Estimation the Radiological Hazard Effects for Soil Samples of Ajmail city, Libya

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الملخص

باستخدام تركيز النشاط الاشعاعي للنويدات المشعة الطبيعية لعينات من التربة السطحية جمعت من خمسة وعشرون موقع في مدينة الجميل – دولة ليبيا للراديوم ^{226}Ra ، والبوتاسيوم ^{40}K ، والثوريوم ^{232}Th تم حساب خطورة النشاط الاشعاعي وتأثيره علي البيئة. ولقد وجد ان دليل خطورة جاما يتراوح بين 0.142 و 0.372 ودليل خطورة الفا يتراوح بين 0.025 و 0.117 وهذه القيم لا تشكل خطورة لأن قيمتها اقل بكثير من الواحد الصحيح. وجرعة التعرض للاشعاع تتراوح بين 39.02 μR/h و μR/h 102.66 ، وتم حساب مكافي الجرعة الفعالة السنوية داخل وخارج المنزل وكانت كل النتائج لاتشكل خطورة اشعاعية لأنها تقع دون المعدل العالمي المسموح به.

Abstract

The specific activities of twenty-five soil samples have been measured with gamma ray spectrometry system using a High Purity Germanium (HPGe) detector in order to evaluate the radiological hazard effects of the natural radioactivity, the activity utilization index(AUI), Gamma Index (I_γ), alpha index (I_α) and the radiation exposure rate (I), The annual effective dose indoor AEDE(μSv y^{-1})$_{indoor}$, and outdoor AEDE(μSv y^{-1})$_{outdoor}$ have been calculated.
The activity utilization index values ranged from 0.06 to 0.34 with an average 0.15, and Gamma Index (I_γ) values ranged from 0.142 to 0.372 with an average of 0.2028, while the alpha index values ranged from 0.025 to 0.117 with an average 0.049, and the values of

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radiation exposure rate (*I*) ranged from 39.02 µR/h to 102.66 µR/h with an average value of 56.34 µR/h.

Keywords: natural radioactivity, Gamma index, Alpha index, radiation, exposure rate, High Purity Germanium (HPGe) detector.

1.Introduction

The exposure concentrations of natural radionuclides of the members is the most significant part of the exposure to radiation. Usually, Radon is the largest natural source of radiation contributing to the exposure of members [1].

Nuclides emitted gamma rays during the decay, and natural radiation is the largest contributor of external dose to the world population, gamma radiation dose from natural sources is important. The concentration of ^{232}Th, ^{226}Ra and ^{40}K varies considerably depending on the type of soil formation [2]. Calculate of radioactivity index is very important to control gamma radiation annual effective doses and monitoring radiation inside human body to be sure that the radiation doesn't exceed the worldwide permissible high dose values [3].

In this work we determined the activity utilization index (AUI), alpha index (Iα) and radiation exposure rate (I) for twenty-five soil samples were collected from Ajmail city. The activity concentrations in **(**Bq/Kg) for ^{232}Th, ^{226}Ra and ^{40}K have been taken from [4].

2. Materials and methods

2.1 Sample Collection and Preparation.

The soil samples were collected from the soil surface (3-5 cm depth), These samples were carried out at Ajmail city, Libya. the coordinates of each sampling location were recorded. Table 1.

A total of Twenty-five soil samples were collected from all of the districts in the selected study area, then macroscopic traces of the stones rubber, and organic matter was removed from these samples by crushed to pass through 2 mm sieve to be homogenized in size. every one of these samples were weighed, then the samples were left to dry, these samples are kept in Marinelli Beakers and left for one month to reach the secular radioactive equilibrium condition.

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High Pure Germanium Detector (HPGe) with relative Efficiency 90% and a resolution of 1.92 Kev for the 1332.5 Kev gamma ray emission of ^{60}Co.

The energy calibration of the detector and the Activity concentrations of ^{40}K, ^{226}Ra, and ^{232}Th in soil samples were measured and present in [4].

Table 1: GPS location of the sampling points.

Sample no.	Sample ID	Latitude	Longitude
1	A	32.856356N	12.116775E
2	B	32.862976N	12.103541E
3	C	32.862793N	12.092794E
4	D	32.870012N	12.070891E
5	E	32.856874N	12.067230E
6	F	32.863019N	12.047417E
7	G	32.861137N	12.024088E
8	H	32.846151N	12.008133E
9	I	32.819937N	11.991301E
10	J	32.801235N	11.975806E
11	K	32.774178N	11.972161E
12	L	32.740948N	11.946293E
13	M	32.739932N	12.000721E
14	N	32.763058N	12.015026E
15	O	32.774702N	12.065032E
16	P	32.792004N	12.130587E
17	Q	32.799482N	12.155671E
18	R	32.815088N	12.110201E
19	S	32.806584N	12.092596E
20	T	32.824735N	12.075307E
21	U	32.817888N	12.050455E
22	V	32.833852N	12.039830E
23	W	32.820830N	12.029158E
24	X	32.839159N	12.015838E
25	Y	32.849068N	12.045101E

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2.2 Calculation of Activity Utilization Index (AUI)

The activity utilization index for soil samples was calculated by using the appropriate conversion factors, an activity utilization index (AUI) is given by the following equation [5]:

$$AUI = \left(\frac{A_{Ra}}{50Bq/Kg}\right) \mathrm{f}_{\mathrm{Ra}} + \left(\frac{A_{Th}}{50Bq/Kg}\right)\mathrm{f}_{\mathrm{Th}} + \left(\frac{A_K}{500Bq/Kg}\right)\mathrm{f}_{\mathrm{K}} \qquad (1)$$

Where A_{Ra} , A_{Th} and A_K are activity concentrations in **(**Bq/Kg) for ^{232}Th, ^{226}Ra and ^{40}K. ($\mathrm{f}_{\mathrm{Ra}} = 0.462$), ($\mathrm{f}_{\mathrm{Th}} = 0.604$), and ($\mathrm{f}_{\mathrm{K}} = 0.041$) are the fractional contributions to the total dose rate in air due to gamma radiation from the actual concentrations of these radionuclides.

2.3 Calculation of Gamma Index

The Gamma index for soil samples was calculated by using following equation [6].

$$I_\gamma = \frac{A_{Ra}}{150Bq/Kg} + \frac{A_{Th}}{100Bq/Kg} + \frac{A_K}{1500Bq/Kg} \leq 1 \qquad (2)$$

Where I_γ is Gamma index, and A_{Ra} , A_{Th} and A_K are activity concentrations in **(**Bq/Kg) for ^{232}Th, ^{226}Ra and ^{40}K . The soil sample environment is generally safe if the Gamma index lower than or equal to one.

2.4 Calculation of Alpha Index (Iα)

The Alpha index for soil samples was calculated by using following equation [7].

$$I_\alpha = \frac{A_{Ra}}{200Bq/Kg} \leq 1 \qquad (3)$$

Where I_α is Alpha index, and A_{Ra} is activity concentrations in **(**Bq/Kg) for ^{226}Ra.

2.4 Calculation of Radiation Exposure Rate (I)

The total electric charge produced in a certain mass of air when radiation passes is called radiation exposure. the radiation exposure rate potential due to ^{232}Th, ^{226}Ra and ^{40}K in soil samples was calculated by using following equation [8].

$$I = 1.90\,A_{Ra} + 2.82A_{Th} + 0.179A_K \qquad (4)$$

Where I is Radiation exposure rate, and A_{Ra} , A_{Th} and A_K are activity concentrations in **(**Bq/Kg) for ^{232}Th, ^{226}Ra and ^{40}K.

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2-5 Calculation of Annual Effective Dose Equivalent

The annual effective dose rate (AEDR) for human in one year due to the soil radioactivity can be determined by using a conversion factor of (0.7 Sv/Gy), with indoor and outdoor occupancy factors of 0.8 and 0.2, respectively. The annual effective dose indoor and outdoor were calculated by using the following equations [9].

$$AEDE(\mu Sv\ y^{-1})_{outdoor} = D_r(nGyh^{-1}) \times 0.7 \times 0.2 \times 8760 \times 10^{-3} \quad (5)$$

$$AEDE(\mu Sv\ y^{-1})_{indoor} = D_r(nGyh^{-1}) \times 0.7 \times 0.8 \times 8760 \times 10^{-3} \quad (6)$$

Where $AEDE(\mu Sv\ y^{-1})_{outdoor}$ is the annual effective dose outdoor, $AEDE(\mu Sv/y)_{indoor}$ the annual effective dose indoor, $D_r(nGyh^{-1})$ is dose rate, and 8760 is the time conversion factor (hy^{-1}).

3. Results and discussion

The activity utilization index(AUI), Gamma Index (I_γ), alpha index (I_α) and the radiation exposure rate (I) for a total of 25 soil samples were presented in Table 2, and figures 1, 2, and 3.

Table 2 The activity utilization index(AUI), Gamma Index (I_γ), alpha index (I_α) and the radiation exposure rate (I) for a total of 25 soil samples.

Sample no.	Soil simple	*AUI*	I_γ	I_α	*I* (μR/h)
1	A	0.097	0.160	0.037	44.10
2	B	0.20	0.196	0.052	54.42
3	C	0.14	0.153	0.035	42.65
4	D	0.14	0.150	0.039	41.71
5	E	0.23	0.258	0.075	77.57
6	F	0.09	0.142	0.038	39.07
7	G	0.17	0.238	0.044	65.82
8	H	0.2	0.231	0.072	64.28
9	I	0.13	0.161	0.035	44.67
10	J	0.10	0.180	0.039	49.29
11	K	0.27	0.372	0.052	102.66
12	L	0.06	0.227	0.034	62.41
13	M	0.11	0.233	0.039	63.70

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14	N	0.17	0.226	0.025	62.66
15	O	0.08	0.142	0.040	39.02
16	P	0.07	0.144	0.032	39.47
17	Q	0.34	0.327	0.117	91.79
18	R	0.15	0.168	0.066	46.68
19	S	0.06	0.147	0.027	40.06
20	T	0.09	0.142	0.038	39.20
21	U	0.19	0.239	0.040	66.11
22	V	0.12	0.200	0.038	54.86
23	W	0.11	0.177	0.0428	48.69
24	X	0.23	0.261	0.072	72.51
25	Y	0.19	0.196	0.101	54.82
Average		0.15	0.2028	0.203	56.34

As illustrated in Table 2 the calculated values of activity utilization index were varying from 0.06 to 0.34 with an average 0.15, which corresponds to an annual effective dose of generally less than 0.3mSv/y[10]. While Gamma Index (I_γ) is ranging from 0.142 to 0.372 with an average of 0.2028. In all soil samples, the calculated values of (I_γ) are smaller than 1, these values are lower than the international assigned levels[11], which implies that these soil could be used.

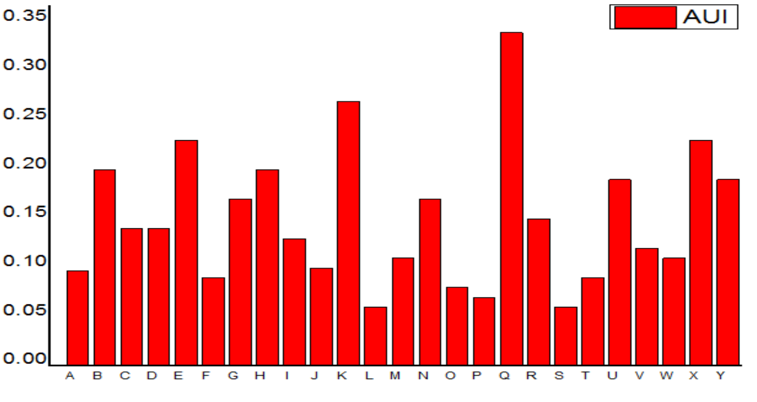

Figure (1): The Activity Utilization Index (AUI) for the soil samples.

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The calculated values of alpha index were varying from 0.025 to 0.117 with an average 0.049, In all soil samples, the calculated values of (I_{α}) are smaller than 1, and the values of radiation exposure rate (I) ranged from 39.02 μR/h to 102.66μR/h with an average value of 56.34μR/h, these values are lower than the international assigned levels[11].

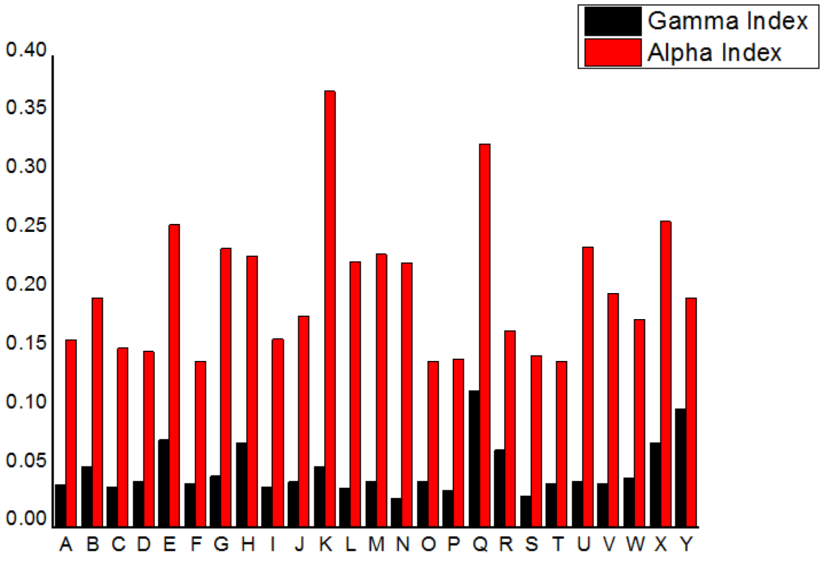

Figure (2): The Gamma Index, and Alpha Index for the soil samples.

Also the results of the annual effective dose indoor AEDE(μSv y^{-1})$_{indoor}$, and outdoor AEDE(μSv y^{-1})$_{outdoor}$ for a total of 25 soil samples were presented in Table 3, and figure 4.
The annual effective dose indoor were varying from 11.28μSv y^{-1} to 22.10 μSv y^{-1} with an average 16.06, and the annual effective dose outdoor were varying from 45.13 to 115.04 with an average 64.16, these values are lower than the international assigned levels which equal to 460 μSv y^{-1} [11].

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Table 3: The annual effective dose indoor AEDE(μSv y^{-1})$_{indoor}$, and outdoor AEDE(μSv y^{-1})$_{outdoor}$ for the soil samples.

Sample no.	Soil simple	AEDE(μSv y^{-1})$_{outdoor}$	AEDE(μSv y^{-1})$_{indoor}$
1	A	12.68	50.72
2	B	15.38	61.51
3	C	11.99	47.98
4	D	11.79	47.14
5	E	22.10	88.40
6	F	11.28	45.13
7	G	18.59	74.37
8	H	18.49	73.98
9	I	12.63	50.53
10	J	14.16	56.66
11	K	28.76	115.04
12	L	17.64	70.54
13	M	18.29	73.14
14	N	17.41	69.66
15	O	11.34	45.38
16	P	11.43	45.72
17	Q	26.13	104.54
18	R	13.57	54.29
19	S	11.58	46.31
20	T	11.32	45.28
21	U	18.54	72.17
22	V	15.63	62.55
23	W	14.01	56.07
24	X	20.59	82.37
25	Y	16.14	64.56
Average		16.06	64.16

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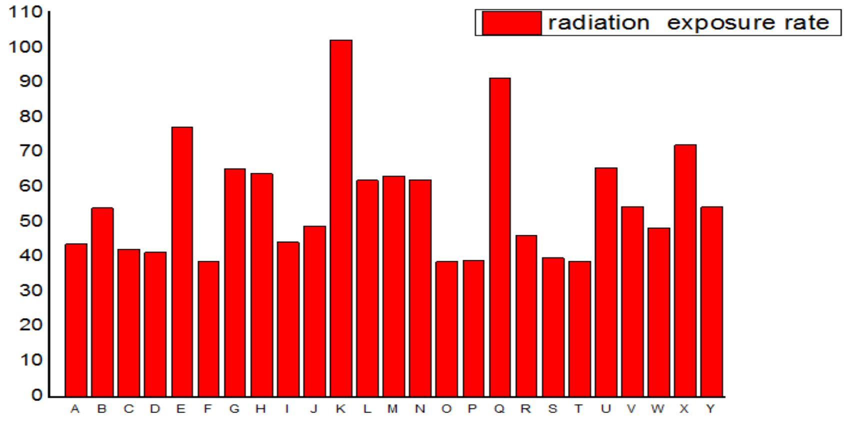

Figure (3): The Radiation Exposure Rate(I) for the soil samples.

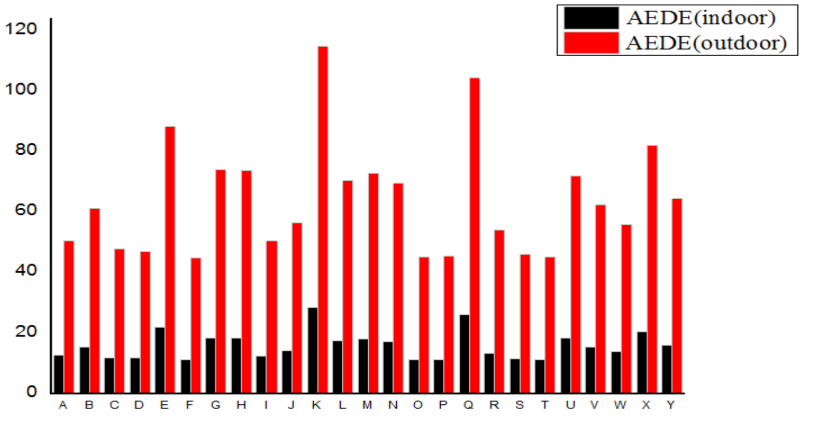

Figure (4): The annual effective dose indoor, and the annual effective dose outdoor for the soil samples.

Conclusion

It is important to determine background radiation level in order to assess health risks. In this study, the activity utilization index(AUI), Gamma Index (I_γ), alpha index (I_α) and the radiation exposure rate (I), The annual effective dose indoor AEDE($\mu Sv\ y^{-1})_{indoor}$, and outdoor AEDE($\mu Sv\ y^{-1})_{outdoor}$ have been calculated. In all soil samples, the calculated values of (I_γ) ,and (I_α) are smaller than 1.

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The annual effective dose values are found to be lower than the corresponding allowed limits which is equal to 460(μSv y^{-1}) [11].

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