Determination of Natural Radioactivity in Some Commercial Motor Oil Samples

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Abstract

In this paper, the measurement of specific activity concentrations of five commercial oil samples obtained from different countries (Kuwait, U.A.E., Iran, and Germany) were carried out using (HPGe) detector. From the measurement it was observed that average values of specific activity concentrations for ^{238}U, ^{232}Th and ^{40}K were equal to (20.206±1.4 Bq/l), (20.080±3.5 Bq/l) and (162.120±49.2Bq/l), respectively. The results were less than their corresponding recommended global values reported by (UNSCEAR, 1994) publication. The radiation hazard indices [I_{γ}, H_{in}, H_{ex}, Ra_{eq}, D_{γ}, $(AEDE)_{in}$ and$(AEDE)_{out}$] were also studied, and all the obtained results and their average value were also observed to be lower than their corresponding average values given by (UNSCEAR,1994, 2000). Finally, the excess life time cancer risk (outdoor), (ELCR), results were found to be ranged from 0.102×10^{-3} (Al-Khaleej) (Kuwaiti origin) sample to 0.147×10^{-3} (Vulcan 330) (Iranian origin) sample, with an average value of $(0.121\pm0.012)\times10^{-3}$, which were less than the world average value. Thus, the results of the present work have shown that, all the studied samples of motor oil are safe when used. [DOI: 10.22401/ANJS.00.2.06]

Keywords: Motor Oil, Natural Radioactivity, Specific Activity, Radiation hazard indices.

Introduction

Most of the radionuclides that appear in gas and oil stream belong to the ^{232}Th and ^{238}U series, in addition to ^{40}K. Attention was given to the quantification of ^{226}Ra, ^{232}Th and ^{40}K since these radionuclides are responsible for most of the external exposure in such facilities [1].

The TENORM waste associated with hydrocarbon operations at the oilfields occur in the form of scale deposits, sludge, and produced water [2].In a previous study, Karim et al.[3] have studied specific activity in ten motor oil samples from different ten origins and they found that all results for the studied samples were less than their corresponding global values, however, some other different commercial brands and from mostly different origins have been not studied yet. Accordingly, the present work is concerned with the evaluation of the specific activity concentration of (^{232}Th, ^{238}U and ^{40}K) and their associated hazard indices, and also the outdoor excess lifetime cancer risk for some selected commercial motor oil samples obtained mostly from different origins, by using a (HPGe) detector.

Materials and Method

Five commercial motor oil samples from four different origins (Kuwait, U.A.E., Iran, and Germany) which were available in the local markets were collected in the present work. One litter Marinelli beakers were used in the present study. Measurements with empty Marinelli beakers under identical conditions to estimate the background radiation were also performed. The net volume of the samples was found from the difference in weights of a sample - filled and an empty beaker.

The sealed Marinelli beakers were left for four weeks before measurements so that to have secular equilibrium for ^{232}Th and ^{238}U with their respective daughters [4].

The calibration of energy was obtained by using a standard source of Marinelli beaker of Europium-152with energies (964.0, 1408.0, 344.3, 411.1, 444.6, 778.9, 121.8, 1112.0, 1085.8 and 244.7 keV). Efficiency calibration of the (HPGe) detector was achieved using the same standard source of Europium-152.

The specific activity concentrations of radionuclides (A) in motor oil samples were obtained by using the relation [5]:

$$A = (\text{Area under the photo peak})/V \times I_\gamma \times \text{eff} \times T \qquad \ldots(1)$$

where:

V : Volume of motor oil sample (liter).
eff : The detectors efficiency.
I_γ : the abundance.
T : Time of measurements (7200 s).

Hazard Indices

In the present work, the following well known radiation hazard indices were determined.

1. Radium Equivalent Activity (Ra_{eq}):
   Which was calculated using the relation [6]:
   $$Ra_{eq}\,(\text{Bq/l}) = 0.077A_K + 1.43A_{Th} + A_U \qquad \ldots(2)$$
   where, A_K, A_{Th} and A_U are the specific activity concentrations of ^{40}K, ^{232}Th and ^{238}U respectively.
2. Absorbed Gamma Dose Rate (D_γ):
   Which was calculated by [7]:
   $$D_\gamma = 0.462A_U + 0.604A_{Th} + 0.0417A_K \qquad \ldots(3)$$
3. Annual Effective Dose Equivalent (AEDE):
   Which was calculated using the relations [8], [9]:
   $$(AEDE)_{in} = D_\gamma \times 10^{-6} \times 8760 \times 0.7 \times 0.80 \qquad \ldots(4)$$
   $$(AEDE)_{out} = D_\gamma \times 10^{-6} \times 8760 \times 0.7 \times 0.20 \qquad \ldots(5)$$
4. Activity concentration Index (I_γ):
   Which was calculated using the relation [9]:
   $$I_\gamma = \frac{A_K}{1500} + \frac{A_{Th}}{100} + \frac{A_U}{150} \qquad \ldots(6)$$
5. Internal (H_{in}) and External (H_{ex}) Hazard Indices:
   (H_{ex}) was calculated using the relation [10]:

$$H_{ex} = \frac{A_K}{4810} + \frac{A_{Th}}{259} + \frac{A_U}{370} \qquad \ldots(7)$$

(H_{in}) is given by [10]:

$$H_{in} = \frac{A_K}{4810} + \frac{A_{Th}}{259} + \frac{A_U}{185} \qquad \ldots(8)$$

Also in the present work we have attempted to determine the Excess Lifetime Cancer Risk (ELCR) was determined by[11]:

$$ELCR = AEDE \times DL \times RF \qquad \ldots(9)$$

where: (AEDE) is the Annual Effective Dose Equivalent,(DL) is the average duration of life (estimated to be 70 years) and (RF) is the risk factor (Sv/Y), i.e., fatal cancer risk per Sievert. For stochastic effects, ICRP uses (RF) as 0.05 Sv^{-1} for the public exposure [11].

In the present work, outdoor $(AEDE)_{out}$ was adopted for the calculation of (ELCR).

Results and Discussion

The results of the specific activity for ^{238}U, ^{232}Th and ^{40}K radionuclides for five commercial motor oil samples are presented in Table(1),from which it can be observed that:

The specific activity of ^{238}U was found to be varied from 18.350 Bq/l (Al-Khaleej) (Kuwaiti origin) to 23.480 Bq/l (Super GT) (U.A.E. origin), with a mean of 20.206±1.4 Bq/l, see Fig. (1). These results were less than the allowed limit of (50 Bq/l) given by (UNSCEAR, 1994) [12], [8].

The specific activityof ^{232}Th was found to be ranged from14.820 Bq/l(Super GT)(U.A.E. origin)to 27.940 Bq/l(Vulcan 330)(Iranian origin), with a mean of 20.080±3.5Bq/l, see Fig.(1). These results were less than the allowed limit of (50 Bq/l)given by(UNSCEAR, 1994, 2000) [12], [8].

The specific activity of ^{40}K was found to be ranged from 98.660 Bq/l (Jumbo Dubai) (U.A.E. origin) to 216.280 Bq/l (Fuchs) (Germanian origin), with a mean of 162.120±49.2 Bq/l, see Fig. (1). These results were less than the allowed limit of (500 Bq/l) given by (UNSCEAR, 1994, 2000) [12], [8].

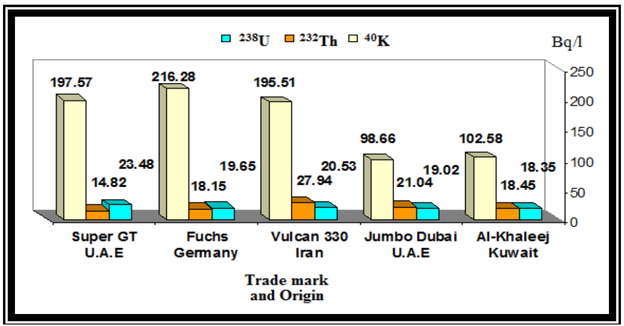

Figure (1) Specific activity concentrations of (^{238}U, ^{232}Th and ^{40}K) for all commercial motor oil samples studied in the present work.

The radium equivalent activity (Ra_{eq}), was found to be ranged from 52.632 Bq/l (Al-Khaleej) (Kuwaiti origin) to 75.538 Bq/l (Vulcan 330) (Iranian origin), with a mean of 61.404±5.9 Bq/l, see Fig. (2). These results were lower than the allowed limit of (370 Bq/l) given by (UNSCEAR, 1994, 2000) [12], [8].

The values of absorbed gamma dose rate (D_γ) were found to be ranged from 23.899 nGy/h (Al-Khaleej) (Kuwaiti origin) to 34.513 nGy/h (Vulcan 330) (Iranian origin), with an average value of 28.224±2.8 nGy/h, see Fig. (2). These results were lower than the allowed limit of (55 nGy/h) given by (UNSCEAR, 1994, 2000) [12], [8].

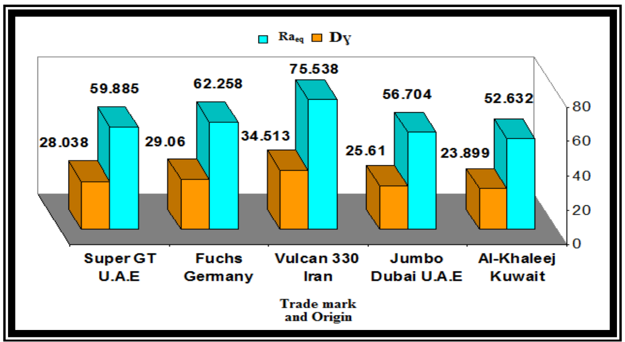

Figure (2) Radium equivalent activity and absorbed dose rate for all commercial motor oil samples studied in the present work.

The values of $(AEDE)_{in}$ was observed to be ranged from 0.117 mSv/y (Al-Khaleej) (Kuwaiti origin) to 0.169 mSv/y (Vulcan 330) (Iranian origin), with a mean of 0.138±0.01 mSv/y, see Fig. (3).These results were lower than the allowed limit of (1 mSv/y) given by (UNSCEAR, 1994, 2000) [12], [8].

The values of $(AEDE)_{out}$ was observed to be ranged from 0.029 mSv/y (Al-Khaleej) (Kuwaiti origin) to 0.042 mSv/y (Vulcan 330) (Iranian origin), with a mean of 0.035±0.003 mSv/y, see Fig. (3).These results were lower than the allowed limit of (1mSv/y) given by (UNSCEAR, 1994) [12], [8].

The values of activity gamma index I_γ was found to be ranged from 0.375(Al-Khaleej) (Kuwaiti origin) to 0.547(Vulcan 330) (Iranian origin), with an average value of 0.444±0.04, see Fig. (3).These results were lower than the allowed limit of (1) given by (UNSCEAR, 2000) [8].

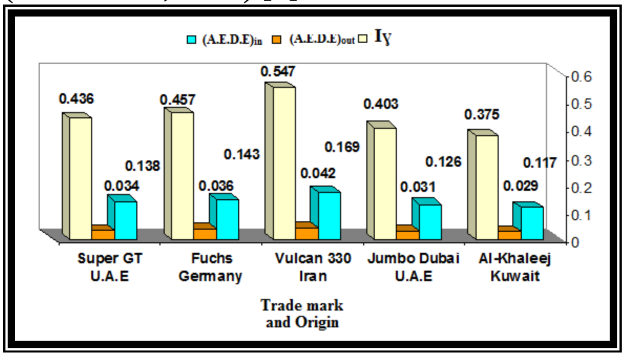

Figure (3) Indoor and outdoor annual effective dose equivalents and activity gamma index for all commercial motor oil samples studied in the present work.

(H_{in}) was observed to be ranged from 0.192 (Al-Khaleej) (Kuwaiti origin) to 0.259 (Vulcan 330) (Iranian origin), with an average value of 0.220±0.01, see Fig. (4).These values were less than the world average value of (1) given by (UNSCEAR, 2000) [8], [9].

The external hazard index was found to be ranged from 0.142 (Al-Khaleej) (Kuwaiti origin) to 0.204 (Vulcan 330) (Iranian origin), with an average value of 0.0.165±0.016, see Fig. (4).These results were less than the allowed limit of (1) given by (UNSCEAR, 2000) [8].

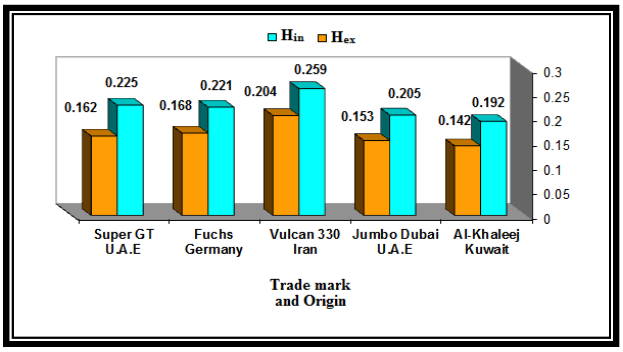

Figure (4) Internal and external hazard indices for all commercial motor oil samples studied in the present work.

In general, all the above present motor oil results were found to be in harmony with their corresponding motor oil results obtained previously, however, for different commercial brands and mostly from different countries as given by Karim et al., [3].

The values of excess lifetime cancer risk were found to be ranged from 0.102×10^{-3} (Al-Khaleej) (Kuwaiti origin) to 0.147×10^{-3} (Vulcan 330) (Iranian origin), with an average value of $(0.121\pm0.012)\times10^{-3}$, see Fig. (5). These values were lower than the allowed limit of (0.29×10^{-3}) given by (Taskin et al., 2009), [11].

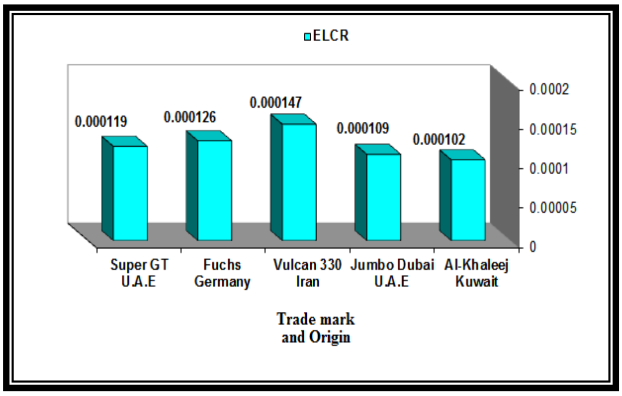

Figure (5) Excess lifetime cancer risk for all commercial motor oil samples.

studied in the present work.

Table (1)
Trade mark, Origin, specific activity concentrations, hazards indices and excess lifetime cancer risk for the commercial motor oil samples studied in the present work

No.	Trade mark	Origin	^{238}U (Bq/l)	^{232}Th (Bq/l)	^{40}K (Bq/l)	Ra_{eq} (Bq/l)	D_{Y} (nGy/h)	(AEDE) (mSv/y) Indoor	Outdoor	I_{Y}	H_{ex}	H_{in}	$ELCR\times10^{-3}$
1	Al-Khaleej	Kuwait	18.350	18.450	102.580	52.632	23.899	0.117	0.029	0.375	0.142	0.192	0.102
2	Jumbo Dubai	U.A.E.	19.020	21.040	98.660	56.704	25.610	0.126	0.031	0.403	0.153	0.205	0.109
3	Vulcan 330	Iran	20.530	27.940	195.510	75.538	34.513	0.169	0.042	0.547	0.204	0.259	0.147
4	Fuchs	Germany	19.650	18.150	216.280	62.258	29.060	0.143	0.036	0.457	0.168	0.221	0.126
5	Super GT	U.A.E.	23.480	14.820	197.570	59.885	28.038	0.138	0.034	0.436	0.162	0.225	0.119
Ave.			20.206 ±1.4	20.080 ±3.5	162.120± 49.2	61.404 ±5.9	28.224 ±2.8	0.138 ±0.01	0.035 ±0.003	0.444± 0.04	0.165± 0.016	0.220± 0.01	0.121 ±0.012
Min.			18.350	14.820	98.660	52.632	23.899	0.117	0.029	0.375	0.142	0.192	0.102
Max.			23.480	27.940	216.280	75.538	34.513	0.169	0.042	0.547	0.204	0.259	0.147

Conclusions

The present study have shown that values of (^{238}U, ^{232}Th and ^{40}K), radiation hazard indices[I_{Y}, H_{in}, H_{ex}, Ra_{eq}, D_{Y}, $(AEDE)_{in}$ and $(AEDE)_{out}$] and also excess lifetime cancer risk(ELCR) were observed to be less than their corresponding world average values. It could therefore be concluded that the potential carcinogenic risk from gamma radiation dose obtained in this work is low or insignificant.

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