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Measurement of Natural Radioactivity in Samples of Fertilized and non-Fertilized Soils in Different Areas of Tikrit, Iraq

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Abstract: The current study aims to measure and calculate the concentrations of natural radioactive elements (^{226}Ra, ^{232}Th, ^{40}K) in samples of fertilized soil and non-fertilized soil in different areas of Tikrit, the administrative center of Salah al-Din Governorate. The measurement was carried out using a gamma-ray spectroscopy system connected with a scintillation detector crystallized by NaI (TI). The results were obtained, and the average concentrations of natural radioactive elements (^{226}Ra, ^{232}Th, ^{40}K) were ($11.24 \pm 0.455\ Bq.Kg^{-1}$,$23.65 \pm 1.305\ Bq.Kg^{-1}$,$291.52 \pm 9.814\ Bq.Kg^{-1}$) on the Respectively in fertilized soil samples. The average concentrations of natural radioactive elements in un fertilized soil samples amounted to ($5.28 \pm 0.216\ Bq.Kg^{-1}$, $11.82 \pm 0.617\ Bq.Kg^{-1}$, $154.17 \pm 5.253\ Bq.Kg^{-1}$), respectively. Thus, all the results in the samples under study that we obtained are less than the global average recommended by the International Atomic Energy Committees at the United Nations, and accordingly, the areas under study are safe and do not pose a source of danger to the environment.

Keywords: fertilized soil, non-fertilized soil, natural radioactive element concentrations.

1 Introduction

The radioactivity that emits nuclear radiation from radionuclides has become the important part of life, because it entered the food chain for our food and our health, and it has many agricultural, medical, industry and energy production applications [1]. Previous studies and research indicated that there are three types of emitted radiation, which are gamma rays, alpha and beta particles [2]. According to the sources of radiation, the radioactivity is of two types. As for the natural radioactivity, it occurs to the heavy elements whose atomic number is($Z > 82$) ., except for potassium (^{40}K) and carbon (^{14}C), which are among the light elements. Or industrial radioactivity that can be made in laboratories, after bombarding certain nuclei with charged particles or neutrons [3]. The natural radioactivity resulting from the emission of gamma rays depends on the geology of the environment, the quality of the soil, and the geographical conditions of that environment [4]. The radioactivity of the components of the Earth's crust is caused by the presence of natural radioactive chains, such as the uranium (^{238}U) series radioactive thorium (^{232}Th) series, as well as the radioactive uranium (^{235}U) series, in addition to the presence of the radioactive potassium (^{40} K) element, which is present alone [5]. Natural radioactive materials represent one of the most important sources of human exposure to radiation, although these materials contain low levels of the natural background radiation, but the cumulative dose may affect human health [6]. The radioactivity in the soil depends on the radioactivity in the rocks from which the soil was formed (the origin of the soil), and on the total activities that occurred to form the soil. Or inhaling suspended particles from them in the air and transported by winds to different distances and directions, or indirectly through the transmission of radiation through eating food and drinks containing radioactive contaminated materials [7]. The agricultural production process includes a wide range of soil exposed to different radiation sources. In the end, the soil is a vital guide to any radiological risk posed to humans in the near future [8,9]. Adding fertilizers with a wide range, especially phosphate fertilizers, to agricultural soils increases the amount of natural radionuclides present in them [10,11]. Thus, agricultural crops are radioactively contaminated, they may be directly or indirectly with natural and artificial radionuclides. Therefore, all this and consumption of them increases the internal radiation dose and the average annual effective dose [12]. One of the most important factors affecting dose determination of human exposure to radionuclides across the food chain in a contaminated location is the transport factor (T.F) for

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radionuclides transported from soil to plants [13]. All these factors differ from one plant to another and generally depend on the physical and chemical properties of the soil, the erosion factors, the chemical composition of radionuclides, and the different environmental conditions [14,15].

2 Geographical Location

The study area is the city of Tikrit, which is located north of the capital Baghdad and far away from it (180), and the astronomical coordinates of the study area are at latitude (34) north and longitude (43) east. Figure (1) shows the geographical location of the study area. Figure (2) shows sites for taking non-fertilized soil samples**.**

Fig. 1: Sites for sampling fertilized soil.

Fig. 2: Non-fertilized soil sampling sites.

3 Sample Collection and Preparation

Fertilized soil: (13) samples of fertilized soil (agricultural) were collected by random integration method from different areas of Tikrit city and experimental samples were taken as a joint process. For this purpose, the study area was divided into several square sections. After that, some of the squares are randomly selected. Three samples were taken from each selected square, then mixed. Soil samples were taken at a depth of (5cm-10cm) where the roots of the field crops are found by using a spade after removing the plants on the soil surface and placed inside polyethylene bags and the name of the area was recorded on them and given a specific code for each Sample and determine its coordinate using the **GPS** system as shown in Table (1). Then, it was transferred to the laboratory. The samples were dried at a temperature of (105 c°) consecutively for two hours to remove moisture using an electric oven, then grinded using an electric grinder and sifted with a sieve with holes (300 nm) to obtain a homogeneous sample. After that, a digital scale was used to weigh the samples by (300 gm) from each model and placed inside A homemade Marnelli container prepared for this purpose is tightly lid and left for at least a month to obtain the radiative balance.

Non-fertilized soil: (7) samples of non-fertilized soil (not treated with fertilizers) were collected from the intersection of the boxes that were selected, and the same steps were followed to prepare samples of fertilized soil. And as shown in Table (2).

4 Calculation of Activity Concentration

After placing the flash detector crystal inside the Marnelli container that contains the samples in its input, surrounding the Marnelli, crystalizing the detector by means of a plate of lead with a thickness of (5cm) and collecting the spectrum for a period of (18000 sec), which is the time required to collect the spectrum in our study. Then we calculate the total area under the curve for the specified energies we have To be used in calculating the concentrations of natural radioactive elements (^{226}Ra, ^{232}Th, ^{40}K) using the following relationship [16]:

$$A = \frac{N - B}{\epsilon \times I_{\gamma} \times t \times m} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

A: Radiation specific activity per unit Bq.Kg^{-1}. **B**: The total area under the light peak of the laboratory background radiation. **N**: The total area under the optical peak and the energy of the radiating element. **ϵ**: Detector efficiency for specific gamma rays. I_{γ}: The relative intensity of gamma rays. **t**: Spectrum collection time in seconds**. m**: The mass of the sample is measured in kilograms.

5 Results and Discussion

Table (3) shows the results of calculating the concentrations of natural radioactive elements in fertilized soil samples and the results were that, the concentrations of radium (^{226}Ra) recorded the sample S6 (High Flag Island) the lowest concentration and reached (7.97$\pm$0.418 $Bq.Kg^{-1}$) and the highest concentration in the sample S12 (soft) and reached (15.66$\pm$0.557 $Bq.Kg^{-1}$) The general average of concentrations reached (11.21$\pm$0.455 $Bq.Kg^{-1}$), so all the results we obtained for concentrations were less than the global recommended average of (35 Bq.Kg^{-1})[17,18]. As for thorium concentrations (^{232}Th), the sample recorded S3

(Lower tibia), the lowest concentration was (18.88±1.191 $Bq.Kg^{-1}$) and the highest concentration in the reached(5.28±0.216 $Bq.Kq^{-1}$). Thus, the concentrations are less than the international average and recommended Adult

Table 1: A code for the symbols and names of the sampling sites and their identification with the GPS system for fertilized soil samples.

Sample ID	name of the place	GPS location coordinates
S1	Medial tibia	W:34.5502899 , L:43.6311284
S2	Western tibia	W:34.5558675 , L:43.6392798,
S3	Lower tibia	W:34.5814924 , L:43.6342581,
S4	AL Awij	W:34.6539356 , L:43.5819731
S5	Southern tibia	W:34.5152332 , L:43.6738906
S6	High Flag Island	W:34.7250873 , L:43.7406348
S7	High Flag Island	W:34.7232685 , L:43.7422974
S8	High Flag Island	W:34.7243181 , L:43.7529805
S9	Flag Taoist	W:34.7087684 , L:43.6740564
S10	Flag Taoist	W:34.7097701 , L:43.6965748
S11	Al Bu Ajil	W:34.5603277 , L:43.7312753
S12	Soft	W:34.6401084 , L:43.9052792
S13	Khank	W:34.6841248 , L:43.6277857

Where W: Latitude L: longitude

Table 2: A code for the symbols and names of the sampling sites and their identification with the GPS system for non-fertilized soil samples.

Sample ID	name of the place	GPS location coordinates
N1	tibia	W:34.575721 , L:43.6342582
N2	Khank	W:34.6731241 , L:43.6288581
N3	High Flag Island	W:34.7241754 , L:43.7432867
N4	High Flag Island	W:34.7207906 , L:43.7558473
N5	Flag Taoist	W:34.70877683 , L:43.6740563
N6	Al Bu Ajil	W:34.5603271 , L:43.7312750
N7	Soft	W:34.6412447 , L:43.9009448

Where W: Latitude L: longitude

sample was S13 (alkhank) was (29.53±1.894 Bq.Kg^{-1}) and the general average of concentrations was (23±1.305 $Bq.Kg^{-1}$). Thus, all concentrations are less than the permissible global average of (30 Bq.Kg^{-1})[17,18]. And potassium concentrations (^{40}K), the sample recorded S2 (Western tibia), the lowest concentration was (195.71±8.490 $Bq.Kg^{-1}$) and the highest concentration in the sample was S8 (High Flag Island) and reached (394.04±10.468 $Bq.Kg^{-1}$) and the general average of the concentrations reached (291.52±9.814 $Bq.Kg^{-1}$), so that all the concentrations of the samples were less than the global and recommended average. It is permitted for the adult (400 Bq.Kg^{-1}). Figure (3) shows the change in the levels of natural radioactive elements concentrations and the global average with the sites of fertilized soil samples.

Table (3) shows the results of calculating the concentrations of natural radioactive elements in non- fertilized soil samples The results were that, the concentrations of radium (^{226}Ra), the sample N6 (Al Bu Ajil), recorded the lowest concentration and reached (4.76±0.172 $Bq.Kg^{-1}$) and the highest concentration in the sample N4 (The High Flag Island) and reached (6.71±0.201 $Bq.Kg^{-1}$) and the general average of the concentrations (35 Bq.Kg^{-1})[17,18]. As for thorium concentrations (^{232}Th), the sample N6 (Albu Ajeel) recorded the lowest concentration and reached (8.68±0.596 $Bq.Kg^{-1}$) and the highest concentration in the sample was N3 (High Flag Island) and reached (13.48±0.484 $Bq.Kg^{-1}$) and the general average of concentrations reached (11.82±0.617 $Bq.Kg^{-1}$). Thus, all the results we obtained are less than the average than the global and recommended average. It is permitted for the adult (30 Bq.Kg) [19-24]. And potassium concentrations (^{40}K) recorded the sample N3 (High Flag Island) the lowest concentration and reached (129.31±4.752 $Bq.Kg^{-1}$) and the highest concentration in the sample was N7 (soft) and reached (195.81±5.699 $Bq.Kg^{-1}$) and the general average of concentrations reached (154.17±5.253 $Bq.Kg^{-1}$). Thus, all results are less than the global, recommended and allowed average (400 Bq.Kg^{-1})[17,18]). Figure (3) shows the change in the levels of natural radioactive elements concentrations and the global average with the sites of non- fertilized soil samples.We note from the results we obtained that the concentration of natural radioactive elements (^{226} Ra, ^{232}Th, ^{40}K) in the fertilized soil samples was almost twice as high, and in general all the results were less than the global average permitted by the International Atomic Energy Committees at the United Nations.

Table 3: Concentrations of natural radioactive elements in fertilized soil samples.

Sample ID	^{226}Ra (Bq.Kg^{-1})	^{232}Th (Bq.Kg^{-1})	^{40}K (Bq.Kg^{-1})
S1	11.41 ± 0.446	21.00 ± 1.225	281 ± 9.304
S2	11.82 ± 0.491	21.54 ± 1.430	195.71 ± 8.490
S3	9.76 ± 0.465	18.88 ± 1.191	311.84 ± 9.701
S4	8.16 ± 0.386	20.85 ± 1.274	294.21 ± 9.045
S5	12.07 ± 0.517	25.75 ± 1.019	329.60 ± 10.428
S6	7.97 ± 0.418	28.71 ± 1.183	307.56 ± 9.248
S7	12.47 ± 0.480	25.22 ± 0.753	209.79 ± 9.676
S8	14.77 ± 0.443	28.31 ± 1.292	394.04 ± 10.468
S9	11.02 ± 0.453	23.93 ± 1.416	296.82 ± 10.054
S10	9.20 ± 0.394	24.01 ± 1.536	243.33 ± 8.662
S11	10.49 ± 0.379	19.98 ± 1.372	330.35 ± 10.844
S12	15.66 ± 0.557	19.75 ± 1.385	203.18 ± 10.321
S13	10.94 ± 0.492	29.53 ± 1.894	391.63 ± 11.399
Min.	7.97 ± 0.418	18.88 ± 1.191	195.71 ± 8.490
Max.	15.66 ± 0.557	29.53 ± 1.894	394.04 ± 10.468
Averag	11.21 ± 0.455	23.65 ± 1.305	291.52 ± 9.814

Table 4: Concentrations of natural radioactive elements in non- fertilized soil samples.

Sample ID	^{226}Ra (Bq.Kg^{-1})	^{232}Th (Bq.Kg^{-1})	^{40}K (Bq.Kg^{-1})
N1	5.63 ± 0.264	10.89 ± 0.698	139.85 ± 4.740
N2	4.77 ± 0.219	12.59 ± 0.792	171.46 ± 5.111
N3	5.11 ± 0.224	13.48 ± 0.484	129.31 ± 4.752
N4	6.71 ± 0.201	12.30 ± 0.192	157.61 ± 4.551
N5	5.05 ± 0.211	11.98 ± 0.738	135.03 ± 6.995
N6	4.76 ± 0.172	8.68 ± 0.596	150.15 ± 4.929
N7	4.97 ± 0.223	12.83 ± 0.823	195.81 ± 5.699
Min.	4.76 ± 0.172	8.68 ± 0.596	129.31 ± 4.752
Max.	6.71 ± 0.201	13.48 ± 0.484	195.81 ± 5.699
Averag	5.28 ± 0.216	11.82 ± 0.617	154.17 ± 5.253

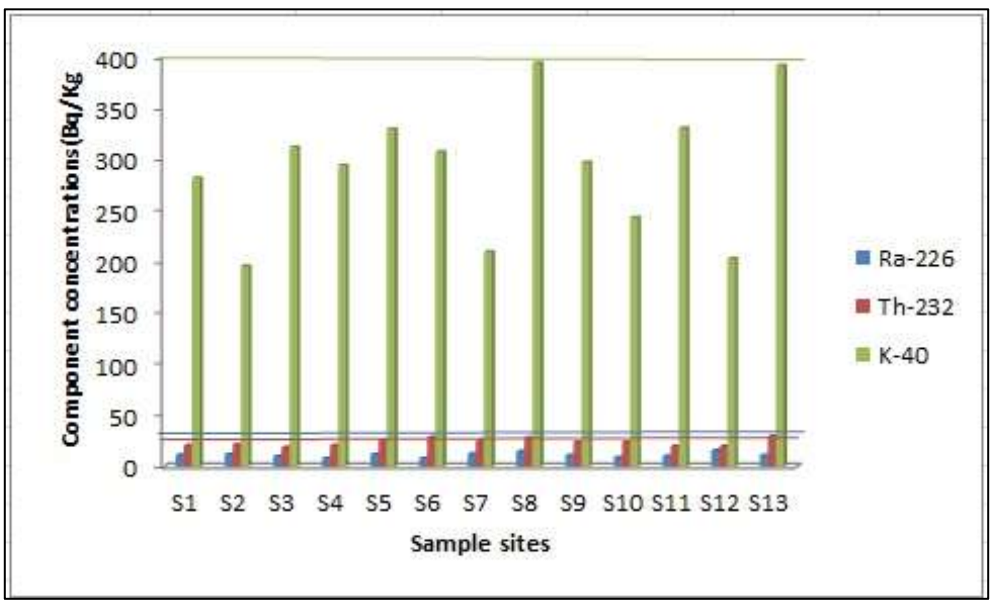

Fig. 3: The levels of natural radioactive element concentrations change with sampling sites in fertilized soil samples.

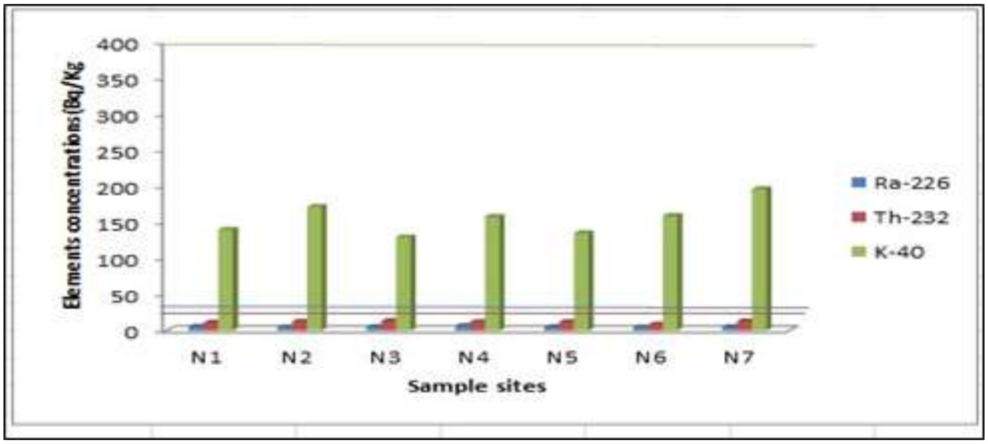

Fig.4: The change in the levels of the natural radioactive elements concentrations with sampling sites in non-fertilized soil samples.

6 Conclusion

In this study, the concentrations of natural radioactive elements were measured and calculated in (13) samples of fertilized soil and (7) samples of non-fertilized soil. By using gamma ray spectroscopy connected to the scintillation detector. All results were less than the recommended global average. Concentrations of natural radioactive elements in fertilized soil samples were almost twice as high as those in non-fertilized soil samples, but they are within the global average and do not constitute a source of radiation hazard and are safe for the area under study. It is recommended for future studies to measure and calculate radon concentrations in the area under study to ensure that it does not lead to radioactive contamination of the environment under study.

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References

[1] L'Annunziata M. F., Radioactivity: Introduction and History. (Elsevier), (2007).

[2] Jum'a, Muhammad Ahmad Mahmoud and Salah al-Din Mustafa Kamal) 1989 Atomic radiation methods guide. Salary House Undergraduate Publishing.

[3] Khalil, Munib Adel (1994) Nuclear Physics, Dar Al-Kutub for Printing and Publishing, University of Mosul, Iraq.

[4] Diab, H.M., S.A. Nouh, A. Hamdy and S.A. El- Fiki (2008). Evaluation of natural radioactivity in a cultivated area around a fertilizer factory. Journal of Nuclear and Radiation Physics., **3(1)**, 53- 62(2008).

[5] Najm, Laith A. and Hamoo, Zainab N. . Radiation risk assessment in soil samples for some selected areas of Mosul city in Iraq. Refidanin Journal of science ., **29(2)**,.86-94 (2020).

[6] Maher, O. and R.Abu Saleh (2006). Radiation measurements in soil in the middle of Gaza- strip using nuclear track detectors CR- 39. Journal Al- Aqsa University., **10**, 273- 280(2006).

[7] Al-Julihawi, Kawthar Hassan Abees (2012) Measurement and study of the natural radioactivity of soil models of circles Official in the province of Qadisiyah. Unpublished MA Thesis, University of Kufa, College of Education for Girls, Department - Physics,Iraq.

[8] Environmental Protection Agency EPA (1997) An Effects Assessment and Analysis: Special Report on Environmental Endocrine Disruption, Washington, DC U. S., Risk Assessment Forum. EPA630R96012.

[9] Steffan JJ, Brevik EC, Burgess LC, Cerdà A (2018) The effect of soil on human health: an overview. European journal of soil science., **69(1)**, 159–171(2018).

[10] Lecomte JF, Shaw P, Liland A, Markkanen M, Egidi P, Andresz S, Mrdakovic-Popic J, Liu F, da Costa LD, Okyar HB, Haridasan PP, Mundig S (2019) Radiological Protection from Naturally Occurring Radioactive Material (NORM) in Industrial Processes, ICRP Publication 142, **48(4)**, 5-67(2019).

[11] Smičiklas I, Šljivić-Ivanović M (2016) Radioactive Contamination of the Soil: Assessments of Pollutants Mobility with Implication to Remediation Strategies. In Soil Contamination – Current Consequences and Further Solutions, InTech., 253–276(2016).

[12] Shaw, G. and Bell, J. N. B. Plants and radionuclides. In: Frago M.E., editor. Plants and chemical elements: biochemistry, uptake, tolerance and toxicityVCH Publishers., (1994).

[13] Davis, P. A., Avadhanula, M. R., Cancio, D., Carboneras, P., Coughtrey, P. and Johansson, G., BIOMOVS II: an international test of the performance of environmental transfer models. J. Environ. Radioact., **42**,117– 30 (1999).

[14] International Atomic Energy Agency. Handbook of Parameter Values for Prediction of Radionuclide Transfer in Temperate Environment (Vienna: IAEA) (1994).

[15] Najm, Laith A. , Younis, Shaher A. and Kithah, Fouzey H. .Natural Radioactivity in soil samples in Nineveh province and the Associated Radiation Hazards. International Journal of physics., **3(3)**, 126-132 (2015).

[16] (UNSCEAR) United Nations Scientific Committee on the Effects of Atomic Radiation, Report to the General Assembly:

Sources and Effects of Ionizing Radiation, New York, (1989).

[17]] UNSCEAR. (2008). Sources and effects of ionizing radiation (Vol. 1). New York, United Nations: United Nations Scientific Committee on the Effects of Atomic Radiation.

[18] UNSCEAR. (2000). Sources and effects of ionizing radiation (Vol. 1). New York, United Nations: United Nations Scientific Committee on the Effects of Atomic Radiation.

[19] Atef El-Taher, LA Najam, AA Abojassim and H Mraity Assessment of Annual effective Dose for Different Age Groups Due to Radon Concentrations in Groundwater Samples at Qassim, Saudi Arabia. Iranian Journal of Medical Physics.,**17**, 15-20 (2020).

[20] AA Abojassim, HAU Mohammed, LA Najam, A El-Taher., Uranium Isotopes Concentrations in Water Surface Samples for Al-Manathera and Al-Heerra Regions of Al-Najaf, Iraq. Environmental Earth Sciences.,**78(5)**, 132(2019).

[21] A, El-Taher and Ahmed El-Turki., Radon Activity Measurements in irrigation water from Qassim Province Using RAD7. Journal of Environmental Biology., **37**, 1299-1302 (2016).

[22] S. A. Alashrah and A. El-Taher Assessment of natural radioactivity levels and radiation hazards in Wadi Al-Rummah Qassim province, Saudi Arabia. Journal of Environmental Biology., **37**, 985-991(2016).

[23] S. Alashrah and A. El-Taher., Gamma Spectroscopic Analysis and Associated Radiation Hazards Parameters of Cement Used in Saudi Arabia. Journal of Environmental Science and Technology., **9(2)**, 228-245 (2016).

[24] SS Althoyaib, A El-Taher The measurement of radon and radium concentrations in well water from Al-Jawaa, Saudi Arabia Journal of Natural Sciences and Mathematics ., **7(2)**, 179-192 (2015).