IHJPAS. 36 (3) 2023

Ibn Al-Haitham Journal for Pure and Applied Sciences

Journal homepage: jih.uobaghdad.edu.iq

Measurement of Radon Concentration in Drink and Well Water Samples for Selected Regions in Baghdad City

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Article history: Received 15 October 2022, Accepted 18 January 2023, Published in July 2023.

doi.org/10.30526/36.3.3075

Abstract

The concentration of radon gas in the samples for drinking water and wells in the same place from selected homes in which wells were built in the Hay-al-Bayaa region of Baghdad was measured, by using a CR-39 nuclear track detector. It turns out that the maximum value of the concentration of radon in drinking water was 3.83 Bq/L, and the lowest was 2.30 Bq/L. As for the estimation of radon gas concentration in well water samples, the highest value was 5.6 Bq/L, while the lowest one was 3.1 Bq/L. In order to assess the committed effective dose received by the public due to the inhalation of radon gas. The highest value of the annual effective dose in drinking water was recorded in Al-Bayaa region, which is equal to 14.30 µSv/y, while the minimum was recorded at 8.40 µSv/y. As it turns out, the annual effective dose in well water samples was 20.4 µSv/y, while the lower one was 11.57 µSv/y. All values for the radon concentration and the annual effective dose in the drinking and well water samples were below the World Health Organization's recommended levels. The results showed that drinking water and wells were free of radioactive contamination in the studied area.

Keywords: Drink and well water, Radon gas, detectors **(**CR-39).

1. Introduction

As the earth is the source of radon gas, the groundwater also contains radon. The water levels, ventilation, and other physical elements all play a role in the gas diffusion from the soil and rocks to the well waters [1,2]. The solubility of radon in water increases sharply as the temperature falls. Salinity affects radon concentrations in water as well, however, the impact has mostly gone unnoticed. The importance of radon, it is necessary to know the concentration of this gas. But the amount of radon in surface and groundwater is not insignificant [3,4]. Underground geological strata allow radon to flow into aquifers and surface waterways. Radon, which is a noble gas and much more freely able to migrate into the water, and radium-226, an immediate predecessor of radon, are locked in the rocks, sands, and clays that make up the aquifers. In homes, due to inhaling radon, people are exposed to many risks [5]. Exposure to radon occurs during bathing, washing dishes, cooking, drinking water, and performing other routine tasks that involve using water [6, 7]. Previous studies showed that the radon concentration in Karbala governorate is higher when compared to the maximum contaminant level of 11.1Bq /L for radon in drinking water [8].

Because the CR-39 detector has a high sensitivity to alpha particles, nuclear track identification techniques based on Radon measurements were applied throughout the current study. This method's basic idea is based on the creation of a track in the detector as a result of alpha particles released by Radon and its offspring [9, 10]. Using an optical microscope, the tracks are manually numbered after being exposed and made visible by chemical etching to determine the Radon concentration and measure the track density [11, 12]. This study's aim is to calculate radon concentrations, estimate the annual effective dose in samples of selected water, and know the validity of drinking water and well water for domestic use by using the CR-39 detector.

2. Collecting and Preparing the Samples

Eighteen samples were collected from drinking and well water in Al-Bayaa region within Baghdad. Samples are divided into two groups, the first of which is nine samples from tap water for drinking. The second is nine samples of well water from the same houses from which drinking water samples were taken in which wells were built, as shown in **Table 1.**

They placed the samples in plastic bottles, then washed them with diluted hydrochloride and filtered the water using filter paper. A capacity of $\frac{1}{4}$ L of drink and well water is kept for 30 days to reach secular equilibrium, then the samples are placed in a sealed cup for measurement, as illustrated in Figure 1. A piece of detector was placed on top of the sealed cup. The detector CR-39 is a polymer with a thickness of (500μm) a density of 1.36 gm/cm^3 and an area of (1×1cm^2). The exposure duration of the detector was 60 days, then chemical etching with 6.25 normal NaOH at 60 °C for 5 hours. A number of tracks have been measured using an optical microscope with 400X magnification.

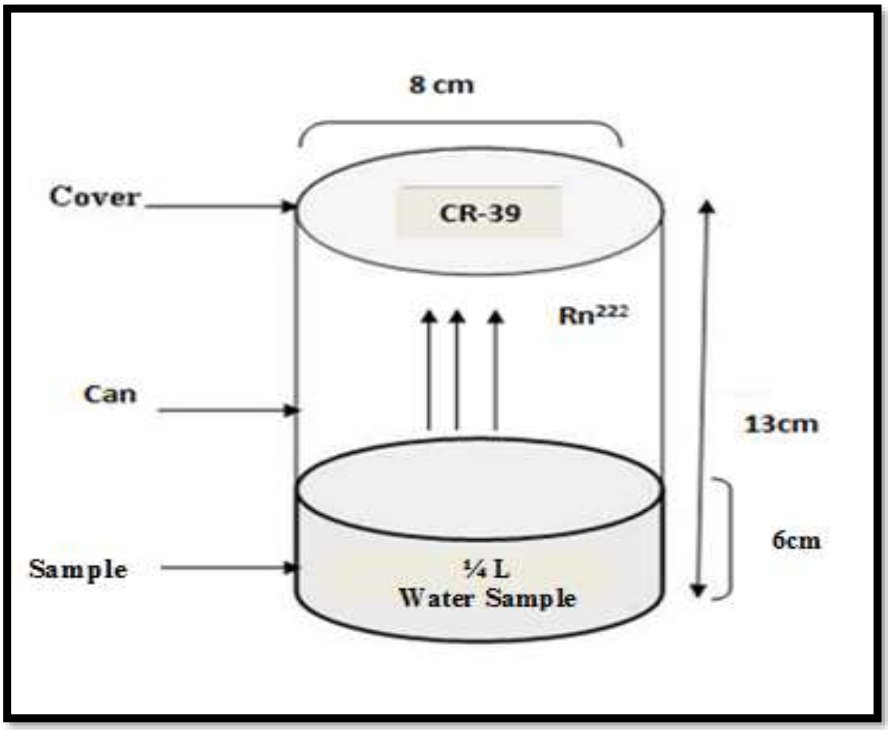

Figure 1. The sealed cup to measure samples.

3. Calculations

3.1 Radon Concentration Measurements

An equation was used to determine the density of the tracks (ρ) for the samples [13, 14]:

$$\text{Tracks density } (\rho) = \frac{\text{average the number of tracks}}{\text{Area of field view}} \quad (1)$$

The following relationship was used to compare the radon concentrations for the water samples, which were determined using the track densities recorded on the detectors of the samples and those of the standard water samples [15, 16]:

$$\frac{C_{Rn}\ (sample)}{\rho_{Rn}\ (sample)} = \frac{\text{Cs(standard)}}{\rho\text{s(standard)}} \quad (2)$$

Where: C_{Rn}: represents the radon concentration in the unknown sample, C_S represents the radon gas concentration in the standard of sample, ρ_{Rn}: the track density of the unknown sample, ρ_s: the track density of the unknown sample, as explained in **Figure 2**.

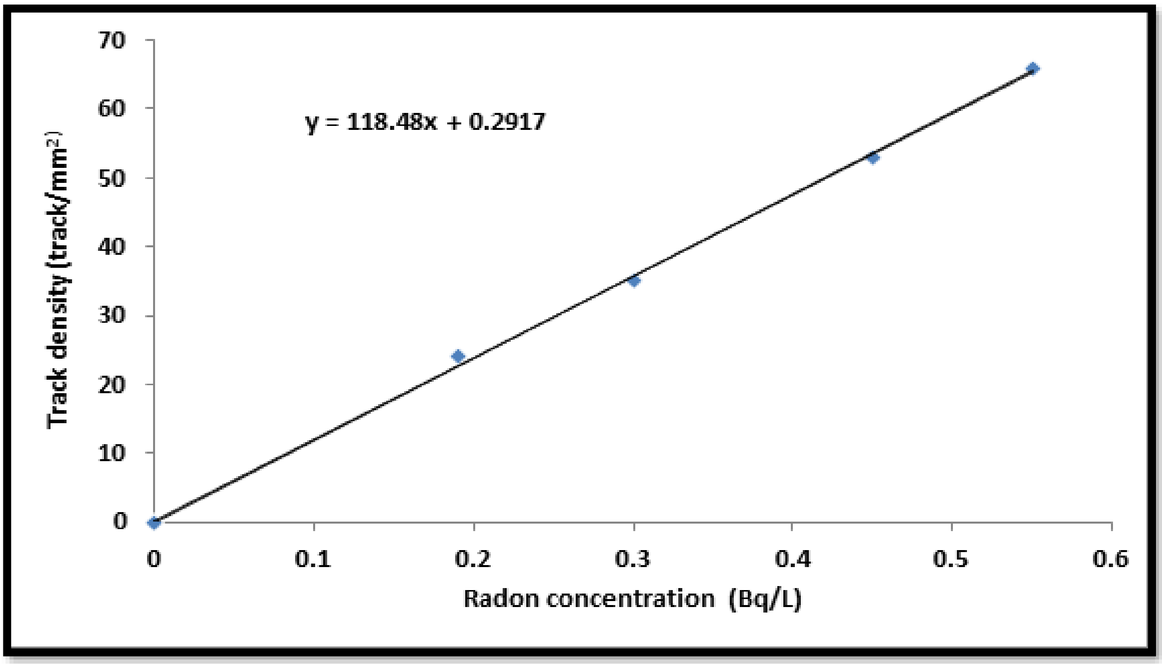

Figure 2. Calibration Curve for standard samples.

3.2. Annual Effective Dose

The relationship used to estimate the annual effective dose due to swallowing radon gas is [17]:

$$AEDE(\mu Sv/y) = C_{Rn} \times D_{cw} \times C_{Rw} \quad (3)$$

Where, C_{Rn} the radon-concentration for ingestion, D_{cw} : the dose conversion factor 5×10^{-9} Sv/Bq ,C_{Rw} : the consumption rate 730L/y.

3.3 Dissolved Radon Concentration

The dissolved radon concentration was calculated using the following equation [18,19]:

$$Cd = \frac{CRn \times h \times \lambda \times T}{L} \quad (4)$$

C_{Rn} is the radon concentration, Bq/L, λ is the decay constant of ^{222}Rn (0.1812 day^{-1}), h is the distance between water sample's surface and detector (0.07m), T is the exposure period for detector (60 days), and L is the sample depth (0.06m).

4. Results and Discussion

Table (1) shows the results for radon gas concentrations in drinking and well water samples of Al-Bayaa region in Baghdad, where it turned out that the highest value of radon concentration in drinking water was found in a sample (D1) which was 3.83 Bq/L, while the lowest value appeared in the sample (D4) which was (2.30 Bq/L) with an average value 3.0±0.92Bq/L. While the highest value of radon concentration in well water was found in a sample (W2) which was (5.6 Bq/L, the lowest value was in a sample (W4), which was (3.1 Bq/L) with an average value 4.7±1.5Bq/L, as shown in

Figure 3. It was found through the study that the values of radon concentration, when they were matched with the global values, were found to be valued less than the recommended limits, which amount to 11.1Bq/L according to [20,21].

It was noted that the concentration of radon in well water is higher than its concentration in drinking water due to the stagnation of well water and the radon increase in it, and that drinking water is subjected to treatment and purification.

Table 1. The concentration of radon, annual effective doses, and dissolved radon concentration in drinking and well water samples for Al-Bayaa region of Baghdad.

Sample No	Coordinates	Water type	C_{Rn}(Bq/L)	AEDE(µSv/y)	Cd(Bq/L)
D1	N=3327714 E=4434739	drink	3.83	14.30	116.79
D2	N=3327727 E=4434629	drink	3.069	11.202	93.43
D3	N=3327651 E=4434833	drink	3.325	12.136	101.21
D4	N=3327861 E=4434647	drink	2.30	8.40	70.074
D5	N=3327582 E=4435046	drink	2.532	9.242	77.08
D6	N=3327590 E=4434919	drink	3.68	13.443	112.11
D7	N=3327293 E=4434777	drink	2.32	8.49	70.85
D8	N=3327594 E=4434929	drink	3.06	11.20	93.43
D9	N=3327998 E=4434681	drink	3.00	10.92	91.09
	Average		**.30±0.92**	**11.03±3.4**	**91.7±28.3**
W1	N=3327714 E=4434739	well	4.066	15.84	123.79
W2	N=3327727 E=4434629	well	5.6	20.4	170.51
W3	N=3327651 E=4434833	well	5.37	19.60	163.50
W4	N=3327861 E=4434647	well	3.1	11.57	96.54
W5	N=3327582 E=4435046	well	5.1	18.67	155.65

W6	N=3327590 E=4434919	well	4.6	17.73	147.9
W7	N=3327293 E=4434777	well	5.1	18.68	155.7
W8	N=3327594 E=4434929	well	5.40	20.07	167.3
W9	N=3327998 E=4434681	well	4.23	15.49	129.2
	Average		**4.7±1.5**	**17.56±5.6**	**145.5±47.2**
	Global limit		**11[22]**	**1mSv/y [23, 24]**	**-------**

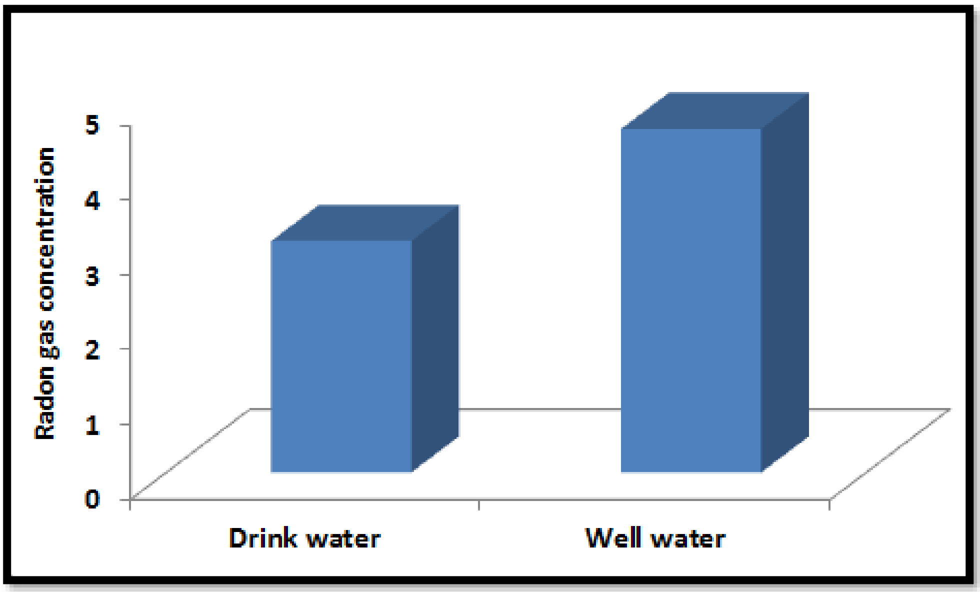

Figure 3. Average radon concentration in drinking and well water samples.

The sample (D1) gets the greatest annual effective dose in drinking samples was 14.30 µSv/y, and the lowest was 8.40 µSv/y in the sample (D4), with an average value of 11.03±3.4, While the highest value of 20.4 µSv/y was in the sample (W2), and the lowest concentration was in the sample (W4) which was 11.57 µSv/y, with a mean value of 17.56±5.6 for the well water samples, see **Figure 4.**

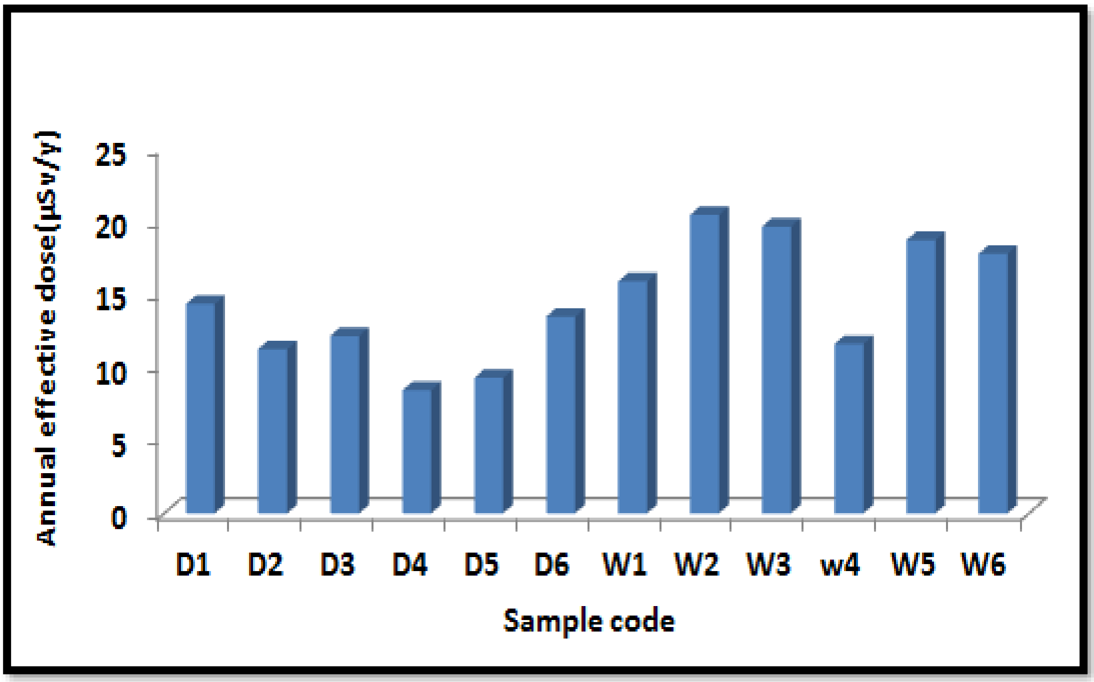

Figure 4. Annual effective dose in drinking and well water samples.

The dissolved radon concentration (Cd) in drinking water and well samples is depicted in **Figure 5.** The highest value of 116.79 Bq/L was in the sample (D1), while the lowest concentration was in the sample (D4) which was equal to 70.074 Bq/L, with an average value 91.7±28.3. While the highest value 170.51Bq/L was in the sample (W2), the lowest concentration was in the sample (W4) which was equal to 96.54 Bq/L, with an average value of 145.5±47.2 for the well water samples. The annual effective dose values and the dissolved radon concentration were both below the UNSCEAR recommended limit, see **Figure 5**.

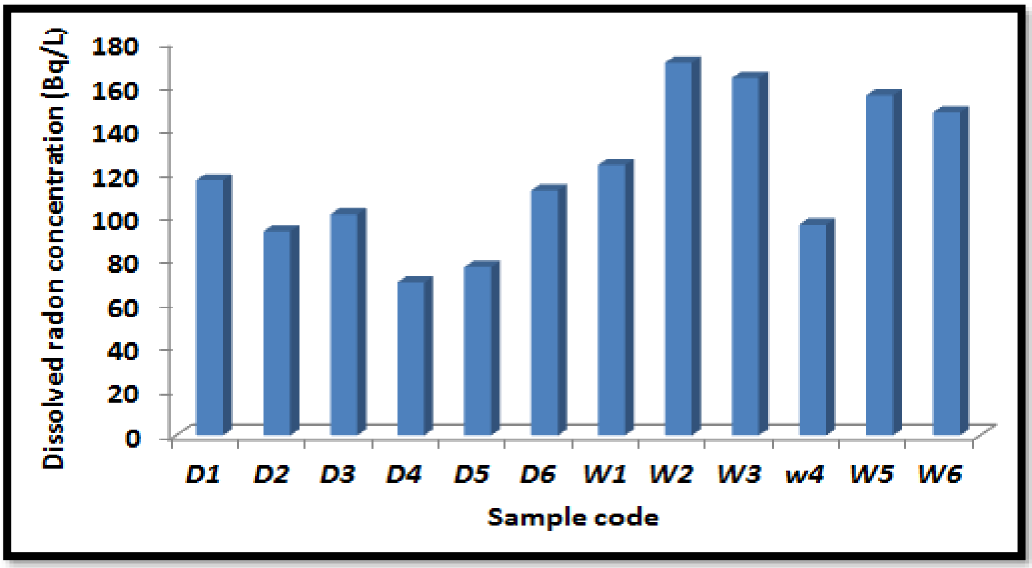

Figure 5. Dissolved radon concentration in samples of selected water.

4.Conclusion

There was a need to dig many wells in recent times because of the severe shortage and the urgent need for water for human use and to meet household needs. Through this study, which included knowledge of the concentration of radon gas in samples of drinking water and wells, it was found that the results obtained are within acceptable limits and do not negatively affect human life and regarding the annual effective dose values and dissolved radon concentration, they are within the recommended limits.

The use of drinking water to drink and well water for domestic use or irrigation poses no risk to people's health in these areas.

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