Aaraf Kh. Thannon [1]
Malik H. Kheder [2]
Yasir Y. Kassim [3]
Hanaa N. Azeez [2]

[1] *Department of Sensing and Nano-Photonics, Laser and Photonics Research Center, University of Al-Hamdaniya, Al-Hamdaniya, IRAQ*
[2] *Department of Physics, College of Education for Pure Sciences, University of Al-Hamdaniya, Al-Hamdaniya, IRAQ*
[3] *Department of Physics, College of Education for Pure Sciences, University of Mosul, Mosul, IRAQ*

Environmental and Radioactive Contamination in the Village of Kabarli in the Nineveh Plain Region in Iraq

Radioactive pollution in the environment is produced by uranium and its progeny. The obtained value of average radon concentrations levels in soil was 164.640 Bq/m^3, for water samples was 208.950 Bq/m^3. Total intake uranium is dependent mostly on the uranium content in the consumed water. The mean uranium concentrations value for soil samples was 18.130 µg/kg, and for water samples average was 21.255 µg/kg, were generally lower than the standard level rate of uranium concentrations in the drinking water, which was set at 30000 µg/kg according to WHO guidelines, still not dangerous. The findings show that the values of the water samples are greater than those of the soil samples because the water originated in the earth's crust's deeper layers, which are home to a large number of heavy minerals that contain radioactive nuclides. 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. The studied area is safe.

Keywords: Uranium; Radioactive pollution; Soil pollution; Water pollution
Received: 06 April 2024; **Revised:** 23 April 2024; **Accepted:** 30 April 2024

1. Introduction

Environmentally damaging battles were fought in Iraq, and there is a connection between those conflicts and an increase in cancer cases, as well as a predicted rise in these diseases in the future due to the pollutants from those conflicts [1]. The environment was impacted by these conflicts in both direct and indirect ways. Chemicals used in warfare as well as garbage and pollution from bombs and missiles were among the immediate effects. Infrastructure damage, however, pointed to the indirect effects [2] Uranium and its byproducts constitute the most major waste contaminant. The heaviest and longest-living element is uranium. Because of its radioactivity, it is one of the most dangerous pollution issues. Because uranium and its compounds are so poisonous, they are dangerous for the environment and human health [3,4]. One of the most prevalent elements in nature, uranium can be found in a variety of solid, liquid, and gaseous forms. It can be found in food, water, air, rocks, soil, and natural materials. With ease, uranium may combine with other elements to form carbonates, silicates, hydroxides, and uranium oxide [5]. The solubility of uranium compounds largely determines their physiological action. While insoluble (less soluble) uranium is regulated because of its radioactive characteristics, soluble uranium is controlled because of its chemical toxicity. However, rather than the potential for serious chemical damage to the renal system, its primary harm will be radiological damage (risk of cancer mortality) to internal organs due to its delayed absorption through the lungs and prolonged retention duration in the body tissues [6]. The human body can absorb uranium in a variety of ways. It can enter the body directly by ingesting uranium-contaminated water or by inhaling uranium-containing dust particles. Additionally, it may inadvertently penetrate via the layer of fertile soil and the food chain [7]. Soil is a major natural source of radioactivity because of its mineral richness. It also makes people more vulnerable to radiation and helps release radioactive materials into the environment. For these reasons, soil's inherent radioactivity is thought to be a key sign of radioactive contamination [8]. Concentration of radionuclides in soil is a primary indicator of natural background radiation [9]. Different types of soil can have dramatically varied natural radioactivity levels. One of these naturally occurring radionuclides that has been on Earth since the beginning is uranium. All uranium isotopes are radioactive, hence there needs to be control over their quantity [10]. Water is the other fundamental element for life, along

with soil, and its supply and continued existence depend on other elements. The direct comprehensiveness of the water is essential to the existence of a wide variety of living organisms and is also necessary to meet their demands. Water is useful to humans since it may be used for food and drink, direct cleanliness, and maintaining good health. But we can't deny that contaminated water can spread illness [11]. Growing water use coupled with population growth indicates that the risk of uranium poisoning typically increases with exposure time and, as a result, the limit of 30 µg/L. When compared to the parent material, the natural background values of uranium in soil range from 0.79 to 11 mg/kg as per WHO guidelines [12]. Keeping daily uranium intake as low as feasible is necessary to minimize the danger of developing uranium-related hazards because uranium ingestion cannot be avoided and the negative effects of uranium have no lower limit [13].

The study aimed to measure the environmental and radioactive contamination, as uranium and its progeny radium and radon in soil and water samples of the Kabarli village thought it has cancer risks.

2. Experimental Part

Samples of soil and water were taken from village of Kabarli. Measurements with 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 radon concentration in samples, shown in (Fig. 1).

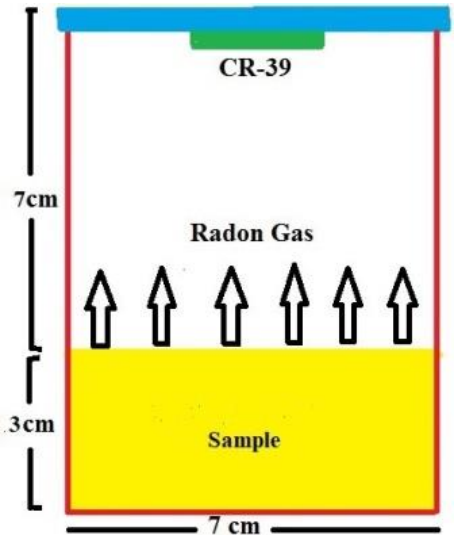

Fig. (1) The dosimeter

Samples with a volume 115.4x10^{-6} m^3 and the height of 3 cm were placed in 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.

The concentration of radon in the air volume within the container, as determined from the equation [14].

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

where 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, and T is exposure period [15]

Radon concentrations in water samples determined using the formula [16]

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

where C_S is the radon concentration in samples (Bq/m^3), C_{Rn} is the concentration of radon 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 [17]

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

The volume of sample volume is ($V=\pi r^2 L$) 115.4x10^{-6} m^3, its thickness (L) is 0.03 m, and its radon dosimeter radius (r) is 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 [18]

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

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 is determined by [19]

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

Here, C_U represents the uranium concentration in (µg/kg) units, with W_S equal to 200g for soil and 170g for water

3. Results and Discussion

Outcomes of soil and water samples are listed in table (1), which contains data on the amounts of uranium in the samples C_U in (µg/kg) and radon in the samples (C_{Rn} in units of Bq/m^3). Radon concentration levels in soil ranged from 131.532 to

209.102 Bq/m^3 with average value 164.640 Bq/m^3, and for water samples ranged 152.990 to 236.770 Bq/m^3 with average value 208.950 Bq/m^3. The level of radon in the water samples was higher than in the soil samples because of differences in the earth's geological features. This is because the water comes from deep underground mining, where mineral metals were present in its journey. The US Environmental Protection Agency's recommended acceptable international concentration limit for radon contamination of drinking water is 11000 Bq/m^3, which is lower than any measured radon concentration in the samples. The uranium concentrations ranged from 14.484 to 23.026 µg/kg on average 18.130 µg/kg for soil samples and from 15.562 to 24.085 µg/kg on average 21.255 µg/kg for water samples, as illustrated in Fig. (2), were generally lower than the standard level rate of uranium concentrations in drinking water, which was set at 30000 µg/kg in accordance with WHO guidelines, but still not dangerous.

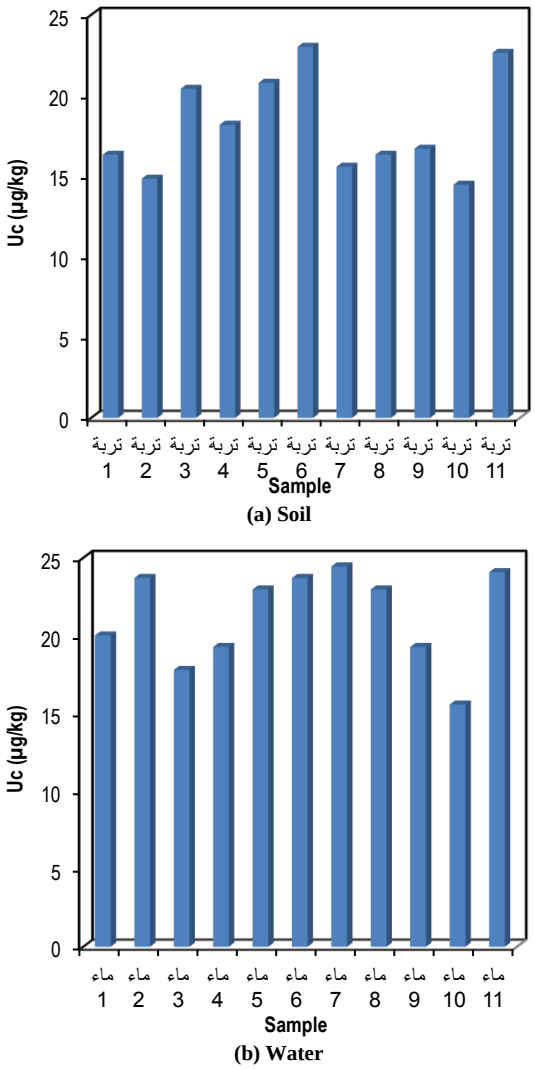

Fig. (2) Uranium concentrations: (a) in soil samples, and (b) in water samples

The findings demonstrated that the water samples had greater values than the soil samples. Radioactive nuclides can be found in many heavy minerals found in the Earth's deeper crustal layers. Public safety and health are at danger due to the high prevalence of uranium availability in certain places, even if there is no harm to human life. Significant health effects linked to uranium have been observed, akin to high-level radon exposure; treatment is not required.

4. Conclusion

The objective of this investigation was to measure the levels of radiation and uranium in soil and water samples from the Iraqi village of Kabarli, which is located in the Nineveh plain. Water with a high radiation level is one of the research area's sources of dangers to the public's health. This makes figuring out the radiation levels in the surrounding important. The study location is safe since the danger of increased uranium intake from drinking tap water is practically very minimal due to very low uranium intake from water.

References

[1] H.K.A. Ridha and J.S. Al-Safi, "The future vision to the cancer incidence in Iraq, a comparative analytical study to the effect of Iraq-Iran war", *Baghdad Coll. Econ. Sci. Uni.*, 25 (2010) 91-102.

[2] K.M. Muhannad, "Risk assessment related to contamination of terrestrial food chains by atmospherically deposited lead particles", *Al-Mustansiriyah J. Sci.*, 21(3) (2010) 103-116.

[3] A. Al-Hamzawi, M. Jaafar and N. Tawfiq, "Concentration of uranium in human cancerous tissues of Southern Iraqi patients using fission track analysis", *J. Radioanal. Nucl. Chem.*, 303(3) (2015) 1703-1709.

[4] W. Zou et al., "Characterization and properties of zeolite as adsorbent for removal of uranium (VI) from solution in fixed bed column", *J. Radioanal. Nucl. Chem.*, 288(3) (2011) 779-788.

[5] D. Banks et al., "Radioelement (U, Th, Rn) concentrations in Norwegian bedrock ground waters", *Enviro. Geo.*, 25(3) (1995) 165-180.

[6] P. Todorov and E. Ilieva, "Contamination with uranium from natural and anthropological sources", *Romanian J. Phys.*, 50(9-10) (2005) 25-30.

[7] A. AL-Hamzawi et al., "Uranium concentration in human blood using fission track etch technique", *J. Nat. Sci. Res.*, 13 (2013) 176-181.

[8] S. Rahman and M. Faheem, "Natural radioactivity measurements in Pakistan an overview", *J. Radiol. Prot.*, 28 (2008) 443.

[9] K. Kapanadze, A. Magalashvili and P. Imnadze, "Distribution of natural radionuclides in the

soils and assessment of radiation hazards in the Khrami Late Variscan crystal massif (Georgia)", *Heliyon*, 5(3) (2019).
[10] G. Graetz, "Energy for whom? Uranium mining, Indigenous people, and navigating risk and rights in Australia", *Ener. Res. Soc. Sci.*, 8 (2015) 113-126.
[11] A.S. Al-Zahrani, "The Water Situation in the Arab World and its Economic and Political Repercussions in a Geographical Perspective", 2nd Forum of Arab Geographers, Cairo, 30-20 November 2000, Part 1 (2002).
[12] World Health Organization (WHO), "Uranium in drinking-water, background document for development of WHO Guidelines for Drinking-water Quality" (2004).
[13] Agency for Toxic Substances and Disease Registry (ATSDR), "Public health statement for uranium", World Health Organization (1999) CAS# 7440-61-1.
[14] B. Al-bataina et al., "Radon measurements in different types of natural waters in Jordan", *Rad. Measur*., 28(1-6) (1997) 591-94.
[15] M.H. Kheder et al., "Radioactivity concentrations in barley and wheat crops in Nineveh plain region in Iraq", *Int. J. Nucl. Ener. Sci. Technol*., 14(1) (2020) 50-60.
[16] M.H. Kheder, H.N. Azeez and F.M. Al-Jomaily, "Alpha emitters radioactivity concentrations in some cosmetics used in Iraq using LR-115 detector", *J. Eureka Phys. Eng.*, 2 (2020) 65-70.
[17] H. Cember and T.E. Johnson, **"Introduction to health physics"**, 4th ed., McGraw-Hill (2009).
[18] M.H. Kheder, "Radium and Uranium Concentrations in Some Fruits and Vegetables Cultivated in Nineveh Governorate, Iraq", *Iraqi J. Appl. Phys.*, 19(3B) (2023) 15-19.
[19] M.H. Kheder, H.N. Azeez, and M.A. Al-Jubbori, "Measurement of Uranium and Radon Concentrations in Wells Water Samples of Some Farms near the Mosul City in Iraq", *Iraqi J. Appl. Phys.*, 19(3B) (2023) 3-8.

Table (1) The radon concentrations, uranium concentrations, and the radium concentrations

No	Soil		Water	
	C_{Rn} (Bq/m³)	C_U (µg/Kg)	C_{Rn} (Bq/m³)	C_U (µg/Kg)
S1	148.395	16.341	196.702	20.009
S2	134.905	14.855	233.128	23.714
S3	185.494	20.426	174.846	17.785
S4	165.258	18.198	189.416	19.268
S5	188.867	20.797	225.843	22.973
S6	209.102	23.026	233.128	23.714
S7	141.650	15.598	240.413	24.455
S8	148.395	16.341	225.843	22.973
S9	151.768	16.712	189.416	19.268
S10	131.532	14.48	152.990	15.562
S11	205.730	22.654	236.770	24.085
min	**131.532**	**14.484**	**152.990**	**15.562**
max	**209.102**	**23.026**	**236.770**	**24.085**
average	**164.640**	**18.130**	**208.950**	**21.255**

