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Measurement of Annual Effective Doses of Radon in Plastic Bottled Mineral Water Samples in Iraq

Abdalsattar K Hashim and Rajaa Hussien Abd Ali

Department of Physics, College of science, Karbala University, Karbala, Iraq

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ABSTRACT

Radon concentration and annual effective doses were measured in fifteen mineral water samples in bottled plastic of Iraq. Measurements were made, using long-term technique for alpha particles emission with solid state nuclear track detector type CR-39. Results show that the maximum value of radon concentration was detected 7.433 Bq/L in Kirkuk water while the minimum value was 0.311Bq/L in Rovian water with mean value 2.594 Bq/L. The annual effective dose was calculated from the measured radon concentration which varied from 2.27μSv/y to 54.26 μSv/y with mean value 18.93 μSv/y . The measured values of radon concentration as well as the annual effective dose were found within the United States Environmental Protection Agency (US-EPA) and World Health Organization (WHO) recommended limits.

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INTRODUCTION

Radon problem is still a very current problem in the scientific world. It is well-known that ^{222}Rn and its short-life descendents contribute to the effective dose equivalent, through inhalation, in a percent of 50% of the total effective dose equivalent from natural sources.

Radon (^{222}Rn) is a naturally occurring radioactive noble gas with a half-life of 3.82 days, which is a member of the ^{238}U decay series (Somlai, K., 2007).

The ^{222}Rn concentration in water is due to the decay of ^{226}Ra associated with the rock and soil. Apparently, the radon gas percolates through the soil and rock, and dissolves in the water.Therefore, the concentration of radon in water is higher than one would expect if the activity were due only to supporting dissolved ^{226}Ra in the water (Lee, J.K., 1998; Xinwei, L., 2006).

The exposure of population to high concentrations of radon and its daughters for along period lead to pathological effects like the respiratory functional changes and the occurrence of lung cancer (BEIR, V.I., 1999).

Dissolved radon is contained in natural ground water due to primordial uranium in rocks and soils with which it comes in contact (Sachs, H.M., 1981; Hess, C.T., 1978). There is dual exposure from radon in water i.e. due to inhalation of the radon released from the water into the ambient air and through ingestion when water is used for drinking. Some people who are exposed to radon in drinking water may have increased risk of getting cancer over the course of their lifetime, especially lung cancer. The two diseases of principal concern associated with radon are stomach cancer from ingestion and lung cancer from inhalation (Mills, W.A. Radon, 1990).

The most important aspect of ^{222}Rn in high concentrations can be health hazard for humans, mainly a cause of lung cancer (Olger, P.F., 1994; Khan, A.J., 2000). However, a very high level of radon in drinking water can lead to a significant risk of stomach and gastrointestinal tract cancer (Kendal, G.M. and T.J. Smith, 2002; Zhuo, W. 2001).

Drinking water has great importance in our food. There for its availability, quality and regulation are delicate and important topics. For this purpose it is fundamental to have regulations about natural radioactivity in drinking water.

The aim of our study was determining of annual effective dose of radon in bottled mineral waters, available in markets of Iraq. So, the measurement of radon concentrations in mineral water drinks is necessary to investigate the role of radon

Corresponding Author: Abdalsattar K Hashim, Department of Physics, College of science, Karbala University, Karbala, Iraq
E-mail: abdalsattarkareem@yahoo.com

concentration in causing various diseases, especially cancer (European Commission, 2001; Otton, J.K., 1992). In addition, Consumers drink bottled water either because they dislike the taste of tap water or because they believe that bottled water is of superior quality and therefore healthier (Opel, A., 1999; Pip, E., 2000).

MATERIALS AND METHODS

In this study, fifteen types of widely-used plastic bottled mineral waters samples which are available in market of Iraq were analyzed. For each sample about 207 gm of water drinks was kept in a small clean vial (15 cm height and 5.5 cm diameter) and marked with a proper number for identification. While the sample-detector distance is still 10 cm and volume (118.79 cm^3) of water samples were kept in plastic cans as shown in Fig. 1. After buying bottles with water were kept in darkness by about one month to ensure a radioactive equilibrium achievement and unsupported radon decay. The samples were collected in well washed bottles which were sealed immediately so that radon may not get out of it.

The bottles were marked and date and time of sample collection were written upon them. The samples were brought to nuclear laboratory of the physics department, Karbala university of Iraq.

Solid State Nuclear Track Detectors (SSNTD) with sheet thickness 250µm was used in this study, which is usually known as CR-39 plastic detector (Durrani, S.A. and R.K. Bull, 1987; Gamboa,A., 1984). Square pieces of detector of size (1 cm × 1 cm) were fixed on the top of inner surface of the can, in such a way, that it is sensitive surface always facing the water sample (Mahur, A.K., 2008).

The detectors were exposed for a period of about 81 days. During exposed period, the sensitive side of the detector always faced the sample and is exposed freely to the emergent radon from the water sample in the can, so that it could record alpha particles resulting from the decay of radon in the remaining volume of the can. In the beginning the radon level is zero in the chamber of the dosimeter. The radon activity level slowly rises from zero to equilibrium value (when the decay and build up rates of radon balance each other).

After expose the detectors were collected and chemically etched using 6N KOH at 70 C° for 6 h. after this chemical treatment, these (SSNTDs) were washed dried and scanned using an optical microscope(A.KRÜSS – optronic) at a magnification of 400X (40x objective and 10x eyepiece) was used to count the number of tracks per cm^2 in each detector.

The determinations of the concentrations of alpha particles from radon gas in samples were performed by using CR-39 from the intercast Europe srl company. The radon gas concentration in samples was obtained by using the sealed-cup technique as shown in Fig.1.

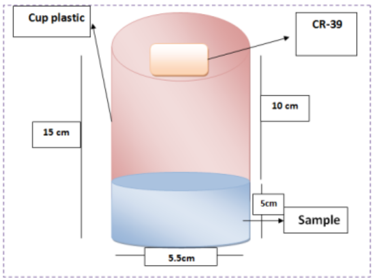

Fig. 1: Shows a test tube technique used in the study.

Theoretical considerations:

In order to measure radon concentration levels in water samples, the track density ρ (in track/cm^2) is related to the radon concentration C_{Rn} (in Bq/m^3) and the exposure time T by the formula (Hamza, V.Z., M.N. Mohankumar, 2009; Mohamed Abd-Elzaher, 2012):

$$\rho = K\, C_{Rn}\, T \quad (1)$$

Where K is the sensitivity factor of CR-39 plastic track detector, which is equal to 5.7953×10^{-2} Track.cm^{-1}.d^{-1} per Bq.m^{-3}.(Abdalsattar, K., 2012).

The dissolved radon concentration in water$_{(C_w)}$ was calculated using equation (2) used by various researchers (Al-Bataina, B., 1997; Abdullah, I., 2012).

$$C_w = \frac{C_{Rn}\lambda h T}{L} \quad (2)$$

Where C_{Rn} = radon concentration in ambient air (Bq/L), λ = Decay constant for radon ($0.1814d^{-1}$), h = the distance from the surface of water to detector (10 cm), T = Time of exposure (81day) and L = the depth of the sample (5 cm).

The can technique was used calculate the annual effective dose of radon in drinking water samples. The annual effective dose (mSv/y) was calculated by taking in account the activity concentration of radon (Bq/L), the dose coefficient (Sv/Bq) and the annual water consumption (L/y) according to equation 3(Ryan, T.P., 2003).

$$E = C_w \times D \times L \quad (3)$$

where C_w is the concentration of radon (Rn-222), D is the dose coefficient ($10^{-8}\ Sv/Bq$) and L is annual water consumption by an adult in litres. We have used daily water consumption by an adult as 2 litres (UNSCEAR, 1993).

Result and discation:

The result of measurments of radon concentrations as well as annual effcteive dose at different in fifteen mineral water samples in bottle plastic of Iraq are shown in Table 1.

Figure 2 (a and b) shows the concentrations and annual effective dose of radon in different fifteen mineral water samples, respectively.

From table 1 it is seen that the highest value of the concentration of radon was 7.433 Bq/L in Kirkuk water sample and the lowest value of the concentration of radon was 0.311 Bq/L in rovian water sample . The mean concentrations of radon for all samples was 2.594Bq/L, as well as the mean value of radon activity in plastic bottled mineral water samples is about four times lower than the value of maximum contement level(MCL)for radon concentration in drinking water.

The annual effective dose expressed in μSv/y varied from 2.27 μSv/y to 54.26 μSv/y with mean value 18.93 μSv/y is also presented in the tabe 1.

For a given radon concentration, the estimated dose varies significantly with the water consumption rate and the dose conversion factor used. The estimated dose coefficient by the United Nations Scientific Committee on the Effects of Atomic Radiation due to ingestion of radon from water is $10^{-8}\ Sv/Bq$ for an adult, 2 x 10^{-8} Sv/Bq for a child and 7 x 10^{-8}Sv/Bq for an infant. The annual effective dose received by an adult from different of plastic bottled mineral water samples in Iraq is given in Table 1. According to UNSCEAR (2000), doses to children and infants for similar consumption rates could be a factor of 2 and 7 higher, respectively.

Table 1: showed the results of radon concentrations for unit (Bq/L)and the rate annual effective dose (for unit μSv/y) of drinking mineral water samples in Iraq.

No.	Samples	Sample code	ρ (Trac/cm^2)	C_{Rn} (Bq/L)	C_w (Bq/L)	E μSv/y
1	Hadeer	HA	564.304	0.120	3.533	25.79
2	Alameer	AA	347.611	0.074	2.176	15.89
3	Alkhazer	AK	76.745	0.016	0.480	3.51
4	Rovian	RO	49.659	0.011	0.311	2.27
5	Yahya	YA	455.958	0.097	2.854	20.84
6	Pearl	PE	212.178	0.045	1.328	9.70
7	Alwaha	AW	916.430	0.195	5.737	41.88
8	Aljanen	AJ	401.785	0.086	2.515	18.36
9	Firat	FI	293.438	0.063	1.837	13.41
10	Kirkuk	KI	1187.296	0.253	7.433	54.26
11	Alghaith	AG	130.919	0.028	0.820	5.98
12	Mina	MI	618.477	0.132	3.872	28.26
13	Hayat	HY	320.525	0.068	2.007	14.65
14	Life	LI	158.005	0.034	0.989	7.22
15	Lava	LA	483.044	0.103	3.024	22.07
Minimum			49.659	0.011	0.311	2.27
Maximum			1187.296	0.253	7.433	54.26
Mean			414.424	0.088	2.594	18.93

The measurements indicate that the levels of radon concentration in the drinking water samples are well below the permissible level recomanded by the United States Environmental Protection Agency (US-EPA) is 11.1 Bq/L (Barnett, J.M., 1965).

The calculated for all values of annual effective dose(E μSv/y) from ^{222}Rn ingested with water is much below the recommended value of 0.1 mSv for public (Somlai, K., 2007; WHO, 2004).

Conclusions:

Nearly 50% of annually radiation dose absorption of human is due to radon which is one of the main cancers cause at respiratory and digestion systems. For improvement of the social health level, it would be better to use the low radon level water source, or reduce the radon in the drinkable water before using by people.

The radon concentration in fifteen plastic bottled mineral water samples were found to be lower than the maximum contamination level recommended for radon in drinking water by EPA (MCL) . The results from this study indicate that the activity concentrations of ^{222}Rn in water range between 0.311 Bq/L and 7.433 Bq/L with an overall average of 2.594 Bq/L and corresponding annual effective dose in the range of 2.27–54.26 μSv with an average of 18.93 μSv. These values are within the levels allowed elsewhere or recommended by the WHO (WHO, 2009).

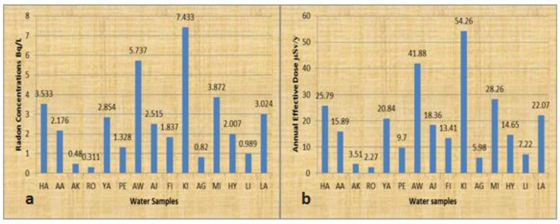

Fig. 2: (a):Radon concentrations (b): Annual effective dose of radon, for the plastic bottled mineral water samples.

REFERENCES

United Nations Scientific Committee on the Effects of Atomic Radiation. Sources, effects and risks of ionizing radiation. 1988 Report to the General Assembly. New York: United Nations, 24-79.

Somlai, K., 2007. ^{222}Rn concentration of water in the Balaton Highland and in the southern part of Hungary, and the assessment of the resulting dose. Radiation Measurements, 42: 491-495.

Lee, J.K., 1998. Radiological risk associated with naturally occurring radioactive nuclides in drinking water and protection standards, Consumer Affairs Institute, Report on “Debate on the Hazardousness of Radioactive Elements in Drinking Water”, 39-49 .

Xinwei, L., 2006. Analysis of radon concentration in drinking water in Baoji (China) and the associated health effects **,** Radiation Protection Dosimetry, 121(2): 158-167.

BEIR, V.I., 1999. Report of the Committee on the Biological effects of Ionizing Radiation, Health effects of exposure to radon. *Natl. Res. Council. Natl. Acad. Press, Washington, DC*.

Sachs, H.M., R. Manlow, T.L. Hernandez, 1981. In the *Proc. Int. Symp. on Indoor Air Quality*, Amherst, Mass.

Hess, C.T., 1978. Measurement of indoor radon-222 in Maine: Summer Vs Winter variations and effects of draftiness of homes, Tech. Inform. Series Report No. 83 CRD 278, General Electric, New York, USA.

Mills, W.A. Radon, 1990. Radium and Uranium in Water, Chalsea., *Lewis Publishers, 27.*

Olger, P.F., 1994. Relationship between ^{222}Rn dissolved in groundwater supplies and indoor ^{222}Rn concentrations in some Colorado front range houses. *Health Phys, 67: 244-252.*

Khan, A.J., 2000. A study of indoor radon levels in Indian dwellings, influencing factors and lung cancer risks. *Radiation Measurements, 32: 87-92.*

Kendal, G.M. and T.J. Smith, 2002. Dose to organs and tissues from radon and its decay products. *J Radiol Prot, 22: 389-406.*

Zhuo, W. and T. Iida, X. Yang, 2001. Occurrence of ^{222}Rn, ^{226} Ra, ^{228}Ra and U in groundwater in Fujain province. China. *J Environ Radioact, 53: 111-20.*

European Commission, 2001. Commission Recommendation of 20 December 2001 on the protection of the public against exposure to radon in drinking water, 2001/982/Euratom

Yousuf, R.M., M.M. Husain and L.A. Najam, 2009. Measurement of Radon 222 Concentration Levels in Spring Water in Iraq. 2-2. Jordan Journal of Physics, 89-93.

Otton, J.K., 1992. "The geology of radon: U.S.Geological Survey", (General Interest Publications of the U.S. Geological Survey, 28.

Opel, A., Constructing Purity: Bottled water and the commodification of Nature. (1999) Journal of American Culture, 22(4): 67-76.

Pip, E., 2000. Survey of bottled drinking water available in Manitoba, Canada. Environmental Health Perspectives, 108(9): 863-866.

Durrani, S.A. and R.K. Bull, 1987. "Solid state Nuclear Track Detector Principle, Method and Applications",Internatinal Series in Nutural Philosophy, Volume-III.

Gamboa, Estisona, A. Moreno, J.I. Golzari and Costillo, F. 1984." Nuclear Tracks and Measurement", 1443-445.

Mahur, A.K., M.S. Khan, A.H. Naqvi, R. Prasad, A. Azam, 2008. Measurement of effective radium content of sand samples collected from Chhatrapur beach, Orissa, India using track etch technique. Radiat Meas 43(Supplement1) S520–S522.

Hamza, V.Z., M.N. Mohankumar, 2009. Cytogenetic damage in human blood lymphocytes exposed in vitro to radon, *Mutation Research*, 661: 1-9.

Mohamed Abd-Elzaher, 2012. An Overview on Studying 222Rn Exhalation Rates using Passive TechniqueSolid-State Nuclear Track Detectors, American Journal of Applied Sciences, 9(10): 1653-1659. ISSN 1546-9239.

Abdalsattar, K., Hashim and Abbas J. Al-Saadi, 2012. Radon Measurements in Different Types of Carbonated Drinks in Iraq. Journal of K erbala University, 10(4): 41-46.

Al-Bataina, B., A. Ismail, M. Kullab, K. Abumurad and H. Mustafa, 1997. Radon measurements in different types of natural waters in Jordan. Radiation Measurement, 28(1): 591.

Abdullah, I., Mohammad Nabil N. Al-Zubaidy, 2012. Estimation of natural radioactivity in water and soil in some villages of Irbid city. Applied Physics Research; Published by Canadian Center of Science and Education, 4(3): 1916-9647.

Ryan, T.P., S. Sequeira, L. McKittrick, P.A. Colgan, 2003. Radon in Drinking Water in Co. Wicklow – a Pilot Study. Radiol Protect Instit Ireland February.

UNSCEAR, 1993. Sources and Effects of Ionizing Radiation. Report to the General Assembly, with Scientific Annexes. New York: United Nations.

Barnett, J.M., K.E. Holbert, B.D. Stewart, W.K. Hood, 1965. Lung dose estimates from ^{222}Rn in Arizona ground water based on Liquid Scintilation measurements. Health Phys, 5: 699-703.

Somlai, K., S. Tokonami, T. Ishikawa, 2007. ^{222}Rn concentration of water in the Balaton Highland and in the southern part of Hungary, and the assessment of the resulting dose. Radiat Measurem, 42: 491-95.

WHO, 2004. Guidelines for Third Edition Recommendations Drinking-water Quality, Geneva.

WHO, 2009. (World Health Organization), 1. Geneva, Switzerland.