Radon gas determination and radiological risk in Shatt Al Arab - Al-Basra governorate, Iraq

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Abstract

This research focuses on measuring the concentrations of radioactive radon gas (222Rn) in water samples that collected from different places in Shatt Al-Arab, the first confluence in Qurna, to the second confluence in Karma Ali, Basra Governorate, using RAD-7 (RAD-7 H2O) detector. Also, annual effective dose (AED) and lifetime cancer risk due to ingestion of 222Rn in samples of present study as drinking water were evaluated. The results show that, 222Rn concentration were ranged from (0.0 to 0.408) with an average 0.183 Bq/L. Also, the range of AED were changed from 0 μSv/y to 1.04 μSv/y, with an average 0.46 μSv/y. While lifetime cancer risk (×10-4) were ranged from 0 to 0.0157, with an average 0.007. Accordingly, 222Rn concentrations in samples of present study was within the permissible limit according to the Environmental Protection Agency (EPA), as the maximum concentration of radon in the water reached (11.1) Bq/L . Also, the values of AED and lifetime cancer risk in all samples were found lower than the safety limit for the healthy drinking water. So, it may be concluded that water in Shatt Al-Arab in the Basra governorate- Iraq have not environmental impacts For Radioactive Radon Gas on the health of human.

INTRODUCTION

Radon is chemically inert, colorless, tasteless and odorless gas. radioactive element , non-flammable and very toxic [1]. It is the second most common cause of lung cancer, after cigarette smoki ng, causing 21,000 lung cancer deaths annually in the United States. About 2,900 deaths occur among people who have never smoked. according to policy-guided Environmental Protection Agency (EPA) estimates [2] . Radon occurs naturally in minute amounts as an intermediate step in the regular radioactive decay chains through which thorium and uranium slowly decay into lead and many other short-lived radioactive elements. Its most stable isotope, 222Rn , has a half-life of only 3.8 days, making it one of the rarest elements. Since thorium and uranium are two of the most common radioactive elements on Earth Radon decay produces many other short-lived nuclides, known as radon daughters [3] There are significant uncertainties about the health effects of low dose exposure [4] Radon daughters are solids and stick to surfaces, like airborne dust particles, which can cause lung

cancer if inhaled.[5] It is under standard conditions, a gaseous and easily inhaled, and therefore a health hazard. It is often the largest single contributor to an individual's background radiation dose, but due to local differences in geology, [6] The level of exposure to radon varies from place to place. The common source is uranium-containing minerals in the earth, and thus accumulates in underground areas such as cellars. Radon can also occur in some ground waters such as spring water and hot springs [7].

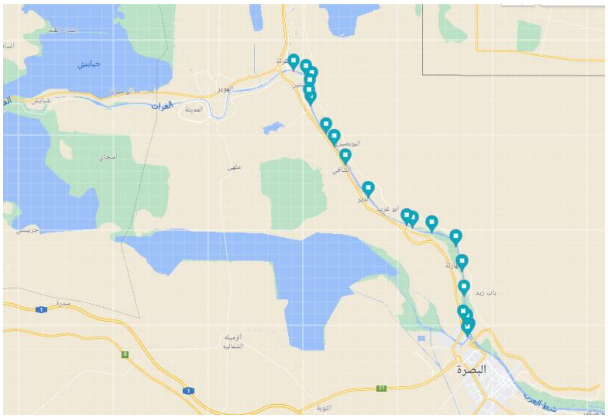
Studies were conducted in different regions of the world to measure the concentration levels of radon gas in water .(Inaam 2012) measured radon gas in the Hilla River using the RAD-7 , she result was concentration of radon (0.1038 Bq/L) [8] , (Taqa , 2015) studied of radon gas and radioactive hazards in tap water in Al-Muthanna Governorate, Iraq, using CR-39, the results that the concentration of radon gas ranged from (0.15 + 2.16 Bq/ L) to (0.18 + 4.32 Bq/L), and the annual effective dose is (0.0039 mSv/y [9] , and (Abdel ,2015) study to determine the concentration of radon gas in its results showed that the average radon concentration was 1.56 Bq/L , and the annual effective dose was 16.42 μSv/y which was within the limits set by the relevant organizations[10] ,Also, (Rafael et al,2016) conducted a study to measure the level of radon concentration on 20 samples of thermal water in the Campen Flegrei volcanic caldera, (southern Italy) by using RAD-7 detector equipped with the accurate accessory RADH2O , with an average value of 152 Bq/L[11]. Also, (Anurani , et al ,2019) study on the spatial and temporal variability of radon in the River Basin (VRB) in southern India and their collected 40 groundwater samples during three seasons of the 2019 using RADH2O and their results of radon concentration in three seasons range of 0.64 – 79.94 Bq/L in pre-monsoon, 0.25–36.95 Bq/L in monsoon and 0.42–59.79 Bq/L in post-monsoon season and 18% of samples exceeded the permissible limit of EPA (11 Bq/L) [12] . It has been chosen and the reason for choosing water as samples to be studied radiologically, because many regions in the Basra governorate that have been bombarded In the recent wars that Iraq was exposed to in the previous period. and water's importance and direct impact on people's, animals', and agricultural crops' life. Also , the incidence of cancerous diseases has increased recently, especially in the southern regions of Iraq, with high numbers recorded compared to previous times.

Location of the study area

The study area was determined by choosing the point of the first confluence of the Tigris and Euphrates rivers in the Qurna district to form the Shatt al-Arab to the second confluence point in Karma Ali district, Al-Najibiya district, Al-Hartha district in Basra governorate, with a path length of approximately 60 km [13].

The samples were taken in the state of receding tide, i.e. when the state of tides occurred by 20%, to ensure that water samples are not repeated in the tide state on the Shatt al-Arab path, in contrast to the water flow towards the Arabian Gulf, where the first sample was taken from the point of the second meeting in Karma Ali near the Najibiyah bridge towards The north reversed the flow of water in the Shatt al-Arab by 20 samples with varying distances between one sample and another according to the nature of the beaches from which the samples were taken, with a distance of 2 km to 3 km and some distances of 4 km between one sample and another as shown in Figure (1) Map of the study site using the GPS location feature [13].

Figure (1): Map of samples on the Shatt al-Arab from the first confluence in the Qurna district to the second confluence in the Karmat Ali sub-district [13].



Experimental Part

RAD-7 represents a semiconductor material (often silicon) which transforms alpha radiance to an electrical sign immediately. The interior sample cell of RAD-7 points out to a (0.7 liters) hemisphere in a combination of an electrical conductor on the interior. The planar Silicon alpha detector, which is solid state and ion implanted, is at the center of charged alpha emitters being electrostatically collected on the surface of a silicon solid-state detector and then detected via spectroscopic analysis [14]. A total of four five-minute counting cycles are executed by RAD-7, bringing the total analysis duration to 30 minutes [14]. and after the end of each run will print out the included summary (mean radon concentration, humidity and temperature, standard deviation) [15]. Also includes other information about the operating number, the 4-circuit diagram and the accumulated spectrum, the number of turns [15]. The rate of radon removal from water in the air ring in a sample of 250 ml is 94% and it is very high. Figure (2) shows the schematic diagram of the RADH2O supplement [15].

Figure (2): RAD-7 detector [15].

Theoretical calculations

AED in unit (Sv/y) based on the ingestion of 222Rn concentrations from water sample when using as drinking water for adults was determined by equation (1) [16]:

$$AED = C \times WC \times DCF \quad \ldots\ldots\ldots (1)$$

where C is 222Rn concentration in unit (Bq/L), WC is the annual water consumption for a person that equal 2 in unit (L/d) [17] and DCF is conversion factor in unit (μSv/Bq) that equal 0.0035 μSv/Bq [17].

The lifetime cancer risk based on the ingestion of 222Rn concentrations from water when using as drinking water for adults was determined by equation (2) [18]:

$$\text{Lifetime cancer risk} = AED \times DL \times RF \ldots\ldots\ldots (2)$$

where, DL is the duration of life (70yr) and RF is the risk factor (0.055 Sv-1) recommended by the ICRP [18].

Results and discussion

The results of 222Rn concentration, AED and, lifetime cancer risk was determined for groundwater samples that collected from different areas of Shatt Al-Arab in Basra Governorate, Iraq as Table (2). which shows the sequence of the sample, the rate of radon concentration in it, the highest value and the lowest value of concentration, the annual effective dose, and the GPS location from which the sample was taken.

Table (1) shows the concentration of radioactive radon gas in selected samples of Shatt al-Arab waters from the Qurna district to Karmat Ali

Sample No	Mean (Bq/L)	High (Bq/L)	Low (Bq/L)	Effective dose µSv/y	Lifetime cancer risk $x10^{-4}$	Location
1	0.16	0.48	0	$1.752*10^{-6}$	0.0157388	N 30°34´51.7 E 47°45´56.3
2	0.08	0.16	0	$8.76*10^{-7}$	0.0078694	N 30°35´09.4 E 47°46´10.6
3	0.04	0.16	0	$4.38*10^{-7}$	0.0039347	N 30°35´55.2 E 47°45´53.5
4	0.04	0.16	0	$4.38*10^{-7}$	0.0039347	N 30°36´21.2 E 47°45´28.1
5	0.04	0.16	0	$4.38*10^{-7}$	0.0039347	N 30°38´43.8 E 47°45´32.4
6	0.08	0.16	0	$8.76*10^{-7}$	0.0078694	N 30°41´06.7 E 47°45´20.2
7	0	0	0	0	0	N 30°43´30.0 E 47°44´40.0
8	0	0	0	0	0	N 30°44´51.0 E 47°41´59.6
9	0.08	0.16	0	$8.76*10^{-7}$	0.0078694	N 30°45´15.3 E 47°39´50.6
10	0	0	0	0	0	N 30°45´30.5 E 47°39´12.2
11	0.04	0.16	0	$4.38*10^{-7}$	0.0039347	N 30°48´08.0 E 47°34´55.0
12	0.12	0.32	0	$1.314*10^{-6}$	0.0118041	N 30°51´14.7 E 47°32´21.4
13	0.16	0.32	0	$1.752*10^{-6}$	0.0157388	N 30°53´03.8 E 47°31´07.5
14	0	0	0	0	0	N 30°54´11.1 E 47°30´13.2
15	0	0	0	0	0	N 30°56´51.5 E 47°28´28.9
16	0.08	0.318	0	$8.76*10^{-7}$	0.0078694	N 30°57´26.8 E 47°28´19.2
17	0.04	0.159	0	$4.38*10^{-7}$	0.0039347	N 30°58´22.6 E 47°28´23.9
18	0.16	0.318	0	$1.752*10^{-6}$	0.0157388	N 30°59´04.5 E 47°28´37.5
19	0.159	0.318	0	$1.74105*10^{-6}$	0.015640433	N 30°59´43.0 E 47°27´58.1
20	0.16	0.48	0	$1.752*10^{-6}$	0.0157388	N 31°00´12.7 E 47°26´37.4

Through the results of examining the water samples shown in Table (1), 222Rn concentration were ranged from 0.0 Bq/L that recorded in the samples (S7, S8, S10, A14 and S15) to 0.16 Bq/L that recorded in the sample (S1, S18 and S20), with an average 0.183 Bq/L. it was found that the radon gas concentrations in water samples of present study were within the permissible limit set by the US Environmental Protection Agency (EPA) because the limit The highest permissible concentration of radon in water (11.1) Bq/L [2].

The percentage the values of the AED as Figure (3) all results of AED was less than the

internationally allowed limit and reaches (0.1) mSv/y [6].

Figure (3): Compering 222Rn concentrations in water samples with permissible value for water samples.

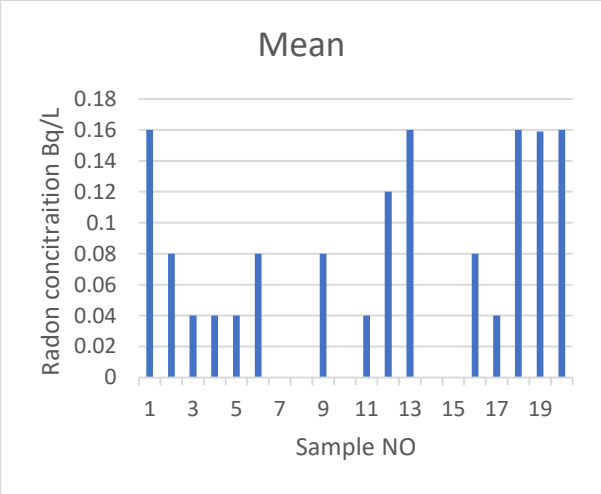
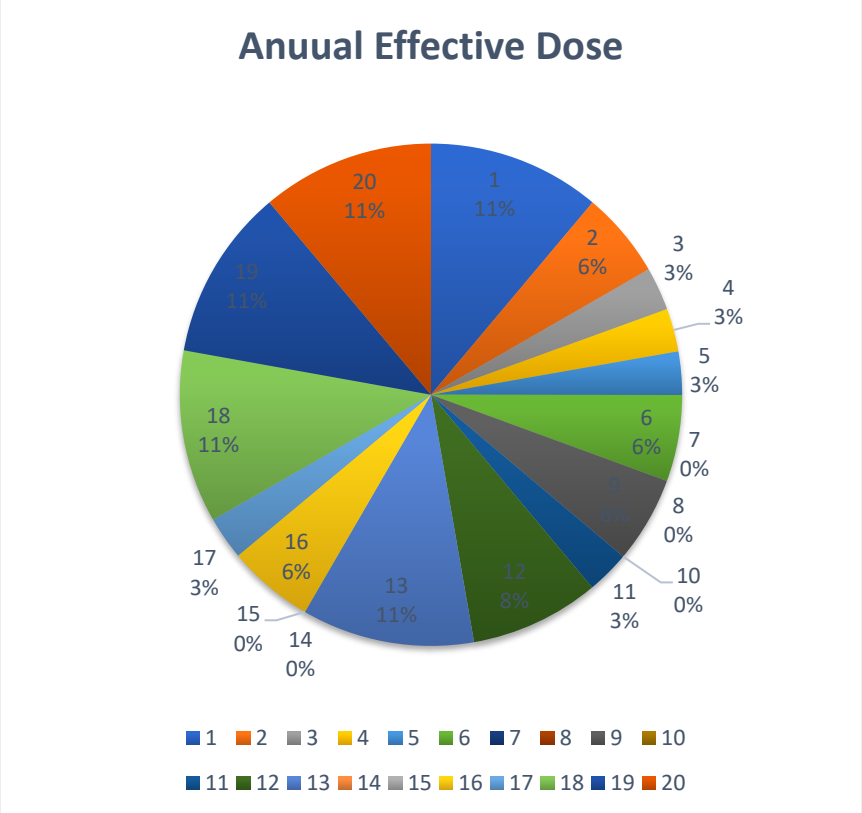
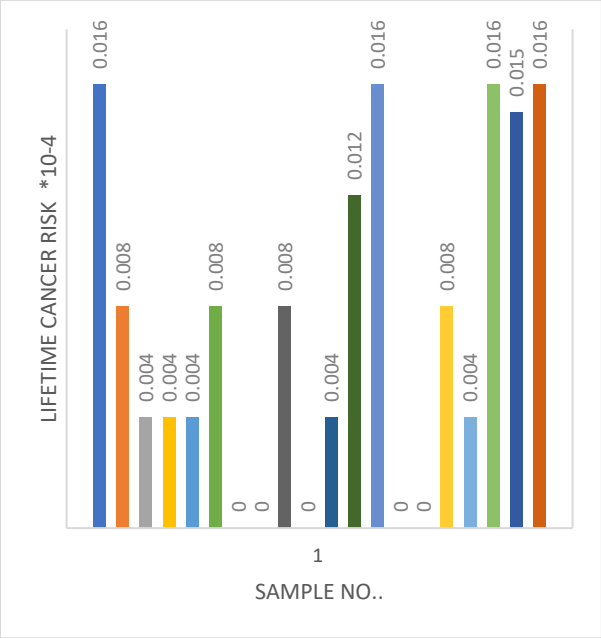


Figure (4): Percentage of AED in samples under study.



The lifetime risk due to 222Rn in water samples intake (see Table 1and Figure 5) was ranged from 0 to 0.0157×10-4, with an average (0.007)×10-4, which it less than the admissible limit of 10-4 [18]. The source of groundwater in these areas is either from rain water that penetrates into the ground through its rock layers, or geological water originating from rocks between fresh water or seas that store water between its rocks.

Figure (5): Results of lifetime cancer risk in samples under study.



The results shown in Table (2) indicated that there are variations in radon concentrations in all samples which it can be attributed to the difference in the geological nature of each area as well as to the movement of water and its speed [19]. On the other hand, radon gas concentration varies due to factors such as temperature, air pressure, humidity and changes in the Earth's layers.

The results of the current research were compared with those of previous researchers, according to Table 2.

The state	Radon concentration (Bq/L)
Iraq -Hilla River	0.103 [8]
Iraq - Karblaa	2.508 [11]
Iraq -Al-Muthanna	4.32 0 [12]
Egypt.	13.0 [13]
southern Italy	5.80 [14]
India.	0.64 [15]
Iraq –Shatt al-Arab	0.183 present study

Conclusions

Through the results obtained in the current study, it is found that the radioactive radon gas concentration in water samples reached the lowest level compared to the permissible limit in the Environmental Protection Agency the United States (EPA) and WHO 1993. Also, AED was less than the permissible limit according to the WHO 2011 which is 0.1 µSv/y. As well as All values of lifetime cancer risk was less than the permissible limit. So, radioactive radon gas in water samples in Shatt Al-Arab at Basra Governorate, Iraq were no danger when using it by human in drinking and other uses.

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