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Assessment of Radon gas concentration in Tap water supply of Haditha Town / west Al-Anbar Governorate / Iraq

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Abstract

The current study was performed to estimate Radon concentration in the tap water and annual effective dose in 22 water samples from three districts in Haditha city (Haditha center, Haqlaniyah and Barwana) in addition to Euphrates river. The results show that overall concentration of radon 226 in drinking water in Haditha city was ranged (0.0091 – 0.031 Bq.L⁻¹). Also, the annual effective dose of radon 226 was calculated. The highest was 0.113166 μSv/y, while the lowest was 0.03322 μSv/y. The rank order of drinking water resources in Haditha region based on the concentration of radon 226 was Euphrates river > Haditha > Barwana > Haqlaniyah. The overall concentration of radon 226 in drinking water in Haditha city was lower than WHO and EPA standard limits.

Keywords: Haditha, Radon 226, Drinking water, concentration, Annual effective.

1. Introduction

Radon (²²²Rn) is a radioactive gas found in nature. It's created by the radium-226, which is a decay product of uranium-238, including rocks and soils [1]. The radioisotope ²²²Rn has a short half-life (3.8 days) [2]. Other radon isotopes exist naturally, but due to differences in half-life and dosimetry, their health impact is negligible compared to that of ²²²Rn [3]. The soil and rock beneath a building are the primary source of indoor air radon, which enters the structure through fractures or breaches in the foundation or basement. [4]. Some well (ground) water in areas having high soil radium content may also be a source of indoor radon. Arithmetic mean radon concentrations in European countries Russia, United States range from about 30 to 140 Bq m⁻³, between 19 and 230 Bq m⁻³; around 50 Bq m⁻³; respectively. The maximum acceptable level of residential radon in the United States has been set by the US EPA at 150 Bq m⁻³, [5,6]. Radon is commonly found in water resources, which then leaches into drinking water; however, Radon can also be detected in drinking water sourced from natural groundwater. Radon is released into the air within homes and buildings when water used for cooking and bathing evaporates [7]. Well water or groundwater is the most common source of Radon in drinking water sources; however, if the concentration of Radon is higher than the EPA's Maximum Contaminated Level (MCL) of 11 Bq/L, surface water can be used instead. [8,9,10].

Radon is responsible for up to 50% of the total internal dose from all natural background radiation sources, which is nearly entirely attributable to two of its children, polonium-218 and polonium-214, which decay by emitting alpha particles. Lung cancer can be caused by alpha particles stuck in the airways of the lungs, which harm the cells lining the airways. [11,12,13]. In Iraq many studies are conducted to estimate the Radon concentration such as [20,21,22; 23, 240]. The aim of this study is to assess the effect of Radon concentration in tap water in Haditha town.



2. Material and Methods

2.1 Study area

Haditha is located in western of Al-Anbar Governorate, about 240km northwest of Baghdad, its situated on the Euphrates River at $34^{\circ}08'23''\text{N}$ $42^{\circ}22'41''\text{E}$ Fig 1. The Haditha District consists of the Sub-Districts of Haditha City, the Haqlaniyah Sub-District, and the Barwana Sub-District. The geology of the study area mainly characterized by four stratigraphic units, which include Anah formation (U. Oligocene), Euphrates Formation (L. Miocene), Fatha Formation (M. Miocene), and Quaternary deposits. (Pleistocene). [14,15], In Haditha region, the karstification occur in the limestone beds of the Euphrates Formation. The climate of Haditha city is arid to semi- arid. The average annual precipitation, Temperature and evaporation are 131mm, 37°C and 234 mm, respectively.

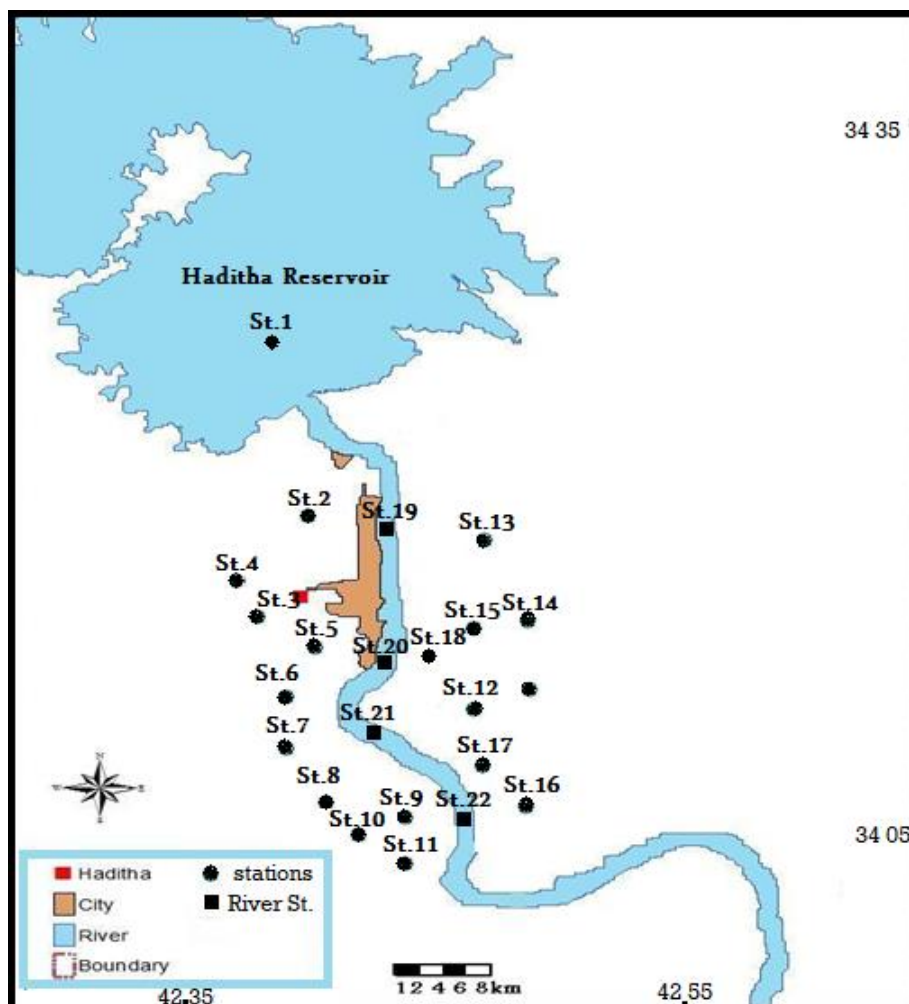


Fig 1 Map of location samples in the study area.

2.2 Sampling

Different samples were collected from different location such as : homes, offices , hospitals, and other locations , Eighteen samples were collected from Hadith (6stations), Haqlanihya (6stations) and

Barwana (7stations) with Four station of Euphrates river near the intake of water plant for drinking water within study area for investigation during February 2019 as shown in table 1. Water samples were kept in Glass and plastic bottles for both Radon measurement and physicochemical analysis, Respectively, and transfer to the laboratory in order to measure and Analysis.

Table 1 locations of study area.

Stations	Symbol	latitude	longitude	Stations	Symbol	latitude	longitude
Haditha Dam	St.1	34.191358	42.356910	K3	St.10	34.0830094	42.325245
Wasta	St.2	34.164660	42.362414	Bazon	St.11	34.083094	42.339664
Haditha hospital	St.3	34.144772	42.375450	Al-Maamonia school	St.12	34.105271	42.39390
Hay Askary	St.4	34.13821	42.354174	Dmama	St.13	34.119483	42.404209
Near hawija	St.5	34.139871	42.356783	Al-Hathaba	St.14	34.113230	42.414509
Sabhani	St.6	34.118059	42.370654	Policy center	St.15	34.109250	42.405582
Bani Daher	St.7	34.106120	42.372027	Hadadia	St.16	34.079113	42.409702
Al-Rafaic	St.8	34.102709	42.358981	Doestic	St.17	34.105271	42.394596
Haglania	St.9	34.093330	42.360264	Barazan home	St.18	34.116072	42.395282
After dam	St.19	34.163243	42.386335	Near haditha	St.21	34.106976	42.387043
Near Barwan	St.20	34.080820	42.377430	Near Haqlaina	St.22	34.079682	42.380863

2.3 Lab Works and measurement

For chemical analysis, multi methods and devices were used. all analysis of cations (Na^+ , Ca^{2+}) and anions (Cl^- , SO_4^{2-}) in addition to (EC, TDS and pH) have been done in the laboratories of the Environment and water Directorate/ Ministry of Science and Technology.

For Radon Measurements, the RAD7 is a high-tech measurement equipment that is widely utilized in laboratories and research projects in the world. The measuring based on a semiconductor detector with a strong electric field. The 250 mL sample bottles were attached to the RAD 7, and the Radon monitor's internal air pump was used to re-circulate a closed air-loop through the water sample, expelling Radon from the water into the airloop. The measurement results can be transferred to a PC for post-analysis and report editing to the end customer. The radon measurements by using the Rad-7 system was conducted at the Isotopes laboratory at the Water research center , Environment and water Directorate, Ministry of Science and Technology. Figure 2.



Fig 2 RAD-7 detector for measuring Radon concentration.

The annual effective dose evaluated using the Eq. (1) [16] ,

$$AED (\mu S y) = C_{Rn} * C_{Rw} * W_{DC} \text{ ----- (1)}$$

Where C_{Rn} is the concentration of radon in tap water in Bq/l.

C_{Rw} is water consumption rate, and equal to 730 l/y .

W_{DC} is the conversion factor, and it is equal to 5×10^{-9} Sv/Bq .

3. Results and Discussion

The chemical analysis of water samples in the studied area are listed in Table 1. The pH of water is slightly alkaline that from 7.5 to 7.7. With an average 7.57. Electrical conductivity ranged from 846 to 863 $\mu S/cm$ with average of 855.2 $\mu S/cm$. The concentrations of Na and Cl, ranged from 54 to 66 and 90 to 96 mg/L with average 60.16, 92.87, respectively. The concentrations of Ca^{2+} (98-104 mg/L) and SO_4^{2-} (111–133 mg/L) with average of 100.8 and 122.95 mg/L, respectively. The variation of EC, Ca, Na, Cl and SO_4 in the studied area as shown in Figures (3 and 4).

Symbol	pH	EC	Ca ²⁺	Na ⁺	Cl ⁻	SO ₄ ²⁻	Symbol	pH	EC	Ca ²⁺	Na ⁺	Cl ⁻	SO ₄ ²⁻
St.1	7.5	855	100	54	90	112	St.10	7.7	861	103	61	93	123
St.2	7.5	854	100	55	92	115	St.11	7.5	857	101	65	95	133
St.3	7.6	855	101	54	92	112	St.12	7.5	857	101	65	9	132
St.4	7.5	848	100	54	92	113	St.13	7.5	859	101	64	95	132
St.5	7.5	846	100	54	90	111	St.14	7.6	856	103	65	94	130
St.6	7.6	852	100	55	91	112	St.15	7.6	853	103	65	94	130
St.7	7.6	862	103	61	94	123	St.16	7.6	854	102	63	94	130
St.8	7.7	863	102	62	94	124	St.17	7.5	855	99	65	95	133
St.9	7.7	862	103	61	93	123	St.18	7.5	855	99	66	95	132
St.19	7.6	852	100	54	90	112	St.21	7.6	853	99	61	93	130
St.20	7.5	853	100	55	92	114	St.22	7.7	855	98	65	95	133

Table 2 Chemical analysis of water samples in the studied area, 2020.

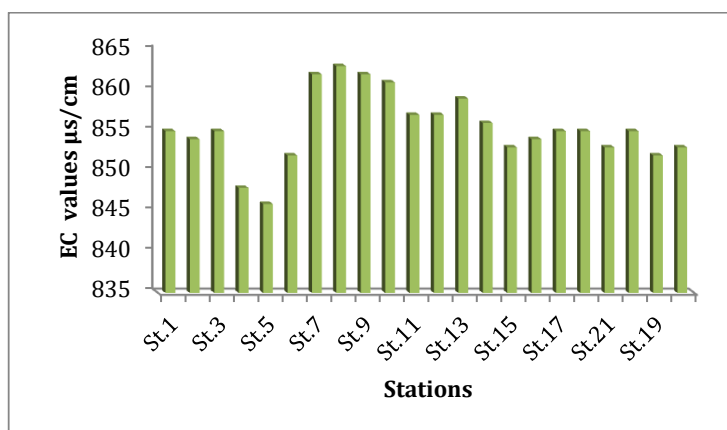


Fig 3 The variation of EC values in the study area.

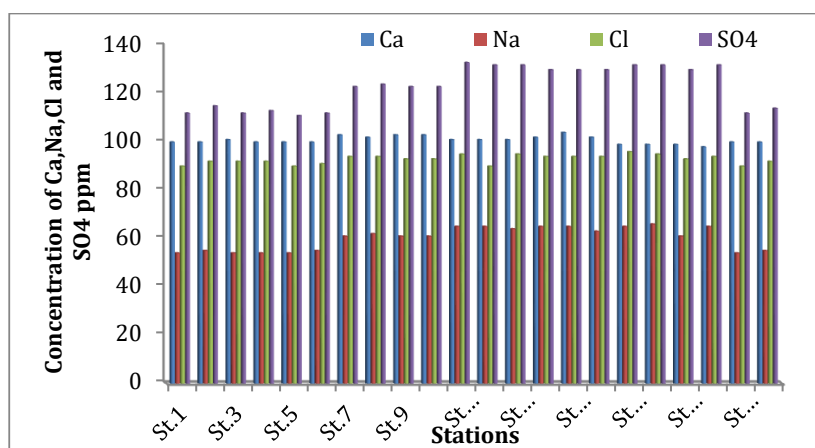


Fig 4 The variation of studied chemical values in the study area.

The results for Radon concentration in water samples in Haditha region, in three districts (Haditha center, Haqlanyah and Barwana) and Euphrates river are presented in Table 3. For total samples, the Radon (^{226}Ra) concentration in terms of area varies from (0.0091 – 0.031 Bq.L^{-1}) with an average value (0.0168 Bq.L^{-1}). The highest concentration of radon recorded 0.031 in St.10 while the lowest concentration is 0.0091 Bq.L^{-1} found in station (st.21). There is a low variation in Radon concentration between all the stations in the study area, this indicate that all locations are similarity in the type of soil, sediments and same conditions in the climate elements in these regions.

Table 3 Concentration of Radon (Bq.L^{-1}) in the study area.

Stations	Radon Conc.	AED ($\mu\text{Sv/y}$)	Stations	Radon Conc.	AED ($\mu\text{Sv/y}$)
St.1	0.0132	0.048187	St.10	0.031	0.113166
St.2	0.013	0.047457	St.11	0.029	0.105865
St.3	0.0122	0.044536	St.12	0.024	0.087612
St.4	0.0134	0.048917	St.13	0.0132	0.048187
St.5	0.0145	0.052932	St.14	0.0134	0.048917
St.6	0.0124	0.045266	St.15	0.0143	0.052202
St.7	0.023	0.083962	St.16	0.0144	0.052567
St.8	0.024	0.087612	St.17	0.021	0.076661
St.9	0.012	0.043806	St.18	0.028	0.102214
St.19	0.0096	0.035045	St.21	0.0091	0.03322
St.20	0.0092	0.033585	St.22	0.0094	0.034315

On the other hand, when comparing the Average Radon concentration in Euphrates river (St.19, St.20, St.21 and St.22) with those locations in three districts (Haditha center, Al-Haqlanyah and Barwana) Fig 5. The results show that, The radon rate of water of the Euphrates river Haditha city was less than the radon rate in different locations of studied area. There is differences in 1.40, 2.41 and 1.86 Bq.L^{-1} between the concentration of radon in Euphrates river and Haditha center, Al-Haqlanyah and Barwana), respectively. This is due to the age of the water network in these locations and the possibility of leakage from groundwater into the water network by fractures and cracks. Depend on EPA (Maximum concentration of Radon is 1000 Bq/m^3). The obtained results of radon concentrations in the studied area are within the safe international recommended concentration limit.

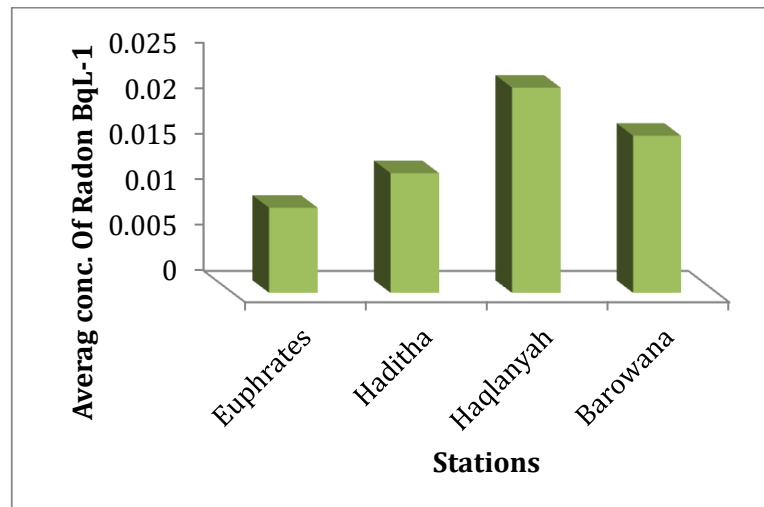


Fig 5 The Average Radon concentration in Euphrates river (St.19,St.20,St.21 and St.22) with locations in three districts (Haditha center, Al-Haqlanyah and Barwana)

In this study , Comparing Radon concentration of the present study with other regional and local studies, The obtained results less than all other countries USA (15 Bq.L^{-1}) [16] ,India (3.97 Bq.L^{-1}) [17], Kuwait (0.74 Bq.L^{-1}) [18], Turkey (0.091 Bq.L^{-1}) [19]. while locally, the results are lower than other measurements in Hilla (0.181 Bq.L^{-1}) [20], Anbar city (2.16 Bq.L^{-1}) [21], Kufa (1.15 Bq.L^{-1}) [22], Baghdad Governorates (0.15 Bq.L^{-1}) [23] (1.13 Bq.L^{-1}) [24].

In present study, The annual effective dose (AED) were calculate. The highest was $0.113166 \mu\text{Sv/y}$, while the lowest was $0.033322 \mu\text{Sv/y}$ with average of $0.061359 \mu\text{Sv/y}$, Table 3. The results of AED in the studied area appears to be lower than permissible standard (1 mSv/y) that recommended by the EPA [25]. Finally, the relation between Radon concentration and annual effective dose AED is positively as shown in (Fig. 6).

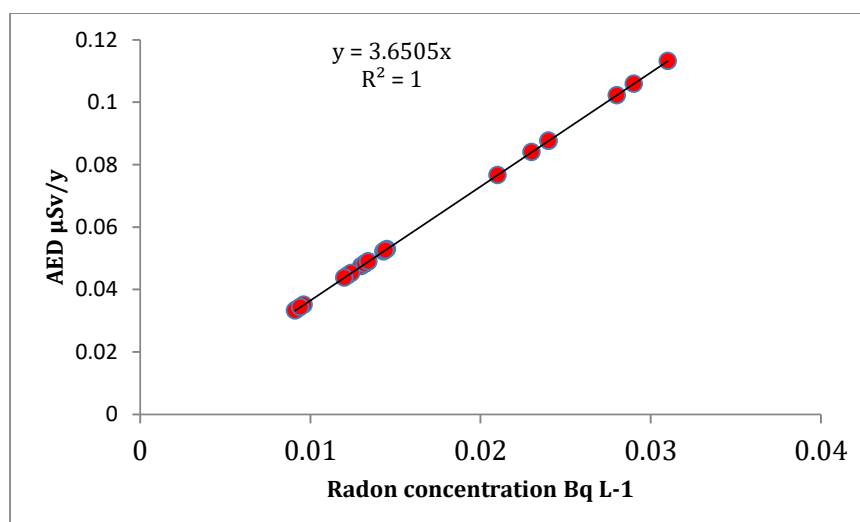


Fig 6. Relationship between ^{226}Ra and AED in the study area.

The values of pH, electrical conductivity, Calcium, Sodium, Chloride and Sulfate have been measured and study their effects to the Radon concentration in the study area. Figures (7,8,9,10,11,12) illustrates no relationship between pH, EC, Ca, Na, Cl, SO_4 with Radon concentration because these are no significant at the 95% confidence level.

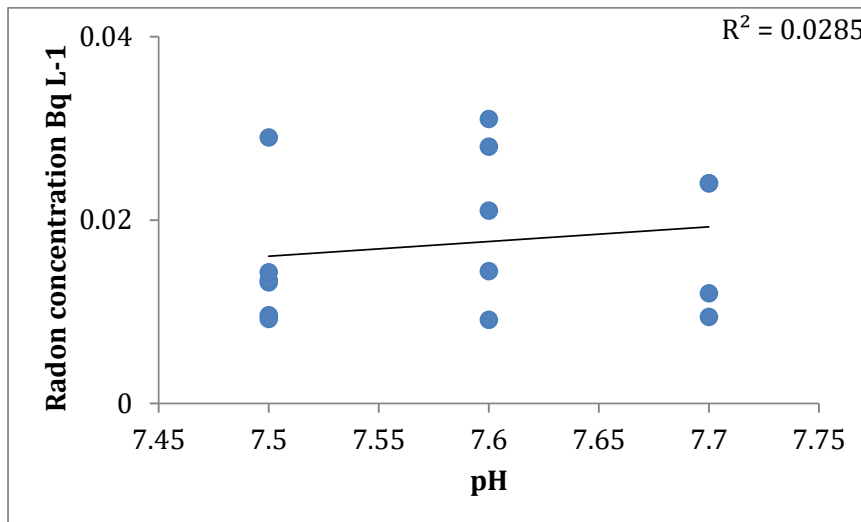


Fig 7. The relationship between pH and Radon concentration in the study area.

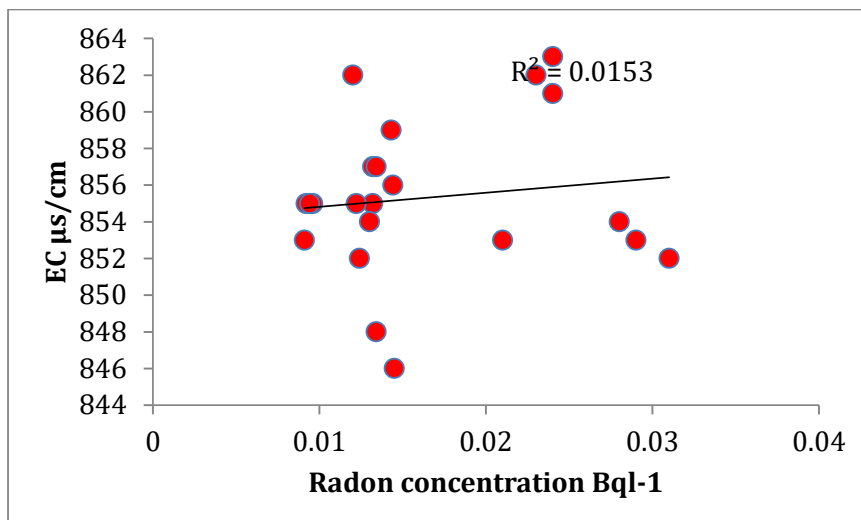


Fig 8. The relationship between EC values and Radon concentration in the study area.

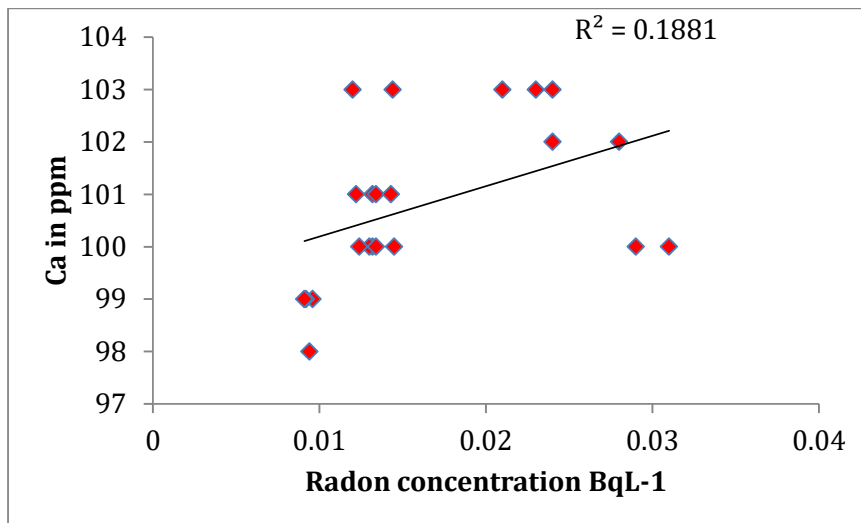


Fig 9. The relationship between Ca values and Radon concentration in the study area.

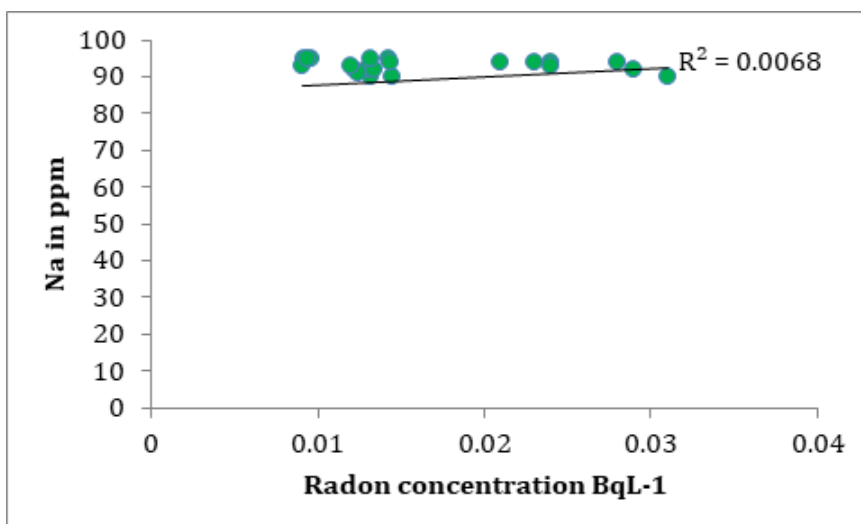


Fig 10. The relationship between Na values and Radon concentration in the study area.

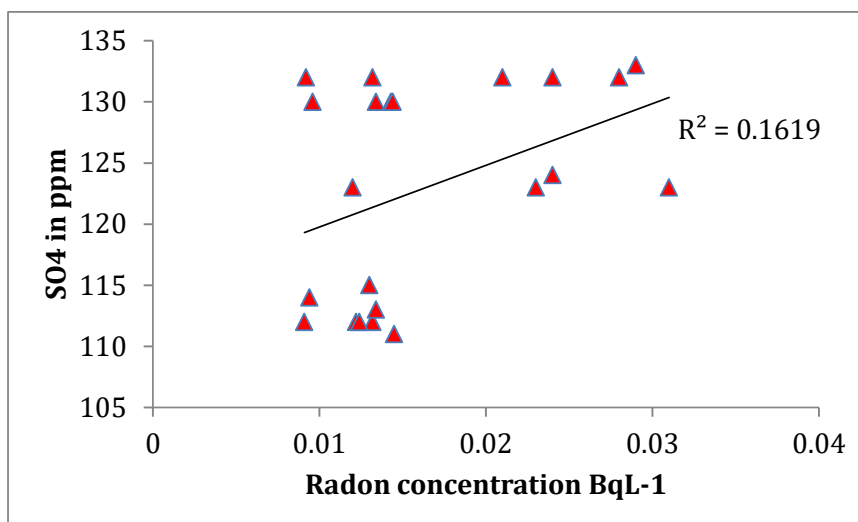


Fig 11 The relationship between SO₄ values and Radon concentration in the study area.

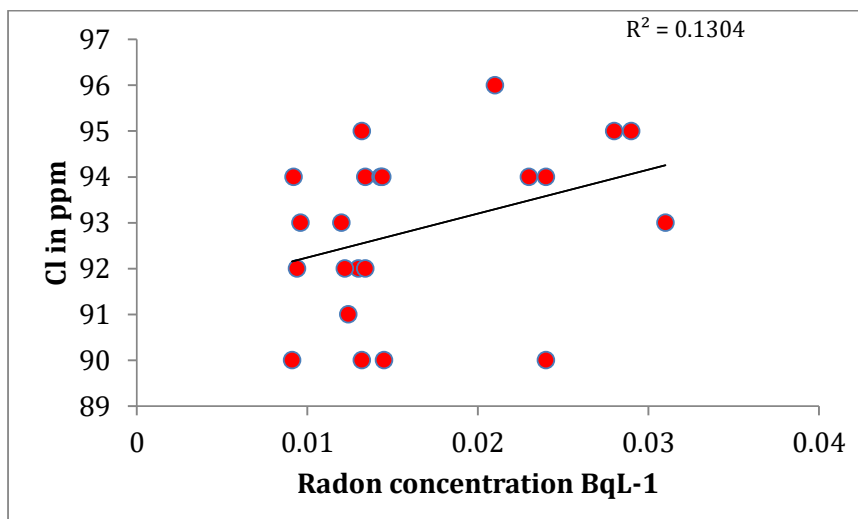


Fig 12. The relationship between Cl values and Radon concentration in the study area.

4. Conclusions

The RAD7 device was used to measure the concentration of radon gas in drinking water in Haditha city and its three districts (Haditha center, Haglanyah and Barwana). The ²²⁶Ra concentration varies from (0.0091 – 0.031 Bq.L⁻¹) with an average value (0.0168 Bq.L⁻¹). while the annual effective dose in all water samples was less than the recommended maximum dose. The correlation between the pH, Ec, Ca, Na, Cl, SO₄ and the radon concentration of the samples in the study area was determined. It found a very weak linear relationship. It is recommended to test the concentration of radon in your home (old, new home) and in the present.

5.Refernces

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