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Measurement of Radon Gas Concentrations and Hazard Effects in Underground Water Samples in Karbala Governorate of Iraq

Abstract- *One of the most characterizations of social health is the existence availability of sources irrigation water. Since the main source of water, contamination is radon gas. Six regions in Karbala province in Iraq were chosen to evaluate Radon level in underground water-samples by using (SSNTD-CR-39) Detector. The current measurements showed that highest level was in Al-Horr region to be 4.152±2.2Bq/L, where lowest concentration was in Hay-Rumdan 2.165±1.6Bq/L. The maximum Annual-Effective Dose (AED) was found in Al-Horr to be 14.34±3.5μSv/y, whereas the minimal value indicated at Hay-Rumdan 8.66±3.1μSv/y. In general, it has been found that Radon-level concentration, in the studied groundwater-samples, was less than allowed permissible value 11.1Bq/L and annual effective-doses were below the recommended international value 1mSv/y. Therefore, groundwater in all underground water studied in Karbala province is safe where the focus of radon obsession is not a public concern.*

Keywords- *Radon, underground-water, Annual Effective Dose, CR-39.*

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1. Introduction

The ^{210}Rn decay to ^{225}Rn among seventeen radioactive radon isotopes has different half-lives of 14.6h to 2.4h respectively. The longer half-life 3.8235day is for ^{222}Rn [1]. Since the underground-water passes though different formation of rocks and soil, dissolves minerals, many compounds, and radioactive materials. Therefore, underground water may has more radioactive isotopes than the surface water [2]. Radon concentrations are formatted from gamma emitting following the decay of the radon progeny ^{214}Pb and ^{214}Bi, after reaching the secular equilibrium with ^{222}Rn [3, 4]. The ingestion of radon gives an additional exposure dose to the human body which possess a risk factor [5]. Hence, the content of radon in underground water-samples must be determined by different reliable methods. Several procedures can be found in the literatures to assess radon measurements in groundwater using different techniques such as solid-state detector or gamma spectrometry [6, 7, 8]. The aim of this study is to investigate radon level measurements in underground water –samples, via CR-39 detectors, from selected regions in Karbala city.

2. Materials and Methods

2.1. Study-Area

Figure 1 explains the sites of selected underground water-samples areas [9].

2.2. The Detector-used

SSNTD-CR-39 with chemical composition $C_{12}H_{18}O_7$, thickness 500μm, density 1.360 gm/cm^3 and area 1cm^2 was used. The etching makes holes which can be simply recognized in microscope [10].

2.3. Sampling and Exposure-Time

Samples were collected from 6 groundwater wells. This supplied the irrigation area around, see Table 1. These samples were collected and analyzed for physical and chemical properties according to the standard methods. Sealed plastic-can technique was used as shown in Figure 2. The water samples were exposure for three months, first month was for pre-equilibrium.

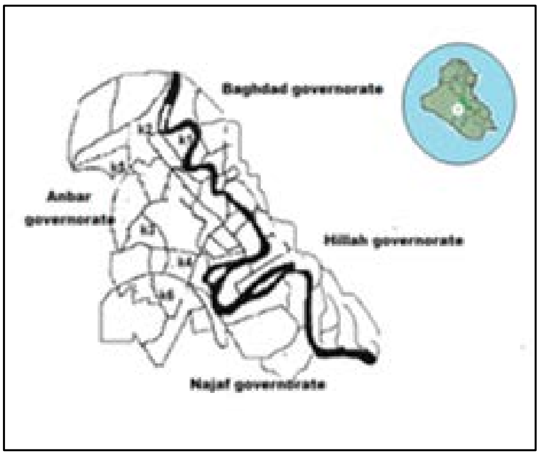

Figure 1: Underground water-samples locations throughout Karbala-City

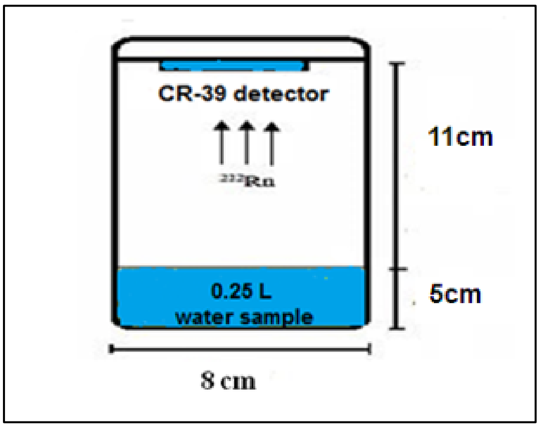

Figure 2: Sealed plastic -can technique used for ground water samples.

3. Basic Considerations

3.1. Radon Gas-Concentration

The following Equation was used to calculate the track density [11]:

$$\text{Tracks density } (\rho) = \frac{\text{Average number of total pits (track)}}{\text{Area of the field view}} \quad (1)$$

See Figure 3, Radon concentrations can be obtained as [12]:

$$C_x(\text{sample})/\rho_x(\text{sample}) = C_s(\text{standard})/\rho_s(\text{standard}) \quad (2)$$

$$C_X = \rho_X \; . \; (C_S / \rho_S) \quad (3)$$

This relation is cleared in Figure 3, as defined in Ref. [9].

3.2. Annual-Effective Dose in Water

For intake consumption of radon, AED can be estimated for popular as [13]:

$$AED\ (\mu Sv/y) = C_{Rn}\ C_{Rw}\ D_{cw} \quad (4)$$

Where C_{Rn} (Bq/L)=concentration of radon, C_{Rw}=730L/y and $D_{cw}=5\times10^{-9}$ Sv/Bq [14].

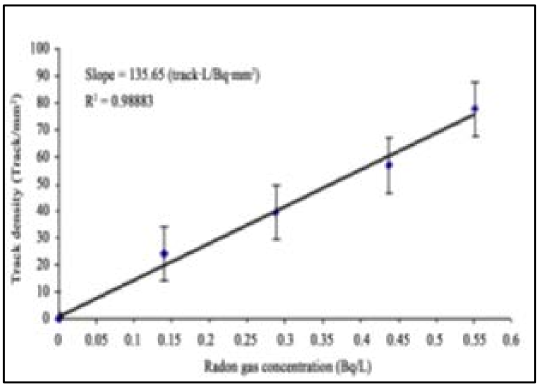

Figure 3: Density of the tracks versus concentrations of radon in standard water samples

3.3. Ra-222 Parameter's in Water Samples

3.3.1. Exhalation-Rate

It defined by [15]:

$$E_A(Bq/m2.h) = \frac{CV\lambda}{A[T + 1/\lambda(e^{-\lambda T} - 1)]} \quad (5)$$

Where C is the integrated Radon-exposure (Bq.h.L^{-1}). A, V, λ and T are as defined in Ref. [9, 13].

3.3.2. Dissolved Radon-Concentration in Water

It can be calculated according to the following Equation [16]:

$$C_d\ (Bq/L) = C_{Rn}\ \lambda\ D\ T\ /\ L_S \quad (6)$$

Where C_{Rn} is the radon-concentration in the ingested water (Bq/L), D is the distance between water surface and the detector (m), and L_S is the sample depth (m).

4. Results and Discussion

The concentrations of radon in the underground water-samples are presented in Table 1. Figure 4 illustrates that maximal value was recorded in Horr 4.152±2.2Bq/L, while the minimum occurred in Hay Rumdan 2.165±1.6Bq/L, with an average 2.848±1.7Bq/L. The maximum value of annual effective dose 14.34±3.5μSv/y estimated at Al-Horr and the minium occurred in Hay-Rumdan 8.66±3.1μSv/y, with an average 10.80±3.1μSv/y, as explained in Figure 5.

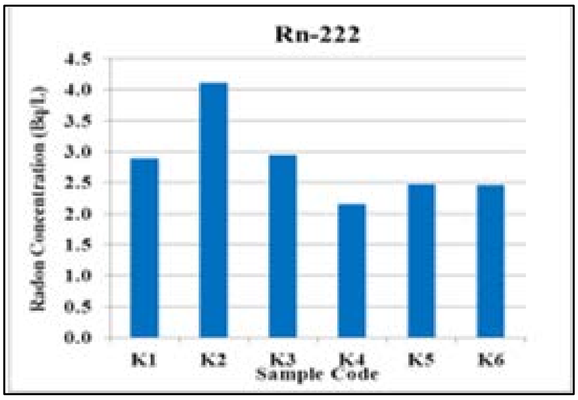

Figure 4: Radon concentration in groundwater samples in Karbala Governorate.

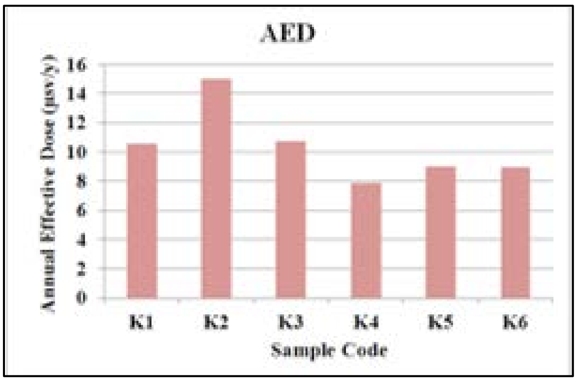

Figure 5: Annual effective dose in groundwater samples in Karbala governorate

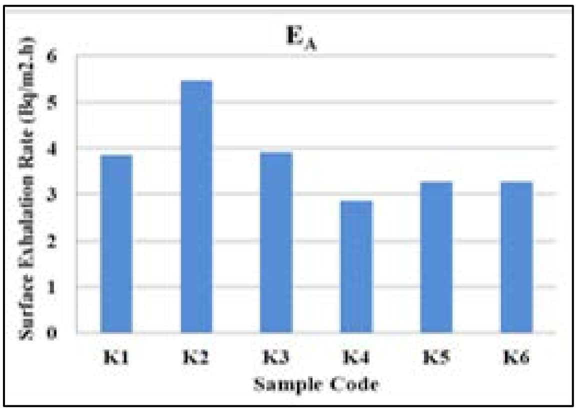

Figure 6: Surface exhalation rate in groundwater Samples in Karbala governorate.

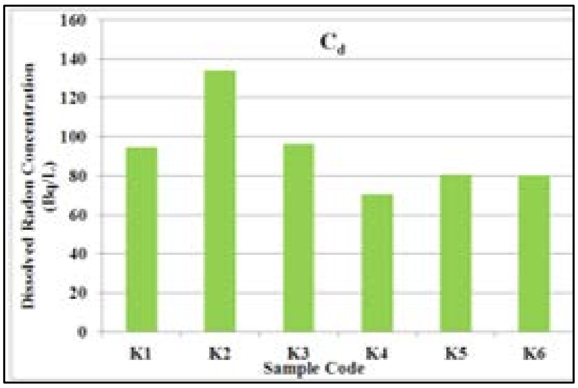

Figure 7: Dissolved radon concentration in groundwater samples in Karbala governorate

The average radon exhalation rate (E_A) was 2.629±1.6Bq/m^2.h. With a maximum 3.834±1.8Bq/m^2.h found in Al-Horr and the minimum recorded in Hay-Rumdan 1.984±1.3Bq/m^2.h, see Figure 6. Figure 7 illustrates the (C_d). The maximum was in Al-Horr 124.842±10.1Bq/L, and the minimum was found in Hay-Rumdan 66.42±8.4Bq/L, with an average 87.716±8.9Bq/L.

The assess results of all samples shows the concentrations of radon was lower than drinking water limit 300pCi/L (or11.1Bq/L)[17]. Also the AED results were less than 1mSv/y [18]. Hence, all results were safe and not worrisome because they are less than conventional in international organizations [19, 20].

Table 2 tabulated different concentrations ranges of radon for five regions throughout Iraq territory are comparable with the present result, which is higher than others.

Table 2. Radon-concentrations in groundwater for different regions in Iraq.

Region (year)	Technique used	C_{Rn} (Bq/L)	Ref.
Iraq/Al- Hella (2013)	RAD-7	0.036 -0.941 Shut- al-Hella's water	Al-Mashhadany et al. [21]
Iraq/Karbala Al-Hindiyah City (2014)	CR-39	0.549±0.041 Drill well water 0.410±0.054 Ground water	Abdalsattar [22]
Iraq/Najaf (2014)	RAD-7	0.569-5.010 Groundwater	Alasedi [23]
Iraq/Najaf/ Al-Haidariya Nahia (2015)	RAD-7	0.487±0.121 Groundwater	Abojassim et al. [2
Iraq/Babyl-Al-Qasim City (2015)	RAD-7	0.793-8.005 Groundwater	Hasan et al. [25]
Present work (2016)	CR-39	2.848±1.7	Present-work

5. Conclusions

Six groundwater samples collected from all territory of Karbala City were examined for determination Radon level-concentrations. The results indicate that Radon-concentrations in groundwater are below the contamination level 11.1Bq/L as announced by 'USEPA'. The total concentrations in samples recorded 2.165±1.6Bq/L as minimum level and 4.152±2.2Bq/L as maximum. In addition, the annual effective dose results were less than 1mSv/y recorded by 'WHO' and 'UNSCEAR'. For this reason, groundwater in Karbala'-City is safe and not bothersome as the results of the concentration of radon are concerned.

References

[1] S. Forkapić, I. Bikit, Lj. Čonkić, M. Vesković, J. Slivka, M. Krmar, N. Žikić-Todorović, E. Varga, and D. Mrđa, "Methods of Radon measurement," Facta Universitatis. Series: Physics, Chemistry and Technology, pp.1-10, 2006.

[2] J.K. Lee, "Radiological risk associated with naturally occurring radioactive nuclides in tap water and protection standards. Consumer Affairs Institute," Report on Debate on the Hazardousness of Radioactive Elements in Tap Water, pp.39-49, 1998.

[3] C.L.A.Q.G. Lei Zhang, "Measurements of thoron and radon progeny concentrations in Beijing, China," *Journal of Radiological Protection*, Vol. 28, PP. 603–607, 2008.

[4] M. Singh, M. Kumar, R.K. Jain, and R.P. Chatrath, "Radon in groundwater related to seismic events," *Radiation Measurements*, Vol. 30, No.4, pp. 465-469, 1999.

[5] N. Ai, E.U. Khan, P. Akhter, F. Khan, and A. Waheed,"Estimation of Mean annual Effective Dose through Radon Concentration in the Water and Indoor air of Islamabad and Murree," *Radiation Protection Dosimetry*, Vol. 141, pp.183-191, 2010.

[6] R.C. Ramola, V.M. Choubey, M.S. Negi, Y Prasad, and G. Prasad, "Radon Occurrence in Soil Gas and Groundwater around an Active Landslide," *Radiation Measurements*, Vol. 43, pp.98-101,2008.

[7] CTDPH, Connecticut Department of Public Health, "Radon Program, List of Qualified Radon Mitigation Professionals," 2017.

[8] EPA, Environmental Protection Agency, EPA/EERF-Manual-78-1 Radon in water sampling program, 1978.

[9] I.T. Al-Alawy and A.A. Hasan, "Radon Concentration and Dose Assessment in Well Water Samples from Karbala Gpvernorate of Iraq", IOP Conf. Series: Journal of Physics: Conf. Series 1003 (2018) 012117, IHSCICONF2017, pp. 1-9, 2018.

[10] M.F. Eissa, "Optical Properties of CR-39 Track Etch Detectors Irradiated by Alpha Particles with Different Energies," *Journal of Materials Science and Engineering*, Vol. **5**, pp. 26-31, 2011.

[11] M. Shahid, "Improvement Calibration of Nuclear Track Detectors for Rare Particle Searches and Fragmentation Studies in Ph.D. Thesis," University of Bologna, Italy, Bologna: Italy, 2007.

[12] S.A. Durrani, R.K. and Bull, Solid State Nuclear Track Detection: Principles. Methods and Applications, Pergammon Press, U.K., 1987.

[13] I.T. AL-Alawy, R.S. Mohammed, H.R. Fadhil, A.A. Hasan. "Determination of Radioactivity Levels, Hazard, Cancer Risk and Radon Concentrations of Water and Sediment Samples in Al-Husseiniya River (Karbala, Iraq)," IOP Conf. Series: Journal of Physics: Conf. Series 1032 (2018) 012012, The Sixth Scientific Conference "Renewable Energy and its Applications", pp.1-18, 2018.

[14] UNSCEAR, United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources and Effects of Ionizing Radiation," Report to the General Assembly, New York: United Nations, Vol. 1, pp. 1-653, 2000.

[15] A.O. Ferreira, B. R. Pecequilo, and R. R. Aquino, "Application of a Sealed Can Technique and CR-39 detectors for measuring radon emanation from undamaged granitic ornamental building materials," *Radioprotection Journal*, Vol. 46, No. 6, pp. 49-54,2011.

[16] K. Kant, S.B. Upadhyay, and S.K. Chakarvarti, "Alpha activity in Indian thermal springs," *Iranian Journal of Radiation Research*, Vol. 2, pp.197-204,2005.

[17] USEPA, United States Environmental Protection Agency, "Edition of the Drinking Water Standards and Health Advisories. EPA 822-S-12-001 Office of Water U.S. ," Environmental Protection Agency Washington, DC., 2012.

[18] EPA, Environmental Protection Agency, "Technical Fact Sheet: Final Rule for (Non-Radon) Radionuclides in Drinking Water," in EPA 815-F-00-013 November 2000.

[19]UNSCEAR, United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources, Effects and Risks of Ionizing Radiation. Report to the General Assembly, with Scientific Annexes A and B Series," Annex A - Attributing health effects to ionizing radiation exposure and inferring risks. Annex B - Uncertainties in risk estimates for radiation-induced cancer. United Nations, New York, 2012.

[20]WHO, World Health Organization, "Progress on Drinking Water and Sanitation," World Health Organization, Geneva, 2012.

[21] A.H. Al-Mashhadany, A.A. Kadhem, and S.H. Lefta, "Radon and Thoron Concentration of Shut Al-Hella's water in Babylon Governorate,"

International *Journal of Current Engineering and Technology*, Vol. 3, No. 3, pp. 872876, 2013.

[22] K.H. Abdalsattar, "Measurement of radon and radium concentrations in different types of water samples in Al-Hindiyah city of Karbala Governorate, Iraq," *Journal of Kufa physics*, Vol. 6, No. 2, pp. 69 - 77, 2014.

[23] K.K. Alasedi, "Ground Water Quality Assessment of Najaf City, Iraq," International *Journal of Scientific and Engineering Research*, Vol. 5, No. 3, pp. 490, 2014.

[24] A.A. Abojassim, H.H. Al-Gasaly, F.A. AL-Temimie, and M. A. Al-Aarajy, "Study of time measured factor on measuring radon concentrations in groundwater," *International Scientific Journal Theoretical and Applied Science*, Vol. 21, No. 01, pp. 16-21, 2015.

[25] A.K. Hasan, N.A. Saleh, F.O. Nasser, "Measurement of radon concentration in the water (surface and groundwater) to the city of Al-Qasim / Governorate of Babylon, and clarify the relationship between radon and all of the following variables Albaalogih (UA,CK,GOT,GPT)," *Advances in Environmental Biology*, Vol. 9, No. 24, pp. 295-298, 2015.