Ahmed and Farhan

Iraqi Journal of Science, 2022, Vol. 63, No. 1, pp: 182-190
DOI: 10.24996/ijs.2022.63.1.19

ISSN: 0067-2904

Natural Radioactivity Evaluation and Radiological Peril in some soil specimens of Al-Taimeem Area in Al-Anbar Province, Iraq

Ahmed M. Ahmed [1*], Ahmed O. Farhan [2]

[1]*Department of Physics , Faculty of Science , University of Anbar , Anbar , Iraq*
[2]*Renewable Energy Research Center, University of Anbar , Anbar , Iraq*

Received: 19/2/2021 Accepted: 16/7/2021

Abstract
In the present work, the radioactivity of ten soil specimens has been measured, which were gathered from various sites from AL-Taimeem area in Al-Anbar province, The qualitative activity of natural radionuclides ^{238}U, ^{232}Th and ^{40}K for soil specimens were evaluated by utilizing gamma-ray spectroscopy with NaI(Tl) detector of (3"×3") dimension. The results revealed that, the qualitative activity, for ^{238}U was varied from (14.730 Bq/kg) to (28.070 Bq/kg), for ^{232}Th was varied from (16.510 Bq/kg) to (29.480 Bq/kg), for ^{40}K was varied from (143.820 Bq/kg) to (231.550 Bq/kg) ,with an average values of (21.152±2.98 Bq/kg) , (24.219±3.93 Bq/kg), (190.720±22.20 Bq/kg), successively. To survey the radiological peril in soil, radium effective activity, absorbed gamma dose in air, annual effective dose equivalent (inner and outer), gamma concentration level index and both (interior and exterior) radiation peril index have been computed, and all the existed results were less than recommended by the International Committee for the Radiation Protection (ICRP).

Keywords: NaI(Tl) System, Soil, Natural Radioactivity, Al-Anbar province.

تقييم النشاط الإشعاعي الطبيعي والمخاطر الإشعاعية في بعض عينات التربة من منطقة التأميم في محافظة الأنبار، العراق

أحمد مظفر أحمد[1*]، أحمد عبيد فرحان[2]

[1]قسم الفيزياء ، كلية العلوم ، جامعة الأنبار ، الأنبار ، العراق
[2]مركز بحوث الطاقة المتجددة ، جامعة الأنبار ، الأنبار ، العراق

الخلاصة
في هذا البحث تم قياس النشاط الاشعاعي لعشرة نماذج تربة تم جمعها من مواقع مختلفة من منطقة التأميم في محافظة الانبار، حسبت الفعالية النوعية للنويات المشعة الطبيعية ^{238}U , ^{232}Th , ^{40}K في عينات من التربة باستخدام منظومة مطياف اشعة كاما المتضمنة كاشف NaI(Tl) الذي ابعاده ("3 × "3). بينت النتائج إلى ان النشاط النوعي لليورانيوم-238 تراوحت قيمته من (14.730 Bq/kg) الى (28.070 Bq/kg), اما النشاط النوعي للثوريوم-232 تراوحت قيمته من (16.510 Bq/kg) الى (29.480 Bq/kg), بينما النشاط

*Email: sc.ahmedmud76@uoanbar.edu.iq

النوعي للبوتاسيوم-40 تراوحت قيمته من (143.820 Bq/kg) الى (231.550 Bq/kg) وبمعدل (21.152±2.98 Bq/kg), (24.219±3.93 Bq/kg), (190.720±22.20 Bq/kg) على التوالي. ولأجل تقييم المخاطر للنشاط الاشعاعي في التربة، فقد تم حساب كل من النشاط المكافئ للراديوم، معدل جرعة امتصاص كاما, الجرعة الفعالة السنوية المكافئة، دليل الخطورة لمستوى تركيز أشعة كاما ومؤشر المخاطر الاشعاعية (الداخلي والخارجي) ومقارنتهم بالقيم العالمية (UNSCEAR, 2008).

Introduction

The sources of radiation to which human beings are exposed permanently are either natural, of cosmic or industrial origin, which human involves in its manufacture for various purposes. Almost all the materials encompassing us contain a small proportion of radioactive material, consequently human are being exposed to a low level of radiation background, so radiation has an effect on environmental contamination and its effect may remain for a long time[1,2]. Radioactive contamination is one of the most important problems facing countries of the civilized world, because of the damage it causes to the environment, to various living things and to the health of humans. The source and behavior of the radioactive pollutants newly deposited in the soil is different from those of the radionuclides originally present in the formed soil, as these pollutants are absorbed by plants. Therefore, researchers are interested in assessing the concentration of environmental elements from soil, water, air and food[3,4].

The soil represents the surface layer of the earth and consists of (45%) metal materials, (5%) organic materials, represented by accumulations of plant and animal wastes, (25%) Gas-like air (CO_2, N_2, O_2) and others (25%) Water, contamination in the soil, in general, occurs when chemical elements are added or lost. Thus, soil fertility and formative depend on the natural, chemical and, biological composition of these components, which directly or indirectly effect those who live above their surface from various creatures[5,6], In addition to the deliberation of radioactive materials and their application in many fields of the most important threats to the elements of the environment, including the soil, Thus, it causes humans to exhibit radiation, so it is essential to know the nature of these materials and their dangers and how to protect against them and utilized them safely[7].

The study of the interaction of radiation with these material is necessary to know the high levels of radioactive elements such as uranium, thorium, potassium and measurement of the radiation doses represented by gamma rays, which are one of the most common and widespread radiations that lead to disturbance of the vital balance of human and his environment if exposed to them[2,3]. The human body contains some radionuclides, the most important of which are uranium, thorium and potassium in varying proportions, many recent studies and research have shown that nuclear radiation has serious biological effects on the life of living organisms, especially when soil and thus these organisms are exposed to greater doses than acceptable values annually[8].

Considering the elements of the environment are affected by radioactivity firstly, the study area was exposed to bombing and environmental neglect more than the rest of the regions secondly, and There are extremely few radiological environmental studies in this field. Therefore, it is necessary to assess the radioactive quantity of radionuclide ^{238}U, ^{232}Th, ^{40}K in soil specimen were gathered from the Al-Taimeem area of Anbar province and to find appropriate solutions to reduce soil Contamination, as well as to estimate the radiological perils as a result of the rising population density of the area studied and use the land in agriculture, which may have an effect on the population of the area and comparison the results with the values recorded globally.

Study area

The Al-Taimeem area is located in the southwest of Ramadi, about 108 km west of Baghdad, with coordinates (33° 25" - 33° 32") north and (43°15"-42°47") to the east as in

(Figure 1). It has an area of about 14 km^2 and includes six neighborhoods and a residential apartment complex.

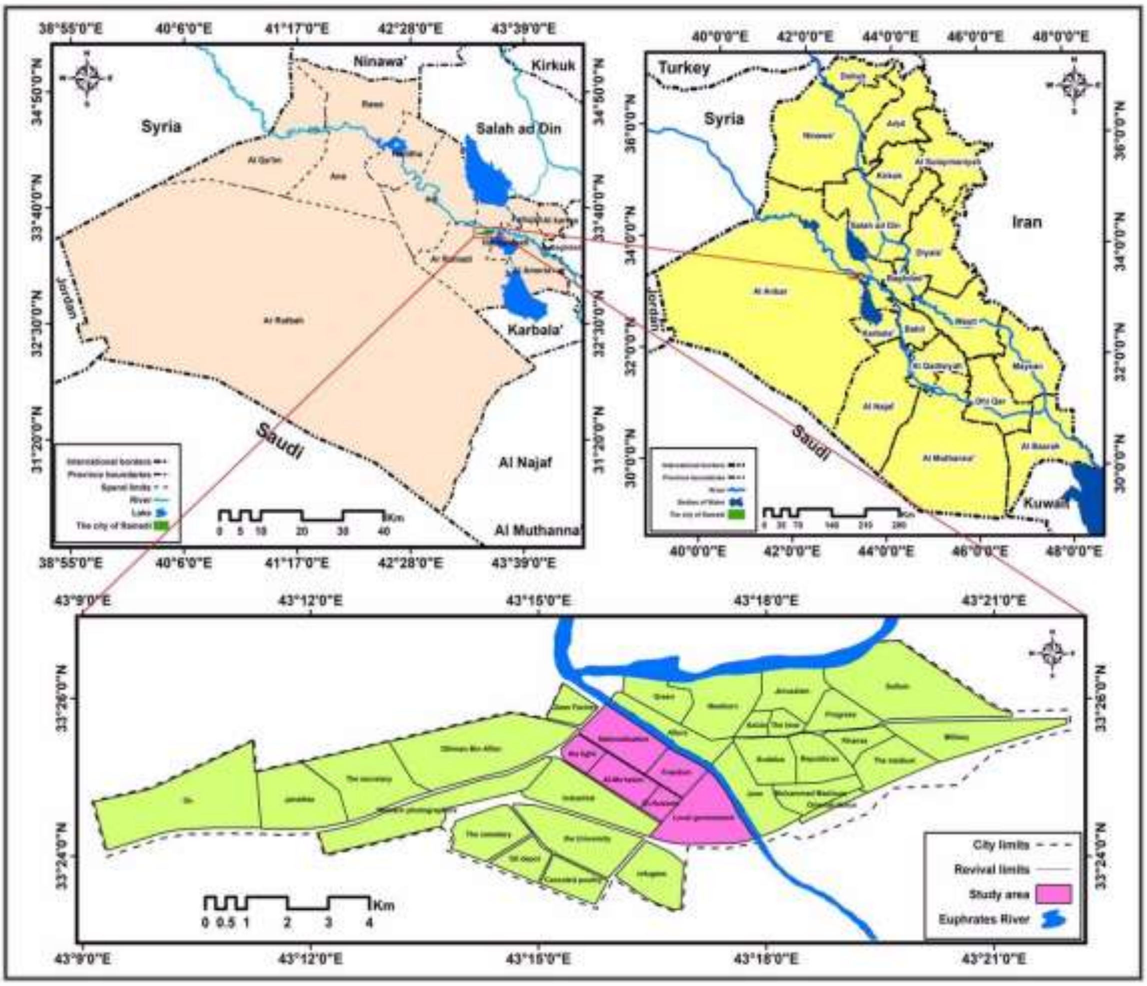

Figure 1- Distribution of specimens within the study area.

Due to the proximity of Al-Taimeem area proximally to the Euphrates river. Its population density is high, with more than 6,000 homes in it, so it is important to know the levels of radioactivity in that area and to calculate the concentration levels of activity and peril indices for human health at this area. This was done through studying the soil of the area.

Materials and Strategies

Specimen collection

Then soil specimens were gathered from various sites in AL-Taimeem area in Anbar province. Impurities were removed from the specimens after which the soil specimens were crushed and grinded until it became in the form of a fine powder. Specimens were left to expose to sunlight for 7 days to obtain dry moisture-free specimens and then sieved with a (1 mm) mesh size sieve to obtain a homogeneous soil free of impurities. The specimens were weighed using a sensitive balance, then the specimen were placed in a (1) liter Marinelli cups and left for four weeks to obtain radioactive balance between the radionuclides.

Sodium Iodide System NaI(Tl)

The parts of the system were connected as in the schematic diagram of Figure 2, The normal radioactivity of radionuclides (gamma-rays) were measured depending on the high penetrating strength of gamma-rays in the specimens by utilizing the electronic count and analysis technique to detect ionizing radiation from the NaI (TI). Sodium iodide system contains of a scintillation sensor sodium iodide stimulate by thallium NaI(Tl), with a multi-channel analyzer reaching of about 2048 channel connected with analog to digital signals conversion unit which assists the analyzer in converting the pulses into numerical values. Both the detector and the holder are placed inside a shield to reduce the radiative background recorded by the detector. The spectroscopic estimations and analysis are executed through the CASSY programming into the computer of the lab.

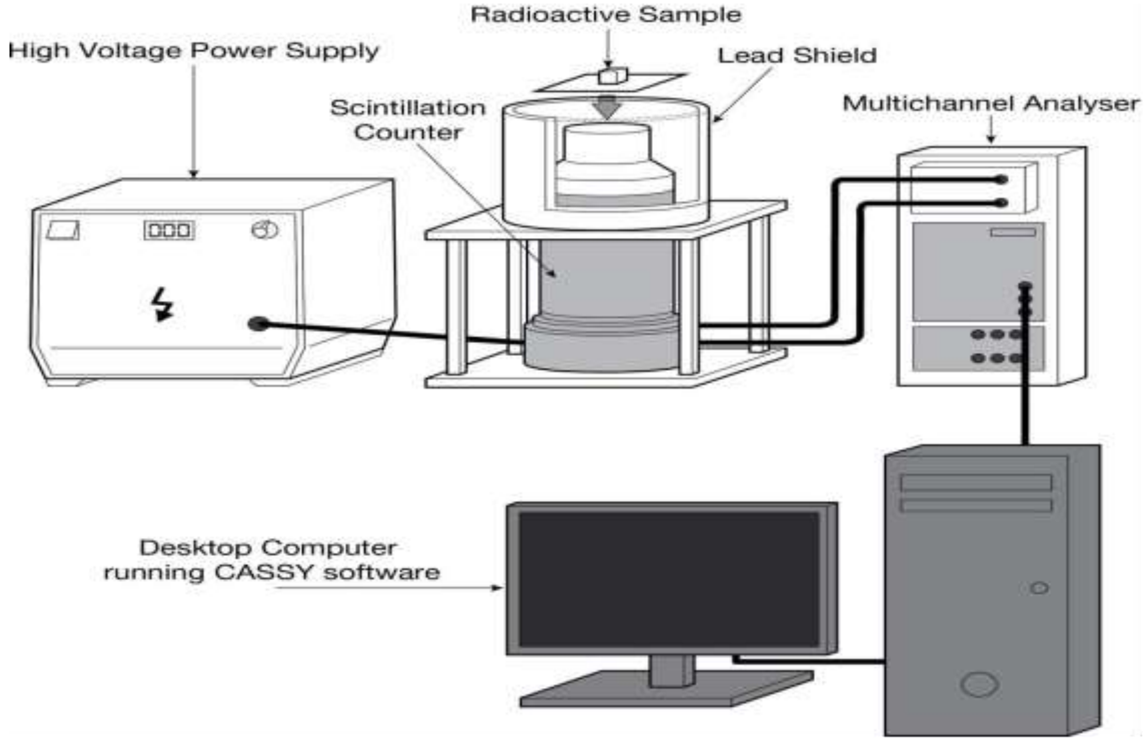

Figure 2- schematic diagram of the sodium iodide system.

Evaluation of Qualitative Activity

It is defined as the quantity of radioactivity in a material or the association between the mass of radiological material and the effectiveness. The qualitative activity for identified radionuclide can be given by[9]:

$$Qualitative\ Activity = \frac{C}{W \times I_{\gamma} \times Eff. \times T} \quad (1)$$

where,

C : the count of γ – ray.

W : the Weight of investigated specimen (kg).

I_γ : Percentage intensity of γ – ray impulsive probability.

Eff.: the calculated efficiency of γ – ray at a certain energy.

T : Measurement time for the detector (sec).

Evaluation of Radiological Risk evidence for γ – Ray:

Based on the qualitative activity of ^{238}U, ^{232}Th and ^{40}K, Several risk indicators can be calculated:

1- Radium Effective Activity ($Ra_{id.}$)

This is employed to evaluate the risks connected with substance which include ^{226}Ra, ^{232}Th and ^{40}K *Bq/kg*. Its activity varies according to the different soil types, and can be standardized relative to the resulting radiation exposure known as the Ra_{id} radionuclide. The Ra_{id} of a specimen can be achieved employing the following expression[10]:

$$Ra_{id.} = (Q.A._{U}) + [(Q.A._{Th} \times 0.143) + (Q.A._{K} \times 0.0077)] \times 10 \quad (2)$$

Where $(Q.A._{U})$, $(Q.A._{Th})$ and $(Q.A._{K})$ are the Qualitative Activity value of ^{238}U, ^{232}Th and ^{40}K successively.

2- Absorbed Gamma Dose (D_γ)

Absorbed gamma dose is defined as the energy from absorbed radiation by the human body or material. The increase in the rate of absorbed dose arises from the gamma-ray radionuclides which are present in very small quantities in the soil. The estimation of the absorbed gamma dose is based on the qualitative activity of the radionuclides, So, D_γ (nGy/h) can be given by[9]:

$$D_{\gamma} = (Q.A._{U} \times 0.462) + (Q.A._{Th} \times 0.604) + (Q.A._{K} \times 0.0417) \quad (3)$$

3- Annual Effective Dose Equivalent (AEDE)

The computations of annual effective dose equivalent rely on the absorbed gamma dose value in air. The conversion constant should be taken into consideration while doing these computations from absorbed gamma dose in air to annual effective dose equivalent taken by grown-up. The estimation of these two boundaries fluctuates contingent upon the climate at the region considered and the normal age of the populace. Based on the fact that humans spend 80% of their time inner their homes and 20% outer and utilizing the conversion factors of 0.7 Sv/Gy, The AEDE (mSv/y) unit can be given by[11]:

$$AEDE_{In} = [D_{\gamma} \times 8760\, h/y \times 0.8 \times 0.7] \times 10^{-6} \quad (4)$$

$$AEDE_{Out} = [D_{\gamma} \times 8760\, h/y \times 0.2 \times 0.7] \times 10^{-6} \quad (5)$$

4- Gamma Concentration Level Index (I_γ)

Gamma concentration level index are utilized to compute the dangerous due to gamma radiance related with the natural radionuclides in the soil. The I_γ is estimated according to the relation given[12]:

$$I_{\gamma} = \frac{Q.A._{U}}{300} + \frac{Q.A._{Th}}{200} + \frac{Q.A._{K}}{3000} \quad (6)$$

The value of I_γ should be equal to ≤ 1 for the radiation risk to be insignificant.

5- Radiation Peril Index (H)

Shows internal respiration of alpha particles transferred from short isotopes, e.g., ^{222}Rn and ^{232}Th accompanied by γ-rays and can be expressed in terms of the internal risk indicator (H_{in}), Which can be illustrated by the following relationship[9]:

$$H_{in} = \frac{Q.A._{U}}{185} + \frac{Q.A._{Th}}{259} + \frac{Q.A._{K}}{4810} \quad (7)$$

There is another peril index called external risk indicator (H_{ex}), The purpose of its compute to estimate the radiological peril of the normal gamma radiation and can be illustrated according to the following relationship:

$$H_{ex} = \frac{Q.A._{U}}{370} + \frac{Q.A._{Th}}{259} + \frac{Q.A._{K}}{4810} \quad (8)$$

Results and Discussion

Ten soil specimen tests were gathered for various sites of the AL-Taimeem area, and the qualitative activity of natural radionuclides (^{238}U, ^{232}Th and ^{40}K) was calculated using the γ-rays spectroscopy with NaI(Tl) detector, as the radiological peril evidence of the soil specimens were calculated as in table. 1., from the results in the table we conclude:

The lowest value of qualitative activity (^{238}U, ^{232}Th and ^{40}K) in soil specimens was equal (14.730, 16.510 and 143.820) Bq/kg successively, the highest value for (^{238}U, ^{232}Th and ^{40}K) was equal (28.070, 29.480 and 231.550) Bq/kg successively, as in (Figure 3.). There is a contrast between the lowest and highest value of the measured sites and this variation due to the geological nature of the inspected area and the different terrain, selected area (residential, agricultural or industrial) soil type, the chemical fertilize utilized for agricultural purposes. the general rate of (^{238}U, ^{232}Th and ^{40}K) was equal (21.152±2.98, 24.219±3.93 and 190.720±22.20) Bq/kg successively. current results illustrate that the qualitative activity rate (^{238}U, ^{232}Th and ^{40}K) in soil specimens for the Al-Taimeem area was less than the values of the permitted Global Rate was equal (35, 30 and 400) Bq/kg successively[13].

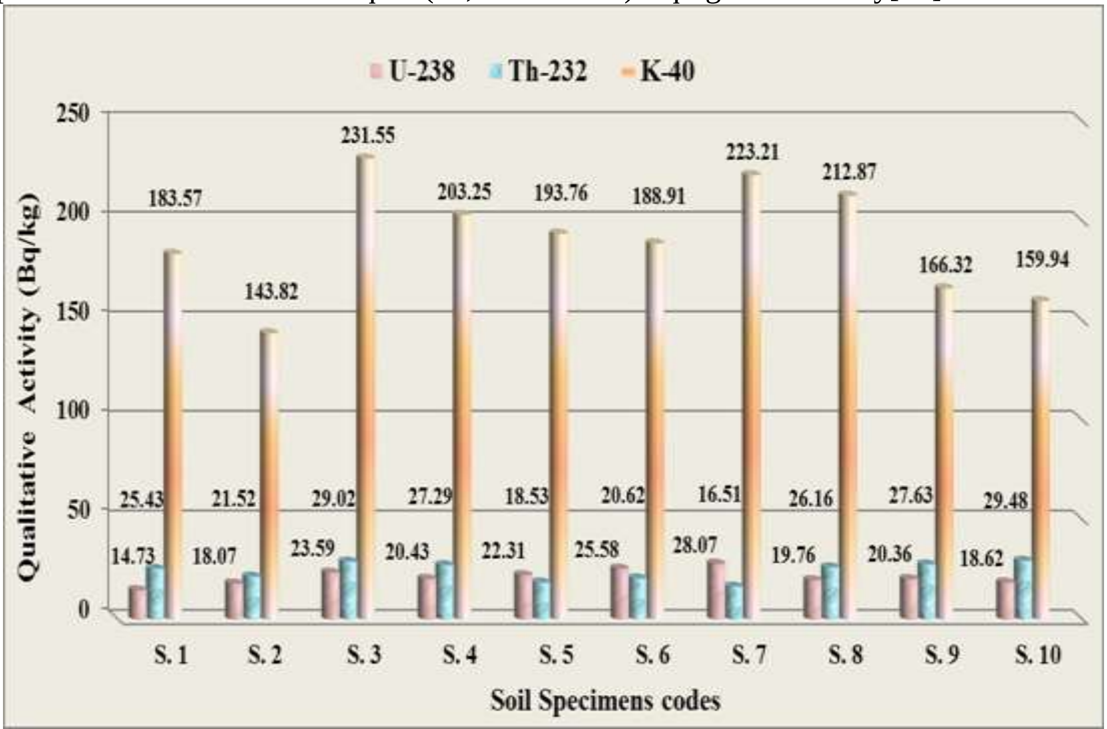

Figure 3- Qualitative Activity concentration of (^{238}U, ^{232}Th and ^{40}K) for soil specimen tests in the Al-Taimeem area.

The lowest value of the radium effective activity (Ra_{id}) and absorbed gamma dose in air (D_γ) in soil specimens was equal (59.918 Bq/kg and 27.344 nGy/h) successively, the highest value of (Ra_{id} and D_γ) was equal (82.918 Bq/kg and 38.082 nGy/h) successively, as in (Figure 4), and the general rate of (Ra_{id} and D_γ) was equal (70.471±5.0 Bq/kg and 32.354±2.12 nGy/h) successively. current results show that the rate of (Ra_{id} and D_γ) in soil specimens was less than the values of the permitted Global Rate was equal (370 Bq/kg and 55 nGy/h) successively[13].

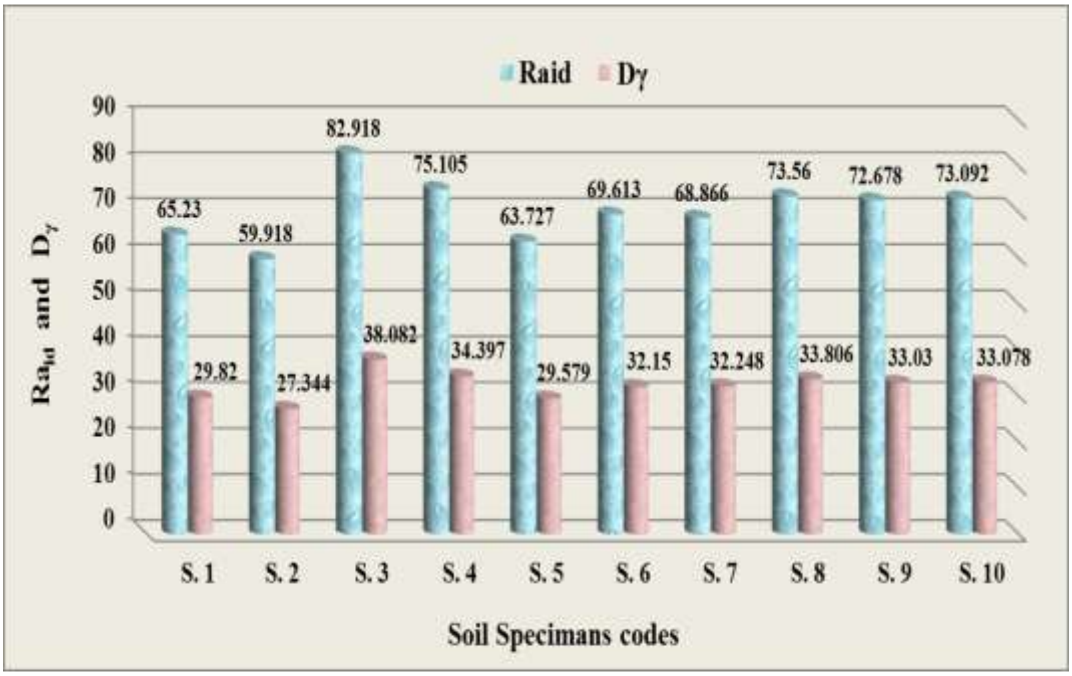

Figure 4-Radium Effective Activity (Ra$_{id}$) and Absorbed Gamma Dose in Air (D$_{\gamma}$) for soil specimen tests in the Al-Taimeem area.

The lowest value of the annual effective dose equivalent (AEDE) (inner and outer), gamma concentration level index (Iγ) and radiation risk index (H) (interior and exterior) in soil specimens was equal (0.134, 0.034, 0.216, 0.211 and 0.162) mSv/y successively, the highest value of (AEDE $_{in,\ out}$), (Iγ) and (H $_{in,\ ex}$) was equal (0.187, 0.047, 0.301, 0.288 and 0.224) mSv/y successively, as in (Figure 5), and the general rate of (AEDE $_{in,\ out}$), (Iγ) and (H $_{in,\ ex}$) was equal (0.159±0.01, 0.04±0.03, 0.255±0.018, 0.247±0.017 and 0.190±0.013) mSv/y successively. current results show that the rate of (AEDE $_{in,\ out}$), (Iγ) and (H $_{in,\ ex}$) in soil specimens was less than the values of the permitted Global Rate was equal (1) mSv/y[13].

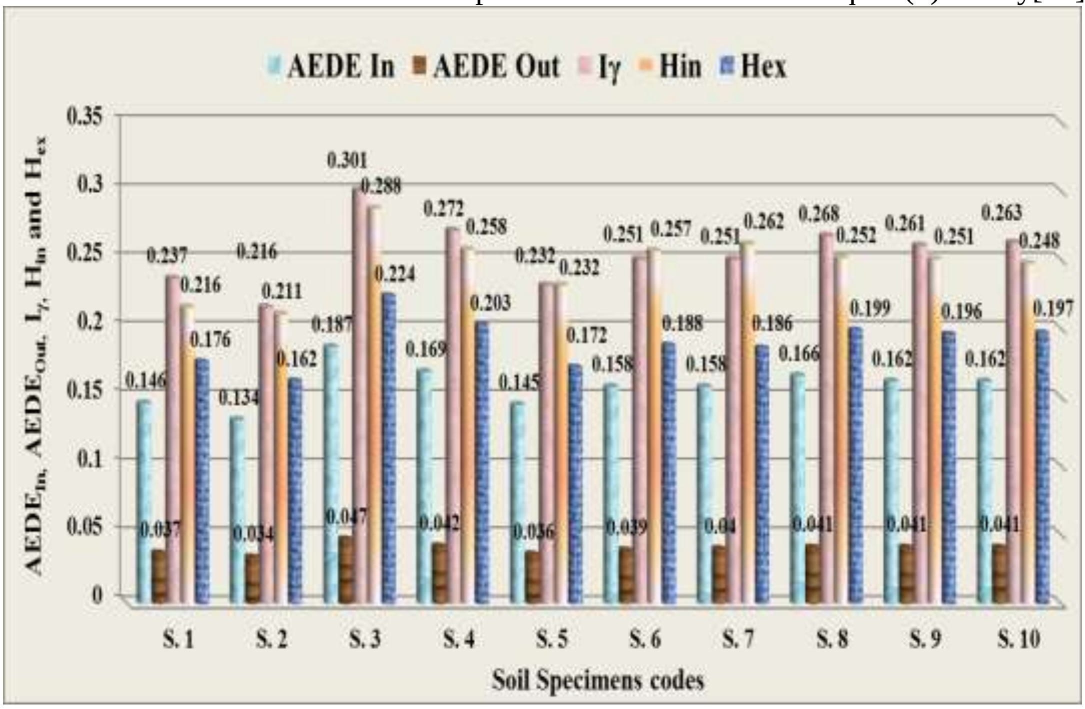

Figure 5-Annual Effective Dose Equivalent (AEDE $_{in,\ out}$), (Iγ) and (H $_{in,\ ex}$) for soil specimen tests in the Al-Taimeem area.

Table 1- The Qualitative Activity of radionuclides and radiological peril evidence of soil specimen tests.

specimen code	^{238}U (Bq/Kg)	^{232}Th (Bq/Kg)	^{40}K (Bq/Kg)	Ra_{id} (Bq/Kg)	Dγ (nGy/h)	(AEDE) (mSv/y)		Iγ	H_{in}	H_{ex}
						$(AEDE_{in})$	$(AEDE_{out})$			
S. 1	14.730	25.430	183.570	65.230	29.820	0.146	0.037	0.237	0.216	0.176
S. 2	18.070	21.520	143.820	59.918	27.344	0.134	0.034	0.216	0.211	0.162
S. 3	23.590	29.020	231.550	82.918	38.082	0.187	0.047	0.301	0.288	0.224
S. 4	20.430	27.290	203.250	75.105	34.397	0.169	0.042	0.272	0.258	0.203
S. 5	22.310	18.530	193.760	63.727	29.579	0.145	0.036	0.232	0.232	0.172
S. 6	25.580	20.620	188.910	69.613	32.150	0.158	0.039	0.251	0.257	0.188
S. 7	28.070	16.510	223.210	68.866	32.248	0.158	0.040	0.251	0.262	0.186
S. 8	19.760	26.160	212.870	73.560	33.806	0.166	0.041	0.268	0.252	0.199
S. 9	20.360	27.630	166.320	72.678	33.030	0.162	0.041	0.261	0.251	0.196
S. 10	18.620	29.480	159.940	73.092	33.078	0.162	0.041	0.263	0.248	0.197
Ave.	21.152 ±2.98	24.219 ±3.93	190.720 ±22.20	70.471 ±5.0	32.354 ±2.12	0.159 ± 0.01	0.040 ± 0.03	0.255 ± 0.018	0.247 ± 0.017	0.190 ± 0.013
Min.	14.730	16.510	143.820	59.918	27.344	0.134	0.034	0.216	0.211	0.162
Max.	28.070	29.480	231.550	82.918	38.082	0.187	0.047	0.301	0.288	0.224
worldwide average [13]	35	30	400	370	55	1	1	1	1	1

Conclusions and Recommendations

we can say that the current study results of the radioactive quantity of radionuclide (^{238}U, ^{232}Th, ^{40}K) and radiological peril evidence of (Ra_{id}, D_{γ}, $AEDE_{in, out}$, Iγ, and $H_{in, ex}$) of the soil specimens under study in the Al-Taimeem area were less than recommended by the International Committee for the Radiation Protection[13], and therefore do not pose a significant peril to human health and environment in terms of radiological and when utilized for agriculture or other purposes. This research recommends taking advantage of the results of the current study as a database of the concentrations that have been measured as well as intensive studies to monitor radioactive pollutants indoors and in water and air for the studied area utilizing different techniques to ensure that it is free of radioactivity and to ensure a safe environment for all living organisms. Promote environmental awareness between the general public regarding the radiological risk exposure through rules and legislation defined by those responsible for the environment.

References

[1] M. Sh. Aswood et al., "Estimation of annual effective dose due to natural radioactivity in ingestion of vegetables from Cameron Highlands, Malaysia", *Environmental Technology and Innovation*, vol. 8, pp. 96–102, 2017.

[2] Al-kubaisi and Farhan, "Measurement of the radioactivity in raw materials used in the ceramic industry in AL-Ramadi ceramic factory using (HPGe) detector", *Iraqi Journal of Science*, vol.59, no.1B, pp. 307-313, 2018.

[3] Farhan et al., "Radon Gas and Effective Dose in Groundwater in Abu- Jir Village in Anbar, Western Iraq", *Iraqi Geological Journal*, vol. 53, no. (2C), pp. 26-33, 2020.

[4] Al-Dabbas and Abdullah, "Assessment of Soil Pollution in the Ishaqi Project Area- Salah Al-Dean Governorate", Iraq. *Iraqi Journal of Science*, vol.61, no.2, pp. 382-388, 2020.

[5] Sparks, D. L., *Environment soil Chemistry*. *Academic press, USA*, 1995.

[6] M. Mehade Hasan et al., "Natural Radioactivity and Assessment of Associated Radiation Hazards in Soil and Water Samples Collected from in and around of the Barapukuria 2×125 MW Coal Fired Thermal Power Plant, Dinajpur, Bangladesh", *Journal of Nuclear and Particle Physics*, vol. 4, no. 1, pp. 17-24, 2014.

[7] Nabeil I. Fawaz and Ahmed M. Ahmed, "Study the Radiation Contamination in Soil and War Waste in the Falluja City Using the Solid State Nuclear Track Detectors (SSNTDs) CR-39", *Journal of university of Anbar for Pure science,* vol.8, no.3, pp. 98-104, 2014.

[8] Annunziata M. F., *Radioactivity, Introduction and History*. *Elsevier Science, USA*, 2007.

[9] Jamal K. Alsaedi, Nada M. Hasan, Ali A. Abdulhasan, "Natural Radioactivity in soil samples from selected Areas in Nineveh Governorate, Iraq", *Nuclear Physics and Atomic Energy*, vol. 21 no. 2, pp. 187-194, 2020.

[10] Casanovas R, Morant J J and Salvadó M., October, "Implementation of gamma-ray spectrometry in two real-time water monitors using NaI (Tl) scintillation detectors", *Applied Radiation and Isotopes*, vol. 80, pp. 49-55, 2013.

[11] Huda, A. A., et al., July, "Determination of the natural radioactivity levels in north west of Dukhan, Qatar using high-resolution gamma-ray spectrometry", *Applied Radiation and Isotopes*, vol. 70, Issue 7, pp. 1344-1350, 2012.

[12] Taqi, A. H., Al-Ani, L. A. A., and Ali, A. M., "Assessment of the natural radioactivity levels in Kirkuk oil field", *Journal of Radiation Research and Applied Sciences*, vol. 9, no. 3, pp. 337-344, 2016.

[13] UNSCEAR, "Sources and Effects of Ionizing Radiation" : *Report to the General Assembly, with scientific annexes*, vol. 1 (United Nations, New York),pp. 1-219, 2008.