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Uranium analysis in some food samples collected from Bathinda area of Punjab, India

Mukesh Kumar[1]*, Sangeeta Prasher[2] and Surinder Singh[3]

[1]Department of Applied Science, RIMT-Institute of Engineering and Technology, Mandi Gobindgarh-147 301, Punjab, India

[2]Department of Physics, Kanya Maha Vidyalaya, Vidyalaya Marg, Jallandhar-144 004, Punjab, India

[3]Department of Physics, Guru Nanak Dev University, Amritsar-143 005, Punjab, India

E-mail : moka_esh9@yahoo.com

Abstract : To strengthen the radiation protection infrastructure in Bathinda, the uranium concentration in daily diet of the residents has been measured and its associated radiation risks were estimated for the adult population. Food samples were collected from major cancer prone areas of the district, from which daily diets were prepared. These diet samples were analyzed using fission track technique. The measured values of the uranium content were found to vary from 0.38 mBq/g in mustard seeds to 4.60 mBq/g in wheat. In case of milk the uranium content is found to vary from 28.57–213.36 mBq/ℓ with mean concentration of 61.35 mBq/ℓ. This leads to a daily dietary intake of 0.90 Bq/day. The measured value of 0.90 Bq d^{-1}, contributes to 1.12 mSv to the cumulative effective dose to the population. This dose is much large than the International Commission for Radiological Protection (ICRP) annual effective dose limit of 1 mSv for the general public [1]. Therefore, it would pose significant health hazard.

Keywords : Uranium intake, cumulative dose, risk assessments, dose rate, food stuffs.

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1. Introduction

Naturally occurring radionuclides are the largest contributors of radiation dose to human being in most countries. These radionuclides reach the human body through the food chain and accumulate in the critical organs and cause radiation damage in the respective organs [2], if present in large amounts.

Uranium (like other radioactive heavy metals) is one of such toxic substances and can pose both chemical and radiological problems. Environmental issues linked with uranium

* Corresponding Author

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mining, mill tailing and other uranium-contaminated sites have refocused attention on uranium. Public radiation exposure from these sites mainly occurs through the surface and groundwater pathway and contamination of foodstuffs following soil-plant transfer. Plants may take up uranium from the soil and soil may adhere to the root surface. Food thereafter may become a vehicle for uptake of depleted uranium in human.

For realistic estimation of the radiation dose to various populations, a determination of the ingestion of uranium through foodstuff is essential. There have been measurements of dietary intake of uranium in several countries. The most exhaustive studies on natural uranium in the diet and of levels in man for specific geographical locations were carried out in the USA by Welford and Baird [3] and by Fisenne *et al* [4] who reported a daily uranium intake of 30.3 mBq for New York City residents. Nozaki *et al* [5] from Japan reported a uranium intake of 32.86 mBq, whereas Hamilton [6] has reported an intake of 25.28 mBq for UK adults, but there is little information available from India for the daily intake of uranium. In the present study, the concentration of U was determined in individual food items collected from Cancer prone areas of Bathinda district [7] located in the central southern part of Punjab state of India (Figure 1). It is situated between 29^{o} 33' and 30^{o} 36' north latitude and 74^{o} 38' and 75^{o} 46' east latitude. The district shares boundaries with Sirsa district of Haryana State in the South; Sangrur and Mansa in the East; Moga and Faridkot in the North and Mukatsar in the West. The Rajasthan desert is also not far away and its heat, sand and dust storms influence the local weather to a great extent.

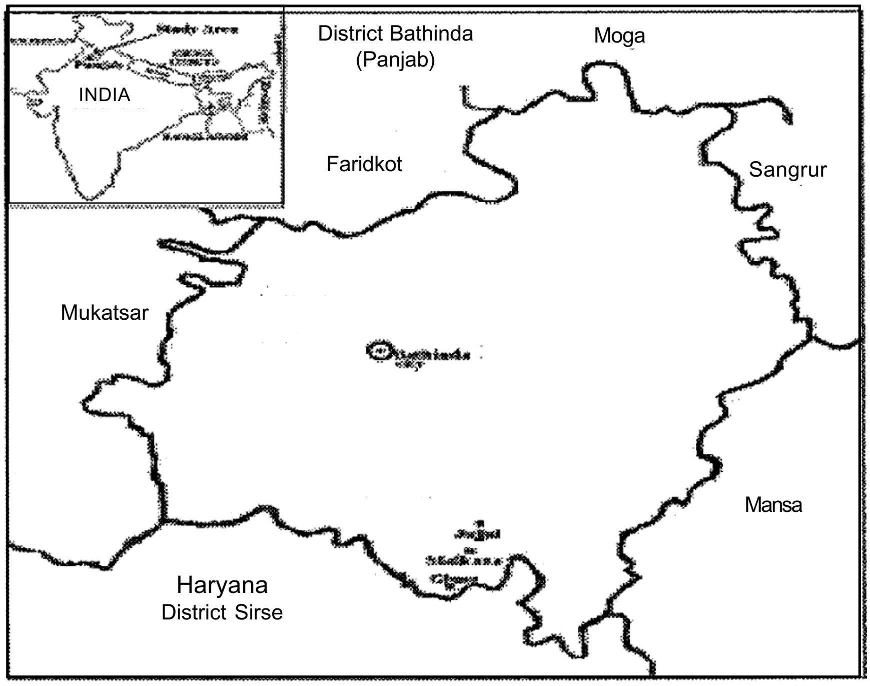

Figure 1. Map showing the study area in Bathinda district, Punjab.

The geological structure of this region is formed of alluvium (fine fertile soil left behind by a flood) and the main soils are coarse sandy loam-to-loam, grey or red desert soils.

2. Experimental techniques

The samples of foodstuffs, *viz*. wheat, pulses, mustard, kidney beans and milk have been collected personally during the fieldwork from three villages Giana, Malkana and Jajjal of Bathinda distrct of Punjab and the uranium concentration is measured using Fission Track Technique [8]. Pellets were made from the samples after drying and grinding the material. These pellets were sandwiched in two lexan detectors. The system was then irradiated with known dose of thermal neutrons (2×10^{15} n/cm^2) from CIRUS reactor at BARC. A glass dosimeter of known U concentration was also irradiated along with the samples. The induced fission tracks recorded in lexan detectors with thermal neutrons were etched and then scanned under an optical microscope. The uranium concentration (U_x) was calculated using the relation [8] :

$$U_x = U_s\left(\frac{T_x}{T_s}\right)\left(\frac{I_s}{I_x}\right)\left(\frac{R_s}{R_x}\right)$$

where the subscripts *x* and *s* represents the sample and standard respectively. *T* is the fission track density and *I* is the isotopic abundance ratio of ^{235}U and ^{238}U. The correction factor (R_s/R_x) has been taken to be unity. Similarly I_s/I_x has also been taken as unity on the assumption that the isotopic abundance ratio is the same for the sample and the standard. However for milk samples the technique developed by Fleischer and Lovett [9] and given in detail by Ilic and Durrani [10] has been employed for the uranium estimation in water, blood, urine and milk samples. The details of the technique are the same as reported earlier [11].

3. Results and discussion

The uranium concentrations found by using the above mentioned relation in some food samples such as milk, wheat, mustard and pulses collected from the villages Jajjal, Malkana and Giana of Bathinda disrict, Punjab are reported in Table 1.

The uranium content in milk has been found to be in the range of 28.57–140.30 mBq/*l* for Jajjal, 34.39–48.28 mBq/l for Malkana and 30.59–213.36 mBq/l for Giana with the average values of 60.17, 39.69 and 84.18 mBq/*l* respectively. The average uranium values in the wheat samples of these villages are found to be 2.81, 1.82 and 2.91 mBq/g, respectively. The values of uranium concentration in milk and wheat are very large as compared to the values reported by Galletti *et al* [12] for Italian fresh milk (3.41 μBq/*l*) and bread (61.68 μBq/g).

The uranium content of pulses collected from these villages ranges between 0.73–1.19 mBq/g, comparable to the value of 1.49 mBq/g for pulses of Chandoli Khurd village of

Table 1. Uranium concentration in foodstuffs collected from Jajjal, Giana and Malkana villages of Bathinda district Punjab, alongwith dose rate, cumulative dose and lifetime cancer risks.

S. No.	Location (Village)	Uranium concentration in				Total daily intake (Bq/day)	Dose rate (μSv/a)	Cumulative dose (mSv)	Lifetime cancer risk % and ratio
		Milk (mBq/*l*)	Milk (mBq/*l*)	Milk (mBq/*l*)	Milk (mBq/*l*)				
		28.57	28.57	28.57	28.57				
		29.32	29.32	29.32	29.32				
1	Jajjal	140.30	140.30	140.30	140.30	0.99	17.60	1.232	0.006
		43.23	43.23	43.23	43.23				(1 : 16234)
		58.65	58.65	58.65	58.65				
	Average	60.17	60.17	60.17	60.17				
		39.44	39.44	39.44	39.44				
2	Malkana	48.28	48.28	48.28	48.28				
		35.64	35.64	35.64	35.64	0.66	11.73	0.821	0.004
		34.39	34.39	34.39	34.39				(1 : 24358)
	Average	39.69	39.69	39.69	39.69				
		30.59	30.59	30.59	30.59				
		213.36	213.36	213.36	213.36				
3	Giana	32.86	32.86	32.86	32.86	1.04	18.49	1.294	0.006
		60.42	60.42	60.42	60.42				(1 : 15452)
	Average	84.18	84.18	84.18	84.18				

Aligarh district [13]. The daily intake of uranium for the population of these villages has been estimated from the daily intake of these foodstuffs given by WHO [14] and are reported in Table 1 along with the uranium content in different food samples.

The daily intake of uranium from foodstuffs (excluding water) is found to be the highest in Giana with 1.04 Bq/day. UNSCEAR [15] estimates the annual intake from the ingestion of U-238 in adults to be 5.7 Bq. The typical world wide dietary intake is estimated to lie between 22.75–113.76 mBq/day with an average of 37.92 mBq/day [17], whereas Yamamato *et al* [17] describes a dietary intake as 73.31–113.76 mBq/day for the population of Okayama. Galletti *et al* [12] has reported a total daily dietary intake of uranium for Italians to be in the range of 73.31–121.34 mBq/day. The daily intake of uranium from foodstuffs excluding water for the residents of the three villages Giana, Jajjal and Malkana, is found to be 1.04, 0.99 and 0.66 Bq/day respectively, which is higher than the world wide average dietary intake of 22.75–113.76 mBq/day. The extensive use of phosphate fertilizers in agriculture may be responsible for the high levels of uranium content in the population of Bathinda district. The major constituents of Indian diets are cereals, milk products and pulses, which are the largest contributors of terrestrial activity of uranium and hence may be ascribed as the cause of high intake of uranium. Spencer *et al* [18] measured the total dietary intake of uranium excluding water and milk (strictly controlled diet of four patients) to be 0.05 Bq/day, which is similar to that quoted by Hamilton [6]. Like many trace metals the bioavailability of uranium in food may be influenced by the food's phytate (or fibre) content [19–20] and the presence of the low molecular weight ligands, such as citrate may promote uptake. Wrenn *et al* [21] reviewed uranium uptake factor across the range of average diets and suggested an uptake factor of 2% to 3%.

The annual dose of natural uranium *via* food items and cumulative effective dose for an average age of 70 yrs of Indians have been calculated using the ICRP-72 biokinetic model and are found to vary from 11.73 to 18.49 μSv/a and 0.821–1.294 mSv, respectively (Table 1). The cumulative effective dose has been found to be higher than that of the ICRP value of 1 mSv. It may pose lifetime cancer fertility risks to the population of these villages. The lifetime cancer risk assessments [22] for the three villages have shown that at least one out of 16234, 24358 and 15452 persons in Jajjal, Malkana and Giana, respectively may be fertile with cancer risks.

4. Conclusions

Analytical data on the baseline dietary intake of uranium in the population of Bathinda district, Punjab has been obtained. The concentration has been found to vary from 0.38 mBq/g in mustard seeds to 4.60 mBq/g in wheat with a mean of 1.67 mBq/g. The measured value of 0.90 mBq d^{-1}, contributes to 1.12 mSv to the cumulative effective dose to the population, and is greater than the limits recommended by ICRP.

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