} < 1 \quad - \quad (2)$$

where A_{Ra}, A_{Th} and A_{K} are the activities of ^{226}Ra, ^{232}Th and ^{40}K in Bq Kg^{-1}, respectively, in building materials. Calculating the sum of the three quotients, the values of riverbed samples (sand) in the present study ranged from 0.075 to 0.217 with an average of 0.129 mSv (Table-1) which is less than the 1. This indicates that gamma activity in the river bed samples do not exceed the proposed criterion level. Comparison of radium equivalent (Ra_{eq})

value of the present study with the different countries of the world is given in Table-2.

Table -2 Comparison of radium equivalent (Ra_{eq}) value of the present study with the different countries of the world

Country	Ra_{eq}	Reference
Australia	65.3	[9]
Algeria	12	[10]
Germany	59.2	[11-12]
Zambia	79	[13]
China	151.0	[14]
Hong Kong	128.0	[14]
Netherland	38.6	[15]
India (Himachal)	90.05	[16]
India(Punjab)	84.15	[16]
India(Utter Pradesh)	170.8	[17]
Brazil	102	[18]
USA	86.0	[19]
Pakistan	107	[20]
Egypt	16.6	[21]
Finland	177.6	[11]
Norway	7.4	[22]
Sweden	140.6	[11]
United Kingdom (UK)	18.5	[23]
Present work	24.86	-

3.3 Estimation of absorbed gamma dose rate and the annual effective dose rate

The absorbed dose rate in and outdoor air (D_R) and the corresponding annual effective dose (H_R) due to gamma-ray emission from the radionuclide (^{226}Ra, ^{232}Th & ^{40}K) in the building materials where evaluated using data and formula provided by UNSCEAR (2000) and EC (1999) [8,24-25]. In the UNSCEAR and European Commission reports, the dose conversion coefficient was calculated for the centre of the standard room. The dimension of the room is 4m × 5m × 2.8 m. The thickness of the walls, floors and the ceiling and density of the structure are 20cm and 2350kgm^{-3} (concrete), respectively. These coefficients correspond to 0.92 nGy h^{-1} per Bq kg^{-1} for ^{226}Ra, 1.11 nGy h^{-1} per Bq kg^{-1} for ^{232}Th and 0.080 nGyh^{-1} per Bq kg^{-1} for ^{40}K

$$\mathbf{D_R\,(nGyh^{-1}) = 0.92 \times A_{Ra} + 1.1 \times A_{Th} + 0.080 \times A_K} \qquad \text{-- (3)}$$

Where A_{Ra} is the mean activity concentration of ^{226}Ra, A_{Th} is the mean activity concentration of ^{232}Th and A_K is the mean activity concentration of ^{40}K in Bq kg^{-1}.

To estimate the annual effective dose, one has to taken into account the conversion factor from absorbed dose in air to effective dose and the indoor occupancy factor. In the recent UNSCEAR (2000) reports, a value of 0.7SvGy^{-1} was used for the conversion factor from absorbed dose in air to effective dose received by adults, and0.8 for the indoor occupancy factor, implying that 80 of time is spent indoors on average around the world. The annual effective dose in units of mSv was estimated using the following formula:

H_R = D_R×8766h × 0.8 (occupancy factor) × 0.7Sv Gyh^{-1} (conversion factor) × 10^{-6}

Where D_R (nGyh$^{-1)}$ is given .by the equation (3).

The estimate results for D_R and the corresponding H_R are given in table 1. The estimated D_R and H_R values for all the studied structural building materials range from 28.56 to 68.88 nGyh^{-1} and 0.1 to 1.2 mSv, respectively. From the data in the table 1, the estimated mean value of D_R in the studied samples is 44.37 nGyh^{-1} which is lower than world average (populated-weighted) indoor absorbed gamma dose rate of 84nGyh^{-1}. Also the mean estimated annual effective dose rate is less than the permissible limit.

3.4 Radiation Hazard Indices

In order to measure the hazards one can define radiation hazard indices [3]
(i) External radiation hazard, H_{ex} and (ii) Internal radiation hazard, H_{in}, as follows

$$H_{ex} = \frac{^{Ra}A}{370} + \frac{^{Th}A}{258} + \frac{^{K}A}{4810}$$

$$H_{in} = \frac{^{Ra}A}{185} + \frac{^{Th}A}{258} + \frac{^{K}A}{4810}$$

If these indices are found to be less than one, there is no indoor radiation hazard. The value of H_{ex} is determined to be 0.098 which is less than one for the average activities due to ^{226}Ra, ^{232}Th and ^{40}K which means that the riverbed samples can be used without danger of external gamma radiation hazard. Similarly, H_{in} has been determined to be 0.127 which is also less than one which indicates that the internal hazards are less than critical value. These results show that the river bed samples are also safe for use as construction materials from the internal dose point of view.

4. CONCLUSION

The riverbed (sand) samples from Manaloorpet area, Tamilnadu, India have been investigated for the gamma ray activity and dose rate calculations. The value of ^{226}Ra activity on average is less than the recommended limits. The average dose equivalent rate is less than the permissible limit. Moreover, the external and internal hazard indices have been determined to be less than one showing that the river bed from the region surveyed do not poes a major source of radiation hazards and that these materials are safe to be used for building construction.

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