Measuring the concentrations of radon gas ^{222}Rn naturally-emitted from water samples selected from the marshes of Basra Governorate, southern Iraq

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Abstract

This study dealt with measuring the concentrations of radioactive radon gas emitted from (35) water samples taken from selected areas of the marshes of Basra Governorate – southern Iraq, to determine the concentrations of the radon gas ^{222}Rn emitted from the selected and newborn samples of the radioactive element Radium ^{226}R resulting from the decay of isotope uranium ^{238}U in (July) 2020. Fast electronic technology has been adopted by the RAD7 device. The results showed that the highest concentration of radon gas in water was 15.531 ± 1.067Bq. L^{-1} in the sample from am alsanadiq of funds in the marshes of Basra city, and the lowest concentration rate was 0.034±0.002 Bq. L^{-1} in a water sample from Qurna among the studied samples. The effective annual dose of water was calculated at the highest concentration rate and found to be 0.843mSv.y^{-1} and this value is higher than the internationally recommended limits by specialized international organizations of 0.1 mSv.y^{-1}. In general, it was found that the radon gas concentrations in some of the water samples selected from the marshes of Basra Governorate–southern Iraq within the study were higher than the permissible values of 11.1 Bq. L^{-1} according to the US Environmental Protection Agency (EPA) and that they may pose a risk to the health of the population in those areas in If no necessary action is taken.

Key words: Radon ^{222}Rn, Radium ^{226}Ra, Uranium ^{238}U, RAD7 device, Annual Effective Dose.

Introduction

Radon gas and its radioactive precipitates are of special interest among all other naturally occurring radioactive materials because they contribute the largest amount to the total annual effective dose for a person (Ali, 2020). Radon gas poses a great danger to health, as studies have shown that there is a relationship between exposure to radon gas and the incidence of lung cancer (Folger *et al.*, 1994 ; Azam, *et al.,* 1994; Duggal, *et al.*, 1995) Exposure to a very high concentration of radon in drinking water can lead to the risk of stomach cancer and gastrointestinal cancer (Kendal *et al.,* 2002 ;Zhuo *et al.,*2001) Knowledge of radon levels in water, especially water from ground sources, is essential to protect people from the effects of excessive exposure to radiation (Ali *et al.*, 2010). Radon ^{222}Rn is a naturally occurring radioactive gas that is colorless, tasteless and odorless, chemically inert due to its electronic stability because it has eight electrons in its outer shell, its density is 9.7kg.m^{-3}, and it contains three important isotopes, which are ^{222}Rn, its half-life is 2.8day, and the newborn from ^{226}Ra of the ^{238}U series, and the second is ^{220}Rn its life. The half-life of 55.65 second from ^{228}Ra of the ^{232}Th series and the third ^{219}Rn is 4S of the ^{235}U series. The first isotope is called Radon, the second is Thoron, and the third is called the actinon. Radon dissolves in water, as its solubility increases as its temperature decreases, so when cold groundwater travels through subterranean soil rocks or when it penetrates through the pores of the rock, it dissolves radon and pulls it from the rocks, in addition to the role of groundwater in dissolving the radium element from which radon descends Directly, and when the water is heated or moved, a good amount of radon is released and released to the outer medium, and the radon content in the water increases with the increase in the water temperature because the hot water has a greater ability to dissolve the mineral elements from rocks and soil. It is known that more than 50% of the effective annual radiation dose a human receives is related to radon and its offspring. One of the basic mechanisms that enter radon inside the dwelling is expiration of the soil as well as exhalation and emission from water (WHO, 1987; Badham *et al.*, 2010; AbdulRide *et al.,* 2014; NRC, 1994; Badham *et al.*, 2010) There are many methods for determining radon concentrations in environmental models. In this study, an effective method was used directly through the use of a fast electronic device called RAD7. This study aims to measure the concentration of radioactive radon gas emitted from the models found in the waters of selected areas of the marshes of Basra Governorate– southern Iraq.

This study is important because Iraq is totally dependent on surface water and that its main source of water comes from the Tigris River and its tributaries and the Euphrates River, and the three countries benefit from these two rivers, Turkey, Syria and Iraq. However, the studied area is characterized by a high population density, and it is the third in population next to Baghdad governorate, as well as creating a radon map for the marsh areas in southern Iraq. This study is considered the first of its kind to measure radon concentrations in marsh waters.

Experimental Work

Description of the area

The study area is located in the city of Basra, in southern Iraq, and the marshes area in southern Iraq extends from the northeast of the city of Amara to the north, Basra to the south and Nasiriyah to the west, and it is located between latitudes 45 ', 30 °, 25' 32 ° north, and longitudes 46 °, 13 ' 48°, east, and Basra city is 55 km from the Arabian Gulf and 450 km from the capital, Baghdad. The marshes occupy a large proportion of the southern part of the alluvial plain of Iraq. It has an area of 19,070km2 and a population of 3 million people. The marshlands are a unique example of freshwater lakes in arid and semi-arid regions of the world. The importance of the study area as a source of economic wealth for Iraq is that it is rich in water and animal resources and is considered one of the tourist areas in Iraq for its attractive natural landscapes, as well as containing the largest giant oil fields in the region.

Sample collection and preparation

Samples were collected in July of 2020 from selected areas of the marshes of Basra city - southern Iraq Figure (1), where the number of samples collected reached 35 samples distributed over the study areas, including samples from the Tigris, Euphrates, Karun and Shatt al-Arab rivers as models for control and comparison. The water was carried out in two-liter sealed plastic bottles at a depth of 20 cm from the surface of the water. It was well washed with Ethanol alcohol to disinfect it from germs, and then it was filled with water from the areas chosen for the study and sealed. The PH was measured using a PH meter type HI-8915 and then placed each sample of the samples in the American-origin

Tuttingen centrifuge has 3600 revolutions/minute to separate suspended impurities and sediments, then it was placed in the RAD7 vial as in Figure (2) to start the measurement process for each sample separately. As for the sediments resulting from the centrifugation process of the water samples, they were dried at a temperature of 110 ° C for 24 hours, then milled using a mill and screened using a2μm sieve to get rid of impurities and foreign bodies. The samples were prepared with agreed international specifications to determine radon concentrations and the effective technique was used through RAD7 device to determine the effective concentrations of radon emitted from the samples under study.

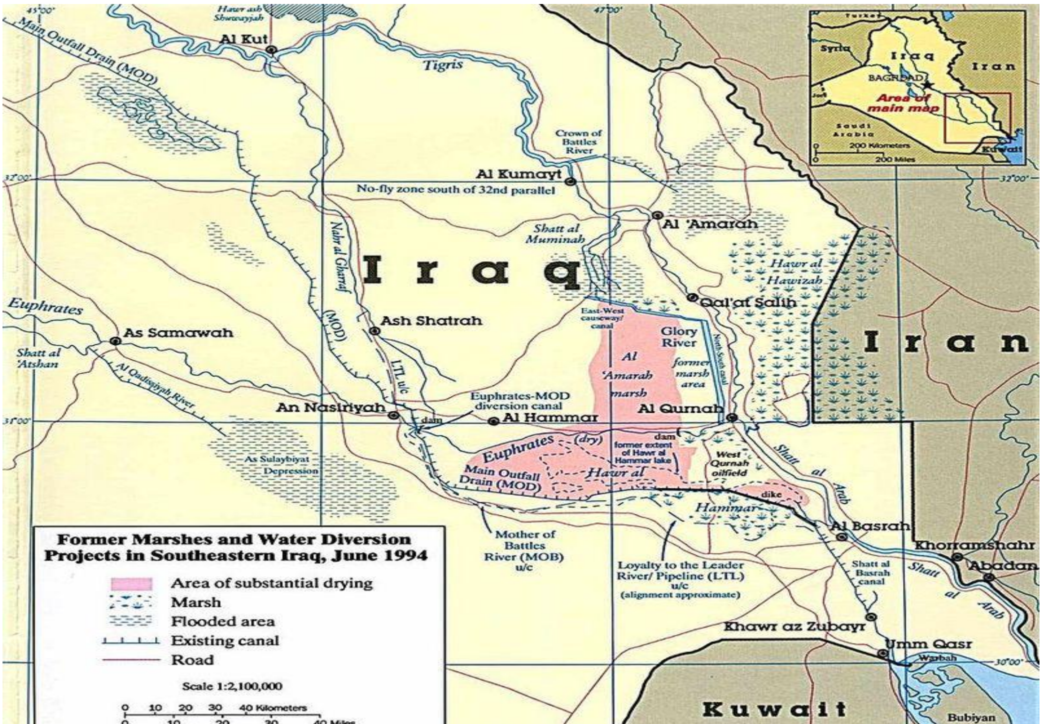

Figure 1: A map of the marshes in southern Iraq.

RAD7 Technique

This technique is considered one of the important and advanced techniques to measure the concentrations of radon and oxen gas in air, water and soil in real time. The advanced RAD7 detector made of silicon converts the alpha energy radiation resulting from the decay of polonium

^{214}Po and Polonium ^{218}Po into an electrical signal in an instant, the signal is amplified by electronic circuits and turns into a formula Digital. Radon gas was measured for the study samples that were collected by a rapid electronic device RAD that works according to the energy of alpha particles emitted from radon and revolution in two ways, the first (sediment samples) where the measurement process took place by pulling the device for a quantity of gas generated from the top of the model and sending it to the LOCAS cell To measure radon concentrations, after making sure that there is no water vapor associated with the gases, the process of pumping the gas into the device takes a period of five minutes, after which the device can count for another five minutes Figure4 This counting process is a measurement of the concentration of the elements Polonium ^{218} Po- (3.05 min) and Polonium ^{214}Po (164 µs). Therefore, the measurement process is 9 -15 minutes. As for the second (water samples) through RADH2O attached to RAD7, the device measures radon gas in water. With high accuracy and a wide range of concentrations to record readings for an hour after taking the sample, or often the readings recorded simultaneously, the device is distinguished by its ability to electronically determine alpha particle energy, and this enables it to distinguish between the isotopes of radon elements polonium ^{218} Po - and polonium ^{214}Po - and between radon and thoron (purging) RAD7 detector with fresh air for ten minutes by connecting the drying unit in a closed loop with RAD7, so the outgoing air passes through the Desiccant and returns to the inside. Where we put the system on the Grab to extract the radon from the sample, and the pump starts to work for five minutes, during which the radon is drawn from the sample and delivered to the measuring room to RAD7, and then RAD7 stops and waits for more than 5 minutes until reaching Due to equilibrium, the RAD7-H2O system reaches this equilibrium state within approximately 5 minutes, after which no more radon can be extracted from the water. The extraction efficiency or percentage of radon removed from water to air loop is very high about 94% for 250 ml sample. The exact value of the extraction efficiency depends to some extent on the ambient temperature, but it is always well above 90%. The RAD7 detector converts the alpha radiation directly into an electrical signal. RAD7 has the ability to tell the difference between the new radon blocks and the old radon blocks remaining from the previous tests (Durridge Company, 2012) this process is repeated for 4 cycles of 5 minutes for each one cycle until the total test duration is 30 minutes. When each operation is completed, RAD7 prints information including (Average radon concentration, standard deviation, humidity and temperature reading inside the device, date and time of test procedure in addition to operating number, number of cycles and then gives the graph of four cycles and the accumulated spectrum.

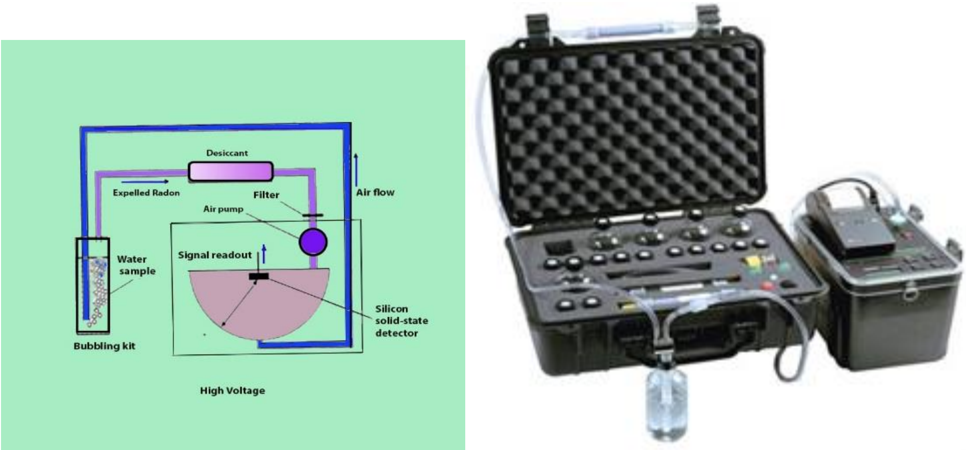

Figure (2) on the right is a picture of the RAD7 device used to measure radon in water models, and on the left is the RADH2O diagram.

The annual effective dose Dw in the case of exposure to radon gas in water was calculated from the following equation (Somashekekar,et al 2010)

Dw = Cw CRw Dcw

whereas:

Dw: annual equivalent dose ($Sv.y^{-1}$)

Cw: radon concentration in water ($Bq.L^{-1}$)

CRw: general per capita consumption ($1095\ L.y^{-1}$)

Dcw: dose conversion factor for radon ($5 * 10\text{-}9\ Sv\ Bq^{-1}$)

(UNSCEAR,1993).

Results and Discussion

From Table No. (1), we note that the lowest value of the rate of radon gas concentration in the treated water samples in selected areas of the marshes of Basra - southern Iraq was $0.034 \pm 0.002\ Bq.\ L^{-1}$ in the

Qurna water sample from the study areas, and the largest gas concentration is L 15.531 ± 1.06 Bq. L^{-1} from the mother of funds in the marshes of Basra city (sample number L15) and the concentration rate is 3.025 ± 0.195 Bq. L^{-1}. We also note from the same table that the pH measurements of the water of the study area ranged (8.4 - 7.2) between acidity and basicity, and these changes were not It has a clear effect, except on specific areas in which the basicity is high due to the presence of bicarbonate, and this indicates that the marsh environment is a suitable environment for the life of the living in certain areas and is not suitable in other areas. Figure (3) shows the relationship between the radon gas concentrations emitted from the treated water samples in the study area from the marshes of Basra - southern Iraq. In the case of raw untreated water, the values of radon concentrations ranged between 0.042 -15.531 Bq. L^{-1} for the same areas. The selected table (2), the concentrations of radon gas in the studied water sediments samples, showed that the greatest concentration of water sediments was 15.872 ± 1.15 Bq. $L^{-1}$from the al almasabu aleamu water sample in the north of the study area and the lowest concentration in the water sediment sample. Sample No. (L20) was taken from Al Shafi. Within the study area, was 1.011 ± 0.07 Bq. L^{-1} . We note that there is a variation in the measurement results of the water models and their sediments Fig. (4). The reason for the variation in these measurement results for water and sediment models with different locations is due to the difference in the nature of the geological composition, in some areas there may be a conclusion The implication is that the high radon concentration may be due to the presence of water resources in the uranium-rich lands, since the study area is an oil lake where the largest giant oil fields in the region are located and the geological composition of the oil fields contains large quantities of naturally occurring radioactive materials Of origin, it may have a clear effect due to the illegal dumping of oil waste, especially the polluted water associated with the oil being thrown into the public outfall, as it is a drain on industrial waste and led to the pollution of that region. Or it may be a result of the exposure of some study sites to air strikes by depleted uranium-coated missiles during the second Gulf War in 1991, such as the Almasabu aleamu area, where the waste of the Second Gulf War since 1991 is still present in the study area. These concentrations of radon gas in water models are higher than the permissible levels set by the International Atomic Energy Agency and the US Environment Agency (USEPA) 11.1 Bq. L^{-1}, and this percentage is high compared to the limits recorded by (UCEPA, 1999) the United States Environmental Protection Agency and by comparing the study results with studies A precedent for radon levels in water in other areas of Basra is what researchers in Basra, such as Subber Abdul RH, Ali Master A. and Salman T. M, have measured the concentrations of radon gas in surface water, well water, and water associated with crude oil production in 2011 (Subber *et al.*, 2011) We find that the rate of radon gas concentration is higher or sometimes close to it in most regions, and this may be attributed to, as mentioned above, or changes in the course of the rivers that feed the marsh areas with water, and the annual effective doses of water ranged between (0.843 - 0.001) mSv.y^{-1} and the highest dose of radon was recorded in a sample. The highest concentration of radon in water was 15.217 Bq. L^{-1} . This value is high compared to the internationally recommended limits in water of (0.1mSv.y^{-1}) (WHO,2004) and it poses a threat to the health of people in the area. a To study in the event that no necessary measures are taken to preserve their health.

Table 1. Radon gas concentration (Bq. L^{-1}) and Effective dose (mSv.y^{-1}) in water samples in the studied stations in the marshes areas of Basra city - southern Iraq.

Site Number	Site Name	pH(Values)	Radon concentration ^{22}Rn in Bq/L (Treated Water)	Radon concentration ^{222}Rn in Bq/L(Untreated water)	Mean (Bq/L)	Effective dose(mSv.y^{-1})
L1	Tunisia	7.4	1.15	1.23	1.19±0.08	0.065
L2	alsuwra	7.5	1.038	1.113	1.075±0.07	0.056
L3	almadina	7.4	0.995	1.041	1.018±0.001	0.055
L4	Waki	7.5	1.019	1.130	1.074± 0.07	0.059
L5	bahila	7.5	1.014	1.021	1.017±0.001	0.056
L6	aleabbara	7.4	0.888	0.911	0.899±0.06	0.045
L7	almaebar	7.7	4.512	4.964	4.738±0.32	0.257
L8	alhayadur	7.3	0.876	0.897	0.893±0.06	0.049
L9	shueayb	7.9	5.635	5.875	5.755±0.39	0.313
L10	Am alsabbah	7.8	2.621	2.821	5.766±0.39	0.314
L11	Abu hisan	7.7	3.598	3.733	3.665±0.25	0.199
L12	silayn	8.2	14.132	14.346	14.293±9.	0.776
L13	Abu sakhir	7.4	0.542	0.5723	0.557±0.03	0. 030
L14	Am altayar	7.6	3.289	3.411	3.35 ±0.22	0.22
L15	Am alsanadiq	8.4	15.217	15.846	15.531±1.06	0.843
L16	alkarun	7.7	5.512	5.712	5.612±0.38	0.305

L17	aljifa	7.7	3.265	3.299	3.282±0.22	0.179
L18	aljunaba	7.6	2.324	2.359	2.341±0.16	0.127
L19	aleuzu	7.2	1.118	1.137	1.127±0.07	0.061
L20	alshafi	7.2	1.039	1.052	1.045±0.07	0.006
L21	Almasabu aleamu	8.4	13.102	13.301	14.201±0.09	0.718
L22	Jari saeida	7.4	1.978	2.123	2.050±0.14	0.111
L23	Shartat aldiyr	7.4	1.036	1.062	1.049±0.07	0.057
L24	alhamra	7.6	2.614	2.876	2.517±0.17	0.137
L25	zajri	7.4	2.212	2.421	2.316±0.16	0.126
L26	aljalae	7.6	1.119	1.167	1.143±0.08	0.062
L27	Karimat Ali	7.4	0.186	0.197	0.191±0.01	0.010
L28	almusahab	7.4	0.191	0.325	0.258±0.01	0.016
L29	alqarna	7.3	0.027	0.042	0.034±0.002	0.001
L30	Abu aljawlan	7.7	1.233	1.286	1.259±0.09	0.069
L31	Am alshwij	7.5	0.342	0.539	0.440±0.03	0.023
L32	Nahr dijla	7.7	1.127	1.143	1.135±0.08	0.061
L33	Nahr alfurat	7.5	1.451	1.629	1.54±0.10	0.083
L34	alsuwib	7.6	1.113	1.152	1.132±0.08	0.061
L35	alkhinziriu	7.8	3.289	3.490	3.389±0.23	0.184

Table 2. Radon gas concentration (Bq. L^{-1}) in water sediment models in the studied stations from the selected study areas.

Site Number	Site Name	Radon concentration ^{222}Rn in Bq/L(Untreated water)
L1	Tunisia	1.62±0.11
L2	alsuwra	1.327±0.09
L3	almadina	1.075±0.07
L4	Waki	1.320±0.09
L5	bahila	1.064±0.07
L6	aleabbara	1.120±0.08
L7	almaebar	6.031±0.4
L8	alhayadur	1.129±0.08
L9	shueayb	7.211±0.5
L10	Am alsabbah	4.312±0.3
L11	Abu hisan	4.233±0.29
L12	silayn	15.152±1.03
L13	Abu sakhir	1.013±0.07
L14	Am altayar	4.104±0.28
L15	Am alsanadiq	13.139±0.26
L16	alkarun	6.218±0.42
L17	aljifa	3.783±0.25
L18	aljunaba	2.868±0.19
L19	aleuzu	1.217±0.08
L20	alshafi	1.011±0.07
L21	Almasabu aleamu	15.872±1.15
L22	Jari saeida	2.325±0.15
L23	Shartat aldiyr	1.092±0.07
L24	alhamra	3.021±0.2
L25	zajri	2.830±0.19
L26	aljalae	1.319±0.09
L27	Karimat Ali	0.311±0.02
L28	almusahab	0.719±0.04
L29	alqarna	0.069±0.004
L30	Abu aljawlan	1.524±0.10
L31	Am alshwij	0.841±0.05
L32	Nahr dijla	1.298±0.09
L33	Nahr alfurat	1.716±0.11
L34	alsuwib	1.297±0.09
L35	alkhinziriu	3.713±0.25

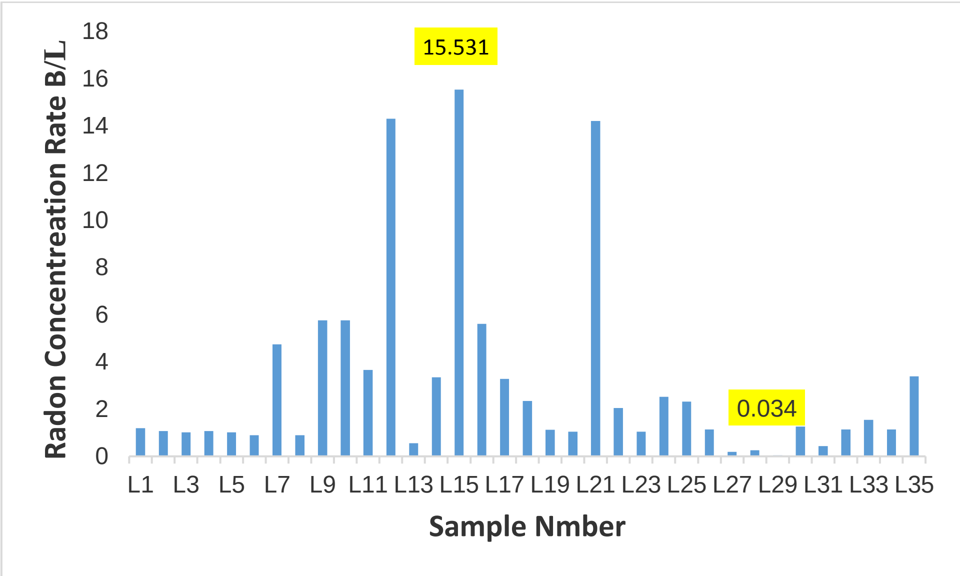

Figure 3. Radon concentration Rate measured in water samples in the study area.

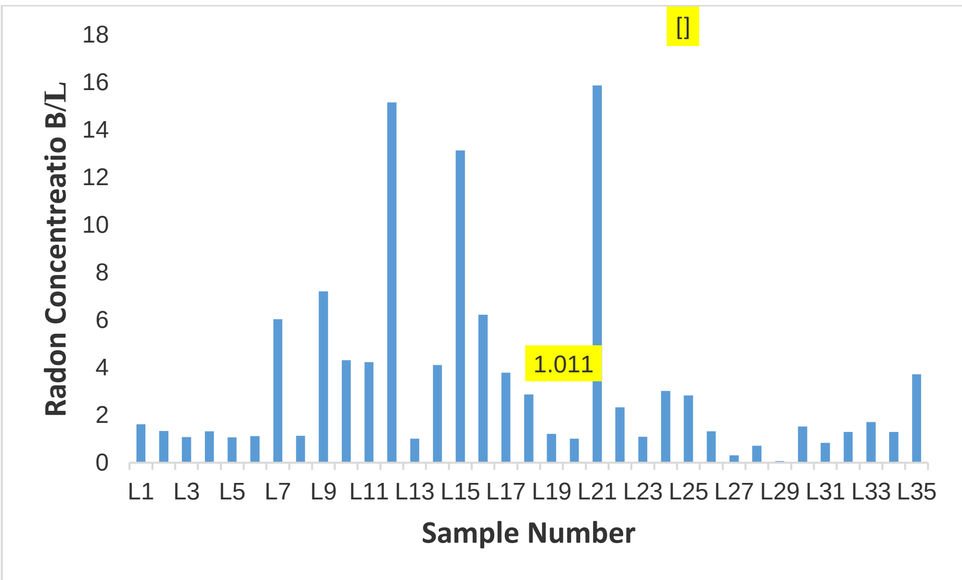

Figure 4: Concentration of centrifuged radon gas in sediment samples of studied water.

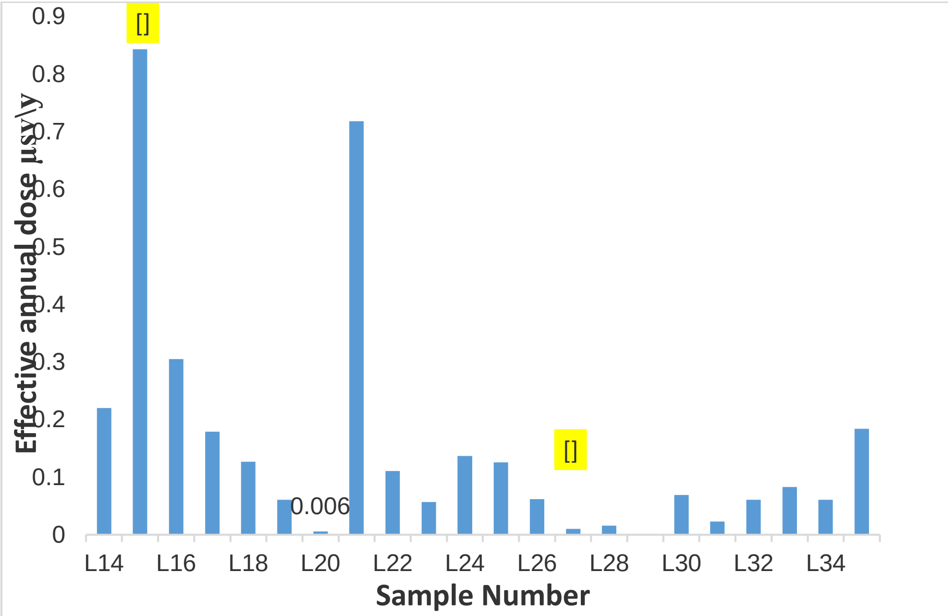

Figure 5. Annual effective dose measured in water samples in the study area.

Conclusion

In this study, the results of radon gas measurements were presented in 35 water samples collected from selected areas in the marshes of Basra - southern Iraq, using an effective technique through a rapid electronic device RAD. The highest concentration of water was in the L15 sample from the mother of the funds in Basra city, which is 15.531 ± 1.06 Bq. L^{-1}. This concentration is very high and needs rapid treatment. The concentration of radon gas in the sediments of centrifuged water samples was also found to be high compared to the limits It was also found that the equivalent annual dose in the water samples in the marshes of Basra - southern Iraq, which were studied, is higher than the permissible dose level of 0.1mSv. y^{-1} recommended by (UNSCEAR, 1993). These concentrations and doses have a negative impact on people's health due to the inhalation of radon gas in these areas in the absence of taking measures to protect them. This study provides an important database on the concentration of radon gas in the water of the marshes of the study area in the city of Basra-southern Iraq.

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"قياس تراكيز غاز الرادون(^{222}Rn) المنبعث طبيعيا من نماذج مياه منتخبة من اهوار محافظة البصرة جنوب العراق"

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الخلاصة

تناولت هذه الدراسة قياس تراكيز غاز الرادون المشع المنبعث من (35) عينة مياه أخذت من مناطق منتخبة من اهوار محافظة البصرة - جنوب العراق، لتحديد تراكيز غاز الرادون ^{222}Rn المنبعث من العينات المنتخبة والوليد لعنصر الراديوم^{226}Rالمشع والناتج من انحلال نظير اليورانيوم ^{238}U في (تموز)2020. لقد اعتمدت تقنية الكترونية سريعة من خلال جهاز RAD7 . أظهرت النتائج إن أعلى معدل تركيز لغاز الرادون في المياه هو $15.531\pm1.067 Bq.L^{-1}$ في عينة ام الصناديق في اهوار مدينة البصرة واقل معدل تركيز كان$0.034\pm0.002 Bq.L^{-1}$ في عينة مياه من مدينة القرنة ضمن العينات المدروسة. تم حساب الجرعة السنوية المؤثرة للماء في اعلى معدل تركيز ووجد انها ($0.843 mSv.y^{-1}$) وهذه القيمة تعد اعلى من الحدود الموصى بها عالميا من قبل المنظمات العالمية المختصة والبالغة $0.1\ mSv.y^{-1}$. وبصورة عامة وجد ان تراكيز غاز الرادون في بعض من عينات المياه المنتخبة من مناطق اهوار محافظة البصرة - جنوب العراق ضمن الدراسة اعلى من القيم المسموحة 11.1Bq/L حسب وكالة حماية البيئة الأمريكية(EPA) وأنها قد تشكل خطورة على صحة السكان في تلك المناطق في حال عدم اتخاذ الإجراءات اللازمة.

كلمات مفتاحية: غاز الرادون ^{222}Rn، الراديوم^{226}Ra، اليورانيوم ^{238}U، جهاز RAD7، الجرعة السنوية المؤثرة.