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Full Length Research Paper

Uranium concentration in ground water samples belonging to some areas of Western Haryana, India using fission track registration technique

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Concentration of uranium was assessed in ground water samples taken from hand pumps at different areas from Bhiwani, Hisar, Fatehabad and Sirsa districts of Western Haryana, India. Fission track registration technique was used to estimate the uranium content in water samples. Uranium content in the water ranges from 6.37 µg/L (Sirsa) to 43.31 µg/L (Bhiwani) with an average value of 19.14 µg/L for the study area. Uranium concentration in all the studied samples were above the recommended value of 1.9 µg/L (ICRP, 1993) but most of the values were comparable to the safe limit of 15 µg/L (WHO, 2008). In only 15% of the samples, recorded values that were higher than the recommended level of 30 µg/L (USEPA, 2003). The results of the measurements could be of vital in radio-epidemiological assessment, diagnosis and prognosis of uranium induced diseases in the local population of the area under investigation.

Key words: Uranium, fission track, water, diagnosis.

INTRODUCTION

Uranium (a primordial radionuclide) occurs in a dispersed state in the earth's crust. Uranium salt is the most soluble of the long-lived radionuclides and forms ions with oxidation states of +4 (UO_2 and U^{4+}) and +6 (UO_3 and UO_2^{2+}) (Banks et al., 1995). Uranium will bond with oxygen to form the uranyl ion, or uranium dioxide, which is soluble in ground water under aerobic conditions. As uranium is a natural lithophilic element and is contained almost in all natural waters; however, its concentration in groundwater depends on lithology, geomorphology and other geological conditions of the region (Sridhar Babu et al., 2008). Uranium present in the earth is transferred to water, plants, food supplements and then to human beings. Uranium has both chemical and radiological toxicity with the two important target organs being the kidneys and lungs (ATSDR, 1990, 1999; WHO, 1998).

High intake of uranium and its decay products may lead to harmful effects in human beings. Uranium nuclides emit alpha rays of high ionization power and therefore it may be hazardous if inhaled or ingested in higher quantity or dose. According to an estimate (Cothern and Lappenbusch, 1983) food contributes about 15% of ingested uranium while drinking water contributes about 85%. An exposure of about 0.1 mg/kg of body weight of soluble natural uranium results in transient chemical damage to the kidneys (Tanner, 1980). The chemical toxicity effects on the human kidney by chronic ingestion of uranium through drinking water in the range of 0.004 to 9 µg/L per body weight per day may produce interference with kidney functions (Zamora, 1998). In a more recent study on humans by Kurttio et al. (2005), nephrotoxic effects of uranium in drinking water were found even for low concentrations–without a clear threshold. Water having uranium concentration above a few µg/L is not safe for drinking purposes.

Hence, the need of estimation of uranium concentration in water is multi fold: it is an important fuel for nuclear power and therefore hydrogeo-chemical prospecting for

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uranium is essential; the assessment of the risk of health hazards due to high concentration of uranium in waters is most important. Uranium prospection through the analysis of soil, rocks, plants and water have been reported by many workers (Dunn, 1981; Dyck, 1979; Sridhar Babu et al., 2008). Uranium decay through radium and produces a gaseous decay product radon, which can diffuse out of material into the atmosphere (Somogyi, 1990). This involves two mechanisms; liberation from the individual grain in which it is formed and transport through bulk medium to a free surface. The aim of the present investigation is to study the health risk assessments in western districts of Haryana.

Geology of the studied area

Haryana is one of the Northern states of India. It lies between 29.14° to 30.30° North Latitude and 74.29° to 76.28°East longitudes shown as dotted line in Figure 1. Physiographically, the studied area is characterised by three distinct features that is upland plain, Alluvial bed (flood plain) of river Ghaggar and Sand dune clusters (Anmol and Sushil, 2008). Soil of the study area is alluvium in nature. It has two types of soils namely Sierozem (found in major parts) and Desert soils (found in smaller parts). The geological formations mainly comprised unconsolidated alluvial deposits of Quaternary age. The alluvial deposits comprises of sand, silt, clay associated with kankar (small particles). The alluvium forms the principal ground water reservoir and the principal aquifer material comprises fine to medium sand and sand mixed with kankar. The thickness of the alluvium varies from 200 to 300 m. Apart from this, The Tusham Ring Complex in Bhiwani district of Haryana, is known to be composed of acidic volcanics and the associated granites (Kochhar, 1989).

MATERIALS AND METHODS

Fission track registration technique was used for the assessment of uranium concentration level in the underground water samples collected from randomly chosen hand pumps in the studied area. A known volume of the water (one drop) was dropped on the small circular detector which is plastic polycarbonate ($C_{16}H_{18}O_3$) with trade name of Lexan (General Electric Company, USA). Two such Lexan samples were prepared from the same water sample and these were allowed to dry over surfaces of the detectors in dust free environment. These two dried lexan samples, prepared from same water sample, were pasted together with dried water surfaces facing each other. Therefore, a total of 22 such water samples like this were prepared. All the samples were enclosed in a standard aluminum capsule and the remaining space in capsule was filled with cotton. Then, these samples in capsule were irradiated with thermal neutrons in the reactor at Bhabha Atomic Research Centre, Mumbai, India with a thermal neutron dose of about $2x10^{15}$ (nvt). After irradiation the individual detector Lexan discs were etched in 6.25 N NaOH solution at 70°C for 25 min to reveal the fission tracks as shown in Figure 2. The developed fission tracks were scanned using an optical microscope at a magnification of 400X. Uranium concentration in the water samples were determined using the technique given by Fleischer and Lovett (1968) and was estimated using the formula:

$$C = \frac{TM}{VGNsFE}$$

where, C is Uranium concentration in water; T the total number of tracks on the Lexan sample; M the atomic weight of uranium of isotope ^{238} U; V the volume of drop (ml); M the atomic weight of uranium of isotope ^{238} U; G the Geometry factor (is assumed to be unity); N is the Avogadro's number (6.023×10^{23}); s the fission cross section; F the total thermal neutron dose 2×10^{15} (nvt) and E the etching efficiency factor for lexan taken as unity.

RESULTS AND DISCUSSION

The uranium concentration in ground water samples from various places of western districts of Haryana are presented in Table 1. The values in samples from Fatehabad district ranges from 10.19 µg/L (Bhundrawas) to 18.13 µg/L (Ratia) with an average value of 15.49 µg/L, for Hisar district these values ranges from 9.23 µg/L (Panjuana) to 17.44 µg/L (Sat road) with an average value of 12.70 µg/L and the values for Sirsa district ranges from 6.37 µg/L (Sirsa) to 24.93 µg/L (Kingre) with an average value of 14.88 µg/L. These values for Bhiwani district ranges from 19.32 µg/L (Khanak) to 43.31 µg/L (Bhiwani) with an average value of 28.12 µg/L. Most of the values of uranium in water samples from three districts of Fatehabad, Hisar and Sirsa are comparable to the safe limit of 15 µg/L (WHO, 2008) whereas the values are higher than the recommended safe limit of 15 µg/L for samples from Bhiwani district.

Uranium concentration in water for the whole of the studied area ranges from 6.37 µg/L (Sirsa) to 43.31 µg/L (Bhiwani) with an average value of 19.14 µg/L for the study area. Uranium concentration in all the studied samples is above the recommended value of 1.9 µg/l (ICRP, 1993) but most of the values are comparable to the safe limit of 15 µg/L (WHO, 2008). In only 15% of the studied samples from Bhiwani, Baliyal and Tusham area, the values are higher than the recommended safe level of 30 µg/L (USEPA, 2003). These high values may be attributed to the fact that the area is known to have high outdoor gamma radiations to which major contributor to dose rates from uranium and thorium decay series (Farai and Jibiri, 2000). The values of uranium concentration in water samples of these areas are higher than those, Kulu area of Himachal Pradesh (Singh et al., 2001), and are comparable to those reported in Malwa region of Punjab (Mehra et al., 2007). These values are lower than in Bathinda Punjab (Singh et al., 1995; Kumar et al., 2003) and are much lower than in the regions of Kolar District, South India, (Sridhar Babu, 2008) where it lies between 0.3 to 1442.9 µg/L.

The values of uranium concentration in drinking water

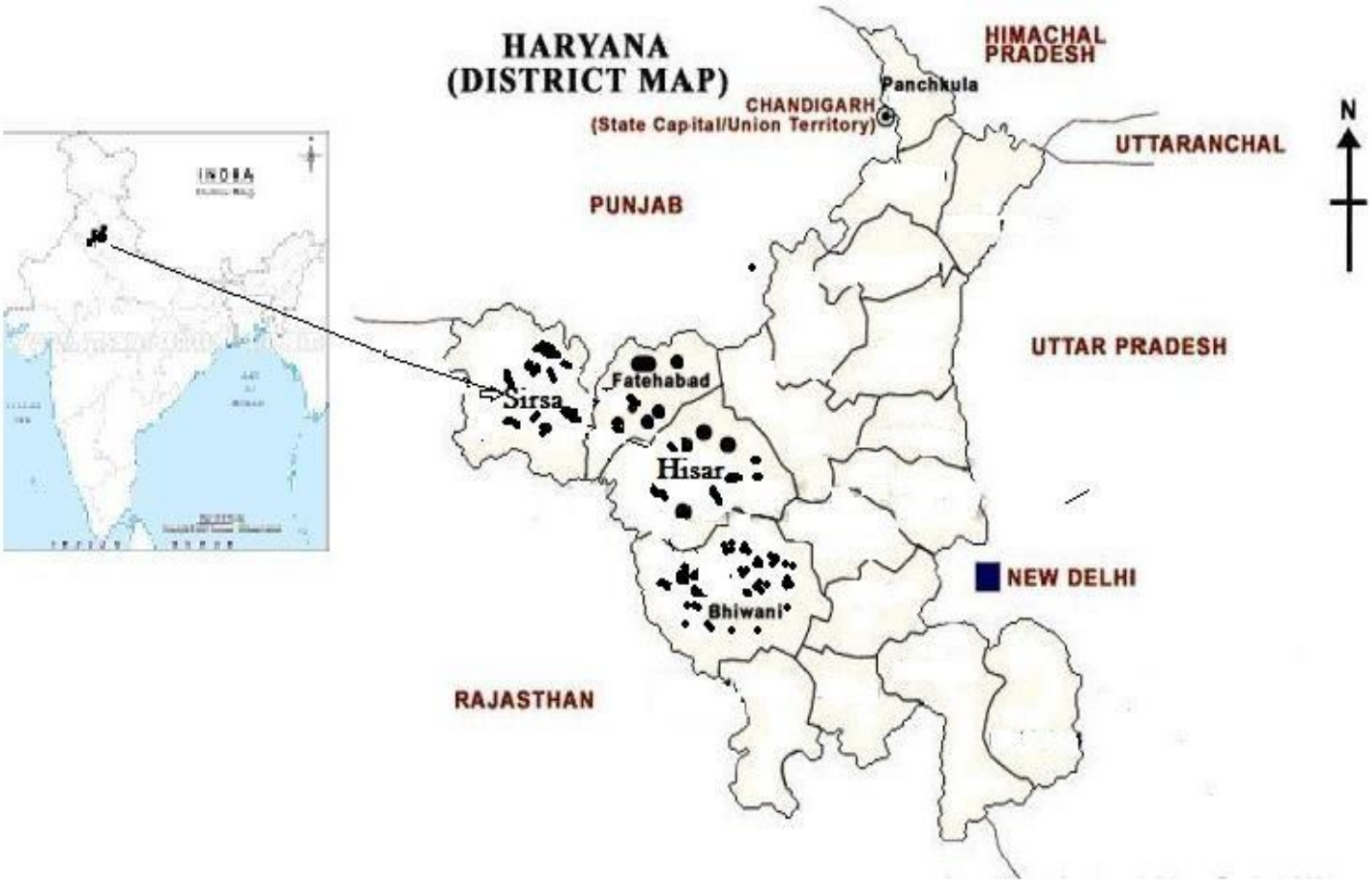

Figure 1. Map of Haryana state showing the dotted area surveyed during the present investigations.

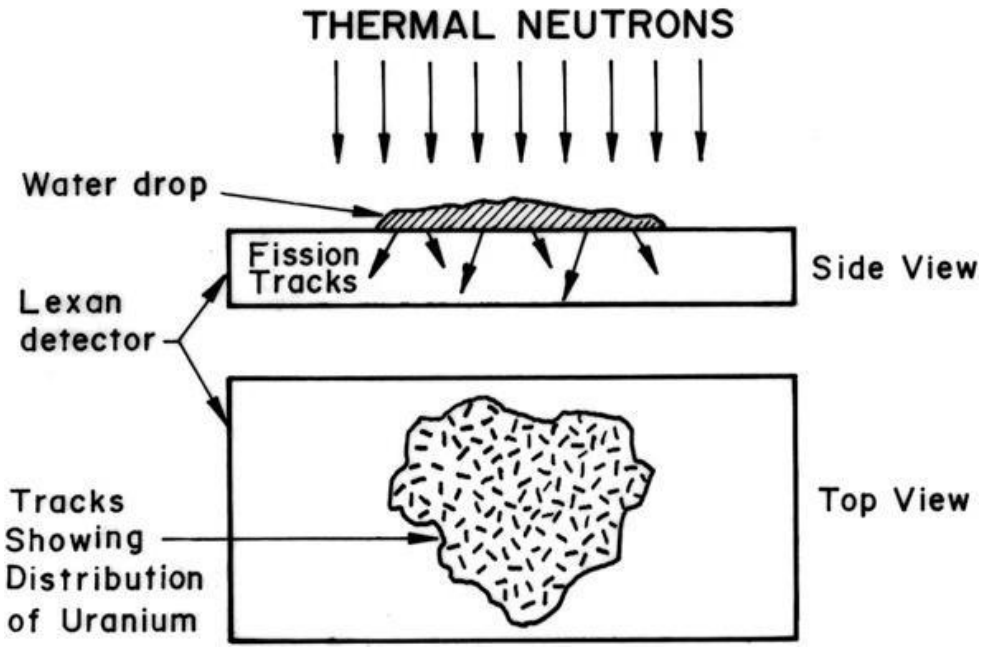

Figure 2. Schematic representation of the Neutron Induced Fission Technique used for uranium determination in drinking water.

Table 1. Uranium concentration in water samples of some areas of western districts of Haryana.

S/N	Sample location	Uranium concentration in water (µg/L)
	Fatehabad district	
1	Ratia	18.13± 0.12*
2	Dadam	17.42 ± 0.13
3	Badalgam	16.32±0.14
4	Fatehabad	15.43 ± 0.12
5	Bhundrawas	10.19±0.15
	Bhiwani district	
6	Biran	19.72 ± 0.15
7	Bapora	20.13 ± 0.20
8	Tosham	38.43 ± 0.14
9	Riwasa	24.43±0.14
10	Baliyal	33.35±0.14
11	Khanak	19.32± 0.13
12	Bhiwani	43.31± 0.13*
13	Jamalpur	26.28± 0.12
	Hisar district	
14	Panjuana	9.23±0.13
15	Hisar	11.17±0.14
16	Kheri	13.42 ± 0.16
17	Sat road	17.44 ± 0.21
18	Ladwa	12.24 ± 0.23
	Sirsa district	
19	Vaidwala	11.78± 0.15
20	kingre	24.93± 0.22
21	Sikandurpura	14.33± 0.11
22	Panniwala Ruldu	17.03± 0.13
23	Sirsa	6.37±0.17*

*Statistical counting error $1\sigma = \pm(1/\sqrt{N}) \times$ uranium content, where N is the number of tracks.

samples obtained in the present investigations in the studied areas are also compared with those available in literature worldwide (Table 2). The uranium concentration in water samples in south Greenland lies in the range of 0.5 to 1.0 µg/L as reported by Brown et al. (1983). The average values of uranium in drinking ground water were found to be 3 µg/L (Cothern and Lappenbusch, 1983) with ranges of 0.015 to 973 µg/L in domestic supplies in the U.S. (Drury et al., 1981). Kumru (1995) has reported uranium concentration in water samples from Turkey in the range of 0.24 to 17.65 µg/L. Bansal et al. (1985, 1988) have reported uranium concentration range of 0.67 to 471.27 µg/L in the Aligarh (in Uttar Pradesh state of India) tube well waters and the domestic Indian water supplies. A very wide range of uranium concentration of 0.04 to 1400 µg/L in drinking water supplies in Jordon has been reported by Gedeon et al. (1994) and Smith et al. (2000). Uranium values obtained in the water samples in the present investigations generally lie above the range reported by other workers except those in the United States, Jordon, and some other workers in India as given in Table 2.

Conclusions

Uranium concentration in water ranges from 6.37 to 43.31 µg/L with an average value of 19.14 µg/L for the studied area. The values of uranium concentration in all water samples are more than the recommended value of 1.9 µg/L (ICRP, 1993) but most of the values are comparable to the safe limit of 15 µg/L (WHO, 2008). In only 15% of the studied samples from Bhiwani, Baliyal and Tusham area, the values are higher than the recommended safe level of 30 µg/L (USEPA, 2003).

The high uranium content in the few ground water

Table 2. Range of uranium concentration in drinking water worldwide.

S/N	Country	Range of Uranium concentration in water (µg/L)	Average value (µg/L)	Reference
1	Ontario, Canada	0.05-4.21	0.40	OMEE (1996), Moss et al. (1983) and Moss (1985)
2	New York, USA	0.03-0.08	-	Fissene and Welford (1986)
3	USA	-	2.55	US EPA (1900,1991)
4	Argentina	0.04-11.0	1.3	Bomben et al. (1996)
5	Japan	-	0.0009	Nozaki et al. (1970)
6	Norway	18% samples had U concentration in excess of 20 ppb	--	Frengstad et al. (2002)
7	New Mexico	>20 ppb	-	Hakonson-Hayes et al. (2002)
8	Central Australia	>20ppb	-	Hostetler et al. (1998)
9	Jordan	0.04-1400	2.4	Gedeon et al. (1994) and Smith et al. (2000)
10	Kuwait	0.02-2.48	-	Bou-Rabee (1995)
11	United States	0.01-652	-	Drury et al. (1981), Edgington (1965) and Cthern and Lappenbusch (1983)
12	South Greenland	0.5-1.0	-	Brown et al. (1983)
13	Turkey	0.24-17.65	-	Kumru (1995)
14	India	0.08-471.27	-	Talukdar et al. (1983), Bansal et al. (1985,1988), Singh et al.(1993, 2003) and Mehra et al. (2007)
15	India, present study	6.37-43.31	19.14	

samples may be due to the radioactive rich granites of Tusham Hills, Bhiwani district of Haryana state of India. Kochhar has already reported high radioactivity in granite rocks of this area (Kochhar, 1989). As in 85% of water samples, uranium concentration lies within the recommended safe levels, so it may not result in any significant risk to health of the residents of the studied area. But for the remaining 15% of studied samples from Bhiwani, Baliyal and Tusham area, more detailed investigation needs to be carried out to reach any conclusion.

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