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Radon Measurements in Different Types of Carbonated Drinks in Iraq
قياس الرادون في أنواع مختلفة من المشروبات الغازية في العراق

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Abstract:

In this study, the concentrations of radon (^{222}Rn) radioactive isotope in different types of carbonated drink samples, as well as, in sterilized drinking water were determined. Measurements were made , using long-term technique for alpha particles emission with solid state nuclear track detector type CR-39. Twelve types of different carbonated drinks were brought from local markets in Iraq. The results showed that Radon concentrations in carbonated drinks samples were ranging between (1.771 - 5.642) Bq/L; while the average value was (3.835 Bq/L). The highest concentration was found in peach drink samples, whereas the lowest concentration was in the orange flavored drink. Also that radon concentration in sterilized drinking water was measured 1.642 Bq/L. However, these values were lower than allowed maximum contaminant level (MCL) for (^{222}Rn) in drinking water as reported by USA Environmental Protection Agency (EPA) which is about 11.1 Bq/L.

Keywords: CR-39 plastic nuclear track detectors; Radon -222 concentration levels; carbonated drinks; MCL.

ملخص

في هذه الدراسة تم قياس تركيز الرادون الموجودة في اثنتي عشر نوعا" من المشروبات الغازية المختلفة وفي مياه الشرب المعقمة. جمعت العينات من الأسواق المحلية العراقية. تمت القياسات باعتماد تقنية القياس طويلة الأمد لانبعاث جسيمات ألفا باستخدام كاشف الأثر النووي الصلب نوع CR-39. لقد أظهرت نتائج هذه الدراسة أن تركيز الرادون في عينات المشروبات الغازية تراوح بين 1.771Bq/L و 5.642Bq/L وبمعدل 3.835 Bq/L . بينما كان تركيز الرادون في عينات مياه الشرب المعقمة 1.642 Bq/L . لقد كانت جميع تراكيز الرادون في عينات المشروبات الغازية وكذلك في مياه الشرب المعقمة التي تمت دراستها أقل من أعلى تركيز مسموح به للرادون في ماء الشرب البالغ 11.1 Bq/L التي توصي بها وكالة الحماية البيئية الأمريكية(EPA) .

1. Introduction

In the natural environment, radon element has three radioactive isotopes, namely: ^{222}Rn (3.82 d), ^{220}Rn (55 s) and ^{219}Rn (~4 s). Normally, ^{220}Rn and ^{219}Rn and their progenies are neglected when studying "radon problem" [1, 2].

The immediate radon precursor is Radium (^{226}Ra), with a half-life of 1600 years, spread widely, particularly in materials which are made from mineral products. The forerunner of radium is Uranium (^{238}U); which has a half-life of 4.47×10^{9} years [3]. Radon is picked up by groundwater passing through rocks and soil containing such radioactive substances; it enters water supplies when this water is pumped up a well [4].

Some radon stays in the water; drinking water containing radon presents a risk of developing internal organ cancers, primarily stomach cancer. However this risk is smaller than the risk of developing lung cancer from radon released to air from tap water. When water leaves a faucet, dissolved gases are released. This process is increased by mechanical sprays during a shower or by the heating and agitation that occur during laundering, washing, and cooking [5]. Based on a National Academy of Science report, Environmental Protection Agency (EPA) estimates that radon in drinking water causes about 168 cancer deaths per year: 89% from lung cancer caused by breathing radon released to the indoor air from water and 11% from stomach cancer caused by consuming water containing radon [6]. Radon is only a concern if drinking water comes from underground, such as a well that pumps water from an aquifer, though not all water from underground sources contains radon.

Drinking water and carbonated drinks have great importance in our food. Therefore 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 and carbonated drinks.
The aim of this study was to determine radon concentrations in thirteen types of carbonated drinks. So, the measurement of radon concentrations in carbonated drinks is necessary to investigate the role of radon concentration in causing various diseases, especially cancer [7-9].

2. Materials and Methods

In this study, thirteen types of widely-used carbonated drinks samples which are available in market were analyzed. For each sample about 250 milliliters of carbonated drinks was kept in a small clean vial (20 cm height and 5.5 cm diameter) and marked with a proper number for identification.
Solid State Nuclear Track Detectors (SSNTD) with sheet thickness 300μm were used in this study, which is usually known as CR-39 plastic detector [10,11].The detectors were small square pieces of size 1cm × 1cm covered with plastic properly and hung inside the sample of the vial [12].
The open mouths of vial were closed properly and then preserved in suitable place free from disturbance. After completion of the exposure, these were etched in (6.25 N) NaOH solution at a constant temperature of 70 ± 1^0C for six hours in a constant water bath. After removal, the detectors were etched with a sharp pin simultaneously in a beaker. For immersing a detector in the beaker and to let is stand erect each detector was fixed with a paper clip properly at the bottom of the beaker [13].
The central portion of the detector strips was scanned by using a microscope (kruss-mbl 20000) at a magnification of 400(40x objective and 10x eyepiece). 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 alpha tracks per cm^2 in each detector were determined using an optical microscope.
The radon gas concentration in samples was obtained by using the sealed-cup technique as shown in Fig.1.The test tubes were sealed and stored for 85 days (from 29-1-2012 to 23-4-2012).

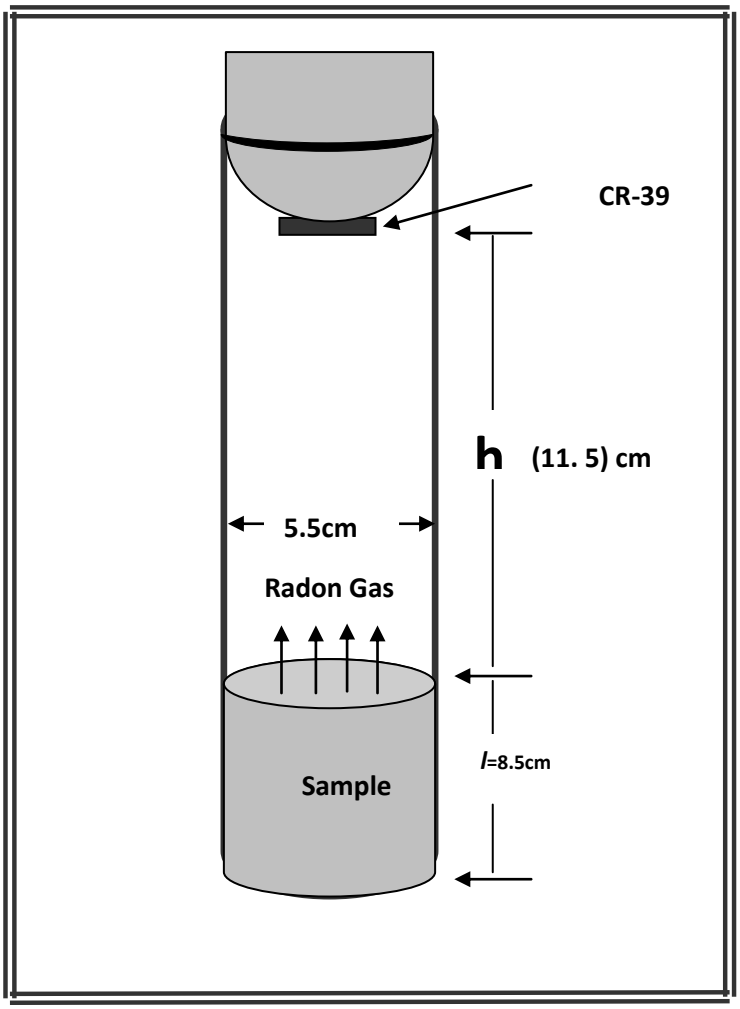

Fig.1. Shows a test tube technique used in the study.

3. Results and Discussion

For the purpose of calculating ^{222}Rn concentration levels in carbonated drinks samples, the radon activity density (C) in the can air above the carbonated drinks samples were determined by measuring the tracks density on the detector according to the following relation[14]:

$$C = \frac{\rho}{K T} \qquad (1)$$

Where C is the ^{222}Rn concentration in the test tube above the sample measured in (Bq/L), ρ is the surface density of tracks on the exposed detectors(Tr/cm^2), T is the exposure time(85 day) and K is the ^{222}Rn gas diffusion constant [15]. Such that

$$K = \frac{1}{4} r \left(2 \cos \theta_c - \frac{r}{R_\alpha}\right) \qquad (2)$$

Where r is the test tube radius (0.0275m), θc is the critical angle for CR-39(35 degree) and R_α is the range of ^{222}Rn alpha particle in air (0.0415 m) [15].

By substituting r, θ_c and R_α in equation(2) we get:-

$$K = 5.7954 \times 10^{-2} \left(\frac{Trac/cm^2.day}{Bq/m^3} \right)$$

The radon activity density in the carbonated drinks samples (C_{Rn}) in the test tube was calculated by using a model proposed by Somogyi [16]. According to this model, the number of radon atoms exhaled from the sample surface is equal to the number of radon atoms in the can air above the carbonated drinks sample multiplied by the probability of decay, which can be written in the following form [16]:

$$C_{Rn} = \frac{\lambda c h T}{l} \qquad (3)$$

where λ is the decay constant of (^{222}Rn) = 7.554x10^{-3}(hr^{-1}), h is the distance from the surface of carbonated drinks in the sample cup to the detector (11.5 cm), T is the exposure time of the sample (2040 hr) and l is the depth of the samples (8.5cm).

The activity of (^{222}Rn) in the carbonated drinks samples will be calculated in (Bq) unit from the following relation:

$$A_{Rn} = C_{Rn} V \qquad (4)$$

Where V is the Volume of the sample in the test tube

$$V = \pi r^2 l \quad (m^3) \qquad (5)$$

The experimental results obtained in this work for radon concentration levels and radon activities in different types of carbonated drinks in Iraq are presented in Table 1.

The peach drink was characterized by the highest value of radon concentration 152.503 PCi/L , which is equivalent to 5.642 Bq/L while the lowest value of radon concentration in carbonated drinks was found in the orange flavored drink 47.872 PCi/L, which is equivalent to 1.771Bq/L.

In addition to that, the average value of radon concentration in carbonated drinks was 103.674 PCi/L , which is equivalent to 3.835 Bq/L. Also the authors found the radon concentrations in sterilized drinking water was 44.384 PCi/L which is equivalent to 1.642 Bq/L .

Therefore, the radon levels in carbonated drinks samples are comparatively low since the recommended maximum contaminant level (MCL) of USA Environmental Protection Agency is 300 PCi/L, which is equivalent to 11.1 Bq/L.

Table 1. Radon concentration in sterilized drinking water and in different types of carbonated drinks in Iraq.

Sample number	Sample name	ρ Trac/cm^2	C PCi/L	C_{Rn} PCi/L	A_{Rn} PCi	C_w PCi/Kgm
1	Sterilized drinking Water	387.790	2.128	44.384	8.963	35.853
2	Crystal up drink	1119.129	6.140	128.089	25.868	103.470
3	Crystal lemon drink	1301.964	7.143	149.015	30.094	120.374
4	Crystal orange drink	783.932	4.301	89.724	18.120	72.479
5	Crystal cola drink	1180.074	6.474	135.064	27.276	109.105
6	Red grape drink	966.766	5.304	110.65	22.346	89.383
7	Orange Flavored drink	418.262	2.295	47.872	9.668	38.671
8	Red fruit drink	1058.184	5.806	121.113	24.459	97.835
9	Pomegranate drink	1027.711	5.639	117.626	23.755	95.018
10	Orange and carrot drink	692.514	3.799	79.261	16.007	64.027
11	Peach drink	1332.436	7.31	152.503	30.798	123.192
12	Apple drink	540.152	2.964	61.823	12.485	49.94
13	Peach rani float drink	448.735	2.462	51.36	10.372	41.488
Mean value of carbonated drinks		905.821	4.696	103.674	20.937	83.748

It is clear from Table 1 that all results were below the maximum contaminate level (MCL) for radon gas in drinking water, as well as , the mean value of radon activity in carbonated drinks sample is about three times lower than the value of (MCL) for radon concentration in drinking water.

Figures 2 and 3 have shown the distribution of radon concentrations in the sterilized drinking water and carbonated drink samples in the test tube.

Figure 4 shown the distribution of radon activity in the sterilized drinking water and in the carbonated drinks samples.

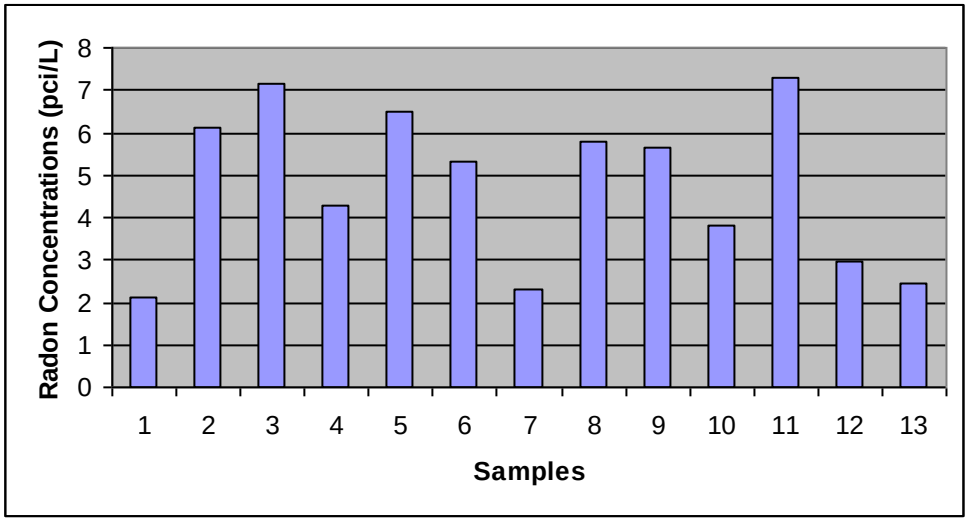

Fig. 2. Radon concentrations in the air above the sterilized drinking water and carbonated drink samples in the test tube.

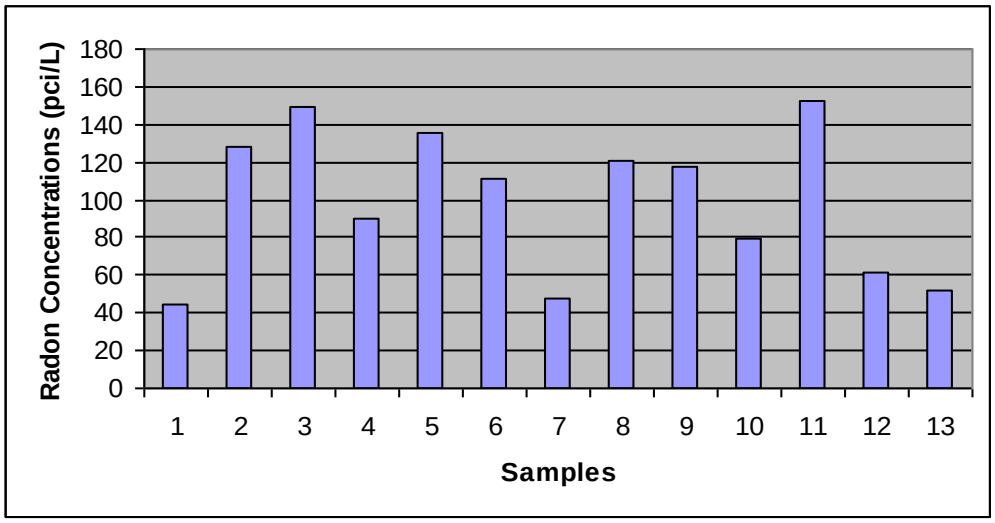

Fig. 3. Radon concentrations for the sterilized drinking water and carbonated drinks samples in the test tube.

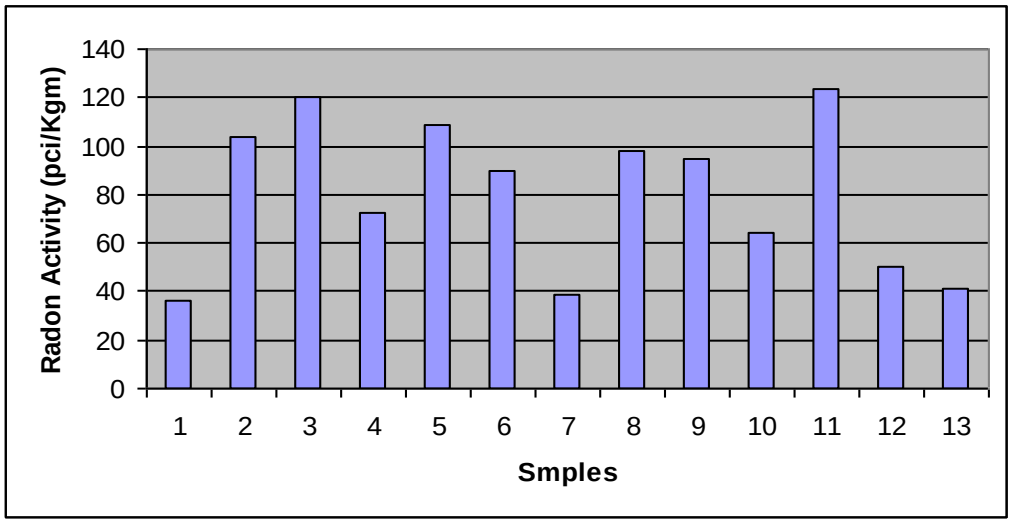

Fig.4.Radon activity in the sterilized drinking water and carbonated drinks samples in (PCi/Kgm).

A comparison of the results obtained in this work was in accordance of the reported values for (^{222}Rn) levels in water samples of other workers as shown in Table 2.

Table 2. Comparison of (^{222}Rn) levels in sterilized drinking water and Carbonated drinks with results from other workers for water samples.

Sample type	Country(Region)	Radon concentration level (PCi/L)	Reference
Water spring	Iraq(Nenevah)	3.820-9.999	[8]
Cold spring	Jordan(Irbid)	89.19-289.2	[17]
Well and spring	Lebanon (different locations)	12.432-1340.5	[18]
ground water	Cyprus(different locations)	2.702-135.14	[19]
tap water	Cyprus(different locations)	5.405-54.054	[19]
Sterilized drinking Water Carbonated drinks	Iraq (different locations) Iraq (different locations)	44.384 47.872-152.503	present results

It is quite clear from the table (2) that, the experimental values obtained in this work were in agreement with results of other workers regarding the radon concentration level in water samples. The authors thought that this difference came from additives to the samples during the manufacturing**.**

4. Conclusions

The present results have showed that radon concentrations in carbonated drinks samples were ranged between (47.872 - 152.503) PCi/L. The highest concentration was found in peach drink, whereas the lowest concentration was found in the orange flavored drink. These results also showed that, the average value of radon concentrations for all carbonated drinks samples were 103.674 PCi/L.

Also concluded that the radon concentration in sterilized drinking water was less than in the carbonated drinks samples.

In general it has been found that radon (^{222}Rn) concentration, in the studied carbonated drinks samples were less than allowed limit coined by USA Environmental Protection Agency (EPA) which is about 11.1 Bq/L, which is equivalent to 300PCi/L, so it has no danger on human being life.

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