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Assessment of age-dependent Uranium intake due to drinking water in Neendakara, Kollam District Kerala

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Abstract- Exposure due to natural radiation is of particular importance because it accounts for the largest contribution (nearly 85 %) to the total collective dose of the world population. An attempt has been made to present the feasibility of uranium occurrence in drinking water samples collected from the coastal regions of Neendakara, Kollam district ,Kerala using Ultraviolet(UV) fluorimeter. The associated age-dependent radiation dose was estimated by taking the prescribed water intake values of different age groups.

Keywords: LED Fluorimeter, Quantalase

I. INTRODUCTION

About 96% of all unfrozen fresh water is found below the earth's surface and is known as groundwater. Groundwater systems globally provide 25–40% of theworld's drinking water. In India, most of the people living in rural areas depend on groundwater for drinking purpose. Naturally, groundwater consists of major ions, minor ions, trace metals, heavy metals, radionuclides, organic matter, etc. The groundwater quality needs to be monitored periodically so as to check that the water quality parameters do not exceed the limits of drinking water quality standards. Uranium is one of the natural radionuclides present in groundwater in minute quantity. Due to its natural existence, uranium is present in all environmental matrices such as water, soil, sediment, food materials, and biota. On a global basis, its concentration in soil varies from 1 to 5 parts per million while in water, it varies from 1 to 3 parts per billion (ppb).[1]
Uranium is a naturally occurring element in groundwater in some portions of Connecticut. However, there is little information on where uranium may be found. Uranium gets into drinking water when groundwater dissolves minerals that contain uranium. The amount of uranium in well water will vary depending upon its concentration in bedrock. However, even within areas that have bedrock types containing uranium, there is a large degree of variation within relatively small areas. Levels of naturally occurring radiation in water are not likely to be high in shallow wells. The potential exists for deep bedrock wells in Connecticut to haveuranium, although most will be very low. High levels
of uranium indicate the potential for radon and radium also to be present.

Naturally occurring uranium has very low levels of radioactivity. However, the chemical properties of uranium in drinking water are of greater concern than its radioactivity. Most ingested uranium is eliminated from the body. However, a small amount is absorbed and carried through the bloodstream. Studies show that drinking water with elevated levels of uranium can affect the kidneys over time. Bathing and showering with water that contains uranium is not a health concern.
The objective of the present study is to find out the distribution of Uranium in Drinking water and also find out the age dependent dose for the water samples collected from the coastal region of Neendakara ,Kollam district.

II. MATERIALS AND METHODS

a) Sampling

Around 20 groundwater samples were collected inclean, plastic bottles from bore wells and open wells, alongthe coastal region of Neendakara ,Kollam district.Collected samples were filtered through 0.45 μm Whatman filter paper. U content in groundwater sample was measured by light‑emittingdiode (LED)‑based ultraviolet (UV) fluorimeter (Model No. UA2, M/S Quantalase Enterprises

Pvt. Ltd., Indore, Madhya Pradesh, India) which works on the principle of measurement of fluorescence of uranium complexes in the aqueous sample, in which a pulsed LED UV light was used to excite uranyl species at 405 nm. The instrument has a dynamic range from 0.2 to 500 ppb with 5% accuracy.

A standard stock solution of 973 mg/l (Sigma‑Aldrich, Merck Company, India) was diluted to working concentrations for regular calibration and checking the performance of the instrument. Water sample analysis was carried out by standard addition method to avoid matrix effect and any other interference by different ions. Five percent sodium pyrophosphate solution was used as a fluorescence enhancing reagent that forms uranyl phosphate complexes which are more stable in the solution 5 ml water sample and 0.5 ml of 5% sodium pyrophosphate were taken in cleaned cuvette and subjected to fluorescence reading by the instrument.

To get blank counts, a blank sample was prepared using double distilled water with the same amount of fluorescing reagent for measurement of U concentration.

b) LED Fluorimeter

Quantalase has developed Fluorimeter which use banks of pulsed LEDs to excite fluorescence in sample under study. The wavelength, pulse duration and peak power of the LED output can be set to match the excitation requirements of the sample. The fluorescence is detected by a pulsed photomultiplier. Suitable filters after the LEDs and before the photomultiplier tube prevent LED light from reaching the photomultiplier tube directly. The filters can be broadband coloured glass filters or multilayer narrow band filters. The instrument is controlled by a microcontroller which pulses the LEDs and photomultiplier tube. The microcontroller also controls the ADC which convert the fluorescence signal fromphotomultiplier to digital form for further processing. A single board computer averages the photomultiplier output over 2000 pulses and carries out any calculationsnecessary. A touch screen display permits the operator to set necessary parameters and also display the fluorescence measurement.

c) Calibration of Fluorimeter

Standard solution of Uranium is used to calibrate LED Fluorimeter. The instrument was calibrated in the range of 1-100 ppb using a stock solution of standard which was prepared by dissolving 1.78g uranyl acetate dehydrate (CH_3 COO)2 $UO_2.2H_2O$) in 1L of Millipore elix-3 water containing 1ml of HNO_3. The blank sample containing the same amount of fluorescing reagent was also measured for the uranium concentration. 5% phosphoric acid in ultra-pure water was used as fluorescence reagent. All reagents used for experimental work were of analytical grade.

d) Preparation of FLUREN (Buffer Solution)

Weigh 5gms of Sodium Pyrophosphate powder and add it to a flask/plastic bottle. Add 100ml of double distilled water and shake well to dissolve the Sodium Pyrophosphate powder. Add Ortho-phosphoric acid drop by drop while monitoring the pH of solution until a pH of 7 is reached. This is the desired buffer solution, also called FLUREN. Adding buffer solution to a uranium sample increases the fluorescence yield by orders of magnitude. It is recommended that 1 part of buffer solution be added to 10 parts of uranium sample solution and this mixture be used for measurements.

Figure 1 :Photograph of the Quantalase LED Fluorimeter

e) Analytical Procedure

A water sample of quantity 6ml is used to find its uranium content. The water sample is taken in the clean and dry quartz cuvette made up of ultrapure fused silica. The instrument was calibrated with the standard uranium solution of known activity. The water sample of quantity 6 ml is mixed with 10% of the buffer solution. Buffer solution is made from sodium pyrophosphate and orthophosphoric acid of pH 7. Buffer solution is used to have the same fluorescence yield of all the uraniumcomplexes present in the water.

Concentration of uranium in water sample = CF x
(Fluorescence from sample – Fluorescence from water)

All these calculations are done by the instrument itself. The instrument averages the fluorescence for 256 pulses and displays the average value of U concentration in the sample.

f) Theoretical Formulation

Ingestion of the uranium through drinking water results in both radiological risk (carcinogenic) and chemical risk (non-carcinogenic). The methodology used for the assessment of the radiological and chemical risk due to uranium concentrations in the water samples is described below:

g)Age-dependent ingestion dose

The radiation dose due to intake of uranium through the drinking water pathway for different age groups was calculated using IAEA dose conversion factors[2] and the prescribed water intake rates[3,4]were assumed. The annual

radiation ingestion dose due to uranium intake through the drinking water
pathway was calculated using the following formula[3]:
Ingestion dose(Sv/ y)=concentration(Bq /l)Xintake(l /y)X DCF(Sv /Bq)
The water intake rates taken for the infants (0–6 months old) and children (7–12 months old) are (0.7and 0.8) l /d, respectively, whereas the those for the
age groups of 1–3, 4–8 and .18-y-old were 1.3, 1.7 and 3.7 l /d, respectively.

III. Results and discussion

Table 1 summarizes the prevalent natural uranium concentration in ground water samples. The uranium concentration in water samples is found to vary from ≤10.12 to 29.6 ppb with an average of 16.12 ppb. It has been observed that there is no much variation in uranium concentration in different locations indicating that natural uranium is uniformly distributed within in the observed range.
Uranium content in groundwater shows a wide variation in India and throughout the world. Variation in uranium concentration mainly depends on the geology of the area and other meteorological parameters. Sahoo *et al*.[5] has been reported U concentration in the range of 0.1–19.6 ppb in the drinking water samples collected from Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh, Kerala, etc. Rana *et al*.[6] has been reported U concentration in the range of 0.38–79.7 ppb in the ground water samples collected nearby the Tummalapalle uranium mining and processing facility. Atomic Energy Regulatory Board (AERB)[7] recommended 60 ppb as the maximum permissible limit of uranium in drinking water. It is observed that the uranium concentration in all the samples collected around Neendakara site lies
well within the limit recommended by AERB.

Table 1: The concentration of Uranium in the Bore and open wells

Location	**Sample Code**	**Uranium Concentration(($\mu g/l$)**		**Uranium Activity Concentration(Bq/l)**	
		Bore well	Open well	Bore well	Open well
Neendakara	NEE 1	20.2	18.5	0.51	0.46
	NEE 2	25.2	12.2	0.63	0.31
	NEE 3	29.5	10.2	0.74	0.25
	NEE 4	27.5	8.56	0.69	0.21
	NEE 5	25.5	11.2	0.64	0.28
	NEE 6	24.5	13.2	0.62	0.33
	NEE 7	25.8	8.56	0.65	0.21
	NEE 8	29.8	9.88	0.75	0.24
	NEE 9	27.5	12.2	0.69	0.31
	NEE 10	24.5	10.4	0.62	0.26
	NEE 11	25.2	11.2	0.51	0.39

Table 2: Age –dependent uranium intake by drinking water pathway

Life stage group	**Age**	**Annual Ingestion Dose(mSv/yr)**			
		Bore well		Open Well	
		Min	Max	Min	Max
Infants	(0-6)months	0.036	0.053	0.015	0.033
	(7-12)months	0.041	0.061	0.017	0.038
Children	(1-3)y	0.067	0.101	0.028	0.062
	(4-8)y	0.088	0.131	0.044	0.081
Male	(9-13)y	0.125	0.182	0.052	0.114
	(14-18)y	0.171	0.252	0.087	0.157
	Adult	0.192	0.281	0.081	0.176
Female	(9-13)y	0.109	0.161	0.046	0.103
	(14-18)y	0.119	0.176	0.051	0.109
	Adult	0.141	0.207	0.059	0.129
Pregnancy	(14-18)y	0.156	0.231	0.066	0.143
	(19-50)y	0.197	0.289	0.083	0.129

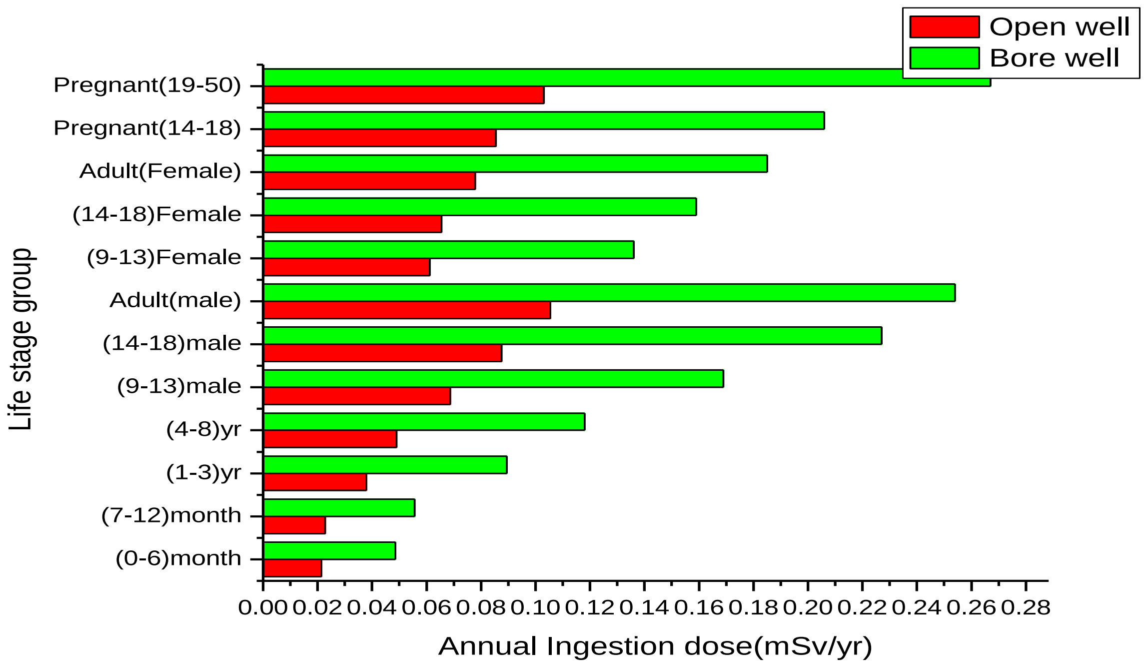

Fig 1: Comparison of mean annual ingestion dose due to uranium with various age groups of males and females

IV. CONCLUSION

The range of Uranium in the water samples varies from (0.21 to 0.75) Bq/l with an average value of 0.59 Bq/l. The measured Uranium content in all the water samples collected from Neendakara has been found to be lower than the recommended limit of 30 $(\mu g/l)$(WHO 2011). The annual effective dose from drinking water samples of these areas is in the range of (0.028 to 0.289)mSv/yr which is safe from the health hazard point of view.The concentration of Uranium increases from open well to bore well . This is due to the presence of Uranium in the bed rock.

V. REFERENCE

[1]World Health Organization. Guidelinesfor Drinking Water Quality, Health Criteria and other SupportingInformation. 3rd ed. Geneva: World Health Organization;2003.

[2]. IAEA, BSS. International basic safety standards for protection against ionizing radiation and for safety of radiation sources. Safety Series No. 115 International Atomic Energy Agency (1996).

[3]Bronzovic, M. and Marovic, G. Age-dependent dose assessment of Ra-226 from bottled water intake.Health Phys. 88(5), 480–485 (2005).

[4] Dietary reference intakes for Water, Food and Nutrition Board. Institute of Medicine.National Academies Press, Available on www.npa.edu.

[5] Sahoo SK, Mohapatra S, Chakrabarty A, Sumesh CG, Jha VN, Tripathi RM, *et al.* Distribution of uranium in drinking water and associated age‑dependent radiation dose in India. Radiat Prot Dosimetry 2009;136:108‑13.

[6] Rana BK, Dhumale MR, Lenka P, Sahoo K, Ravi PM, Tripathi RM. A study of natural uranium content in groundwater around Tummalapalle uranium mining and processing facility, India. J Radioanal Nucl Chem2016;307:1499-506.

[7] AERB Safety Guidelines; Radiological Safety in Uranium Mining and Milling Guidelines No. AERB/FE‑FCF/SG‑2; 2007.

