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Radioactivity Content in the Soils of Chitradurga District, India.

Shivaprakash M C[1], Seshadri B S[2]

[1]*Department of Physics, Channabasaveshwara Institute of Technology, Gubbi -572 216*
[2]*Department of Postgraduate Studies and Research in Physics, The National Degree College (Autonomous), Jayanagar, Bangalore – 560 070*

***Abstract* — Concentrations of ^{226}Ra, ^{232}Th and ^{40}K in the soil samples collected from various locations of Chitradurga district were studied in detail using HPGe gamma ray spectrometer. The ^{226}Ra, ^{232}Th and ^{40}K contents in the soil samples were found to vary from 17.2 – 46.2 Bqkg^{-1}, 34.3 – 110.9 Bqkg^{-1} and 386.2 – 792.8 Bqkg^{-1}, respectively. The ambient gamma radiation level was also measured using low level radiation dosemeter and was found to vary from 99.5 – 284.5 nGyh^{-1}. The results are presented in this paper are discussed in the light of the geological features of the region.**

***Keywords* - Chitradurga, HPGe Detecting system, Primordial radionuclides, Radiation level, Radiation Hazard.**

I. Introduction

The natural radiation comprises mainly ^{40}K, ^{232}Th and ^{238}U radionuclides present in the earth's crust and the radionuclides produced by cosmic radiation interactions. This natural radiation contributes about four-fifths of the average annual radiation dose received by the world's population. The natural radiation gives rise to both external and internal dose received by man. The study area Chitradurga District is in Karnataka, India. It lies between13º34′ and 15º02′ north latitude and 75º37′ and 77º01′ east longitude. Chitradurga has an average elevation of 2401feet. The whole District is a Dry land, characterized by huge undulating plains. The geological features of study area is largely composed of crystalline schists, granitic gneisses and the newer granites with a few later intrusive basic dykes, all belonging to the oldest rock formations recognized in India.

In this paper, the ambient gamma radiation level in and around Chitradurga is presented and the results of gamma radiation measurements in the soils of various locations of Chitradurga district are presented. Since Chitradurga District is on a granite base, it was felt appropriate to study environmental radioactivity and its relation to the presence of granites in the Chitradurga region. Since no such study has been reported so far in respect of this part of the Country, the present study happens to be the first of its kind.

II. Materials And Methods

The ambient gamma radiation level has been measured using a digital type Environmental Radiation Dosimeter (ER-709). The equipment has the sensitivity of 1 μR h^{-1} (10nGy/h). The soil samples were collected and processed using standard procedures. The activities of ^{226}Ra,^{232}Th and ^{40}K in soil samples were determined by gamma ray spectrometry employing 42% efficiency close ended co-axial n-type low background High Purity Germanium (HPGe) detector(CANBERRA,USA) with carbon fiber window. The detector was enclosed in a 10 cm thick graded lead shield. The resolution of the detector is 2.01 keV at 1.33 MeV. The spectrum was acquired and analyzed by employing a PC based 16K multi channel analyser (DSA-1000, CANBERRA) and Genie 2000 software. The efficiency calibration of the detector was performed using the IAEA quality assurance reference materials RGU-238, RGTh-232, RGK-40 and Soil-6 calibration (Karunakara et al.2000). The minimum detection levels (MDL) for ^{226}Ra, ^{232}Th and ^{40}K for this detector were 0.41, 0.22 and 2.71Bqkg^{-1} respectively.

III. Results And Discussions

The measured absorbed gamma dose rates for all the 15 locations mentioned in the paper vary in the range 99.5 to 284.5nGyh^{-1}.The measured dose rates were significantly high at places where granites and granitic outcrops were prominent. The absorbed dose rates were also estimated from the specific activities of ^{226}Ra, ^{232}Th and ^{40}K from the soil samples of all the 15 locations. The estimation of gamma radiation dose to the population was estimated using the relation Doserate (nGy/h)=$0.462C_{Ra}+0.604C_{Th}+0.0417C_K$. Where, C_{Ra}, C_{Th} and C_K were the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K.The values are shown in the Table1.The estimated dose rates varied in the range 50.6 to 117.1 nGyh^{-1}. The small variation in the measured and estimated dose values may be attributed to the fact that the measured absorbed dose rates may not have come wholly from the sampled soil.

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They could have originated from other matrices also like soils, rocks, etc., on the surface of the sampling site. And also, in the theoretical calculation of absorbed dose rates, other nuclides such as ^{137}Cs, ^{235}U, ^{231}Th, ^{211}Bi and ^{22}Na were neglected owing to the fact that their contribution is very little to the total dose rates from environmental background. The highest dose rate was observed in and around Chitradurga fort and the lowest dose rate was observed in Bagenal. The geological map of Chitradurga is shown in figure2.

The distribution of ^{226}Ra, ^{232}Th and ^{40}K in the soil samples of Chitradurga is shown in figure1.One part of the Chitradurga fort is composed of granodiorites and the granites and the other part is purely of amphibolitic rocks. Amphibolitic rocks mainly contain amphiboles and plagioclase with little or no quartz. Soil samples were collected from only granitic part of the fort and soil sampling was conducted during summer. Hence considerable amount of radioactivity was observed (Concentration of ^{226}Ra, 46.1Bqkg^{-1}, Concentration of ^{232}Th, 110.9Bqkg^{-1} and Concentration of ^{40}K, 691.3Bqkg^{-1}) in the soil samples of Chitradurga fort.

A parabolic shaped granitic bed is overlapping the amphibolitic bed in the central part of the Chitradurga taluk between GR Halli and Stadium. This probably is the reason for observing a high concentration of radioactivity in the Stadium (concentration of ^{226}Ra, 32.8Bqkg^{-1} concentration of ^{232}Th, 94.5Bqkg^{-1}, concentration of ^{40}K, 552.1Bqkg^{-1}). Along with granodioritic to tonalitic gneisses, migmatites are also present in Seebara, which is located in the south west of Chitradurga. The presence of migmatites along with gneiss may be the reason for obtaining a good concentration of radionuclides in the soil of Seebara.

Study location Kunabhevu has displayed a lesser tendancy towards binding ^{226}Ra (concentration, 17.2Bqkg^{-1}) and ^{232}Th (concentration 36.1Bqkg^{-1}) radionuclides in their soil matrix. However, concentration of ^{40}K (concentration, 499.4Bqkg^{-1}) at this place is comparatively high. Greywackes (sand stones) and argillites (silt stones) are present largely at these places. Argillites have more potash than soda. Argillite rocks have slightly more alumina and slightly less silica. Greywackes are silicious, with more soda. Since abundance of potassium to some extent is due to silica content of the rocks. This may be the reason for observing a little high concentration of ^{40}K in the soil of Khunabhevu. ^{226}Ra concentration was observed low at Khunabhevu(17.2Bqkg^{-1}) and high at Chitradurga town(46.2Bqkg^{-1}). ^{232}Th concentration was observed low at Bagenal(34.3Bqkg^{-1}) and high at Fort(110.9Bqkg^{-1}).

^{40}K concentration was observed low at Murghamutt(386.2Bqkg^{-1}) and high at Adumalleshwara(792.8Bqkg^{-1}).

The radium equivalent activity in soil samples was calculated using the relation $Ra_{eq} = (C_{Th}\times1.43) + C_{Ra} + (C_K\times0.077)$. The results of these calculations are presented in Table1.

The external and internal hazard indices for the samples were calculated using the relations $H_{ex} = C_{Ra}/370 + C_{Th}/259 + C_K/4810 \leq 1$ and $H_{in} = C_{Ra}/185 + C_{Th}/259 + C_K/4810 \leq 1$ respectively and the results are presented in columns 8 and 9 of Table1.

The annual effective dose (AED) was calculated from the activity concentration of the radionuclides in soil using the conversion coefficient of 0.7SvGy^{-1} and an outdoor occupancy factor of 0.2 (UNSCEAR, 2000) as,

AED = D (nGyh^{-1})X24hours X365days X 0.2 X 0.7(SvGy^{-1})X10^{-3}

The values for AED obtained in the present study are shown in col.10.The annual effective dose (AED) was found to be in the range of 62 to 143.6μSvy^{-1}.

TABLE I
CONCENTRATION OF PRIMORDIAL RADIONUCLIDES IN SOIL SAMPLES

Locations	Radioactivity concentration (Bqkg^{-1})			Dose Rate (nGyh^{-1})	Hex ≤1	Hin ≤1	Iγr	AMD μSvy^{-1}
	^{226}Ra	^{232}Th	^{40}K					
Chitradurga town	46.2	83.2	680.2	100.0	0.6	0.7	1.6	122.6
S.J.M College	26.6	42.1	562.1	61.2	0.4	0.4	1.0	75.0
JMIT	31.2	46.3	698.2	71.5	0.4	0.5	1.1	87.7
Govt Hospital	39.2	52.8	582.1	74.3	0.4	0.5	1.2	91.1
District Library	34.1	54.7	499.2	69.6	0.4	0.5	1.1	85.4
Murughamatt	35.2	46.3	386.2	60.3	0.4	0.5	1.0	74.0
Fort	46.1	110.9	691.3	117.1	0.7	0.8	1.9	143.6
Seebara	32.6	89.4	578.2	93.2	0.6	0.6	1.5	114.3
Science College	36.7	77.6	649.4	90.9	0.5	0.6	1.5	111.5
Stadium	32.8	94.5	552.1	95.3	0.6	0.7	1.5	116.8
Adumalleshwara	34.2	98.7	792.8	108.5	0.6	0.7	1.7	133.0
Chandravalli	21.6	93.1	791.4	99.2	0.6	0.6	1.6	121.7
Gonur	42.6	52.6	688.4	80.2	0.5	0.6	1.3	98.3
Bagenal	19.4	34.3	571.2	53.5	0.3	0.4	0.9	65.6
Kunabhevu	17.2	36.1	499.4	50.6	0.3	0.3	0.8	62.0

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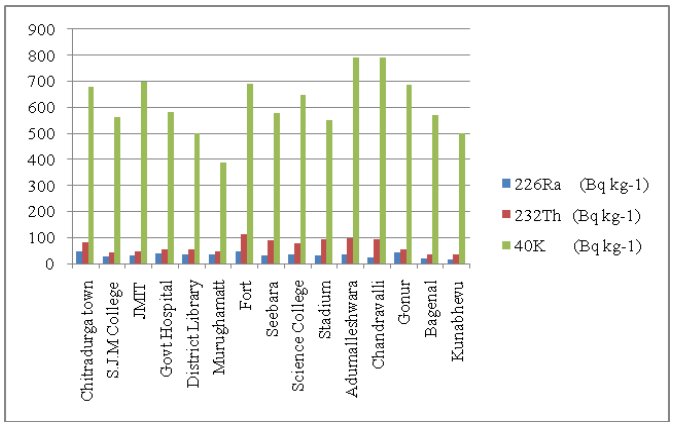

Figure 1 Distribution of radionuclides in soil samples

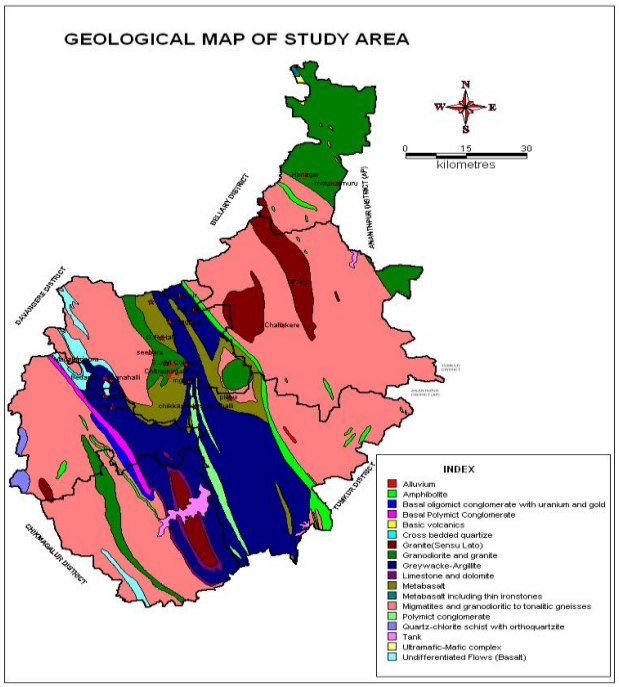

Figure 2 Geological Map of Chitradurga

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