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# Analysis of Natural Uranium in Groundwater of Jhajjar District of Haryana, India using LED Fluorimeter

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Natural radioactivity has been a part of the environment since the creation of earth. Natural elements like uranium and its by-products can be reason of health problems if they are present in groundwater at excessive amount. Uranium is very harmful because it is very toxic. This study gives the information about the uranium concentration in 40 groundwater samples collected from different water sources like hand pump and tube wells of different depths from numerous locations of Jhajjar district of Haryana, India. Uranium concentration was measured using the LED fluorimetry technique. The observed value of uranium concentration ranged from 5 $\mu gL^{-1}$ to 91 $\mu gL^{-1}$ with mean value of 28.49 $\mu gL^{-1}$. The mean value of uranium concentration is below the safe limit suggested by World Health Organisation (WHO) and Atomic Energy Regulatory Board (AERB), India. The uranium concentration in some region is high because of nearby industries, increasing uses of fertilizer for agriculture and the local subsurface geology of the region. The calculated risk factors for lifelong cancer morbidity and mortality are not significant because they are much lower than the permitted hazard limits. The chemical toxicity of uranium is measured in form of LADD (Lifetime Average Daily Dose) value was ranging from 0.39 to 6.67 $\mu g\ kg^{-1}\ day^{-1}$ with mean value of 2.02 $\mu g\ kg^{-1}\ day^{-1}$g which is more than the WHO recommended daily consumption threshold of LADD of 1.0 $\mu g\ kg^{-1}\ day^{-1}$. Values of annual effective dose is varying from 0.89-15.16 µSv/Y with mean value is 4.74 µSv/Y, which is below the safe limit of 100 µSv/y (WHO).

**Keywords:** Experimental technique; Natural uranium; LED fluorimeter

## 1 Introduction

Uranium, radon, and radium are the most frequently discovered radionuclides in drinking water. Uranium is a natural radioactive element with a mass per atom of 238 and an atomic number of 92 that is found in particular kinds of rocks and soils. Water sources contain varying concentrations of uranium, which are dissolved as a result of water passing through minerals and rock. The environment may also be exposed to uranium is outcome of different human activities, including mining, combustion from coal and from phosphate fertilisers[1]. The element uranium ($^{238}U$) is poisonous so it is very harmful to our health. Uranium toxicity depends on different factors like solubility of particles, ways of elimination and exposure and contact time[2]. Mostly $^{238}U$ is ingested by humans through water consumption, which is 85%[3] and also from food and the air, which is 15% [4]. $^{238}U$ as nephrotoxin may harm the kidneys[5]. The assessment of radionuclides in drinking water becomes very important[6], Because high concentration of radionuclides (Uranium) can cause serious health issues. There are two different ways that uranium can have an impact, One is stochastic, which is brought on by consuming 50-150 mg of uranium, and it can cause in critical kidney failure and even death. Another is non-stochastic and is caused by modest levels (25 to 40 mg) of uranium intake, which is determined by the occurrence of proteins and urine with dead cells. In this case, the kidney returns to normal function after a few weeks[7]. Uranium concentration in the ground water in the Jhajjar district of Haryana, India, is the primary focus of this study. This study area is important due to industries and poor quality of water. Study area is vicinity of Gurugram which is an industrial area. These water samples are collected from tube-wells and handpumps from which water is directly used for drinking as well as for irrigation without any proper treatment.

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## 2 Method and materials

### 2.1 Sample collection

A total of 40 samples of groundwater are collected from the different parts of Jhajjar district. These samples are collected from tube wells and hand pumps from various sites of Jhajjar. The water samples were stored in one litre cleaned and dried polyethylene bottles. These water samples were acidified by adding 4 to 5 drops of nitric acid to avoid the evaporation of water components[8].

### 2.2 Methodology

To measure the amount of uranium content in the water for this study, light emitting diode (LED) fluorimetry was employed[9]. When UV light of the right wavelength strikes a uranium compound; it is excited and emits green fluorescence that is measured by photo-multiplier tube (PMT). This fluorescence provides data about the amount of uranium existing in ground water[10].

## 3 Results and Discussions

The data of uranium concentration (µg/L), cancer mortality and morbidity and uranium annual effective dose (µSv per year) is shown in Table 1. The variation in uranium concentration was observed in the range of 5 to 91 µg/L with mean estimation of 28.49 µg/l. The value of safe limit of uranium concentration in groundwater is 60 µg/L according to AERB[13], India, while according to WHO[11] and USEPA[12] it is 30 µg/L, 9 µg/L according to UNSCEAR[17] and 1.9 µg/L according to ICRP[18]. Out of 40 investigated samples, 27 are within the limit of 30 µg/L, 9 samples have uranium values lies between 30 µg/L - 60 µg/L. There are 4 samples with uranium concentrations above 60 µg/L. The variation of number of samples with uranium concentration range is shown in pie chart (Fig 1). The mean value of U concentration for this whole research region is found to be below the acceptable limits suggested by the WHO, 2011 and AERB, 2004. The uranium concentration in some region is high because of nearby industries, increasing uses of fertilizer for agriculture and the local subsurface geology of the region.

### 3.1 Radiological Effect

The amount of uranium activity (Uconc) in Bq/l was considered by using[14] conversion factor 1 µg/L= 0.02528Bq/L.

The following condition is used to evaluate radiological cancer risk (RCR):

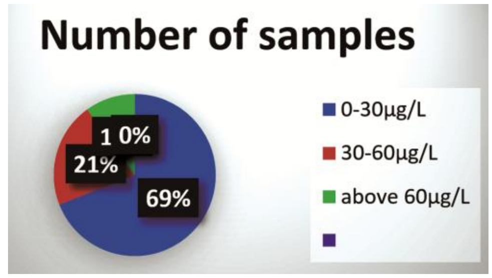


Fig. 1 — Variation of Uranium Concentration in Study area.

$$RCR = Uconc\left(\frac{Bq}{l}\right) \times RF\left(per\,\frac{Bq}{l}\right) \qquad \dots (1)$$

Where RF is risk factor[14] and calculated by using:

$$RF = RC\left(Bq^{-1}\right) \times WDR\left(\frac{L}{day}\right) \times TEP(days) \qquad \dots (2)$$

Risk constants(RC) in equation (2) was taken to be $1.19 \times 10^{-9}$ $Bq^{-1}$ and $1.84 \times 10^{-9}$ $Bq^{-1}$for mortality and morbidity respectively. The TEP is total exposure period that is life expectancy (69.89 years) that is 25509 days[14], with a daily water digestion rate (WDR) of 1.38 L.

The calculated risk factors for lifelong cancer morbidity and mortality are not significant because they are much lower than the permitted hazard limits.

### 3.2 Risks Associated with Chemicals

Potential of any compound for poisonous quality is assessed in relation to LADD, where LADD (µg $kg^{-1}$ $day^{-1}$) is lifetime Average daily dose. The formula for LADD evaluation is

$$LADD = \left(\frac{UC}{AT}\right) \times \left(\frac{WIR}{Wt}\right) \times F \times LE \qquad \dots (3)$$

Here UC in condition (3) is Uconc (µg/L), and WIR is water intake rate and expressed in litres per day (L/D) = 1.38 L/D. The presentation recurrence is F, measured in days per year (365 days). LE stands for "life expectancy," that is defined as "69.89 years."Wt is short for "human body weight," = 70 kg. The average time (AT) is assumed to be 25509 days [15]. Chemical hazard (LADD value) ranged from 0.39 to 6.67 µg $kg^{-1}$ $day^{-1}$, with average value of 2.02 µg$kg^{-1}$ $day^{-1}$ that is higher above the daily intake threshold for the WHO (2011), accepted a LADD of 1.0 µg$kg^{-1}$ $day^{-1}$.

The value of Hazard Quotient is calculated by using

$$Hazard\ Quotient = \frac{LADD}{RD} \qquad \dots (4)$$

Where RD is reference dose and RD = 4.4 µg $kg^{-1}$ $day^{-1}$ (AERB)[13] and RD = 1.2 µg $kg^{-1}$ $day^{-1}$(WHO)[19].

Table 1 — Uranium conc., annual effective dose, LADD, and other data of study area.

| Sample code | Location | Uranium conc.(μg/L) | Uraniumactivity conc.(Bq/L) | Uranium annual effective dose (μSv /y) | LADD (μg/kg/d) | Hazard Quotient (AERB) | Cancer mortality* 10-6 | Cancer morbidity* 10-6 |
|---|---|---|---|---|---|---|---|---|
| 1 | Chimani - Durana | 9.03 | 0.02257 | 1.50 | 0.66 | 0.15 | 0.13 | 0.25 |
| 2 | Dubaldhan | 22.41 | 0.05603 | 3.73 | 1.64 | 0.37 | 0.31 | 0.62 |
| 3 | Palra | 38.95 | 0.09738 | 6.49 | 2.85 | 0.64 | 0.55 | 1.08 |
| 4 | M.P.Majra | 18.02 | 0.04504 | 3.00 | 1.32 | 0.30 | 0.25 | 0.50 |
| 5 | Beri | 48.53 | 0.12133 | 8.08 | 0.64 | 0.14 | 0.68 | 1.34 |
| 6 | Dujana | 13.88 | 0.03471 | 2.31 | 1.02 | 0.23 | 0.20 | 0.38 |
| 7 | Dighal | 22.71 | 0.05678 | 3.78 | 1.66 | 0.37 | 0.32 | 0.63 |
| 8 | Chara | 21.8 | 0.05450 | 3.63 | 1.60 | 0.36 | 0.31 | 0.60 |
| 9 | Bhaproda | 19.57 | 0.04892 | 3.26 | 1.43 | 0.32 | 0.27 | 0.54 |
| 10 | Jaundhi | 60.25 | 0.15062 | 10.03 | 4.41 | 1.00 | 0.85 | 1.67 |
| 11 | Gudha | 11.27 | 0.02818 | 1.88 | 0.83 | 0.18 | 0.16 | 0.31 |
| 12 | Chhuchkws | 9.85 | 0.02462 | 1.64 | 0.72 | 0.16 | 0.14 | 0.27 |
| 13 | Jahazgarh | 52.95 | 0.13237 | 8.82 | 3.88 | 0.88 | 0.74 | 1.46 |
| 14 | Malikpur-Paharipur | 22.92 | 0.05731 | 3.82 | 1.68 | 0.38 | 0.32 | 0.63 |
| 15 | Matanhail | 26.18 | 0.06546 | 4.36 | 1.92 | 0.43 | 0.37 | 0.72 |
| 16 | Sasroli | 56.1 | 0.14025 | 9.34 | 4.11 | 0.93 | 0.79 | 1.55 |
| 17 | Khanpur | 33.63 | 0.08407 | 5.60 | 2.46 | 0.55 | 0.47 | 0.93 |
| 18 | Salahawas | 47.11 | 0.11777 | 7.84 | 3.45 | 0.78 | 0.66 | 1.30 |
| 19 | Bithala | 14.7 | 0.03676 | 2.45 | 1.08 | 0.24 | 0.21 | 0.41 |
| 20 | Talao | 12.53 | 0.03133 | 2.09 | 0.92 | 0.20 | 0.18 | 0.35 |
| 21 | Bhadana | 21.77 | 0.05443 | 3.63 | 1.60 | 0.36 | 0.31 | 0.60 |
| 22 | Khungai | 5.35 | 0.01337 | 0.89 | 0.39 | 0.08 | 0.08 | 0.15 |
| 23 | Kheri-Jatt | 22.88 | 0.05721 | 3.81 | 1.68 | 0.38 | 0.32 | 0.63 |
| 24 | Badali | 11.55 | 0.02887 | 1.92 | 0.85 | 0.19 | 0.16 | 0.32 |
| 25 | Badsa | 9.86 | 0.02465 | 1.64 | 0.72 | 0.16 | 0.14 | 0.27 |
| 26 | Bamdola | 23.37 | 0.05843 | 3.89 | 1.71 | 0.38 | 0.33 | 0.65 |
| 27 | Surah | 6.52 | 0.01631 | 1.09 | 0.48 | 0.10 | 0.09 | 0.18 |
| 28 | Dawla | 91.06 | 0.22766 | 15.15 | 6.67 | 1.51 | 1.28 | 2.52 |
| 29 | Kasni | 6.56 | 0.01639 | 1.09 | 0.48 | 0.10 | 0.09 | 0.18 |
| 30 | Subana | 69.4 | 0.17349 | 11.55 | 5.09 | 1.15 | 0.98 | 1.92 |
| 31 | Bhurawas | 17.82 | 0.04454 | 2.97 | 1.31 | 0.29 | 0.25 | 0.49 |
| 32 | Ladain | 17.99 | 0.04497 | 2.99 | 1.32 | 0.30 | 0.25 | 0.50 |
| 33 | Nilaheri | 33.09 | 0.08273 | 5.51 | 2.42 | 0.55 | 0.46 | 0.91 |
| 34 | Dhakla | 9.37 | 0.02342 | 1.56 | 0.69 | 0.15 | 0.13 | 0.26 |
| 35 | Chappar | 30.84 | 0.07709 | 5.13 | 2.26 | 0.51 | 0.43 | 0.85 |
| 36 | Patauda | 14.5 | 0.03625 | 2.41 | 1.06 | 0.24 | 0.20 | 0.40 |
| 37 | Kulana | 69.46 | 0.17365 | 11.57 | 5.09 | 1.15 | 0.98 | 1.92 |
| 38 | Machhrauli | 10.64 | 0.02660 | 1.77 | 0.78 | 0.17 | 0.15 | 0.29 |
| 39 | Dadanpur | 48.51 | 0.12127 | 8.08 | 3.55 | 0.80 | 0.68 | 1.34 |
| 40 | Jhajjar | 17.42 | 0.04356 | 2.90 | 1.28 | 0.29 | 0.24 | 0.48 |
| | Max. | 91.06 | 0.23 | 15.16 | 6.67 | 1.51 | 1.28 | 2.52 |
| | Min. | 5.35 | 0.01 | 0.89 | 0.39 | 0.08 | 0.08 | 0.15 |
| | Average | 28.49 | 0.07 | 4.74 | 2.02 | 0.43 | 0.40 | 0.79 |

HQ values varies from 0.08 – 1.51 with average value is 0.43. Average value of HQ in this region is within the safe limit of 1. There is no chemical effect of uranium on the resident of study area. The chemical toxicity of uranium in the study region may cause non-cancer health concerns.

### 3.3 Annual Effective Dose

The dosage for the entire body is measured by the yearly effective dose.

$$DS = Uconc \times ED \times Wintake \quad \text{... (5)}$$

In equation (5), DS stands for the yearly effective dose (Sv/Y), Uconc is used to represent the uranium activity concentration in (Bq/L) and ED is used to represent the effective dosage per unit intake (Sv/Y/Bq/L), is $4.5\times10^{-8}$ and Wintake is water intake per year and its value is 1480L(4.05 x 365) per year [14],[16]. Values of yearly effective dose is shown into table 1, mean value of DS is 4.74 μSv/Y, which is below the safe limit of 100 μSv/y (WHO, 2011)[11]. Values of annual effective dose are varying from 0.89-15.16 μSv/Y.

## 4 Conclusion

Uranium (U) concentration in water samples varied from 5.35 to 91.06 μg/L, with average value of 28.49 μg/L.The average value of U concentration in study is lying within acceptable limits suggested by the WHO, 2011 and AERB, 2004. The calculated risk factors for lifelong cancer morbidity and mortality are much lower than the permitted hazard limits. The LADD value is more than the WHO[11] recommended daily consumption threshold value. Values of annual effective dose are below the safe limit of 100 μSv/y (WHO)[11]. Therefore, there is no risk of human cancer, although chemical toxicity of uranium in the research region may cause non-cancer health concerns. Authors are advised that water will be drink after treatment.

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## References

1 Bjorklund G, Semenon Y, Pivina L, Dadar M, Rahman Md M, Aaseth J & Chirumbolo S, *Arch Toxicol*, 94 (2020) 1551.

2 ATDSR, *Toxilogical profile for uranium*, Atlanta, Georgia: US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, (1999).

3 Bajwa B S, Kumar S, Singh S, Sahoo S K & Tripathi R M, *J Radiat Res Appl Sci*, 10 (2015) 13.

4 Amaral R D S, Vasconcelos W E, Borges E, Silveira S V & Mazzilli B P, *J Environ Radioact*, 82 (2005) 383.

5 WHO (World Health Organization), Guidelines for Drinking-Water Quality, Geneva, Switzerland, Edn 4 (2022).

6 Wisser S, Frenzel E & Dittmer M, *Appl Radiat Isot*, 64 (2005) 368.

7 Sztajnkrycer M D & Otten E J, *Mil Med*, 169 (2004) 212.

8 Chahal A, Kumar S, Panghal A, Kumar A, Singh J, Singh P & Bajwa B S, *J Geol Soc India*, 94 (2019) 428.

9 Kumar M, Kumar A, Singh S, Mahajan R K & Walia T P S, *Radiat Meas*, 36 (2003) 479.

10 Rani A, Mehra R, Duggal D & Balaram V, *Health Phys*, 104 (2013) 251.

11 WHO, World Health Organization,“*Guidelines for drinking-water quality, (4th Edn)”*, Geneva, Switzerland (2011).

12 USEPA, United States Environmental Protection Agency, Edition of the Drinking Water Standards and Health Advisories, EPA 820-R-11-002, Office of Water, USEPA, (2011).

13 AERB, Atomic Energy Regulatory Board, *Drinking Water Specifications in India*, Mumbai, India (2004).

14 Mathew D & Edward J O, *Military Medicine*, 169 (2004) 212.

15 Gahrouei D S, Gholami M & Setayandeh S, *Adv Biomed Res*, 2 (2013) 65.

16 Yadav A K, Sahoo S K, Mahapatra S, Kumar AV, Pandey G, Lenka P & Tripathi R M, *Toxicol Environ Chem*, 96 (2014) 192.

17 UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) Ionizing Radiation, Sources and Biological Effects, New York, NY, USA, (1982).

18 ICRP, International Commission on Radiological Protection, Annals of the ICRP 23(2), ICRP Publication 65, Pergamon Press, Oxford, (1993).

19 WHO (World Health Organisation), Uranium in drinking water, background document for development of WHO guidelines for drinking water quality, World Health Organization, Geneva, (2011).