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Natural Radioactive Contamination in Shampoo and Dishwashing Samples Used in Iraq by NaI(Tl) Detector

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In Iraqi markets, there are no sufficient comprehensive study to identify the natural radioactivity in detergents samples such as shampoo and dishwashing. The aim of the present research is to measure the natural radioactivity in different types of shampoo and dishwashing samples are available in Iraq markets. Also, it is to calculate the radiological hazard indices such as radium equivalent activities and external hazard indices for samples. Measurements were made, using gamma spectrometer for gamma emission such as ^{238}U, ^{232}Th and ^{40}K. Results show that the average values of specific activity in shampoo and dishwashing liquid samples for ^{238}U, ^{232}Th and ^{40}K were (3.50 ± 0.60) Bq/kg, (1.77 ± 0.22) Bq/kg and (119.60 ± 7.27) Bq/kg, respectively. The radium equivalent activity and external hazard index were calculated from the measured natural radioactivity. The average values of the radium equivalent activity and external hazard index in samples under study were (172.22 ± 10.30) Bq/kg and (0.46 ± 0.02), respectively. The present study show that the radium equivalent activity and external hazard index due to natural radioactivity were found within below the action level recommended which are (370 Bq/kg and 1) according to Organization for Economic Cooperation and Development and International Commission on Radiological Protection. It is concluded that the samples of the products under study are well below the limits recommended by recognized authorities.

Keywords: Natural radioactivity, Shampoo and Dishwashing, Iraq markets, NaI(Tl) detector.

INTRODUCTION

Radioactive contamination is that the deposition of, or presence of radioactive substances on surfaces or among solids, liquids or gases, wherever their presence is unintentional or undesirable [1]. A contamination existence like that is a risk due to the radioactive decay of the pollutants, which produce unsafe ionizing radiation like β- or α-particles, neutrons or γ-rays. The risk level is estimated by the concentration of the pollutants, the emitted energy of radiation, the sort of radiation and the parameter of contamination to the body organs. It is worth clarifying that the contamination causes the radiation risk and the terms "contamination" and "radiation" are not synonymous in this context [2]. Natural radioactive decay series such as ^{238}U and ^{232}Th as well as singly occurring radionuclides such as ^{40}K exist in the earth and atmosphere in varied levels. The radioactivity present on air or in the agricultural land and in soil may transfer to the crops grown on it. It happens, however that an amount of some radioactive elements find their way into human bodies [3,4]. Radioactive contamination can irradiation the human body from an internal or external origin. Radioactive contamination (internal irradiation) can be ingested into the human body if it is airborne or is taken in as contamination of drink or food and will irradiate the body internally. The science of evaluating radiation dose that is generated internally is called internal dosimetry. External radiation is caused by radiation from pollution outside the human body. The source could occur in the body or on the surface of the skin. The level of health hazard depends on period, the type, power of radiation. Penetrating radiation such as γ-rays, X-rays, neutrons or β-particles create the biggest risk from an external source [5]. Human body can be exposed for natural radioactivity by detergent products such as shampoos and dishwasher products externally exposure, because it may contain these product at origin structure materials that have radioactive contamination. The measurement of natural radioactivity and radiological parameters in detergents were studied less. In 2010 Abir Ksouri measured specific activity of ^{235}U, ^{238}U, ^{232}Th and ^{40}K and to Detergent Products samples in France, using gamma spectroscopy (HPGe) detector [6]. Abojassim *et al.* [7] have measured radionuclides of detergent powders in Kuwait, using gamma spectroscopy. The aim of this study focuses on the evaluation of the level of radionuclides (^{238}U, ^{232}Th, ^{40}K) in two types the detergents (shampoos and dishwasher products) that available in Iraq markets. We are also estimated some of the radiological parameters such as radium equivalent activity and external exposure.

EXPERIMENTAL

Collection and preparation samples: Twenty one samples of liquid detergent products are collected from market of Iraq for the period from 1/10/2015 to 1/2/2016 to measure the natural radioactivity levels. We divided these samples into two groups according to the types of detergent products shampoo and dishwashing as shown in Table-1. After collection of liquid detergent products samples in this study from different local markets of Iraq then transferred to the laboratory of radiation detection and measurement in the physics department, faculty of science, University of Kufa. In this work a 1 L polyethylene marinelli beaker is used as a sampling and measuring container. Before use, the containers are washed with dilute hydrochloric acid and rinsed with distilled water. The respective net weights are measured and recorded with a highly sensitive balance assuring a percentage error of about ± 0.01 %. After that, about 700 g of each sample is then packed in a standard marinelli beaker that is hermetically sealed. All samples were stored for about one month before counting, to allow secular equilibrium to be attained between ^{222}Rn and its parent ^{226}Ra in uranium chain [8].

Gamma spectrometer: Gamma-ray spectrometer equipment consists of a NaI (Tl) scintillation detector of dimension (3" × 3") crystal (ORTEC), provided by (Alpha Spectra, Inc.-12I12/3), paired with a multi-channel analyzer (MCA) (ORTEC-Digi Base) with 4096 channel range linked with ADC (Analog to Digital Convertor) unit, by interface. The measurements of spectroscope and analysis are conducted by the (MAESTRO-32) software into the PC, as in Fig. 1. The energy resolution is 8 % at the 0.662 MeV gamma of ^{137}Cs source; it can be compared with the typical values measured at this energy in commercial NaI (Tl) detectors which are in the range (5-10) % [9].

Measurement of radioactivity: The radioactivity measurement the samples were made by placing them on the detector inside the lead shielding and spectrum was collected. Each sample was measured during an accumulating time of 24 h. The determining of the specific activity is possible at an honest separated photo-peaks at high energies as that obtained in our results from the γ-rays emitted by the progenies of ^{238}U and ^{232}Th that were in secular equilibrium with them whereas, ^{40}K was estimated directly by its gamma-line of 1460.8 kev. Hence the specific activity of ^{238}U were determined exploitation the gamma-lines 1765 kev (^{214}Bi). The corresponding results of ^{232}Th were determined exploitation the γ-ray lines 2614 kev (^{208}Tl) [3,7].

The specific activity of the radionuclide in Bq/kg, can be calculated using the following equation [10].

TABLE-1
SHOW DETERGENT PRODUCTS SAMPLES ACCORDING TO THE PRODUCING COUNTRY

No.	Groups	Samples names	Samples code	Origin
1	Shampoo	Ipek	S1	Turkey
2		Elvive	S2	Egypt
3		Palmolive	S3	Morocco
4		Sunsilk	S4	Egypt
5		Fax	S5	Turkey
6		Pert(plus)	S6	Saudi Arabia
7		Nono	S7	Turkey
8		Repair	S8	China
9		Vinos	S9	Turkey
10		wellic	S10	France
11		Head & Sholder	S11	Saudi Arabia
12	Dishwashing	Berfy	S12	Germany
13		Al ammer	S13	Iraq
14		Fairy	S14	Saudi Arabia
15		Alwazir	S15	Iraq
16		Al jazira	S16	Garden
17		Cif	S17	Turkey
18		Alykut	S18	Iraq
19		Al emlaq	S19	Jordan
20		Rand	S20	Iraq
21		Crystal	S21	Iraq

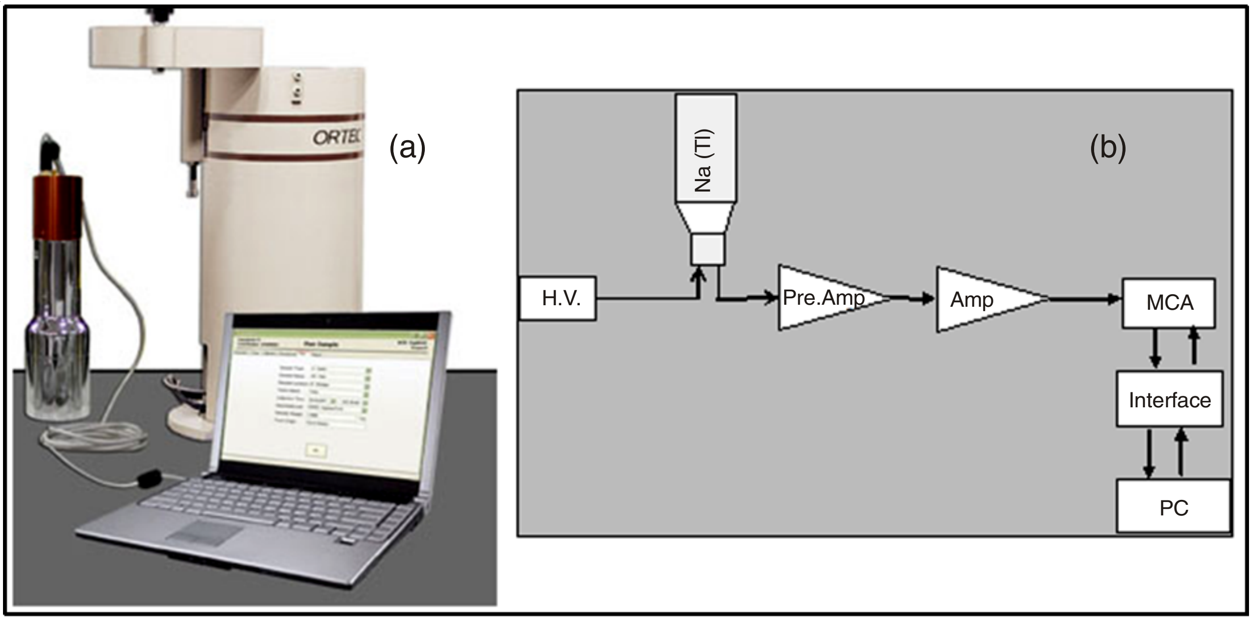

Fig. 1. (a) Experimental set-up, (b) set-up block diagram

$$A\left(\frac{Bq}{Kg}\right)=\frac{c}{\varepsilon I_{\gamma} t m} \quad (1)$$

where C is net peak count, ε the relative efficiency, I_γ the percentage of gamma emission probability of the radionuclide under study, t the counting time in second and m the mass of the sample in (kg).

The significance of ^{238}U (^{226}Ra), ^{232}Th and ^{40}K activities were defined in terms radium equivalent activity (Ra_{eq}) in Bq/kg that is calculated from equation [6,7,11].

$$Ra_{eq}\left(\frac{Bq}{Kg}\right)=A_{Ra}+1.43A_{Th}+0.077A_{K} \quad (2)$$

where A_{Ra}, A_{Th} and A_K are the specific activity of ^{226}Ra, ^{232}Th and ^{40}K in (Bq/kg), respectively.

To reflect the external exposure, a widely used hazard index this hazard, defined in terms of external radiation hazard index and denoted by H_{ex}, can be calculated using equation [6,7,12].

$$H_{ex}=\frac{A_{Ra}}{370}+\frac{A_{Th}}{259}+\frac{A_{K}}{4810} \quad (3)$$

The values of the index should be but the unity so as to stay the radiation hazard to be insignificant unity adore the higher limit of radium equivalent activity (370) Bq/kg [12].

RESULTS AND DISCUSSION

The specific activity values of ^{238}U, ^{232}Th and ^{40}K radionuclides associated with the natural radionuclides in Bq/kg for (21) detergent products (11 shampoo and 10 dishwashing) samples are tabulated in Table-2. The data of specific activity of ^{238}U, ^{232}Th and ^{40}K ranged from (1.04 ± 0.11 to 8.36 ± 0.34) Bq/kg, with an average (3.50 ± 0.60) Bq/kg, from (1.00 ± 0.06 to 3.49 ± 0.12) Bq/kg with an average (1.77 ± 0.22) Bq/kg and from (46.48 ± 0.85 to 187.19 ± 1.64) Bq/kg with an average (119.60 ± 7.27) Bq/kg, respectively. Whereas the data have revealed that sample (S5) has recorded the highest specific activity of ^{238}U, which is made in Turkey and lower specific activity ^{238}U recorded in sample (S20) which is made in Iraq. The highest specific activity of ^{232}Th recorded in sample (S15) which is made in Iraq and lower specific activity of ^{232}Th recorded in sample (S4) which is made in Egypt. The highest specific activity of ^{40}K recorded in sample (S19) which is made in Jordan and lower specific activity of ^{40}K recorded in sample (S6) which is made in Saudi Arabia. The obtained results are comparable to the worldwide average recommended by UNSCEAR 2000 which are 32, 35 and 400 Bq/kg for ^{238}U, ^{232}Th and ^{40}K, respectively [13]. The values obtained for radium equivalent activity (Ra_{eq}) and external hazard index (H_{ex}) are presented in Table-3. As can be seen from Table-3, the radium equivalent values range from (69.11 to 269.23) Bq/kg, whereas highest value represented in sample (S19) and lower value in sample (S6) with an average value (172.22 ± 10.30) Bq/kg. It can be seen that the Ra_{eq} values for detergent products samples were lower than the recommended maximum value 370 Bq/kg by [14]. The external hazard index of detergent products values was records maximum values (0.72) in sample (S19) and recorded minimum values (0.18) in sample (S6). Obviously, all values of these operators for all samples studied are less than unity which is the maximum value of the permi-ssible safety limit recommended by ICRP (2000) [15].

TABLE-2
SPECIFIC ACTIVITIES OF RADIONUCLIDES IN DETERGENT PRODUCTS SAMPLES

Samples code	Specific activity of radionuclides (Bq/kg)		
	^{238}U	^{232}Th	^{40}K
S1	3.41 ± 0.18	BDL[a]	134.28 ± 1.20
S2	BDL[a]	BDL[a]	139.04 ± 1.42
S3	BDL[a]	1.31 ± 0.06	101.49 ± 0.99
S4	2.57 ± 0.19	1.00 ± 0.06	133.98 ± 1.42
S5	8.36 ± 0.34	BDL[a]	99.83 ± 1.23
S6	5.88 ± 0.28	2.20 ± 0.09	46.48 ± 0.85
S7	BDL[a]	BDL[a]	141.40 ± 1.54
S8	7.25 ± 0.32	1.2 ± 0.05	105.36 ± 0.87
S9	BDL[a]	2.39 ± 0.08	151.07 ± 1.60
S10	2.95 ± 0.20	BDL[a]	156.32 ± 1.57
S11	1.93 ± 0.16	BDL[a]	114.59 ± 1.30
S12	4.09 ± 0.22	1.18 ± 0.05	121.21 ± 1.25
S13	BDL[a]	1.58 ± 0.08	105.12 ± 1.22
S14	3.01 ± 0.19	1.14 ± 0.06	101.01 ± 1.17
S15	1.70 ± 0.16	3.49 ± 0.12	98.98 ± 1.26
S16	1.57 ± 0.15	2.61 ± 0.10	107.09 ± 1.28
S17	BDL[a]	BDL[a]	88.28 ± 0.92
S18	2.70 ± 0.18	BDL[a]	124.18 ± 1.30
S19	2.55 ± 0.18	1.36 ± 0.05	187.19 ± 1.64
S20	1.04 ± 0.11	1.87 ± 0.06	80.33 ± 1.05
S21	BDL[a]	BDL[a]	174.42 ± 1.68
Average ± S.D	3.50 ± 0.60	1.77 ± 0.22	119.60 ± 7.27

*BDL[a], below detection limit

TABLE-3
RADIUM EQUIVALENT ACTIVITY AND EXTERNAL HAZARD INDEX IN DETERGENT PRODUCTS SAMPLES

Samples code	Ra_{eq} (Bq/kg)	H_{ex}
S1	192.28	0.52
S2	198.82	0.54
S3	146.44	0.40
S4	192.78	0.52
S5	143.40	0.38
S6	69.11	0.18
S7	202.20	0.54
S8	152.42	0.41
S9	218.42	0.58
S10	223.76	0.60
S11	164.01	0.44
S12	174.82	0.47
S13	151.90	0.41
S14	145.81	0.39
S15	145.16	0.39
S16	155.86	0.42
S17	126.24	0.34
S18	177.78	0.48
S19	269.23	0.72
S20	116.82	0.31
S21	249.42	0.67
Average ± S.D	172.22 ± 10.30	0.46 ± 0.02

The results of the present work suggested that in the samples detergent products (shampoo and dishwashing) in Iraq markets are comparable with another studies that determined the natural radiation level (^{238}U, ^{232}Th, ^{40}K) in detergent products. In Iraq [7] and France [6] the average natural radiation level

(^{238}U, ^{232}Th, ^{40}K) are lower than worldwide average levels. It is found that detergent products are not contaminated by radioactivity, are healthy and do not have harmful radiological impact on the consumer

Conclusion

Detergent products (shampoo and dishwashing) samples were analyzed for radioactivity due to ^{238}U, ^{232}Th and ^{40}K radionuclides. The results of the specific activity, radium equivalent activity and external hazard index in samples under study have been found lower than the regulatory standard recommended according to UNSCEAR, ICRP 2000 and OECD 1979, respectively. It is concluded that the detergent products (shampoo and dishwashing) in Iraq markets the levels of natural radioactivity are well within acceptable values and do not have any harmful radiological impact on the consumer.

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