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RADON GAS AND EFFECTIVE DOSE IN GROUNDWATER IN ABU- JIR VILLAGE IN ANBAR, WESTERN IRAQ

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ABSTRACT

In the present study, radon gas concentration in the shallow groundwater samples of the Abu-Jir region in Anbar governorate was measured by using Rad-7 detector. The highest radon gas level in the samples is up to 9.3 Bq/L, while the lowest level is 2.1 Bq/L, with an average of 6.44±1.8 Bq/L. The annual effective dose is varied from 33.945 µSv/y to 7.66 µSv/y, with an average of 0.145±0.06 µSv/y. Consequently, the radon level in the groundwater studied is lower than the standard recommended value (11 Bq/L) reported by the United States Environmental Protection Agency (USEPA). The potential source of radon is uranium-rich hydrocarbons that are leakage to the surface along the Abu-Jir Fault. This research did not indicate any risk that radon gas concentrations may occur in the groundwater in the study area, and despite this, the research strongly recommends to propose a new Iraqi specification that defines the permissible level of radon gas concentrations in the groundwater and air to avoid harm to human health and will be an Iraqi standard that will be applied for the first time in Iraq.
Keywords: Groundwater; Radon: Effective dose; Abu-Jir

INTRODUCTION

Radiation is a source of danger to the environment, and therefore researchers are interested in measuring its concentrations in soils, rocks and water (Ali et al., 2014). Radon gas level is an important issue that needs to be estimated in air, soil, and water so that it can enter houses through the water systems. Surface and groundwater usually contain very little content of radon due to escaping to the air (Xinwei and Xiaolan, 2004). Groundwater is one of the essential sources for human living, and it is better if would have regulations for natural radioactivity (Duenas et al., 1999). The communities depended on surface water usually do not have a radon problem from their water, but other communities used groundwater as the primary water source to make their daily demands. Some of the domestic wells typically represent a closed system, so it is of short transit times do not allow radon to escape. Radon leaves water to the indoor air through daily works as people, for example, used showers, cleaning cloths, or other water uses (Shashikumar et al., 2011). Areas most likely to have problems with radon in groundwater are areas that have high levels of uranium in the underlying rocks, where radon is a natural production of radioactive decay chain. Hence, it becomes clear the importance of studying radon concentrations in groundwater, so it reflects the benefits for human health. Al-Malabeh and Hamed (2020) mentioned that the ^{222}Rn is mainly produced as a result of ^{238}Udecay in interstitial glass rather than from the emission of radon from cracks and fractured of inferred faults. The research problem is concentrated in that the study area is located within a depression along the Abu-Jir fault zone, as it has a distinct location over a huge quantity of hydrocarbons composing mostly of bitumen and asphaltene. The study area is covered by bitumen and asphaltene that are ascending upward along the fault plane and flow on the surface. The bitumen and asphaltene represent the remnants of heavy crude oil that are migrating from the petroleum reservoir toward low pressure, where the brine chemistry in the reservoir controls the pressure (Awadh et al., 2019; Awadh et al., 2018a). The subsurface strata near the study area may generate the oil and gas from the Jurassic Sargelu Formation as a source, then hydrocarbons are accumulated within a pay of petroleum system of Cretaceous to Tertiary ages and some hydrocarbons are escaped as a surface seep (Al-Rawi et al., 2014). It is well known that the organic matter (bitumen and asphaltene) is rich in uranium (Awadh and Hussien, 2015). Some of hydrocarbons flow with spring waters to the Euphrates River (Awadh and Ahmed, 2013), and others go into groundwater, so it is worth studying the radon level in the groundwater. In such areas, radon in groundwater can leak indoor air (Oliver and Kharyat, 1999). This research aims to measure the radon level in groundwater as well as the annual effective dose.

STUDY AREA

Abu-Jir village is located about 50 km to the west of Ramadi in the Western Desert of Iraq. It locates on a small depression having coordinates of 33° 14"-33° 22" north and 42°14"-42°48" east. The quaternary sediments cover the underlying Fat'ha Formation composed mainly of gypsum and emplaced on the limestone of the Euphrates Formation. Hydrocarbons seep composing mainly of bitumen and asphaltene are common in the study area covering a large area, in which oil seeps along Abu-Jir Fault Zone are dominated by the normal alkanes, more complex mixture of branched and cyclic hydrocarbons (Awadh and Hussien, 2015). The origin of hydrocarbon is a deep oil reservoir cross-cutting fault zone (Awadh et al., 2018a). Fluids such as oilfield waters moved along fault planes upward to the surface (Al-Mimar et al., 2018; Awadh et al., 2018a; Awadh et al., 2018b). The area is characterized by sulfurous water springs (Awadh and Al-Ghani, 2014).

MATERIALS AND METHODS

Sampling

A total of 12 groundwater samples were collected from 12 domestic wells of 8 to 20 m depth from the different areas of the Abu- Jir village on May-June 2018 (Fig.1). Water samples were kept in plastic bottles and transfer to the laboratory for the measurement of radon.

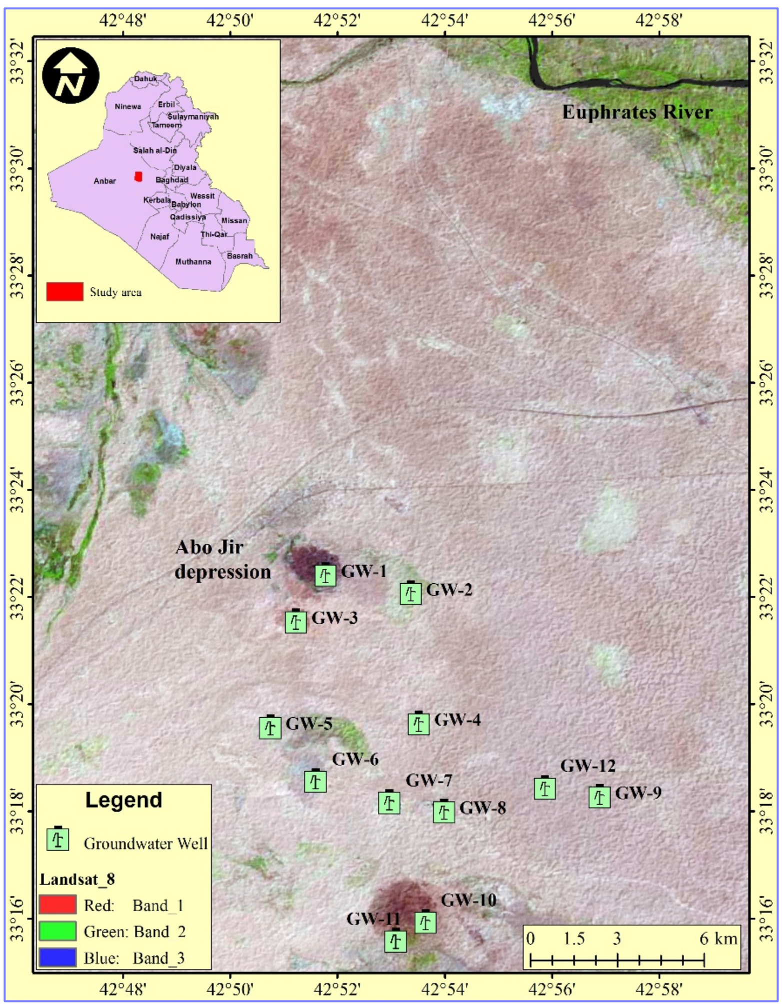

Fig. 1. The study area showing well numbers

Radon measurements

The RAD-7 is a common measuring instrument widely used on-site or in the laboratory (Hayes and Chiou, 2003). The instrument used in this study is a computerized device that was normalized before use, as it is highly accurate (Hayes and Chiou, 2003). The measuring system consists of degassing and security vessel, the Alpha Pump, Alpha GUARD, and the progeny filter (Radon, 2013). RAD-7 was connected with tubing and desiccant ($CaSO_4$) to absorb the moisture (Fig. 2). The radon measurements by using the Rad-7 system was conducted at the nuclear laboratory at the College of Education, University of Mustansiriyah.

Fig. 2. RAD-7 detector used in this study for measuring radon concentration

RESULTS AND DISCUSSION

Radon concentration

The radon concentration, annual effective dose (AED), temperature, and humidity were measured, and the results were listed in Table 1. The ^{222}Rn concentration is restricted between 2.1 to 9.3 Bq/l as lowest and highest values respectively with an average of 6.44±1.8 Bq/l indicating acceptable levels as it compared to the recommended standard (11.1 Bq/l) stated by the United States of Environmental Protection Agency (EPA, 2012). The variation of radon concentration in the groundwater studied is illustrated in Fig. 3.

Table 1. Radon concentration and annual effective dose in groundwater with temperature and humidity as climatic parameters

Sample No.	Depth (m)	^{222}Rn (Bq/l)	*AED (µSv/y)	Temp C	**RH %
Gw-1	12	4.6	16.79	28.4	9
Gw-2	16	4.7	17.15	27.1	8
GW-3	17	6.4	23.36	28.0	7
GW-4	9	4.4	16.06	28.4	8
GW-5	18	2.1	7.66	26.4	7
GW-6	8	8.2	29.93	27.1	8
GW-7	15	6.9	25.18	28.0	8
GW-8	13	9.2	33.58	26.4	8
GW-9	14	7.4	27.01	26.4	7
GW-10	9	5.4	19.71	27.1	8
GW-11	10	8.7	31.75	28.0	7
GW-12	16	9.3	33.94	27.4	8
Average	---	6.44±1.8	23.51±6.7	---	---

*AED is an annual effective dose; **RH is relative humidity

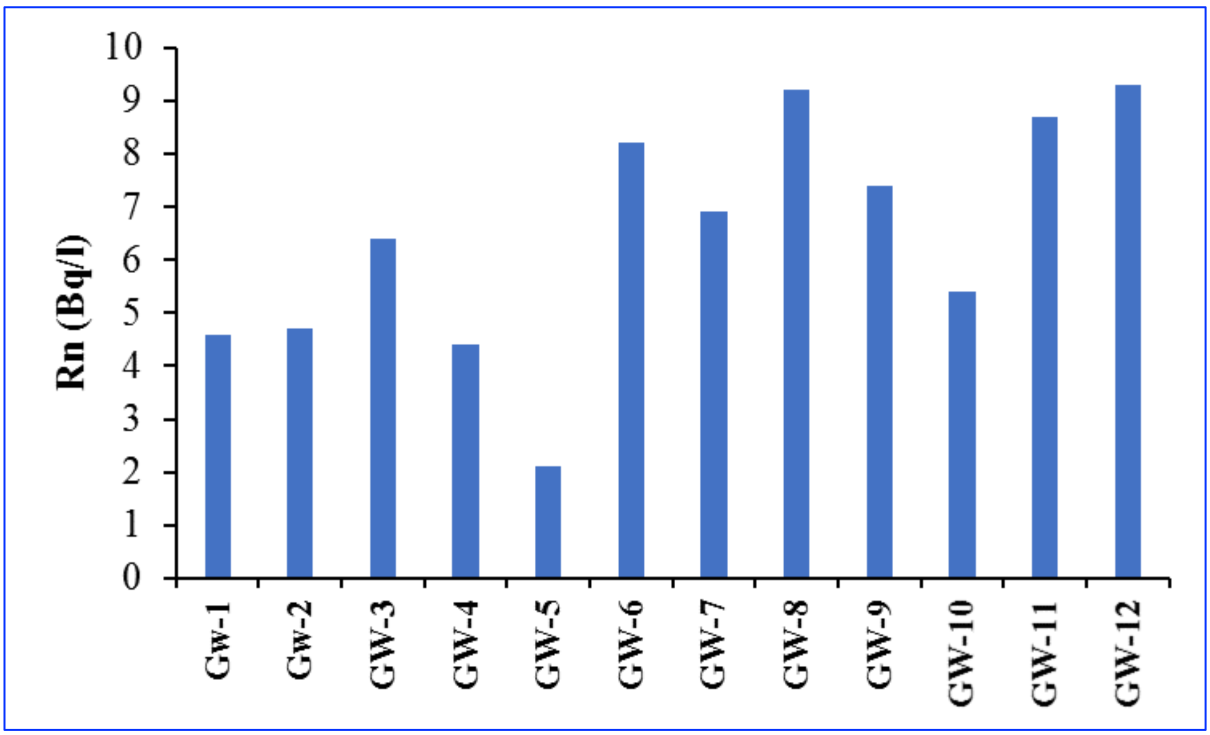

Fig. 3. Radon concentration in the groundwater wells

Annual Effective Dose

The annual effective dose (AED) of an individual consumer due to intake of radon from tap water (μSv/y) was obtained using the equation (Alam et al., 1999) in equation 1:

$$AED\left(\frac{\mu S}{y}\right) = C_{Rn}C_{Rw}D_{Cw} \qquad (1)$$

Where C_{Rn} is the concentration of radon in the ingested tap water in Bq/l units, C_{Rw} is consumption rate of water, and it is equal to 730 l/y and D_{cw} is the dose conversion factor, and it is equal to 5×10^{-9} Sv/Bq (UNSCEAR, 2000).

The AED was accordingly computed as 33.94 μSv/y as the highest dose, while the lowest is 7.66 μSv/y with an average value 23.51μ Sv/y. However, the AED appears less than the maximum permissible standard (1mSv/y) recommended by the Environmental Protection Agency (EPA, 2000). Finally, the AED is positively correlated to the ^{222}Rn concentration (Fig. 2).

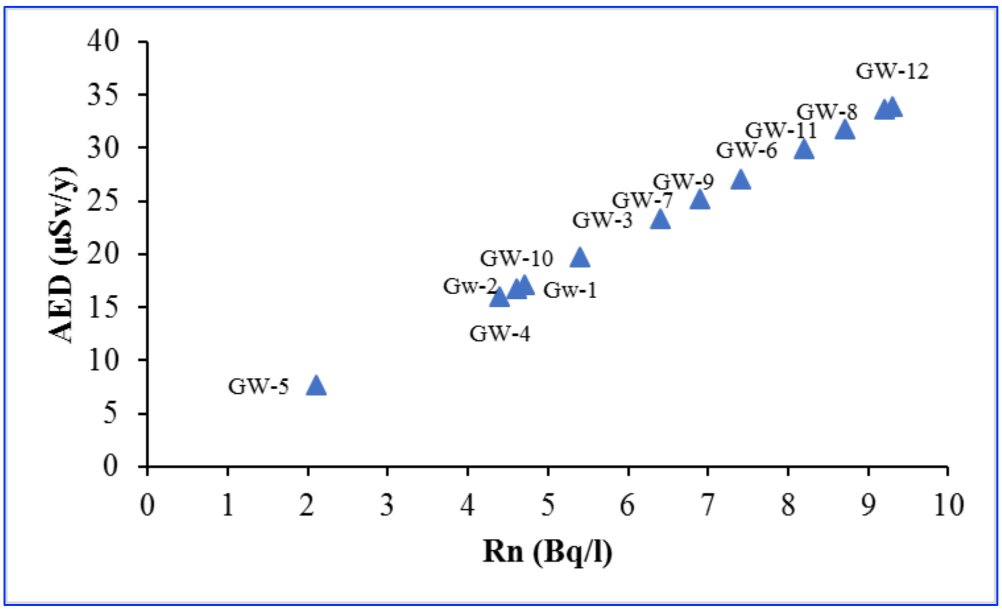

Fig. 2. Relationship between Ra concentration and AED

CONCLUSIONS AND RECOMMENDATIONS

This study showed the state of groundwater in the study area in terms of radon gas concentrations and its impact on public health. It has drawn a finding that the shallow groundwater in the Abu-Jir village despite it hosted in gypsum-carbonates interfingering with bitumen and asphaltene accumulations. The radon gas is dissolved in a quantity of less than of the recommended standard of United States Environmental Protection Agency (EPA, 2012), from the potential source of uranium-rich hydrocarbons. The significant uranium within organic matter-rich sediments is well known (Yang et al., 2012 and Susan et al., 2016). This research recommends proposing to regulate the ^{222}Ra in the drinking water quality in Iraq through clear regulations to ensure safe drinking water. The specification can be derived based on information of the global agencies; for example, the USEPA has finalized a maximum permissible concentration of radon in drinking water and the limitation of the hazard level of radon in the air as well (Zhuo et al., 2001).

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