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NATURAL RADIOACTIVITY IN THE SOIL SAMPLES OF YADGIR, KARNATAKA USING GAMMA SPECTROMETRY

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ABSTRACT
Radionuclides activity of the selected radionuclides ^{40}K, ^{238}U and ^{232}Th were measured in surface soil samples collected from 20 villages of Yadgir and Gurmitakal sampling stations of Yadgir district of Karnataka. Standard procedures were adopted for the soil sample collection. A 4" x 4" NaI (Tl) detector based gamma spectrometer used for the estimation of radionuclides. The least squares fitting method was adopted for the estimation of the activity of soil samples. Among the soil samples Yadgir sampling station soils shows higher activity values than the Gurmitakal sampling station. Radiological indices were estimated for the health hazards of all soil samples.

Keywords: Natural radioactivity, Gamma Spectrometry, NaI (Tl) detector, Activity, Dose rate.

INTRODUCTION:

Our Planet is continuously exposed to ionizing radiation of both terrestrial and extraterrestrial origins. The terrestrial natural radioactivity is composed of the radiations emitted by primordial and anthropogenic radionuclides. The soil is a complex mixture of different compounds and rocks in the natural environment. The earth's crust is the principal source of natural radionuclides in soils and rocks. [1] Thus man is exposed to these radiations in varying degrees depending upon the location and his activities. Gamma radiations from ^{238}U, ^{232}Th and ^{40}K represent the main external source of the irradiation to the human body. These radionuclides reach the human body through the food chain and accumulate in the critical organs and cause radiation damage in the respective organs [2]. We inhale and ingest radionuclides every day in our lives through air and food. The inhalation and ingestion of these radionuclides above the permissible limits become a health hazard. Therefore concern of monitoring of these radionuclides in the environment is increasing worldwide at all level, due to their harmful effect. Uranium is the parent source of radium and radon. It is essential to generate base line radiological data of the region before any mining operation to assess the environmental impact and it is necessary to monitor release of radioactivity into the environment in order to be able to provide an appropriate protection of humans.

Due to the importance of Yadgir taluka from radioactive exposure point of view the present study focuses on determining the uranium, thorium and potassium activity in the environmental samples of Yadgir taluka. ^{238}U, ^{232}Th and ^{40}K activity was determined in soil samples collected from different locations of Yadgir taluka, using 4"X4" NaI(Tl) scintillation detector based gamma spectroscopy. The present work provides the background radiation levels of the study area due to natural radionuclides.

Materials and methods

Sample collection and preparation

A total of twenty soil samples are soils collected from Yadgir and Gurmitakal. ASTM standard procedure was followed for soil sample collection and preparation where surface soil over an area 50 cm * 50 cm and 5 cm depth was mixed thoroughly and about 2-3 kg of each sample was collected. After collection pebbles, dried leaves, roots and other mixed materials were removed from the soil samples. The samples were placed in a hot air oven for drying at 110˚C for 24 h to ensure that the moisture is completely removed. All

samples were pulverized to get fine powder and sieved through a 200-mesh sieve to separate the unevenly crushed soil particles. Each pulverized sieved sample was then transferred to a 250 mL cylindrical plastic (PVC) container. The containers were filled fully, sealed with an adhesive, coded, weighed and then stored for a period of four to five weeks to attain secular equilibrium between radon (^{222}Rn) and thoron (^{220}Rn) and its daughter products before subjecting to gamma spectrometric analysis.

Gamma Spectrometric Analysis

Efficiency calibration of the detector system was performed using IAEA standards. Standards are packed and sealed in a 250 ml (7.5 cm * 7.5 cm) cylindrical container, the same geometry as that for soil samples. The standards were counted sufficiently long for good statistics. Photo peak areas of the most prominent and well separated photo peaks were calculated. For the efficiency calibration, prominent gamma energies from ^{60}Co and ^{137}Cs were used.

Results and discussion

Activity measurement

Each sample was measured for a counting period of 60,000 seconds (16.66 h) to reduce the counting errors. Assuming the daughter products of ^{226}Ra and ^{232}Th were in equilibrium the activity concentration of the radionuclides were estimated. Background radiation was measured and subtracted to get the net count rate for each sample. The activity concentrations were calculated from the intensity of each gamma line, taking into account the mass of the sample, the time of counting and the efficiency of the detector.

Radium Equivalent Activity

To represent the activity levels of ^{238}U, ^{232}Th and ^{40}K by a single quantity, a common radiological index called radium equivalent activity has been introduced. It can be calculated by the relation [3]

$$Ra_{eq} = C_{Ra} + {}^{A}C_{Th} + {}^{B}C_{K}$$

Where C_{Ra}, C_{Th} and C_K are activity of ^{238}U ,^{232}Th and ^{40}K and A = 1.43, B= 0.077 are constants.

Radiation dose parameters

In order to estimate the absorbed gamma dose rate and other dose related parameters the radionuclide concentrations in air were used for all the samples. The external terrestrial gamma absorbed dose rates due to terrestrial gamma rays at 1 m above the earth's surface were calculated from the concentrations of ^{232}Th, ^{226}Ra and ^{40}K and the conversion factors of 0.604, 0.462 and 0.0417 respectively were used as given by UNSCEAR (2000) report

$$D = (0.604C_{Th} + 0.462C_{Ra} + 0.0417C_K)nGyh^{-1}$$

where C_{Th}, C_{Ra} and C_K are the average activity concentration of ^{232}Th, ^{226}Ra and ^{40}K respectively.

The annual average effective dose received by a member was calculated using the conversion factor of 0.7 SvGy^{-1} used to convert absorbed dose rate to human effective dose equivalent with an indoor occupancy of 80 % as given by [4].

$$Annual\ effective\ \ dose\ (mSvy^{-1}) = D\ (nGy\ h^{-1}) \times 8760\ (hy^{-1}) \times 0.7\ (SvGy^{-1}) x 0.2$$

The external (H_{ex}) and internal (H_{in}) hazard indices were also estimated by the equation derived by [3].

$$H_{ex} = \frac{C_{Ra}}{370} + \frac{C_{Th}}{259} + \frac{C_K}{4810}$$

$$H_{in} = \frac{C_{Ra}}{185} + \frac{C_{Th}}{259} + \frac{C_K}{4810}$$

The value of the hazard indices should 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 radium equivalent activity Ra_{eq} (370 Bq/kg).

Another radiation hazard index called the gamma activity concentration index I_γ (Bq/kg) is calculated given by [5]

$$I_\gamma = \frac{C_{Ra}}{300} + \frac{C_{Th}}{200} + \frac{C_K}{3000}$$

Table: 1 Activity of the soil samples of Yadgir and Gurmitakal.

SL No	Sample Code	Activity (Bq/kg)		
		^{238}U	^{232}Th	^{40}K
01	SL010901	20.6 ± 0.9	31.5 ± 0.6	1768±11
02	SL010902	64.4 ± 2.8	95.29±1.9	1061±28
03	SL010903	51.0 ± 1.9	73.0 ± 1.2	1229±20
04	SL010904	35.7 ± 1.2	64.4 ± 0.9	1138±15
05	SL010905	44.8 ± 1.4	54.1 ± 0.9	1062±15
06	SL010906	73.6 ±3.0	89.9± 2.0	966± 28
07	SL010907	96.4 ± 2.4	49.8 ± 0.9	318 ±13
08	SL010908	25.4 ± 0.8	23.1 ± 0.6	285 ± 08
09	SL010909	59.7 ± 1.5	71.4 ± 1.0	946 ± 16
10	SL010910	21.9 ± 1.0	35.6 ± 0.8	337 ± 11
11	SL010911	41.7 ± 1.2	56.9 ±1.1	831 ± 14
12	SL010912	13.2 ± 0.5	15.3 ± 0.4	168 ± 05
13	SL010913	28.9 ± 0.5	40.0 ± 1.2	122 ± 06
14	SL010914	10.5 ± 0.4	20.3 ± 0.3	242 ± 05
15	SL010915	23.2 ± 1.0	31.4 ± 0.9	149 ± 20
16	SL010916	25.3 ± 0.7	28.5 ± 0.5	133 ± 10
17	SL010917	47.8 ± 1.8	59.7 ± 1.5	839 ± 28
18	SL010918	13.6 ± 0.9	26.3 ± 0.8	409 ± 13
19	SL010919	18.3 ± 0.7	21.3 ± 0.6	99 ± 08
20	SL010920	53.9 ± 1.0	47.0 ± 0.8	194 ± 12

Table: 2 Radiological parameters of the Yadgir and Gurmitakal soil samples.

SL No	Sample Code	Ra_{eq}	Absorbed dose ($nGyh^{-1}$)	AED outdoor ($mSvy^{-1}$)	H_{ex}	H_{in}	I_γ
01	SL010901	201.8	102.3	0.125	0.54	0.60	0.82
02	SL010902	224.1	131.5	0.161	0.76	0.94	0.97
03	SL010903	279.6	118.6	0.145	0.66	0.80	0.94
04	SL010904	215.4	102.9	0.126	0.58	0.68	0.82
05	SL010905	203.9	97.66	0.120	0.55	0.67	0.77
06	Sl010906	219.1	127.9	0.157	0.700	0.97	0.90
07	SL010907	192.1	87.88	0.108	0.52	0.78	0.68
08	SL010908	80.39	37.58	0.046	0.22	0.29	0.30
09	SL010909	234.6	110.1	0.135	0.63	0.80	0.87
10	SL010910	98.76	45.67	0.056	0.27	0.33	0.36
11	SL010911	187.0	88.27	0.108	0.51	0.62	0.70
12	SL010912	48.02	22.35	0.027	0.13	0.17	0.18
13	SL010913	95.46	42.58	0.052	0.26	0.34	0.34
14	SL010914	57.98	27.12	0.033	0.16	0.19	0.22
15	SL010915	79.54	35.88	0.044	0.22	0.28	0.28
16	SL010916	76.27	34.43	0.042	0.21	0.27	0.27
17	SL010917	197.8	93.12	0.114	0.53	0.66	0.74
18	SL010918	82.68	39.21	0.048	0.22	0.26	0.31
19	SL010919	56.37	25.44	0.031	0.15	0.20	0.20
20	SL010920	136.0	61.36	0.075	0.37	0.51	0.48

Conclusion

The obtained results of the activity concentration of the radionuclides in the soil samples are presented in the table 1. Few soil samples of Yadgir region showed a higher activity of the radionuclides as it is known that soil samples are collected from the agricultural land and the part of the area is covered with granites stones, granites are igneous rocks. And the earlier studies have shown that the activity is higher in igneous rocks as compared to sedimentary rocks [6]. The granite samples exhibit an enhanced activity of radium and thorium compared to the very low abundance of these elements observed in the mantle and the crust of the Earth. According to geologists this behavior is due to the geochemical and geological formation of the granites. Where, in the course of partial melting and fractional crystallization of magma, which enables uranium and thorium to be concentrated in the liquid phase and become incorporated into the more silica-rich products [7]. For that reason, igneous rocks of granitic composition are strongly enriched in uranium or radium and thorium compared to the other environmental materials [8-10]. The mean activity concentration of radionuclides for soil samples was measured as 45, 50.7 and 657 Bq/kg for ^{238}U,^{232}Th and ^{40}K respectively. Also the present data showed that the ^{40}K concentration in samples is higher than in the other materials whereas the ^{226}Ra and ^{232}Th concentrations are in the similar trend and all the radiological parameters are comes within the acceptable limit except few samples.

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