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Effect of Time and Temperature Changing on The Radioactive Measurements for NaI(Tl) Detector

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Abstract

There are many and varied working conditions very important for the researcher. In this work, two of these conditions and their change effects on the radioactive measurement were studied, time and temperature. Seven powder samples of the most commonly spices which used in the Iraqi kitchens were collected from different markets. The radioactive spectrum of each sample is taken by using NaI(Tl) detector have crystal of (3×3) inch, then the specific activity were calculated with two times, 3 hrs. and 24 hrs. and compared with their effect on the samples. The results shows that the specific activity values of the three nuclides ^{40}K, ^{214}Bi and ^{208}Tl decrease with the increasing of measurement time. This result leads to whenever the time of measurement is higher the specific activity is lower, therefore, the measurement at 24 is more suitable for all radioactivity measurements for low radioactive materials like spices.

With respect to the temperature change, the measurements, hence specific activity were estimated in Summer and Winter seasons. The results show that all the specific activity values of the nuclide ^{40}K increase with the decreasing of measurement temperature, while It is the opposite behavior for the nuclides ^{214}Bi and ^{208}Tl. All these increasing and decreasing behavior are very slight, therefore, the changing of temperature or weather of measurement for low radioactive materials has no significant effects on the results.

Key Words:

Time, temperature, spices, NaI(Tl) detector , specific activity .

1.Introduction

Radioactivity is the emission of radiation originating as a result of the spontaneous decay of unstable atomic nuclei or from a nuclear reaction. The term radioactive decay refers to the process whereby unstable atomic nuclei decay with the loss of energy by the emission of elementary particles (e.g., alpha particles, beta particles, neutrons, gamma ray photons) directly from the nucleus or the atomic electron shells (e.g., Auger electrons and X-ray photons) [1].

The radiation is present everywhere at different levels due to many reasons such as the location (Geographical conditions) or layers of the earth (Geological conditions). Soils are naturally radioactive, primarily because of their mineral content. The main natural radionuclides are Potassium-40 (K-40) and the radioactive nuclides of the Uranium-238 (U-238) and Thorium-232 (Th-232) decay series. The natural radioactivity may vary considerably from one type of soil to another depending on the mineral make up and composition [2,3].

More than 1,500 radionuclides recognized today. A few occur in nature; any way most of them are made artificially. Simply 10% are fundamental and are utilized practically [4]. The human body is exposed to natural radiation daily from many sources such as food, air, building materials as well as substances in the body itself [5]. Human is exposed to radiation externally, (through cosmic radiation and radiation from radioactive substances that occur naturally outside the body), man also exposed to radiation internally (through natural radionuclides found in the body, inhalation of air and ingested food), Terrestrial radiations the largest natural cause of exposure and is about 85% of the average annual dose [6, 7].

The scintillation technique has high reliability and relatively low cost, it is selected to be the first choice for outdoor gamma spectrometry. This technique is not subjected to a significant temperature variation at short time operation in outdoor environment; therefore, it can be operated in the same way as in laboratory. For its continuous operation in outdoor environment, as in the case of continuous monitoring of environmental radiation, it is likely to be impacted by temperature effect [8-10], which is regard one of the most drawbacks of NaI(Tl) based systems, besides the low resolution. This effect is concluded from the temperature dependence of the system including its dependence of the scintillator's light output and decay time constants [11-14]. The most great contribution of the temperature effect coming from the photomultiplier tube is too difficult to handle [15], so the spectrum processing methods would be a necessary way to correct the temperature effect. All of correction methods are related to restoring a shifted spectrum recorded with different temperatures to the origin spectrum position which allows the restored spectrum to be active together with the reference spectrum, hence eliminating the effect of the temperature change between their measurements [13, 16].

2. Experimental Methods

2.1 Sample preparation

Seven powder samples of the most commonly spices which used in the Iraqi kitchens were collected from different markets. Each sample was grinded and sieved with a 630- μm mesh sieve for homogeneity and to obtain the highest possible mass in a small volume. Each sample was then sealed in a one-litre Marinelli beaker and waiting for 30 days to obtained radioactive equilibrium. The sample masses ranged from 0.760 kg to 0.930 kg (Table 1).

Table 1: Samples and their weights.

No.	Sample	Code	Weight (kg)
1	Turmeric	TUR1	0.830
2	Cinnamon	CEN1	0.886
3	Cumin	CUM1	0.840

4	Ginger	GIN1	0.764
5	Black Pepper	PEP1	0.884
6	Coriander	COR1	0.760
7	Cloves	CLO1	0.930

2.2 Gamma Spectroscopy

The natural radioactive nuclides of K-40, Bi-214, and Tl-208 was estimated by using NaI(Tl) detector have crystal of (3×3) inch , model 12/12/3, made in U.S.A , and have a digital multi-channel analyzer of Bright SPES model Bmca type .It analyzes the gamma spectrum for gamma rays at 4096 channels.

The calibration of detector is verified with standard point Europium source (Eu-152) from IAEA. The specific activity of radionuclide in this work were mainly K-40, Bi-214, and Tl-208 measured in (Bq/kg), and for a peak at energy Eγ, is given by [17, 18].

$$\mathbf{A(E_{\gamma}) = \frac{N}{\mathcal{E}(E\gamma) \times I_{\gamma}(E\gamma) \times t \times M}} \qquad \mathbf{(1)}$$

Where: N is the net peak area under the specific peak corrected for the background count rate. t is the time of measurement in seconds. $I_{\gamma}(E_{\gamma})$ is the abundance of energy E_{γ}. $\mathcal{E}(E_{\gamma})$ is the detection efficiency at energy E_{γ}. M is the mass of the measured sample in kg.

This work was done with two scenarios, first the specific activity of the samples were calculated for 3 hours and for 24 hour and compare their results for each nuclide. Secondly this activity were calculated for all samples in the Summer and then in Winter season and also compare their results.

3. Results and Discussions

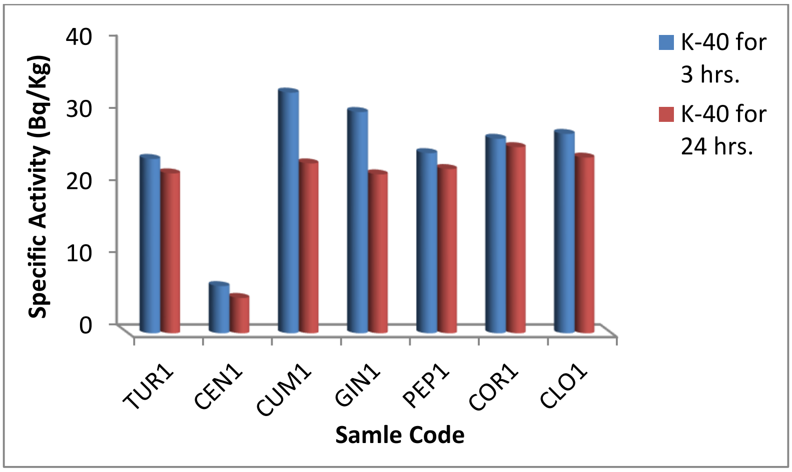
3.1 Specific activity as a function of time

The specific activity in (Bq/Kg) of the samples were calculated for 3 hours and for 24 hour by using eq. (1), and its results were put in the the table 2.

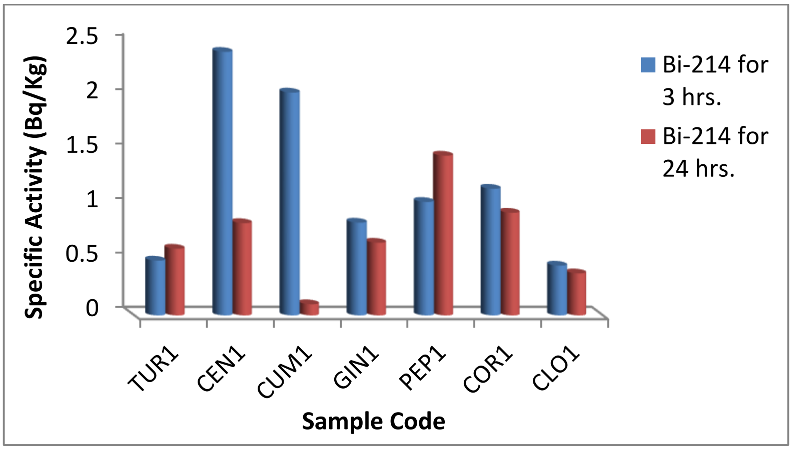
Table 2: Comparision of the specific activity in (Bq/Kg) for two times.

No.	**Code**	**3 hrs.**			**24 hrs.**		
		K-40	**U-238 Series Bi-214**	**Th-232 Series Tl-208**	**K-40**	**U-238 Series Bi-214**	**Th-232 Series Tl-208**
1	TUR1	24.132	0.502	1.289	22.130	0.611	0.527
2	CEN1	6.527	2.416	1.719	4.888	0.846	1.135
3	CUM1	33.325	2.043	1.935	23.507	0.102	0.218
4	GIN1	30.637	0.850	1.369	21.988	0.666	0.683
5	PEP1	24.936	1.040	1.160	22.729	1.464	0.672
6	COR1	26.926	1.161	0.762	25.764	0.941	0.899
7	CLO1	27.601	0.456	0.320	24.313	0.385	0.472

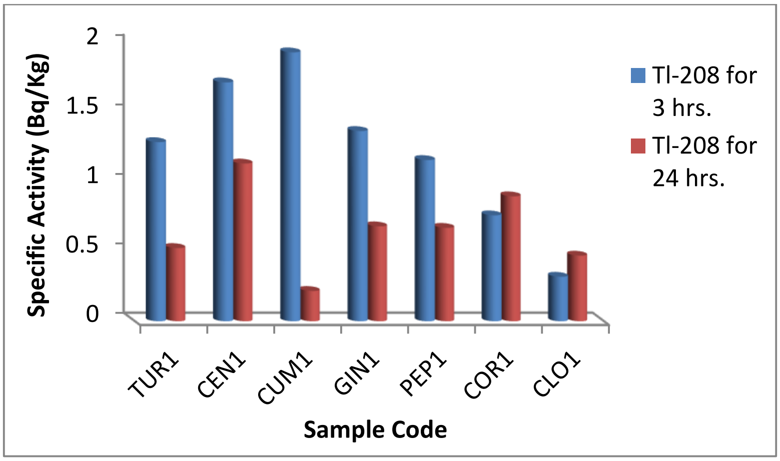
According to the table 2, it is clearly that all specific activity values of the nuclide ^{40}K decrease with the increasing of measurement time (from 3hrs. to 24 hrs.). It is the same behavior for the second nuclide ^{214}Bi except for the sample 1 (turmeric) and sample 5 (black pepper) which are show little increasing of specific activity with the increasing measurement time, while the third nuclide ^{208}Tl also show the same previous behavior except for the sample 6 (coriander) and sample 7 (cloves). The similar behavior of the second and third nuclides belong to the low specific activity with comparisons of the high specific activity of the first nuclide ^{40}K which is single radioactive nuclide, while each of the others is a result nuclide from the ^{238}Ur and ^{232}Th series respectively.



(a) For ^{40}K nuclide



(b) For ^{214}Bi nuclide



(c) For ^{208}Tl nuclide

Figure 1: Specific activity vs. time for three nuclides (^{40}k, ^{214}Bi, and ^{208}Tl).

3.2 Specific activity as a function of temperature (Summer and Winter)

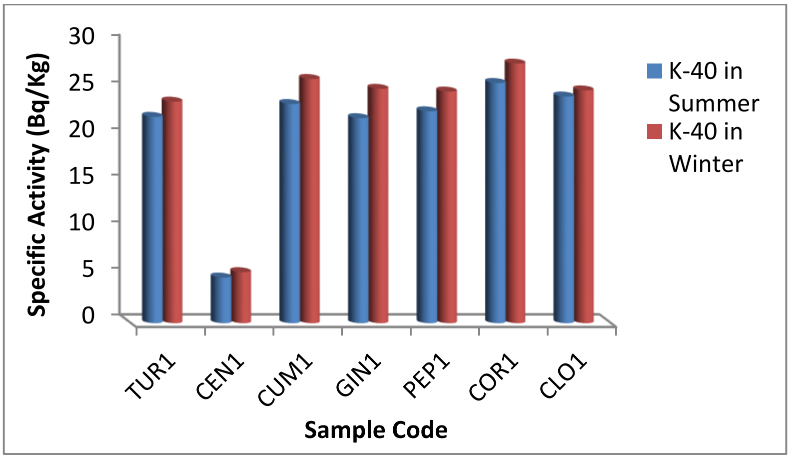
By the same way, the specific activity in (Bq/Kg) of the samples were calculated by using eq. (1), but only for 24 hrs. which is clear more than 3 hrs.. The measurements were made in the center of hot Summer weather, July month (at $T_{ave.} = 45^{0}C$) and in the center of cold Winter, January month (at $T_{ave.} = 2^{0}C$) in Baghdad city, hence their comparision results were put in the the table 3.

Table 3: Comparision of the specific activity in (Bq/Kg) for two seasons.

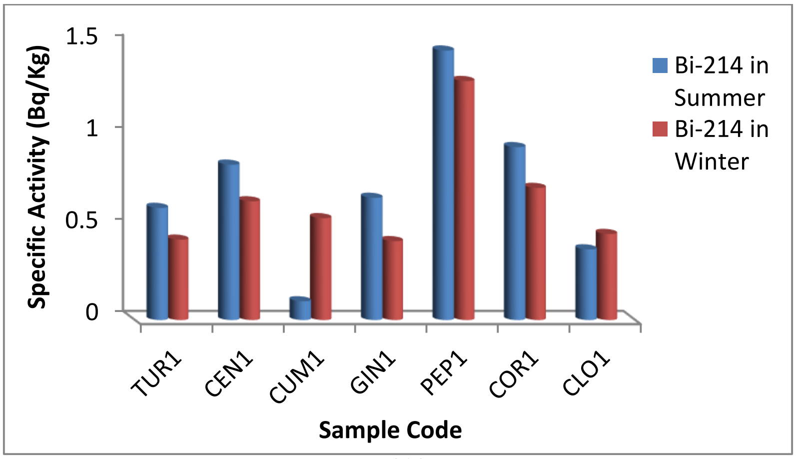
No.	**Code**	**In Summer season**			**In Winter Season**		
		K-40	**U-238 Series**	**Th-232 Series**	**K-40**	**U-238 Series**	**Th-232 Series**

			Bi-214	**Tl-208**		**Bi-214**	**Tl-208**
1	TUR1	22.130	0.611	0.527	23.762	0.438	0.317
2	CEN1	4.888	0.846	1.135	5.469	0.647	0.949
3	CUM1	23.507	0.102	0.218	26.192	0.555	0.599
4	GIN1	21.988	0.666	0.683	25.137	0.430	0.599
5	PEP1	22.729	1.464	0.672	24.847	1.299	0.569
6	COR1	25.764	0.941	0.899	27.845	0.720	0.718
7	CLO1	24.313	0.385	0.472	24.969	0.469	0.591

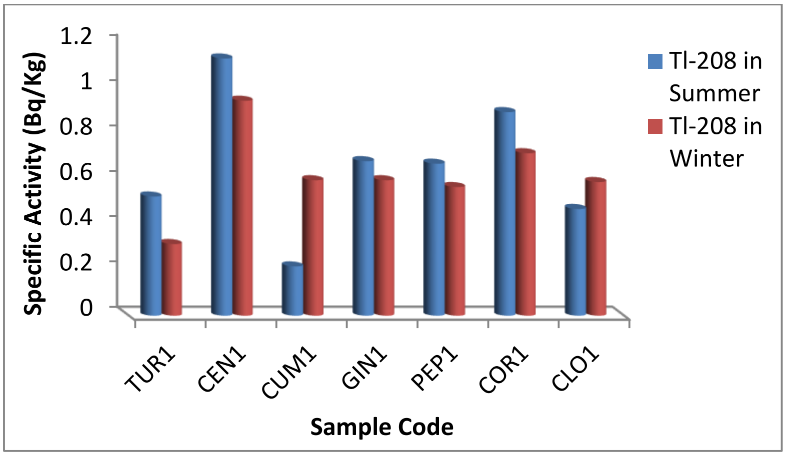
Table 3 clearly shows that all the specific activity values of the nuclide ^{40}K increase with the decreasing of measurement temperature (from Summer weather to Winter weather). It is the opposite behavior for the second nuclide ^{214}Bi except for the sample 3 (cumin) and sample 7 (cloves) which are show little increasing of specific activity with the decreasing measurement temperature, while the third nuclide ^{208}Tl also show the same previous behavior exactly. The similar behavior of the second and third nuclides belong to the low specific activity with comparisons of the high specific activity of the first nuclide ^{40}K which shows simple decreasing with changing of weather.



(a) For ^{40}K nuclide



(b) For ^{214}Bi nuclide



(c) For ^{208}Tl nuclide

Figure 2: Specific activity vs. temperature for three nuclides (^{40}k, ^{214}Bi, and ^{208}Tl).

4. Conclusions

For the time changing, in general, the specific activity values decrease with the increasing of measurement time. This result leads to whenever the time of measurement is higher the specific activity is lower, therefore, the measurement at 24 is more suitable for all radioactivity measurements for low radioactive materials like spices.

For the temperature changing, all the specific activity values of the nuclide ^{40}K increase with the decreasing of measurement temperature (from Summer weather to Winter weather). The second nuclide ^{214}Bi and third nuclide^{208}Tl have the same behavior exactly which are in general, show opposite behavior of ^{40}K nuclide. All these increasing and decreasing behavior are very slight, therefore, the changing of temperature or weather of measurement for low radioactive materials has no significant effects on the results, but may effect on the high radioactive materials.

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