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Measurement of Radon Concentrations in Mineral Water of Iraqi Local Markets Using RAD7 Technique

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ABSTRACT

The effective technique of RAD7 has been applied to determine the concentrations of radon and annual effective dose of mineral water samples collected from Iraqi local markets. The results show that the level of radon concentrations in mineral water samples ranged between 0.035 and 0.248 Bq/L with an average value of 0.120 Bq/L. In addition to the annual effective dose ranged from 0.129 to 0.905 μSv/y with an average value of 0.440 μSv/y. It was found that the mean value of radon concentration and annual effective dose in all the studied mineral water samples were within the acceptable limits according to the International Commission on Radiological Protection (ICRP) and World Health Organization (WHO).

INTRODUCTION

The water of good quality is free from harmful substances, contaminants and microbes. There are many radioactive materials in different types of waters depending on the type and source of water, seawater contains the highest concentration of potassium-40 (300μc per litre), as for the fountains, contain a high percentage of radium (Canu et al. 2011). Uranium is the most common radioactive element found in the groundwater, with a concentration of 5-10 ppb, which is considered the most dangerous radioactive material (Mohsen & Abojassim 2019, Al-Hamzawi et al. 2014, Al-Hamzawi et al. 2015). Radon, also abundant in groundwater, is a colourless, tasteless and odourless gas with a very short half-life of 3.8 days (Cobb 2013). It is also easy to dissolve in water; however, it does not cause health problems unless it is raised in the form of gas when the water that is dissolved in it is extracted (Castleton et al. 2011). After radon enters the human body through the respiratory system and releases the alpha particles inside the human lung, causing it to damage in the beginning, and then turns into radioactive polonium, which releases the alpha particles then turns into a lead (Kubba 2009). All these disintegrations occur inside the lung, eventually causing lung cancer. Radon can enter the human body through the digestive system while drinking contaminated water. A recent US study suggests that deaths from lung cancer are 14 to 21 thousand cases a year, and the problem is increasing because the gas surrounds us without feeling it (Appleton 2013). Therefore, it is necessary to develop monitoring programs for this dangerous gas to know its concentrations and address the problem of increasing. UNSCEAR organization estimates the radon and its radionuclides produced by its decay, contributions with about three-quarters of the annual effective dose equivalent which are exposed to individuals from terrestrial sources and about half of their doses of all-natural sources combined (UNSCEAR 2000). Method for calculating radon concentrations called (short-term measurements) where the radon concentrations are calculated simultaneously, it is used to observe the level of radon emission for geological sites and earthquake prediction research. In this way, many detectors are employed such as RAD7 detector (Ǘrguz et al. 2017). This study aims to develop a database by monitoring the concentrations of radioactive radon gas in most samples of drinking water available in local markets using RAD7 technique as well as determine the annual equivalent dose that reaches the Iraqi people through drinking water.

MATERIALS AND METHODS

Samples Collection

The drinking water was collected in plastic bottles from the markets for several governorates and then was classified according to the trade name and the origin of manufacturing. The total number of water samples was 15 (Table 1). The water samples were labelled with the code of the samples and stored in the refrigerator to the time of analysis.

Table 1: Basic information about mineral water samples.

Sample code	Trade name	Origin
S1	Nawar	Iraq-Najaf
S2	Al-sanam	Iraq-Najaf
S3	Al-taor	Iraq-Najaf
S4	Al-mazaya	Iraq-Najaf
S5	Buratha	Iraq-Najaf
S6	Al-saqee	Iraq-Najaf
S7	Sawa	Iraq-Babil
S8	Al-wahaa	Iraq-Babil
S9	Al-janayin	Iraq-Baghdad
S10	Venezia	Iraq-Baghdad
S11	Muna	Iraq-Kirkuk
S12	Karawan	Iraq-Kirkuk
S13	Life	Iraq-Zakho
S14	Zalal	Iraq-Duhok
S15	Mira	Iraq-Arbil

Experimental Methods

Radon gas concentrations in mineral water samples were measured by using the effective technique of an electronic radon detector RAD7-H_2O (Durridge Co., USA) for one month. This device is customized to determine the levels of radon gas in water at high resolution. The most important feature of this device is the ability to determine the energy of each alpha particle electronically making it possible to tell exactly which isotope. The technique used gives the radon concentrations in the form of a card which represents radon concentrations in the sample (Badhan et al. 2010). A very important factor is the average annual effective dose was determined of water samples received by humans throughout the year. This factor was calculated based on the equation (Kheder et al. 2019):

$$D_w\left(\frac{\mu\text{Sv}}{\text{y}}\right) = C_w\, C_{RW}\, D_{cw} \qquad \ldots(1)$$

Where D_w is annual equivalent dose; C_W is the concentration of radon in water (Bq/L); C_{RW} is consumption amount of water (730 L/y) and D_{Cw} is effective dose coefficient (5×10^{-9} Sv/Bq).

RESULTS

The analytical results obtained from the selected mineral water samples collected from Iraqi markets which represent concentrations of radon and annual effective dose are involved in this study and are shown in Table 2.

From Table 2, the highest value of radon concentrations was 0.248 Bq/L found in sample S13 which belongs to the mineral water, bearing the commercial brand (Life) collected from Zakho city northern of Iraq. While the lowest value of radon concentrations was 0.035 Bq/L found in sample S9 which belongs to the mineral water, bearing the commercial brand (Al-janayin) collected from Baghdad city central of Iraq, with the average value of the radon concentrations was 0.120 Bq/L.

As regards to the annual effective dose, the results ranged between 0.905 to 0.129 µSv/y which were found in sample S13 and S9 respectively, with the average value of the annual effective dose equals to 0.440 µSv/y. Based on these values, the average value of radon concentration is within the permissible limit of radon 0.5 Bq/L as reported elsewhere (Griffiths et al. 2012, Brenner 1994). On the other side, the average value of the annual effective dose is less than the global allowed limit which equals to 1 mSv/y as reported by (WHO 2008, UNSCEAR 1958).

DISCUSSION

According to these results, the concentrations of Rn-222 in mineral water samples collected from different cities of Iraq ranged between 0.248 Bq/L found in sample S13 from Zakho city northern of Iraq and 0.035 Bq/L found in sample S9 from Baghdad city central of Iraq. The reason for the high radon concentrations in mineral water samples from the city of Zakho in northern Iraq with a mountainous nature can be

Table 2: Radon concentrations and annual effective dose in mineral water samples.

Sample code	Radon concentration Bq/L	Annual effective dose µSv/y
S1	0.070	0.258
S2	0.094	0.345
S3	0.212	0.775
S4	0.106	0.388
S5	0.177	0.646
S6	0.141	0.516
S7	0.071	0.259
S8	0.095	0.346
S9	0.035	0.129
S10	0.132	0.484
S11	0.096	0.350
S12	0.089	0.324
S13	0.248	0.905
S14	*BLD	*BLD
S15	0.118	0.430
Mean ± Std Error	0.120 ± 0.058	0.440 ± 0.13

*BLD means below the detection limit

Table 3: Radon concentrations and annual effective dose in water samples for different countries.

Country	Description	Radon concentration Bq/L	Annual effective dose μSv/y	Reference
Iraq	tap water	0.072 – 0.325	1.74	(Al-jnaby 2016)
Iraq	mineral water	0.001 – 0.142	0.096 – 11.402	(Al-Hamidawi 2013)
Iraq	tap water	0.073 – 0.190	0.267 – 0.493	(Tawfiq et al. 2015)
Iran	drinking water	3.79 – 4.17	–	(Keramati et al. 2018)
Syria	drinking water	2.8 – 15.3	–	(Shweikani & Raja 2015)
Jordan	drinking water	0.02 – 0.386	–	(Kullab 2005)
Saudi Arabia	drinking water	1.65 – 3.82	16.3 – 37.5	(El-Araby et al. 2019)
Turkey	tap water	0.0004 – 0.0024	5.87	(Oner et al. 2009)
Iraq	mineral water	0.035 – 0.248	0.129 – 0.905	Present work

attributed to the fact that mountainous areas, in general, have more radioactive materials than low-lying areas as reported elsewhere (Lochard et al. 2009). The average value of radon concentration in selected Iraqi mineral water from different locations of Iraq 0.120 Bq/L is within the permissible limit according to the United States Environmental Protection Agency (US EPA) and International Commission on Radiological Protection (ICRP) 0.5 Bq/L (Griffiths et al. 2012; Brenner 1994). On other hand, the annual effective dose of the mineral water samples varied from 0.905 to 0.129 μSv/y which was found in samples S13 and S9, respectively. The average value of the annual effective in studied samples which equals to 0.440 μSv/y is less than the global allowed limit as reported by United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and World Health Organization (WHO) 1 mSv/y (WHO 2008, UNSCEAR 1958). These findings indicated that the mineral water samples in Iraqi markets are free from the radiological contaminants and valid for people. Table 3 gives a comparison of the results in the present study with those by the previous researchers in Iraq and different countries. In the present investigation study, the range of radon concentrations and annual effective dose is 0.035 to 0.248 Bq/L and 0.129 to 0.905 μSv/y, respectively. The figures of this study are higher than Turkey and lower than Saudi Arabia, Syria and Iran.

CONCLUSIONS

The results obtained show that the radon concentration levels and annual effective dose of the mineral water samples collected from Iraqi markets were within the acceptable limits. The study indicates that the samples of mineral water are free from radon contamination and suitable for human use.

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