



Estimation of radiation dose due to uranium in water to the public in Chamarajanagar district, Karnataka State, India

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Abstract: Uranium is the fundamental energy mineral of the nuclear power programme. It is a radioactive element, which delivers some quantity of radiation dose to the public. Uranium dissolves in oxygen-rich water that accounts for its presence in surface and ground water. Among its three isotopes of uranium, ^{238}U is of more abundance in nature. Uranium and its progenies are expected to be in various matrices such as water, food, air, soil and rocks. Higher concentrations of uranium in water and food may leads to health risk in human beings. Estimation of uranium in water is essential, in order to assess the health risk from uranium in water. Therefore, activity concentrations of uranium in water samples in some locations of Chamarajanagar district, in Karnataka state of India were made, using the method of fluorimetry. This paper presents the variation in concentration of uranium, in water samples, from different locations of Chamaraja Nagar district, of Karnataka state, India. The concentration of uranium in water samples varies from, $0.75\text{--}115.66\text{mBqL}^{-1}$, with a median of 13.67mBqL^{-1} . The annual ingestion dose due to ^{238}U , is $0.05\text{--}7.598\mu\text{Sv}^{-1}$, with a median of $0.9\mu\text{Sv}^{-1}$.

Keywords: Uranium; Water; Fluorimeter; Chamaraja Nagar.

I. Introduction

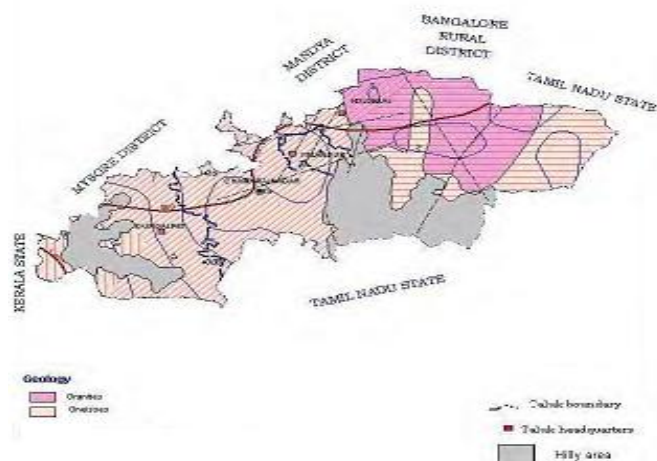
Exposure of man to natural radionuclides occurs through water, food and inhalation of air. The quantity of radiation dose received from natural sources varies from location to location, depending on the radioactivity content in air, water, rock, soil, and building materials [1]. According to the United Nations Scientific Committee on the Effect of Atomic Radiation, exposure to natural sources contributes more than 98% of the radiation dose to the general public[2,3]. The world average of human exposure from natural sources is 2.4mSv.y^{-1} . Uranium (^{238}U) is a naturally occurring heavy element, with an half life of 4.5×10^9 years, and is interest of study, due to its high abundance in nature. It occurs in minerals, monazite sands, lignite, phosphate rocks and fertilizers. It under goes a series of decay until it reaches the final stable product lead (^{206}Pb). Uranium enters into the human body through drinking (ingestion) of water. Estimation of uranium concentration in water serves in two important purposes; hydrogeochemical prospecting of uranium and an assessment of health risk from uranium [4-6].

Some experimental evidences have shown that foodstuffs contributes nearly 15% of ingested uranium, and drinking water contributes about 85% [7,8]. The experimental evidence suggests that exposures to uranium may affect the respiratory and reproductive systems [9]. The main target of toxicity of uranium is kidney and lungs. Long term ingestion of uranium may results in an increase in the risk of kidney damage, cancer, and cardiovascular diseases [2,10]. An exposure of about 0.1mgkg^{-1} of body weight soluble natural uranium, in water causes transient damage to kidney [11]. United States Environmental Protection Agency, has recommended the maximum contamination level of uranium as zero tolerance only the safest limit [12,13]. World health organization recommended a reference level of $15\mu\text{g}^{-1}$ [9]. As per US EPA the recommended safe level of uranium in water is $30\mu\text{g}^{-1}$ [13]. In the present study, an effort is made to study the activity concentration of uranium, in water samples at some locations in Chamaraja Nagar district, of Karnataka State, India.

II. Geology of the Study Area

The district is located in the southern tip of Karnataka state and lies between North latitude $11^{\circ} 40' 58''$ and $12^{\circ} 6' 32''$ and East longitude $76^{\circ} 24' 14''$ and $77^{\circ} 64' 55''$ It has an average elevation of 662m. Topography is undulating and mountainous with north south trending hill ranges of Eastern Ghats. Salem and Coimbatore districts of Tamilnadu in the East, Mandya and Bangalore districts in the North parts of Mysore district in the west and Nilgiris district of Tamilnadu in the south, bound the Chamaraja Nagara District. Chamaraja Nagar, Yelanduru, Kollegala, and Gundlupet are the taluks of the district. The district is endowed with rich both metallic and nonmetallic mineral sources. The major water supplies are boreholes for domestic and other purposes.

Figure 1 Geology of Chamaraja Nagar District



III. Title Materials and methods

A. Estimation of uranium in water by the method of fluorometry

About 25 drinking water samples (20 litre at each location) were collected in plastic cans, from borewells, from different locations of the study area. The samples are then labeled, denoting the details of time, place and date of sampling. The concentration level of uranium, were determined by the method of fluorometry. The amount of uranium present in the water sample is estimated by using the equations 1 and 2, respectively.

$$\text{Sample Counts} = \frac{(\text{Sample} + \text{Background}) - (\text{Background})}{(\text{Counts for } 6 \text{ ppb } ^{238}\text{U standard}) - (\text{Background})} \times 6 \dots\dots\dots 1$$

$$\text{Uranium concentration in the sample} = \frac{\text{Sample Counts} \times 3}{\text{Volume of sample taken for analysis}} \mu\text{g/l} \dots\dots\dots 2$$

B. Dose due to ^{238}U in water:

Radiation dose due to intake of uranium through the drinking water pathway for different age groups was calculated using the ICRP (International Commission on Radiological Protection) dose coefficients and prescribed water intake rates for different age groups[14]. The water intake rates taken (in Ld^{-1}) for, infants of 0-6, and 7-12 months old are 0.7 and 0.8 respectively. For the children of age groups 1-3, and 4-8 years, 1.3 and 1.7 respectively. For 9-13 years, male children 2.4 and 2.1 for female children. For teenagers (age group 14-18 years), 3.3 for male teens and 2.3 for female teens and above 18 years (adults) it is taken as 3.7 (for male) and 2.7 (for females), is taken. ICRP-1996 is used. The annual radiation ingestion dose due to uranium intake through the drinking water pathway was calculated by using the equation 3.

$$\text{A.D.}(\mu\text{Sv/y}) = \text{MMCU}(\text{Bq/l}) \times \text{IW}(\text{l/y}) \times \text{DCF}(\mu\text{Sv/Bq}) \dots\dots\dots 3$$

Where, AD is annual dose due to uranium ($\mu\text{Sv.y}^{-1}$), MMCU is measured mass concentration of uranium in water (Bq.l^{-1}), IW is Intake of water (ly^{-1}), DCF is dose conversion factor ($\mu\text{Sv.Bq}^{-1}$).

IV. Results and Discussion

Estimation of uranium concentration in water samples were made by the method of fluorometry, using LED Fluorimeter. The concentration of uranium in water samples and corresponding annual ingestion dose due to uranium in water were calculated and shown in Table.I. The concentration of uranium in water samples of the study area varies from, $0.75\text{-}115.66 \text{mBqL}^{-1}$, with a median of 13.67mBqL^{-1} . The annual ingestion dose due to ^{238}U , is $0.05\text{-}7.598 \mu\text{Svy}^{-1}$, with a median of $0.9 \mu\text{Svy}^{-1}$.

Various health and environmental protection agencies have recommended some limit for uranium in drinking water for human being. World health organization has recommended $15 \mu\text{gl}^{-1}$ in water is the safest limit [9]. United States Environmental Protection Agency suggests maximum contamination level of uranium in water as $30 \mu\text{gl}^{-1}$ [11,13]. Further UNSCEAR and ICRP have recommended the safe limits of uranium in drinking water as $9 \mu\text{gl}^{-1}$ and $1.9 \mu\text{gl}^{-1}$ respectively[2,15].

The activity concentration of uranium in some locations of the study area such as Malai Mahadeshwara (MM) Hill, Uthamballi, Kunthuru, and Alur villages are found to be higher than the recommended value of $1.9 \mu\text{gl}^{-1}$ as per ICRP, 1979. Since uranium is a natural lithophilic element and it is present in all natural waters. The activity

concentration of uranium depends on lithology, geomorphology, and other geological conditions of the study area [16].

Table I Concentration of uranium and dose due to uranium in water samples at different locations in Chamarajanagar district.

Sl.No.	Location	^{238}U Conc. ($\mu\text{g l}^{-1}$)	^{238}U Conc. (mBq l^{-1})	Annual Ingestion dose due to ^{238}U ($\mu\text{Sv y}^{-1}$)
1	MM Hills	4.626	115.66	7.598
2	Kowdalli	1.439	35.98	2.363
3	Uthamballi	4.410	110.25	7.243
4	Hanuru	0.547	13.67	0.898
5	Kunthuru	3.820	95.5	6.274
6	Mangala.K.T	0.770	19.25	1.264
7	Madhuvinahalli	0.380	9.50	0.624
8	Doddinduvadi	0.330	8.25	0.542
9	Kollegala town	0.081	2.02	0.132
10	Aluru	3.344	83.61	5.493
11	Mangala.C.T.	0.340	8.50	0.279
12	Badanaguppe	0.692	17.31	1.137
13	Hebbasuru	0.293	7.32	0.48
14	Panyadahundi	0.0436	1.09	0.071
15	Bendaravadi	0.03	0.75	0.05
	Range	0.03-4.63	0.75-115.66	0.05-7.598
	Average	1.41	35.24	2.476
	Median	0.55	13.67	0.9

Higher concentrations of uranium observed in the water samples, may be due to ground water may contains traces of natural radioactivity related to uranium and thorium in soils and rocks. The higher activity concentrations of uranium in water samples may also due to traces of associated uranium mineralization and the geology of the study area.

The southern and eastern portions of Kollegala taluk consists of lofty hills like MM Hills (which includes 77 hill ranges). Dodda Sampige hill range extended about 6km from north to south, which comprises of pale pink and gray granite. Due to presence of radioactive rich granites in these regions, the activity concentration of uranium in ground water samples of MM Hill, Uthamballi, Kunthuru, may be high. ^{238}U and ^{226}Ra commonly migrated to sites along fracture surface that are close to rock water interfaces. In Alur, village, the concentration of uranium content in soil being high, which may leach in to the water due to this reason higher concentrations of uranium in water were observed.

However only in 27% of the water samples, uranium content is higher than the recommended limit of $1.9\mu\text{g l}^{-1}$ (ICRP, 1979). But in remaining 73% of the water samples, in the study area are found to be well below the recommended limits according to UNSCEAR, WHO, USEPA, [2, 9, 13]. The effective dose due to uranium in water in the study area are well below the reference level of committed effective dose of $100\mu\text{Sv}$, recommended by WHO. Further, from the results the value observed in the study area is very much low compared to worldwide observed values, $0.37\text{--}75.3\mu\text{g l}^{-1}$, in France; $0.04\text{--}12146\mu\text{g l}^{-1}$, in Finland; $0.043\text{--}48.6\mu\text{g l}^{-1}$, in Germany; and $0.008\text{--}56.63\mu\text{g l}^{-1}$, in China.

Comparison of range of the activity concentration of uranium in water in study area with different countries is shown in Table II. Based on the rate of water consumed, the range, average median and standard deviation of annual ingestion dose ($\mu\text{Sv.y}^{-1}$) due to uranium for different age group were calculated and is shown in Table III. Compared to females, the dose rate due to uranium in water is found to be high in males of age group 9-13, 14-18years old, and >18years(adults).

Table II Comparison of concentration of uranium in different countries.

Location No.	Country	Range of Uranium ($\mu\text{g/l}$)	References
1	United States	0.012-3.08	UNSCEAR, 2000
2	France	0.18-37.2	UNSCEAR, 2000
3	Argentina	0.04-11.0	Bomben et.al.,1996
4	Romania	0.02-1.48	UNSCEAR,2000
5	Turkey	0.24-17.65	Kumru, 1995
6	Italy	0.02-5.2	UNSCEAR,2000
7	Germany	0.02-24	UNSCEAR, 2000
8	Central Australia	>20	Hostetler et.al.,1998
9	Finland	0.02-6000	UNSCEAR, 2000
10	Jordan	0.04-1400	Smith et.al.,2000
11	China	0.004-28	UNSCEAR, 2000
12	India(Chamarajanagar)	0.03-4.63	Present Work

Table III Dose due uranium for different age groups.

Stages of Life	Age Group		Dose due to ^{238}U (μSv^{-1})			SD
			Range	Average	Median	
Infants	0-6 Months		0.01-1.33	0.44	0.16	0.49
	7-12Months		0.01-1.52	0.50	0.18	0.56
Children	1-3 Years		0.02-2.47	0.81	0.29	0.91
	4-8 Years		0.02-3.23	1.06	0.38	1.19
	9-13 Years	Males	0.03-4.56	1.49	0.53	1.68
		Females	0.03-3.99	1.31	0.47	1.47
Teens	14-18 Years	Males	0.04-6.27	2.06	0.74	2.31
		Females	0.03-4.37	1.43	0.52	1.61
Adults	>18 Years	Males	0.05-7.03	2.31	0.83	2.59
		Females	0.03-5.13	1.68	0.61	1.89

V. Conclusion

The concentration of uranium in water samples of the study area varies from, 0.75-115.66mBqL⁻¹, with a median of 13.67mBqL⁻¹. The annual ingestion dose due to ^{238}U , is 0.05-7.6 μSv^{-1} , with a median of 0.9 μSv^{-1} . Based on the rate of water consumed, the ingestion dose (μSv^{-1}) due to uranium for different age group was calculated. The dose rate due to uranium in water is found to be high in male children of age group 9-13years old, male teens of age 14-8years old and male adults (>18years) than the female children, female teens and female adults. The effective dose due to uranium in water in the study area are well below the reference level of committed effective dose of 100 μSv^{-1} recommended by WHO.

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