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Uranium distribution study in the drinking water samples of SW Punjab, India

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ABSTRACT

In the present investigations, the Laser Fluorimetery technique has been used for the microanalysis of uranium concentration in 141 ground water samples collected from different sources like the hand pumps, tube-wells of various depths from wide range of locations from the Mansa, Bathinda and Faridkot districts of SW-Punjab, India. The major objective of the present investigation was to investigate the uranium concentration levels of groundwater being used for the drinking purposes and thus determination of its health effects to the local population of this region. It has been observed from the data analysis that average value of uranium content in ground water samples collected from all the three districts was higher than WHO & USEPA recommended safe limit of 30 µg/l and even it also exceeds the threshold of 60 µg/l recommended by AERB, DAE, India. The maximum values of uranium concentration in drinking water samples has been found to be 645.2, 323.9 & 375.8 µg/l in the Mansa, Bathinda & Faridkot districts respectively, which exceeds the national and international recommended safe limits.

Keywords: Uranium, Groundwater, Punjab

INTRODUCTION

Uranium, a ubiquitous element in our environment, possesses radiological as well as chemical toxic effects. It is lithophilic element & present in earth's crust with an average concentration of $4x10^{-4}$ percent by mass. Uranium gets mixed with groundwater by leaching process & enters into our food chain. Nephrotoxicity, genotoxicity and developmental defects are main health concerns due to excessive intake of uranium [1]. Among all the long lived radio-nuclides, uranium is most stable. It binds with oxygen to form uranyl ion (UO_2^{+2}) which is soluble in water. Harmful biological effects in humans can occur if its concentration in water is higher than 30 µg/l [2]. It is non essential in body as it has no known metabolic function [3]. When ingested through water, uranyl compounds combines with proteins &nucleotides to form stable complexes in the body. The principal sites of uranium deposition in the body are the kidneys, the liver and the bones. Many authors have studied the effects of uranium on kidney [4-5] as well as other body parts [6-8].

In the present study, uranium content in 141 groundwater samples collected from three major districts of SW-region of Punjab state, India has been studied using the state of the art Laser Fluorimetery technique. The region was especially selected due to its cancer prevalence as compared to the other states of Punjab. Along with the study of spatial variation of the uranium concentration, the depth-wise distribution has also been analyzed for the entire study region.

MATERIALS AND METHODS

Geology of studied region:
Punjab State is located in the northwest of India. The geographic location of the study region in SW Punjab is between 29°38' and 30.48°N latitude and 74°34' and 75°44'E longitude which mainly covers the Mansa, Bathinda & Faridkot districts. Figure 1, shows the geographical location of the state of Punjab in India and the highlighted part shows the location of the sampling regions/districts in Punjab. The SW Punjab is semiarid, eventually merging into the Thar Desert. The soil of SW Punjab is loose, sandy, calcareous and alluvial, which is an admixture of gravel, sand, silt and clay in varying proportions. The land in the SW Punjab is used for agriculture all over the year but many industries like thermal power plants, fertilizer factories, chemical factories, and cement factories are established in the SW region.

Sampling Strategy
One hundred and forty one (141) groundwater samples from different locations of Mansa, Bathinda and Faridkot districts of Punjab has been collected in the present study. Number of samples in each district has been mentioned in table 1 in parenthesis. The source of sample comprises hand pumps, tubewells and borewells. For 5-10 minutes, water source was kept running and fresh water was taken in polyethylene bottles and then filtered using 0.45 micron whatmann filter paper for removal of suspended particles.

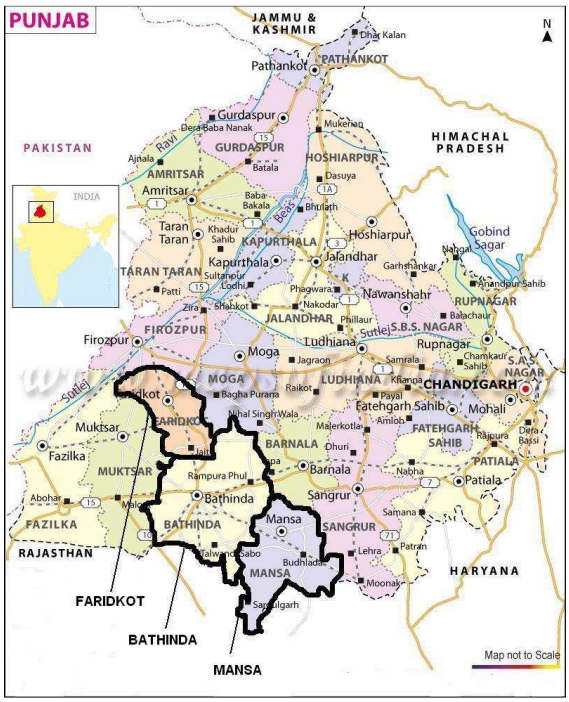

Figure 1. Map of study region

Experimental Technique
Nitrogen based laser fluorimeter model QL/NLF/02 manufactured by Quantalase Enterprises Pvt. Ltd has been utilized for estimation of uranium concentration in groundwater samples in the present study. Laser fluorimetery is one of the most efficient, sensitive & quick technique for uranium analysis in liquid samples with quite lower detection limit of 0.1 µg/l. This instrument mainly consists of three parts: Nitrogen laser tube as an excitation source, sample compartment & photomultiplier tube. Ultraviolet radiation from laser source with wavelength 337.1 nm carrying energy of 20 µJ & pulse width of 7ns excites the uranyl ion present in the liquid sample placed in the sample compartment. On de-excitation, uranyl ion emits green luminescence which is further measured by PMT.

Fluorescence given by organic matter in the water sample, if present, is at around 400 nm, when excited by nitrogen laser and its interference is blocked by using long pass filter which only allows radiation above 450 nm. But, this

procedure can't completely eliminate the fluorescence from organic matter. Pulsed excitation by proper time gating of PMT blocks this florescence as it lasts for few tens of nanosecond, whereas fluorescence due to uranyl ion remains for few tens of microsecond.

Reagents & Chemicals:

Five percent solution of sodium pyrophosphate was prepared in double distilled water & orthophosphoric acid was added for the adjustment of pH value of 7.0. This solution when added to groundwater samples, forms uranyl phosphate complex with uranium which is stable. This solution acts as fluorescence enhancing agent. The instrument was calibrated with 10, 5 & 2.5 µg/l uranium standard solutions before analyses of ground water samples.

RESULTS AND DISCUSSION

The results of the uranium concentration from the three districts of the study region of SW-Punjab analysed using the Laser Fluorimetery technique are summarised/tabulated in Table 1. The overall uranium concentration observed in drinking water samples of the study region has been found to vary from 5.9 µg/l to 645.2 µg/l, with an average of 84.6 µg/l. On comparing the observed uranium concentrations with recommended safe limits, it has been observed that only 33 percent samples of all the three districts were within the WHO and USEPA proposed limits of 30 µg/ [2, 9], whereas 59 percent samples were found to be within the AERB proposed limit of 60µg/l (10). Thus, considering even the national safe limits it has been observed that around 41 percent groundwater samples are not suitable for drinking purposes in the SW region of Punjab, which clearly corroborates the results reported by our group in our previous studies [11].

Uranium concentration at different percentiles is also reported in table 1, from where it can be observed that mean value is higher than the median value. This shows that distribution of uranium concentration is right skewed. On the average, around five percent of samples from SW Punjab were having higher value than 300 µg/l and 50 percent samples were having uranium content below 51 µg/l. It is also observed that 25 percent samples from studied region were having uranium content between 51.1 to 93.8 µg/l.

In Mansa district, value of uranium concentration varied from 5.9 µg/l at Kishangarh village to 645.2 µg/l at Jatana Kainchian village. The observed wide variation might be due to variations of soil-parameters of different geographical locations, different depths of the sample collection points and may also be due to enrichment of uranium due to different geochemical parameters. From fig.2, it can be seen that in Mansa district, about 32 percent samples were below 30 µg/l & 55 percent samples below than 60 µg/l.

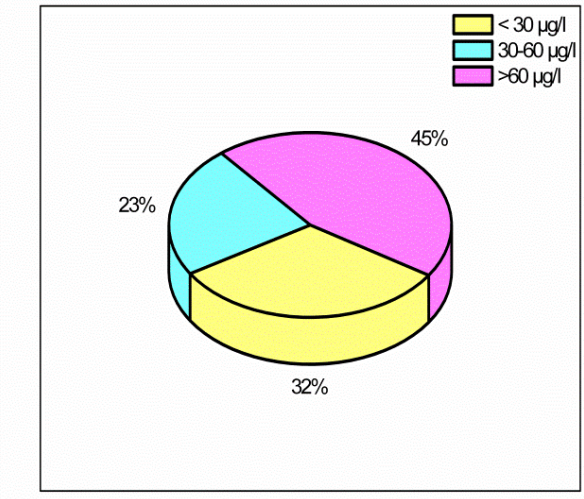

Figure 2. Distribution of uranium concentration in groundwater samples of Mansa district

Table 1. District wise uranium concentration in groundwater samples

District (No. of samples)	Mansa (47)	Bathinda (46)	Faridkot (48)
Area covered (km^2)	2174	3344	1472
Average uranium concentration (µg/l)	96.4	69.3	87.8
Maximum uranium concentration (µg/l	645.2	323.9	375.8
Minimum uranium concentration (µg/l)	5.9	7.9	7.6
P_{5th}	8.6	8.3	7.9
P_{25th}	25.1	21.0	26.4
P_{50th}	55.1	37.4	52.9
P_{75th}	97.2	83.9	93.3
P_{95th}	325.9	220.7	300.3

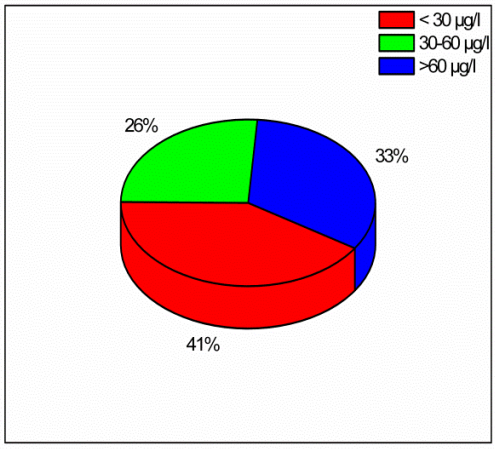

Figure 3. Distribution of uranium concentration in groundwater samples of Bathinda district

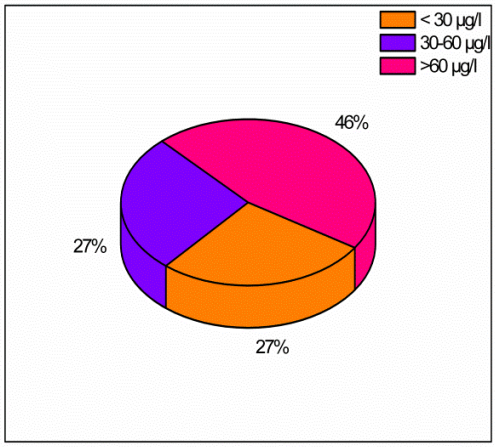

Figure 4. Distribution of uranium concentration in groundwater samples of Faridkot district

From figures 3 and 4, it can be seen that in Bathinda district 33 percent samples were above 60 µg/l content of uranium and in Faridkot district 46 percent samples were above this safe limit and not suitable for drinking purposes. Observed range of uranium content in Bathinda and Faridkot district was 7.9-323.9 and 7.6-375.8 µg/l. Maximum & minimum value of uranium concentration observed in Bathinda district is at village Gurusar saine & Kot bhakhtu respectively. Whereas in Faridkot district maximum & minimum value observed at Dhurkot & Wada daudaka village. High content of synthetic fertilizers and pesticides are used in this belt of Punjab. It has been reported that 75% of total pesticides used in Punjab is only consumed by Malwa region which covers only 15

percent land area of Punjab. Malwa region is known for its rich cotton farming and it is reported that in India, 54% of total pesticides consumption is on cotton alone in 5% area of total cultivated area [12]. Use of phosphate fertilizers, mining and combustion from coal & other fuels in various industries in this region has also elevated uranium levels in its groundwater [13].

Depth wise variation

To study the vertical distribution of uranium concentration, the groundwater samples were also collected from different depths from the study region. Its purpose was mainly to find some correlation, if any, between uranium concentration and the depth of groundwater. From fig 5, it can be observed that the maximum mean uranium content was observed at the depth range of 101-200 ft. The results obtained from the study regions prove that the uranium concentration decreases with increase in depth. The uranium content at the depth range of 101-200 ft is nearly 17 times the level at the depth >400 ft. The high uranium concentration observed mainly at shallow depths may be due to leaching through soil by extensive use of fertilizers in the agriculture and may also be due to wastes released from factories, thermal power plants in the study region,

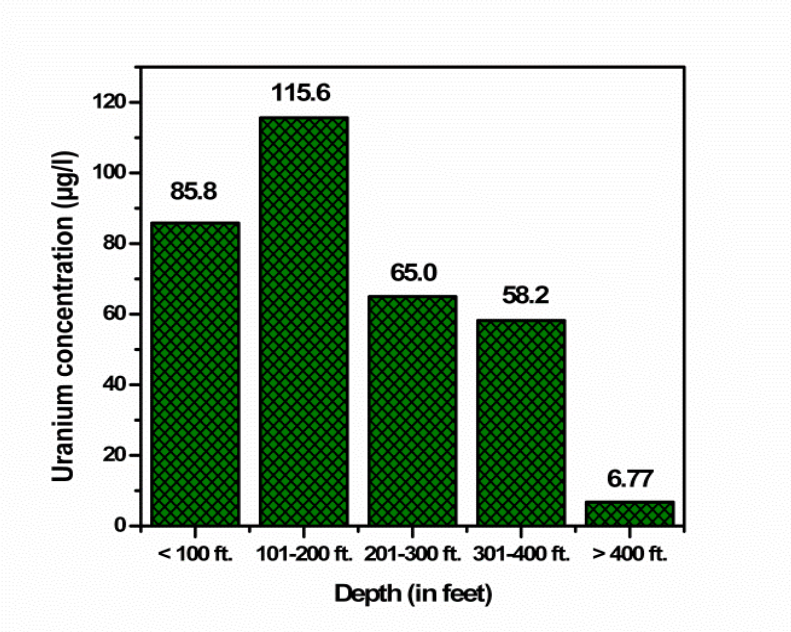

Figure 5. Variation of uranium concentration with depth in groundwater

CONCLUSION

1. A large variation (5.9–645.2 $\mu g l^{-1}$) in the uranium concentrations has been observed in the analyzed drinking water samples of the SW-Punjab.
2. The level of uranium content in 67% groundwater samples of the study region were higher than MCL recommended by USEPA, WHO and 41% samples were higher than AERB proposed limits.
3. Major industries like cement factories, fertilizer factories, chemical factories, coal fired thermal power plants etc. in this region might be the possible reason for higher uranium concentration in groundwater.
4. But extensively high concentration of uranium levels observed, although in only few collected samples of SW- Punjab region, may also be due to leaching of uranium from basement granite rich rock formations and of-course wide spread use of fertilizers and pesticides is always the additional region for increasing the radioactivity of groundwater of the study region
5. Maximum content of uranium observed is at depth range of 101-200 ft. from the surface and decreases with depth further.
6. Bore well at depth more than 200 ft. should be preferred in this region for safe drinking and irrigation purposes because of comparatively lower level of uranium.

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