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NOTE

Ingestion Dose Due to Uranium in Water Samples from the Southern Coast of Kerala

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Uranium is the ubiquitous heaviest radioactive element found in all terrestrial substances in different level and is important because of its chemical and radioactive properties. Water comes into contact with minerals under the earth's surface and uranium is transferred into water due to its leaching property. Studies on levels of uranium in water bodies will help to understand the mobilization of the tracer amount of uranium in the ecosystem. Water samples from various water sources distributed around the high background region of south India were collected and analyzed for uranium, using dry fission track registration technique, capable of determining the uranium levels even in sub-ppb (particles per billion) level. It is observed that the concentration of uranium is high in seawater as compared to that in tap water. Present work discusses the methods of measurements and the results obtained in detail. From the measured concentration of uranium in water samples, ingestion dose were calculated for an individual using the dose coefficients

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Uranium is the ubiquitous heaviest radioactive element found in all terrestrial substances in different level and is important because of its chemical and radioactive properties. Water comes in contact with several minerals under the earth's surface and uranium is transferred to water by its leaching characteristics. Water plays an important role in the geophysical and geochemical processes, which slowly recycles the trace elements to and from the biosphere. At higher levels uranium can become carcinogenic. Main organ, which is severely affected by water-borne uranium, is kidney[1,2]. According to an estimate, food contributes to *ca.* 15 % of ingested uranium while drinking water supplies contributes *ca.* 85 %[3]. Hence the need for the estimation of radiation dose due to uranium in water supplies is important.

One hundred twenty water samples were collected and analyzed from the high background radiation regions of south west coast of Kerala, from different sources namely sea, river, pond and well. Fission track registration technique was employed for the analysis of water samples. A known volume of water sample was allowed to

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evaporate on dielectric fission track detector disc (Makrofol-KG) cut in the form of circular discs of 1.3 cm diameter, to leave a circular residue of non-volatile substances in the water samples including uranium. Each detector disc was then covered with another identical detector disc to form a pellet[2]. These pellets were encapsulated in an aluminum can of about 5 cm length and 1.5 cm diameter. A blank pellet, without any water sample residue in it, was also placed in the can to assess the background tracks, if any. A pair of micro-slides, of circular shape, which acts as neutron flux dosimeters, were also kept in the can. The can containing the pellets were neutron irradiated in the thermal column of the APSARA reactor at a flux of 10^{16} nvt for 2 to 3 h.

After irradiation, the detector discs were separated and chemically etched in 6.25 N KOH solution at 60 ºC for 20 min so that the fission tracks were clearly visible. Needle like fission fragment tracks were seen on the detectors. The distribution of tracks was such that the circular region had a non-uniform distribution of tracks. The rim of the circular region had a higher track density and the interior had almost uniform distribution of tracks. To find the total number of tracks on the detector, the rim as well as the interior was scanned separately using an optical transmission microscope of magnification 400X. Then the total number of tracks on the detector was calculated from the track densities in the central region of the detector (N_A) and that along the rim of the detector (N_L). Total track density on the detector was calculated from the track densities measured using the equation[1]:

$$N = 2\pi RN_L + \pi(R - \delta)^2 N_A \quad (1)$$

where, N is the estimated total number of tracks on the detector, R is the radius of the circular area, N_L is the tracks counted per unit length along the rim having a width δ and N_A is the tracks per unit area in the interior region.

Uranium concentrations in water samples were calculated using the equation:

$$C_w = [(NM)/(VGN_aE\sigma\phi I] \quad (2)$$

where C_w is the concentration of uranium in water samples, N is the total number of tracks, M is the atomic weight of the fissile material (235), V is the volume of the water droplet, N_a is the Avogadro's number, E is the etching efficiency of the makrofol-KG detector (taken as unity), σ is fission cross section of the fissile isotope (580 barns), ϕ is the neutron flux used and I is the isotopic abundance ratio. It is assumed that natural uranium contains ^{238}U, ^{235}U and ^{234}U in ratio 99.27, 0.72 and 0.006, respectively. For this combination of uranium isotopes it can be shown that 1 mg of uranium has an activity of 24.79 Bq. From the measured concentration of uranium in water samples, ingestion dose were calculated for an individual using the dose coefficients given by the International Commission on Radiological Protection (ICRP 72, 1996).

Volume specific activity of uranium in water samples from various sources are shown in the Table-1. Sea water is found to contain higher levels of uranium as compared with the other water samples, back water the least. Well water in certain locations near to the sea was found to have elevated levels of uranium.

TABLE-1
URANIUM CONCENTRATION (μg/L) IN WATER SAMPLES
FROM DIFFERENT SOURCES

Locations	Sea water	Pond	Well	River	Backwater
A1	1.45 ± 0.49	0.54 ± 0.23	0.31 ± 0.14	0.93 ± 0.32	0.61 ± 0.37
A2	1.55 ± 0.44	0.49 ± 0.32	0.49 ± 0.30	0.65 ± 0.44	0.62 ± 0.43
A3	1.25 ± 0.34	1.24 ± 0.66	1.08 ± 0.66	1.05 ± 0.66	1.03 ± 0.66
A4	1.43 ± 0.30	1.20 ± 0.46	1.10 ± 0.45	1.09 ± 0.45	1.09 ± 0.45
A5	1.86 ± 0.25	1.09 ± 0.51	0.92 ± 0.54	0.87 ± 0.54	0.68 ± 0.26
A6	2.06 ± 0.37	1.22 ± 0.49	1.06 ± 0.59	1.15 ± 0.36	1.07 ± 0.44
A7	2.08 ± 0.22	1.92 ± 0.21	1.65 ± 0.17	0.63 ± 0.17	0.62 ± 0.18
A8	1.88 ± 0.34	1.04 ± 0.33	0.64 ± 0.33	0.66 ± 0.33	0.66 ± 0.36
Range	0.61-2.75	0.34-1.98	0.04-1.72	0.33-1.34	0.26-1.38
Average ± SD	1.70 ± 0.31	1.04 ± 0.48	0.91 ± 0.42	0.88 ± 0.21	0.80 ± 0.22

Table-2 shows the calculated values of ingestion dose from drinking water sources due to uranium based on the dose coefficients prescribed by ICRP. Dose from uranium isotopes constitutes only a small fraction of the total dose from natural radio nuclides of uranium and thorium series ingested with food and water which is estimated to be about 90 μSv. The dose apportion limit for dose from ingestion of drinking water as 30 μSv/y[4].

TABLE-2
ESTIMATED INGESTION DOSE FROM DRINKING WATER
SAMPLES FROM DIFFERENT LOCATIONS

Location	Pond (Dose μSv/y)	Well (Dose μSv/y)	Location	Pond (Dose μSv/y)	Well (Dose μSv/y)
A1	0.97	0.56	A7	3.46	2.97
A2	0.88	0.88	A8	1.15	1.15
A3	2.21	1.94	Min.	0.58	0.51
A4	2.16	1.98	Max.	3.56	3.12
A5	2.01	1.66	Av.	1.87	1.63
A6	2.20	1.91	SD	0.86	0.76

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