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Level of Radionuclide Contents in Surface Water from Shutt-Al-Arab River in Basrah Governorate, Iraq

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Abstract: *The study aims at providing a base-line data for the effective monitoring of radioactive contents in water of investigated area. Attempts were made to measure the radionuclide's concentrations level in the 17samples of surface water taken form Shutt – Alarab River, in the Southern - East province in Basrah governorate. The contents of radionuclide's were obtained by using different techniques; radon gas concentrations measured by CR-39 detector and RAD7 electronic instrument. Gamma ray spectroscopy analysis system NaI was applied to measure natural radioactivity concentration of uranium, radium and thorium in the water samples. It was found that, the average radon concentrations in water varies from 0.040±0.008 Bq/L to 0.112±0.018 Bq/L and radium concentration measured by gamma spectroscopy is 0.030±0.210 Bq/L to 13.829±950 Bq/L. The average radon inhalation effective dose was estimated to be 0.005 mSv/y and average radium ingestion effective dose was 1.153 mSv/y. All the results were within the international limits recommended by ICRP, UNSCEAR and WHO.*

Keywords: *Natural radioactivity, Radon gas, CR39, NaI, Radium, effective dose.*

1. INTRODUCTION

Water is essential to human life as air to breath. Thus, it is important to investigate the level of radionuclides in water. Naturally occurring radioactive elements such as uranium, radium, and radon are dissolved in very low concentration during normal reaction between water and rock or soil. The main concern of environmental monitoring is the measurement of the natural radiation arising from naturally radioactive materials and their progenies exist in air and water. The natural radioactive gas radon ^{222}Rn and its decay products are one causes of lung cancer [1-3].Radon is a natural inert radioactive tasteless and odorless gas, whose density is 7.5 times higher than that of air. It dissolves in water and can readily diffuse with gases and water vapor, thus building up significant concentrations. Radon is particularly well suited to study groundwater and surface water and their interaction, because of activity in groundwater is 1 to100 kBq m^{-3}; depending on the lithology of the area, which is much higher than the surface water 1 to 100 Bq m^{-3} [4]. The sources of Radon in water are; either from radioactive decay of dissolved radium in water, or, from a direct release of radon from minerals containing member of uranium and thorium decay series. Groundwater can have unusually high constituents of a dissolved radioactive contribution that build up during the period of water with rock contact for a long time period, or water injected in the well in order to maintain pressure in the well during oil production process [5].

Radium and radon concentration in ground and surface water were matter of investigations carried out by many researchers recently [6-9]. The results of these investigations show changeability in the concentration with time and geological structure of the area.

This work aims, to determined radon and radium concentration from water and estimate the effective dose due to the use of this water in different purposes. The investigation also covered the gamma concentration from ^{238}U, ^{226}Ra and ^{232}Th in water of Shutt- Alrab River, the main source of drinking water in Basra Governorate.

2. EXPERIMENTAL METHODS

In Basra governorate, the household water is supplied from two sources; one from Bada'a (on Euphrates River) and the other from Shatt-Alrab river (formed by the confluence of the Euphrates

and the Tigris rivers). Samples from 17 stations and locations were collected during March 2014, one sample each 2km from Basra center. The sample was1Lbottles completely filled with water and well-sealed to avoid any connection with air. Each water sample was sealed off for 3-4hrs and allowed for ^{222}Rnprogeny to reach equilibrium with ^{222}Rn. The measurements of radon concentrations in water were carried out by two methods (Passive by SSNDTs and Active by RAD7an electronic instrument. The measurements of gamma emitter's concentrations in water were carried out by using NaI (Tl) (3"x 3").

2.1. Active Method for Radon Concentration

The calibrated alpha spectrometer DURRIDGE *RAD 7 USA*, with special accessories for radon measurement in water was used for measurements of Radon concentration in the surface water. The detector converts alpha radiation directly to an electric signal and has the possibility of determining electronically the energy of each particle, which allows the identification of the isotopes (^{218}Po, ^{214}Po) produced by radiation, so it is possible to instantaneously distinguish between old and new radon, radon from Thoron, and signal from noise.

Figure 1 shows RAD7 and schematic diagram of RADH2O accessories. The radon detector was used for measuring radon in water by connecting it with a bubbling kit which enables to degas radon from a water sample into the air in a closed loop. A sample of water was taken in a radon-tight reagent bottle of 250ml capacity. This bottle was connected in a close circuit with a zinc Sulphide coated detection chamber which acts as Scintillator to detect alpha activity and a glass bulb containing calcium chloride to absorb the moisture. Air was then circulated in a closed circuit for a period of 5-10 min until the radon was uniformly mixed with the air and the resulting alpha activity was recorded and it directly gives the radon concentration.

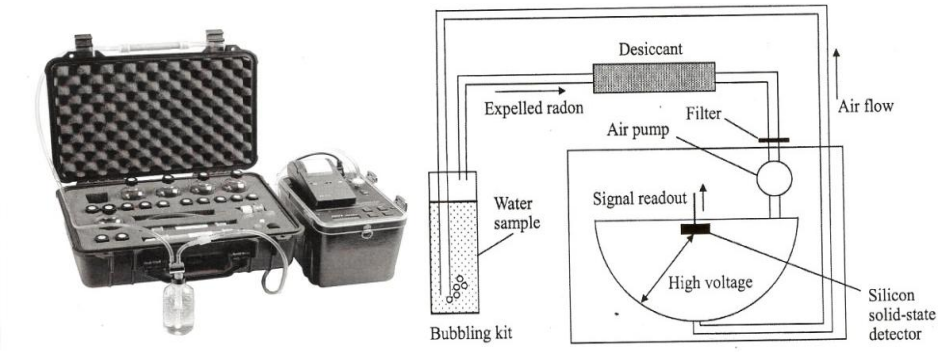

Fig1. *The RAD7 connected with RAD7H2O accessories.*

2.2. Passive Method for Radon Concentration

Solid State Nuclear Track Detector (SSNTD) type CR-39, was used for the measurements of Radon concentration in surface water using Can technique (30 cm x7.5cm) [10,11]. The water samples were collected from different locations, placed inside the cylindrical can, for 5 cm high. On the top inside of the can, the CR-39 detector was glued facing the sample. Small thickness sponge inserted between the detector and water sample to make sure absence of thoron gas in the hemisphere of the detector. The dosimeter then closed for a period of 60 days. After exposure the detectors were removed and then etched in 6.25 N NaOH for 7h using constant temperature bath. The tracks were counted using a microscope 400x.

The track density calculated from;

$$\rho = \frac{Average\ Track\ number}{Field\ of\ view\ area}\ Tr/cm^2 \quad (1)$$

The track density and radon gas activity were obtained through the measured calibration factor of K=0.2857±0.01431 Tr cm^{-2} d^{-1} per Bq m^{-3} [12]

Radon gas concentration is given by [13];

$$A_{Rn} = \frac{\rho}{tK} \quad (2)$$

whereρ is track density in Tr/cm^2 , t exposure time in day and K the calibration factor in Tr/cm^2.day / Bq.m^{-3}.

2.3. Radium and Thorium Concentration Measurements

The gamma ray spectroscopy used in this work consist of highly shield and well calibrated 3"x3" NaI(Tl) detector enclosed in 5 cm thickness lead shielding for background reduction. The system consist of computer based multichannel analyzer for date acquisition and software to controls these data acquisitions, supplied by manufacturer. The spectrometer was calibrated with ^{57}Co, ^{60}Co and ^{137}Cs slandered sources. The background was counted for, by counting with empty Marinelli beaker for 8h.

After measuring the count rate (area under the peak) for each peak and subtract the background, the activity concentration for each environmental isotope calculated from[14]

$$A = \frac{Net\ count}{\varepsilon \times I_\gamma \times M \times t} \quad (3)$$

where ε is absolute gamma peak efficiency of the detector at this particular gamma-ray energy, I_γ decay intensity for the specific energy peak (including the decay branching ratio information), M the mass of the sample in kg and t is the counting time of the measurement in second.

3. Results and Discussions

3.1. Radon Concentration

The results of short term measurements using the RAD7 accessories and long term measurement using the SSNTDs, for surface water taken from Shutt-Arab River were listed in table 1. The results show low radon concentrations in the water of the river, which are expected results due to the motion of the water and turbulences.

Table1. *Radon concentration in Bq/m^3 measured by active (RAD7) and passive (CR-39) methods*

Sample No	Con. Bq/m^3 Passive	Con. Bq/m^3 Active
1	52.41±7	59.9±17
2	58.03±8	62.2±13
3	106.69±13	116.7±23
4	46.80±5	57.6±27
5	50.54±6	53±15
6	63.64±8.1	65±18
7	65.51±8.9	62±14
8	54.28±7.6	65±12
9	52. 41±7	52±12
10	35.56±5	44±12
11	63.64±8.1	72.2±14
12	58.03±8	66.4±17
13	50.54±6	60.8±11
14	46.80±5	56.3±13
15	65.51±8.9	71±12
16	54.28±7.6	63.3±12
17	46.80±5	61.3±11

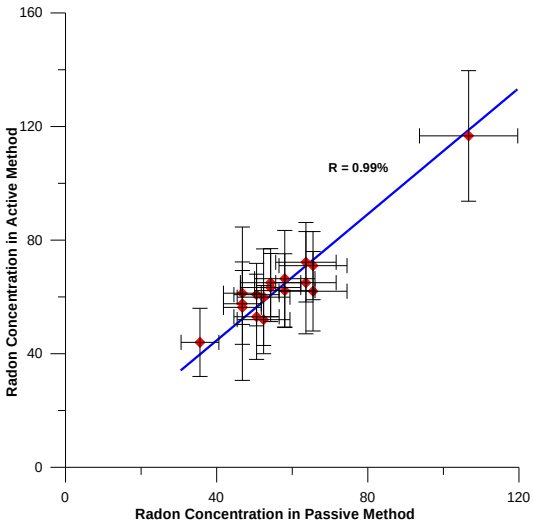

Fig2. *Correlation between RAD7 measurement and CR-39 Radon detector.*

Figure 2 shows the correlation between the two methods and looking at the details of the results, for both kinds of tests, one can recognize that the results are in excellent correlation, R=0.99%. According to the EPA; the maximum contaminate level in drinking water is 0.185 Bq/L, or 185 Bq/m^3. The maximum value of radon concentration in our result is 116.7±23 Bq/m^3 measured by RAD7, means that, the result is less than EPA maximum limit.

3.2. Radium and Thorium Concentration

The radium, thorium and uranium concentrations are presented in table 2. The ^{226}Ra concentration in water varies from 0.086±0.006 pCi/L to 0.374±0.026 pCi/L with average value 0.153±0.012 pCi/L. The average ^{222}Rn concentration of two methods varies from 0.0011±0.0002 pCi/L to 0.0011±0.0002 pCi/L with arithmetic mean value 0.0017±0.0003 pCi/L. The values of radium and average radon in all samples are in excellent correlation R=97% as one can see from figure 3. The concentrations of ^{222}Rn, ^{226}Ra, ^{232}Th and ^{238}U in table 2 in Shutt-Alarab River found to be within the accepted level of international committees [8, 9, 16].

Table2. *^{222}Rn, ^{226}Ra, ^{232}Th and ^{238}Uconcentrations in unit pCi/L*

S.N	^{222}Rn (average)	^{226}Ra	^{232}Th	^{238}U
1	0.0015±0.0003	0.126 ± 0.008	0.043 ± 0.004	0.039 ± 0.009
2	0.0016±0.0003	0.135 ± 0.009	0.181 ± 0.014	0.016 ± 0.003
3	0.0030±0.0005	0.374 ± 0.026	0.000 ± 0.000	0.038 ± 0.009
4	0.0014±0.0004	0.082 ± 0.006	0.000 ± 0.000	0.013 ± 0.001
5	0.0014±0.0003	0.094 ± 0.011	0.038 ± 0.004	0.009 ± 0.004
6	0.0017±0.0004	0.168 ± 0.015	0.001 ± 0.001	0.011 ± 0.003
7	0.0017±0.0003	0.214 ± 0.017	0.026 ± 0.007	0.143 ± 0.032
8	0.0016±0.0003	0.110± 0.008	0.000 ± 0.000	0.235 ± 0.059
9	0.0014±0.0003	0.109 ± 0.008	0.000 ± 0.000	0.024 ± 0.006
10	0.0011±0.0002	0.099 ± 0.008	0.000 ± 0.000	0.001 ± 0.026
11	0.0018±0.0003	0.155 ± 0.013	0.059 ± 0.015	0.458 ± 0.108
12	0.0017±0.0003	0.135 ± 0.012	0.001 ± 0.001	0.029 ± 0.004
13	0.0015±0.0002	0.107 ± 0.011	0.002 ± 0.001	0.017 ± 0.004
14	0.0014±0.0002	0.086 ± 0.007	0.216 ± 0.016	0.700 ± 0.176
15	0.0018±0.0003	0.230 ± 0.017	0.043 ± 0.004	0.192 ± 0.048
16	0.0016±0.0003	0.105 ± 0.008	0.001 ± 0.001	0.192 ± 0.048
17	0.0015±0.0002	0.114 ± 0.009	0.001 ± 0.001	0.467 ± 0.112
Max.	0.0030±0.0005	0.374 ± 0.026	0.216 ± 0.016	0.700 ± 0.176
Min.	0.0011±0.0002	0.082 ± 0.006	0.000 ± 0.000	0.001 ± 0.001
Ave.	0.0017±0.0003	0.153 ± 0.012	0.044 ± 0.004	0.173 ± 0.044

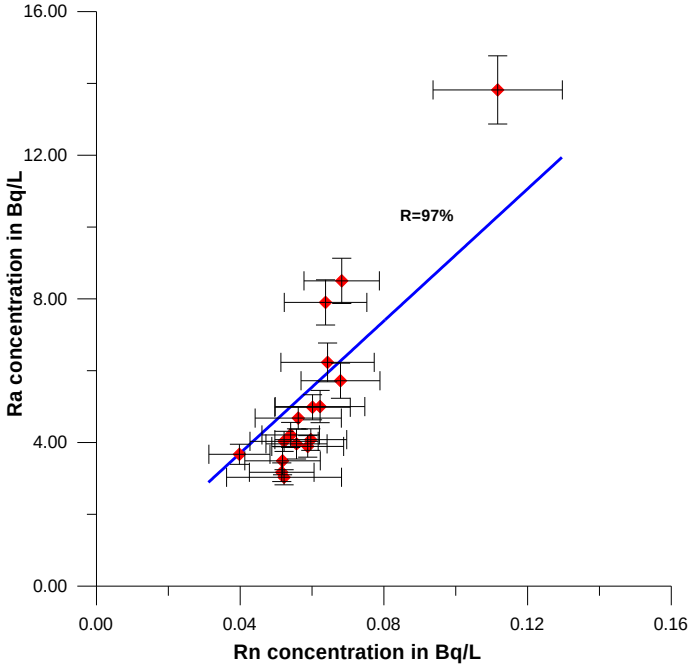

Fig3.*The correlation between ^{222}Rn and ^{226}Ra in water samples.*

3.3. The Effective Doses

The committed effective dose for the population in the region close to the river was estimated using the concentration of ^{222}Rn and ^{226}Ra in water samples. The annual effective doses for inhalation and ingestion were estimated according to parameters introduced by UNSCEAR report [13,14].

$$D_{water}\left(\frac{mSv}{y}\right) = F_{Rn}\, x\, C_w x A_w \quad (4)$$

where F_{Rn} is the committed effective dose per unit in water intake, taken as $0.01\ \frac{mSv}{Bq}$, for radon and 0.028 $\frac{mSv}{Bq}$ for radium , C_w is the water conception taken as 20 L per a day in unit L/y , and A_w activity concentration for radon or radium in water in Bq/L. Table 3 contains the annual effective dose of radium and radon in water samples in present work

Table3. *Average radon, radium concentrations in unit Bq/L and annual effective doses in unit mSv/y in water samples.*

Sample. No	Rn in Bq/L (average)	Ra in Bq/L	D_{Rn}mSv/y	D_{Ra}mSv/y
1	0.056 ± 0.012	4.680 ± 0.310	0.004	0.957
2	0.060 ± 0.011	4.980 ± 0.350	0.004	1.018
3	0.018 ± 0.018	13.820 ± 0.950	0.008	2.825
4	0.052 ± 0.016	3.030 ± 0.210	0.004	0.619
5	0.052 ± 0.011	3.490 ± 0.390	0.004	0.713
6	0.064 ± 0.013	6.230 ± 0.540	0.005	1.273
7	0.064 ± 0.012	7.900 ± 0.630	0.005	1.615
8	0.060 ± 0.010	4.080 ± 0.300	0.004	0.834
9	0.052 ± 0.010	4.030 ± 0.280	0.004	0.824
10	0.040 ± 0.009	3.670 ± 0.280	0.003	0.750
11	0.068 ± 0.011	5.720 ± 0.490	0.005	1.169
12	0.062 ± 0.013	5.000 ± 0.450	0.005	1.022
13	0.056 ± 0.009	3.960 ± 0.420	0.004	0.809
14	0.052 ± 0.009	3.170 ± 0.260	0.004	0.648
15	0.068 ± 0.011	8.500 ± 0.630	0.005	1.737
16	0.059 ± 0.010	3.890 ± 0.300	0.004	0.795
17	0.054 ± 0.008	4.210 ± 0.350	0.004	0.861
Max.	0.112 ± 0.018	13.820 ± 0.950	0.008	2.825
Min.	0.040 ± 0.008	3.030 ± 0.210	0.003	0.619
Ave.	0.062 ± 0.011	5.643 ± 0.437	0.005	1.153

From the table radon inhalation dose varies between 0.003 mSv/y to 0.008 mSv/y with an average 0.005 mSv/y, all of these values are not exceed the recommended limit of total effective dose. Effective dose related to ingestion of radium is also less than warning levels.

4. CONCLUSIONS

The results of this study clearly indicate that the radon and radium concentration in Shutt-Arab river water samples were within recommended limits. The concentration of radon was in excellent correlation between active and passive methods. The average values for radon and radium varies from 0.040±0.008 Bq/L to 0.112±0.018 Bq/L and 3.030±0.210 Bq/L to 13.829±950 respectively. The average radon inhalation effective dose was estimated to be 0.005mSv/y and average radium ingestion effective dose was 1.153 mSv/y . It is worth to say that all data indicate that, the water is safe limits as proposed by ICRP, UNSCEAR and WHO.

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