International Journal of Chemical Sciences

International Journal of Chemical Sciences
ISSN: 0972-768 X

Research | Vol 15 Iss 3

Radon Flux Density in Some Liquid of Cleaning Materials Samples in Iraq

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Received: March 27, 2017; **Accepted:** July 29, 2017; **Published:** July 31, 2017

Abstract

In this study, thirty samples of cleaning materials (liquid) were collected from the local markets of Al-Najaf government to assess radium content and radon flux density (radon exhalation rate) using LR-115 Type II technique. These samples were divided into six groups according to country of origin (i.e. Iraq, Turkey, Jordon, Saudi Arabia, Egypt and other countries). The results demonstrate that, the average of radium content in six groups (Iraq, Turkey, Jordon, Saudi Arabia, Egypt and other counties) were 55.22 Bq/kg ± 0.29 Bq/kg, 56.15 Bq/kg ± 0.37 Bq/kg, 32.38 Bq/kg ± 0.37 Bq/kg, 27.28 Bq/kg ± 0.63 Bq/kg, 60.34 Bq/kg ± 0.73 Bq/kg and 41.90 Bq/kg ± 0.23 Bq/kg respectively. The average values of radon flux density were 9.24 µBq/m^2.h ± 0.25 µBq/m^2.h, 11.00 µBq/m^2.h ± 0.31 µBq/m^2.h, 6.06 µBq/m^2.h ± 0.31 µBq/m^2.h, 4.55 µBq/m^2.h ± 0.59 µBq/m^2.h,11.17 µBq/m^2.h ± 0.64 µBq/m^2.h and 7.33 µBq/m^2.h ± 0.20 µBq/m^2.h respectively. All values of radium content and radon flux density in the study samples were found to be less than the allowed the values of 57.600 mBq/m^2.h and 370 Bq/kg published by UNSCEAR and OECD.

Keywords: ***Radium content; Radon exhalation rates; Liquid cleaning material; LR-115 Type II detector***

Introduction

The highest percentage of human radiation exposure comes from the naturally existed sources. These include terrestrial and extra-terrestrial sources. The origin of the extraterrestrial radiation is the outer space as cosmic rays that reach the atmosphere. However, terrestrial ones are coming from radioactive nuclei exits in trace amounts across the earth's crust which includes soils and rocks. The types of radiations that emitted from those nuclei can be transferred to human beings either *via* food chains or by inhalation causing deposition of energy within tissues. In this context, people are always exposing to ionizing radiation from naturally occurring radioactive sources [1]. Alpha-emitting radioactive sources are harmful elements to human being because of their high energy. The alpha particles are able to cause damage to normal tissues of different organs through chemical and toxicity effects [2]. The radon as a short-lived decay product is responsible for most of the radiation hazards after it has been taken inhalation. The radon inhalation hazard results from that it’s emitted alpha particles trapped in the lung and depositing their energies in the tissue, causing a higher damage than that of beta particles or gamma-rays. The cancer of lung and skin, and kidney diseases are the resulted health effects that attributed to radon-decay products inhalation [3]. Radium-226 and the corresponding radon-222 mainly originated from the naturally occurring uranium-238, that is existed in every type of rocks, building materials and soils in form of parts per million (ppm). The uranium content world average in the earth's crust is estimated to be around 4 ppm. The Radium element is being a member of uranium radioactive series, is present elsewhere in the earth's crust; hence, radon, which is the daughter of radium, is also presents everywhere but in different levels [4]. Knowledge about the level of the radioactivity in cleaning materials enables people to be aware of any possible radiation hazard resulting from the use of consuming such materials. In the light of the aforementioned facts, it is therefore, necessary to evaluate the radioactivity in some types of cleaning materials. Measuring of radon concentration and radon exhalation rates of liquid materials is a key in the radiation protection field. Environmental effects of cleaning agents are caused by chemical compounds in cleaning products. Cleaning agents may be bioactive with an effect that is ranging from mild to severe. Endocrine disruptors have been linked to cleaning agents [5,6]. Green cleaning can be considered as an approach to address the problems associated with traditional cleaning materials. [7-11]. In the present study, radium content and radon exhalation rates from different liquid cleaning materials commonly used in Iraqi were assessed using solid state nuclear track detectors (LR-115 Type II).

Material and Methods

Thirty of liquid cleaning material samples were collected from different markets in Iraq. These samples were divided in to six groups according to country of mad as shown in TABLE 1.

TABLE 1. **Samples of liquefied cleaning materials used in this study.**

No.	Country	Sample type	Sample name	Sample code
1	Iraq	Dishwasher	Al-Ammer	I1
2		Dishwasher	Al-Wazir	I2
3		Dishwasher	Al-Yakuet	I3
4		Dishwasher	Rand	I4
6		Dishwasher	Dina	I5
7		Chlorine detergent	Fas	I6
8	Turkey	Dishwasher	Cif	T1
9		Shampoo	Ipek	T2
11		Shampoo	Nono	T3
12		Shampoo	Vinos	T4
13		Shampoo	Fax	T5
14	Jordon	Dishwasher	Al-Jazira	J1
15		Dishwasher	Al-Emlaq	J2
16		Dishwasher	Tauri	J3
17		Chlorine detergent	Flash	J4

18			Cloth washer	Lara	J5
19	Saudi Arabia		Dishwasher	Fairy	SA1
20			Shampoo	Pert (plus)	SA2
21			Shampoo	Head & Shoulders	SA3
22	Egypt		Chlorine detergent	Mr muscle	E1
23			Shampoo	Elvive	E2
24			Shampoo	Sunsilk	E3
25	Other	Labanon	Cloth washer	Persil	O1
26			Cloth washer	Persil (black)	O2
27		Bahrain	Cloth washer	Vanish	O3
28		Moroccan	Shampoo	Palmoive	O4
29		Chain	Shampoo	Repair	O5
30		France	Shampoo	Wellice	O6
31		Germany	Dishwasher	Berfy	O7

Experimental setup

A LR-115 type II detector with a (12 µm) thickness was used to measure radium content and radon exhalation rates in the samples of liquid cleaning material. Every sample was placed inside a plastic cylindrical container with 7 cm length and 3.5 cm radius in a position that face the track detector. The same weight of the sample was placed in an emanation chamber, which then closed for a period of four weeks in order to reach a state of equilibrium between radium and radon. The dimensions of each detector were $1 \times 1\ cm^2$ and placed in the upper part of each containers (cylinder cover), while the samples placed the container floor and then sealed for 30 days exposure. After that, the LR-115 detector was etched in a sodium hydroxide (NaOH) solution of (2.5) normality. This solution was prepared by dissolving 40 g of NaOH in 0.4 L of distilled water. After preparing the etching solution using magnetic stirrer, it was kept for 24 h to reach the homogeneity state. During this time, the detectors were carefully removed from the containers and, if possible, to maintain the surface of the detectors free of scratches. Next, detectors were placed in NaOH solution at the water bath locking it's temperature at (60°C) for 90 min. Lastly, the detectors were removed from the solution and washed extensively by distilled water and then dried by soft papers. The numbers of tracks per unit area of detector were then counted using a 400X magnification power optical microscope (HDCE-50B Digital Camera, System Microscope N-120A).

Calculations of radium content and radon flux density

Radium content in study samples was calculated using the following eqn. [12,13]:

$$C_{Ra}\left(\frac{Bq}{kg}\right)=\left[\frac{\rho}{KT_e}\right]\left[\frac{h}{AM}\right] \qquad (1)$$

where, ρ refers to the track density which was calculated by [14]:

$$\rho\left(\frac{Track}{cm^2}\right)=\frac{No.of\ track}{Area\ of\ View} \qquad (2)$$

T_e refers to the effective exposure time given by [13]:

$$T_e(d)=\left[T-\frac{(1-e^{-\lambda_{Rn}T})}{\lambda_{Rn}}\right] \qquad (3)$$

K refers to the calibration factor. The calibration factor in this study for exposed dosimeters (5 days-30 days) to radium-226 (radon-222 source) of an activity of 3300 Bq was calculated to be (0.02 ± 0.003) (track/cm^2)/(Bq.d. m^3), which would agree well with many previous studies [15-18]. M is the sample mass (kg), A is the cross-section area of the can (m^2) and h is the distance between the detection and top surface of the samples (m).

The radon flux density (Bq/m^2.h) of the sample for the release of the radon can be calculated using the following expression [19]:

$$E_x\left(\frac{Bq}{m^2.h}\right)=\left[C_{Ra}\left(\frac{\lambda_{Ra}}{\lambda_{Rn}}\right).\frac{1}{T_e}\right]\frac{M}{A} \qquad (4)$$

Results and Discussion

TABLES 2-7 present the values of radium content and radon flux density for liquid cleaning materials samples. From TABLE 2, it can be seen that the value of radium content and radon flux density in Iraqi samples were varied from (24.35) Bq/kg to (85.07) Bq/kg with an average of (55.22 ± 0.29) Bq/kg and varied from (4.18) µBq/m^2.h to (16.72) µBq/m^2.h with an average of (9.24 ± 0.25) µBq/m^2.h respectively.

TABLE 2. **Results of C_{Ra} and E_x for samples under study that made in Iraq.**

No.	Sample code	C_{Ra} (Bq/kg)	E_x (µBq/m^2.h)
1	I1	56.83	10.47
2	I2	85.07	16.72
3	I3	78.15	11.52
4	I4	24.35	4.18
5	I5	56.92	6.29
6	I6	30.02	6.27
Average ± S. D		55.22 ± 0.29	9.24 ± 0.25

According to TABLE 3, it can be seen that the value of radium content and radon flux density in Iraqi samples were varied from (30.09) Bq/kg to (101.24) Bq/kg with an average of (56.15 ± 0.37) Bq/kg and varied from (6.28) µBq/m^2.h to (19.90) µBq/m^2.h with an average of (11.00 ± 0.31) µBq/m^2.h respectively.

TABLE 3. **Results of C_{Ra} and E_x for samples under study that made in Turkey.**

No.	Sample code	C_{Ra} (Bq/kg)	E_x (μBq/m^2.h)
1	T1	31.36	7.32
2	T2	30.09	6.28
3	T3	48.69	11.93
4	T4	101.24	9.57
5	T5	69.37	19.90
Average ± S.D		56.15 ± 0.37	11.00 ± 0.31

From TABLE 4, It is clear that the value of radium content and radon flux density in Iraqi samples were varied from (10) Bq/kg to (75.06) Bq/kg with an average of (32.38 ± 0.37) Bq/kg and varied from (2.08) μBq/m^2.h to (15.68) μBq/m^2.h with an average of (6.06 ± 0.31) μBq/m^2.h respectively.

TABLE 4. **Results of C_{Ra} and E_x for samples under study that made in Jordon.**

No.	Sample code	C_{Ra} (Bq/kg)	E_x (μ Bq/m^2.h)
1	J1	10	2.08
2	J2	19.71	3.14
3	J3	75.06	15.68
4	J4	24.4	4.19
5	J5	32.77	5.23
Average ± S.D		32.38 ± 0.37	6.06 ± 0.31

From TABLE 5, it can be seen that the value of radium content and radon flux density in Iraqi samples were varied from (21.26) Bq/kg to (34.35) Bq/kg with an average of (27.28 ± 0.63) Bq/kg and varied from (3.13) μBq/m^2.h to (6.33) μBq/m^2.h with an average of (4.55 ± 0.59) μBq/m^2.h respectively.

TABLE 5. **Results of C_{Ra} and E_x for samples under study that made in Saudi Arabia.**

No.	Sample code	C_{Ra} (Bq/kg)	E_x (μ Bq/m^2.h)
1	SA1	34.35	6.33
2	SA2	26.23	4.19
3	SA3	21.26	3.13
Average ± S. D		27.28 ± 0.63	4.55 ± 0.59

Regarding TABLE 6, it can be seen that the value of radium content and radon flux density in Iraqi samples were varied from (28.41) Bq/kg to (97.58) Bq/kg with an average of (60.34 ± 0.73) Bq/kg and varied from (5.23) μBq/m^2.h to (16.78) μBq/m^2.h with an average of (11.17 ± 0.64) μBq/m^2.h respectively.

TABLE 6. **Results of C_{Ra} and E_x for samples under study that made in Egypt.**

No.	Sample code	C_{Ra} (Bq/kg)	E_x (μBq/m^2.h)
1	E1	97.58	16.78
2	E2	28.41	5.23
3	E3	55.05	11.50
Average ± S. D		60.34 ± 0.73	11.17 ± 0.64

From TABLE 7, It can be seen that the value of radium content and radon flux density in Iraqi samples were varied from (19.05) Bq/kg to (62.75) Bq/kg with an average of (41.90 ± 0.23) Bq/kg and varied from (4.19) μBq/m^2.h to (12.54) μBq/m^2.h with an average of (7.33 ± 0.20) μBq/m^2.h respectively.

According to above, it can be noticed that there are some variations in the findings of each of radium content and radon flux density across the study samples. These variations may be attributed to the differences in the nature of the samples composite and nuclei percentage of these samples. Nevertheless, the findings of radium content are less than the permissible level (370 Bq/kg) which had been recommended by Organization for Economic Cooperation and Development (OECD) [20]. Therefore, the results show that the samples of liquified cleaning materials as attributed to different counters were clearly safe as far as the hazards of radium are concerned. Additionally, it is found that, radon flux density (radon exhalation rates) as being observed in samples of the current study are well below the world average of 57 600 mBq/m^2 h therefore this would not pose any health hazards to the human beings [21].

TABLE 7. **Results of C_{Ra} and E_x for samples under study that made in other country.**

No.	Sample code	C_{Ra} (Bq/kg)	E_x (μ Bq/m^2.h)
1	O1	56.71	6.27
2	O2	62.75	11.56
3	O3	32.02	6.29
4	O4	60.05	12.54
5	O5	36.53	6.28
6	O6	26.23	4.19
7	O7	19.05	4.21
Average ± S. D		41.90 ± 0.23	7.33 ± 0.20

TABLE 8 presents a summary for the radium content and radon flux density if the liquefied cleaning materials samples that are made in Iraq, Turkey, Jordon, Saudi Arabia, Egypt and other countries supported by FIG. 1 and 2. The Egypt samples were characterized by the highest value of radium content and radon flux density, while the lowest value of radium content and radon flux density in Saudi Arabia samples.

TABLE 8. **Summary results of C_{Ra} and E_x for samples under study across different countries.**

Country	C_{Ra}	E_x
Iraq	55.22	6.65
Turkey	56.15	7.92
Jordon	32.38	4.36
Saudi Arabia	27.28	3.27
Egypt	60.34	8.04
Other countries	41.90	5.27

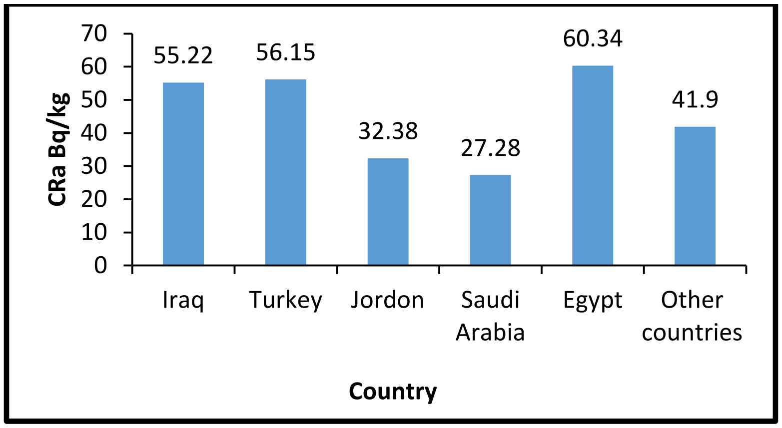

FIG. 1. **C_{Ra} as a function of country that made the samples under study.**

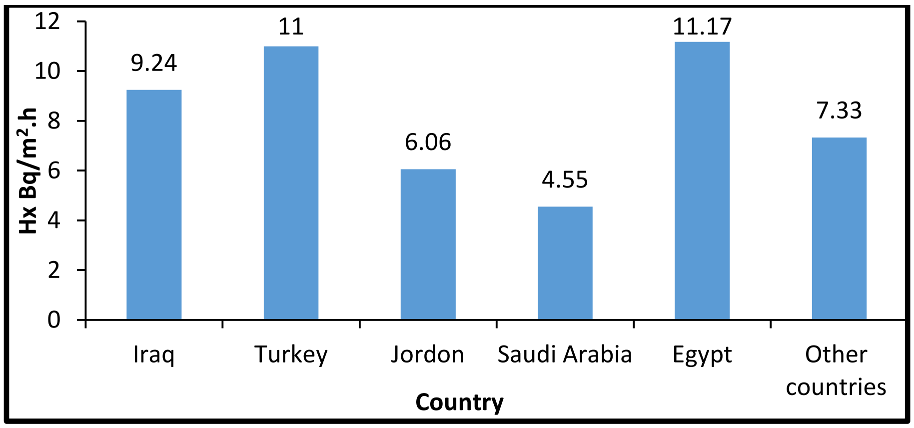

FIG. 2. **E_x as a function of country that made the samples under study.**

Conclusion

The study of radium content and radon flux density in some liquid of cleaning materials samples in Iraq showed that, all samples been tested had radium content and radon flux density less than the world average values of 370 Bq/kg and 57.600 mBq/m^2.h recommended by UNSCEAR and OECD respectively. From a radioprotection point of view, it can be concluded that the studied samples can be used by human with negligible radiation hazards.

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21. UNSCEAR. Report of The United Nations Scientific Committee on The Effects of Atomic Radiation to the General Assembly. ANNEX B Exposures from Natural Radiation Sources.