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Calculation of Radionuclids Concentration in the Rising Dust Caused by the Movements of Cars and Wheels in Tikrit Streets

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Abstract: ***The aim of this study is to calculate the concentration of radionuclides in the dust rising from the streets of Tikrit as a result of the movement of cars and wheels by using the Gama ray source of ^{60}Co and the high-purity Germanium (HpGe) detector with 2.6 kV for energy (1332 MeV) ^{60}Co. 50 dust samples from the streets of Tikrit were collected The results shows a concentration of ^{238}U to be (5.2017 ± 2.28 Bk/kg), the ^{232}Th was (11.1702 ± 3.34 Bk/kg) , ^{137}Cs was (10.8843 ± 3.3 Bq / Kg) and Radium Equivalent Ra_{eq} was (49.448 Bq / Kg) , Absorbed Dose (24.09311 nGy / h) , External and Internal Hazard Indices was (H_{ex}) (0.0337 mSv / y) and (H_{in}) was (0.1349 mSv/y), Annual Effective Dose Equivalent (AEDE) and Gamma Radiation Level Index (I_γ) was (0.38444).***

Keywords: Natural radioactivity, Gamma spectroscopy, Iraq

1. Introduction

Radioisotopes are a form of non-stable atomic nuclei that are decomposed by ionizing radiation in the form of alpha, beta or gamma rays, Many radioisotopes such as ^{226}R, ^{235}U, ^{238}U, ^{232}Th and ^{40}K are found naturally in rocks and soils, Other radioactive isotopes such as ^{137}Cs and ^{60}Co are iodine I, Which are produced mainly as fission products from the atomic dust of atomic bombs, nuclear reactors or radiation of other sources.[1]

Radiation materials was merge, whether solid, liquid or gaseous , with the elements of the environment of water, air and soil, The velocity of gaseous substances in the air is often greater than liquid or solid.[2]

A human is exposed to a low level of background radiation, That radiation has an impact on the environment and may remain in effect for many years, Affects the genetic makeup of humans and animals. Leading to a genetic defect that has an effect on later generations, The impact of this pollution reaches water , soil And enters the food chain of both human and animal.[3]

Therefore, it is a very necessary to study the effect of radiation, on human and its cause on the pollution of the environment by Using several techniques. For the detection of radioactive materials Gamma Ray spectroscopy were adopted .

2. The Theoretical Part

A) Background Radiation

The following equation was used to calculate background radiation [4]:

$$A_{BG} = \frac{\text{Net}_{BG}}{I(E_\gamma)\times\varepsilon(E_\gamma)\times T} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where A_{BG} is the background activity of radionuclides in (Bq),Net_{BG} is the net peak area under the specific peak of background. I (Eγ): Intensity of the isotopes at energy Eγ.ε (Eγ): Detection efficiency at energy Eγ. . T is the time of measurement (10800s).

B) Specific Activity of Radionuclides

$$S.A(E_\gamma) = \frac{\text{Net}}{T\times I(E_\gamma)\times\varepsilon(E_\gamma)\times m} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:

m: weight of sample in kg. The parameters □ (E□), I□(E□) and T are as defined in equation (1).

C) Determination of Some Gamma Radiation Parameters

1- **Radium Equivalent**[5]

$$Ra_{eq} = A_{Ra} + 1.43\,A_{Th} + 0.07\,A_K \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where: A_{Ra}, A_{Th} and A_K are the specific activity of ^{238}U (^{226}Ra), ^{232}Th and ^{40}K in Bq/kg, respectively.

2- **Absorbed Dose** [6]

$$D_\gamma\,(nGy.h^{-1}) = 0.462\,A_U + 0.604\,A_{Th} + 0.0417\,A_K \ldots (4)$$

where:

D_γ:Absorbed dose rate in $nGy.h^{-1}$.

3- **External (H_{ex}) and Internal (H_{in}) Hazard Indices**[7]

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where A_U, $A_{Th}$and A_K represent the measured activity concentrations in ($Bq.kg^{-1}$)for ^{238}U,^{232}Th and ^{40}K respectively.

4- **Annual Effective Dose Equivalent (AEDE)** [8]

$$AEDE_{out}\,(mSv.h^{-1}) = D_\gamma\,(nGy/h) \times 10^{-6} \times 0.2 \times 0.7\ (Sv/Gy) \quad (7)$$

$$AEDE_{in}\ (mSv.h^{-1}) = D_\gamma\ (nGy/h) \times 10^{-6} \times 0.8 \times 0.7\ (Sv/Gy) \quad (8)$$

where D_γ is the calculated dose rate in ($nGy.h^{-1}$).

5- **Gamma Radiation Level Index (I_γ): [8]**

$$I_\gamma = \frac{1}{150}A_U + \frac{1}{100}A_{Th} + \frac{1}{1500}A_K \quad \ldots\ldots\ldots (9)$$

where A_U, A_{Th} and A_K are as defined in equation (5).

3. Experiment

A- Collection of samples

The rising dust samples were collected from the streets of Tikrit. In October 2017 we collect 50 samples. The city of Tikrit is the administrative center of the province of Salah al-Din in northern Iraq, located 140 kilometers northwest of Baghdad and 220 kilometers southeast of the city of Mosul, on the Tigris River. Where the study area is located according to its astronomical location between the latitudes (45,534 and 50,534) north and the longitude lines (30, 543, 10 544) east. [9] Figure 1 illustrates the geographical location of Salahuddin Governorate and the collection sites.

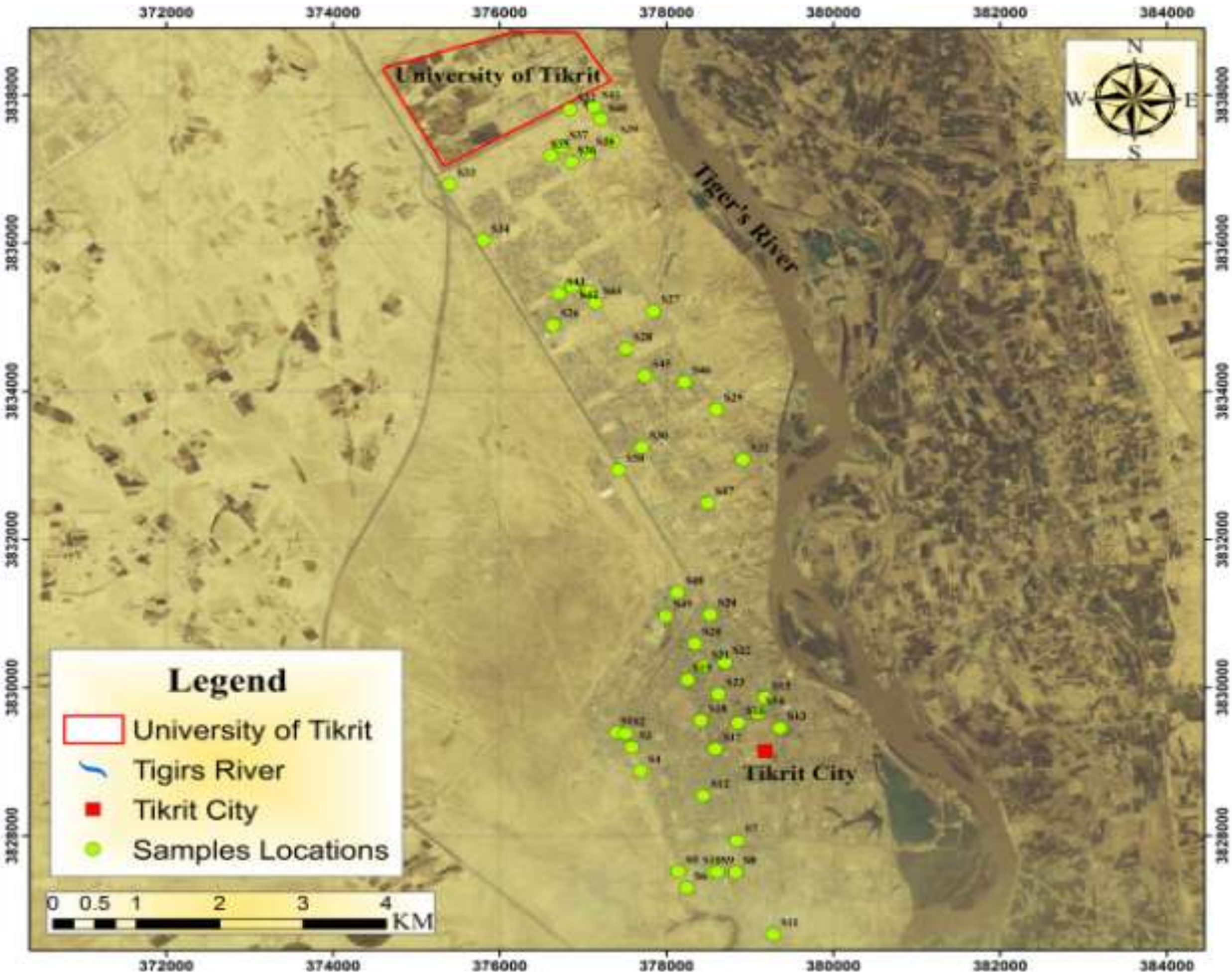

Figure 1: The geographical location of Salah al-Din Governorate and the collection sites of the samples

B- **Preparation of samples**

The samples were prepared by drying them at 80C for 1.5 hours, grinding them with 75µm sieve, and keeping them for one month in order to obtain long-term radiative balance.

C- **Measurement system**

The gamma ray spectrometer system consists of the (HPGE) High-purity germanium detector. The detector is surrounded by a shield of lead to reduce the radiation background. High-Voltage Power Supply).,Preamplifier, Main Amplifier, Multichannel Analyzer (MCA), Computer and Software, the special program which is an Integrated Computer Spectrometer (ICS-PCI 4K). Figure (2) shows the main components of the gamma-ray spectroscopy system.

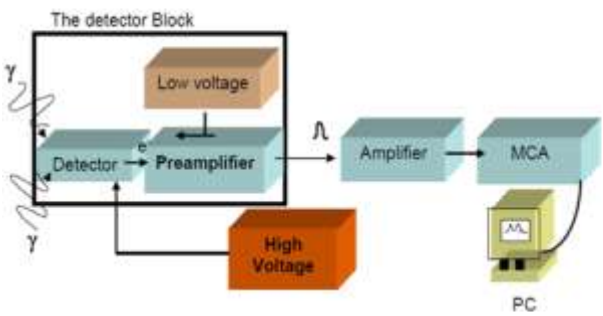

Figure 2: Basic gamma spectroscopy system.

1- **Energy calibration**

The energy was calibrated using the standard Europium (152Eu) source, which contains energies (121.8, 244.7, 344.3, 411.1, 444.6, 778.9, 964, 1085.8, 1112 ,1408 Kev) .

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Three energy calibration points were selected (121.8, 778.9 , 1408.0 keV) , It was introduced into the ICS-PCI 4K program to automatically calibrate.

2- **Efficiency Calibration**

The efficiency equation can be given as follows [10]

$$\varepsilon(E\gamma) = \frac{Net}{A \times I(E\gamma) \times T} \times 100\% \qquad \ldots\ldots\ldots\ldots(10)$$

The parameters □ (E□), I□(E□) and T are as defined in equation (1). A represents the specific efficiency of Bq / kg for the standard source used.

4. Results and Discussion

1) Specific Activity of samples

Six radioactive isotopes were detected in the Uranium-238 series, the thorium-232 and the potassium-40 ,Which is found in nature alone and isotope cesium -137, The specific activity of the bismuth-214 and lead-214 Adopted at the two energies (351.92,609.32 keV) as equivalent to the Specific Activity to the Uranium-238, By choosing the most value Specific activity. Specific activity of actinium-228, lead-212, and -talium-208 at energies (583.19, 238.63, 911.16 keV), as equivalent to the specific activity of thorium -232, The specific activity of Potassium-40 was adopted at (1460.8 keV), The specific activity of cesium-137 was adopted at (661.61 keV). The results were arranged in Table 1 according to the samples position in the streets of Tikrit city.

Table 1: Specific levels of effectiveness of different nuclei In the rising dust patterns in the streets of Tikrit

No. pos.	Specific Activity (Bq. kg^{-1})			
	^{238}U	^{232}Th	^{40}K	^{137}Cs
S1	5.2017±2.28	11.1702±3.34	198.4385±18.01	10.8843±3.3
S2	12.6337±3.55	11.2716±3.35	324.5470±18.01	7.1198±2.67
S3	5.2890±2.29	6.9878±2.64	238.7221±15.45	4.2035±2.05
S4	12.7728±3.57	26.7925±5.17	399.2213±19.98	11.1696±3.34
S5	11.8919±3.44	22.1541±4.70	272.8976±16.51	7.4464±2.73
S6	12.4636±3.53	23.7856±4.87	210.2179±14.49	1.3007±1.14
S7	14.3576±3.78	32.4763±5.69	162.0839±12.73	1.6856±1.3
S8	9.0755±3.01	10.0471±3.16	150.3998±12.26	4.3992±2.1
S9	8.0626±2.83	16.1124±4.01	381.4731±19.53	8.1632±2.86
S10	8.5438±2.92	12.8694±3.58	237.8313±15.42	5.3499±2.31
S11	13.2880±3.64	8.3439±2.88	313.4500±17.70	8.4547±2.91
S12	8.6572±2.94	8.2070±2.86	216.2488±14.70	8.8705±2.98
S13	8.8923±2.98	18.0493±4.24	268.7060±16.39	4.0001±2
S14	8.4687±2.91	17.5659±4.19	199.1538±14.11	1.9777±1.41
S15	9.1050±3.01	27.4179±5.23	292.6741±17.10	8.5519±2.92
S16	3.9351±1.98	3.8300±1.95	279.1419±16.70	11.0882±3.33
S17	11.9220±3.45	11.3995±3.37	228.8663±15.12	4.0001±2
S18	5.3692±2.31	21.7791±4.66	154.9912±12.44	5.3499±2.31
S19	2.8479±1.68	23.9584±4.89	113.1257±10.63	10.6998±3.27
S20	5.0283±2.24	28.2303±5.31	88.46673±9.40	0.7515±0.87
S21	6.9577±2.63	18.6227±4.31	166.0417±12.88	11.4364±3.38
S22	7.5984±2.75	12.6059±3.55	145.1865±12.04	1.2976±1.14
S23	17.2661±4.15	23.7657±4.87	160.4295±12.66	10.6797±3.27
S24	2.8998±1.70	10.2774±3.20	294.1640±17.15	9.6842±3.11
S25	9.2989±3.04	18.5568±4.30	182.1409±13.49	8.9566±2.99
S26	5.1784±2.27	12.2045±3.49	254.1441±15.94	9.4222±3.07
S27	12.1120±3.48	19.7758±4.44	243.2084±15.59	7.8993±2.81
S28	5.8388±2.41	18.7040±4.32	218.0301±14.76	3.3514±1.83
S29	4.8821±2.20	12.4783±3.53	195.0751±14.76	6.4963±2.55
S30	4.3286±2.08	22.9800±4.79	298.0959±17.26	6.2833±2.51
S31	8.7995±2.96	28.4672±5.33	227.7361±15.09	3.0061±1.73
S32	7.0710±2.65	27.1481±5.21	344.0677±18.54	5.9888±2.45
S33	4.1886±2.04	22.5313±4.74	179.8845±13.41	6.0526±2.46
S34	11.9377±3.45	5.0423±2.24	130.8191±11.43	6.4880±2.55
S35	6.8125±2.61	22.6094±4.75	350.0807±18.71	6.9092±2.63
S36	12.9963±3.60	8.0872±2.84	318.5611±17.84	9.7121±3.12
S37	4.43153±2.10	22.4644±4.73	174.6426±13.21	1.7343±1.32
S38	4.3643±2.08	26.5489±5.15	175.1816±13.23	2.7328±1.65
S39	6.1026±2.47	15.6743±3.95	289.8973±17.02	9.0911±3.02
S40	8.9868±2.99	5.8430±2.41	263.8906±16.24	6.0762±2.47
S41	9.8837±3.14	16.6879±4.08	280.0403±16.73	0.6441±0.8
S42	8.9022±2.98	9.8628±3.14	262.4244±16.19	1.4931±1.22
S43	17.4864±4.18	8.5811±2.92	249.1988±15.78	1.4931±1.22
S44	25.2843±5.02	14.0178±3.74	171.6780±13.10	5.1104±2.26
S45	7.9169±2.81	6.9666±2.63	258.6724±16.08	11.832±3.44
S46	8.8436±2.97	23.8241±4.88	215.7500±14.68	0.2966±0.54
S47	5.3342±2.30	17.0149±4.12	308.3197±17.55	5.0102±2.24
S48	14.5680±3.81	19.9033±4.46	129.0303±11.35	8.3964±2.9
S49	10.2145±3.19	11.5986±3.40	260.9088±16.15	6.3960±2.53
S50	13.7136±3.70	12.8504±3.58	262.7724±16.21	5.3290±2.31
av	5.2017±2.28	11.1702±3.34	198.4385±18.01	10.8843±3.3
Accepted limit [11]	35	30	400	14.8

from Table 1

a) The lowest value for the specific activity of 238U detected in the position (S19) (Bq / kg 2.84794 ± 1.68), the highest value (25.28436 ± 5.02 Bq / kg) in the (S44) position and the general rate of specific uranium activity (5.20172 ± 2.28 Bq / kg) The current results show that the specific activity rate of 238U, the dust of the city of Tikrit is lower than the global average quality of 238U (35 Bq / kg) [11].

b) The lowest value of 232Th in the measured samples was the lowest value (3.83001 ± 1.95 Bq / kg) in the position (S16), the highest value (32.47632 ± 5.69 Bq / kg) in the position (S7) and the general rate of thorium specific activity (11.17026 ± 3.34 Bq / kg). Current results indicate that the specific activity of 232Th in the dust of the city of Tikrit is lower than the global average of 232Th (30 Bq / kg) [11].

c) The lowest value of the specific activity of 40K in the measured samples with the lowest value (88.466734 ± 9.40 Bq / kg) in the position (S20) and the highest value (399.22131 ± 19.98 Bq / kg) in the position (S4) and the general rate of the specific activity of potassium (198.43853 ± 18.01 Bq / kg). Current results show that the specific activity of 40K in the dust of the city of Tikrit is lower than the global average quality of 40K (400 Bq / kg) [11].

d) The lowest value of the specific activity of 137Cs in the measured samples with the lowest value (0.49666 ± 0.54 Bq / Kg) in the position (S46) and the highest value was (11.8327 ± 3.44 Bq / kg) in the position (S45) and the general rate of the specific activity of 137Cs was(10.8843 ± 3.3). Current results show that the specific activity of cesium-137 in the dust of the city of Tikrit is lower than the global average quality of 137Cs (14.8 Bq / kg) [11].

Table 2: Radiation risk factors in the rising dust samples of Tikrit

S.No	Raeq (Bq.kg -1)	Dγ (nGy.h-1)	(AEDE)mSv.y-1		I_γ	H_{in}	H_{ex}
			in	out			
S1	35.066	17.42492	0.0976	0.0244	0.27867	0.1125	0.09844
S2	51.471	26.17849	0.1466	0.0366	0.41331	0.1793	0.14514
S3	31.992	16.61892	0.0931	0.0233	0.26429	0.1052	0.09091
S4	79.032	38.73126	0.2169	0.0542	0.61922	0.2555	0.22097
S5	62.675	30.25505	0.1694	0.0424	0.48275	0.2066	0.17441
S6	61.192	28.89083	0.1618	0.0404	0.46109	0.2029	0.16923
S7	72.145	33.00782	0.1848	0.0462	0.52854	0.2367	0.19789
S8	33.971	16.53304	0.0926	0.0231	0.26124	0.1191	0.09459
S9	57.807	29.36431	0.1644	0.0411	0.46919	0.1851	0.16331
S10	43.595	21.638	0.1212	0.0303	0.34421	0.1453	0.12223
S11	47.161	24.24967	0.1358	0.0339	0.38099	0.1692	0.1333
S12	35.531	17.97428	0.1007	0.0252	0.28395	0.1234	0.10004
S13	53.512	26.21511	0.1468	0.0367	0.41891	0.1736	0.14959
S14	47.529	22.82715	0.1278	0.032	0.36489	0.155	0.13212
S15	68.8	32.97145	0.1846	0.0462	0.53	0.2159	0.19132
S16	28.952	15.77156	0.0883	0.0221	0.25063	0.0941	0.08346
S17	44.244	21.93704	0.1228	0.0307	0.34605	0.156	0.12382
S18	47.363	22.09832	0.1238	0.0309	0.35691	0.1453	0.13082
S19	45.027	20.50397	0.1148	0.0287	0.33399	0.1314	0.12372
S20	51.59	23.0633	0.1292	0.0323	0.3748	0.1546	0.14098
S21	45.211	21.38654	0.1198	0.0299	0.34331	0.144	0.12523
S22	35.788	17.17876	0.0962	0.0241	0.27351	0.1199	0.09939
S23	62.481	29.02138	0.1625	0.0406	0.45972	0.2184	0.17178
S24	38.188	19.81395	0.111	0.0277	0.31822	0.1165	0.10868
S25	48.585	23.09972	0.1294	0.0323	0.36899	0.1598	0.13465
S26	40.421	20.36182	0.114	0.0285	0.326	0.128	0.11395
S27	57.416	27.68219	0.155	0.0388	0.44064	0.1924	0.15965
S28	47.848	23.08663	0.1293	0.0323	0.37132	0.1491	0.13333
S29	36.381	17.92712	0.1004	0.0251	0.28738	0.1151	0.10193
S30	58.057	28.31038	0.1585	0.0396	0.45739	0.1741	0.1624
S31	65.449	30.75622	0.1722	0.0431	0.49516	0.2048	0.18104
S32	69.978	34.01197	0.1905	0.0476	0.548	0.2146	0.19546
S33	49	23.04527	0.1291	0.0323	0.37316	0.147	0.13571
S34	28.306	14.01601	0.0785	0.0196	0.21722	0.1112	0.07893
S35	63.65	31.40187	0.1759	0.044	0.5049	0.1969	0.17849
S36	46.86	24.17297	0.1354	0.0338	0.37989	0.1677	0.13258
S37	48.781	22.89852	0.1282	0.0321	0.37062	0.147	0.13502
S38	54.592	25.35698	0.142	0.0355	0.41137	0.1625	0.15072
S39	48.81	24.37547	0.1365	0.0341	0.39069	0.1538	0.13728
S40	35.815	18.68533	0.1046	0.0262	0.29427	0.126	0.10171
S41	53.35	26.32347	0.1474	0.0369	0.41946	0.1761	0.14937
S42	41.376	21.0131	0.1177	0.0294	0.33293	0.1408	0.1167
S43	47.201	23.65334	0.1325	0.0331	0.36852	0.1795	0.1322
S44	57.347	27.30713	0.1529	0.0382	0.42319	0.2265	0.15815
S45	35.986	18.65215	0.1045	0.0261	0.29489	0.1235	0.10207
S46	58.015	27.47234	0.1538	0.0385	0.44103	0.1846	0.16074
S47	51.248	25.59836	0.1434	0.0358	0.41126	0.1586	0.14421
S48	52.062	24.13263	0.1351	0.0338	0.38217	0.1824	0.14305
S49	45.064	22.60462	0.1266	0.0316	0.35802	0.1542	0.12663
S50	50.484	25.05497	0.1403	0.0351	0.39511	0.1784	0.14131
Av	49.448	24.09311	0.1349	0.0337	0.38444	0.1624	0.13797
Accepted limit [11]	370	55	1	1	1	1	1

Evaluation of Radiological Hazard Effects for Soil Samples

From Table (2)

a) The lowest value of the radionuclide efficiency (Ra_{eq}) in the measured samples (28.306 Bq / kg) in the position (S34) and the highest value (79.032 Bq / kg) in the position (S4) and the general average of the radium equivalent (49.448 Bq / kg). The equivalent radium activity rate in the dust of the city of Tikrit is lower than the global average of the equivalent radium activity (370 Bq / kg) [11].
b) (D) in the increasing soil dose (14.01601 nGy / h) samples in the position (S34) and the highest value (38.73126 nGy / h) in the position (S4) and the general rate (24.09311 nGy / h). The rate of air intake in Tikrit is less than the global average of (55 nGy / h) [11].
c) The lowest annual effective dose of external exposure ($AEDE_{out}$) in the measured models (mSv / y 0.019622) for model (34 S), the highest value of (mSv / y 0.054224) for model (S4) and the general average of (0.0337 mSv / y). Current results show that the annual effective external dose rate in Tikrit is less than the global average of (1mSv / y) [11].
d) The lowest annual effective dose of internal exposure ($AEDE_{in}$) in the measured samples (0.0940 mSv / y) in the position (S16), the highest (0.2554 mSv / y) in the position (S4) and the general rate of (0.1624 mSv / y). The current results show that the annual effective dose rate in Tikrit is less than the global average of (1mSv/y) [11].
e) The minimum value of the external risk index (H_{ex}) in the measured samples (0.0789) in the position (S34), the highest value (0.2209) in the position (S4) and the general rate (0.1379) . H_{ex} in the city of Tikrit is less than the global average of (1) [11].
f) The lowest value of the internal risk index (H_{in}) in the measured samples (0.094) in the position (S16) and the highest value (0.255) in the position (S4) and the general rate (0.162405). Current results show that the rate of (H_{in})in the city of Tikrit is less than the global average of (1) [11].
g) The lowest value of the risk index for Gama(I_γ) was in the measured samples (0.217) in the position (S34), the highest value (0.619) in the position (S4) and the general rate (0.384). The current results show that the risk index for gama radiation in Tikrit Less than the global average of (1) [11].

5. Conclusions

1) The results obtained showed that most of the specific efficacy rates of the different neweeds were lower than the global average and indicated in the tables. However, there is a S7 model that indicates a level of specific radiation activity that is relatively higher than the global average for Th232 and we have no explanation for this
2) There was a discrepancy in the results of the one site and this confirms that the samples taken from the same site is a variable focus and means that the source is transferred from different areas due to prevailing winds and soil type.
3) The results of radioactive effects all are less than the rate allowed globally, but we believe that the accumulation may have a negative impact on public health because it will enter through the respiratory system .
4) The results obtained for the values of the specific activity and radiation risk factors are similar to the results of the reference [12].

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