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ESTIMATION OF NATURAL RADIOACTIVITY LEVEL AND ASSESSMENT OF RADIATION HAZARD INDICES IN BUILDINGMATERIALS USED AROUND KOLAR GOLD FIELDS, KOLAR DISTRICT, KARNATAKA, INDIA

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ABSTRACT

The study on natural radioactivity level in the building material splays a significant role in health physics. The present study has been carried out with the aim of estimating activity concentration of radionuclide's in construction material10 different samples used for construction around Kolar Gold Fields, Kolar district using gamma ray spectrometry. Average values of activity concentration of ^{226}Ra, ^{232}Th and ^{40}K of the present study are46.1±1.5, 75.1 ± 2.0 and 492.7 ± 4.9 Bq.kg^{-1}, respectively. The average radium equivalent activity (Ra_{eq}), absorbed dose rate and annual effective dose were calculated.

KEYWORDS: ***Primordial radionuclide's, Radium equivalent activity, Dose, Hazard indices.***

INTRODUCTION

Building Materials are the essential resource available for construction of buildings. They consists of organic matter, mineral particles, air, organisms and water [1, 2]. The activity of radionuclides in Building materials mainly depends on activity of radionuclide's present in the parent rock, types of rock, interaction of rock with water and meteorological parameters and chemical changes. Physiochemical properties of Building materials play a vital role in the distribution, concentration and behavior of radionuclide's in soil [3-5]. People living in granite or mineralized sand areas receive more terrestrial radiation compare to other areas. Thepublic living or working at high altitude receive more cosmic radiation [6-8]. Whether it is natural or artificial radionuclides, they are accessible for uptake by animals and plants and enter into the human food chain [9]. When radionuclides enter in to the atmosphere, they undergo decay and deposited on the surface of earth by dry or wet deposition within relatively short periods [10]. The activity of radionuclides in food grains is also depends on activity of radionuclides present on the surface of building materials. Hence, assessment of radiological risk due to the radionuclides present in building materials are very important.

The area of present study is around KGF, Kolar. The second deepest underground mines (3209m) Bharath Gold Mine Limited (BGML) is located in the area of study. Geologically, the study area belonged to hornblende gneiss, closepet granite, quartzite, champion gneiss, metabasalt, dolerite dyke and grey granite. Major portion of the study area consists of granite and hornblende gneiss. The types of soil in study area are red sandy / loamy and lateritic. This study is important to provide baseline data for the general public of the study area from the health point view. Furthermore, no research work on measurement of radionuclides concentration in the soil was carried out in Kolar district to date.

MATERIALS AND METHODS

Collection and preparation of building material samples

The 10 different building material samples were collected at the study area and the samples prepared as per standard procedure [11]. These samples were kept in an oven for overnight at 110ºC to remove water content in the samples. Then the samples were sieved through 200 µm mesh. About 300g of each sample was taken and packed in a 300 ml plastic bottle and left at least 40 days before taking readings to attain radioactive equilibrium between ^{226}Ra, ^{222}Rn and their progeny.

Activity concentration of radionuclide

The gamma ray spectrometric procedure is used to determine the activity concentration of ^{226}Ra, ^{232}Th and ^{40}Kin the collected building material samples at different places of the study area [12]. The detector used is Hyper Pure Germanium (HPGe) detector. The activity of radionuclides (in Bq.kg^{-1}) is calculated by using the relation [13]

$$Activity(Bq.kg^{-1}) = \frac{(s\pm\sigma)\text{x } 100 \text{ x } 1000 \text{ x } 100}{EWA} \qquad (1)$$

where, s is the net counts per second under the photo peak of intensity, σ is the standard deviation of s, E is the counting (%) efficiency, A is the gamma abundance (%) of the radionuclide's and W is the mass of the sample (kg).

Radium equivalent activity (Ra_{eq}), absorbed and effective dose

To compare the specific activity of the material containing amounts of ^{226}Ra, ^{232}Th and ^{40}K, radium equivalent activity in Bq.kg^{-1}has been calculated using the relation [14, 15]

$$Ra_{eq}\,(Bq.kg^{-1}) = A_{Ra} + 1.43A_{Th} + 0.07\,A_K \quad (2)$$

where, A_{Ra}, A_{Th}, and A_K, are the measured activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in $Bq.kg^{-1}$, respectively.

The absorbed gamma dose rate (D) in $nGy.h^{-1}$ is calculated using the relation [10]

$$D\,(nGy.h^{-1}) = 0.462\,A_{Ra} + 0.604\,A_{Th} + 0.042\,A_K \quad (3)$$

where, A_{Ra}, A_{Th}, and A_K, are the measured activity concentration of ^{226}Ra, ^{232}Th, and ^{40}K in $Bq.kg^{-1}$, respectively and 0.462, 0.604 and 0.042 are corresponding dose coefficients.

Indoor and outdoor annual effective dose (E) was estimated from the absorbed doe rate by using fallowing equation [10]

$$E\,(mSv.y^{-1}) = D \times 8760 \times OF \times CF \quad (4)$$

where, D is the absorbed dose in $nGy.h^{-1}$, OF is the Occupancy Factor and it is 0.2 for outdoor and 0.8 for indoor. CF is the Conversion Factor from absorbed dose rate in air to effective dose received by the person (0.7×10-6 $Sv.y^{-1}$).The time spent in the indoor and outdoor is $8760 \times 0.8\ h.y^{-1}$ and $8760 \times 0.2\ h.y^{-1}$, respectively.

RESULTS AND DISCUSSION

Distribution of radionuclide's in building material samples

The average activity concentration of primordial radionuclide's in commonly used 10 types of building material samples used for construction around the study area is determined using HPGe detector, and values obtained are summarized in Table. 1 and their variation is shown in Fig. 1.The average activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in collected samples vary from 17.2±1.2 to118.4±3.7 $Bq.kg^{-1}$, 23.2±1.9 to 186.7±3.2 $Bq.kg^{-1}$ and 54.7±2.9 to 1321.8±9.7 $Bq.kg^{-1}$ with an average value of 46.1±1.5, 75.1±2.0 and 492.7±4.9 $Bq.kg^{-1}$, respectively.This huge variation in activities among the building materials is due to their radioactive mineral content and the geological, geochemical and geographical origins of the raw materials, among the other factors [16].

Lesser activity values of ^{226}Ra, ^{232}Th and ^{40}K are observed in sand, cement and marble samples. This is because marbles are made of amphibolite, biotite, feldspar, hornblende, mica, muscovite minerals which have lesser activity. Cement consists of calcium oxide mixed with silicon dioxide and aluminum oxide in addition with raw materials like silica sand, iron oxide and bauxite and sand mainly consists of silica and quartz which have lesser activity concentration of radionuclides. Hence the above building materials have lesser activity concentration.

Table 1 Average activity of ^{226}Ra, ^{232}Th and ^{40}K in common building materials used in and around Kolar Gold Fields.

Sl. No.	Material	Activity of Radionuclide's (Bq.kg^{-1})			^{232}Th/ ^{226}Ra	Ra$_{eq}$ (Bq.kg^{-1})
		^{226}Ra	^{232}Th	^{40}K		
01	Sand	18.4±0.9	32.7±1.6	76.8±2.4	1.8	70.5
02	Cement	17.2±1.2	23.2±1.9	54.7±2.9	1.3	54.2
03	Soil Bricks	30.3±0.8	102.1±1.7	594.6±3.2	3.4	217.9
04	Cement Bricks	36.7±1.3	48.4±1.8	386.4±5.2	1.3	133.0
05	Vitrified Tiles	47.2±1.7	62.3±1.7	212.7±3.6	1.3	151.2
06	Ceramic Tiles	58.6±1.9	87.4±2.6	406.5±4.1	1.5	212.0
07	Pink Granite	118.4±3.7	186.7±3.2	1321.8±9.7	1.6	477.9
08	Grey Granite	87.2±1.8	132.4±2.1	1184.4±12.1	1.5	359.4
09	Mosaic	25.8±1.2	39.2±1.7	486.5±3.6	1.5	115.9
10	Marble	21.6±0.7	36.4±1.9	202.4±2.6	1.7	87.8
Minimum		17.2±1.2	23.2±1.9	54.7±2.9	1.3	54.2
Maximum		118.4±3.7	186.7±3.2	1321.8±9.7	3.4	477.9
Average		46.1±1.5	75.1±2.0	492.7±4.9	1.7	188.0

Slightly higher activity concentration of ^{226}Ra, ^{232}Th and ^{40}K is observed in ceramic and vitrified tiles. This is because ceramic tiles are manufactured by the mixture of illicit white clay, kaolin white clay, calcite, dolomite, sodium feldspar, perlite, talc, quartz particles and sand granule, and vitrified tiles are made from the mixture of clay and elements like silica, quartz and feldspar which have slightly higher activity of radionuclides[17]. The primary components in their manufacture differ from each other, and hence ceramic tiles have higher activity when compared to vitrified tiles.

Higher activity concentration of ^{226}Ra, ^{232}Th and ^{40}K is observed in pink granite and grey granite. The different colors of the granite are due to variations in chemical and mineral compositions. The main raw material of these granites is raw granite which has higher value of activity of radionuclides. Pink rocks are younger than grey granites, and contain higher concentration of radionuclides [18].

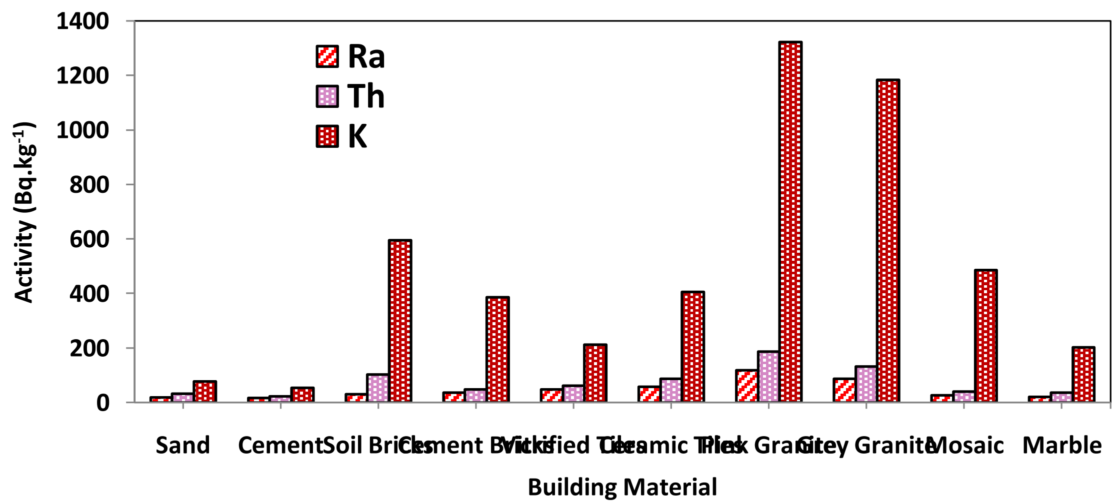

Fig. 1 Variation of average activity of radionuclide's in different building materials.

Correlation between activities of primordial radionuclides in building material samples

The correlation between the activity concentrations of ^{226}Ra and ^{232}Th, ^{226}Ra and ^{40}K, and ^{232}Th and ^{40}Kin the common building materials used in the study area isshown in Fig.2, Fig. 3 and Fig. 4, respectively. This shows that thereis a positive correlation with correlation coefficients 0.875, 0.803 and 0.865 between ^{226}Ra and ^{232}Th, ^{226}Ra and ^{40}K, and ^{232}Th and ^{40}K respectively.

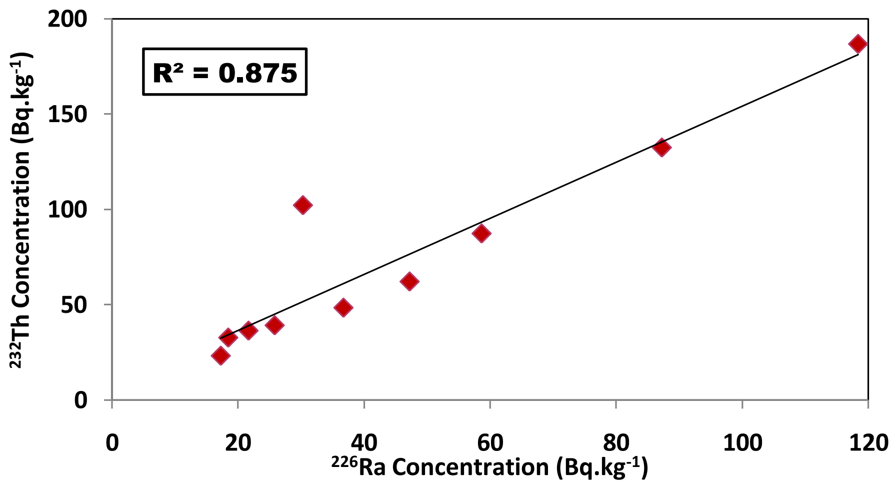

Fig. 2 Correlation between radium and thorium concentration in building material samples.

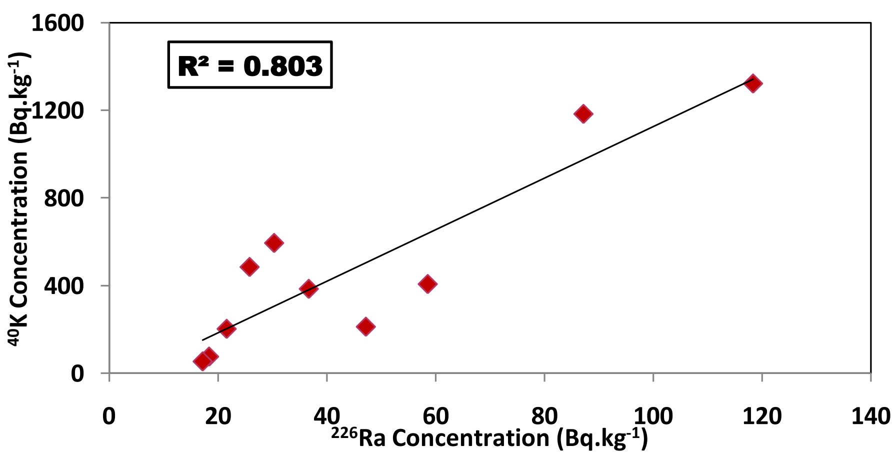

Fig. 3 Correlation between radium and potassium concentration in building material samples.

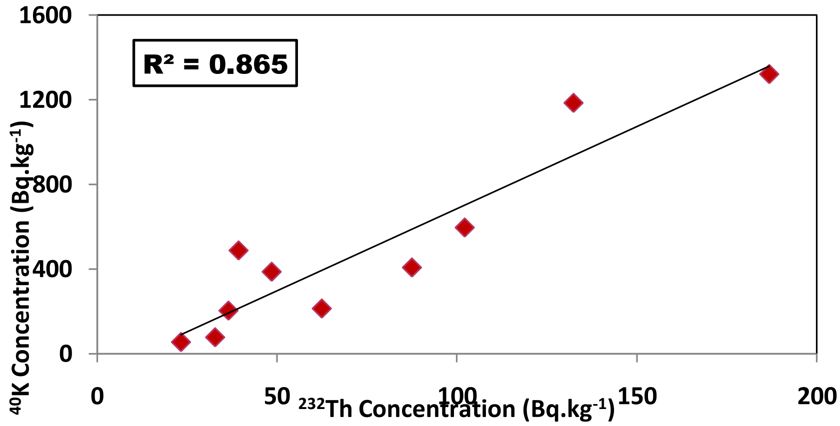

Fig. 4 Correlation between thorium and potassium concentration in building material samples.

Activity ratio of ^{226}Ra and ^{232}Th and Radium equivalent activity (Ra_{eq}) in building materials

The ratio of ^{232}Th and ^{226}Ra values in the building material samples vary from 1.3 to 3.4 with an average value of 1.7 summarized in Table 4.8. This ratio gives the sign of relative presence of uranium and thorium. The activity concentration of radium is lower than thorium in all the collected samples.

The Radium equivalent activity (Ra_{eq}) in building material samples ranges from 54.2 to 477.9Bq.kg^{-1}with an average value of 188.0Bq.kg^{-1}and it is summarized in Table 4.8 whichisless than the criterion limit of 370 Bq.kg^{-1}[19].This shows that the collected building material samples of the study area do not create any radiological hazards when they are used for construction. Correlation between activity concentrations of ^{232}Thand $Ra_{eq}$for building material samples are shown in Fig. 5 with the correlation coefficient value of 0.983have been observed. This shows that radium equivalent activity is mainly due to concentration of ^{232}Th in the samples.

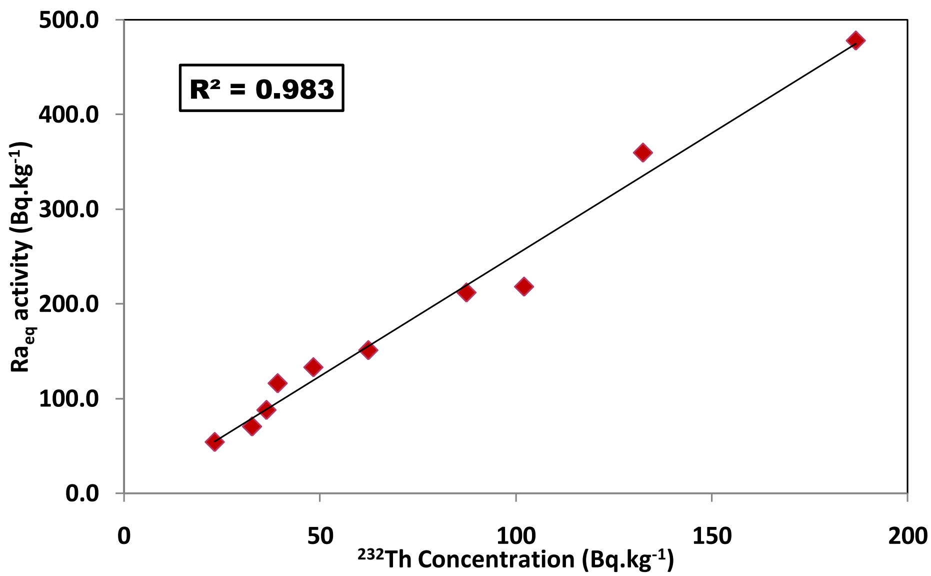

Fig. 5 Correlation between thorium and radium equivalent activity in building material samples.

CONCLUSION

From the study, it has been observed that there is a huge variation in activities among the building materials.This is due to their radioactive mineral content and the geological, geochemical and geographical origins of the raw materials, among the other factors.Higher activity concentration of ^{226}Ra, ^{232}Th and ^{40}K is observed in pink and grey granites. Pink granite rocks are younger than that of grey granites and are containing higher concentration of radionuclides. However, lesser activity values of radionuclides have been observed in sand, cement and marble samples. A positive correlation with coefficients 0.875, 0.803 and 0.865 between ^{226}Ra and ^{232}Th, ^{226}Ra and ^{40}K, and ^{232}Th and ^{40}K concentration in building materials samples have been observed, respectively.The average values of radium equivalent activity (Ra_{eq}) due to radionuclides building material samples of the study area is 188.0 Bq.kg^{-1}, which is lesser than that of criterionlimit of 370Bq.kg^{-1} (UNSCEAR 2000). This indicates that the building material samples of the study area do not create any radiological hazard, and can be used for construction of dwellings.

REFERENCES

1. RamachandranT V, K.P.Eappen, R.N.Nair, Y.S.Mayya and V.D.Puranik(2005) Background Radiation Exposure Levels: Indian Scenario. International Congress series 5-6
2. ISO (International Organization for Standardization)(2003) Measurement of radioactivity in the environment–Soil—Part 1, General guide and definitions.
3. Tufail M, Asghar M, Akram M, Javied S, Khan K, Mujahid SA(2013) Measurement of natural radioactivity in soil from Peshawar basin of Pakistan.J RadioanalNuclChem 298:1085–1096
4. Belvermis M, Kılıc O, Cotuk Y, Topcuoglu S (2010) The effectsof physicochemical properties on gamma emitting natural radionuclide levels in the soil profile of Istanbul. Environ Monit assess 163: 15–26
5. Patra AC, Sahoo SK, Tripathi RM, Puranik VD (2013)Distributionof radionuclides in surface soils, Singhbhum Shear Zone, India and associated dose. Environ Monit Assess 185: 833–7843
6. Flodin U, Fredriksson M, Persson B and Axelon O (1990) Acute myeloid leukemia and backgroundradiation in an expanded case–referent study. Arch.Environ. Med. 55:106
7. Sannappa J, Chandrashekera M. S., Sathish L. A,Paramesh L. and Venkataramaiah P (2003) Study of background radiation dose in Mysore city, Karnataka State, India. RadiatMeas37: 55
8. Narayan KK, Krishnan DN and Subbaramu MC (1991) Population exposure to ionizing radiation inIndia, Indian association for radiation protection(ISRP), ISRP (K) BR3.
9. Kabir KA, Islam SM and Rahman M (2009) Distribution of radionuclides in surface soil and bottom sediment in the district of Jessori, Bangladesh and evaluation of radiation hazard. J. BanglAcadSci 33(1):117–130
10. United Nations Scientific Committee on the Effects of Atomic Radiation.(UNSCEAR) (2000) Sources and effects of ionizing radiation. Report to the General Assembly with Scientific Annexes. Vol. 1, Annex B: Exposure from natural radiation sources. United Nations.
11. Volchok HL, dc Planque G (1983) EML Procedure manual. 26thedn.Environmental measurement Laboratory, New York.
12. Krishnan M.S (1982) Geology of India and Burma, 6th edn. Batra Art Printers, New Delhi.
13. IAEA/RCA (1989) Regional work on environmental sampling and measurement of radioactivity for monitoring purposes. In: Health Physics Division (Kalpakkam, India: BARC).

14. Beretka J, Mathew PJ (1985) Natural radioactivity of Australian building materials, industrial wastes and by products. Health Phys 48:87–95
15. Al-Trabuls HA, Khater AEM, Habbani FI (2011) Radioactivity levels and radiological hazard indices at the Saudi coastline of the Gulf of Aqaba. RadiatPhysChem 80:343–348
16. El-dine and Walley Nadia; Study of natural radioactivity and the state of radioactive disequilibrium in U-series for rock samples, North eastern desert, Egypt. *Appl. Radiat. Isot.* 66(1):80-85, 2008.
17. Chandrashekar MS, Veda SM, Paramesh L; Studies on radiation dose due to radioactive elements present in ground water and soil samples around Mysore City, India. *Radiat. Prot. Dosim.* 149(3):315-320, 2012.
18. Nambi KSV, Bapat VN, David M, Sundaram VK, Sunta CM, and Soman SD; Natural background radiation and population dose distribution in India. *Health Phys. Division,* BARC, India. 1-30, 1986.
19. Beretka J, Mathew PJ; Natural radioactivity of Australian building materials, industrial wastes and by products. *Health Phys.* 48(1):87-95, 1985.