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Uranium and radon concentration in ground water in Aucashat city (Iraq) and the associated health effects

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ABSTRACT

Uranium and radon gas concentrations in ground water were determined for six locations in Aucashat city using CR-39 track detector. For uranium concentration, fission fragments track technique was used, the nuclear reaction of nuclear fission fragments obtained by the bombardment of ^{235}U with thermal neutrons from (Am-Be) neutron source with flux (5000n.cm^{-2}.s^{-1}). For radon concentration, the natural exposure method using the sealed cup technique, the concentration values were calculated by a comparison with standard samples. The results of the measurements show that the uranium concentration in water samples various from 8.8±0.12 to 12.63±0.19µ g/l with an average 10.23±1.3µg/l. For radon concentrations in ground water various from 8.02 ± 0.14 to 11.7±0. 16 kBqm^{-3} with an average 9.35±1.24 kBqm^{-3}, and the annual effective dose from ingestion (stomach) various from 0.84 to 1.23 mSv/y, from inhalation (lung) various from 2.25 to 3.28 mSv/y and for whole body various from 3.09 to 4.51 mSv/y.

Key words: CR-39, Uranium concentration, Radon concentration, Ground water

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INTRODUCTION

Uranium is a naturally occurring element in ground water in some portions of connecticut. Uranium gets into drinking water when groundwater dissolves minerals that contain uranium[1]. The amount of uranium in well water will vary depending upon its concentration in bedrock. Levels of naturally occurring radiation in water are not likely to be high in shallow wells. The potential exists for deep bedrock wells in Connecticut to have uranium, although most will be very low. High levels of uranium indicate the potential for radon and radium also to be present. The uranium concentration in ground water depends on lithology and other geological conditions of the region and also contamination from human activities such as the use of phosphate fertilizers, mining, and combustion from coal or other fuels. The natural weathering of rocks such as granite dissolves the natural uranium, which goes into groundwater by leaching and precipitation called illumination process [2]. Nuclides of uranium emit alpha rays of high ionization power and therefore it may be hazardous if inhaled or ingested[3]. Radon in groundwater could be derived from two different sources radioactive decay of dissolved radium and direct release from the uranium and thorium decay series[4].

Two major sources of radioactive elements in water can be distinguished:

1- Infiltration of the naturally occurring radionuclide in the uranium and thorium decay series in rocks and soils.
2- Contamination of the natural environment resulting from man-made sources of radiation and radioactive wastes which are released to the environment.

According to the Environmental Protection Agency, drinking uranium-rich water over many years may cause kidney damage and increase the chances of getting cancer because of non-biodegradable natures of uranium[5].The provisional guideline value for tolerable daily intake of uranium for drinking water is 30µg/l[6].

The EPA has estimated that the additional lifetime risk associated with drinking water that contains 30µg/l, the MCL for uranium, is about 1 in 10,000. This increased risk should be viewed in the context of current cancer statistics. Consuming drinking water containing uranium at the MCL permitted under the Safe Drinking Water Act might increase the number of deaths in the 10,000 individuals so exposed by one. The greatest risk from radon in drinking water is from the radon that escapes to the indoor air[7].

The aim of this work is to determine the radon and uranium concentrations in ground water used for drinking and other purposes by SSNTD technology in order to estimate the corresponding radiation dose received by peoples lived in Aucashat city and to assess the contribution from radon in water to the total environmental radon level.

MATERIALS AND METHODS

Samples of ground water from western sector of the country was taken and from chosen sites of Aucashat (phosphate mines), (phosphate state Establishment). The well water samples obtained from different depth-well (water-bearing levels), i.e. shallow well (well depth under 10 m) water, middle well (well depth 10–30 m) water and deep well water.

Fission track registration technique was used for the assessment of uranium concentration level in the ground water samples. A known volume of water samples and standard solution few drops (~ 2 drops) was dropped on CR-39 track detector, water droplets are allowed to evaporate on the detectors in dust free environment at normally room temperature, this leaves a thin residue of non-volatile constituents, the detector was then covered with a second piece of the detector on both sides and were put in a plate of paraffin wax at a distance of 5 cm from Am–Be neutron source with thermal flounce ($3.0249x10^{9}n.cm^{-2}$), to registration fission tracks to the detectors due to $^{235}U(n, f)$ reaction as shown in Fig 1., after irradiation, the CR-39 detectors were etched in 6.25 N NaOH at temperature of $60^{o}C$ for 6 h, the detectors were then rinsed in distilled water and then dried. The developed fission tracks were scanned using an optical microscope at a magnification of 400X.

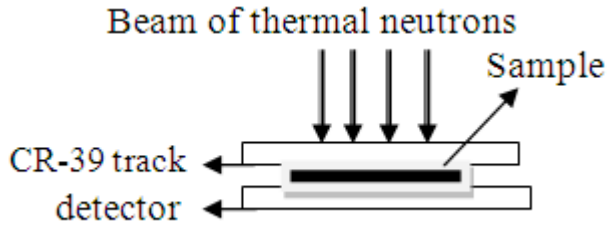

Fig 1: Schematic representation of the Neutron Induced Fission Technique used for uranium determination in ground water.

The natural exposure method using the sealed cup technique was used for radon estimation as shown in Fig2. (0.25 litter) of each sample and standard samples of water of known concentration prepared from Uranium Acetate $[(CH_3COO)_2.UO_2.2H_2O]$, were put in cylindrical plastic cans, CR-39 track detectors size (2x2) cm^2 was put at the ceiling of the can at a distance of (9cm) over the water sample and closed very tightly. After two month of exposure CR-39 detectors were chemically etched in 6.25 N NaOH solutions at $60^{o}C$ for 6 h, the detectors were washed by distilled water, and then dried, the density of tracks was calculated by optical microscope at a magnification of 400X.

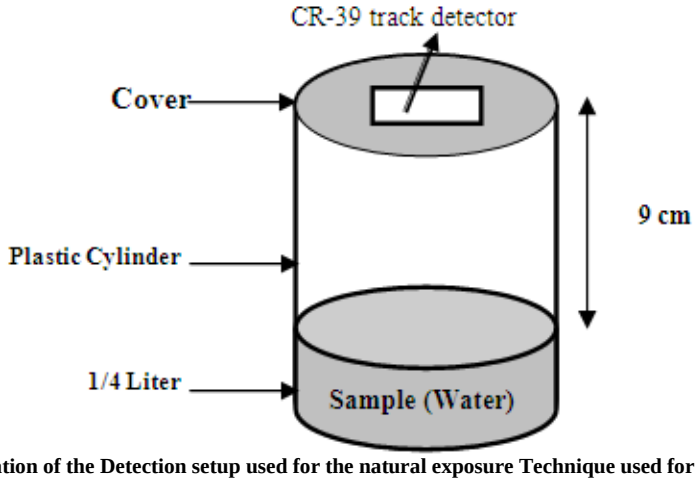

Fig. 2: Schematic representation of the Detection setup used for the natural exposure Technique used for radon determination in ground water

Calculations

Uranium concentrations in the water samples were determined using the formula[8];

$$Ux = Us\ \rho x/\rho s\ Is/\ Ix\ .Rs/\ Rx$$

where the subscripts x and s stand for the unknown and the standard, respectively; U, is the uranium content; ρx and ρs are the densities of the fission tracks for the unknown and the standard samples, respectively; I: is the isotopic abundance ratio of ^{235}U to ^{238}U; and R: is the range of fission fragments in mg cm^{-2}. The correction factor (Rs/Rx) is taken to be unity. Similarly, taking (Is/Ix) as unity, the equation becomes

$$Ux/Us = \rho x/\rho s$$

Radon concentrations in the water samples were determined using the formula[8];

$$Cx = Cs\ \rho x/\rho s$$

where the subscripts x and s stand for the unknown and the standard, respectively; C, is the radon content; ρx and ρs are the densities of the tracks.

The relation of uranium concentration and track densities in standard samples are shown in Fig.3 and the relation of radon concentration and track densities shown in Fig4.

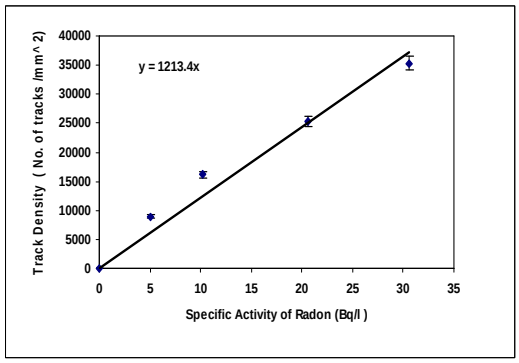

Fig.3: Track density versus radon concentration in standard samples

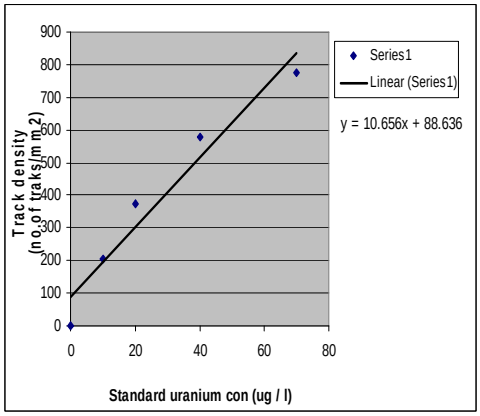

Fig 4: Track density versus uranium concentration in standard samples

RESULTS AND DISCUSSION

The results of uranium concentration in ground water in Aucashat city are shown in Table 1., it may be seen that uranium concentration in ground water varied from 8.8±0.12 to 12.63±0.19µg/l with an average 10.23±1.3 µg/l.

The results of radon content in ground water are shown in Table 1., it can be seen that radon concentration varied from 8.02 ± 0.14 to 11.7±0.16 $kBqm^{-3}$ with an average 9.35±1.24$kBqm^{-3}$. Currently, the ^{222}Rn concentration in drinking water is not regulated, but the US Environmental Protection Agency (EPA) has proposed a maximum

Contaminate level (MCL) of 11Bql^{-1} (300pCil^{-1})[7].

The results show that higher concentration of uranium and radon/thoron was in sample (4). The reason for radon concentrations could be a function of geological structure of the city, depth of the water, source and also difference in the climate, due to the nature of place, where the specific concentration of the natural uranium and radium–226 in the soil, which is said to be the reason of high concentration especially in sample 4. The water found in and adjacent to uranium ore body in groundwater is naturally contaminated and unsuitable for drinking.

The radiation dose due to radon can be divided into two parts, namely, the dose from ingestion and the dose from inhalation. For the ingestion part, we see that radon and its daughters in drinks impart a radiation dose to the stomach. The annual effective dose to an individual consumer due to intake of radon from drinking water is evaluated using the equation[9];

$D_W = C_w C_{Rw} D_{cw}$

Where, D_W is the annual dose (Sv/y) due to ingestion of radionuclide from the consumption of water which equal to 730 ly^{-1}. C_w is the concentration of radon in the ingested drinking water (Bq/l). D_{cw} is the ingested dose conversion factor for radon (Sv/Bq), The conversion factor[4], that we used for our calculation was D = 14.4 µSv kBq^{-1} ^{222}Rn.

The calculated annual effective dose for the stomach is presented in Table 2.

Table 1: uranium and radon concentrations in ground water in Aucashat city

Sample	Uranium concentration µg/l	Radon/Thoron concentration kBqm^{-3}
S1	10.16±0.18	9.25±0.11
S2	9.8±0.12	8.88±0.21
S3	10.4±0.16	9.49±0.14
S4	12.63±0.19	11.7±0.16
S5	9.6±0.17	8.75±0.12
S6	8.8±0.12	8.02±0.14
average	10.23±1.3	9.35±1.24

Table 2: Annual Effective Dose (mSvy^{-1})

Sample	Stomach (ingestion)	Lung (inhalation)	Whole body
S1	0.97	2.6	3.57
S2	0.93	2.48	3.41
S3	1.0	2.65	3.65
S4	1.23	3.28	4.51
S5	0.92	2.45	3.37
S6	0.84	2.25	3.09

Table 3: Status of ground water uranium in different countries

Country	Name of the city/state	Year	Concentration of uranium reported
USA [10]	Kleberg County, Texas	2011	160 and 771 ppb
USA [11]	Grand Junction, Colorado	2010	0.11 mg/l(MCL= 0.044 mg/l)
Japan [12]	Malvesi conversion plant	2008	110-200µg/l
Australia [13]	Queensland	2011	0.71 Bq/l
India [14]	KaramgarhSatran, Dhillawan,Giana and Guddavillages of Bathinda, Punjab		644 µg/l, 463.6 µg/l, 292.65 µg/l and 165.85 µg/l respectively
India [15]	Jaduguda, Jharkhand	2011	3.5-208 mBq/l
India [3]	Sirsa and Bhiwani, Haryana	2011	19.14µg/l
India [16]	Peddagattu and Seripalli, Andhra Pradesh	2010	0.2-118.4 ppb
China [17]	Hengyang, Hunan Province	2008	20mg/l
China [18]	Seoul Gyeonggi and Daejeon, South Korea	2004	322 µg/l and 402.30 µg/l respectively
Pakistan [19]	Muzaffarabad and Reshian	2004	0.03-6.67 µg/l
Bangladesh [20]	Bualda, Fulbaria, Jamjami, and Komlapur	2009	< 0.2-10 µg/l

For the inhalation part, we know that the dissolved radon is a source of indoor radon, and its contribution will depend on the radon concentration, usage rate, the volume of the indoor environment and the air exchange rate. According to the UNSCEAR report[22], 1 Bqm^{-3} of radon in air, with an equilibrium factor of 0.4 and an occupation factor of 0.8, gives an effective dose to the lung of 28µSvyear^{-1}[4]. Assuming the ratio between the radon concentration in air released from water to that in water to be 10^{-4}[4], the conversion factor from unit concentration

of radon at equilibrium is 2.8 μSvy^{-1}Bq^{-1} m^3. The annual effective dose for the lung and for the whole body received by peoples resulting from radon concentration in ground water and drinks was shown in Table 2.

The results of the research in different countries were agreement with the results of groundwater uranium of different countries as given in Table 3.

CONCLUSION

The uranium concentration in ground water and the annual effective dose have been estimated in Aucashat city using an integrating etched track detector. The values of uranium concentration average radon concentration in natural mineral water samples is the highest, but this is still below the US EPA's proposed limit of 11 Bq 1-l.

REFERENCES

[1] Simsek, C., Turkey *Environ Geol* **2008**,55, 1637.
[2] Singh H., Singh J., Singh S. Bajwa B.S., *Indian J. Phys.*,**2009** 83(7),1039.
[3] Kansal S., Mehra R., Singh N.P., *J.Public Health and Epidemiol*. **2011** 3(8), 352.
[4] Yu K. N., Guan Z. J., Stokes M. J. Young E. C. M., *Applied Radiation and Isotopes*,**1994,**45,809.
[5] Jagtar Singh, Shweta Sinha, *IJPAES*, **2012**, 2(1),112.
[6] World Health Organization Guidelines for drinking-water quality, **2011**, 4th Edition.
[7] Environmental Protection Agency (EPA) regulations *Final Rule for Non-Radon Radionuclides in Drinking Water*, Technical Fact Sheet, EPA, **2000**, 815-F-00-013.
[8] Fleischer R.L., Price P.B., R.M., Walker Nuclear Tracks in Solids, Principles and Applications. University of California Press, Berkeley, (USA), **1975**
[9] Alam M. N., M. I. Chowdhry, M. Kamal, S. Ghose, M. N. Islam Waruddin M. A., (1999), *Radi. Prot. Dosim.*,**1999**, 82,207.
[10] Yaneth, G., Waldy, F. and Lee W.C., Survey of groundwater concentrations of uranium, radon and other constituents in Kleberg County, (2011)
[11] Uranium mill tailings radiation control act Title I disposal sites-Grand Junction, Colorado, disposal site. 2009 Annual Site Inspection and Monitoring Report, LMS/S05884. **2010**.
[12] Uranium concentration in surface waters near Malvesi conversion plant exceeds WHO drinking water guidance available at http://www.wise- uranium.org/epfr.html., **2011**.
[13] Kleinschmidt, R., Black, J. and Akber, R., *J Environ Radioact*., **2011**,102(3), 235.
[14] Groundwater uranium level 20 times higher than normal in Bathinda village, Global Sikh News. Available at http://www.sikhsangat.org/2011/10/groundwater-uranium-level-20-timeshigher-than-normal-in-bathinda-village/,**2011**.
[15] Tripathi, RM., Jha, V.N., Sahoo, S.K., Sethy, N.K., Shukla, A.K., Puranik, V.D. and Kushwaha, H.S., India, *Radiat. Prot.Dosimetry*., **2011**.
[16] Brindha, K., Rajesh, R., Murugan, R., Elango, L.N. and Nair, R.N. Spacial and seasonal variation in groundwater level and uranium concentration in Peddagattu and Seripalli area of Nalgonda district, Andhra Pradesh, India, 17th Nation Symposium on Environment,**2010**.
[17] Qing-liang, W., De-xin, D., E-ming, H., Run-lan, Y. and Guan-zhou,Q., *bacteria.Trans.Nonferrous. Met. Soc*. China, **2008**,18,1529.
[18] Kim, Y-S., Park, H-S., Kim, J-Y., Park, S-K., Cho, B-W., Sung, I-H. and Shin, D-C., *J. Env. Radioact*. **2004**, 77(1), 77.
[19] Akram, M., Khattak, N.U., Qureshi, A.A., Iqbal, A., Tufail, M. and Qureshi, I.E., *Health Phys*., **2004**, 86, 296.
[20] Frisbie, S. H., Mitchell, E. J., Mastera, L.J., Maynard, D.M., Yusuf, A. Z., Siddiq, M.Y., Ortega, R., Dunn, R. K., Westerman, D. S., Bacquart, T. and Sarkar, B. *Environ Health Perspect*, **2009**, 117(3), 410.
[21] United Nations Scientific Committee on the effects of Atomic Radiation, *Sources, Effects and Risks of Ionizing Radiation.* Report to the General Assembly, pp. 2479. United Nations, New York., **1988**.