

Analysis of Uranium Intake, Risk Assessments, U-Content In Blood and Urine of Bathinda Residents, India

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ABSTRACT

Bathinda district of Punjab is in focus for last many years because of the high cancer reports. In order to explore the possibility of uranium as one of the causes for cancer, efforts have been made to estimate uranium content in water and to correlate it with U-content in the blood and urine of the cancer patients and normal residents of the area. Uranium content has been found to exceed the recommended safe limits in many of the drinking water samples. The cancer risk due to drinking of uranium contaminated water during the life time of seventy years has been calculated. Daily uranium intake from drinking water by residents of study area has also been estimated using the daily intake recommended by WHO and is found to exceed the typical worldwide dietary intake of 0.9-4.5 µg/day. The study reveals that U-content is higher in the blood of cancer patients but lower in the urine excretion as compared to the normal persons from village of Giana.

Keywords: Cancer risk assessments of uranium, Urine excretion, U-content in blood, Annual effective dose, Daily intake.

INTRODUCTION

The determination of Uranium in environmental samples has played an outstanding role in gauging the exposure due to naturally occurring radioactive elements. The radioactive elements produced due to nuclear activities, mining, coal combustion, and applications of phosphoric fertilizers [1] helps in enhancing the transportation of these radioactive elements to the vegetation through the water sources by flood wash-down or dust deposition or root uptake. As a result, small amounts are forward to humans through food chain [2]. It is readily absorbed from the gastrointestinal tract and widely distributed in body fluids such as urine [3] and blood [4]. Many studies have been conducted to examine the effect of long term environmental uranium exposure in animals and human beings [4-9] when ingested or inhaled. However, the uranium analysis for modelling using biodynamic and biokinetic parameters connected to bioassay consequences are not carried out very often but are executed as part of an autopsy.

Study on animals have indicated that proximal tubule in the kidney has been most effected by the high dose of uranium [10]. As uranium forms the complexes with phospholipids or proteins in the proximal tubules and result in uranium accumulation in the kidney and resulting to a site of kidney damage [11]. Studies have shown a positive correlations of calcium excretion in urine with uranium content in drinking water and increased calcium and phosphate excretion in the urine with uranium in the drinking water [7]. Animal studies have also established that uranium after crossing the blood-brain barrier

(BBB), readily mount up in the brain [12-13]. Various studies have shown the accumulation of uranium in the kidney and its toxic actions on the kidney [6-7, 14-21].

This work is designed to assess the association between the persisting health problems [22-24] in the inhabitants of the villages Malkana, Jajjal and Giana of Bathinda and their exposure to uranium via ingestion by measuring the uranium content in water, and calculating the commutative dose, life time cancer risks, urinal excretion rate and uranium level in kidney from the data, as the cause of uranium contamination seems to be from geological deposits.

The information of the uranium content and its urinary excretion of the general public serve as input for the accurate measurement of internal radiation dose. The uranium content in urine and blood of normal and cancer patients has been measured to compare the results.

METHODS AND TECHNIQUES USED

The sampling of soil and water has been accomplished in the villages Malkana, Giana and Jajjal of Bathinda District (fig. 1 depicts the sampling locations). Some samples of human blood and urine of 18 individuals of age group 55 or above comprising healthy and certified cancers patients [22] have also been collected with the help of doctor and with the consent of the participants. The villagers have been informed that the data collected obtained from the analysis will be used for research and will not be utilized for personal or business interest. All blood samples were treated with ammonium citrate- a preservative and anticoagulant. The known volume of treated blood samples was dried on filter paper (Wattman no.1) and sandwiched between two lexan discs. The uranium concentration (C) has been calculated using the technique [25] and given in detail elsewhere [26]. Uranium level in soil have been estimated using the technique [27] and given in detail elsewhere [28]. The calculations for dose rate have

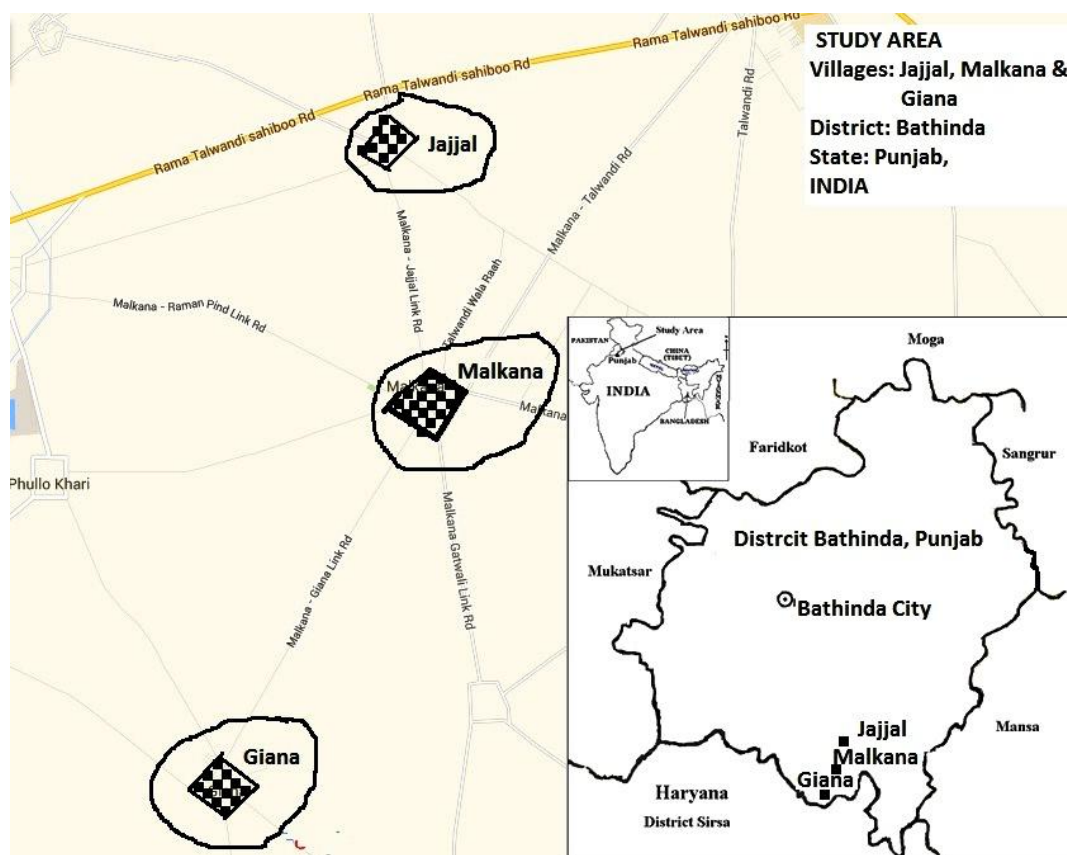


Fig. 1 Map showing the study area in Bathinda district, Punjab

been made by using the dose factor for gamma radiations in air as 0.7 Sv per Gy [29].

$$\text{Annual dose} = \text{Dose per unit intake} \times \text{Annual water consumption} \times \text{Radionuclide concentration}$$

The lifetime risk of a fatal cancer resulting from exposure to radiations have been estimated by using the conversion factor given by ICRP-72 [29].

RESULTS AND DISCUSSIONS

Some drinking ground water from the study area along-with the blood and urine samples of the residents have been analysed for uranium concentration and the life time cancer risk have been calculated using ICRP model as discussed in this section.

Uranium content in drinking water samples

Total 24 drinking water samples have been collected and analyzed for uranium concentration and the average uranium values have been detailed in Table 1. It has been observed to range between $17.61 \pm 0.06 \mu\text{g/l}$ to $48.66 \pm 0.06 \mu\text{g/l}$ in Malkana and Giana with a minimum value of $1.84 \mu\text{g/l}$ in Malkana and the maximum of $99.88 \mu\text{g/l}$ in Giana.

Table 1: The uranium level in water samples from the villages Jajjal, Giana and Malkana of district Bathinda

S. No.	Location (village)	No. of Samples	Average uranium Content $\pm \sigma^*$ ($\mu\text{g/l}$)	Range of uranium content	
				Minimum	Maximum
1	Jajjal	6	31.84 ± 0.08	7.94	63.19
2	Giana	13	48.66 ± 0.06	2.87	99.88
3	Malkana	5	17.61 ± 0.06	1.84	59.65

*Statistical counting error, $\sigma = \frac{U_{conc}}{\sqrt{N}}$, where N is the total number of tracks counted

USEPA[30], WHO[31] and UNSCEAR[32] have recommended $30 \mu\text{g/l}$ as the permissible value of uranium content in the water for drinking purpose, whereas Bureau of Indian Standards [33] has proposed $60 \mu\text{g/l}$ of uranium in water as the safe value for drinking purpose. However most of the countries such as Australia [34], Canada [35], California [36] have set $20 \mu\text{g/l}$ as safe value. The safe limits of U-content in the drinking water signify that the consumption of such water will not cause any notable health hazard to public over the lifetime. It is revealed from the results that average level of uranium in waters of Jajjal and Giana lie above the safe limit provided by UNSCEAR [32], World Health Organization [31] and USEPA [30] but lower than the safe value of $60 \mu\text{g/l}$ by BIS[33] except five samples from Giana and one each from Jajjal and Malkana.

The uranium concentration in the 24 drinking ground water samples collected from the different sources, has been compared with the safe level given by the agencies dealing with health hazards (shown in fig 2). About 45.83% of the total samples have shown uranium concentration above the permissible limit of $30 \mu\text{g/l}$. Although the hazardous effects of uranium can be assessed by its determination in various organs, its resident time, retention and excretion from the body-the higher incidence of different types of cancers in these villages suggests the possible connection. The results obtained in the present investigations have been compared with the uranium concentration reported by some other workers in Indian waters and found higher than those reported by Talukdar et al. [37] for the water samples of Guhawati area, Assam (0.08 - $5.32 \mu\text{g/l}$) and Bhangare et al. [38] for the waters of Vishakhapatnam, Orissa (0.6 - $12.3 \mu\text{g/l}$). Whereas the results are in agreement with those obtained by Singh et al. [39], and Kumar et al. [40] in some water samples of Bathinda

district, Punjab (11.71-113.70 $\mu\text{g/l}$ and 1.65 ± 0.06 to $74.98 \pm 0.38 \mu\text{g/l}$, respectively) and some areas of upper shivaliks, Himachal Pradesh (0.67-20.26 $\mu\text{g/l}$) reported by Singh et al. [41].

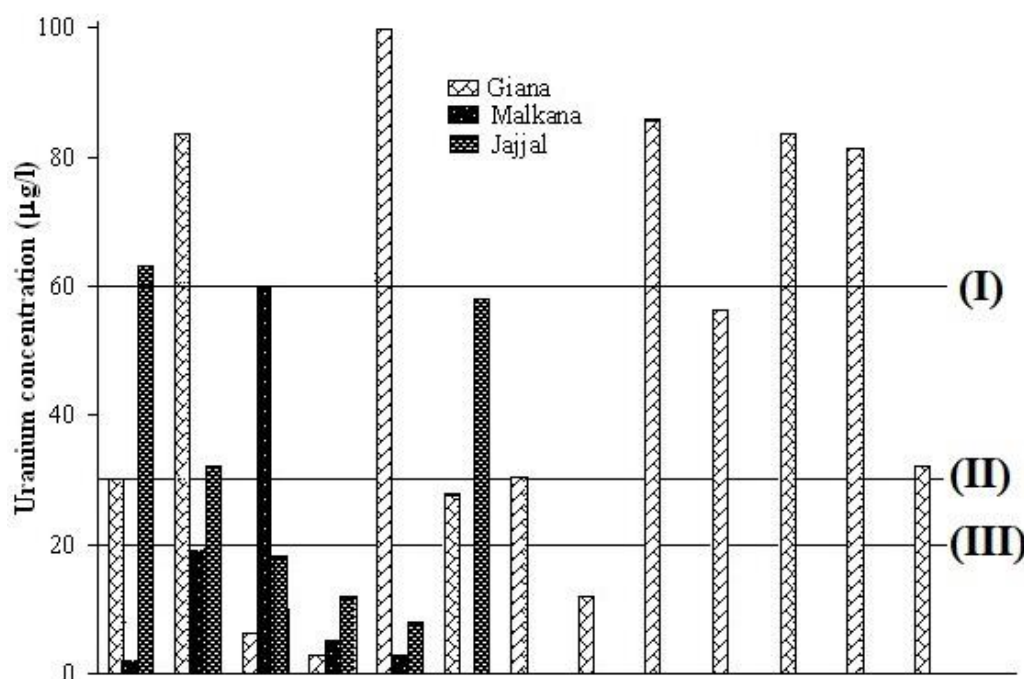


Fig. 2 Comparison of uranium level in the drinking water samples of the three villages with safe limits 60 $\mu\text{g/l}$ (I) by BIS [33], 30 $\mu\text{g/l}$ (II) by USEPA[30], WHO [31] & UNSCEAR [32], 20 $\mu\text{g/l}$ (III) by FPTCEOH [35], CEPA [36] & NHMRC [34].

The higher uranium concentrations in water may be attributed to uranium rich granite rocks of the Tusham Hills of Bhiwani district of Haryana as reported by the study [42]. More prevalent use of uranium rich phosphate fertilizers for the cultivation of cotton crops[43]and the installation of four thermal power plants in the nearby area may have been considered another source to enhance the U-content in ground water but lower concentration of uranium in soil has reduced the possibilities.

Risk Assessments

Results for the annual dose rate of uranium from drinking water, its cumulative dose for lifetime ingestion and cancer risk factor have been reported in table 2 by considering a daily water intake of 2 liters. The annual dose rate is found to vary from 15.82 in Malkana to 43.74 $\mu\text{Sv/a}$ in Giana causing an accumulation of 3.061-1.108 mSv of dose during the period of 70 years.

Table 2. The variation in uranium intake, specific intake, dose rate, cumulative dose, lifetime cancer risk and uranium concentration in kidney of the residents of study area

Location (village)	Uranium intake ($\mu\text{g/d}$)	Specific intake ($\mu\text{g/day. kg}$)	Dose rate ($\mu\text{Sv/a}$)	Cumulative Dose (mSv)	Life time cancer risk (%)	Maximum Uranium concentration in kidney (ng/g)
Jajjal	63.68	0.90	28.62	2.003	0.010	5.968
Giana	97.32	1.37	43.74	3.061	0.015	9.121
Malkana	35.22	0.50	15.83	1.108	0.006	3.301

The excess cancer risk due to such a high accumulation is found to vary from 0.006-0.015%, which means that at least one individual out of 6532-18049 may be influenced by cancer. However the risk may be much greater in Giana where the maximum uranium content of

99.88 $\mu\text{g/l}$ is found. That may lead to the accumulation of 6.285 mSv and thus cancer risk rises to 0.031 % i.e. out of 3182 persons one person may have a chance to be influenced by cancer. The average specific intake of individuals consuming the water has been calculated and is reported in table 3. The specific intake has been found to be 1.37, 0.50 and 0.90 $\mu\text{g}/(\text{day.kg})$ of body weight for Giana, Malkana and Jajjal residents respectively. The average weight of the residents has been considered as 71 kg and AMAD has been taken as 1 μg used for public. The specific intake is alarmingly high for the residents of Giana and Jajjal than that of the standard limit of 0.06 $\mu\text{g}/(\text{day.kg})$ specified by WHO. [44].

Various studies on animals and occupationally exposed miners reports that the chemical toxicity effects of uranium to kidney are the major causes of threats to health, rather than a radiation hazard [6, 44-46]. The functional and histologic damage to the proximal tubules have been verified by many researchers[5,18,47]. The results of uranium content accumulated in the kidney from drinking uranium contaminated water have also been included in the table 2. It is found to vary in the range of 3.301-9.121 ng/g for the residents of Malkana and Giana, respectively. The uranium content in blood and urine has been calculated from the ICRP biokinetic model using the GI absorption factor of 0.02 and the excreted urine volume of 1.38 liters per day and has been reported in table 3. The default values for other parameters have been chosen from USEPA [48].

The uranium content in urine and blood samples from 18 individuals of Giana, Jajjal and Malkana have also been examined as the data may serve as an index to propose a biokinetic model to the workers. The study has been carried out with the blood and urine of healthy and certified cancer patients of the same family and the results obtained are reported in table 3.

Table 3. Uranium concentration in blood and urine calculated using ICRP biokinetic model and experimentally measured in samples of residents of villages Jajjal, Giana and Malkana of district Bathinda of Punjab.

S. No.	Location (village)	Uranium concentrations calculated from daily intakes using ICRP 72		Uranium concentration ($\mu\text{g/l}$)		
		Blood (μg)	Urine ($\mu\text{g/l}$)	Person	Blood (C_B)	Urine (C_U)
1.	Jajjal	0.106	0.827	Patient	1.31	0.53
				Normal	0.99	0.65
				Normal	1.21	0.20
				Patient	0.85	0.59
				Normal	1.79	0.14
				Patient	1.35	--
				Normal	0.82	0.35
2.	Giana	0.163	1.265	Patient	1.33	0.23
				Normal	1.77	0.44
				Patient	1.32	0.39
				Normal	0.97	0.18
				Patient	1.05	0.11
				Normal	1.01	0.32
				Normal	1.27	0.54
3.	Malkana	0.058	0.458	Patient	1.28	0.38
				Normal	0.85	0.40
				Patient	2.04	0.88

	Normal	1.17	0.58
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The concentration has been found to vary between 0.82-1.79 $\mu\text{g/l}$ and 0.14-0.65 $\mu\text{g/l}$ for normal persons to 0.85-2.04 $\mu\text{g/l}$ and 0.11-0.88 $\mu\text{g/l}$ for cancer patients, in blood and urine samples, respectively. The uranium excreted in urine is found to be less as compared to that of the calculated using ICRP Biokinetic model in the residents of Giana and Jajjal villages, whereas the U-content in blood is found to be high in the three villages as compared to the calculated one. The findings support the higher occurrence of cancer in Giana and Jajjal. The excretion of uranium through urine in patient is a bit lesser as compared to the normal person in the residents of Giana. The higher value of uranium excretion through urine as compared to the calculated one minimizes the probable cancer cases in Malkana. The outcomes of the present study aids to conclude that the U-content in urine and blood of cancer patients is higher as compared to the normal persons. The results corroborate the findings of Das and Goswami [49] as they have also reported the higher uranium content in cancer patients (2.27 – 3.48 $\mu\text{g/l}$) than the normal persons (0.64 – 0.94 $\mu\text{g/l}$). So the study leads to a conclusion that high U concentration in drinking water and foodstuffs [50] may be one of the cause of various carcinogenic diseases or cancer incidences in these villages.

Investigation of uranium content in the urine samples from unexposed individuals from Japan have been carried out by Tolmachev et al. [51] to assess daily excretion of uranium and observed U content in urine in the range 0.8 - 35.6 ng/l. The urinary uranium concentrations and their creatinine normalized values public of Southwest Nigeria have been reported by Höllriegl et al. [52] has reported the U content in urine of public of age above 15 years of both genders from Southwest Nigeria in the range 10.4-150 ng L⁻¹ and their creatinine normalized values in the range 2.52-252.7 ng g⁻¹ creatinine. They have estimated 45.1 ng of uranium per day by the children and 14.2 ng per day by the adults.

CONCLUSIONS

1. Anomalous uranium concentration has been found in the drinking waters of the Bathinda district, Punjab. The average concentration of uranium is even higher than the recommended limits of 30 $\mu\text{g/l}$ (USEPA 2009) in the villages Giana and Jajjal. Uranium rich granites rocks of the Tusham Hills [42] in the neighbouring state Haryana may be the cause of the high content of uranium in the drinking ground water of the study area.
2. The cancer risk estimate from drinking of uranium contaminated water during the lifetime of 70 years is very high and approximately one individual out of 12865 may be influenced. The average annual effective uranium dose from the drinking water received by residents belonging to these villages varies from 15.82 to 43.74 $\mu\text{Sv/a}$.
3. The case studies reveal that uranium retention in body may be considered as a cause of cancer.

DECLARATION

The manuscript does not contain any individual identification or personal information. The blood and urine samples have been collected after the consent of the individual and with the help of a qualified and experienced doctor. A care has taken during the experiment that no human being should get harmed as a consequence of participation in the research study. The study has not been carried out for any beneficiary or business and the participants of the study were informed about the purpose of the study. The ethical and regularity norms have been considered during the conduct of experiment.

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