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External Gamma Dose Levels In The Soil Samples of HBRAs of Kerala and Tamil Nadu, India

Reeba Maria Jose[1*], S. Ben Byju [2], S. Anilkumar [3], M P Chougaonkar [3]

[1] Research and Development Centre, Bharathiar University, Coimbatore 641046, India
[2] Centre for Advanced Research in Physical Sciences, Research Department of Physics,
[3] Bhabha Atomic Research Centre, Mumbai 400085, India

reebamgeorge@rediffmail.com

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ABSTRACT

Knowledge on the distribution of these radionuclides in soil is of great important for radiation protection and measurement. A systematic radiological survey has been carried out in the region of HBRAs in Kollam district of Kerala and Manavalakurichi in Tamilnadu in India to compare the natural gamma-radiation levels. 180 soil samples collected and were analysed for ^{238}U, ^{232}Th and ^{40}K by NaI(Tl) gamma ray spectrometry. Heterogeneous distribution of radionuclides in the region may be attributed to the deposition phenomenon of soil in the region. The result of gamma dose rate measured at the sampling sites using survey meter showed an excellent correlation with dose rates computed from the natural radionuclides estimated from the soil samples. From these radioactivity levels, the radium equivalent activity and the external hazard index which resulted from the natural radionuclides in sediments are also tabulated for the analysed samples and compared with internationally recommended values.

Keywords: Ether, Inertial reference frame, Principle of relativity

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INTRODUCTION

Scientists have studied radiation forever 100 years and we know a great deal about it. Radioactive Materials are present in environment of earth right from its formation and there are about 60 radionuclides are present in nature. Naturally occurring radionuclides namely uranium, thorium, and its decay product and potassium-40 is present in various environmental compartments such as air, water, soil, plants and animals. These nuclides have longer half-lives so that they continue to exist for centuries. The health risk is greater with long lived isotopes that remain in the body for longer duration causing large internal radiation doses (Harty, 2007). The natural radionuclides are distributed everywhere in earth's environment with different concentration. The earth crust is the principle source of natural radionuclides in soil and rocks (Radiation, 2000). Soil result from the weathering of rocks, which involve the destruction of rock forming minerals. This natural radiation background has remained fairly constant for thousands of years; India is one of the few countries in the world having higher natural back ground radiation levels. The highest back ground radiation areas in India are the southwest coast of Kerala, Ullal in Karnataka and Manavalakuruchi in Tamilnadu (Mishra, 1993; Radhakrishna, Somashekarappa, Narayana, & Siddappa, 1993; Sunta, 1993). This higher background radiation levels is essentially due to the presence of monazite in beach sands and in land soils. The radionuclides are transported from their source to biotic community through different pathways such as air, water, food chain etc. Therefore, the estimation of primordial radio nuclei levels in surface soil in the region is of great importance in terms of radiological concern.

MATERIALS AND METHODS

For the present study, 100 soil samples were collected from the coastal villages in Kollam and Karunagappally taluks in Kollam district of Kerala State. The locations of the sample collection were demarcated using a GPS and are shown in the Figure1. The experimental area is bounded by the lat-long coordinates, 8-10^0 East and 76^0 25'-76^0 50' North covering about 120 square kilometre. 75 soil samples were also collected from the southwest coast of Tamil Nadu which is a high level natural radiation area is situated in the south India, for the comparative study. Several studies have been undertaken during the past one or two decades to determine the effect of radiation on the Public. The monazite content in the soil of Manavalakurichi and its surrounding area, Kanyakumari district varies from 0.3% to 6% . The area is bound by the lat-long coordinates, 77^0 32' -77^0 16' East and 08^0 05'-08^0 16' North covering about 50 square kilometre. Approximate locations of sample collection in the study area in Tamilnadu is shown in Fig-2. Five samples were collected from normal background radiation areas (NBRAs) near Kollam, Kerala.

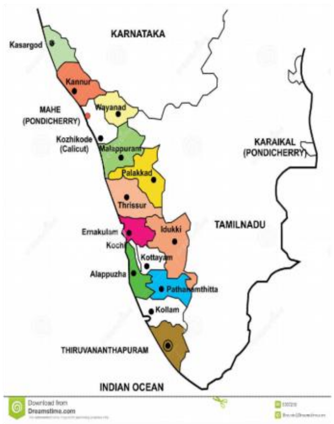

Fig 1. Approximate locations of sample collection in the study area in Kerala.

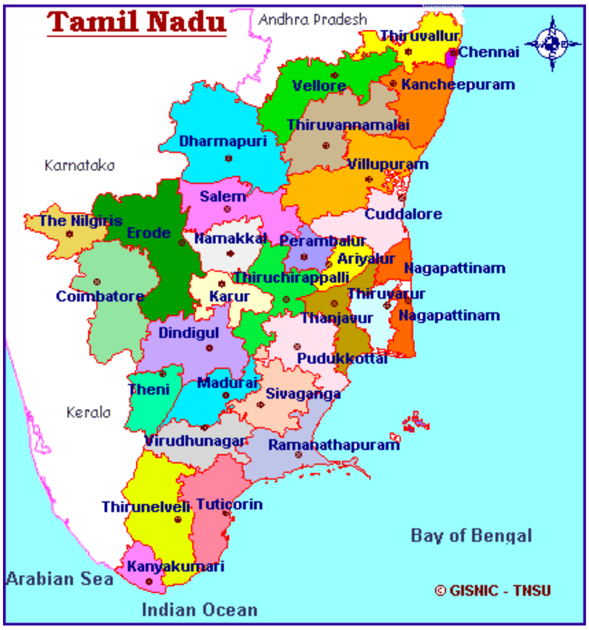

Fig 2. Approximate locations of sample collection in the study area in Tamilnadu.

A total of 180 soil samples were collected for the present study region as per the Environmental Measurements Laboratory Procedure Manual (Krey & Beck, 1990). The soil samples were then dried in an oven for 24 h at 110^{0}C. All the collected samples were crushed, sieved, sealed and properly labelled with the weight of the soil samples .The samples were then stored for a period 40 days to attain a secular radioactive equilibrium of progeny nuclides. The prepared samples were then subjected to gamma spectrometric measurements using a 4″ × 4″ NaI(Tl) scintillation detector system which is most important in low level environmental radiation measurements. The detector was surrounded by 3" thick lead shield on all sides to reduce the back ground radiations originating from the environment. The gamma ray spectrum was recorded using 1k PC based multichannel analyzer (WinTMCA 32) with a built in spectroscopic amplifier. Adequate shielding of the detector Samples were analyzed for ^{238}U (^{226}Ra), ^{232} Th and ^{40}K . The background spectra counts were recorded and subtracted to get a net count rate for each sample. Each soil sample was counted for a period of 60000 s and the obtained spectra were analyzed for the activity of radionuclides. The activity of ^{40}K was evaluated from the 1460 keV photo peak of its own gamma, the activity of ^{238}U from 1764 keV gamma of Bi and that of ^{232}Th from 2614 keV gamma of ^{208}Tl. The minimum detectable activities were 4.7, 14.3 and 27.2 Bq/ kg for uranium, thorium and potassium, respectively. External gamma dose rates at each sampling location were measured using a GM-based survey meter. Readings were taken at ground and at a height of one meter from the ground and the average of three readings was recorded for each sampling point. Latitude and longitude details of sampling locations were also noted using a GPS.

RADIUM EQUIVALENT ACTIVITY

Exposure to natural radionuclides is computed through a term called 'radium equivalent' (Ra_{eq}). It was calculated using the following relation (Yu K N, 1993).

$$Ra_{eq} = C_{Ra} + 1.43\, C_{Th} + 0.07\, C_K \qquad (1)$$

Where C_{Ra}, C_{Th} and C_K are the activity concentrations of in Bq/kg^{238}U (^{226}Ra), ^{232} Th and ^{40}K respectively.

Absorbed dose: The radiation dose (nGy/ h) expected to be present at the sampling location (normally measured at 1 m height) resulting from the natural radionuclides in the soil at the sampling locations were computed using the dose conversion coefficients given by UNSCEAR 2000 (Radiation, 2000).

$$D\ (nGy/h) = 0.461\ C_{Ra} + 0.623\ C_{Th} + 0.0414\ C_K \quad (2)$$

Where, C_{Ra}, C_{Th} and C_K are the activity concentrations (Bq/ kg) of radium, thorium and Potassium in the samples.

Annual effective dose: To estimate annual effective doses, account must be taken of the conversion coefficient from absorbed dose in air to effective dose and the indoor occupancy factor. Annual estimated average effective dose equivalent received by a member is calculated using a conversion factor of 0.7 Sv/Gy, which is used to convert the absorbed rate to human effective dose equivalent with an outdoor and indoor occupancy of 0.2 and 0.8 respectively (Radiation, 2000). The annual effective doses are determined as follows,

$$\text{Outdoor(mSv/y)} = \text{Absorbed dose(nGy/h)} \times 8760h \times 0.2 \times 0.7 Sv/Gy \times 10^{-6} \quad (3)$$

External hazard index (H_{ex}): The external hazard index H_{ex} can be calculated by the following equation (Beretka & Mathew, 1985)

$$H_{ex} = C_{Ra}/370 + C_{Th}/259 + C_K/4810 \leq 1 \quad (4)$$

where C_{Ra}, C_{Th} and C_K are the activity concentrations of ^{238}U (^{226}Ra), ^{232} Th and ^{40}K in Bq/kg respectively. The values of this index must be less than unity in order to keep the radiation hazard to be insignificant. The maximum value of H_{ex} equal to unity corresponds to the upper limit of Ra_{eq} (370 Bq/kg).

RESULTS AND DISCUSSION

Results of the soil samples (Kollam and manavalakurichi from HBRA and 5 samples from NBRA) by gamma-ray spectroscopy are summarised in Table 1. World average concentrations are 35 Bq/ kg, 30Bq/ kg, and 400 Bq/ kg for ^{226}Ra, ^{232}Th and ^{40}K respectively. In general, the average and ranges of activity concentration of ^{232}Th in soil of these HBRA areas are higher than the world Figures. However, the Concentration for ^{226}Ra is very much comparable and a concentration for ^{40}K is lower as Compared with world figures. The range of activity concentrations of ^{238}U, ^{232}Th and ^{40}K in the soil from the study areas (Kollam)varies from 17 Bq/kg to 368 Bq /kg, 25 Bq/kg to 555 Bq/ kg and 70 Bq/ kg to 320 Bq/ kg with overall mean values of 208Bq/ kg, 415 Bq/ kg and 290 Bq/ kg respectively. Table 2 shows the Comparison of activity concentrations of ^{238}U, ^{232}Th, and ^{40}K in Bq /kg in the soil samples of the different parts of the world with the present study.

Table. 1 Distribution of natural radionuclides (Bq/kg) in soil samples from the study area .

Location	No of samples collected	^{238}U (Bq/kg)	^{232} Th (Bq/kg)	^{40}K (Bq/kg)
Kollam	100	17-368	125-555	70-320
Manavalakurichi	75	19-168	21-127	34-204
NBRA	5	BDL-12	BDL-27	48-122

Table. 2 Comparison of activity concentrations of ^{238}U, ^{232}Th, and ^{40}K in Bq /kg in the soil samples of the different parts of the world with the present study.

Region/country	^{238} **U** (Bq/kg)	^{232}**Th** (Bq/kg)	^{40} **K** (Bq/kg)	**Reference**
Kollam	208	415	290	
Manavalakurichi	118	99	184	
NBRA	7	16	112	
World wide	25	25	370	(Radiation, 2000)
Ullal in Karnataka	374	158	158	(Radhakrishna et al., 1993)
Nigeria	16	24	35	(Arogunjo, Farai, & Fuwape, 2004)

Table. 3 Comparison of Radium equivalent activity, absorbed dose rate, Annual effective dose rate and Hazard indices of all soil samples.

Location	**Radium Equivalent Activity Bq/kg**	**Absorbed Gamma Effective Dose Rate nGy/h**	**Outdoor Annual Effective Dose Rate mSv**	**External Hazard ndex**
Kollam	57-1183	52-638	0.063-0.39	0.15-3.2
Average	821	467	0.572	2.2
Manavalakurichi	51-363	35-239	0.04-0.29	0.13-0.98
Average	272	191	0.234	0.739
NBRA	BDL-59	BDL-27	BDL-0.03	BDL-0.16
Average	37	17	0.03	0.104
World wide	370	55	0.5	1

Radium equivalent was found to vary from 57-1183 Bq/kg with an average value of 821Bq/kg. Which is higher than the safe limit (370Bq/kg) recommended by OECD, 1979(OECD, 1979). Total absorbed gamma dose rates were found to vary from 52-638nGy/h with an average value of 467nGy/h. The gamma absorbed does rates in air of soil in areas under study are comparable to the average global terrestrial radiation of 55nGy/h. The outdoor annual effective dose rates due to the activity of soil samples varied from 0.06-.78mSv/y respectively. While the world wide average annual effective dose is approximately 0.5 mSv. A comparison of radium equivalent activity, absorbed dose rate, annual effective dose rate and hazard indices of all soil samples in HBRAs and NBRA with worldwide accepted values shown in Table 3. Generally similar type of trend is observed in all the samples and no regular trend in the variation in the annual effective dose and absorbed dose rare is observed from the soil samples. Our results for average annual effective dose are within the range of world wide average value. External hazard index and the estimated were ranged from 0.15-3.2. Since these values are higher than unity, according to the radiation protection 112 report (Europeas, 2000) and respectively. HBRA in kerala compared with HBRA in Tamilnadu and NBRA . In the estimated dose values in kerala is higher than Tamilnadu.

CONCLUSION

The concentration of ^{232}Th and ^{226}Ra in soil samples of are higher than the world figures reported in UNSCEAR, 2000. However, the concentration of ^{40}K is lower than world figures. The annual exposure in HBRA due to external gamma dose is found to be very high as compared with the natural background region. For NBRA a less heterogeneous distribution of radionuclides is seen. This work has been able to establish studies on radiation levels and radionuclide distribution in the environment provide vital radiological baseline information. Such information is essential in understanding human exposure from natural and man-made sources of radiation and necessary in establishing rules and regulations relating to radiation baseline information on the natural radionuclides concentrations in Kollam, Kerala, which will serve as a reference for future assessment. Further study may be necessary to estimate internal doses and external doses from other sources for the population of HBRA.

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