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Radionuclides Concentration and Radiological Risk in the Dust Rising in Some Streets of Diwaniyah City Due to the Movement of Wheels and Cars

Khalid Hadi Mahdi[1], Raad Mahmoud Nassif[2], Kawthar Hassan Obayes[3]

University of Baghdad / College of Education for Pure Sciences / Ibn al-Haytham
[3]University of Qadisiyah / College of Education

Abstract: ***This research aims to calculate the concentration of radionuclides in the dust risining samples, from some streets in the big side of Diwaniyah city due to the movement of wheels and cars using Gamma- rays spectroscopy of purity germanium detector (HpGe) with resolution of (2.3keV) for the energy of the ^{60}Co (1.332 MeV). The 30 dust samples were collected from some of the streets in the big side of Diwaniyah , The average activity concentrations of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs in the samples were found to be (20.37928±4.5 , 20.46139±4.5 , 303.3944±17.4) Bq\kg respectively. The calculated radium equivalent (Ra_{eq}) was (72.46534) Bq/kg, the absorbed dose rate (35.47465 nGy / h), the external annual effective dose of exposure rate $ABCDE_{out}$ was(0.435 mSv/y), $ABCDE_{in}$ was(0.174024 mSv / y), the value of the external risk index (H_{ex}) was 0.200328 and the internal risk index (H_{in}) was (0.314272).***

Keywords: High purity Germanium Detector, Gamma Ray, Radon, Radioactivity

1. Introduction

The increase of population has led to a similar increase in environmental pollutants. Today's pollution is a mode problem and the world's major issue, especially countries that lack strict legislation or regulations to limit the increase in pollutant emissions into the environment. The study of air pollution is one of the most important branches of environmental chemistry because of the close correlation between air pollution with soil and water pollution through the fall of particulate matter. Suspended particles are very small minutes that are stuck in the air. Some of them carry many heavy metals radioactive nuclei and carcinogenic factors because of their small size, it can penetrated the respiratory tract and reaching the alveoli and accumulating in them causing multiple diseases [1].

Street dust is an important source in the generation of these particles and their release into the air by means of transport and air currents. It constitutes 33% of air pollutants, so the amount of dust and the quality of its contents is an indicator of environmental pollution in cities, and a source of hazardous air pollutants on the public health of the population ,and ecosystem components of these cities [2].

For the purpose of obtaining the nearest real values of the concentration of these nuclides and the consequences of radiation indicators This study focused on the dust rising as a result of movement, the possibility of inhalation is very large and as a result of the raising with small particle size that can enter the human body with un insignificant concentrations.

2. Location of Study Area

The province of Diwaniyah occupies the southern part of the Middle of the Mesopotamian plain, which is one of the provinces of the Middle Euphrates, bordered to the north by Babel province, to the south by Al-Muthanna province and from the east by Wasit and Dhi Qar provinces as shown in figure (1) .

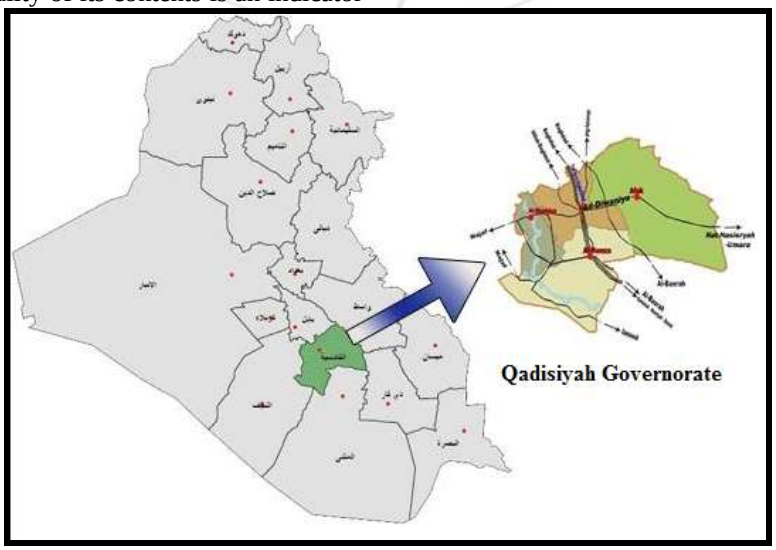

Figure 1: Geographical location of Qadisiyah Governorate

Al-Qadisiyah Governorate was chosen as a study area of 52 square kilometers divided by the Diwaniyah River into the two large and small parts. 30 samples of air aerosols distributed over some of the large part of the governorate were selected. Fignre.(2) shows the map of Diwaniyah City .

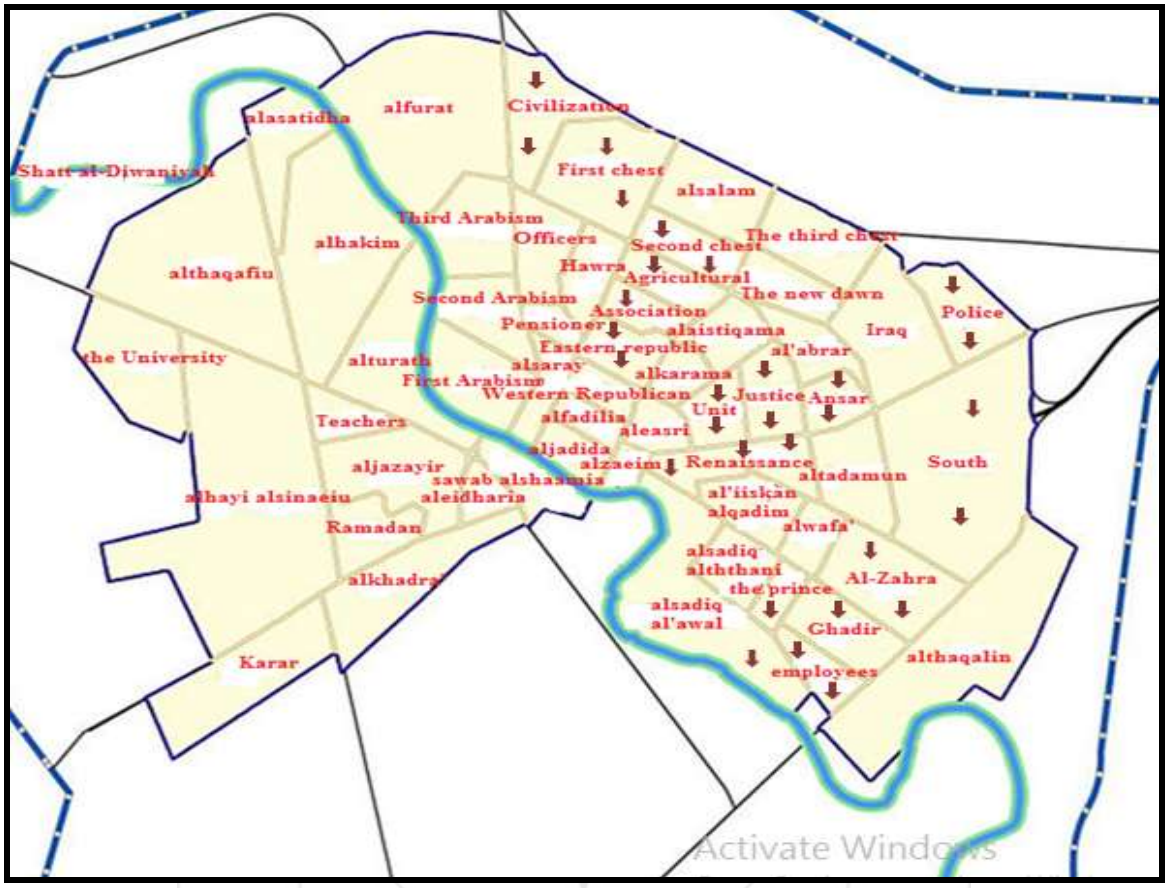

Figure 2: Shows the map of the districts of Qadisiyah Governorate (Diwaniyah)

3. Experimental

The natural and industrial radionuclide concentrations in the dust samples were measured using Gamma spectroscopy HpGe system, which is made up by CANBEERA company and the crystal size of "3 × 3", operating voltage of(- 3500) volts , efficiency of 40% and resolution of 2.3 keV at 1.332 MeV of cobalt - 60, the detector is covered with lead shield to protect it from the radiation background. as shown in figure (3) :

Figure 3: The measurement system

After collecting the dust samples from some of the streets of the Great House of Diwaniyah by 30 models by an electric device to pull dust and then preparing them for measurement by drying them at (100^0C) for two hours and grinding and sifting them with a 75µm sieve and keeping for one-month amputation for long radiation balance, and measured by gamma ray spectrometry:

1- **Energy Resolution**:

The cobalt-60 coupling, which has two gamma lines at the two energies (1173 keV, 1332 keV) and the cesium-137, which has a Gamma line at 661.6 keV, were used to measure the energy resolution by the following equation . [3]

$$\text{Resolution} = \frac{\Delta E}{\Delta Ch} \times F.W.H.M \qquad (1)$$

ΔCh :The difference between the location of the two peaks of the gamma- ray lines of the cobalt-60 in the channel

ΔE :The difference between line energy in (keV).

Figure (4) shows the energy spectrum of the cobalt-60 and the cesium-137 and the mid-peak energy of 1332 keV.

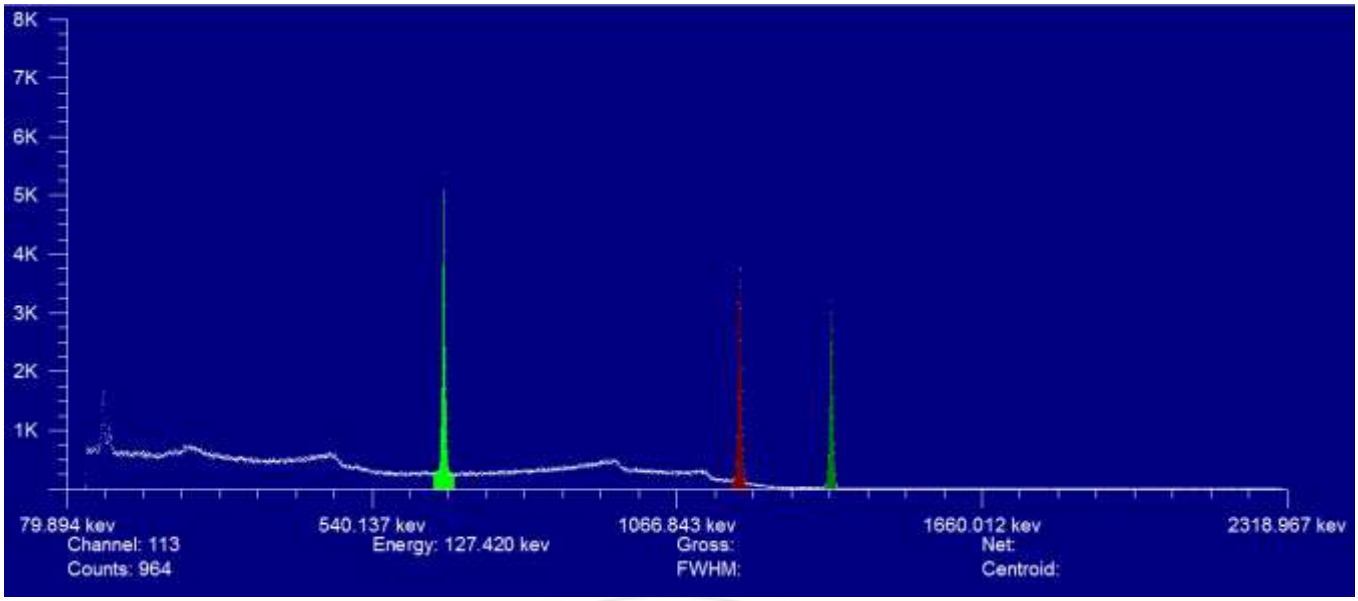

Figure 4: Shows the energy spectrum of the cobalt-60 and cesium-137 isotopes

After the measurement period was completed, it was found that:

$$R = 0.517\frac{keV}{ch} \times 4.61ch = 2.3keV$$

This value represents the energy resolution of the pure germanium detector.

2. Calibration of the measurement system:

Two calibration have been done for this system . The energy calibration and the efficiency calibration:

A- **Energy Calibration** :

Figure (5) shows the graph of the relationship between energy and the channel number:

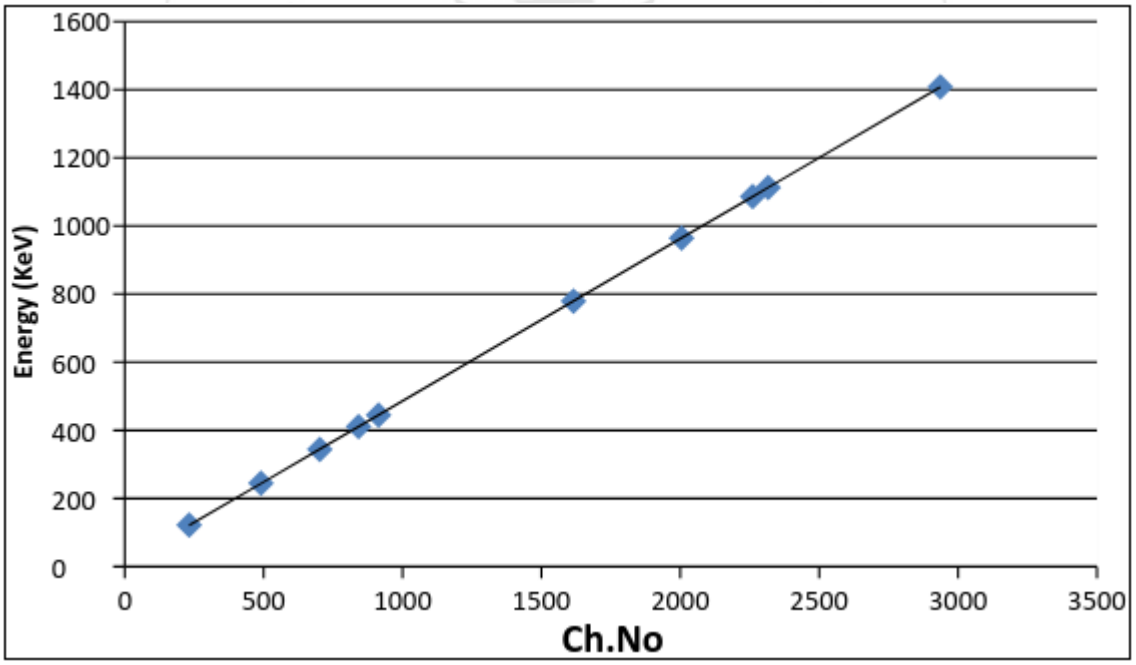

Figure 5: The graph of the relationship between energy and the channel number

B- **Background Measurement**:

Before any measurement of activity in any sample of background of system must be taken for the possibility of radioactive sources or polluting materials become a source of radiation. The background was measured in this study by placing an empty Peter dish [the same receptacle used to measure the (S.A) of the samples] for the same time , The area under the curve will subtracted from the recorded spectrum for samples the same energies [4] .

C- **Efficiency Calibration** :

The following equation was used to correct the specific activity of the standard source :

$$A = A_o e^{-\lambda t} \quad \text{.....(2)}$$

The recorded radioactivity was also measured by the detector for each energy of the source ^{152} Eu for three hours,

after that the efficiency (ε_f) was calculated by following equation [5].

$$\varepsilon_f = \frac{CPS}{S.A \times I_\gamma} \times 100\% \quad \ldots\ldots(3)$$

Where ε_f represents the efficiency of the detector, CPS is the count per second and we get it by dividing the net area under the peak of the selected energy on the measurement time (10800 s), I represents the relative intensity of each energy of the source of radiation, S.A represents the specific activity in Bq / kg unit .

The efficiency curve, was plotted as a function of the energy, which is shown in Figure 7. This curve enables us to assign the detector's efficiency to different energies and to any other radioactive source according to the following equation:

$$Eff(\%) = Y_0 + A_1 \times exp(-Z_1 \times E) + A_2 \times exp(-Z_2 \times E) \quad ..(4)$$

Y_0 = 0.042375 ±0.216 A_1= 1.4878 ± 0.19
Z_1= 0.0015259 ±0.000788 A_2 = 16.942±4.15
Z_2= 0.015727±0.00258

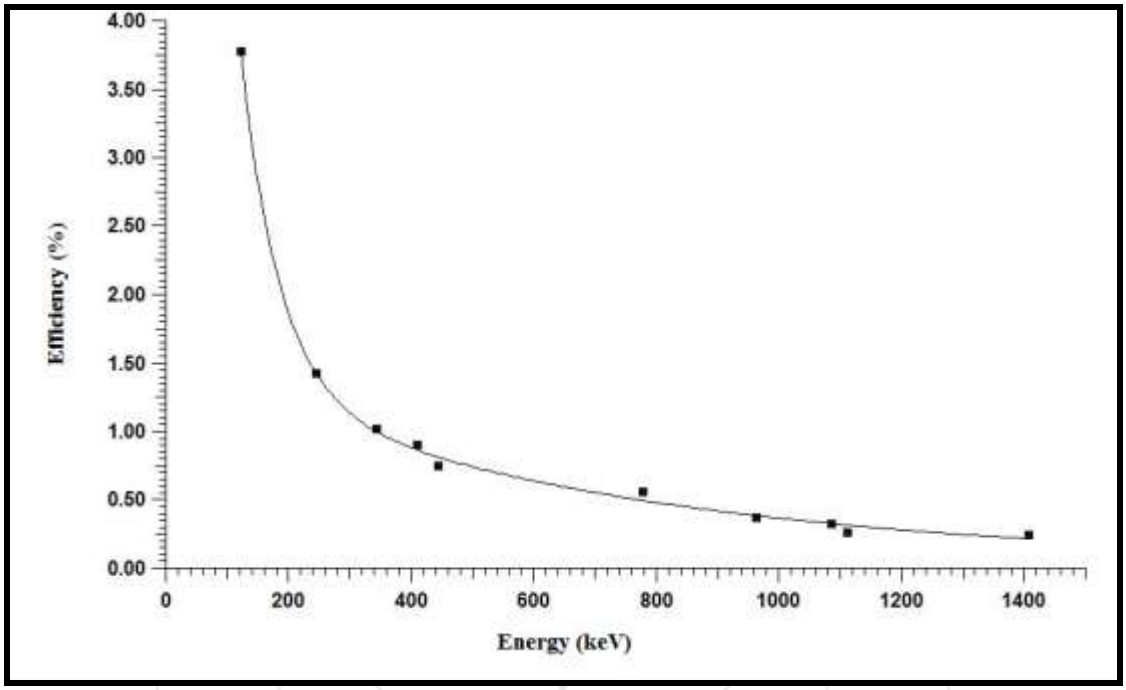

Figure 6: The efficiency curve for Eurobium-152 source

Specific Activity :

The specific efficiency was calculated by gentian the sample in Peter dish and placed it is installed on the detector and then recording the spectrum for 10800 sec . The specific activity of the sample calculated by following equation [5]:

$$A = \frac{N}{t \times I_\gamma \times \varepsilon \times M} \quad \ldots\ldots\ldots\ldots \quad (5)$$

A represents the specific activity , N is the net count under the peace, t represents the measurement time in seconds , I_γ represents the energy intensity of Gamma rays, the efficiency of the detector, M is the mass of the sample .

Depending on the specific activity, the risk factors were calculated:

A- Radium Equivalent]6[
B- Absorbed Dose]7[
C- The Annual Effective Dose]8[
D- External Hazard Index]9 [
E- Hazard Internal Index] 10[

Using the following equations:

$$Ra_{eq}\left(\frac{Bq}{Kg}\right) = A_u + 1.43A_{Th} + 0.077A_k \quad \ldots(6)$$

$$D_r\left(\frac{nGy}{h}\right) = 0.427A_U + 0.662A_{Th} + 0.0432A_K \quad \ldots.(7)$$

$$AED_{out}\left(\frac{\mu Sv}{y}\right) = D_r\left(\frac{nGy}{h}\right) \times 8760\left(\frac{h}{y}\right) \times 0.2 \times 0.7\left(\frac{SvG}{y}\right) \times 10^{-3} \ldots(8)$$

$$AED_{in}\left(\frac{\mu Sv}{y}\right) = D_r\left(\frac{nGy}{h}\right) \times 8760\left(\frac{h}{y}\right) \times 0.8 \times 0.7\left(\frac{SvG}{y}\right) \times 10^{-3} \ldots(9)$$

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad \ldots.(10)$$

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad \ldots\ldots.(11)$$

4. Results and Discussion

The specific activity (S.A) of the dust samples of some area in large side of Diwaniyah city was calculated using the high-purity germanium detector (HpGe). The radioactive nuclides belonging to the Uranium-238, thorium 232 series, and the potassium-40 as naturally radioactive, in addition to industrial nuclide cesium-137.Table 1 shows radioactive nuclides sensitized in dust by the detector.

Table 1: Radionuclides sensitized in dust samples

Series	Equivalent isotope	Half - life	E (keV)	I_γ (E_γ) (%)
Th^{232}	Pb^{212}	10.64 h	238.63	43.50
U^{238}	Pb^{214}	26.80 m	295.21	19.20
U^{238}	Pb^{214}	26.80 m	351.92	35.10
Th^{232}	Tl^{208}	3.07 m	583.19	30.58
U^{238}	Bi^{214}	19.90 m	609.32	44.60
…...	Cs^{137}	30 y	661.61	87.50
Th^{232}	Ac^{228}	6.13 h	911.16	26.60
……	K^{40}	1.2×10^9 y	1460.80	10.67

The energies of (295.21, 351.91,609.32) keV was used as a reward for the specific activity of uranium-238 by selecting

the most valuable efficacy, the energies of (583.19, 238.63, 911.16) keV as a reward for the specific activity of thorium-232 [11] , the energy of (1460.80) for ^{40}K , and the energy of (662.61) keV for ^{137}Cs , Table (2) shows the specific activity of the different nuclides in dust samples:

A) The lowest specific activity of uranium-238 was (6.825259 ± 2.6 Bq / kg) in the sample (S_5) in the (Second chest /the first location) and the highest value was (37.42724 ± 6.1 Bq / kg in the sample(S_{22}) in (South sector / First location) and the average rate of specific activity was (20.37928 ± 4.5 Bq / kg).Current results show that the specific activity of uranium-238 in dust samples in Diwaniyah is below the global average of the specific effectiveness of uranium-238 (35 Bq / kg) [12].

B) Specific activity of thorium-232 in dust sample shams low value (9.841936 ± 3.1 Bq / kg) in sample (S_{14}) in (Sector Renaissance / Second location)and the highest value was (30.30835 ± 5.5 Bq / kg) S) in the sample (S_{11}) (Sector Unit/ first location) and the average rate of Thorium specific activity was (20.46139 ± 4.5Bq / kg). Current results show that the specific activity of thorium-232 in dust sample in Diwaniyah is lower than the global average of thorium-232 (30 Bq / kg) [12].

C) The low value of ^{40}K was (212.953 ± 13.071 Bq / kg) in model (S_2) in (civilization sector / second location) and the highest was (564.0522 ± 23.7 Bq / kg) in sample(S_{21}) in (police sector / second locality), and the average specific activity was (303.3944 ± 17.4 Bq / kg). Current results show that the specific activity of potassium-40 in dust rising sample in Diwaniyah is lower than the global average quality of Potassium- 40 (400 Bq / kg) [12].

D) The low specific activity of cesium-137 was (0.526373 ± 0.7 Bq / kg) in sample (S_4) in (Sector First chest / Second location) and the highest value was (12.27503 ± 3.5 Bq / kg) in the sample (S_{22}) (Sector South/ first location), with average value of cesium (6.258451 ± 2.5Bq / kg). Current results show that the specific activity of cesium-137 in dust samples were lower than the global average quality of cesium-137 (14.8 Bq / kg) [12].

Table 2: Shows the specific efficacy levels of the different newids in aerosol models

No.	Location	U-238 (Bq/kg)	Th-232 (Bq/kg)	K-40 (Bq/kg)	CS-137 (Bq/kg)
S_1	Sector Civilization/ first location	21.19358±4.6	10.22789±3.2	196.8988±14.0	5.287817±2.3
S_2	Sector Civilization / Second location	25.58937±5.1	13.91449±3.7	117.8792±10.9	10.58192±3.3
S_3	Sector First chest/ first location	24.97495±5.0	17.38742±4.2	303.3917±17.4	10.04321±3.2
S_4	Sector First chest / Second location	14.00173±3.7	22.96452±4.8	427.3123±20.7	0.526373±0.7
S_5	Second chest/ first location	6.825259±2.6	25.91394±5.1	139.6982±11.8	1.609488±1.2
S_6	Second chest/ Second location	9.145944±3.0	17.79815±4.2	383.5716±19.6	5.857804±2.4
S_7	Sector Agricultural sector/ first location	32.1486±5.7	17.38742±4.1	264.9336±16.3	11.15912±3.3
S_8	Sector Association / first location	28.07043±5.3	21.73427±4.7	205.1099±14.3	7.253426±2.6
S_9	Sector Eastern republic/ first location	19.34643±4.4	23.63339±4.9	477.0962±21.8	0.541705±0.7
S_{10}	Sector Eastern republic / Second location	11.35614±3.4	11.21769±3.3	120.6123±10.9	7.649395±2.7
S_{11}	Sector Unit/ first location	12.67516±3.7	30.30835±5.5	227.3772±15.1	10.74961±3.3
S_{12}	Sector Unit/ Second location	18.21881±4.3	28.13662±5.3	183.1338±13.5	5.490994±2.3
S_{13}	Sector Renaissance/ first location	14.05598±3.7	23.54344±4.9	342.696±18.5	1.841439±1.3
S_{14}	Sector Renaissance / Second location	15.28976±3.9	9.841936±3.1	326.5311±18.1	11.75567±3.4
S_{15}	Sector Renaissance/Third location	23.93849±4.9	21.97388±4.7	283.4646±16.8	4.051165±2.0
S_{16}	Sector Ansar / first location	12.75316±3.5	21.11587±4.6	529.8672±23.0	8.183353±2.8
S_{17}	Sector Ansar/ Second location	24.90621±4.9	27.17947±5.2	168.6759±12.9	5.710075±2.3
S_{18}	Sector Justice / first location	17.47337±4.1	15.4501±3.9	473.5082±21.7	9.885705±3.1
S_{19}	Sector Justice/ Second location	16.20715±4.0	20.8649±4.6	478.5897±21.9	0.371971±0.6
S_{20}	Sector Police/ first location	25.77202±5.1	24.34239±4.9	286.2992±16.9	0.557956±0.7
S_{21}	Sector Police / Second location	18.59836±4.3	17.79053±4.2	564.0522±23.7	5.393573±2.3
S_{22}	Sector South/ first location	37.42724±6.1	17.14961±4.1	307.6648±17.5	12.27503±3.5
S_{23}	Sector South / Second location	21.25527±4.6	21.73427±4.7	346.1229±18.6	5.951529±2.4
S_{24}	Main street Diwaniya - Afak/ first location	32.94567±5.7	25.21176±5.0	132.4668±11.5	7.811382±2.7
S_{25}	Sector Al-Zahra / first location	23.44332±4.8	21.30811±4.6	506.9096±22.5	4.376124±2.1
S_{26}	Sector Al-Zahra / Second location	25.77202±5.1	19.16721±4.3	525.5941±22.9	10.78715±3.3
S_{27}	Sector Ghadir/ first location	23.91218±4.9	17.38742±4.2	149.5593±12.2	11.71707±3.4
S_{28}	Sector employees / first location	16.88503±4.1	27.6107±5.3	267.5694±16.3	3.823997±1.9
S_{29}	Sector employees/ Second location	23.3808±4.8	21.32893±4.6	346.1229±18.6	2.045838±1.4
S_{30}	Sector the prince / first location	13.81593±3.7	24.34239±4.9	517.0478±22.7	4.463647±2.1
	Average	20.37928±4.5	20.46139±4.5	303.3944±17.4	6.258451±2.5
	World average [12]	35	30	400	14.8

Table (3) shows that the lowest value of Ra_{eq} in dust sample was (36.68459Bq / kg) for sample (S_{10}) (Sector Eastern republic/ Second location) and highest in sample (S_{26}) (Sector Al-Zahra / Second location) (93.65188 Bq / kg) The current results show that the average radium efficiency rate in the city of Diwaniyah is lower than the global average of the equivalent radium activity (370 Bq / kg) [12].

And the lowest value of the air-absorbed dose (D_r) in air aerosol models (16.01904nGy / h) in sample (S_2) (sector civilization / second location) and the highest value of

(46.39901nGy / h) in sample (S_{26}) (Sector Al-Zahra / Second location) with average value (35.47465 nGy / h) . The current results show that the of absorb dose is below the global average of (55 nGy / h) [12].

The lowest annual mean effective dose of external exposure ($AEDE_{out}$) in dust rising sample was (0.019646mSv / y) for sample (S_2) (civilization sector / second location) and highest was (0.06904mSv / y) for sample (S_{26}) (Al-Zahra sector / second location) and the average (0.043506mSv / y). Current results show that the annual effective external dose rate in Diwaniyah is less than the global average of (1 mSv / y) [12].

The lowest annual effective dose of internal exposure ($AEDE_{in}$) in dust rising sample was (0.078583mSv / y) for sample(S_2) (civilization sector / second location) and highest was (0.277615 mSv / y)for sample (S_{26})(Sector Al-Zahra / Second location) , (mSv / y 0.174024). Current results show that the annual effective dose rate in Diwaniyah city is less than the global average of(1 mSv / y) [12].

The lowest value of the external risk index (H_{ex}) in dust sample (0.099079) for sample (S_{10}) (eastern republican sector / second location) and the highest value was (0.25293) for sample (S_{26}) (Zahra sector / second location) with average value of (0.200328) , Current results show that the rate of external risk index in the city of Diwaniyah is less than the global average of (1) [12].

The lowest value of the internal risk index (H_{in}) in the dust sample (0.129771) for sample (S_{10}) (the eastern republican sector / second site) and the highest value of (0.332488) for sample (S_{22}) (South sector / first location) with average value of (0.314272)). Current results show that the rate of internal risk index in the city of Diwaniyah is less than the global average of (1) [12].

Table 3: Shows the risk factors for aerosol models

No.	Location	Ra_{eq} (Bq/Kg)	D_r ($nGy.h^{-1}$)	Out AED ($mSv.y^{-1}$)	In AED ($mSv.y^{-1}$)	H_{in}	H_{ex}
S_1	Sector Civilization/ first location	50.98068	24.32655	0.029834	0.119336	0.194985	0.137705
S_2	Sector Civilization/ Second location	54.5638	16.01904	0.019646	0.078583	0.216552	0.147391
S_3	Sector First chest / first location	73.20012	35.28129	0.043269	0.173076	0.265208	0.197708
S_4	Sector First chest / Second location	79.74403	39.64114	0.048616	0.194464	0.253189	0.215347
S_5	Second chest/ first location	54.63896	26.10438	0.032014	0.128058	0.16599	0.147544
S_6	Second chest /Second location	64.13231	32.25799	0.039561	0.158245	0.197901	0.173182
S_7	Sector Agricultural sector/ first location	77.4125	36.68306	0.044988	0.179952	0.295989	0.209101
S_8	Sector Association / first location	74.9439	35.23491	0.043212	0.172848	0.278291	0.202425
S_9	Sector Eastern republic/ first location	89.87857	44.51678	0.054595	0.218382	0.295012	0.242725
S_{10}	Sector Eastern republic / Second location	36.68459	17.48564	0.021444	0.085778	0.129771	0.099079
S_{11}	Sector Unit/ first location	73.52414	35.29911	0.043291	0.173163	0.232807	0.19855
S_{12}	Sector Unit/ Second location	72.55547	34.31725	0.042087	0.168347	0.245189	0.195949
S_{13}	Sector Renaissance/ first location	74.11069	36.39213	0.044631	0.178525	0.238126	0.200137
S_{14}	Sector Renaissance / Second location	54.50662	27.15023	0.033297	0.133188	0.188533	0.147209
S_{15}	Sector Renaissance/Third location	77.1879	37.01411	0.045394	0.181576	0.273171	0.208472
S_{16}	Sector Ansar / first location	83.74863	42.31457	0.051895	0.207578	0.246228	0.21176
S_{17}	Sector Ansar/ Second location	76.76089	35.91456	0.044046	0.176182	0.274636	0.205437
S_{18}	Sector Justice / first location	76.02714	38.14465	0.046781	0.187122	0.252546	0.205321
S_{19}	Sector Justice/ Second location	82.89537	41.40809	0.050783	0.203132	0.267665	0.215843
S_{20}	Sector Police/ first location	82.62667	39.48744	0.048427	0.19371	0.292816	0.223162
S_{21}	Sector Police / Second location	87.47084	44.08589	0.054067	0.216268	0.286488	0.236222
S_{22}	Sector South/ first location	85.64137	40.62559	0.049823	0.199293	0.332488	0.231333
S_{23}	Sector South / Second location	78.98675	38.4166	0.047114	0.188456	0.270769	0.213322
S_{24}	Main street Diwaniya - Afak/ first location	79.19843	36.48055	0.04474	0.178959	0.302967	0.213925
S_{25}	Sector Al-Zahra / first location	92.94596	46.01476	0.056433	0.22573	0.314378	0.251018
S_{26}	Sector Al-Zahra / Second location	93.65188	46.39901	0.056904	0.227615	0.322584	0.25293
S_{27}	Sector Ghadir/ first location	60.29226	28.18193	0.034562	0.138249	0.227481	0.162854
S_{28}	Sector employees / first location	76.97117	25.63586	0.03144	0.125759	0.253503	0.207868
S_{29}	Sector employees/ Second location	80.53263	39.05586	0.047898	0.191592	0.280693	0.217501
S_{30}	Sector the prince / first location	88.43822	44.35053	0.054391	0.217566	0.276161	0.238821
	Average	72.46534	35.47465	0.043506	0.174024	0.314272	0.200328
	World average [12]	370	55	1	1	1	1

5. Conclusion

1) The results showed that most of the specific activity of the different dust sample were lower than the global average. However, in some areas the activity was close to the global average for U 238, Th 232 and Cs 137 and higher than the global average For K-40 and within experimental error.
2) The results of variance for the same location that confirms this work about the variation of dust concentration and that the soil was from different sources which transferred by wind.
3) From the results of radiation indicators, the absorbed dose rate was close to the global average while the other indicators were less.

4) The specific activity and radiation indicators were lower than the global limits, we believe that the accumulation may have a negative impact on public health.

6. Recommendation

And we propose to conduct the process of paving the streets or at least sprayed with water to reduce environmental damage while conducting periodic monitoring of dust pollutants and support this study geological surveys and geochemical studies of the region.

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