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The Study Analyzed Soil Samples from the Bellary District of Karnataka, India, and Revealed Activity Concentrations of ^{238}U, ^{232}Th, and ^{40}K

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Abstract
Research has been conducted to examine the depth profile distribution of natural occurring radioactive elements, including ^{40}K, ^{232}Th, and ^{238}U, in the soil of the Bellary District of Karnataka, India. Gamma-ray spectrometry techniques were employed to evaluate samples from five talukas in the Bellary districts employing 4″x4″ NaI (TI) Scintillation detectors. According to depth profiles and the distribution of naturally found radionuclides, the soil samples exhibit an amount of ^{238}U at 91.81 Bq/kg, with the greatest concentration at 189.74 Bq/kg. But the concentration of ^{232}Th also varies, ranging from 106.51 to 303.55 Bq/kg. Between 604.88 and 1080.29 Bq/kg, the range corresponds to a ^{40}K activity concentration. In these areas, there has been no evident correlation between the quantities of ^{238}U and ^{232}Th in a soil surrounding the residences. $^{40}K/^{232}Th$ and $^{40}K/^{238}U$ proportion forecasts were also made using surface-level samples, which could not have included identical ratios as the ones being examined.

Keywords: *Activity concentration; Depth–profile; NaI (TI) gamma-ray spectrometry; Radionuclide's; Soil.*

1. Introduction
The Earth's composition is a result of a series of nuclear processes, starting with the Big Bang and continuing through flaming star cores and supernovas. Most radioactive nuclides have decayed, but some still exist today with half-lives greater than or equivalent to the Earth's ages (Baeza et al., 1992; Edling et al., 1984).These radioisotopes contribute significantly to the radiation background we are bombarded by throughout our lives and make up the majority of naturally occurring ambient radioactivity (Kumar et al., 1990). Some radioisotopes, such as K-40, decay into other active isotopes, such as uranium-238 and uranium-235. The half-life (t1/2) describes the time required for fifty percent of the radioactive components in a sample to decay (Londhe & Rao, 1988; Mollah et al., 1986). All naturally occurring radioisotopes, except radon (Rn), are harmless to life due to their chemical bond to rocks' minerals. The quantity of radioactive substances in soil is influenced by geology and human activity (Al-Khawlany et al., 2018; Nagaraju et al., 2012). Natural radiation includes both cosmic radiation and radioactivity from natural radionuclide decay. Primordial radionuclide half-lives are comparable to the Earth's age (Sevc et al., 1976). Cosmic radionuclides are created when stable nuclides are continuously blasted by cosmic rays, primarily in the atmosphere (Steinhäusler & Lettner, 1992). In most parts of the world, natural radiation from outside influences increases by a value of four, but in other locations, the variation is mainly due to abnormally high or low levels of radioactive elements in the soil (Stranden & Strand, 1988). Humans are subjected to natural rays from external sources, including cosmic rays and radionuclides found in the Earth, in addition to their internal radiation from (Gür et al., 2001;

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Kerur et al., 2010; Nagaraju et al., 2013). The region receives an average of 639 mm of rain annually.

1.1 Geography of The Research Area

Vijayanagara District was separated from Ballari District in 2021, and Anantapur District was established in 1882. The region, known for its iron ore reserves, rich natural resources, historical sites, and agriculture, is also known as Metal City and the work of Gani Nadu. The district is situated at latitudes 15° 30' and 15° 50' north and longitudes 75° 40' and 77° 11' east. The district covers 8447 square kilometers and is bounded by Rajur District to the north, Koppal District to the west, Chitradurga Town to the south, and Anantapur District and Kurnool District to the east. The region receives an average of 639 mm of rain annually.

2. Methods

2.1 Experimental Set-Up

A crucial tool in gamma-ray spectroscopy is a 4″ x 4″ NaI (TI) Scintillating Detector, which combines a sodium ion with a thorium-doped scintillation device. A lead barrier protects it from air radiation, and the crystal's size determines how sensitive and capable it is of detection. Gamma radiation gets amplified by a preamplifier and then passes through the crystal to produce an electron pulse. The spectrum is evaluated using software PC-based a thousand (Scinti. SPEC). The detector operates at 720 V dc, with a fine resolution of 1.6, and collects the spectrum in 10,000 seconds. This study aims to investigate ambient radioactivity by comprehending the principles of gamma spectrometry and the operation of NaI (TI) scintillation detectors.

2.2 Measurement of Natural Radioactivity

This study looks at the properties of soil samples from five talukas in the Bellary districts in a lab environment. At each monitoring site, ten samples were collected at depths ranging from 20 to 200 feet; no sample size was chosen at the district or taluk boundaries. From every taluka, samples weighing two to three kg were gathered. After being filtered through a 200-mesh screen, the materials were crushed, sieved, and put in an Araldite-covered plastic container. The radon, radium, and their offspring attained a secular equilibrium at room temperature for a few weeks. The exact locations of geological features were marked using GPS, whereas gamma spectrometry was employed for examination. Table 1 shows Sampling Locations

Table 1 Sampling Locations

Sl No	Sampling Point	North (N)	East (E)	Sample Codes
01	Bellary	15.139393, ° N	76.921440 ° E	SL050101- SL050110
02	Siruguppa	15.625062, ° N	76.895218 ° E	SL050201- SL050210
03	Sandur	15.056000, ° N	76.326000 ° E	SL050301- SL050310
04	Kurugodu	15.138548, ° N	76.918724 ° E	SL050401- SL050410
05	Kampli	14.625850, ° N	74.881060 ° E	SL050501- SL050510

3. Results and Discussion

3.1 Results

The study used high-resolution gamma-ray spectrometry to find naturally occurring radioactive substances in soil samples from Bellary regions. Table (1) lists the sampling locations. Siruguppa,

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Mustagatti, Chikkajantakal, and New Raghava Kala Mandir Bellary soil samples were used to measure the total activity levels for ^{40}K, ^{238}U, and ^{232}Th. The activity concentrations for ^{238}U, ^{232}Th, and ^{40}K were 91.81±0.62 Bq/kg, 106.51±0.36 Bq/kg, and 860.22±5.28 Bq/kg, respectively, compared to other Bellary sites (Table 2). For ^{238}U, ^{232}Th, and ^{40}K, the corresponding values in the Chikkajantakal sample were 123.80±0.65 Bq/Kg, 143.27±0.45 Bq/Kg, and 604.88±6.26 Bq/Kg, respectively. For soil samples plot a graph of Depth Vs Activity concentration obtained is shown in Figure (1). Table 2 shows The Study Reveals That the Soils in Bellary District Have Natural Radioactivity Levels Of 40K, 232Th, And 238U.

Table 2 The Study Reveals That the Soils in Bellary District Have Natural Radioactivity Levels Of ^{40}K, ^{232}Th, And ^{238}U.

Sl No	Location	Sample Codes	Depth from Ground Level in (Feet)	Activity Concentration in (Bq/kg)		
				^{238}U	^{232}Th	^{40}K
01	Bellary	SL050101-10	20-200	186.36±0.89	260.56±0.57	1080.29±8.02
02	Siruguppa	SL050201-10	20-200	189.74±0.64	249.56±0.42	1094.04±7.85
03	Sandur	SL050301-10	20-200	214.07±0.67	303.55±0.42	1086.93±7.70
04	Kurugodu	SL050401-10	20-200	91.81±0.62	106.51±0.36	860.22±5.28
05	Kampli	SL050501-10	20-200	123.80±0.65	143.27±0.45	604.88±6.26

3.2 Discussion

In the Bellary district the results demonstrated a good linear link among the ^{238}U and ^{232}Th activity, suggesting that the samples are geochemically coherent. Perhaps as a result of the presence of rocks like granite foundation, mudstone, sandstone, and orthoquartzite, the soil samples collected from Sandur taluk from Adarsh School in local Bellary regions proved to be more active than those from other talukas of Bellary districts. An uneven distribution of these naturally produced radionuclides was indicated by the study's finding that the soil's activity concentration varied considerably within a narrow area. Compared to other Kalyana Karnataka areas, the Bellary district showed higher quantities of ^{238}U, ^{232}Th, and ^{40}K.

3.3 Correlation Studies

As shown in Fig. (2), the graphs of ^{238}U and ^{232}Th for a soil specimen of the five talukas of Bellary districts are plotted to determine whether radionuclides coexist in a particular location. This plotting shows fluctuations in Uranium activity with varying depths of Thorium activity with soil samples of the Bellary district talukas. This is how ^{232}Th and ^{238}U correlation investigations are carried out. The correlation pattern in the graph indicates that the ^{232}Th and ^{238}U activity levels are unrelated. It suggests that water may draw uranium out of the soil. Figure 1 shows The Study Investigates the Activity Concentration of 40K, 232Th, and 238U In the Soil of Bellary Districts Figure 2 shows The Soils of Bellary District Have A Correlation Between

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Activity Concentrations of the 232Th And238u. This study aims to investigate ambient radioactivity by comprehending principles.

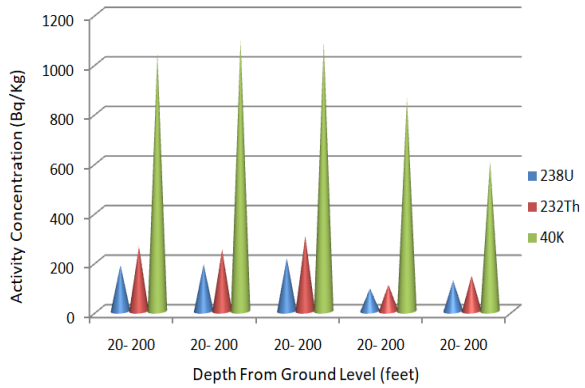

Figure 1 The Study Investigates the Activity Concentration of ^{40}K, ^{232}Th, And ^{238}U In the Soil of Bellary Districts

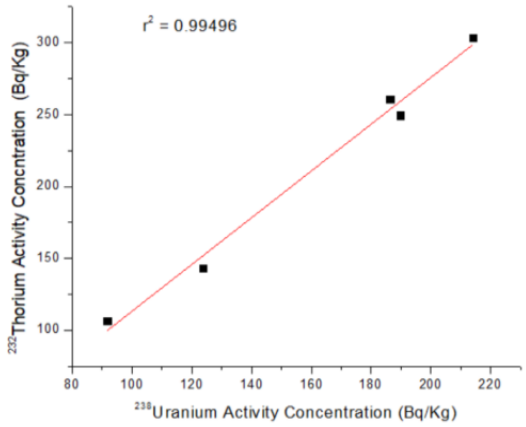

Figure 2 The Soils of Bellary District Have A Correlation Between Activity Concentrations of the ^{232}Th And^{238}u

Conclusion

The study investigates natural radioactivity and gamma radiation levels in Karnataka's Bellary district to raise public awareness about health risks associated with soil radioactivity. The research measured the activity of radionuclides ^{238}U, ^{232}Th, and ^{40}K in soil samples from Bisilahalli village and Cowl Bazar outskirts using a NaI(TI) scintillation detector. The study found increased ^{40}K activity, mainly for fertilizer intake, and a high value of ^{232}Th due to uranium mineralization and active faults. After water washing, samples showed a minimum of ^{238}U activity. The low activity concentrations and allowable limits of natural radioactivity do not pose a serious threat to the public.

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Conflict of Interest

The author clarifies that there is no conflict of interest in the publication of this paper.

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