Concentration of 226Ra, 232Th and 40K Radionuclides in Natural Products Commonly Used as Cosmetics Materials

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Abstract: Natural product samples used as cosmetic materials were collected from various markets in Saudi Arabia, analyzed using a high purity germanium detector (HPGe) to determine radioactivity concentrations of the natural radionuclides ^{226}Ra, ^{232}Th and ^{40}K. The obtained concentrations for 226Ra and 232Th ranged from 0.65±0.17 to 6.47±1.07and from 0.34±0.11 to 8.54±1.16 Bq kg^{-1}, respectively, while the concentration of 40K ranged from 10.62±0.35 to 1202.84±15.95Bq kg^{-1}, with overall mean values of 2.72, 3.73 and 444.09 Bq kg^{-1} respectively. The mean values of radium equivalent, absorbed dose rate and the annual effective dose of the samples under study were determined as 42.25 Bq kg^{-1}, 22.58 nGyh^{-1} and 0.028 mSvy^{-1}, respectively. The present results are lower than the permitted limits and are found to be safety for the human usage.
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1. Introduction

Natural Cosmetics containing plant extracts and minerals are commonly used all over the Arab regions by applying directly to the human skin and hair in order, to clean, improve or change the appearance of them. So, these materials should be safe for health, especially the increasing sale and use of natural cosmetics without available censorship in the presence of dangerous metals or codified instructions and usage. The occurrence of natural radionuclides in industrial and natural cosmetic materials has been performed in different countries to assess the safety of cosmetic materials usage (Sherif et al; 2015, Papadopoulos et al; 2014, Parisa Ziarati et al;2012). The present study is focused on the problems related to the presence of the natural radioactive concentrations of 226Ra, 232Th and 40K in natural cosmetics collected from local markets in Saudi Arabia to assess the risk present in these materials to human health. This work would be useful for establishing baseline data on the gamma background radiation levels in the studied samples for assessment the radiation exposures to the population.

2. Materials and Methods

Different samples of a natural product (local and imported) are commonly used as cosmetic materials in Saudi Arabia were analyzed to determine the concentrations of ^{226}Ra, ^{232}Th series, and ^{40}K by using a High Purity detector (HPGe) with 25% efficiency and FWHM 4.2 keV at 1461 keV. The investigated samples were crushed and milled to a fine powder, oven-dried at 60ºC to constant weight, homogenized and then the samples packed into Marinelli beakers and kept sealed for four weeks to establish secular radioactive equilibrium of 226Ra and 232Th with their short-lived daughter products. The background distribution was determined by an empty container under the same measuring conditions in the same geometry as for the samples. The 226Ra, 232Th, and 40K activity concentrations were obtained for each of the measured samples together with their corresponding total uncertainties. The measurements were performed in a period of 36000sec. The characteristic gamma peaks selected for the determination of the different radionuclides were 295.1 and 351.9 keV (214Pb) and 609.3 keV (214Bi) for 226Ra, 911.1 and 583.2 keV (208Tl) for 232Th, while the 40K activity was determined from the 1460.7 keV emission (El Arabi et al. 2006). The activity concentrations of 238U, 232Th series and 40K of each isotope were calculated using the following equation:

$$A(BqKg^{-1}) = C / M \beta \varepsilon \quad \ldots\ldots\ldots\ldots (1)$$

Where A is the activity concentration of the radionuclide (Bq kg^{-1}),c is the net counting rate of a specific gamma ray (count per second), M is the mass of the sample (kg) , β is the absolute transition probability of gamma decay, and Ɛ is the detector efficiency at the specific gamma-ray energy.

3. Results and Discussion

3.1 Activity concentration

The local and imported natural cosmetic samples are named as shown in Table 1. In this Table, the activity concentrations obtained for 226Ra ranged

from 0.65±0.17 Bq kg^{-1} (sample C9) to 6.47±1.07 Bq kg^{-1} (sample C3) with a mean value 2.72 Bq kg^{-1}. 232Th ranged from 0.34±0.11 Bq kg^{-1} (sample C12) to 8.54±1.16 Bq kg^{-1}(sample C3) with an average 3.73 Bq kg^{-1}, while the 40K concentration ranged from 7.39±2.13 Bq kg^{-1} (sample C9) to 796.12±12. Bq kg^{-1} (sample C11) with a mean value 444.09 Bq kg^{-1}. The most abundant of the total activity concentration of the three nuclides is 40K, about 98% of which is agreed upon the fact that" the potassium in the earth's crust is of the order of percentage while U and Th are in ppm level (Ramasamy et al 2011)." The world average values of ^{226}Ra, ^{232}Th and ^{40}K concentrations reported for normal background areas are 30, 45 and 420 Bq·kg^{-1}, respectively, UNSCEAR2000. The obtained average values for 226Ra and 232Th are lower than these average values, whereas, 40K averagely is in the same order of the world average.

3.2 Rdiumeqivalent activity (Raeq).

The radium equivalent concentration index was calculated from this equation (UNSCEAR, 2000):-

$$Ra_{eq}\ (Bq/\ kg) = C_{Ra} + 1.43C_{Th} + 0.077C_{K} \quad \ldots\ldots\ (2)$$

Where: C_{Ra}, C_{Th} and C_K are the specific activities (Bq/kg dry weight) of ^{226}Ra, ^{232}Th, and ^{40}K, respectively. To keep the γ -radiation doses below1.5 mSv $year^{-1}$, one has to make sure that the maximum value of Raeq is 370 Bq kg^{-1}, as shown in Table 2, the radium equivalent activity varied from (4.05) to (96.78) Bq$kg^{-1}$with a mean value 42.25 Bqkg^{-1} which is much lower than the maximum value 370 Bqkg^{-1} as reported by (UNSCEAR 1993; NEA-OECD 1979).

3.3 Exposure and dose rate

The measured activity ^{226}Ra ^{232}Th and ^{40}K was used to estimate the dose rate in (nGy/h) as the following relation (UNSCEAR 2000):-

$$D\ (nGy/\ h) = 0.427C_{Ra} + 0.623C_{Th} + 0.043C_{K} \ldots\ldots(3)$$

Where 0.427, 0.623 and 0.043 (nGyh^{-1}Bqkg^{-1}) are the conversion factors for Ra, Th and K, respectively, and C_{Ra}, C_{Th} and C_K are the activity concentrations (Bq/ kg) of ^{226}Ra, ^{232}Th and ^{40}K, respectively

The estimated annual effective dose equivalent is calculated using a conversion factor of 0.7 SvG/y, which is used to convert the absorbed dose rate to annual effective dose with an outdoor occupancy of 20% (UNSCEAR 2000):-

$$D_{eff}\ (mSv/y) = D\ (nGy\ /h) \times 8760\ (h/y) \times 0.7(Sv/Gy)\ ) \times 0.2 \times 10^{-6} \ldots\ldots\ldots(4)$$

Table2 shows the results of the absorbed dose in (nGy/h) and annual effective dose in (mSv/y) for adults due to a specific activity of ^{238}U, ^{232}Th and ^{40}K in natural cosmetic samples. It is observed that the absorbed dose rate mean values of ^{226}Ra, 232Th and 40K were 1.16, 2.32 and 19.10 nGyh^{-1} respectively. The 226Ra and 232Th mean values were less than the median values 16 nGyh^{-1} and 18 nGyh^{-1} of the absorbed dose rates in air from radionuclides of the 238U and 232Th series (UNSCEAR 2000). The total absorbed dose of the three terrestrial gamma radiation as present in Table (2) ranged from 1.84 to 53.51 nGyh^{-1} with a mean value of 22.58 nGyh^{-1}, which is lower than the recommended limit 59 nGy h^{-1} (UNSCEAR 2000). Fig 2 shows the absorbed dose and radium equivalent of the available samples. Fig 3 shows the calculated contributions of Th and U series and 40K to the total absorbed dose rate as 5.15%, 10.27% and 84.57%, respectively. 40K represents the highest contribution dose, but this radionuclide is an essential element, homeostatic control of the human body and then its effect on the radiation dose is limited (UNSCEAR1982)

The annual effective dose rates from the terrestrial gamma radiation varied from 0.001 to 0.066 $mSvy^{-1}$ with a mean value of 0.028 $mSvy^{-1}$. These values are below the worldwide average 0.07 $mSvy^{-1}$ of the Outdoor effective dose (UNSCEAR 2000) and is about 2.8% of the maximum annual dose 1.0 mSv $year^{-1}$ reported by (ICRP-65 1996). Therefore, the studied samples were to be safety usage of the public health.

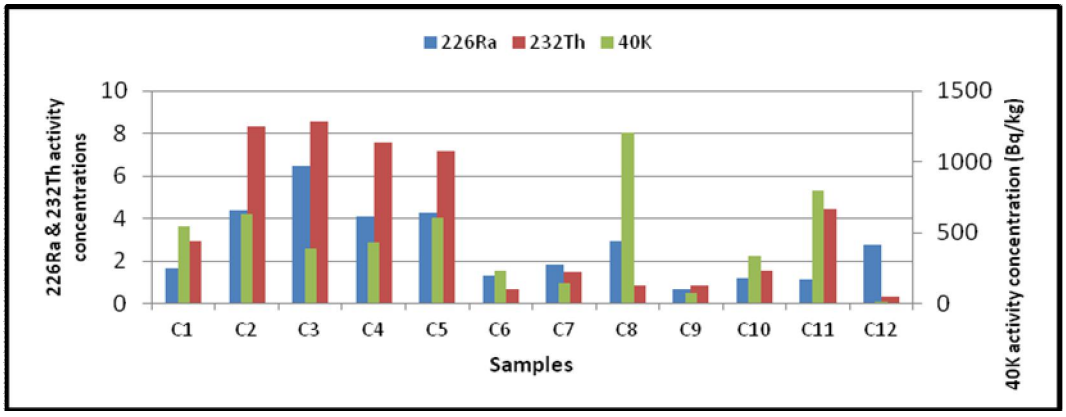

Fig. 1 Activity concentrations of 226Ra, 232Th and 40K for natural cosmetic product samples, Saudi Arabia

Table 1. The activity concentrations of 226Ra, 232Th and 40K in natural cosmetic samples.

Sample code	Common name	Origin	Radioactivity concentration (Bq/kg^{-})		
			^{226}Ra	^{232}Th	^{40}K
C1	Nokhalah	Saudi Arabia	1.67±0.38	2.95±0.71	544.61±11.13
C2	Saudi Henna	Saudi Arabia	4.39±0.53	8.33±1.23	633.87±10.21
C3	Yemeni Henna	Yemen	6.47±1.07	8.54±1.16	387.24±8.08
C4	Indian Henna	India	4.08±0.56	7.58±1.11	430.51±8.67
C5	Black Henna	India	4.27±0.45	7.18±0.88	601.96±9.43
C6	Seber	Yemen	1.31±0.28	0.64±0.24	232.02±5.07
C7	Ethiopian Seber	Ethiopia	1.84±0.30	1.49±0.40	142.78±3.25
C8	Khamerah	Egypt	2.95±0.34	0.85±0.27	1202.84±15.95
C9	Bakhoor	*Indian*	0.65±0.17	0.82±0.25	71.39±2.13
C10	Kojorati	Egypt	1.18±0.31	1.55±0.48	339.11±6.52
C11	Terms	Egypt	1.12±0.15	4.44±0.72	796.12±12.32
C12	Kohl	India	2.75±0.42	0.34±0.11	10.62±0.35
Range			0.65±0.17- 6.47±1.07	0.34±0.11 - 8.54±1.16	10.62±0.35-1202.84±15.95
Mean			2.72	3.73	444.09

Table(2). Absorbed dose rates and annual effective doses calculated for natural product samples used as cosmetic materials in Saudi Arabia.

Samples no.	Radiueqavalent (Bq/kg)	Absorbed dose (nGh^{-1})				AED (mSv/y)
		^{226}Ra	^{232}Th	^{40}K	Total(D)	
C1	47.82	0.71	1.84	23.42	25.97	0.032
C2	65.11	1.87	5.19	27.26	34.32	0.042
C3	48.50	2.76	5.32	16.65	24.73	0.030
C4	48.07	1.74	4.72	18.51	24.98	0.031
C5	60.89	1.82	4.47	25.88	32.18	0.039
C6	20.09	0.56	0.40	9.98	10.93	0.013
C7	14.96	0.79	0.93	6.14	7.85	0.009
C8	96.78	1.26	0.53	51.72	53.51	0.066
C9	2.39	0.28	0.51	0.32	1.11	0.001
C10	29.51	0.50	0.97	14.58	16.05	0.019
C11	68.77	0.48	2.77	34.23	37.48	0.046
C12	4.05	1.17	0.21	0.46	1.84	0.002
Range	2.39-96.78	0.48-2.76	0.21- 5.32	0.32-51.72	1.84-53.51	0.001-0.066
Mean	42.25	1.163	2.32	19.10	22.58	0.028
World average (UNSCEAR 2000)	< 370	16	18		59	0.07

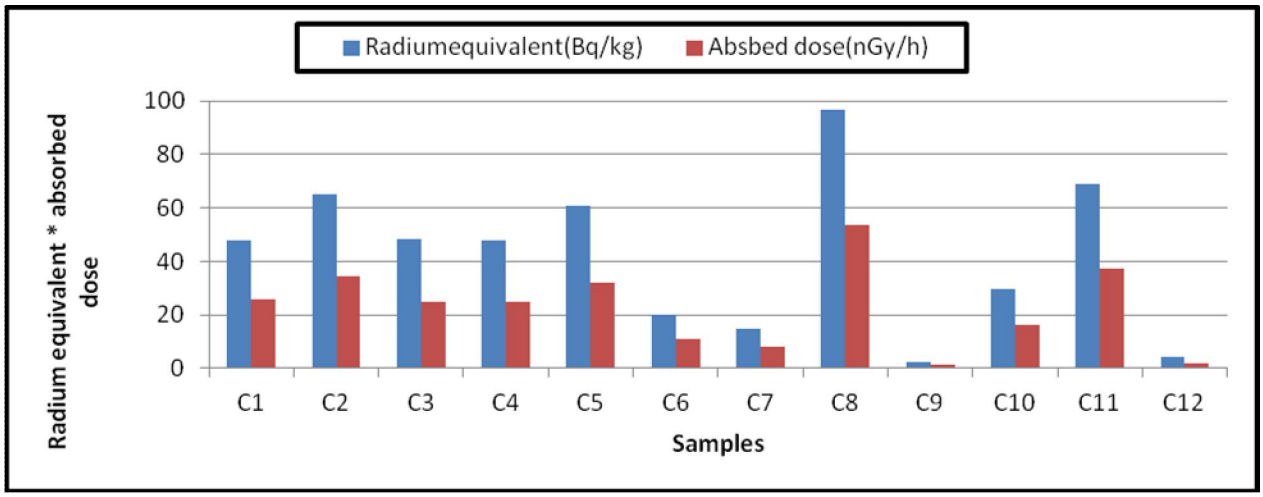

Fig.2 Radium equivalent (Bq/Kg) and Absorbed dose rate (nGy/h) for cosmetic samples, Saudi Arabia.

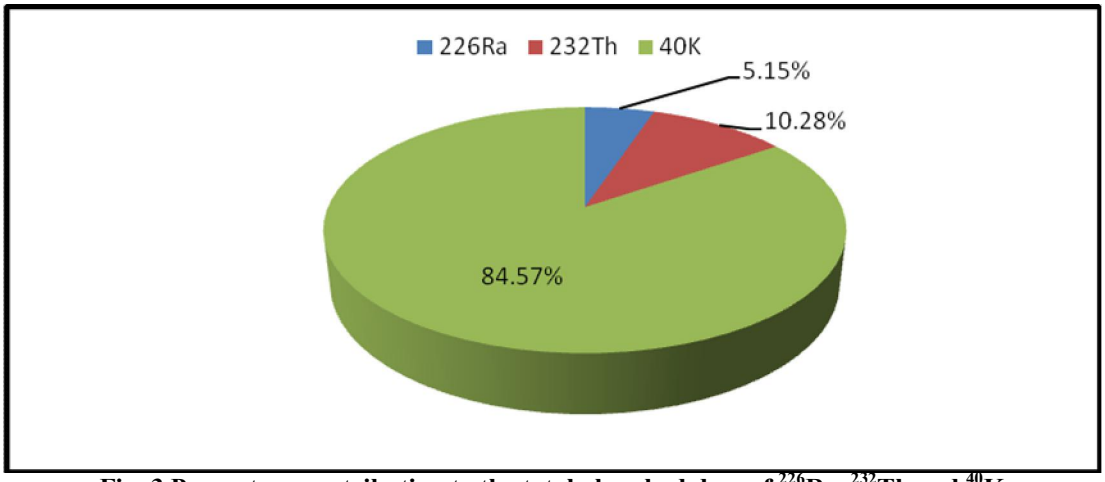

Fig. 3 Percentage contribution to the total absorbed dose of ^{226}Ra, ^{232}Th and ^{40}K

4. Conclusion

The activity of radionuclides ^{238}U, ^{232}Th and ^{40}K, were measured in different types of natural product which are used as cosmetic materials in Saudi Arabia. The present results indicated that the specific activity concentrations of these radionuclides in cosmetic samples and radium equivalent activity were lower than the reported values by UNSCEAR. Also, the effective dose values obtained were found to be below the standards limit 1 mSv/y, hence the studied natural samples products are safe to the human usage as cosmetic materials.

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