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Advances in Applied Science Research, 2011, 2 (2): 103-108

Advances in Applied Science Research
Pelagia Research Library
ISSN: 0976-8610
CODEN (USA): AASRFC

Measurement of natural radio activity in brick samples

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ABSTRACT

Natural radioactivity in the brick samples in mainly due to ^{226}Ra, ^{232} Th and ^{40}K and their daughter products. In this study, these measurements have been estimated in gamma-ray spectrometry and their levels for seven different concentrations (10%-50%) of samples are compared and also the radium equivalent concentration (Ra_{eq}) are calculated and compared well with the reported values.

Keywords: Equivalent activity; Annual effective dose; Radiological hazard.

INTRODUCTION

An established fact that all the construction material contains trace amount of natural radio activity. This activity in a major source of external and internal radiation exposure to the occupants of the dwelling. The most commonly emountered radio nuclides in the construction materials are ^{238}U, ^{232}Th their decay products and ^{40}K. Radon isotopes are amongst the members of radioactive series of Uranium and Thorium. The internal exposure due to radon and its radioactive daughters, present in the environment, result in the largest contribution to the average effective does received by human being [1]. Therefore, it is important to measure the radon levels in the built-up areas to assess the radiological consequences. Even more important is the knowledge of the amount of natural activity present in the materials which are used in the construction of dwellings. The amount of activity present in building materials will decide its use in the construction of dwellings.

MATERIALS AND METHODS

Experimental details

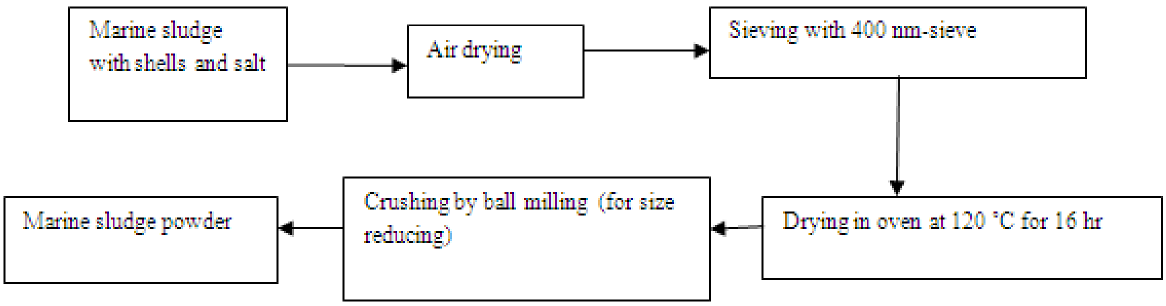
The concentration of the natural radioactivity (^{226}Ra, ^{232}Th and ^{40}K) in the brick samples, were measured using the gamma ray spectrometer in the Laboratory of Health and Safety Division, IGCAR, Kalpakkam, Tamilnadu NAI(TI) crystal detector of size 3”×3” combined with 8K multi channel analyzer. The technique used for measurement is a direct γ counting method. The counting time fixed for each sample was 20,000 seconds. The activity of standard sources used were KCL (329 grams), R-226(0.09μci) and Ra 28 (6000pci) with the counting time of 20,000 seconds, the minimum detectable activity limits were 13.25 Bq/Kg for K-40, 8.5 Bq/Kg for ^{226}Ra and 1Bq/Kg for Th-232. In-site dose rate measurement was done by using digital environmental radiation dosimeter (ERDM Type 107, nucleonix).

Sample Preparation

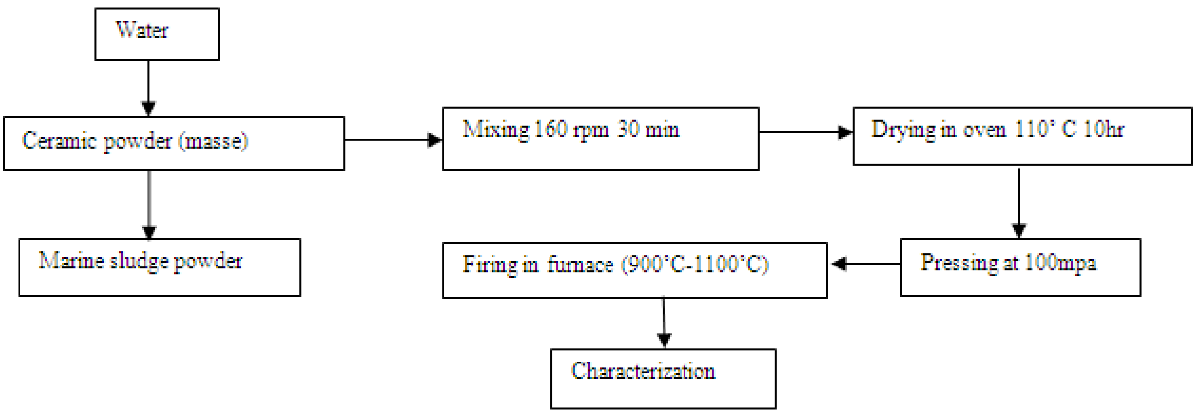
Samples	**S_0**	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**S_6**
Ceramic powder (masse)	-	100%	90%	80%	70%	60%	50%
Marine sludge	100%	0%	10%	20%	30%	40%	50%

The marine sludge was collected from Cuddalore harbour region and ceramic powder (masse) were collected (Government ceramic institute) Virudhachalam. The seven samples (S_0-S_6) have been prepared in different proportions as given below in the table.

Flow chart of marine sludge treatment process



Processing flow sheet for ceramic powder (masse) contains marine sludge additives



The brick samples were powdered to obtain even grain size. The dry samples were transferred to uniform (250ml) containers. Weighted, sealed and kept for 4 weeks so that a secular progeny equilibrium between ^{226}Ra and ^{232}Th and their ld be reached (The sealed counting vials were stored for 30 days to allow ^{226} Ra and its short lived decay products to reach radioactive equilibrium).

RESULTS AND DISCUSSION

Activities due to the presence of ^{226}Ra, ^{232} Th and ^{40}K radio nuclides have been determined in all the collected samples. The minimum, maximum and mean activity values of ^{226}Ra, ^{232} Th and ^{40}K found in these samples are listed in table 1. As may be seen in this table the measured values of activity in the samples due to ^{232}Th vary from 25.35 $Bqkg^{-1}$ to 62.02 $Bqkg^{-1}$, ^{226}Ra activities vary from 9.89 $Bqkg^{-1}$ to 23.48 $Bqkg^{-1}$ and variation in ^{40}K activities ranges from 342.48 $Bqkg^{-1}$ to 405.24 $Bqkg^{-1}$.

Table 1. The minimum, maximum and average values of the activities due to ^{226}Ra, ^{232}Th and ^{40}k in bricks used for the construction of dwelling in cuddalore marine areas

Range	^{232}Th concentration ($Bqkg^{-1}$)	^{226}Th concentration ($Bqkg^{-1}$)	^{40}Th concentration ($Bqkg^{-1}$)
Minimum	25.35	9.89	342.48
maximum	62.02	23.48	405.25
mean	46.78	19.57	349.87

To assess the radiological hazard of the building materials used, it is useful to calculate an index called the radium equivalent activity, Ra_{eq}, defined according to the estimation that 1 Bq/kg of ^{226}Ra, 0.7Bq/kg of ^{232}U and 13Bq/kg of ^{40}K produce the same γ-ray dose [2]. This index Ra_{eq} is given as:

$$Ra_{eq}=C_{Ra}+1.43C_{Th}+0.077C_{K} \qquad \text{------} \qquad (1)$$

Where C_{Ra}, C_{Th} and C_K are the activity concentration in Bqkg of ^{226}Ra, ^{232}Th and ^{40}K, respectively. The calculated values of the radium equivalent Ra_{eq} for the studied building materials are given in table 2.

Table 2 The minimum, maximum and average values of the activities due to Radium equivalent activity ($Bqkg^{-1}$), Annual dose rate (mSv) and Iγr in bricks used for the construction of dwelling in cuddalore marine areas.

Range	Radium equivalent activity ($Bqkg^{-1}$)	Annual dose rate (mSv)	Iγr
Minimum	84.88	0.11	0.630
maximum	136.509	0.183	0.9908
Mean	113.54	0.1529	0.8354

Another radiation hazard index, the representative level index, Iγr, used to estimate the levels of γ-radiation hazard associated with the natural radionuclides in specific building materials, is defined as [3].

$$I\gamma r = (C_{Ra}/150) + (C_{Th}/100) + (C_K/1500) \quad \text{-------} \quad (2)$$

Where C_{Ra}, C_{Th} and C_K are the activity concentrations in Bq/kg of ^{226}Ra, ^{232}Th and ^{40}K respectively. The values of Iγr for the studied samples are given in table 2. It is clear that all the Studied building materials do not exceed the upper limit for the representative level which is unity, except the brick samples which have values of 1.3 and 1.5.

Gamma index

A number of indexes dealing with the assessment of the excess gamma radiation originating from building materials (frequently called "gamma-indexes" or "external indexes") have been proposed [4-8]. In this study, the gamma-index was calculated as proposed by the commission suggests that building materials should be exampled from all restrictions concerning their radioactivity if the excess gamma radiation originating from then increasing the effective dose of a member of the public by 0.3 mSv at the most. On the contrary, doses higher than 1 mSv should be accepted only in some very exceptional cases where materials are used locally.

Gamma-index values suggested by the European Commission (1999) taking in to account typical way and amounts in which the material is used in a building

Dose criterion	**0.3mSvy**	**1mSvy-1**
Materials used in bulk amount, eg. Bricks	Iγ≤0.5	Iγ≤1
Superficial and other materials with restricted use: tiles, bricks and boards, etc.,	Iγ≤2	Iγ≤6

The gamma index (Iγ) proposed by the European commission [9] is calculated using following formula:

$$I = \frac{CRa}{300Bqkg{-1}} + \frac{CTh}{200Bqkg{-1}} + \frac{CK}{3000Bqkg{-1}} \quad - - - - - (3)$$

Where C_{Ra}, C_{Th} and C_k are the ^{226}Ra ^{232}Th and ^{40}K activity concentration ($Bqkg^{-1}$), respectively in the building material the index shall not exceed the values in above table 2, depending on the dose criterion and the way and amount the material is used in a building.

Activity concentration and radium equivalent activities for different brick samples are compared with results obtained by various authors in table 3.

It is possible to observe, activity concentrations results lower than those reported by various authors.

Table 3. Comparism of activity concentration and radium equivalent activities in brick samples in different areas of the world.

Country	Brick type of origin	Number of samples	^{226}Ra	^{232}Th	^{40}K	Ra_{eq}	Reference
Italy		(n,m)	110±9	97±8	380±30	0.90	10
Hungary		(n,m)	50	50	670	-	11
Egypt	Clay brick	(n,m)	33.4±1.0	27.7±0.8	284±13.1	0.689	12
	Cement Brick	(n,m)	10.6	3.1	54.1	0.134	12
	Sand brick	(n,m)	9.0	4.3	107	0.7	12
U.K	Clay	(n,m)	65	48	620	181	13
	White	(5)	4	5	12	121	3
	Crushed Granite	(n.m)	40	39	800	157	13
Norway	Clay	(6)	104	62	1058	216	5
Sweden	-	(n,m)	96	127	962	352	3
Germany	Traditional	(109)	59.0	67.0	673	207	3
	Red mud	(23)	281	233	337	640	3
Finland	Clay	(33)	78	62	962	241	3
	White	(3)	22	23	77	99.3	3
China	Clay	(n,m)	4.0	52.0	717	174	14
	Sand lime	(n,m)	32.0	32.0	634	127	14
	Coal spoil	(n,m)	53.0	59.0	641	187	14
Australia	Clay	(25)	40.7	88.8	681	220	15
	Mud	(4)	22.2	81.4	448	173	15
	Red-mud-Clay	(1)	104	500	196	834	15
Netherland	Clay	(14)	39	41	560	141	16
	Porous	(6)	72	73	1030	256	16
Pakistan		(n,m)	43.2	53.7	631	169	17
Bangladesh	Soil	(5)	101	119	315	295	18
	Red	(5)	109	58.1	234	210	18
	Concrete	(5)	166	171	295	433	18
U.S.A	Atlanta	(24)	66.6	70.3	629	216	15
	Brozil	(n,m)	51.7	65.3	747	203	2
Srilanka	Brick	(n,m)	35	72	585	183	19
India	Clay	(1)	48	52	381	152	20
India	Sludge brick		18.20	46.78	369.27	113.54	Present study

CONCLUSION

To conclude, radium equivalent activities calculated from measured values of ^{226}Ra, ^{232}Th and ^{40}K activities in all the brick samples are lower than the upper recommended limit of 370Bqkg^{-1}. The calculated internal and external hazard indices are less than unity. Therefore, according to the critter on laid down by OECD countries, the brick of studied is acceptable for use as construction materials.

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