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ASSESSMENT OF NATURAL RADIOACTIVITY IN CLAY SAMPLES OF TIRUVANNAMALAI DIST, TAMILNADU, INDIA AND THEIR ASSOCIATED RADIATION HAZARDS

Y. RAGHU[a], R. RAVISANKAR[b,*], A. CHANDRASEKARAN[c], P. VIJAYAGOPAL[d] and B. VENKATRAMAN[d]

[a]Department of Physics, Aarupadai Veedu Institute of Technology, Paiyanoor, CHENNAI – 603104 (T.N.) INDIA
[b]Post Graduate and Research Department of Physics, Government Arts College, TIRUVANNAMALAI – 606603 (T.N.) INDIA
[c]Department of Physics, SSN College of Engineering, Kalavakkam, CHENNAI – 603110 (T.N.) INDIA
[d]Radiation Safety Section, Radiological Safety Division, Indira Gandhi Centre for Atomic Research, KALPAKKAM – 603102 (T.N.) INDIA

ABSTRACT

Due to increased global demand for clay, the present work involves the use of gamma ray spectrometry for the measurement of concentrations of natural radionuclides in clay samples. The activity concentration of ^{226}Ra, ^{232}Th and ^{40}K were determined in 32 clay samples collected from Tiruvannamalai district, Tamilnadu by using NaI(TI) detector. The activity concentration of these radio nuclides is compared with world average values. The radiation exposure risk due to natural radionuclides, as a result of the use of clay as raw materials in construction, the radiation hazard indices such as radium equivalent activity (Ra_{eq}), criteria formula (CF) and the external hazard index (H_{ex}) due to internal exposure to radio nuclides distributed in clay samples have been computed. From the analysis, clay samples could be used as a raw material for brick industry and clay data are useful to those dealing with clay applications.

Key words: Clay samples, Natural radionuclides, Radiation Indices.

INTRODUCTION

It is a well-established fact that construction materials contain a trace amount of natural radioactivity, which may contribute significantly towards an increased radiation dose

[*]Author for correspondence; E-mail: yraghu76@gmail.com

received by human beings. The most commonly encountered radio nuclides in the construction materials are ^{226}Ra, ^{232}Th, their decay products and ^{40}K. Therefore, it is important to measure the concentration of these radio nuclides in soil and building materials. Radioactivity level contribution by building materials to human exposure have become of great concern worldwide.

Clay bricks have been common building materials for a long time. In India, bricks as building materials are mainly prepared from clay using the deposited sediments of rivers, and the radionuclide contents in bricks and brick-making clays should vary by origin and geological condition. Most buildings are constructed of clay bricks in Tamilnadu as well as India. This study aims at assessing the level of natural radioactivity hazards of clay which is used to produce bricks in Tiruvannamalai district and provides information and data for evaluation of radiation exposure levels associated with clay.

EXPERIMENTAL

Materials and methods

Thirty two brick making clay samples were collected from fabrication and kiln sites of Tiruvannamalai Dist, Tamilnadu. The location site map is as shown in Fig. 1.

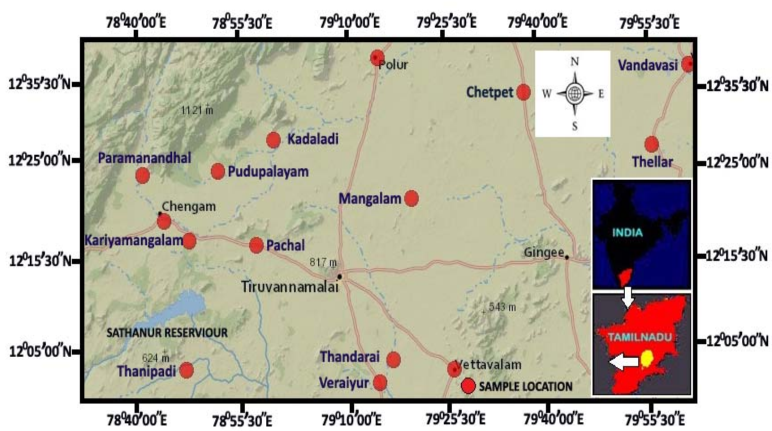

Fig. 1: Sampling location map of Tiruvannamalai district, Tamilnadu, India

The samples were properly catalogued and marked according to the location site. The collected samples were dried in an oven at 110°C until the sample weight became constant and sieved through sieve of 150 µm mesh to make uniform particle size. Then the samples were sealed in radon-impermeable plastic containers and were stored for more than

30 days to bring ^{222}Rn and its short-lived daughter products into equilibrium with ^{226}Ra. All samples were subjected to gamma spectral analysis with a counting time of 20,000 secs. 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.

RESULTS AND DISCUSSION

Specific activity concentration of radio nuclides in clay samples

The determined activity concentrations of ^{226}Ra ^{232}Th and ^{40}K in clay samples are given in Table 1. The highest values found for the specific activities of ^{226}Ra, ^{232}Th and ^{40}K are 16.22 (CL-26), 191.47 (CL-20) and 900.87 (CL-20) in Bq Kg^{-1} respectively while the lowest values found for the specific activities of the same radionuclides are ≤ 2.21 (BDL), 18.27 (CL-29) and 287.84 (CL-2) in Bq Kg^{-1} respectively. The mean activity concentrations of ^{226}Ra and ^{40}K are lower than the world average value whereas the mean activity concentration of ^{232}Th is higher than the world average value[1].

Table 1: Different located clay samples of Tiruvannamalai Dist, Tamilnadu, India with activity concentration and radiological parameters

Location	Sample ID	Activity concentrations (Bq Kg^{-1})			Radium equivalent (Ra_{eq}) (Bq Kg^{-1})	Criteria formula (CF)	External hazard index (H_{ex})
		^{226}Ra	^{232}Th	^{40}K			
Polur	CL-1	7.76	45.04	332.03	97.73	0.1316	0.2639
	CL-2	9.71	43.83	287.84	94.55	0.1273	0.2553
	CL-3	4.81	37.32	350.80	85.19	0.1147	0.2300
	CL-4	8.16	34.45	386.06	87.15	0.1174	0.2353
	CL-5	BDL	42.40	343.34	87.07	0.1172	0.2351
	CL-6	BDL	43.80	362.65	90.56	0.1219	0.2445
	CL-7	BDL	51.17	396.12	103.67	0.1396	0.2799
	CL-8	BDL	32.90	486.52	84.51	0.1138	0.2282

Cont…

Location	Sample ID	Activity concentrations (Bq Kg^{-1})			Radium equivalent (Ra_{eq}) (Bq Kg^{-1})	Criteria formula (CF)	External hazard index (H_{ex})
		^{226}Ra	^{232}Th	^{40}K			
Pudupalayam	CL-9	4.87	33.42	394.83	83.06	0.1119	0.2243
	CL-10	BDL	41.81	410.04	91.36	0.1230	0.2467
	CL-11	BDL	72.89	384.42	133.83	0.1801	0.3613
	CL-12	BDL	86.09	405.73	154.35	0.2077	0.4167
Paramananthal	CL-13	BDL	65.58	375.54	122.70	0.1652	0.3313
	CL-14	BDL	64.26	408.27	123.33	0.1660	0.3330
	CL-15	BDL	34.90	378.26	79.03	0.1064	0.2134
	CL-16	BDL	40.76	396.30	88.80	0.1196	0.2398
Kariyamangalam	CL-17	10.8	108.89	426.18	199.33	0.2683	0.5382
Pachal	CL-18	BDL	77.8	414.5	143.17	0.1927	0.3866
Mangalam	CL-19	BDL	37.76	294.22	76.65	0.1032	0.2070
Chetpet	CL-20	11.61	191.47	900.87	354.78	0.4775	0.9579
Thandarai	CL-21	5.63	29	388.04	76.98	0.1037	0.2079
Chengam	CL-22	8.72	72.19	428.84	144.97	0.1952	0.3914
Thanipadi	CL-23	9.59	27.21	338.21	74.54	0.1004	0.2013
Vettavalam	CL-24	BDL	69.07	496.73	137.02	0.1845	0.3699
Kadaladi	CL-25	15.01	93.67	361.94	176.83	0.2380	0.4775
	CL-26	16.22	84.09	339.88	162.64	0.2190	0.4392
Thellar	CL-27	BDL	30.79	347.34	70.77	0.0953	0.1911
	CL-28	BDL	81.29	399.09	146.97	0.1978	0.3968
Vandawasi	CL-29	BDL	18.27	412.96	57.92	0.0781	0.1564
	CL-30	BDL	18.63	453.77	61.58	0.0830	0.1663
Veraiyur	CL-31	BDL	47.67	391.23	98.29	0.1323	0.2654
	CL-32	9.96	49.45	394.95	111.08	0.1496	0.3000
Average		**3.84**	**56.50**	**402.73**	**115.64**	**0.1557**	**0.3122**

Radium equivalent activity (Ra_{eq})

Radium equivalent activity (Ra_{eq}) is a widely used radiological hazard index. It is a convenient index to compare the specific activities of samples containing different concentrations of ^{226}Ra, ^{232}Th and ^{40}K and given by Beretka and Mathew, (1985)[2].

$$Ra_{eq}(Bq\ Kg^{-1}) = A_{Ra} + 1.43A_{Th} + 0.077A_{K} \quad \ldots(1)$$

where A_{Ra}, A_{Th} and A_{K} are the activities of ^{226}Ra, ^{232}Th and ^{40}K, respectively in units of Bq kg^{-1}. The calculated values of Ra_{eq} for the clay materials are given in Table 1 and its values are ranging from 57.92 (CL-29) to 354.78 (CL-20) in Bq Kg^{-1} with an average of 115.64 Bq Kg^{-1}. The calculated results of Ra_{eq} obtained for all the clay samples are well below the worldwide recommended maximum value (370 Bq Kg^{-1})[3]. Hence the clay can be considered as a safe building material in the study area.

Criteria formula (CF)

The criterion formula (CF) to limit the annual radiation dose from building materials based on the formula was given by Keller and Muth, (1990)[4].

$$CF = \frac{A_{Ra}}{740\ Bq/kg} + \frac{A_{Th}}{520\ Bq/kg} + \frac{A_{K}}{9620\ Bq/kg} \quad \ldots(2)$$

Where A_{Ra}, A_{Th} and A_{K} are the activities of ^{226}Ra, ^{232}Th and ^{40}K.The calculated criterion values are given in the Table 1. The criteria values are ranging from 0.0781 (CL-29) to 0.4775 (CL-20) with an average of 0.1557. The values of all the studied samples are well below the recommended maximum value (<1). This indicates that the clay samples can be safely used for construction purposes.

External radiation hazard (H_{ex})

The external hazard index is an additional criterion to assess the radiological suitability of a material. It is defined as follows:

$$H_{ex} = \frac{A_{Ra}}{370\ Bq/kg} + \frac{A_{Th}}{259\ Bq/kg} + \frac{A_{K}}{4810\ Bq/kg} \leq 1 \quad \ldots(3)$$

Where A_{Ra}, A_{Th} and A_{K} are the activities of ^{226}Ra, ^{232}Th and ^{40}K respectively. From the Table 1, it can be observed that the external hazard index values are ranging from 0.1564 (CL-29) to 0.9579 (CL-20) with the mean value of 0.3122. The obtained values of H_{ex} is well below the permissible limit (<1) and indicating that the materials are free from radiation hazards.

CONCLUSION

The natural radio nuclides ^{226}Ra, ^{232}Th and ^{40}K of the terrestrial origin have been measured in samples of clay used to prepare the bricks in Tiruvannamalai Dist, Tamilnadu, India. The results show that the mean activity concentrations of ^{226}Ra and ^{40}K are lower and ^{232}Th is higher than the world average values. The radium equivalent activity was well below the defined limit of 370 Bq Kg^{-1}. The criteria formula (CF) and external hazard index (H_{ex}) was found to be less than 1, indicating a low dose. In view of the above facts, these materials are quite safe to be used as building materials.

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