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DETERMINATION OF RADIONUCLIDE'S CONCENTRATION AND RADIOLOGICAL RISK IN THE SOIL SAMPLES OF MADENAT AL-ELEM UNIVERSITY COLLEGE USING GAMMA SPECTROSCOPY

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ABSTRACT

This research aims to calculate the concentration of radionuclide's in the soil samples, collected from in and around madenatAl-Elem university area using Gamma- rays spectroscopy with high purity germanium detector (HpGe) with resolution of (2.3keV) for the energy of the ^{60}Co (1.332 MeV). The 25 soil samples were collected from this area, the average activity concentrations of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs in the samples were found to be (38.089±6.172 , 35.147±5.93 , 700.109±26.46 and 3.854±1.963) Bq\kg respectively. The calculated radium equivalent (Ra_{eq}) was (142.536±11.939) Bq/kg, the absorbed dose rate(68.137±8.254nGy / h), the external annual effective dose of exposure rate $AEDE_{out}$was(0.332mSv/y), $AEDE_{in}$wa (0.083mSv /y), the gamma index (I_γ) for soil samples was(1.073),the value of the external risk index (H_{ex}) was (0.487) and the internal risk index (H_{in}) was (0.384).Thus , the present results revealed that the area is safe as far as the health effect are concerned ,but this area continuo's monitoring in future.

Keywords:*Natural radioactivity, Soil,Gamma-Spectrometry, (HpGe).*

1.INTRODUCTION

It is well known that traces of radionuclide's are found in (air, soil, water and human bodies), we inhale and ingest radionuclide's every day of our lives and radioactive materials have been ubiquitous on earth since its creation. The presence of natural radioactivity in soil results in internal and external exposure to humans[1].Three radioactive series are now exists in nature, namely, ^{238}U, ^{235}U and ^{232}Th in which heavy nuclides lost mass and changed their atomic number in successive steps, the changes ending only when the element became a stable isotope of lead[2].

A fourth series, neptunium series, is also included in natural radioactive series, but it does not now occur naturally in nature because of its relatively short half-life (2.14×10^6) year [3], of the longest lived member of the series, namely, ^{237}Np which is much shorter than the age of the earth [4].

Human activities like mining and milling of mineral ores, processing and enrichment, nuclear fuel fabrications, and handling of the fuel cycle tail end products cause release of additional amounts of natural radionuclide's into the environment[5].

The aim of the present work is to determine the specific activity of (^{238}U, ^{232}Th, ^{40}K and ^{137}Cs), radium equivalent activity, absorbed gamma dose rate, indoor and outdoor annual effective dose rates, external annual effective dose, activity concentration index, internal and external hazard indices in surface soil samples in some selected regions inMadenat Al- Elem University Collegeby using high purity germanium (HPGe) detector.

2. EXPERIMENTAL PART

Surface soil samples were taken from someselected regions inMadenat Al Elem University College Figure (1). The surface soilsamples (2 kg) were dried at (60 °C) for two hours were crushed in to a fine powder by using electrical mill.A fine soil powder of a grain size of about (300 mm) was obtained by using special sieves ,and were packaged in a capacity of one litter marinelli beaker. The sealed marinelli beaker were kept for one month before measurements in order to achieve the secular equilibrium for ^{238}U and ^{232}Th with their respective progenies.

In the present work (HPGe) detector with an efficiency of 40% and energy resolution (2.6 keV) at energy (1332.6 keV) for ^{60}Co was used. The detector is surrounded by lead shield of about 10 cm in thickness to reduce the background radiation.

The energy calibration of (HPGe) detector was achieved by using the standard source of one litter marinelli beaker of Europium ($^{152}_{63}Eu$), which has been prepared previously by reference [6] , with energies (121.8, 244.7, 344.3, 411.1, 444.6, 778.9, 964.0, 1085.8, 1112.0 and 1408.0 keV) [6], is shown in Figure (2).

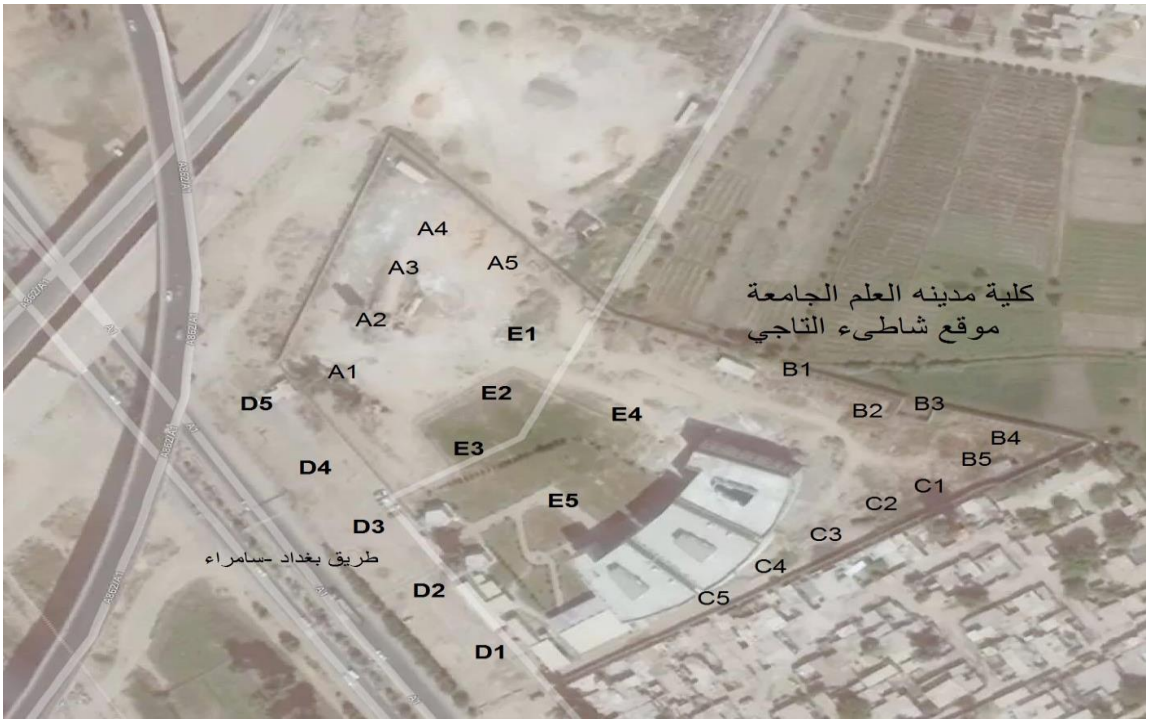

Figure (1):Map Satellite for Madenat Al-Elem University Collegesite and locations of the Samples.

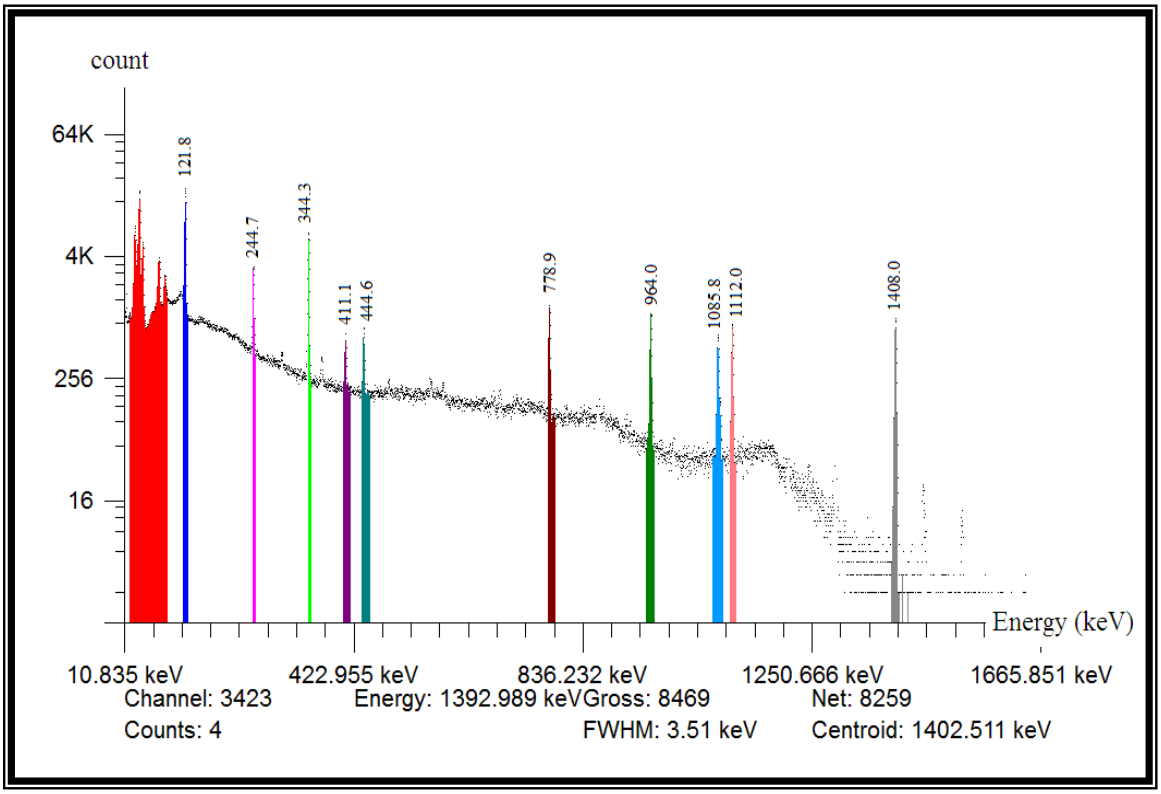

Figure (2) :^{152}Eu spectrum as the standard source.

The detector efficiency Ɛ(Eγ) at energy (Eγ) can be found from the relation [7]:

$$\varepsilon(E\gamma) = \frac{N}{A \times I\gamma(E\gamma) \times T} \times 100\% \quad \ldots (1)$$

where:

Ɛ(Eγ): The detector efficiency at energy (E) .

N: is the net peak area under the specific peak corrected for the background at energy (Eγ).

A: is the activity in (Bq) of the standard source.

I_γ (Eγ): is the abundance at energy (Eγ).

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

To find the efficiencies of other energies of any radioactive isotopes, the fitting relation shown in Figure (3) between the gamma energy (Eγ) and the efficiency Ɛ(Eγ) was used .

Detection Limit (DL) is given by the relation [8]:

$$\text{D.L.} = \left(2.77 + 3.29\sqrt{\text{B.G}}\right) \times \frac{\text{concentration}}{\text{Net Area(A)}} \quad \ldots . (2)$$

The specific activity of radionuclide's, in (Bq/kg) units, in soil samples were obtained by using the relation [9]:

A= [Area under the photo peak at energy (E)-B.G)] / (M×Iγ (Eγ)×Ɛ(Eγ)×T) … (3)

where:

A: is the specific activity concentration of radionuclide measured in (Bq/kg) units.

B.G: is the net peak area under the specific peak of background with shielding.

M: is the mass of the soil sample (kg).

Iγ (Eγ): is the abundance at energy (Eγ).

Ɛ(Eγ): is the detector efficiency at energy (Eγ).

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

The gamma energies employed in the present work are given in Table (1) [8]

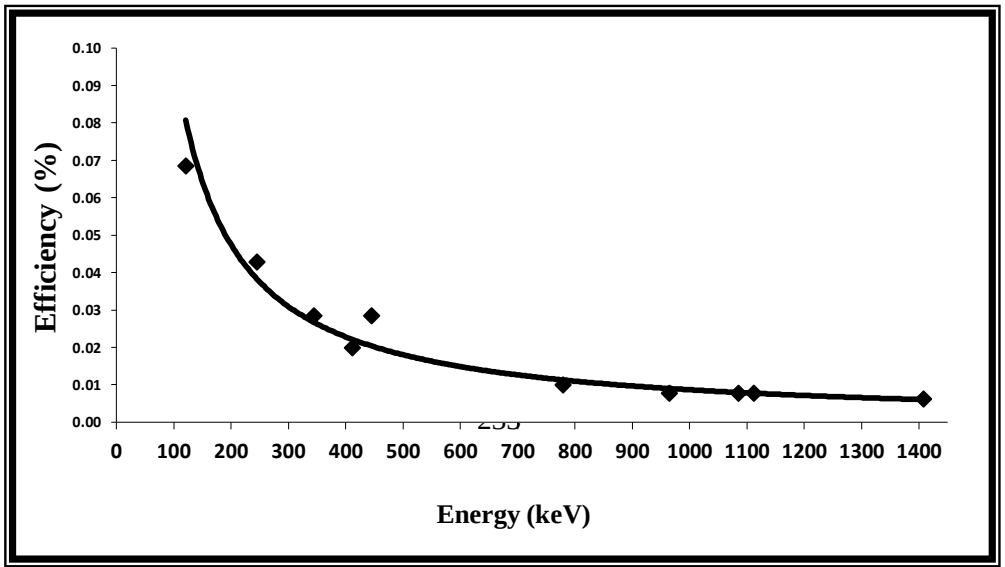

Figure (3):Efficiency calibration curve of (HPGe) detector using (^{152}Eu) prepared standard source.

Table (1) the gamma energies for isotopes used in the present work [8].

Series	Equivalent isotope	Half-life	E (keV)	$I_\gamma(E_\gamma)$ (%)
^{232}Th	Pb^{212}	10.64 h	238.63	43.50
^{238}U	^{214}Pb	26.80 m	295.21	19.20
^{238}U	^{214}Pb	26.80 m	351.92	35.10
^{232}Th	^{208}Tl	3.07 m	583.19	30.58
^{238}U	^{214}Bi	19.90 m	609.32	44.60
-----	^{137}Cs	30 y	661.61	87.50
^{232}Th	^{228}Ac	6.13 h	911.16	26.60
-----	^{40}K	1.28×10^{9}y	1460.80	10.67

The radium equivalent activity (Ra_{eq}) which is used to ensure the uniformity in the distribution of natural radionuclide's^{238}U, ^{232}Th and ^{40}K and is given by the expression [10]:

$Ra_{eq}(Bq/kg)=A_{Ra}+1.43A_{Th}+0.077A_K$ ….(4)

Where A_{Ra}, A_{Th} and A_K are the specific activities concentrations of ^{226}Ra, ^{232}Th and ^{40}K in (Bq/kg) respectively.

Outdoor air gamma absorbed dose rate (D_γ) in (nGy/h) due to terrestrial gamma rays at (1 m) above the ground surface which can be computed from specific activities A_{Ra}, A_{Th} and A_K of ^{226}Ra, ^{232}Th and ^{40}K in (Bq/kg) respectively using the following relation [10]:

$$D\left(\frac{\text{nGy}}{\text{h}}\right) = 0.462\,A_{Ra} + 0.604\,A + 0.0417\,A_{K(nGy.h^{-1})} \ldots.(5)$$

The estimated annual effective dose equivalent received by a member was calculated by using a conversion factor of (0.7 Sv/Gy), which was used to convert the absorbed rate to human effective dose equivalent with an outdoor occupancy of 20 % and 80 % for indoors [11]:

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810}$$

$$AEDE_{out}(mSv.y^{-1}) = D(nGy.h^{-1}) \times 8760h \times 0.7Sv.Gy^{-1} \times 0.2 \times 10^{-6}\ldots.(6)$$

$$\text{AEDE}_{\text{in}}(\text{mSv.y}^{-1}) = \text{D}(\text{nGy.h}^{-1}) \times 8760\text{h} \times 0.7\text{Sv.Gy}^{-1} \times 0.8 \times 10^{-6}\ldots\ldots(7)$$

the internal hazard index (H_{in}) as given below:

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad ..(8)$$

the external hazard index (H_{ex}) can then be defined as given below [10]:

….(9)

This index value must be less than unity in order to keep the radiation hazard to be insignificant.

The gamma index (I_γ) for soil samples was calculated by using the following equation [12]**:**

$$I_\gamma = \frac{A_{Ra}}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \ldots\ldots(10)$$

RESULTS AND DISCUSSION

From Table (1),it can be noticed that:

For specific activity of (^{238}U), the highest value in B_4 (Indoor garden) region which was equal to (46.556Bq/kg), while the lowestwas in C_3(College Garage) region which was equal to (30.784 Bq/kg) , with an average value of(38.089±6.172 Bq/kg). The present results have shown that values of specific activity for (^{238}U) inMadenat Al-Elem University College were approximate to the recommended value of (35Bq/kg) for the specific activity of (^{238}U) given by (UNSCEAR , 2000[13]) when taking in to consideration the combined experimental error.

For specific activity of (^{232}Th), the highest value of specific activity of (^{232}Th) was found in B_2 (Indoor garden) region which was equal to (43.667Bq/kg), while the lowest value was found in E_5 (High pressure lines) region which was equal to (28.277 Bq/kg) ,with an average value of(35.147±5.930 Bq/kg). Where for (^{232}Th)

inMadenat Al-Elem University College were approximate to the recommended value of (35Bq/kg) for the specific activity of (^{232}Th) given by (UNSCEAR , 2000[13]) when taking in to consideration the combined experimental error.

For specific activity of (^{40}K), the highest value of specific activity of (^{40}K) was found in B_3 (Indoor garden) region which was equal to (741.280Bq/kg), while the lowestvalue was found in E_5 (High pressure lines) with an average value of(700.109±26.460Bq/kg).

The present results have shown that values of specific activity for (^{40}K) inMadenat Al-Elem University College were more than the recommended value of (400Bq/kg) for the specific activity of (^{40}K) given by (UNSCEAR , 2000) [13].

For specific activity of (^{137}Cs), the highest value was found in B_1 (Indoor garden) region which was equal to (5.681Bq/kg), while the lowest value was found in A_2 ,C_3 and E_4 which were (B.D.L), with an average value of(3.854±1.963Bq/kg).

The present results have shown that values of specific activity for (^{137}Cs)were less than the recommended value of (14.8Bq/kg) for the specific activity of (^{137}Cs) given by (UNSCEAR , 1993) [14] .

Table (2) shown that the average value for radium equivalent activity (Ra_{eq}) was (142.536±11.939Bq/kg). which was less than the recommended value of (370Bq/kg)for the radium equivalentactivity given by (UNSCEAR , 2000) [13].

The absorbed gamma dose rate (D_γ) has an average value of(68.137±8.254nGy/h). which was less than the recommended value of (55nGy/h) for the absorbed gamma dose rate given by (UNSCEAR , 2000) [13].

For indoor annual effective dose equivalent $(AED)_{in}$ has an average value of(0.332mSv/y). which was lessthan therecommended value of (1mSv/y) for the indoor annual effective dose equivalent given by (UNSCEAR , 2000) [13] .

Also the outdoor annual effective dose equivalent $(AED)_{out}$ has an average value of(0.083mSv/y). which was lessthan therecommended value of (1mSv/y) for the outdoor annual effective dose equivalent given by (UNSCEAR,2000) [13].

The external annual effective dose (EAD) has an average value of(0.637mSv/y). which was less than therecommended value of (1.5mSv/y) for the external annual effective dose given by (UNSCEAR , 2000) [92] .

For activity concentration index (I_γ) has an average value of(1.073).

Which was equal to the recommended value of (1) for the activity concentration index given by (UNSCEAR , 2000) [13].

For internal hazard index (H_{in}) and external hazard index (H_{ex}) the average value were(0.487) and (0.384) respectively.Whichwere less than the recommended value of (1) for the internal hazard index given by (UNSCEAR , 2000) [13] .

Table (2):Samples locations and S.A. of radionuclide's in Madenat Al-Elem University College soil samples.

Sample location	^{214}Bi (Bq/kg)	^{228}Ac (Bq/kg)	^{40}K (Bq/kg)	^{137}Cs (Bq/kg)
DeanshipA1	38.376	34.614	706.230	3.538
A2	36.380	38.325	711.878	B.D.L
A3	40.427	40.930	712.142	4.010
A4	40.563	33.847	723.973	3.833
A5	37.632	32.019	714.691	3.776
Average	**38.676**	**35.947**	**713.783**	**3.031**
Indoor gardens B1	42.828	41.900	730.706	5.681
B2	41.912	43.667	721.412	5.478
B3	46.054	38.460	741.280	4.783
B4	44.318	37.543	728.731	4.813
B5	46.556	40.854	714.288	4.645
Average	**44.334**	**40.485**	**727.728**	**5.080**
C1 College Garage	36.048	30.817	690.168	3.412
C2	32.135	32.706	698.222	3.695
C3	30.784	31.825	709.688	3.887
C4	36.620	33.779	720.232	B.D.L
C5	39.548	31.173	717.412	3.489
Average	**35.027**	**32.06**	**707.144**	**3.628**
Stadium D1	39.406	33.412	664.291	3.642
D2	37.194	38.453	703.715	4.212
D3	41.378	33.700	681.319	4.436
D4	38.175	40.285	660.584	4.211
D5	40.900	39.872	673.460	3.877
Average	**39.411**	**36.144**	**676.674**	**4.076**
High pressure linesE1	32.914	31.602	686.655	3.165
E2	33.572	33.285	682.083	4.597
E3	34.584	32.499	674.298	3.804
E4	31.480	29.836	669.883	B.D.L
E5	32.435	28.277	663.169	5.715
Average	**32.997**	**31.100**	**675.218**	**3.456**

Table(3): The radiation parameters of radionuclide's in Madenat Al-Elem University College soil samples

Ra_{eq} (Bq/kg)	D_{γ} (nGy/h)	Annual effective dose (mSv/y)		EAD (mSv/y)	I_{γ}	Hazard index	
		$(AED)_{in}$	$(AED)_{out}$			H_{in}	H_{ex}
142.253	68.086	0.334	0.083	0.637	1.072	0.487	0.384
145.999	69.641	0.341	0.085	0.65	1.100	0.492	0.394
153.791	73.095	0.358	0.089	0.683	1.153	0.524	0.415
144.710	69.373	0.340	0.085	0.65	1.091	0.500	0.390
138.450	66.528	0.326	0.081	0.623	1.047	0.475	0.373
145.040	**69.344**	**0.339**	**0.084**	**0.648**	**1.092**	**0.495**	**0.391**
159.009	75.564	0.370	0.092	0.706	1.191	0.545	0.429
159.904	75.821	0.371	0.092	0.708	1.197	0.545	0.431
158.130	75.418	0.369	0.092	0.706	1.185	0.551	0.427
154.116	73.538	0.360	0.090	0.689	1.156	0.536	0.416
159.977	75.970	0.372	0.093	0.711	1.195	0.557	0.432
158.227	**75.262**	**0.368**	**0.091**	**0.704**	**1.184**	**0.546**	**0.427**
133.259	64.047	0.314	0.078	0.6	1.008	0.457	0.359
132.667	63.716	0.312	0.078	0.596	1.006	0.445	0.358
130.939	63.038	0.309	0.077	0.589	0.996	0.436	0.353
140.381	67.354	0.330	0.082	0.63	1.062	0.478	0.379
139.366	67.015	0.328	0.082	0.628	1.053	0.483	0.376
135.322	**65.034**	**0.318**	**0.079**	**0.608**	**1.025**	**0.459**	**0.365**
138.335	66.087	0.324	0.081	0.619	1.039	0.480	0.373
146.367	69.754	0.342	0.085	0.652	1.101	0.495	0.395
142.030	67.882	0.333	0.083	0.636	1.067	0.495	0.383
146.647	69.515	0.341	0.085	0.649	1.097	0.499	0.396
149.773	71.061	0.348	0.087	0.664	1.120	0.515	0.404
144.630	**68.859**	**0.337**	**0.084**	**0.644**	**1.084**	**0.496**	**0.390**
130.977	62.927	0.308	0.077	0.589	0.993	0.442	0.353
133.689	64.057	0.314	0.078	0.599	1.011	0.451	0.361
132.978	63.725	0.312	0.078	0.596	1.005	0.452	0.359
125.726	60.498	0.296	0.074	0.566	0.954	0.424	0.339
123.935	59.718	0.292	0.073	0.559	0.941	0.422	0.334
129.461	**62.185**	**0.304**	**0.076**	**0.581**	**0.980**	**0.438**	**0.349**

CONC

LUSION

The specific activity of ^{238}U and ^{232}Th were approximate to the recommended value of (35Bq/kg) for the specific activity of (^{238}U) given by (UNSCEAR , 2000[13]) and less than Ref.[15],when taking in to consideration the combined experimental error,and for ^{137}Cs it was less than the recommended value of (14.8Bq/kg) for the specific activity of (^{137}Cs) given by (UNSCEAR , 1993) [14].But for ^{40}K in Madenat Al-Elem University College were more than the recommended value of (400Bq/kg) for the specific activity of (^{40}K) given by (UNSCEAR , 2000) [13] .The reason for this may be due to the nature of the composition of the soil, which has been transferred from another place during the previous period.

All radiation parameters were within their limits except activity concentration index (I_γ) ,approximately equal to the limits. Thus , the present results revealed that the area is safe as far as the health effect are concerned ,but this area continuo's monitoring in future.

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حساب تراكيز العناصر المشعة والمخاطر الإشعاعية في نماذج من التربة ماخوذه من داخل و محيط كلية مدينة العلم الجامعة باستخدام تقنية مطيافية كاما

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الخلاصة:

الهدف من البحث هو حساب تراكيز العناصر المشعة في نماذج من التربة جمعت من داخل ومحيط كلية مدينة العلم الجامعة باستخدام مطيافية أشعةكاما(كاشف الجرمانيوم) بطاقة فصل 2.3 كيلو إلكترون فولت (1.332 م.ا.ف) لعنصر الكوبالت- 60جمعت 25 نموذج تربة من المنطقة,معدل تركيز الفعالبه لليورانيوم-238 والثوريوم- 232والبوتاسيوم- 40والسيزيوم-137في النماذج وجدت$\pm$ 38.089 $(1.963 \pm 26.46,3.854 \pm 5.93,700.09 \pm 6.172,35.147)Bq/kg$بالتعاقب , وقيمة الراديوم المكافئة هو (142.536) بكرل/كلغم ومعدل الجرعةالممتصة هي (68.137) نانوكري/ساعه والجرعةالمكافئةالمؤثرةالسنويةالخارجية هي(0.332) ملي سفرت /سنه والداخلية هي 0.083) ملي سفرت /سنه ومعامل كاما لنماذج التربة 1.073ومعامل الخطورةالخارجيةوالداخلية اقل من واحد , إن هذه القيم المحسوبة في هذه المنطقة هي ضمن الحدود المسموحة عالميا

الكلمات المفتاحية. النشاط الاشعاعي الطبيعي, تربه, مطيافيه اشعة كاما, كاشف الجرمانيوم