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Environmental Radioactive Contamination Assessment in the Water Samples of Nineveh Province

Naturally occurring radioactive and poisonous heavy metals, radium, and uranium with liquid and solid meals and collect in the, liver, kidneys, and bones while radon collect in the lung, where these metals can cause cancer. The obtained mean radon concentrations in tap and private well waters were 0.0430 and 0.1317 Bq.l^{-1} respectively. Total intake uranium is dependent mostly on the uranium content in the consumed water. The mean uranium concentrations in tap and private well waters were 8.8406 and 27.076 µg l^{-1}, whereas these values were below of 30 µg.l^{-1} the limit according to guidelines of WHO. This indicates that the risk of increased uranium intake from drinking tap water is almost very low. The excess cancer risk is 0.1222 and 0.3745 x10^{-4} indicates that the probability of 12 and 37 per million people will die by uranium intake from water which is very low so the studied area is safe.

Keywords: Radioactive pollution; Uranium; Well waters; Excess cancer risk
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1. Introduction

The uranium is a heavy and radioactive metal is found in the natural world. While most sources believe that radioactive decay has a detrimental biological impact [1-3], some sources assert that low radiation has a beneficial influence on living processes [4]. In comparison to the parent material, the soil natural background values for uranium range from 0.79 to 11 mg kg^{-1} [5]. Leaching from the natural deposits or from anthropogenic activities like nuclear power, mining, the disposal of the medical waste and industrial, and the use of phosphate fertilizers in agriculture can all result in elevated uranium concentrations in environmental compartments [6-11]. Inhalation, ingestion, or skin contact by humans or animals exposed to uranium compounds may result in harmful health effects. Although skin contact with uranium poses a special risk to those employed in the uranium industry, ingestion and inhalation are likely routes of infection for larger segments of the populace residing in uranium-polluted areas. Uranium is ingested by drinking water and by way of food chains that include crops, animal products, and animal feed. The sensitivity of mammals to Uranium is especially strong [12]. After entering the body, uranium is moved to the extracellular fluids and then to other organs via the blood. Uranyl, in its soluble state, is carried and combines with anions and proteins to form complexes. The uranium is tends to build up in body, primarily in the bones, liver, kidneys, and spleen. Radiological and chemical dangers are associated with exposure to uranium. Given that uranium contributes only slightly to the total amount of radioactivity in the environment, it is undoubtedly a negligible cause for concern [13]. After uranium is absorbed by organism and integrated into its bones and tissues, this evaluation must be reevaluated. Cancer is the most notable harm that comes with low and medium exposure levels [14]. Uranium contaminations pose a significant risk to kidney health due to their peak concentrations during the excretion process. These risks are associated with the binding of uranium to organic molecules. The amount of uranium that is accumulated in the body is directly correlated with the amount of uranium that is inhaled in solid and liquid food. The amount of uranium that accumulates increases with age in an individual. This suggests that the likelihood of suffering harm from uranium usually rises with exposure duration and, consequently, and the limit of 30 µg l^{-1} according to WHO guidelines [15]. Keeping the daily uranium intake as low as feasible is necessary to minimize the risk of contracting uranium-related hazards, given that the ingestion of uranium cannot be prevented and there is no the lower limits for harmful effects from the uranium [16]. The quality of the drinking water is one of the constants in human existence household taps are connected to clearly defined private wells or public suppliers.

It was believed that the main factor impacting people' was the amount of uranium in drinking water. The research effort detailed here aimed to investigate the effects of different sources of water on metropolitan populations.

2. Experimental Part

Samples were taken from both private wells and the tap water. Very seldom is well water utilized for human consumption; instead, it is used to irrigate gardens. In the event that the water supply from the water works fails, the various water of wells have been examined to provide an indication of the water supply quality in a restricted region as in (Fig. 1).

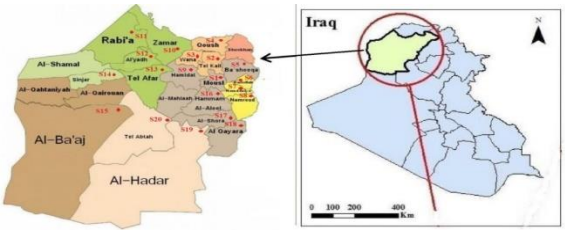

Fig. (1) The site map of samples

Measurements of the CR-39 detector are made using a plastic can radon dosimeter (7 cm in diameter and 10 cm in length). The detector is put on the bottom of the dosimeter cover and is used to measure the concentration of radon in the samples, shown in (Fig. 2). Samples with a volume of 115.4 ml and a height of 3 cm were placed in the dosimeter; the distance from the water samples to the surface of detector was 7 cm. Samples were filled and kept in the plastic can for duration of 60 days. Following a 60-day exposure period, the detectors were taken out of the dosimeter and etched chemically in a 6.25N solution of NaOH at 70°C for seven hours. Utilizing a 400x optical microscope, the tracks were counted.

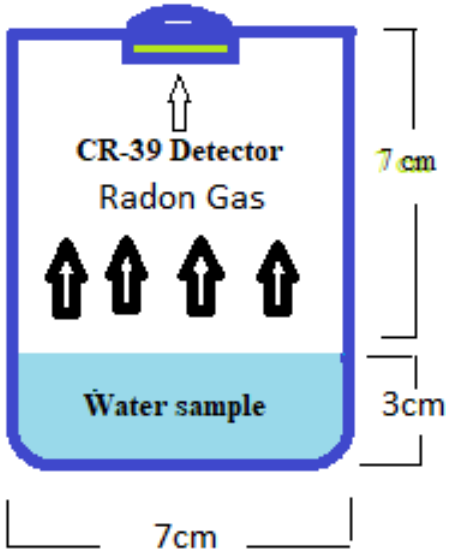

Fig. (2) The dosimeter

The radon concentration in the air volume within the container, as determined from the equation [17]

$$C_{Rn=}\rho[KT]^{-1} \quad (1)$$

K= 0.05916 Tr/cm^2.d/Bq/m^3; is the radon dosimeter utilized in this study's CR-39 detector calibration factor; ρ is the density of tracks; T is exposure period [18]

Radon concentrations in water samples determined using the formula [19]

$$C_S = \lambda_{Rn} C_{Rn} HT[l]^{-1} \quad (2)$$

where C_S is the radon concentration in water samples (Bq/m^3), C_{Rn} is the radon concentration in air space (Bq/m^3), and λ_{Rn} is the radon constant of decay (0.1814 day^{-1}), the T stands for exposure time (60 days), H is for height of air gap in the plastic can (7 cm), and l stands for sample thickness (3 cm)

The uranium contents were calculated by the secular activity equilibrium between the uranium and its daughters, and the concentration of radon measured with using the CR-39 detector. Activity of radon A_{Rn} in sample may calculated thanks to the correlation between C_{Rn} and the amount of radon in the sample [20]

$$A_{Rn} = C_{Rn} V \quad (3)$$

The sample volume is ($V=\pi r^2 L$) = 115.4 X 10^{-6} m^3 = 115.4 mL, its thickness is l = 0.03 m, and its radon dosimeter radius is r = 0.035 m

$$\lambda_{Rn} N_{Rn} = A_{Rn} \quad (4)$$

The equation of the equilibrium between the uranium with its daughter (the uranium activity equals the activity of radon) was used to compute the uranium atoms number (N_U) in samples [21].

$$\lambda_U N_U = \lambda_{Rn} N_{Rn} \quad (5)$$

In this case, the uranium decay constant is λ_U = 4.883X10^{-18}s^{-1}. The uranium atom number N_U was then used to compute the uranium weight in samples using the equation

$$W_U = \frac{N_U a_U}{N_{avo.}} \quad (6)$$

where W_U is measured in micrograms (µg), N_{avo}= (6.02X10^{23}atom/Mol) is number of Avogadro, a_U is uranium mass number 238. Uranium content, determined by [22]

$$C_U = \frac{W_U}{W_S} \quad (7)$$

C_U represents the uranium concentration in (µg/L) units, with Ws equal to 115.4 mL.

Calculating excess risk of cancer: radiological risk evaluation, radioactive risk based on the specific activity (activity per unit of weight) or activity concentration of radiation. In the case of uranium equation (7) is used to compute Ac, or uranium activity concentration in (BqL^{-1}) unit, in the form

$$Ac = \lambda_U N_{avo.} [At_U]^{-1} C_U \quad (8)$$

The increased risk of cancer due to uranium in water, as determined by the provided method of [23].

$$ECR = AcR \quad (9)$$

According to BqL^{-1}, R is a risk factor, and ECR is the excess cancer risk. The factor of risk R associated with the ingestion of uranium via water is determined by multiplying the per capita activity intake (I) by the uranium risk coefficient (r) (1.19×10^{-9}) Bq^{-1} for death. Where (I) for uranium computed as the product of daily water consumption of 4.05 L day^{-1} and life expectancy of 63.7 years, or 23250 days [24]. The

factor of the risk value R= r×I=1.19×10^{-9} Bq^{-1}×94162.5 L=1.12×10^{-4} LBq^{-1} when I = 4.05 $Lday^{-1}$×23250 day=94162.5 L.

3. Results and Discussion

Results of the water samples collected the various study locations are listed in table (1). Table (1) includes information on the concentration of radon in water samples C_{Rn} in units of Bq/L, the concentrations of uranium in the samples of water C_U in (µg/L), and the exceed cancer risk ECR. In tap and well water samples from the Nineveh Province, concentration levels of radon gas range from 0.0236 to 0.0607Bq/L for tap water, and 0.0708 to 0.1517 Bq/L in well water, due to variations in geological characteristics, the amount of radon in the samples of water varied from one place to another. Every detected concentration of radon in the samples of water was below the safe internationally recommended concentration limit, indicating that long-term exposure to high amounts of danger does not have a negative impact on health. The permissible limit of radon in drinking water for humans, as suggested by the agencies of health and environmental protection, is 4–40 Bq/L [25], the maximum radon contamination level in the drinking water, from to the US Environmental Protection Agency, is 11 Bq/L. The measurements results of radon in the drinking samples of water that were collected are safe. Results showed that, on average, the concentrations of uranium in units of µg/L, which averaged 8.8406 µg/L and 27.076 µg/L for tap and well water respectively, shown in (Fig 3), were generally lower than the standard level rate of uranium concentrations in the drinking water, which was set at 30 µg/L according to WHO guidelines, still not dangerous. Surface waters are mostly supplied by precipitation, which explains why their uranium level is lower than that of mineral waters [26]. Deeper layers of the earth's crust are home to many heavy minerals that contain radioactive nuclides; granite rocks, in particular, often have uranium concentrations of less than 1%. As a result, uranium concentrations in lower-depth water are anticipated to be higher than in surface water [27]. Water from very deep depths loses radioactivity when it rises to the earth's surface because of a mechanism Yoshida et al. [28]. Simplified, this procedure utilizes a mechanism similar to that seen in chromatography, whereby heavy molecules remain behind lighter ones in a stream passing down a column. Nevertheless, in an attempt to boost a source's yield, boosting the flow through a column weakens the separation process and therefore increases the amount of heavier radionuclides transferred to the surface. This is comparable to forcing mineral water through a pump.

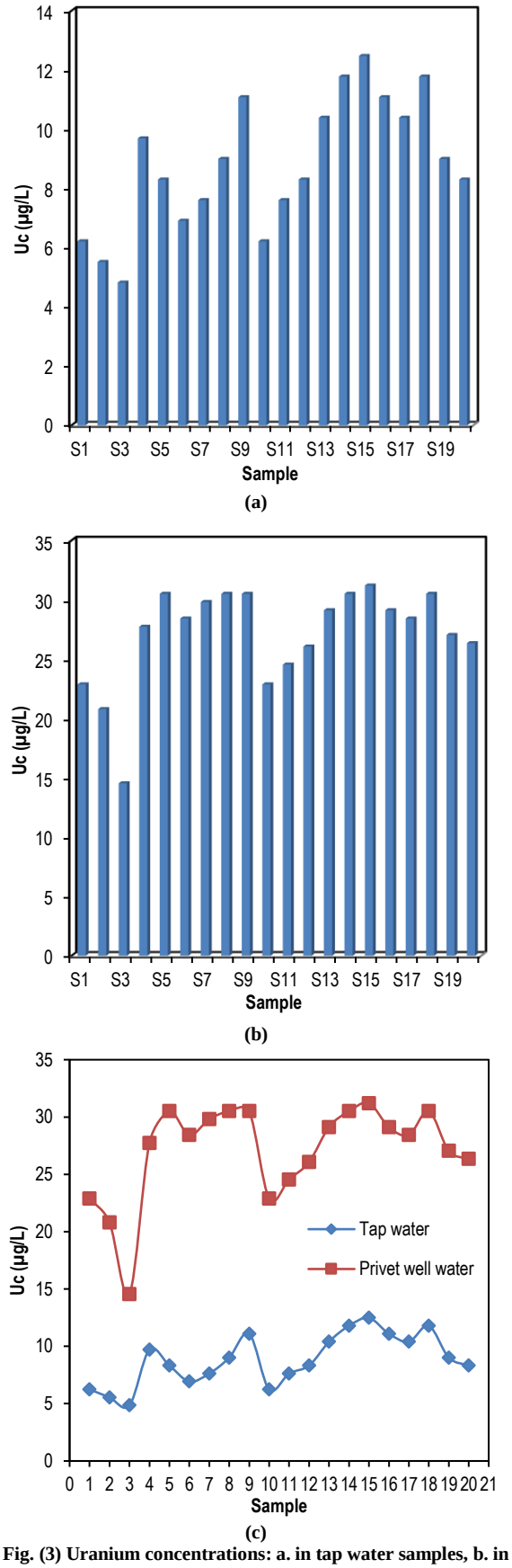

Fig. (3) Uranium concentrations: a. in tap water samples, b. in well water samples, c. the comparison between tap and well waters

With the mean value 0.1222 x10^{-4}, 0.3745 x10^{-4} for tap and well water indicates that the probability of 12 and 37 per million people will die by uranium intake from water which is very low so the studied area is safe. The water in these places poses a risk of cancer to 12 and 37 per million residents. Although there is no risk to human life, the high incidence of uranium availability in particular areas poses a risk to public safety and health. Similar to high-level radon exposure, significant health impacts associated with uranium have been seen; no treatment is necessary.

4. Conclusion

High radiation content water is one of the study area's causes of public health risks. The findings might be used to determine the background levels of uranium and radon in tap and well water, as well as to determine the uranium's impacts on cancer risk (ECR). The mean radon concentrations in tap and well waters were 0.0430 and 0.1317 Bq l^{-1} respectively. The mean uranium concentrations in tap and private well waters were 8.8406 and 27.076 µg l^{-1}, whereas these values were below the limit of 30 µg l^{-1} according to WHO guidelines. This indicates that the risk of increased uranium intake from drinking tap water is almost very low. The excess cancer risk is 0.1222 and 0.3745 x10^{-4} meaning that the water in these places poses a cancer risk to 12 and 37 out of every million residents for tap and well water respectively, by uranium intake from water which is very low so the studied area is safe.

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Table (1) The radon concentrations, and the annual effective dose, uranium activity concentrations, and the exceed cancer risk

No	Location	Tap water			Privet well water		
		C_{Rn} (Bq/L)	C_U (µg/L)	ECR x 10^{-4}	C_{Rn} (Bq/L)	C_U (µg/L)	ECR x 10^{-4}
S1	Mosul	0.0303	6.2404	0.0863	0.1112	22.881	0.3164
S2	Telkaif	0.0269	5.5470	0.0767	0.1011	20.801	0.2877
S3	Wana	0.0236	4.8536	0.0671	0.0708	14.561	0.2014
S4	Al-Qoush	0.0472	9.7073	0.1342	0.1349	27.735	0.3836
S5	Ba'sheeqa	0.0404	8.3206	0.1150	0.1483	30.508	0.4219
S6	Bartellah	0.0337	6.9338	0.0959	0.1382	28.428	0.3932
S7	Al-Hamdaniya	0.0370	7.6272	0.1055	0.1450	29.815	0.4124
S8	Al-Namroud	0.0438	9.0139	0.1246	0.1483	30.508	0.4219
S9	Al-Hamidat	0.0539	11.094	0.1534	0.1483	30.508	0.4219
S10	Zummar	0.0303	6.2404	0.0863	0.1112	22.881	0.3164
S11	Rabia'a	0.0370	7.6272	0.1055	0.1194	24.552	0.3396
S12	Al-Iyadiah	0.0404	8.3206	0.1150	0.1268	26.071	0.3606
S13	Talla'far	0.0505	10.400	0.1438	0.1416	29.122	0.4028
S14	Sinjar	0.0573	11.787	0.1630	0.1483	30.508	0.4219
S15	Al-Ba'aj	0.0607	12.480	0.1726	0.1517	31.202	0.4315
S16	Hammam Al-Aleel	0.0539	11.094	0.1534	0.1416	29.122	0.4028
S17	Al-Shora	0.0505	10.400	0.1438	0.1382	28.428	0.3932
S18	Al-Qayara	0.0573	11.787	0.1630	0.1483	30.508	0.4219
S19	Al-Hadar	0.0438	9.0139	0.1246	0.1315	27.041	0.3740
S20	Telabtah	0.0404	8.3206	0.1150	0.1281	26.348	0.3644
	Min	**0.0236**	**15.254**	**0.2109**	**0.0708**	**45.763**	**0.6329**
	Max	**0.0607**	**39.225**	**0.5425**	**0.1517**	**98.064**	**1.3564**
	Mean	**0.0430**	**8.8406**	**0.1222**	**0.1317**	**27.076**	**0.3745**

