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Measurement of Radioactivity in Some Motor Oil Samples by Using (HPGe) Detector

Mahmood Salim Karim, Hasan Hadi Daroysh, Taghreed Khalid Hameed

Department of Physics, College of Education, Al-Mustansiriyah University, Baghdad, Iraq

Email address:
mahmood_msc74@yahoo.co.uk (M. S. Karim)

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Abstract: In this work, we have measured specific activity in ten motor oil samples for ten origins taken from the local markets by using high purity germanium (HPGe) detector. The results obtained have shown that the highest values of specific activity of (U-238, Th-232 and K-40) which was equal to (22.520 Bq/l, 26.640 Bq/l and 221.340 Bq/l), for [(Rasheed) sample (Iraq origin), (Noblu) sample (Iran origin) and (Maas) sample (Netherland origin)], respectively, while the lowest values of specific activity for (^{238}U,^{232}Th and ^{40}K) was found in (Jopetrol) sample (Jourden origin) which was equal to (12.340 Bq/l, 11.450 Bq/l and 97.530 Bq/l), respectively, the paper consider is the first study in Iraq to measured specific activity for motor oil samples.

Keywords: (HPGe) Detector, Motor Oil, Specific Activity, Hazards Indicies

1. Introduction

Natural environmental radioactivity and the associated external exposure due to gamma radiation depend mainly on the local geological and geographical conditions and appear at different levels in each region in the World. natural radionuclides in the ground, oil, air, food, the universe and even elements our own bodies. The assessment of these doses from natural materials is important as an external radiation exposures from natural materials which contribute to about 50% of the average annual dose to humans from all radiation sources [1].

Gamma radiation emitted from naturally occurring radioisotopes, such as K-40 and the radionuclides from the Th-232 and U-238 series and their decay products (also called terrestrial background radiation), which exist as trace levels in all ground formations, represents the main external source of irradiation to the human body [2].

Radioisotopes that are present in soil significantly affect terrestrial gamma radiation levels. In the last decade, several studies were carried out to assess the average outdoor terrestrial gamma dose rate in air [3]. Oil, motor oil, and gas are used in a number of different ways, containing: fuel for lubricants, electricity production, transport, and consumer products and numerous industrial. In terms of the raw materials, gas and oil originate from the breakdown of organic matter in a sedimentary formation (the source rock) and may become trapped in a suitable reservoir structure. Many types of reservoir structures are known, but all require that the vertical migration of oil and gas from the porous reservoir rock be prevented by an impervious covering known as the Caprock (often rock salt or clay) [4].

The radionuclides identified in the gas and oil streams belong to the decay chains of the naturally occurring primordial radionuclides U-238 and Th-232. These parent radionuclides have very long half-lives and are present in the earth's crust with activity concentrations that depend on the type of the rock. Radioactive decay of U-238 and Th-232 produces several series of daughter radioisotopes of different physical characteristics and of different elements with respect to their half-lives, modes of decay, and types and energies of emitted radiation [5]. The major radioactive of elements that are enhanced by the oil and the gas industry and that have potentially hazardous effects on the environment and humans due to their radiotoxicity and long half-lives are Ra-226 belonging to U-238 decay series and Ra-228 that belongs to the Th-232 decay series

[6]. The aim of the present work is to measured specific activity in different types for motor oil samples from different origins by using high purity germanium (HPGe) detector.

2. Experimental Setup

A. Collection and Preparation of the samples

Motor oil samples which were available in the local markets, some of them were Iraqi origins and the others from different foreign origins, then weighed and transferred to (1000 ml) labelled Marinelli beakers and stored. The sealed motor oil samples were then kept for about one month before measurements in order to achieve secular equilibrium for U-238 and Th-232 with their respective progenies [7].

B. Specific activity concentrations of radionuclides

The specific activity concentrations of radionuclides in motor oil samples were obtained by using the equation [8]:

$$A=(Net\ \ Area-B.G)/M\times I_{\gamma}(E\gamma)\times eff\times T \quad \ldots (1)$$

where:

B.G: Background activity.

A: specific activity concentrations of the radionuclides measured in (Bq/l) units.

eff: efficiency of the detectors at energy E_{γ}.

M : mass motor oil samples (liter) .

I_{γ} (E_{γ}): is the abundance at energy E_{γ}.

T: time of measurement which was equal to (7200 s).

C. Radiation Hazard indices Calculation

1. Radium Equivalent Activity (Ra_{eq})

The distribution of U-238, Th-232 and K-40 in motor oil is not uniform. Uniformity in respect of exposure to radiation has been defined in terms of (Raeq) in (Bq/l) units and is it given by the expression [9]:

$$Ra_{eq}(Bq/kg)=A_U+1.43A_{Th}+0.077A_K \quad \ldots\ldots (2)$$

Where, A_U, A_{Th} and A_K are the specific activity concentrations of U-238, Th-232 and K-40 in (Bq/l) units respectively.

2. Absorbed Gamma Dose Rate (D_{γ})

Absorbed dose rate *(D_{γ})* in (nGy/h) units can be calculated using the following formula [10]:

$$D_{\gamma}(nGy/h)=0.462A_U+0.604A_{Th}+0.0417A_K \quad \ldots(3)$$

3. Annual Effective Dose Equivalent (AEDE)

The (AEDE) received by a member is calculated from the absorbed dose rate by applying dose conversion factor of (0.7 Sv/Gy) and the occupancy factor for outdoor and indoor was 0.2 and 0.8 respectively (AEDE) is determined using the following equations [11]:

$$(AED)_{in}(mSv/y)=D_{\gamma}(nGy/h)\times 10^{-6}\times 8760h/y\times 0.80\times 0.7Sv/Gy \quad (4)$$

$$(AED)_{out}(mSv/y)=D_{\gamma}(nGy/h)\times 10^{-6}\times 8760h/y\times 0.20\times 0.7Sv/Gy \quad (5)$$

4. Gamma Index (I_{γ})

The gamma index (I_{γ}) was determined by using the following relation [12]:

$$I_{\gamma}=\frac{A_U}{150}+\frac{A_{Th}}{100}+\frac{A_K}{1500} \quad \ldots\ldots\ldots (6)$$

5. External (H_{ex}) and Internal (H_{in}) Hazard Indicies

To estimate radiation dose expected to be delivered externally if a building is constructed, (H_{ex}), due to the emitted γ-rays, can be calculated using the following equation [13]:

$$H_{ex}=\frac{A_U}{370}+\frac{A_{Th}}{259}+\frac{A_K}{4810} \leq 1 \quad \ldots (7)$$

In addition to the external irradiation, radon and its daughter products are also hazardous to the respiratory organs. The internal exposure to radon and its short-lived products is proscribed by (H_{in}). The Internal hazard index is calculated by the following formula [13]:

$$H_{in}=\frac{A_U}{185}+\frac{A_{Th}}{259}+\frac{A_K}{4810} \leq 1 \quad \ldots (8)$$

3. Results and Discussions

Our present investigation is based on the study of ten motor oil samples from different origins taken from the local markets, table 1 it can be noticed that:

Table 1. *Kinds, Origins, specific activities of radionuclides and some other parameters hazards indicies in motor oil samples.*

No.	Kinds	Origins	U-238 (Bq/l)	Th-232 (Bq/l)	K-40 (Bq/l)	Ra_{eq} (Bq/l)	D_{γ} (nGy/h)	(A.E.D) (mSv/y)		I_{γ}	Hazard index	
								E_{in}	E_{out}		H_{in}	H_{ex}
1	Jopetrol	Jourden	12.340	11.450	97.530	36.223	16.684	0.082	0.020	0.262	0.131	0.098
2	Lexus	Japan	21.220	17.540	103.640	54.282	24.720	0.121	0.030	0.386	0.204	0.147
3	Maas	Netherland	14.340	13.870	221.340	51.217	24.232	0.119	0.030	0.382	0.177	0.138
4	Crafft	KSA	20.440	20.460	201.740	65.232	30.214	0.148	0.037	0.475	0.231	0.176
5	Fury	Kuwait	18.340	13.530	143.760	48.757	22.640	0.111	0.028	0.353	0.181	0.132
6	Noblu	Iran	22.510	26.640	165.550	73.353	33.394	0.164	0.041	0.527	0.259	0.198
7	Liqui Moli	Germany	16.680	17.750	213.230	58.481	27.319	0.134	0.034	0.431	0.203	0.158
8	Mobil 1	Farance	19.870	21.850	200.750	66.573	30.749	0.151	0.038	0.485	0.234	0.180
9	Furtcs	U.A.E	20.450	15.620	176.520	56.379	26.243	0.129	0.032	0.410	0.208	0.152
10	Rasheed	Iraq	22.520	20.080	189.610	65.834	30.439	0.149	0.037	0.477	0.239	0.178
Ave.			18.871	17.879	171.367	57.633	26.663	0.131	0.033	0.419	0.207	0.156

No.	Kinds	Origins	U-238 (Bq/l)	Th-232 (Bq/l)	K-40 (Bq/l)	Ra_{eq} (Bq/l)	D_Y (nGy/h)	(A.E.D) (mSv/y)		I_Y	Hazard index	
								E_{in}	E_{out}		H_{in}	H_{ex}
			±2.7	±3.5	±34.9	±8.2	±3.7	±0.01	±0.005	±0.06	±0.02	±0.02
Min.			12.340	11.450	97.530	36.223	16.684	0.082	0.020	0.262	0.131	0.098
Max.			22.520	26.640	221.340	73.353	33.394	0.164	0.041	0.527	0.259	0.198

The highest value of specific activity of (^{238}U) was found in (Rasheed) sample (Iraq origin) which was equal to (22.520 Bq/l), while the lowest value of specific activity of (^{238}U) was found in (Jopetrol) sample (Jourden origin) which was equal to (12.340 Bq/l), see Figure 1, with an average value of (18.871±2.7 Bq/l).

The highest value of specific activity of (^{232}Th) was found in (Noblu) sample (Iran origin) which was equal to (26.640 Bq/l), while the lowest value of specific activity of (^{232}Th) was found in (Jopetrol) sample (Jourden origin) which was equal to (11.450 Bq/l), see Figure 3, with an average value of (17.879 ±3.5 Bq/l).

The highest value of specific activity of (^{40}K) was found in (Maas) sample (Netherland origin) which was equal to (221.340 Bq/l), while the lowest value of specific activity of (^{40}K) was found in (Jopetrol) sample (Jourden origin) which was equal to (97.530 Bq/l), see Figure 3, with an average value of (171.367±34.9 Bq/l).

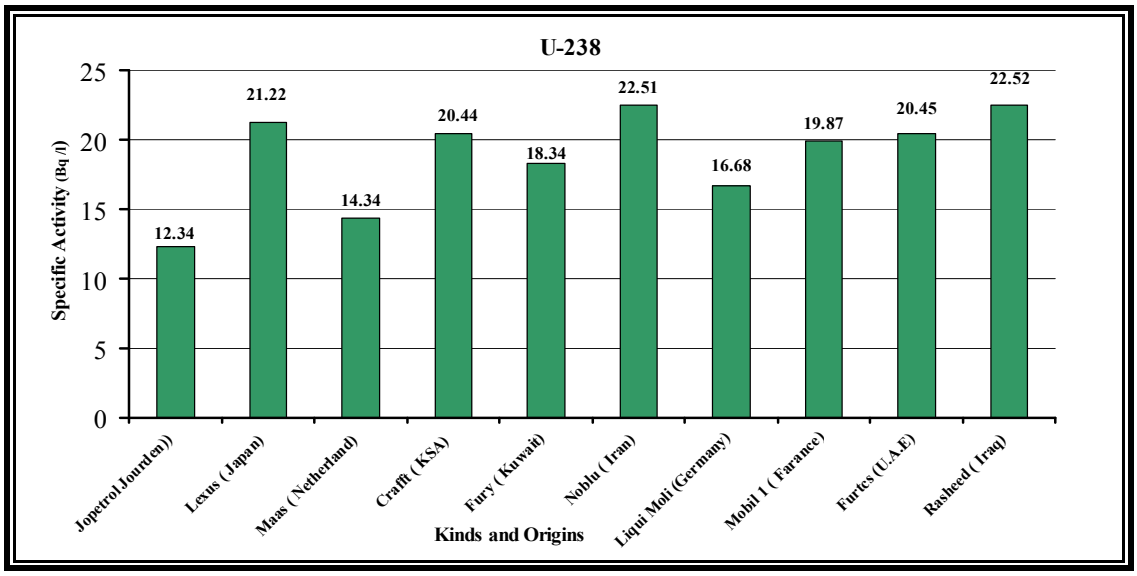

Figure 1. *Specific activity of (^{238}U) for all the motor oil samples.*

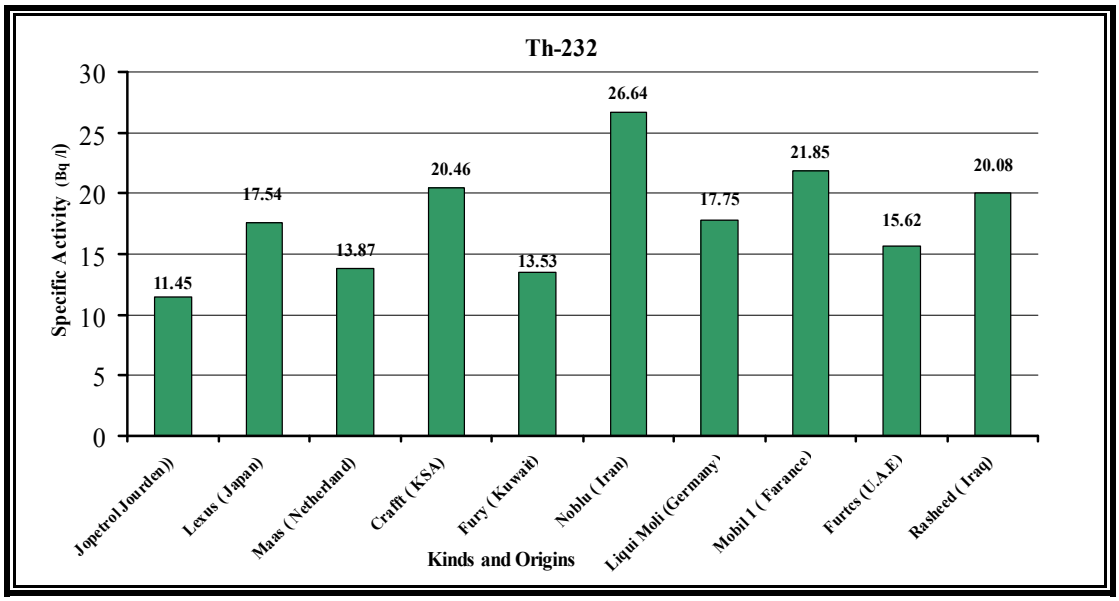

Figure 2. *Specific activity of (^{232}Th) for all the motor oil samples.*

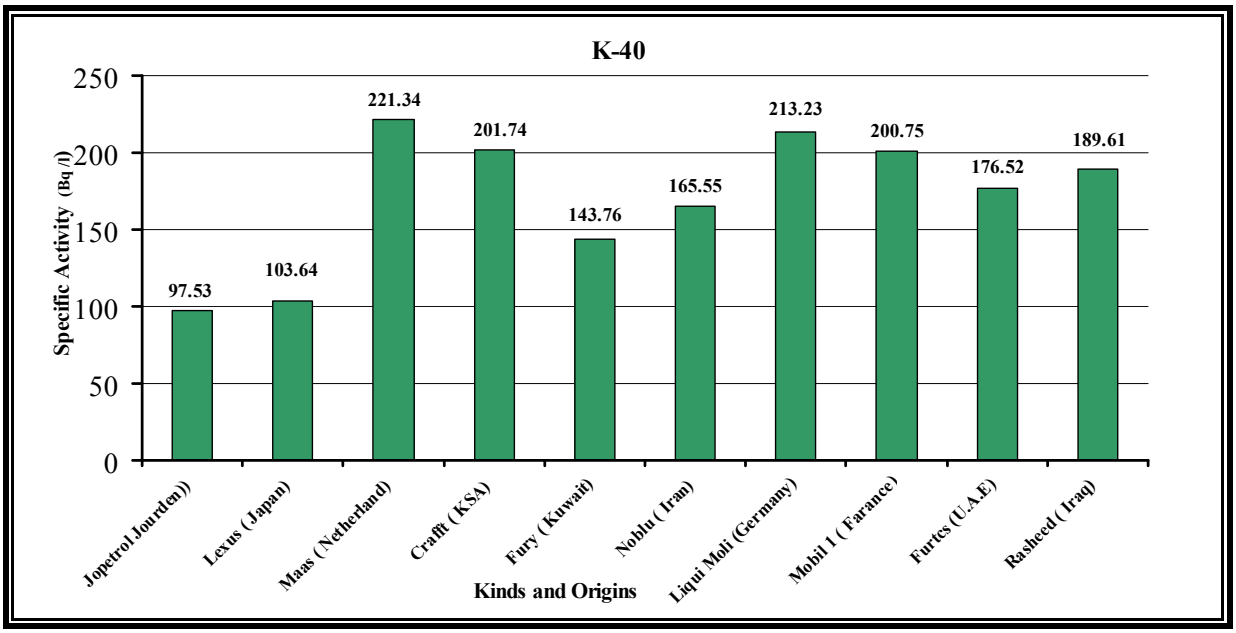

Figure 3. *Specific activity of (^{40}K) for all the motor oil samples.*

The highest value of (Ra_{eq}) was found in (Noblu) sample (Iran origin) which was equal to (73.353 Bq/l), while the lowest value of (Ra_{eq}) was found in(Jopetrol) sample (Jourden origin) which was equal to (36.223 Bq/l), with an average value of (57.633±8.2 Bq/l).

The highest value of (D_γ) was found in (Noblu) sample (Iran origin) which was equal to (33.394 nGy/h), while the lowest value of (D_γ) was found in (Jopetrol) sample (Jourden origin) which was equal to (16.684 nGy/h), with an average value of (26.663±3.7 nGy/h).

The highest value $(AED)_{in}$ was found in (Noblu) sample (Iran origin) which was equal to (0.164 mSv/y), while the lowest value of $(AED)_{in}$ was found in (Jopetrol) sample (Jourden origin) which was equal to (0.082 mSv/y), with an average value of (0.131±0.01 mSv/y).

The highest value of $(AEDE)_{out}$ was found in (Noblu) sample (Iran origin) which was equal to (0.041 mSv/y), while the lowest value of $(AEDE)_{out}$ was found in (Jopetrol) sample (Jourden origin) which was equal to (0.020 mSv/y), with an average value of (0.033±0.005 mSv/y).

The highest value of (I_γ) was found in (Noblu) sample (Iran origin) which was equal to (0.527), while the lowest value of (I_γ) was found in (Jopetrol) sample (Jourden origin) which was equal to (0.262), with an average value of (0.419±0.06).

The highest value of (H_{in}) was found in (Noblu) sample (Iran origin) which was equal to (0.259), while the lowest value of specific activity of (H_{in}) was found in (Jopetrol) sample (Jourden origin) which was equal to (0.131), with an average value of (0.207±0.02).

The highest value of (H_{ex}) was found in (Noblu) sample (Iran origin) which was equal to (0.198), while the lowest value of specific activity of (H_{ex}) was found in (Jopetrol) sample (Jourden origin) which was equal to (0.098), with an average value of (0.156±0.02). this paper consider is the first study in Iraq to measured specific activity for motor oil samples of different available kinds of motor oil which were available in the local markets by using high purity germanium (HPGe) detector, finally, we would like to mention that the present study is considered to be very important and vital because it is concerned with people health and safety in the first place.

4. Conclusions

In this paper we can be concluded that:

1. The lowest values of specific activity for (^{238}U, ^{232}Th and ^{40}K) and the parameters hazards indicies [Ra_{eq}, D_γ, $(AEDE)_{in}$, $(AED)_{out}$, I_γ, H_{in} and H_{ex}] was found in (Jopetrol) sample (Jourden origin).
2. The highest value of specific activity of (^{238}U) was found in (Rasheed) sample (Iraq origin).
3. The highest value of specific activity of (^{232}Th) was found in (Noblu) sample (Iran origin).
4. The highest value of specific activity of (^{40}K) was found in (Maas) sample (Netherland origin).
5. The highest value of all the parameters hazards indicies [Ra_{eq}, D_γ, $(AEDE)_{in}$, $(AEDE)_{out}$, I_γ, H_{in} and H_{ex}] was found in (Noblu) sample (Iran origin).

References

[1] UNSCEAR (2010), Sources and effects of ionizing radiation. United Nations Scientific Committee on the Effects of Atomic Radiation. United Nations Publication, New York, USA.

[2] Harb S., El-Kamel A. H., Abd El-Mageed A. I., Abbady A., Rashed W. (2008) "Concentration of U-238, U-235, Ra-226, Th-232 And K- 40 For Some granite samples in eastern desert of Egypt. Proceedings of the 3rd Environmental Physics Conference, Feb., Aswan, Egypt, 19-23.

[3] Faheem M., Mujahid S. A., (2008) "Assessment of radiological hazards due to the natural radioactivity in soil and building material samples collected from six districts of the Punjab province-Pakistan". Radiat Meas, 43, 1443-1447.

[4] Van A. W., Pace I., Strand T., Lysebo I., Watkins S., Sterker T., Meijne E. I. M. and Butter K. R. (1997) "Current Practices of Dealing with Natural Radioactivity from Oil and Gas Production in EU Member States", Report. EUR 17621EN, Commission of the European Communities, Luxembourg.

[5] OGP, (2008) "Guidelines for the management of Naturally Occurring Radioactive Material (NORM) in the oil & gas industry", Report No.412.

[6] (IAEA), (2003) "Extent of Environmental Contamination by Naturally Radioactive Material (Norm)", IAEA Technical Report Series No.419, Vienna-Austria.

[7] Zalewski M., Tomczak M. and Kapata J., (2001)" Radioactivity of Building Materials Available in Northeastern Poland" Polish Journal of Environmental Studies, 10 (3), 183-188.

[8] Yousuf R. M. and Abullah M. K., (2015) "Measurement of natural radioactivity in soil collected from the eastern of Sulaimanyi governorate in Kurdistan-region, Iraq" ARPN Journal of Science and Technology, 3 (7), 749-757.

[9] Vosniakos F., Zavalaris K. and Papaligas T., (2003)"Indoor concentration of natural radioactivity and the impact to human health", Journal of Environ. Protect. Ecol., 4 (3), 733-737.

[10] Organization for economic cooperation and development, (1979) "Exposure to radiation from the natural radioactivity in building materials", Report by group of experts of the OECD, Nuclear Energy Agency, Paris, France, 78-79.

[11] United Nations Scientific Committee on the Effects of Atomic Radiation, (1993) "Sources and Effects of Ionizing Radiation", Report to General Assembly, UNSCEAR, United Nations.

[12] IAEA (1990) "The use of gamma ray data to define the natural radiation environment", a technical document issued by the International Atomic Energy Agency (IAEA), Vienna.

[13] Jose A., Jorge J., Cleomacio M., Sueldo V. and Romilton D. S., (2005) "Analysis of the K-40 levels in soil using gamma spectrometry", Brazilian archives of biology and technology, 48, 221-228.