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RESEARCH ARTICLE

Radon. Radium, and Uranium Levels in Some Samples of women Hair Treatment Materials

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ABSTRACT

Background: The objective of the present study is to measure the radon (222Rn) gas, radium (226Ra), and uranium (238U) concentrations in some samples (twenty-one samples) of hair treatments materials, which were collected from the local markets in Najaf Governorate, Iraq. The majority of samples are made in Brazil, the USA and South Africa. Also, the radon exhalation rate in all samples of the present study was estimated. Materials and Methods: A "Solid-state nuclear track detectors" (SSNTD) of CR-39 detector type whose dimensions are (2.5x2.5 and density of 1.31 gm.cm-3). The TASLImage system (made in the United Kingdom) was used to measure radon concentrations. Results: The results show that the values of radon concentrations were ranged from 14.95 Bq/m3 to 183.09 Bq/m3, with an average value of 48.00±7.89 Bq/m3, while the exhalation rate values ranged from 4.15 mBq/m2.h to 50.86 mBq/m2.h, with an average of 13.33±2.19 mBq/m2.h. Also, the average values of 226Ea and 238U in all samples of the present study were 36.84±7.89 mBq/kg and 0.045±0.009 ppm, respectively. The values of radon concentrations and it is exhalation rate in all samples were seen to be lower than the acceptable limit according to ICRP "International Commission on Radiological Protection" (200-300 Bq/m3) and UNSCEAR "United Nations Scientific Committee on the Effects of Atomic Radiation" (57.6 Bq/m2.h), respectively. Conclusion: Therefore, it can be concluded that the hair treatment materials samples which are commonly used by women (in Iraq and other countries) are not contaminated and are safe to use.

INTRODUCTION

People are exposed to radiation in two ways, either from sources of radiation outside the body which called 'external exposure' or they might be exposed to internal radiation from radioactive substances existed in the body. One of the main causes of radiation exposure is the natural and non-industrial radioactivity [1]. Among the most important natural factors that are considered as primary sources of radiation that lead to the external and internal radiation exposure are the terrestrial radionuclides and cosmic radionuclides. Uranium-238, thorium-232 with the melting chains and the radioactive analogue of potassium-40 are those radionuclides that available in nature, and for this reason they are classified as the main responsible factor for the external gamma radiation. By contrast, concerning what people receives internally, naturally occurring radionuclides such as ^{238}U instead of ^{226}Ra and their daughters' products are responsible for this[2]. In general, external exposure has fewer effects than that of the internal exposure. To illustrate, this is attributed to alpha particles lack the penetration ability of the skin outer dead layer [3]. When considering the ingestion of the

radionuclides emitting alpha particles, or inhalation, they would be very toxic. This is due to that they might release a large quantity of energy in a small distance, within living tissue [4]. In major, those elements that are emitting alpha particles can be listed as follow: Uranium, radon, and plutonium. Given that when alphas are swallowed and inhaled, they might be absorbed into the bloodstream; in this case, alpha radiation can result in lung cancer [2]. The high concentration of these radionuclides can be attributed to their large abundance in nature [4]. During human ingestion of food and water, alpha and beta emitted (as natural radionuclides) are of importance in relation to potential internal radiation exposure [1]. The hair treatments substances contain many natural materials that is used for hair treatments and hair growth massage. These natural materials include Aloe vera, Coconut oil, Viviscal, Fish oil, Ginseng, Onion juice and Rosemary oil which may contain natural radioactivity. In this regards, radiation can trigger hair loss. This means that if it has radiation in the hair of the head, this can therefore impact people hair follicles [5]. Radon is a noble gas that results from uranium decay. In nature, it can be found in abundance. Because of the alpha particles released by Rn-226, radon can often be found naturally with high concentrations that is higher than the acceptable limit. Radon, is a radioactive gas produced by the breakdown of radium in rocks and minerals as a component of the uranium radioactive process [1]. When a person uses detergents (such as shampoos, hair conditioners and hair treatments), he/she may be directly exposed to radioactivity, and therefore to external exposure. The reason for the latter is that one of the materials included in the composition of these materials is radioactive polluting raw materials [6]. In this context, many researchers who searched for radon concentrations in different materials that used to clean the body, skin, and hair [7-10]. All natural martials may contain a percentage of radionuclides. According to what many studies have revealed regarding the raw materials used in the manufacture of hair treatments, it has become necessary to study the radioactivity in these materials. Since hair treatments are widely used by almost both genders, assessment of the level of radon gas, radium, and uranium in different types of (hair treatments) available in the Iraqi market, were among the most important goals of this work.

1. RESEARCH METHODOLOGY

Figure 1 shows the flowchart of the research methodology that was used to achieve the study's aims.

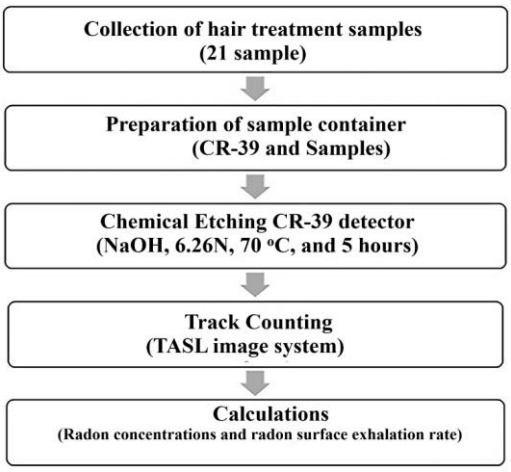

Figure 1. Flowchart of the research methodology

1.1. Collection Of Samples

Twenty-one imported types of hair treatments were gathered from Iraqi markets, as shown in Table (1).

Table 1. Kinds and country of origin of hair treatments Samples.

No.	Designated Code	Sample Name	Country of Origin
1	H1	Keratin	Brazil
2	H2	ULTRALISS	Brazil
3	H3	PRIME	Brazil
4	H4	Vinhoterapia	Brazil
5	H5	HARMANY hair professional VIP EFFECT	Brazil
6	H6	SAMAR	Brazil
7	H7	FLAMINGO	Brazil
8	H8	4 QUATTROLIO	USA
9	H9	DIAMOND CELLS	USA
10	H10	RIO LISS treatment super emollient	Brazil
11	H11	PRO SK RP	Brazil
12	H12	Pro Hairmony apple stem cell	USA
13	H13	PREMIUM	Brazil
14	H14	AB SOULU TE	USA
15	H15	Top car botox	Brazil
16	H16	Hanna Lee	Brazil
17	H17	SORALI	Brazil
18	H18	sofn'free	South Africa
19	H19	W one	Brazil
20	H20	Lissage Caviar	Brazil
21	H21	Delicada	Brazil

1.2. Experimental setup

Each of the 21 hair treatments samples were placed in cylindrical plastic containers with height of (7 centimetres) and diameter (4 centimetres), where the height of the sample in the container was (1 centimetre). The thickness of the CR-39 SSNTD used to measure radon gas is 1 mm, with a density of 1.31 gm.cm^{-3}. To separate radon from other radiations and from dust, the container containing the sample was covered with an airtight membrane, to allow the spread of radon inside the container. To distinguish between containers, they were all labelled by a specific code. The containers were left at room temperature for a period of (3 months) for the exposure. To get rid of electrostatic charge and ensure electrical conductivity, these containers were chosen since they are made of polypropylene. To prevent the leakage of radioactive gases (radon), the containers are impermeable and covered with a tight lid. The area of the detector SSNTD (CR-39) was (2cm×2cm) for each piece. The (CR-39) detector was fixed at the top of the container.

1.3. Chemical Etching

The process (Etching) the detector after radiation exposure was carried out using a solution of sodium hydroxide (NaOH) at a temperature of (70) degrees Celsius and for a period of (5) hours. To prepare a natural (6.25) solution, (100) g of (NaOH) was dissolved in (0.4) litters of distilled water [11]. Then, the solution was left for (21, 24) hours to obtain a solution with high homogeneity. The detectors were, next, removed from the containers, and at this time the surface of the detectors must be protected from scratches. Finally, the detectors were removed from the solution, washed thoroughly with distilled water, and then dried with soft paper towels.

1.4. Track Counting Process

The TASLIMAGE system is utilized for routine neutron and radon dosimetry, and the TASLIMAGE program is known as one of best system advantages. This system has a very high magnification feature when compared with other reading devices. This feature makes it with better quality in reading the engraved tracks. TASLIMAGE has several advantages; the most important of which are:

- It scans bullets and engraved paths completely and automatically.
- Focused automatically and according to the program.
- Ability to distinguish between engraved paths and background characteristics.
- Its ability to automatically subtract the radiation background of each detector.
- The speed of the detector reading, which ranges between (30 - 60) seconds.
- Its ability to convert survey data into a dose automatically and export it to the Excel program so that it can be used later [12].

1.5. Theoretical Equations

^{222}Rn concentration in air space (C), within sample (C_S), and the radon surface exhalation rate (E_S) as well as ^{226}Ra concentration (C_{Ra}) and ^{238}U concentration can be calculated according to the following relationship [13-16]:

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

$$C_S = C\,\frac{\lambda h t}{L} \quad (2)$$

$$E_S = \frac{C\,V\,\lambda}{A\,T_e} \quad (3)$$

$$C_{Ra} = \frac{C\,h\,S}{M} \quad (4)$$

$$C_U = \frac{M_U}{M} \quad (5)$$

where (ρ) represents the density of the track recorded on the detector, (t) is the exposure time, and (k) represents the calibration factor of the measure mental system, which is approximately (0.28) Track cm^{-2} day^{-1}/Bq.m^{-3} [15, 22], V and A are the volume and cross section area of the container, **λ** is the decay constant, T_e represents the actual exposure time, M_U is mass of uranium-238, and M is mass of sample.

Statistical investigation

Statistical study was done by using the statistics software package SPSS version 26.0 for Windows.

RESULTS

Table 2, shows the results of radon concentrations in air space of tube (C), within samples (C_S), and Radon exhalation rate (E_S) in hair treatments samples of the present study. Radon concentration values were extended from 14.95 Bq/m^3 (which recorded for the sample H_9 named "DIAMOND CELLS" and of USA origin) to 183.09 Bq/m^3 (which recorded for the model H_{12} which named "Pro Hairmony apple stem cell" and of USA origin too) with an average value of 48.00±7.89 Bq/m^3. The values of radon concentrations within samples (C_S) were ranged from 1220.07 Bq/m^3 to 14945.86

Bq/m^3, with an average value of 3918.45±644.56 Bq/m^3. While, The Radon surface exhalation rate (E_S) ranged from 4.15 to 50.86 mBq/m^2.h and for the same two samples H_9 and H_{12} above, respectively. While, the average value of E_S was 13.33 mBq/m^2.h.

Table 2. Radon concentrations (Bq/m^3) and Radon exhalation rate (mBq/m^2.hour) in hair treatments samples.

No.	Sample code	Radon gas		E_S (mBq/m^2.h)
		C (Bq/m^3)	**C_S (Bq/m^3)**	
1	H_1	59.79	4880.28	16.61
2	H_2	58.66	4788.77	16.30
3	H_3	38.26	3123.38	10.63
4	H_4	37.37	3050.17	10.38
5	H_5	33.63	2745.16	9.34
6	H_6	18.68	1525.09	5.19
7	H_7	44.84	3660.21	12.46
8	H_8	26.16	2135.12	7.27
9	H_9	**14.95**	**1220.07**	**4.15**
10	H_{10}	28.77	2348.63	7.99
11	H_{11}	22.42	1830.10	6.23
12	H_{12}	**183.09**	**14945.86**	**50.86**
13	H_{13}	104.62	8540.49	29.06
14	H_{14}	29.89	2440.14	8.30
15	H_{15}	52.31	4270.24	14.53
16	H_{16}	58.59	4782.67	16.27
17	H_{17}	34.82	2842.76	9.67
18	H_{18}	38.19	3117.28	10.61
19	H_{19}	28.17	2299.83	7.83
20	H_{20}	27.58	2251.03	7.66
21	H_{21}	67.26	5490.31	18.68
Average±S.E.		48.00±7.89	3918.45±644.56	13.33±2.19
Action levels		200-300 Bq/m^3 [17]	----	57.6 Bqm^2.h [18]

Table 3, shows the results of radium (^{226}Ra) activity (C_{Ra}) and uranium (^{238}U) concentrations (U_C) in hair treatments samples of the present study. C_{Ra} values were extended from 6.43 mBq/kg (which recorded for the sample H_9 named "DIAMOND CELLS" and of USA origin) to 180.55 mBq/kg (which

recorded for the model H_{12} which named "Pro Hairmony apple stem cell" and of USA origin too) with an average value of 36.84±7.89 mBq/kg. While, the results of U_C ranged from 0.01 ppm to 0.22 ppm and for the same two samples H_9 and H_{12}, respectively. While, the average value of U_C was 0.045±0.009 ppm.

Table 3. Radium activity (mBq/kg) and uranium concentrations (ppm) in hair treatments Samples.

No.	Sample code	C_{Ra} (mBq/kg)	C_U (ppm)
1	H_1	65.78	0.08
2	H_2	25.44	0.03
3	H_3	21.62	0.03
4	H_4	19.93	0.02
5	H_5	26.43	0.03
6	H_6	10.79	0.01
7	H_7	26.33	0.03
8	H_8	12.78	0.02
9	H_9	6.43	0.01
10	H_{10}	16.99	0.02
11	H_{11}	8.78	0.01
12	H_{12}	180.55	0.22
13	H_{13}	70.10	0.09
14	H_{14}	27.90	0.03
15	H_{15}	35.51	0.04
16	H_{16}	49.39	0.06
17	H_{17}	34.67	0.04
18	H_{18}	36.62	0.05
19	H_{19}	26.06	0.03
20	H_{20}	23.43	0.03
21	H_{21}	48.15	0.06
Average±S.E.		36.84±7.89	0.045±0.009
Action levels		30 [19]	11 [20]

DISCUSSION

The results of radon concentrations were changed in all samples under study. This can be attributed to the radioactivity in the natural materials that form the samples such as chemical material together with other important factor such as the geology. The results of the present work on hair treatments indicate that the maximum value of radon concentration was seen in sample H_{12} is still within normal

limits which it is ranged from 200 to 300 Bq/m^3 according to ICRP [17]. However, data presented in Table (2) can confirm that radon concentration was nearly varied across all samples. It can also be seen that radon concentration in hair treatment samples (H_{12}) is higher than in other materials. These samples vary from sample to other one, which might be attributed to the variation in the level of uranium contamination in the original structure of the considered samples. It is clear from Figure 2 that the radon concentration in all samples of hair treatments was less than the internationally permitted limits (i.e. 200-300 Bq/m^3) [17], and Figure 3 demonstrated that the inhalation rate was also within the internationally safe limits of 57.6 Bqm^2.h [18].

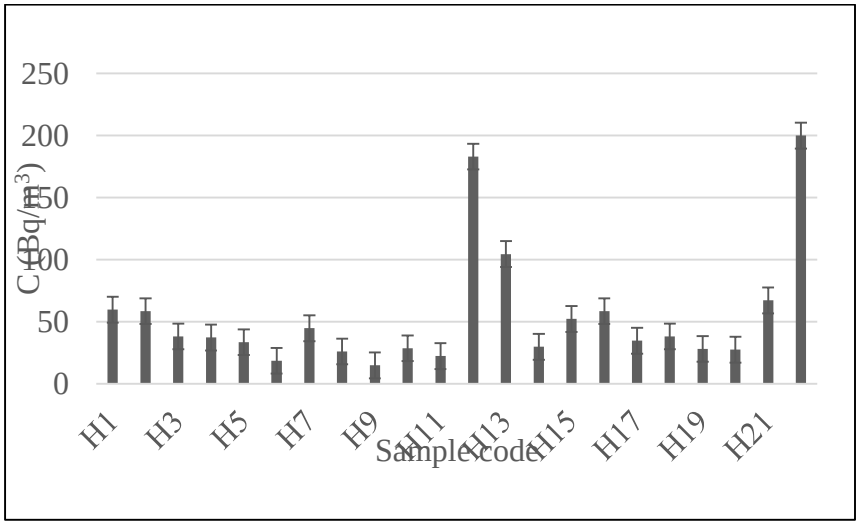

Figure 2. Comparing of C for hair treatments samples with action level.

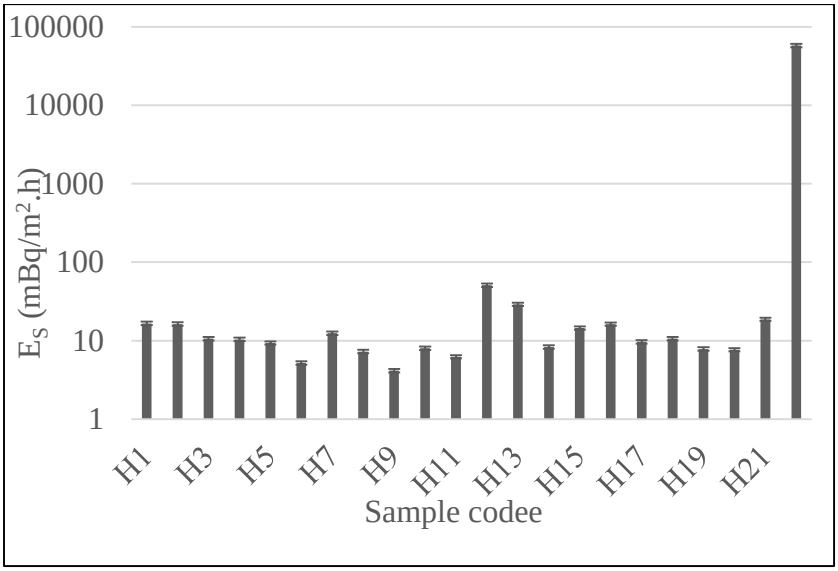

Figure 3. Comparing of E_S for hair treatments samples with action level.

The results of the present work on hair treatments indicate that the maximum value of radium activity seen in sample H12 is still less than the normal limit which is 30 Bq/kg according to UNSCEAR [19], as shown in Figure 4. Also, it is noted that all results of uranium concentrations were still lower than the normal limit which is 11 ppm according to UNSCEAR [20], , as shown in Figure 5.

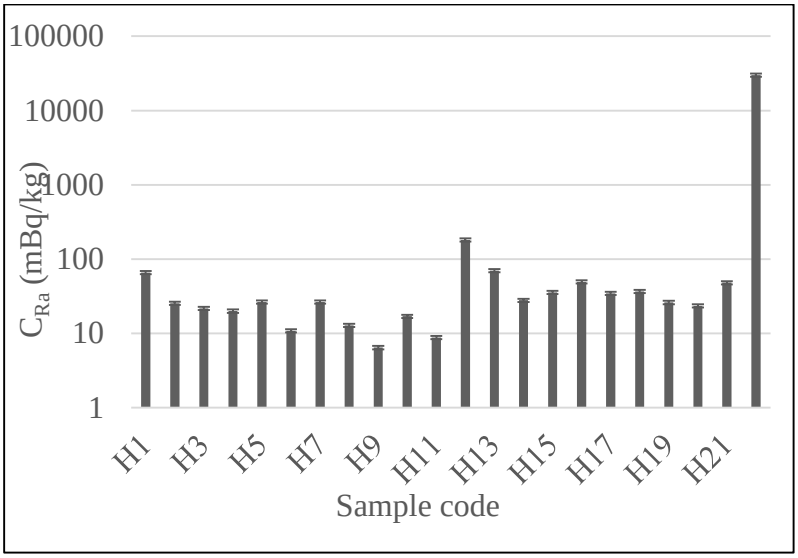

Figure 4. Comparison the results of ^{226}Ra for hair treatments samples with action level.

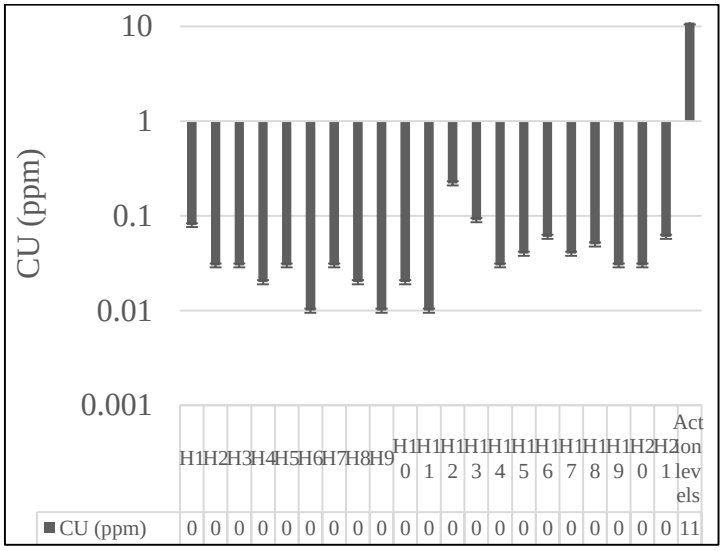

Figure 5. Comparison the results of ^{238}U for hair treatments samples with action level.

Because of the absence the relevant previous studies of radon concentrations in the same samples under study, it can be argued that it may be difficult to compare our results with previous studies. The results of our work concerning hair treatment materials in Iraqi markets are comparable with another study that determined the radon concentrations in relevant materials to our sample of the present study. These include the liquid of cleaning materials [7], cosmetics [8,9], and toothpaste [10] which found that the average radon concentrations are less than those worldwide average levels. We

also found that hair treatment materials are not contaminated by radon, and healthy, and therefore do not result in harmful radiological impacts to the consumer. Indeed, the current work is the first trial to assess the risk related to radon existence in hair treatment material. The total number of samples measured should be extended in the future.

CONCLUSIONS

The study of radon, radium, and uranium levels in hair treatment material samples that are frequently used by women in Iraq and other countries of the world has provided baseline data in the areas of study. However, these data can be a good background for the samples under study which can play a major role in the study of the healthy effect of radon gas. Based on the results obtained in this study, it was noted that the concentration of ^{222}Rn in all samples of hair treatments was very low concentrations, much less than the internationally permitted limits by ICRP2010. Also, the Radon exhalation rate was very small, which is smaller than the internationally recommended safe value according to UNSCEAR 2000. Thus, it can be said that all studied samples were safe and suitable for human use. Moreover, the results of radium and uranium was very small, which is smaller than the internationally recommended safe value according to UNSCEAR. When the findings were compared to those of other studies for closer samples of the present study such as cleaning materials, cosmetics materials, and toothpaste, it was revealed that the current study's radon concentrations were lower than those of other previous studies. In order to monitor the environment from being contaminated by radioactivity, it is necessary to measure concentrations of radon continuously and then ensure that the people are with safe environment.

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Declaration of Competing Interest

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors

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