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Assessment of Radon Radiation risk in Water Samples from Al-Tuwaitha and Surrounding Areas using the Alpha Guard detector

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Abstract
In this study, the Alpha Guard PQ2000 PRO detector was used to measure direct water samples from 36 locations southeast of Baghdad Governorate. This included 10 samples collected from the Tuwaitha nuclear site. Twenty-six samples were collected. While outside the Tuwaitha nuclear site, including from health centers, mosques, schools, and gas stations near the Tuwaitha nuclear site. The highest radon concentration in the water tank was recorded at 0.44204 Bq/L at the Central Laboratories Directorate/Model Room (sample W9). In contrast, the lowest concentration was recorded at 0.13364 Bq/L at the Riyadh Health Center (sample W11). The annual effective dose from inhalation and ingestion of radon-222 was calculated for all these locations and was found to be lower than the recommended reference level. The natural limit for radon concentration in water is 100 Bq/L according to the World Health Organization, while the Environmental Protection Agency (EPA) proposed maximum containment level of approximately 11 Bq/L. Radon gas and its short-lived decay products contribute significantly to human exposure to natural radiation, which can cause cancer. Ongoing monitoring is essential to mitigate potential risks.

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1. Introduction

Radioactivity is an important part of our daily lives. It is present everywhere around us and undetectable by our senses [1]. The radioactive gas radon occurs naturally within rocks, soil, and building materials. The main sources of environmental radon emissions are soil emissions, while the gas also leaks through oceans and groundwater and from human activities such as mining [2]. Natural water serves as the main transmitter of soil-borne radionuclides that create radioactive pollution, while industrial waste from nuclear processes ranks as the second major source. Drinking water contains natural radioactive isotopes such as uranium and thorium, which decay to produce radon gas along with their radioactive byproducts, radium and polonium [3]. Radon gas is produced by the decay of the naturally occurring radioactive uranium chain, which begins with uranium-238(^{238}U). A key intermediate in this chain is Radon-222 (^{222}Rn), a gas with a half-life of 3.824 days. Because its density is about 7.5 times that of air, it tends to accumulate in low-lying areas, where it poses a health hazard by emitting alpha particles [4]. The body absorbs radon when people consume contaminated water or eat animal products containing contaminants from plants exposed to radon. The food chain is the most important route for rapidly moving radioactive materials through environmental layers among the various transmission routes. This process leads to the accumulation of radionuclides in plants, animals, and their products [5].

Radioactive particles from radon gas affect human health only through inhalation or ingestion of contaminated materials. Therefore, lung cancer is one of the most common malignancies in terms of incidence and may be the leading cause of this cancer in non-smokers [6]. Various international organizations have created regulations to reduce these hazards. Member states of the European Union need to determine Radon Priority Areas that have radon levels higher than safety thresholds [2]. The examination of ^{222}Rn concentrations in drinking water is a key focus within environmental research. Numerous researchers have quantified radon levels in drinking water globally [7]. Matsumoto et al. (2023) examined the concentrations of ^{222}Rn in potable water. The World Health Organization (WHO) supports the recommendation of 100 Bq/L as the maximum radon concentration level in drinking water [8]. The U.S. Environmental Protection Agency (EPA) maintains a stricter standard for radon at 11 Bq/L [9]. Lung cancer stands as the leading cause of death from cancer throughout Central and South America, where Venezuela and Argentina demonstrate the highest female mortality rates [10]. The high death rates from lung cancer stem from widespread smoking and exposure to radioactive dust during mining operations, combined with insufficient public understanding of radon dangers. High geological uranium concentrations in certain regions require immediate implementation of better monitoring systems and strict regulatory measures. The framework established by international regulations needs support from both communities and scientific bodies to detect radon through regular screenings and integrate it into national health plans for elimination.

Several studies have examined radon concentrations in water and soil using Alpha Guard and similar detectors. Naskar et al. (2022) conducted extensive field measurements in India [11]. More recently, Matsumoto et al. (2023) in Japan [8] and Sahu et al. (2024) in coastal regions further advanced monitoring approaches [8-12]. In Iran, the Modirkhameneh et al. study (2025) focused on cumulative radon and thoron concentrations across six districts [13]. Building on these efforts, the present study in Al-Tuwaitha and surrounding areas in Baghdad (2024–2025) provides new baseline data to support the assessment of radiological risks.

The study aimed to determine radon gas levels in water to assess radiological risks in the Al-Tuwaitha area and surrounding areas in Baghdad. However, despite the well-documented health risks of radon in drinking water worldwide, there is a clear lack of systematic studies focusing on the Al-Tuwaitha region, particularly regarding radon levels in local water sources and their potential contribution to public exposure. Previous Iraqi studies have been limited in scope, either concentrating on indoor air or covering small geographical areas without detailed assessment of waterborne radon. Therefore, this study attempts to fill this gap by providing baseline data on radon concentrations in drinking water reservoirs in Al-Tuwaitha and surrounding areas, together with an evaluation of the corresponding annual effective dose to the local population.

2. Experimental Part

2.1. Preparation

Thirty-six water samples were collected from the designated study area. Each sample was taken five minutes after the initial flushing to ensure accurate results. The collection bottles were thoroughly rinsed and then filled continuously with running water to prevent radon loss and air bubble formation. After sterilizing and labeling the bottles, 100 mL of the collected water was transferred into a suitable glass vial. The sample, contained in a plastic syringe, was then placed in the inlet of the degassing device. The sample was slowly injected into the device, as shown in Fig. 1, to avoid air bubbles. An Alpha Guard PQ2000 PRO detector monitored radon activity levels. This device can concurrently gauge humidity, temperature, and air pressure. On the other hand, the Alpha Guard PQ2000 radon detector can also evaluate radiation levels in building materials, air, and water. The pump runs for 10 minutes before each measurement to ensure uniform gas dispersion throughout the system, since the air in the detection assembly generates radon in the water. The Alpha Guard gadget runs for 20 minutes after the water sample is placed in the degassing tube, and the pump is switched off so it correctly measures radon levels. The airflow rate was 0.3 L/min. at the pump's performance level. VIEW PRO program offers simple Windows 10 PC software for regular graphical workup, assessment, archiving, and presentation of the measured data. Additional outside sensors will complete the Alpha Guard Monitoring System [11]. Fig. 1 shows the radon activity concentration measuring system schematically. The system measures radon activity concentration .Once the measurement is complete, set the Alpha PUMP flow rate to 1 liter per minute. To add room air to the system, turn the switch to the "ON" position. Cleaning continues until radon levels drop to normal room air levels [14].

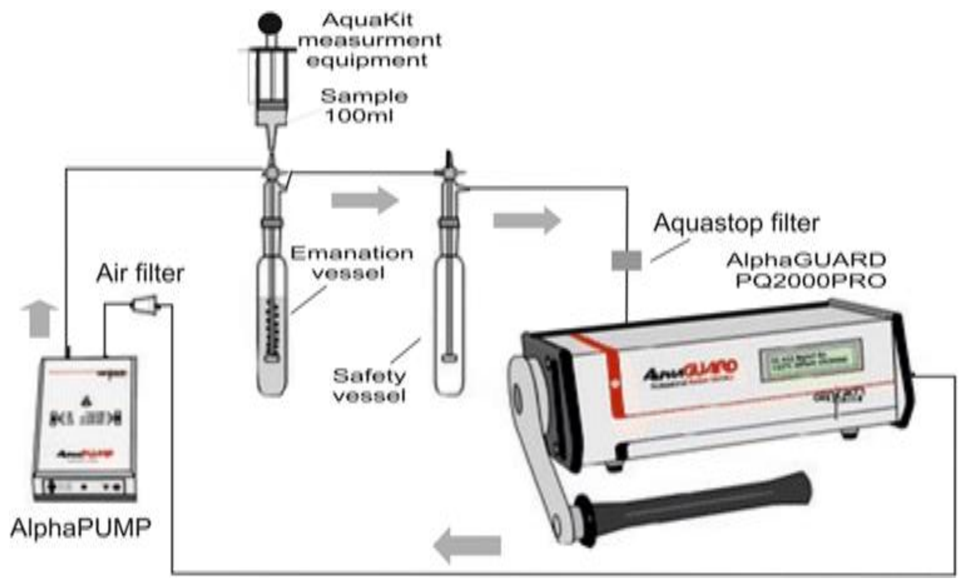

Figure 1: Setup of Alpha GUARD PQ2000 PRO, Alpha PUMP, and Aqua KIT (from the manual for Alpha GUARD PQ2000 PRO).

2.2. Description of Study Area

The Al-Tuwaitha nuclear facility is located several kilometers from Baghdad, situated on the Tigris floodplain. The site perimeter is protected by sand. The site is surrounded by sand berms approximately 50 meters high. The facility stands one kilometer east of the Tigris River and 18 kilometers south of Baghdad within a 1.3 square kilometer area [15]. The study collected 10 samples from the nuclear facility site and obtained 26 additional samples from Jisr Diyala, Ishtar, Al-Tamim, Al-Jaara, and Al-Wardiya locations. The collected samples served to evaluate the radiation exposure risk for workers and residents in the area. The samples originated from the front yards of schools and administrative buildings, farms, residential areas, radiology labs, and sites that stored radioactive and other dangerous materials. The data are presented in Table 1 and visualized in Fig. 2.

Table 1: Sample site coordinates.

Samples	East	North	Samples	East	North
W1	33.20594444	44.50955556	W19	33.23052778	44.51852778
W2	33.20925	44.51138889	W20	33.2245	44.51133333
W3	33.20544444	44.51658333	W21	33.22488889	44.51511111
W4	33.205	44.51758333	W22	33.22583333	44.52591667
W5	33.20913889	44.51597222	W23	33.22275	44.52280556
W6	33.20475	44.51744444	W24	33.19283333	44.53161111
W7	33.20866667	44.51141667	W25	33.20758333	44.55183333
W8	33.20727778	44.51744444	W26	33.18291667	44.54777778
W9	33.20763889	44.51297222	W27	33.18219444	44.55466667
W10	33.20694444	44.51366667	W28	33.19163889	44.54741667
W11	33.23358333	44.53022222	W29	33.20352778	44.55158333
W12	33.21438889	44.54722222	W30	33.17666667	44.55252778
W13	33.22363889	44.54347222	W31	33.16786111	44.56541667
W14	33.22702778	44.53377778	W32	33.17	44.56708333
W15	33.24030556	44.53291667	W33	33.20719444	44.56244444
W16	33.23516667	44.52494444	W34	33.20816667	44.56622222
W17	33.23080556	44.52327778	W35	33.20425	44.55897222
W18	33.22747222	44.52041667	W36	33.19717656	44.55133333

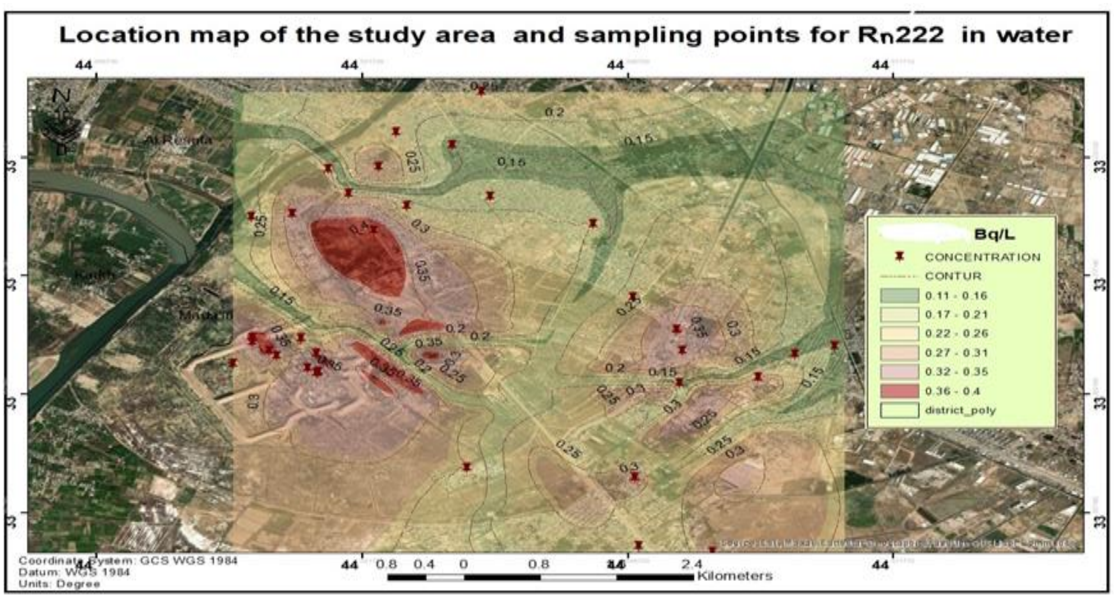

Figure 2: Map showing the sites of the water samples assessed with the Alpha Guard in Al-Tuwaitha and the Surrounding Area.

3. Results and Discussion

3.1. Calculation of Radon Concentration

Through this study, radon gas (^{222}Rn) levels were evaluated in 36 drinking water samples. Ten samples were tested from water tanks located at the Tuwaitha nuclear site, while 26 samples were taken from areas surrounding the nuclear site, distributed across different regions, including Al-Wardiya, Al-Tamim, Al-Jaara, Jisr Diyala, and Ishtar village. We collected these samples from water tanks in homes and schools, mosque water taps, and gas station water tanks. Four samples were collected from health centers, one sample from a drain, eleven samples from mosques, eight samples from schools, and two samples from gas stations near the Tuwaitha nuclear site. The samples were measured using an Alpha Guard PQ2000 PRO detector during the spring and winter seasons, and GPS technology was used to locate them. The samples were measured over a half-hour period. The highest radon concentration was recorded at 0.44204 Bq/L (W9) in the Central Laboratories Directorate/Model Room, at 18.1°C and 1058.1 mbar. The lowest radon concentration was recorded at the Riyadh Health Center at 0.13364 (W11), at 19.1°C and 1058.1 mbar. Fig. 3 shows the radon concentration levels at the Tuwaitha nuclear site and surrounding areas. According to the U.S. EPA, the radon concentration in water is estimated at 11 Bq/L. The WHO standard limit for drinking water for radon-222 is 100 Bq/L, as is the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). However, the study calculated the annual effective dose equivalents for inhaled and ingested radon for workers at the Tuwaitha nuclear site and the population. Concentration readings for all samples were below the permissible limits set by various organizations. The unit of measurement was liters, so concentrations were converted from liters to Becquerel per cubic meter using Eq. (3), which is derived from Eqs. (1 and 2). By computing the atmospheric radon activity logged by the Alpha Guard equipment, the real radon activity in the water samples was determined as follows [11]:

$$C_{\mathrm{Rn\ (water)}} = \frac{\frac{\left\{C_{\mathrm{air}} \times \left(\left(V_{\mathrm{System}} - V_{\mathrm{Sample}}\right) + K\right) - C_0\right\}}{V_{\mathrm{Sample}}}}{1000} \quad (\mathbf{1})$$

$$K = 0.106 + 0.405\ e^{-0.05 x T(C^\circ)} \quad (\mathbf{2})$$

C_{air} represents the radon activity in the measuring setup (Bq/m³); V_{system} is the internal volume of the measuring system (ml). V_{sample} represents the volume of the measured water sample (mL). C_0 is the activity of ^{222}Rn in the measurement setup before sampling (Bq/m³) referenced by Alpha Guard, and $C_{(water)}$ is the activity of ^{222}Rn in the water sample (Bq/L). The coefficient of radon diffusion, K, is the radon partition coefficient, which varies with temperature, decreasing as temperature increases. When the temperature of radon gas increases, it transitions from the liquid to the gaseous state. Therefore, the partition coefficient K is defined as the ratio of radon concentration in the liquid phase to its concentration in the gaseous phase. We calculated the value of K using the average temperature during the measurement, which is a suitable and accurate approximation [14]. Table 2 shows the results of the calculation using Eq. (3):

$$C_{\mathrm{Rn\ (water)}}\left(\frac{\mathrm{Bq}}{\mathrm{L}}\right) = \frac{\left(C_{\mathrm{air}}\left(\frac{\mathrm{Bq}}{\mathrm{m}^3}\right) x10.28\right)}{1000} \quad (\mathbf{3})$$

Table 2: The average temperature, pressure, and radon concentration amounts for the determined regions in the Tuwaitha nuclear site and surrounding areas.

Sample lD	Sample location name	Date	C_{Rn} (Bq/m^3)	C_{Rn} (Bq/L)	T(°C)	Air pressure (mbar)
1	Nuclear Applications Building	12/11/2024	23	0.23644	23.6	1057.9
W2	Projects and Technical Support Department	12/11/2024	37	0.38036	23	1057
W3	Presidency of the Atomic Energy Authority	12/11/2024	29	0.29812	23.2	1057
W4	Radioactive Waste Treatment Department	12/11/2024	30	0.3084	23.4	1057.9
W5	Inside the library building	28/11/2024	22	0.22616	18.5	1058.1
W6	Inside the policy circle	28/11/2024	39	0.40092	18.1	1058.1
W7	Medical building	28/11/2024	32	0.32896	17.9	1058
W8	Administrative and Financial Department	28/11/2024	39	0.40092	17.9	1058.1
W9	Central Laboratories Directorate	28/11/2024	43	0.44204	18.1	1058.1
W10	Directorate of Nuclear and Radiation Safety and Security	28/11/2024	22	0.22616	18.9	1058.1
W11	Riyadh Health Center	17/12/2024	13	0.13364	19.1	1058.1
W12	Noor Al Mustafa Mosque	17/12/2024	21	0.21588	20	1058.1
W13	Pure Soul School	17/12/2024	20	0.2056	22.6	1057.9
W14	Qais Al-Ansari Intermediate School	17/12/2024	18	0.18504	23.6	1057.9
W15	Al-Muhaimin Mosque	17/12/2024	25	0.257	24.4	1057.9
W16	Al Basair Elementary School	17/12/2024	21	0.21588	24.8	1057.8
W17	Diyala Bridge Club	18/12/2024	30	0.3084	24.9	1057.8
W18	Rafidain Bank / Diyala Bridge	18/12/2024	23	0.23644	21.4	1058
W19	Diyala Grand Bridge Mosque	18/12/2024	25	0.257	22.7	1057
W20	Ibn Al-Khatib Hospital	02/01/2025	16	0.16	23.4	1057.9
W21	Mustafa Mosque	18/12/2024	35	0.35	23.9	1057.9
W22	Khatam Al-Nabiyyin High School	18/12/2024	19	0.19	24.4	1057.9
W23	Al Tagamoa Primary Private Academy	18/12/2024	41	0.41	24.9	1057
W24	Al-Takhi Mixed Primary School	18/12/2024	25	0.25	24	1057
W25	Al-Anwar Al-Muhammadiyah Mosque	18/12/2024	32	0.32	26.6	1057.8
W26	Sheikh Issa Mosque	22/12/2024	20	0.2	18.1	1058.1
W27	Imam Al-Baqir Mosque	22/12/2024	27	0.27	17.5	1058.1
W28	Al Rahman Mosque	22/12/2024	38	0.38	17.4	1058.1
W29	The mosque of religions	22/12/2024	27	0.28	17.3	1058.1
W30	Al-Jaara Health Center	22/12/2024	23	0.23	17	1058.1
W31	Imam al-Muntazar Mosque	23/12/2024	29	0.29	20.1	1058
W32	Al Zahraa Mosque	23/12/2024	23	0.23	22.2	1058
W33	Al Tamim Health Center	01/01/2025	17	0.17	21.3	1056
W34	Sumer Elementary School	01/01/2025	16	0.16	19	1058.1
W35	Future fuel station	01/01/2025	28	0.28	18.1	1058.1
W36	Gulf Flower Gas Station	01/01/2025	36	0.37	17.7	1058
W11	Min.		13			
W9	Max.		43			
	Ave.		26.78			

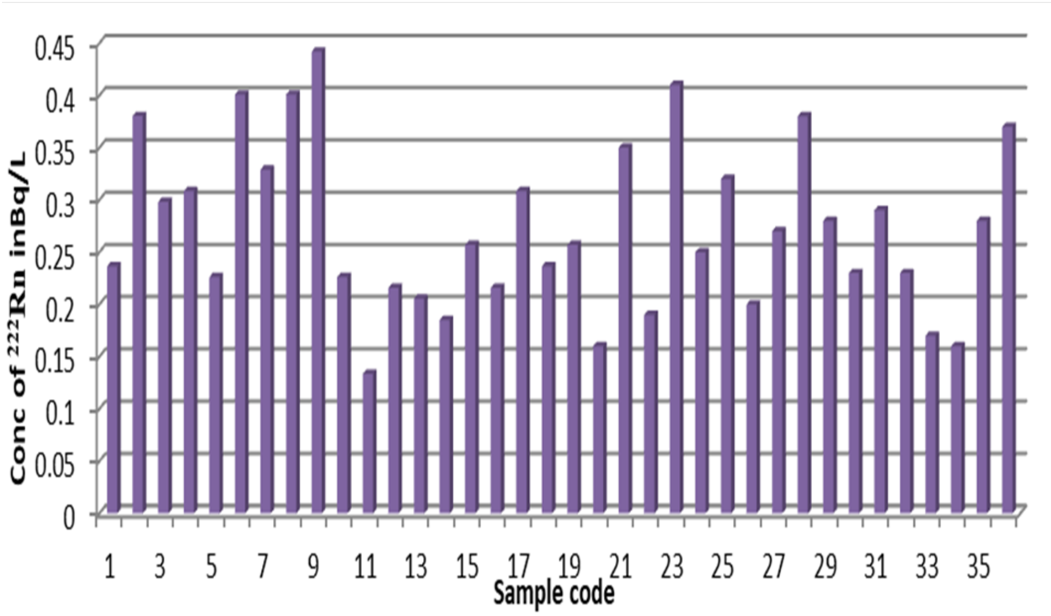

Figure 3: Displaying the mean radon concentration levels for the chosen Tuwaitha nuclear site and Surrounding Area samples.

3.2. Estimate of the Natural Radiation Exposure

Measuring radon dose from drinking water is a major challenge in assessing radiation dose. Drinking water contributes to radon exposure through both inhalation of radon from the surrounding air and direct ingestion. An average adult consumes an average of 2 L of water per day, equivalent to 730 L/year. Ingestion of radon in drinking water exposes lung tissue to radiation. The total annual effective dose from radon in drinking water can be calculated by adding the inhalation dose to the ingestion dose. Due to differences in estimates of annual water consumption, the WHO guidelines provide dose estimates from ingestion. This dose is expressed in Eqs. (4, 4.1), where 1×10^{-8} Sievert/Bq. Ia is the annual water consumption rate, measured in 1 L/year [7]. Based on an annual water consumption of 730 liters, as determined by the United Nations Scientific Committee on the Effects of Ionizing Radiation [11], the dose conversion factor (DF) for ingestion is used to convert the amount of ingested radioactivity (in becquerels) into an equivalent effective dose (in sieverts or microsieverts). This factor is measured in sieverts/becquerel. Since concentrations are measured in microsieverts, the result is multiplied by 1×10^{6} [7], as shown in Eqs. (4,4.1):

$$E_{Ing} = C_{Rn} \text{ x } I_a \text{ x } D_f \tag{4}$$

where

$$E_{Ing} \left(\frac{\mu Sv}{year}\right) = C_{Rn} \left(\frac{Bq}{L}\right) \text{x } 730 \left(\frac{L}{year}\right) \text{x}10^{-8} \left(\frac{Sv}{Bq}\right) \text{x}10^{6} \left(\frac{\mu Sv}{Sv}\right) \tag{4.1}$$

The average annual effective dose to an exposed person near the workplace depends on radon levels. Eqs. (5,5.1) show a site-specific radon equilibrium factor (F) of 0.4, a common value for indoor workplaces. This represents the equilibrium point between indoor radon and its components [16]. T is the exposure time in hours (7000 hours/year), RW is the air/water concentration ratio 10^{-4} (Bq/m^3)/(Bq/L), The dose conversion factor (D_F) is used in this case to calculate the dose resulting from inhalation of radon transferred from water to indoor air, and is given as 9 nSv (Bq.hm^{-3})$^{-1}$. While Eq. (4) expresses the conversion factor in units of (Sv/Bq), the value of the DF in the inhalation equation is determined based on several factors, including: the rate of radon release from water to air (transfer factor), the duration of annual exposure, the equilibrium factor between radon and its short lived derivatives, and physiological factors related to radon absorption in the respiratory system [7].

$$E_{Inh} = C_{Rn}\, x R_w \,x\, F \,x\, T\, x D_F \tag{5}$$

where

$$E_{Inh}\left(\frac{\mu Sv}{year}\right) = C_{Rn}\left(\frac{Bq}{L}\right) x \;(10^{-4} \left(\frac{\frac{Bq}{m^3}}{\frac{Bq}{L}}\right)) x\, 0.4 x\; 7000\left(\frac{h}{y}\right) x\; 9\; nSv(\,Bq.hm^3)^{-1} \tag{5.1}$$

The results showed that all samples were safe, as none exceeded the WHO limit of 100 microsieverts per year. Accurate assessment of total exposure allows for the determination of dose and risk once the radioactivity level of the material is understood. Eqs. (4 and 5) allowed us to estimate the radiation risks associated with radon. Reporting standards were used to calculate the average annual effective ingestion and inhalation doses, as shown in Table 3. Here, the average annual effective ingestion dose (E_{Ing}) and inhalation dose (E_{Inh}) are expressed in microsieverts per year [16]. Fig. 4 shows the relationship between radon concentration and the E_{Ing} and E_{Inh} for 36 samples. The blue line represents the change in calculated radon concentration in water. The highest radon concentration was recorded at 0.44204 Bq/L in sample W9, while the lowest was 0.13364 Bq/L in sample W11, with an average value of 0.2723 Bq/L. The green line represents the annual inhalation dose in µSv/year. The highest radon dose was recorded at 1.114 µSv/year in sample W9, and the lowest dose was 0.337 µSv/year, with an average value of 0.686 µSv/year. The yellow line represents the annual effective ingestion dose in µSv/year, the highest of the three. The highest radon dose was recorded at 3.23 µSv/year, and the lowest was 0.98 µSv/year. The average value was 1.987 µSv/year. The graph shows that sample W9 had the highest values in all indicators, while sample W11 had the lowest values. All readings were below the internationally permitted limits, indicating that radon levels were within the safe limits for health, as shown in Table 3.

Many countries have conducted national or subnational measurements of radon levels in homes. Radon concentrations in groundwater vary globally, with India having the highest range (1.78–3213.50 Bq/L) in 2021, followed by Portugal (2–1690 Bq/L) in 2017, and Poland (5.5–215.70 Bq/L) in 2011. Spain (1.40–104.90 Bq/L) in 2016 and Thailand (0.18–98.10 Bq/L) in 2015 showed moderate levels [11]. Low-risk areas include Hungary (0.31–24.30 Bq/L) in 2007, Iran (2.16–4.11 Bq/L) in 2018, Saudi Arabia (1.65–3.82 Bq/L) in 2019, Turkey (0.39–0.71 Bq/L) in 2019, and Egypt (22.0±0.7–118.0±3.0 mBq/L, converted to 0.022–0.118 Bq/L) in 2020 [11]. Subsequent studies in Iran (0.187–14.8 Bq/L) in 2014 [17]. Bangladesh (0.36–15.70 Bq/L) 2021[18], and Jordan (0.26±0.03 to 3.58±0.55 Bq/L) in 2019 [19]. And Morocco (0.104±0.023Bq/L) in 2024 [20], regional variations are influenced by geological factors and measurement methodologies. Meanwhile, measurements of radon concentrations in groundwater and domestic water across multiple Iraqi regions show significant variation. Anbar Governorate recorded the highest concentration (6.44 ± 1.8 Bq/L) in 2020 [21], followed by Kurdistan (0.93 ± 0.43 to 11.39 ± 1.86 Bq/L) in 2023 [22], while in 2022, the village of Barserin in Erbil recorded

0.06 ± 0.11Bq/L [23]. In contrast, Baghdad showed lower levels (0.09277–0.221 Bq/L) in 2021 [24]. While Kirkuk showed a range of (0.0359–2.7401 Bq/L) in a 2017 study [25]. Diwaniyah reported lower concentrations (0.05–0.47 Bq/L) in 2020 [26]. In the Thi-Qar governorate, the results indicate an activity concentration of (0.26 ± 0.17Bq/L) in 2025[27]. In Najaf, the average concentration was 0.114 Bq/L in 2023 [28], and a recent Baghdad study (2025) indicates a range of 0.13364–0.44204 Bq/L.

Table 3: Radon concentration in the table reveals the yearly equivalent effective dose.

Sample (ID)	C_{Rn} (Bq/L)	E_{Ing} (µSv/year)	E_{Inh}(µSv/year)
W1	0.23644	1.73	0.596
W2	0.38036	2.78	0.959
W3	0.29812	2.18	0.751
W4	0.3084	2.25	0.777
W5	0.22616	1.65	0.570
W6	0.40092	2.93	1.011
W7	0.32896	2.40	0.829
W8	0.40092	2.93	1.011
W9	0.44204	3.23	1.114
W10	0.22616	1.65	0.570
W11	0.13364	0.98	0.337
W12	0.21588	1.58	0.544
W13	0.2056	1.50	0.518
W14	0.18504	1.35	0.466
W15	0.257	1.88	0.648
W16	0.21588	1.58	0.544
W17	0.3084	2.25	0.777
W18	0.23644	1.73	0.596
W19	0.257	1.88	0.648
W20	0.16	1.17	0.403
W21	0.35	2.56	0.882
W22	0.19	1.39	0.479
W23	0.41	2.99	1.033
W24	0.25	1.83	0.630
W25	0.32	2.34	0.806
W26	0.2	1.46	0.504
W27	0.27	1.97	0.680
W28	0.38	2.77	0.958
W29	0.28	2.04	0.706
W30	0.23	1.68	0.580
W31	0.29	2.12	0.731
W32	0.23	1.68	0.580
W33	0.17	1.24	0.429
W34	0.16	1.17	0.403
W35	0.28	2.04	0.706
W36	0.37	2.70	0.932
Max	0.44204	3.23	1.114
Min	0.13364	0.98	0.337
Ave.	0.2723	1.987	0.686

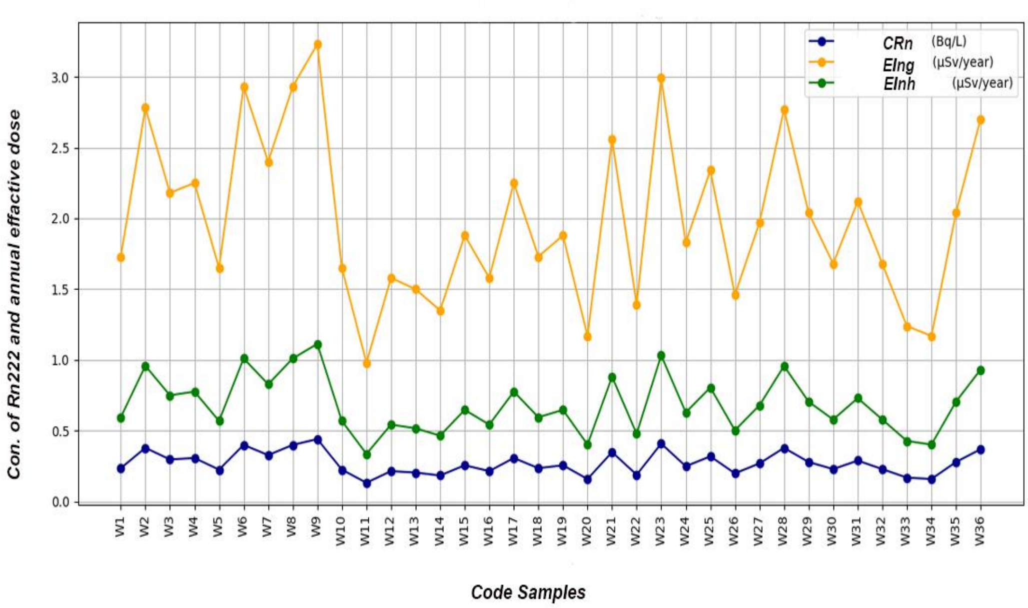

Figure 4: A graph showing the relationship between radon concentration and annual effective dose from ingestion and inhalation.

4. Conclusions

Radon-222 is a radioactive isotope with significant health implications. Its decay products, particularly polonium-218 and polonium-214, can have a significant negative impact on lung tissue, leading to lung cancer in many cases. In this study, we measured the radon-222 concentration in 36 samples collected from reservoir water located within the Tuwaitha nuclear site and surrounding areas using an Alpha Guard PQ2000 PROEPA, a precise and easy-to-use environmental instrument. The annual effective dose resulting from ingestion and inhalation of the emitted radon was calculated. The results showed that all samples were well below the maximum limit of 11 Bq/L set by the U.S. EPA and the global limit of 100 Bq/L set by the WHO. Compliance with radiation protection legislation and regulations is critical when assessing the potential health risks posed by radiation exposure to the population. Although radon concentrations in this study were low and did not exceed the permissible levels, there is still a need to conduct continuous monitoring and extensive studies of radon concentrations in water in various regions of Iraq.

Conflict of Interest

The authors declare that they have no conflict of interest.

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تقييم مخاطر اشعاع الرادون في عينات المياه من منطقة التويثة والمناطق المحيطة بها باستعمال كاشف الفا كارد

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الخلاصة
تم في هذه الدراسة، استُخدم جهاز الكشف Alpha Guard PQ2000 PRO لقياس عينات مياه مباشرة من 36 موقعًا جنوب شرق محافظة بغداد. وشمل ذلك 10 عينات جُمعت من موقع التويثة النووي، و26 عينة أخرى جُمعت من خارج موقع التويثة النووي، بما في ذلك من مراكز صحية ومساجد ومدارس ومحطات وقود قريبة من الموقع. سُجّل أعلى تركيز للرادون في خزان المياه عند 0.44204 بيكريل/لتر في مديرية المختبرات المركزية/غرفة النماذج (العينة W9). في المقابل، سُجّل أدنى تركيز عند 0.13364 بيكريل/لتر في مركز الرياض الصحي (العينة W11). حُسبت الجرعة الفعالة السنوية الناتجة عن استنشاق وابتلاع الرادون-222 لجميع هذه المواقع، ووُجد أنها أقل من المستوى المرجعي الموصى به. يبلغ الحد الطبيعي لتركيز غاز الرادون في الماء 100 بيكريل/لتر وفقًا لمنظمة الصحة العالمية، بينما اقترحت وكالة حماية البيئة الأمريكية مستوى احتواء أقصى يبلغ حوالي 11 بيكريل/لتر. يُساهم غاز الرادون ونواتج تحلله قصيرة العمر بشكل كبير في تعرض الإنسان للإشعاع الطبيعي، الذي قد يُسبب السرطان. لذا، يُعد الرصد المستمر ضروريًا للحد من المخاطر المحتملة.

الكلمات المفتاحية: الرادون، الماء، ألفا كارد، الجرعة الفعالة السنوية، موقع التويثة النووي.