Determination of Natural Isotope and Radionuclide of Out Door High Dose Rate in Garmik Area-kurdistan Region NE-Iraq.

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Abstract

Radioactive materials, containing high-count rate, are found in some areas in the world which have worldwide use as construction and facing material. The radiation doses, in the Garmik area, are about 268.6 nGy h⁻¹, which are density population by residents of ten of villages and two towns.

The outdoor terrestrial gamma-ray background in some region of Garmik area was studied in order to determine the absorbed gamma dose rates of the soils and rocks. Gamma ray spectra have been recorded using the advance nuclear measurement system (digital spectroscopy analyzer DSA with NaI (TI) detector). This method is very suitable for measuring outdoor gamma radiation dose because the gamma count and human -radiation exposure will not be lost by the method by which the whole radiation exposure has been determined. A new equation has been formulated for this method. The total dose rates inside Sulaimani city was (42.873) nGy h⁻¹ considered as a normal local outdoor dose rate (background).

The average values of outdoor dose rates of the studied samples, in Tatan, Hangazhal and Garmik areas have been found to be (226.1005, 257.477,322.541) nGy h⁻¹ respectively. These values are nearly 6 times greater than the normal local outdoor dose rate of the background of Northeastern Iraq. The dose rate of each radioactive elements or isotopes have been determined for each spectrum of each mentioned area which are equal to 8.4554, 67.0995, 66.9057, 50.6143 nGy h⁻¹ for Sulaimani city, Tatan, Hangazhal and Garmik respectively. The total rate of radionuclide is about 77.22% of total outdoor dose rate.

Introduction

Garmik area is located in the extreme northeast of Iraq and about 60km to the northeast of Sulaimani city near the border with Iran Fig.1. The area situated between the latitude 35°43’28.63`` N and longitude (45°57’00.85``) E and with the elevation of 4092 feet from mean sea level (msl). The area covers about 200km², which consists low grade of metamorphic rocks (phyllite) which are derived from metamorphism of pelletic sedimentary rocks (shale) as shown in Fig 2.
In literatures, the natural background radiation defined as cosmic, radon gas and terrestrial radiation. They mentioned that the external radiation exposure attributed mainly to cosmic rays and terrestrial radionuclide that are occurring at trace levels in all rocks and soils (UNSCEAR, 2000). Average outdoor absorbed dose rate of the world value, in the air, is 44 nGy h$^{-1}$ (Daryoush, 2003). The specific levels of the terrestrial background radiation are related to the types of rocks from which the soils originated. Therefore, the natural environmental radiation mainly depends on geological and geographical conditions. Higher radiation levels are associated with igneous rocks, such as granite, and lower levels with sedimentary rocks. There are exceptions, however, as some shale and phosphate rocks have relatively high content of radionuclide (Michalis, 2003).

Cosmic radiations vary according to height from ground regularly in all location on the world, but the terrestrial radiation vary from small area to another which depend on rock layer components. Therefore, different count rates and dose rates have been recorded in the studied area, which shows anomalies (high dose rate) in Garmik area comparing with Sulaimani city (area of the background) in which normal local outdoor dose is measured.

The gamma radiation dose rate of the mentioned area must be oriented as a national interest and duty of the Regional Government of Kurdistan and Iraq for which the Iraqi Authority has established National Establishment for Radiation Protection. Moreover of late, the local governorates (i.e. Kurdistan Region) now trying to establish local office for this purpose. Several works have done TUFAIL (2000) used a NaI(Tl) detector with gamma ray spectrometer employing the spectrum stripping technique for determining the values of whole body equivalent dose and got 27-108 nGy/h range in Pakistan marble Shagjamba (2006) used portable scintillation spectrometry with 3×3 NaI (Tl) detectors for measuring the external outdoor radiation level and terrestrial gamma dose rate for urban environments in Mongolia and found equal to 86.9 ± 15.0 nGy/h Seiichi (2003) used pocket gamma ray dosimeters and a handy neutron rem counter for measuring terrestrial gamma ray dose rate which was nearly equal 0.45 mSv/y Dragović (2006) studied the gamma dose rates due to naturally occurring terrestrial radionuclides (Ra$^{226}$, Th$^{232}$ and K$^{40}$). Their calculations were based on radioactivity in collected soil samples from 21 different regions of Serbia and Montenegro, the measured gamma dose rates, was ranged from (7.40 to 29.7) nGy/h for Ra$^{226}$; from (12.9 to 46.5) nGy/h for Th$^{232}$ and from (12.5 to 37.1) nGy/h for K$^{40}$. They mentioned that, the total absorbed gamma dose rate due to these radionuclides varied from (34.5 to 97.6) nGy/h with mean of 66.8 nGy/h.
Uosif (2007) selected sedimentary samples from different locations on the east and west banks of the Nile River in Upper Egypt, he found that the samples were contained Ra, Th and K in concentrations up to (52±7.3), (76.2±6.2) and (351.9±17.6) Bq/kg, respectively. Al-Ghorabie (2005) employed CaSO4:Dy (TLD-900) thermo-luminescent dosimeters for the detection of terrestrial gamma radiation at three different mountainous locations in the three locations: Al-Taif city, Al-Hada village and Ash-Shafa village, in the western region of the Saudi Arabia, he cited that, the average gamma radiation dose rates were 468, 541, and 781 µGy/y for At-Taif city, Al-Hada village and Ash-Shafa village, respectively. Merdanoğlu (2006) used HPGe detector for determining external hazard index and terrestrial absorbed dose rate for Th\textsuperscript{232} and U\textsuperscript{238} in the area of Kestanbol (Canakkale), Turkey, they recorded the dose of 1.4 nGy/h and 219 nGy/h, respectively for the two mentioned radionuclide, Patricia (2007) studied external natural radiation, cosmic and terrestrial components, by using NaI scintillation counters while driving along the roads in Costa Rica for the period July 2003–July 2005. The average air-absorbed dose for the terrestrial component was 29.52±14.46 nGy/h.

Fig.1: Geological and location map of the Shalair valley (northeast Iraq) has the high count rate from phyllite rock.
Fig.2: Two photos of the weathered (left) and fresh outcrop phyllite metamorphic rock with high count rate at Shalair valley (northeast Iraq)

**Experimental Procedure**

**Gamma-ray detection system:**

High-efficiency spectroscopic system has been used for the measurement of the energy spectrum of the emitted gamma rays in the energy range between 10 keV and 2000 keV. The system consists of a scintillation (NaI(Tl)) detector (with crystal size 2inch × 2inch) Experimental arrangement for spectra collection includes detector and signal processing electronics, which is consisted of digital spectroscopy analyzer-DSA with characteristics of multi functions spectroscopy amplifier, single channel analyzer-SCA, multi channel analyzer and personal computer with Genie2000 soft ware program as shown in Fig.3. The employed DSA-1000 is a full featured 16K channel integrated Multi-channel Analyzer based on advanced digital signal process in techniques (DSP). When it is paired with the suitable computer, the DSA-1000 becomes a complete spectroscopy workstation, capable of high quality acquisition and analysis (Canberra, 2001; Genie, 2004).

![Fig.3: Shows the schematic diagram of the setup.](image)

**Spectra collection of ground (soil and Rock):**

The preparation was started by putting the standard source (Cs-137) of activity 18.6 mBq under the detector, which is shielded by cylinder of Pb with 50mm thickness. The detector is modulated to the DSA, which in turn
modulated to computer via Genie (2000) software program and then the high voltage were adjusted to 900V by activating a MCA-adjust in new window in the gamma spectrum software. After collecting spectrum for two hours the energy calibration of the source has been done through window in gamma spectrum software.

**Data collection:**

The radiation in the mentioned areas were detected by portable detector (BGO), more than 200 count /sec. were accumulated. Also the gamma detection system were operated by putting the detector window on the ground which consists of soil and phyllite for the three areas (Hangazhal, Garmik and Tatan) spectra is recorded for two hours in each areas of high anomaly and in the area of background in the Sulaimani city directly as shown in Figs(4,5,6 & 7).

![Spectral Data Plot](image-url)

**Fig .4:** Background natural radiation from rock and soil of Sulaimani city- Sardarawa.
Fig. 5: Background of natural radiation from rock and soil of Tatan village.

Fig. 6: Background of natural radiation from rock and soil of Hangazhal village.
Fig.7: Natural Background radiation from rock and soil of Garmik town.

**Direct detection theory:**

The aim of this work is to determine gamma radiation exposure on human directly, thus this process need new suitable formula, which directly measures gamma spectrum and whole energy of exposure radiation. Several factor and parameter have been used for reducing energy loss also. In order to get an exposure radiation equation of the area, the following equations have been modified by adding several factors and then formulating new equation as shown below. The new formula does not contain mass of radioactive material because this was the only possible direct measurement to achieve in the areas. The distance was neglected as equation (1) because the detector was located on the soil of areas.

\[
Exposure\ rate = 6 \times C \times E \times N \quad \text{(1)} (\text{James, 2000})
\]

Where: \(C\) = source activity in Curie (Ci), \(E\) = gamma energy in MeV, \(N\) = No. of gamma photons per disintegration (photon yield). Hereafter, the new formula contains factors like (efficiency, geometry factor and mass of human). In this work, the exposure could not be considered from a point source because many factors to be added if so, to equation (1);

\[
Exposure\ rate (X) = A_{up} \times E_p \quad \text{(2)}
\]

\(A_{up}\) = Area under peak,

\(E_p\) = peak energy/sec

Where \(C\) in the equation is replaced by the area under peak of the spectrum in the equation (1) it means that the radiation comes from all.
around, the energy of each peak in the outdoor spectrum was used instead of unique energy of the source and factor N, can be neglected because NaI(Tl) detector recorded gamma and x-ray only. The multiplied integer 6 was removed from the equation because there are many sources in different distances; therefore the inverse square law is not applied for the point source equation. This means that equation (2) does not contain distance factor. Equation (2) then multiplied by total time \( T_{total} \) to obtain the total energy during one year. It will be directly proportional to the exposure rate. Therefore measuring exposure radiation per one hour doesn’t need to add \( T_{total} \). Then new equation we obtained.

\[
Exposure\ rate\ (X) = A_{up} \times E_p \times T_{total} \quad \ldots\ (3)
\]

Another two factors must be added which are:

G-factor must be added to the equation in order to decrease the energy loss due to the difference between the area of the scintillation counter and the human body. Since G-factor can be defined as the ratio between the area of the human body \( \approx \) rectangular area and the area of the scintillation counter.

\[
G = \frac{A_{Human}}{A_{Detector}} \quad \ldots\ (4)
\]

Where \( A_{Human} = \) average human body area \((6080\ \text{cm}^2 = 0.608\ \text{m}^2)\). \( A_{Detector} = \) detector area which is found by the area of the circle with radius: \( r = 2.54\text{cm} \), \( G \approx 300\)

\[
Exposure\ rate\ (X) = A_{up} \times E_p \times T_{total} \times G \quad \ldots\ (5)
\]

By adding the efficiency factor to the relation (5) one gets;

\[
Exposure\ rate\ (X) = \frac{A_{up} \times E_p \times T_{total} \times G}{\xi_{eff}} \quad \ldots\ (6)
\]

Another factor to be considered which added to the equation is the accumulation time (2 hours) of detecting counts by the scintillation detector.

\[
Exposure\ rate\ (X) = \frac{A_{up} \times E_p \times T_{total} \times G}{2 \times \xi_{eff}} \quad \ldots\ (7)
\]

The above equation represents total energy of the spectrum in order to convert it to dose rate which it must be divided by the human body mass. The average weight of the human assumed to be (70Kgs).

The absorbed dose \( (D) = \) exposure rate of radiation\( (X) \), Mass \( (m) \).

\[
Absorbed\ dose\ (D) = \frac{A_{up} \times E_p \times T_{total} \times G}{2 \times \xi_{eff} \times W_{average}} \quad \ldots\ (8)
\]
The summation must be added to obtain the absorbed dose of each area of the peaks which containing the spectrum.

\[
\text{Absorbed dose (D)}_{\text{position}} = \sum_{i}^{n} \frac{A_{(i)up} \times E_{(i)p} \times T_{\text{total}} \times G}{2 \times \xi_{(i)eff} \times W_{\text{average}}} \quad \ldots (9)
\]

To obtain the equivalent dose (D_E) in rem, absorbed dose (D) is multiply by quality factor (Q=0.7) and the final equation became as shown below.

\[
\text{Equivalent dose (D_E)}_{\text{position}} = \sum_{i}^{n} \frac{A_{(i)up} \times E_{(i)p} \times T_{\text{total}} \times G}{2 \times \xi_{(i)eff} \times W_{\text{average}}} \times Q \quad \ldots (10)
\]

Dose radiation detection by equation (10) had exactly the same to the measuring dose rate by wallac-instrument (universal survey meter RD-8).

**Method of calculation of dose rate:**

Each measured γ-ray spectrum has been analyzed by a dedicated software program (Gamma analyzer – Genie 2000), which performs a simultaneous fit to all the significant photopeaks appearing in the spectrum and obtaining best spectrum optimization. Menu-driven standard reports are available as a summary which includes peak number, centroid channel, energy, net area counts, background counts, FWHM, radionuclide identification and half life time as selected by using scroll of each peaks in the spectrum. Moreover, the summery include the average activity in Bq, error ratio, peak fitting for each detected radionuclide. The report can be printed for each spectra of a certain region as shown in tables (1, 2, 3, & 4).

Using hard wares: Digital Spectroscopy Analyzer –DSA and software program Genie 2000 the best spectrum optimization were obtained.

One of the characteristic of gamma analyzer software is smart analyzing work. The NaI(Tl) detector ( as example in this study which has rare resolution energy between(6-8) Kev) are used with DSA and Genie 2000 software cause to reduce the resolution energy to 2 Kev as shown in Table 4.Therefore, the isotopes or radionuclide of spectrum could be distinguished easily as shown in Tables (9, 10, 11, & 12). Radionuclide specification could be determined by using a method of comparison between software program nuclear data sheet (NDS) and peak energy of spectrums .The difference between software energy peak of radionuclide and spectrum peak energy is reduced to 1.6 KeV as shown in Tables (9,10,11,& 12).

Generally total exposure dose rate of all peaks with background of each spectra of these three areas have been calculated by using equation (9)as shown in tables (5,6,7 & 8). In the other side, the activity and exposure dose of each peak in the spectrum of isotope or radionuclide have been calculated by using equation (10) as shown in tables (9,10,11,&12).
Table 1: Peak energy versus radionuclide count rate by using soft standard analysis report to collect data spectra of Sulaimani city-Sardarawa.

| PK | ID | Area under peak | Area under peak | Peak background | FWHM | Channel | Left | PW | Counts/Sec |
|----|----|----------------|----------------|----------------|------|---------|------|----|------------|
| 1  |    | 55.16          | 4673           | 30559          | 16.92| 49.24   | 42   | 31 | 1.3E+000   |
| 2  | Xe$^{133}$ | 69.83          | 1831           | 25182          | 7.18 | 57.68   | 42   | 31 | 7.3E-001   |
| 3  | Ac$^{228}$ | 81.19          | 2623           | 38757          | 15.00| 64.21   | 42   | 31 | 2.9E-001   |
| 4  |      | 208.20         | 1032           | 18049          | 19.45| 137.24  | 127  | 29 | 3.6E-001   |
| 5  |      | 213.54         | 1281           | 22277          | 19.85| 140.31  | 127  | 29 | 3.6E-001   |
| 6  | Pa$^{234}$ | 227.43         | 658            | 11751          | 20.93| 148.30  | 127  | 29 | 1.8E-001   |
| 7  | Br$^{82}$ | 555.66         | 1558           | 7066           | 38.84| 337.03  | 313  | 51 | 4.3E-001   |
| 8  |      | 590.23         | 568            | 1908           | 23.92| 356.92  | 313  | 51 | 1.6E-001   |
| 9  |      | 1245.41        | 517            | 1975           | 57.86| 733.63  | 703  | 65 | 1.4E-001   |
| 10 |      | 1339.96        | 172            | 971            | 54.97| 788.00  | 767  | 94 | 4.8E-002   |
| 11 |      | 1360.62        | 1200           | 1284           | 49.85| 799.88  | 767  | 94 | 3.3E-001   |
| 12 |      | 1406.04        | 808            | 987            | 56.30| 826.00  | 767  | 94 | 2.2E-001   |

Table 2: Peak energy versus radionuclide count rate by using soft standard analysis report to collect data spectra of Tatan Village.

| PK | ID | Peak energy /KeV | Area under peak | Peak Background | FWHM | Channel | Left | PW | Counts/Sec |
|----|----|-----------------|----------------|----------------|------|---------|------|----|------------|
| 1  | Th$^{227}$ | 49.78           | 7351           | 48162          | 6.56 | 46.15   | 43   | 32 | 2.0E+000   |
| 2  | Th$^{232}$ | 58.52           | 27860          | 165752         | 18.93| 51.17   | 43   | 32 | 7.7E+000   |
| 3  | Pb$^{212}$ | 76.63           | 21886          | 268339         | 23.89| 61.58   | 43   | 32 | 6.1E+000   |
| 4  |      | 94.10           | 1266           | 70837          | 4.30 | 71.63   | 43   | 32 | 3.5E-001   |
| 5  | U$^{235}$ | 206.94          | 17689          | 120742         | 22.27| 136.51  | 121  | 30 | 4.9E+000   |
| 6  | Rh$^{105}$ | 306.02          | 3590           | 49996          | 19.81| 193.48  | 177  | 27 | 1.0E+000   |
| 7  |      | 512.47          | 1613           | 20350          | 27.55| 312.20  | 296  | 61 | 4.5E-001   |
| 8  | Rb$^{83}$ | 530.28          | 1609           | 28457          | 27.92| 322.44  | 296  | 61 | 4.5E-001   |
| 9  | Cs$^{138}$ | 545.17          | 3516           | 28338          | 35.09| 331.00  | 296  | 61 | 9.8E-001   |
| 10 |      | 571.78          | 1302           | 10949          | 29.23| 346.30  | 296  | 61 | 3.6E-001   |
| 11 |      | 1297.35         | 6436           | 7784           | 65.16| 763.50  | 711  | 130| 1.8E+000   |
| 12 |      | 1322.57         | 6622           | 6572           | 54.61| 778.00  | 711  | 130| 1.8E+000   |
| 13 |      | 1357.35         | 3986           | 5480           | 55.32| 798.00  | 711  | 130| 1.1E+000   |
| 14 |      | 1417.71         | 739            | 905            | 45.72| 832.71  | 711  | 130| 2.1E-001   |
Table 3: Peak energy versus radionuclide count rate by using soft standard analysis report to collect data spectra of Hangazhal village.

| PK | ID     | Peak energy /KeV | Area under peak | Peak B.ground | FWHM | Channel | Left | PW | Cts/Sec |
|----|--------|-------------------|-----------------|---------------|------|---------|------|----|---------|
| 1  | Cs$^{136}$ | 66.40             | 27199           | 125395        | 15.03| 55.71   | 49   | 43 | 7.6E+000 |
| 2  | Xe$^{133}$ | 82.65             | 27045           | 234601        | 15.01| 65.05   | 49   | 43 | 7.5E+000 |
| 3  | 97.37   | 7699              | 208939          | 13.50         | 73.51| 49      | 43   | 40 | 4.0E+000 |
| 4  | 110.09  | 122.26            | 164439          | 10.39         | 80.82| 49      | 43   | 2.1E+000 |
| 5  | 125.61  | 235.61            | 82596           | 10.95         | 87.83| 49      | 43   | 9.5E-001 |
| 6  | Eu$^{152}$ | 246.15            | 74496           | 23.10         | 153.00| 49      | 43   | 1.2E+000 |
| 7  | 261.93  | 355.37            | 107979          | 21.24         | 159.06| 49      | 43   | 3.4E+000 |
| 8  | 373.11  | 621.82            | 38199           | 21.90         | 168.14| 49      | 43   | 4.5E-001 |
| 9  | Zr$^{97}$ | 373.11            | 39776           | 17.40         | 221.86| 49      | 43   | 5.3E-001 |
| 10 | I$^{134}$ | 623.43            | 40494           | 27.90         | 232.06| 49      | 43   | 1.2E+000 |
| 11 | 663.43  | 355.37            | 38199           | 21.90         | 168.14| 49      | 43   | 4.5E-001 |
| 12 | 1551.33 | 663.43            | 14411           | 38.70         | 399.00| 49      | 43   | 7.7E-001 |

Table 4: Peak energy versus radionuclide count rate by using soft standard analysis report to collect data spectra of Garmik town.

| PK | ID     | Area under peak | Area under peak | Peak B.ground | FWHM | Channel | Left | PW | Cts/Sec |
|----|--------|-----------------|-----------------|---------------|------|---------|------|----|---------|
| 1  | Ba$^{133}$ | 11.66            | 309             | 10148         | 3.72 | 24.43   | 23   | 4  | 8.6E-002 |
| 2  | 63.34  | 21747           | 92331           | 13.38         | 53.95| 48      | 42   | 6.0E+000 |
| 3  | 78.29  | 23367           | 220299          | 15.11         | 62.54| 48      | 42   | 6.5E+000 |
| 4  | 93.54  | 15279           | 230630          | 15.48         | 71.31| 48      | 42   | 4.2E+000 |
| 5  | 107.18 | 7461            | 189206          | 12.73         | 79.15| 48      | 42   | 2.1E+000 |
| 6  | 118.12 | 77836           | 77836           | 13.32         | 85.44| 48      | 42   | 3.2E-001 |
| 7  | 225.60 | 6564            | 76619           | 18.22         | 147.24| 48      | 42   | 1.8E+000 |
| 8  | 244.30 | 11683           | 69847           | 23.52         | 158.00| 48      | 42   | 3.2E+000 |
| 9  | 345.43 | 4311            | 48900           | 22.87         | 216.15| 48      | 42   | 1.2E+000 |
| 10 | 369.52 | 2103            | 22452           | 28.91         | 230.00| 48      | 42   | 5.8E-001 |
| 11 | 580.08 | 718             | 13646           | 13.78         | 351.07| 335     | 60   | 2.0E-001 |
| 12 | 608.99 | 4614            | 28434           | 46.80         | 367.70| 335     | 60   | 1.3E+000 |
| 13 | 1431.86 | 10552          | 3917            | 50.93         | 840.84| 812     | 120  | 2.9E+000 |
| 14 | 1475.50 | 4995           | 4343            | 41.82         | 865.94| 812     | 120  | 1.4E+000 |
| 15 | 1477.35 | 19677          | 5949            | 57.71         | 867.00| 812     | 120  | 5.5E+000 |
Table 5: Total radiation exposure outdoor dose rate from soil and rock of Sulaimani city – Sardarawa.

| Peak Energy/KeV | Area under peak | Peak B.ground Area | efficiency | Dose nGy/hr | Dose mrad/yr |
|----------------|-----------------|--------------------|------------|-------------|--------------|
| 55.16          | 4673            | 30559              | 1          | 0.6663      | 0.5841       |
| 69.83          | 1831            | 25182              | 1          | 0.6474      | 0.5669       |
| 81.19          | 2623            | 38757              | 1          | 1.1518      | 1.001        |
| 208.2          | 1032            | 18049              | 1          | 1.3621      | 1.1939       |
| 213.54         | 1281            | 22277              | 0.95       | 1.8155      | 1.5915       |
| 227.43         | 658             | 11751              | 88         | 1.1         | 0.9639       |
| 555.66         | 1558            | 7066               | 0          | 4.8415      | 4.2441       |
| 590.23         | 568             | 1908               | 0.28       | 1.7895      | 1.5686       |
| 1245.41        | 517             | 1975               | 0.14       | 7.6         | 6.6626       |
| 1339.96        | 172             | 971                | 0.12       | 4.3759      | 3.8359       |
| 1360.62        | 1200            | 1284               | 0.12       | 9.6565      | 8.4649       |
| 1406.04        | 208             | 987                | 0.11       | 7.8665      | 6.8958       |
| Total          |                 |                    |            | 42.873      | 37.5732      |

Table 6: Total radiation exposure outdoor dose rate from soil and rock of Tatan village.

| Peak Energy/KeV | Area under peak | Peak B.ground Area | efficiency | Dose nGy/hr | Dose mrad/yr |
|----------------|-----------------|--------------------|------------|-------------|--------------|
| 49.78          | 7351            | 48162              | 1          | 0.9474      | 0.8305       |
| 58.52          | 27860           | 165752             | 1          | 2.9135      | 2.554        |
| 76.63          | 21886           | 268337             | 1          | 7.6251      | 6.685        |
| 94.1           | 1266            | 70837              | 1          | 2.3262      | 2.0392       |
| 206.94         | 17689           | 12074.2            | 1          | 9.8218      | 8.6098       |
| 306.02         | 3590            | 49996              | 0.6        | 9.3705      | 8.2142       |
| 512.47         | 1613            | 20350              | 0.34       | 11.35       | 9.9494       |
| 530.28         | 1609            | 28475              | 0.33       | 16.5745     | 14.5292      |
| 545.17         | 3516            | 28338              | 0.3        | 19.8467     | 17.3976      |
| 571.78         | 1302            | 10949              | 0.295      | 8.1413      | 7.1366       |
| 1297.35        | 6436            | 7784               | 0.13       | 48.6549     | 42.651       |
| 1322.57        | 6622            | 6572               | 0.13       | 46.0219     | 40.3428      |
| 1357.35        | 3986            | 5080               | 0.125      | 35.2421     | 30.8932      |
| 1417.71        | 739             | 905                | 0.11       | 7.2646      | 6.3681       |
| Total          |                 |                    |            | 226.1005    | 198.2006     |
Table 7: Total radiation exposure outdoor dose rate from soil and rock of Hangazhal village.

| Peak Energy/KeV | Area under peak | Peak Background Area | Efficiency | Dose nGy / hr | Dose mrad / yr |
|-----------------|-----------------|----------------------|------------|---------------|---------------|
| 66.4            | 27199           | 125395               | 1          | 3.4739        | 3.0452        |
| 82.65           | 27045           | 234601               | 1          | 7.4143        | 6.5           |
| 97.37           | 14502           | 208939               | 1          | 7.4594        | 6.5388        |
| 110.09          | 7699            | 164439               | 1          | 6.4974        | 5.6956        |
| 122.26          | 3424            | 82596                | 1          | 3.6057        | 3.1608        |
| 235.61          | 4218            | 74496                | 0.87       | 7.3087        | 6.4068        |
| 246.15          | 12413           | 107979               | 0.78       | 13.0261       | 11.4187       |
| 261.93          | 1613            | 38199                | 0.73       | 4.7           | 4.2952        |
| 355.37          | 1908            | 39776                | 0.53       | 9.5827        | 8.4           |
| 373.11          | 4385            | 40494                | 0.47       | 12.215        | 10.7077       |
| 612.82          | 1509            | 23525                | 0.275      | 19.1268       | 16.7666       |
| 625.43          | 3355            | 29612                | 0.27       | 26.1          | 22.878        |
| 663.43          | 2784            | 14411                | 0.26       | 15.0431       | 13.1868       |
| 1551.33         | 16104           | 6819                 | 0.1        | 121.9239      | 106.8785      |
| Total           |                 |                      |            | 257.477       | 225.8787      |

Table 8: Total radiation exposure outdoor dose rate from soil and rock of Garmik town.

| Peak Energy/KeV | Area under peak | Peak Background Area | Efficiency | Dose nGy / hr | Dose mrad / yr |
|-----------------|-----------------|----------------------|------------|---------------|---------------|
| 11.66           | 309             | 10148                | 1          | 0.0418        | 0.0366        |
| 63.54           | 21747           | 92331                | 1          | 2.4774        | 2.172         |
| 78.29           | 23367           | 220299               | 1          | 6.5405        | 5.7335        |
| 93.54           | 15279           | 230630               | 1          | 7.8865        | 6.9133        |
| 107.18          | 7461            | 189206               | 1          | 7.227         | 6.3352        |
| 118.12          | 1160            | 77836                | 1          | 3.1992        | 2.8044        |
| 225.6           | 6564            | 76619                | 0.88       | 7.3115        | 6.4092        |
| 244.3           | 11683           | 69847                | 0.78       | 8.755         | 7.6746        |
| 345.43          | 4311            | 48900                | 0.54       | 11.6703       | 10.2302       |
| 369.52          | 2103            | 22452                | 0.47       | 6.619         | 5.8022        |
| 580             | 718             | 13646                | 0.28       | 10.2014       | 8.9425        |
| 608.99          | 4614            | 28434                | 0.275      | 25.092        | 21.9957       |
| 1431.86         | 10552           | 3917                 | 0.11       | 64.5743       | 56.6058       |
| 1475.5          | 4995            | 4343                 | 0.11       | 42.9451       | 37.6456       |
| 1477.35         | 19677           | 5949                 | 0.11       | 118           | 103.4394      |
| Total           |                 |                      |            | 322.541       | 282.7402      |
Table 9: Radiation exposure outdoor dose rate of natural radionuclide from soil and rock of Sulaimani city -Sardarwa.

| Radio nuclide | Spectra peak energy/KeV | NDS peak energy/KeV | Area under peak | Peak B. ground Area | Activity /Bq | Dose nGy/hr | Half life |
|---------------|-------------------------|---------------------|----------------|---------------------|--------------|-------------|-----------|
| Xe\(^{133}\) | 81.19                   | 81                  | 2623           | 38757              | 0.73         | 1.1518      | 5.24d     |
| Ac\(^{228}\)  | 208.2                   | 209.3               | 1032           | 18049              | 0.29         | 1.3621      | 1.405*10\(^{10}\) yr |
| Pa\(^{234}\)  | 227.43                  | 226.9               | 658            | 11751              | 0.18         | 1.1         | 4.468*10\(^{7}\) yr |
| Bi\(^{82}\)   | 555.6                   | 554.3               | 1558           | 7066               | 0.43         | 4.8415      | 211.8m    |
| TOTAL         |                         |                     |                |                    |              | 8.4554      |           |

Table 10: Radiation exposure outdoor dose rate of natural radionuclide from soil and rock of Garmik town.

| Radio nuclide | Peak energy/KeV | NDS peak energy/KeV | Area U. peak | Peak B. ground Area | Activity /Bq | Dose nGy/hr | Half life |
|---------------|-----------------|---------------------|--------------|---------------------|--------------|-------------|-----------|
| Ba\(^{133}\)  | 78.3            | 79.6                | 23367        | 220299              | 6.5          | 6.5405      | 10.5y     |
| Pa\(^{234}\)  | 225.6           | 226.9               | 6564         | 76619               | 1.8          | 7.3115      | 4.468*10\(^{9}\) y |
| Kr\(^{89}\)   | 345             | 345                 | 4311         | 48900               | 1.2          | 11.6703     | 3.16m     |
| Bi\(^{214}\)  | 609             | 609.3               | 4614         | 28434               | 1.3          | 25.092      | 1600.01y  |
| TOTAL         |                 |                     |              |                     |              | 50.6143     |           |

Table 11: Radiation exposure outdoor dose rate of natural radionuclide from soil and rock of Tatan village.

| Radio nuclide | Peak energy/KeV | NDS peak energy/KeV | Area Under peak | Peak B.Ground Area | Activity /Bq | Dose nGy/hr | Half life |
|---------------|-----------------|---------------------|----------------|-------------------|--------------|-------------|-----------|
| Th\(^{227}\)  | 49.8            | 50.2                | 7351           | 48162             | 2.0          | 0.9474      | 7.038*10\(^{8}\) y |
| Th\(^{232}\)  | 58.5            | 59                  | 27860          | 165752            | 7.7          | 2.9135      | 1.405*10\(^{10}\) y |
| Pb\(^{212}\)  | 76.6            | 77.1                | 21886          | 268339            | 6.1          | 7.6251      | 1.405*10\(^{10}\) y |
| U\(^{235}\)   | 207             | 205.3               | 17689          | 120742            | 4.9          | 9.8218      | 7.038*10\(^{8}\) y |
| Rh\(^{105}\)  | 306             | 306.1               | 3590           | 49996             | 1.0          | 9.3705      | 2121.6m   |
| Rb\(^{83}\)   | 530.3           | 529.6               | 1609           | 28475             | 0.45         | 16.5745     | 86.2d     |
| Cs\(^{138}\)  | 545.2           | 546.9               | 351            | 28338             | 0.98         | 19.8467     | 32.2M     |
| TOTAL         |                 |                     |                |                    |              | 67.0995     |           |
Discussion

The method which employed, in this work, is different radically from all previous works because the total outdoor gamma absorption dose has a large difference with total outdoor radionuclide absorption dose. The total outdoor absorbed dose in each area has different value which ranges from (226.1 to 322.5) nGy/hr as shown in Tables (5, 6, 7 & 8). This value is about six time more than local standard absorbed dose of Sulaimani city-Sardarawa (42.8) nGy·h⁻¹. The local standard absorbed dose was close to the world standard outdoor dose which is about 44 nGy·h⁻¹ (Daryoush, 2003). The total equivalent outdoor dose is ranged from 37.57 to 282.74 m rem /yr which are estimated from Tables (5,6,7 & 8) by using equation (10). This value was six times more than the world average of outdoor(terrestrial and cosmic ) natural radiation (from 60 to160) m rem /yr (Michalis,2003) specially in Tatan, Hangazhal, Garmik(198.2,225.87, 282.74 ) m rem / yr.

The average fractional total radionuclide dose (FTRD) was about (22.76 %) of total outdoor absorbed dose (TOAD). The contribution of FTRD in Sulaimani city –Sardarawa was about 19.72% of the TOAD in the studied locations as shown in Tables (5,9) while that of Hangazhal- village was about 26 % of total outdoor absorbed dose in this location as shown in Tables (7, 12). The contribution of FTRD in Garmik –town was about 15.7 % of total outdoor absorbed dose in this location as shown in Table (8, 10). It is about 29.7 % of the TOAD in Tatan-village as shown in Tables (6, 11).

This work differs from previous ones by determining radionuclide or natural isotopes which are not exist in natural radioactive series. Their dose values is apart of the total dose value either in radionuclide dose or outdoor dose. Therefore more than half of the absorbed dose has been lost if compared with previous works as indicate bellow. The absorbed doses of

| Radio Nuclide | Peak energy /KeV | NDS peak energy /KeV | Area Under peak | Peak B.ground Area | Activity /Bq | Dose nGy/hr | Half life |
|---------------|------------------|----------------------|-----------------|-------------------|--------------|-------------|----------|
| Cs¹³⁶          | 66.4             | 66.9                 | 27199           | 125395            | 7.6          | 3.4739      | 13.16d   |
| Xe¹³³          | 82.65            | 81                   | 27045           | 234601            | 7.5          | 7.4143      | 5.245d   |
| Nb⁹⁵M          | 235.6            | 235.7                | 4218            | 74496             | 1.2          | 7.3087      | 5196m    |
| Eu¹⁵²          | 246.1            | 244.7                | 12413           | 107979            | 3.4          | 13.0261     | 13.6y    |
| Zr⁹⁷           | 355.4            | 355.4                | 1908            | 39776             | 0.53         | 9.5827      | 16.9h    |
| I¹³¹           | 623.4            | 621.8                | 3355            | 29612             | 0.93         | 26.1        | 52.6m    |

TOTAL            | 66.9057          |
Xe$^{133}$ and Br$^{82}$ are about 73% of total radionuclide dose (TRD) in Sulaimani city–Sardarawa. Each dose contributes in about 14% and 59% of TRD respectively as shown in Table 9. The absorbed dose of Ba$^{133}$ and K$^{89}$ are about 36% of TRD in Garmik town, each of them contribute in about 13% and 23% of TRD respectively as shown in Table 10. The value for Rh$^{105}$, Rb$^{183}$ and Cs$^{138}$ are about 68.25 of TRD in Tatan-village and each of them contribute in about 14%, 24.7% and 29.6% respectively as shown in Table 11. However, Hangazhal-village didn’t contained a natural radionuclide series elements. But it is containing other natural radionuclide like Cs$^{136}$, Xe$^{133}$, Nb$^{95}$, Eu$^{152}$, Zr$^{97}$ and I$^{134}$ which are contributing in about 5.2%, 11.0%, 10.9%, 19.6%, 14.3%, and 39% respectively as shown in Table 12.

Further more, the natural radioactive series are calculated which is a contribute in total outdoor absorbed dose (TOAD); The U$^{238}$ and Th$^{232}$ are found in Sulaimani city–Sardarawa with dose rate 1.36 nGy·h$^{-1}$ and 1.1 nGy·h$^{-1}$ which are equal to 16.1% and 13% of TRD in Sulaimani city–Sardarawa respectively as shown in Table 13. The U$^{235}$ and Th$^{232}$ are found in Tatan village with dose rate 10.54 nGy·h$^{-1}$, 67.22 nGy·h$^{-1}$, 67.01 nGy·h$^{-1}$ which were equal to 16% and 15.7% of TRD in Tatan village respectively as shown in Table 13. The U$^{238}$ has been found in Garmik town with dose rate equal to 64% of TRD in Garmik town as shown in Table 13.

**Table 13: Th$^{232}$, U$^{238}$, U$^{235}$ dose ratio from soil and rock of all studied area.**

| Area                   | Th$^{232}$ Dose | Its ratio of radionuclei | U$^{238}$ Dose | Its ratio of radionuclei | U$^{235}$ Dose | Its ratio of radionuclei |
|------------------------|-----------------|--------------------------|-----------------|--------------------------|-----------------|--------------------------|
|                        | nGy/hr          | dose                     | nGy/hr          | dose                     | nGy/hr          | dose                     |
| Sulaimani city–Sardarawa | 1.36            | 16.1%                    | 1.1             | 13%                      |                 |                          |
| Tatan village          | 10.54           | 15.7%                    |                 |                          | 10.77           | 16%                      |
| Garmik village         |                 |                          | 32.4            | 64%                      |                 |                          |
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تحديد الجرعة الأشعاعية للنظائر الطبيعية ونواة مشعة خارج الباب ذو العد العالي

منطقة كرمك شمال شرقي إقليم كردستان – العراق.

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الخلاصة

توجد المواد المشعة ذو العد العالي في بعض مناطق بلدان العالم، هذه المواد توجد بنسب ملحوظة في الصخور التي تستخدم كمواد أساسية في البناء. الجرعة الأشعاعية في منطقة كرمك تقدر حوالي 728.2 nGy/h. تم دراسة خلفية إشعاعية كاما خارج الباب لبعض مناطق كرمك للحصول على جرعة كاما الممتصة من تربة وصخور جبال المنطقة.

لقد سجل الطيف الكاملي لبعض المواقع في منطقة كرمك بواسطة المنظومة المتقدمة لقياس الأشعة النووية والتي تتكون من المحلاط المطيافي الرقمي DSA مع الكاشف الوميضي NaI(Tl). هذه الطريقة تتاسب جيداً مع جرعة كاما خارج الباب لأنه يسجل أكثر العد الكاملي وهذا يفيد تحديد كمية إشعاع كاما التي يتعرض لها الإنسان. تم استخدام صيغة جديدة لحساب الجرعة الأشعاعية. تقدر جرعة الأشعاعية المحلية لمدينة السليمانية بـ 17.82 nGy/h، والتي تعتبر كالجرعة الأشعاعية الاعتية المحلية.

تم الحصول على جرعة الأشعاعية الأرجحية لمدينة السليمانية التي تقدر بـ 2873 nGy/h، والتي اعتبرت كالجرعة خارج الباب الاعتية المحلية. وقمة معدل الجرعة الأشعاعية المنطقة خارج الباب للمناخ في المواقع تانية هنكلز كرمك حوالي 2,054,222 nGy/h.

وفقاً للجرعة الإشعاعية المحلية لمنطقة كرمك، هذه القيم تقربها أكثر من قيم الجرعة الإشعاعية خارج الباب لمدينة السليمانية المحلية لمدينة السليمانية بست مرات. وكله هذه القيم تشير إلى أن جرعة الأشعاعية المحلية لمدينة السليمانية تفوق جرعة الأشعاعية المحلية للمناخ في المواقع.

كما تم استنتاج نسبة البلورات المنوية للجرعة الإشعاعية المحلية للمناخ المشع في المواقع التي تعود داخل السلاسل الإشعاعية الطبيعية (27.72%) من الجرعة الإشعاعية الكلية في هذه المنطقة.