Natural gamma emitters in soil samples of Governmental departments of Al- Nasiriya city, Iraq

Kawthar Hassan Obayes

Department of Physics, College of Education, University of Al-Qadisiyah, Qadisiyah Governorate, Iraq

► ***Short report***

***Corresponding author:**
K.H. Obayes, Assist. Prof. D.
E-mail:
kawthar.aljelehawy@qu.edu.iq

Received: November 2022
Final revised: March 2023
Accepted: June 2023

Int. J. Radiat. Res., January 2024; 22(1): 219-222

DOI: 10.52547/ijrr.21.31

ABSTRACT

Background: The radionuclide concentrations of ^{238}U, ^{232}Th, and ^{40}K were measured in soil samples of some Governmental departments of Nasiriya city, at Thi Qar governorate Iraq. ***Materials and Methods:*** Using a NaI(Tl) detector, the specific activity of natural radionuclides in soil samples was evaluated. ***Results:*** The present investigation showed that the average values of specific activities (^{238}U, ^{232}Th, and ^{40}K) were (5.37, 2.24, and 189.41 Bq/Kg), respectively. The averages values of the radiological hazards radium equivalent (Ra_{eq}), absorbed dose rate (Dγ), annual effective dose (AEDE), inside risk records (Hin), and external hazard index (Hex) were (23.16 Bq/kg, 11.96 nGy/h, 0.015 µSv/y, 0.059 µSv/y , 0.077, 0.063), respectively. ***Conclusion:*** According to these values, the results of the current study not exceeded the global permissible values of the natural radionuclides.

Keywords: *Natural radioactivity, Na I (Tl) detector, Nasiriya, Thi Qar governorate.*

INTRODUCTION

The use of radionuclides in industry, agriculture, medicine, and other nuclear and radiological applications is expanding, as is the development of nuclear technology. This could be accompanied by an increase in accidents and a sharp increase in the dangers of radionuclide contamination of internal organs and external exposure of people to ionizing radiation [1]. There are both natural and industrial sources of radiation in the environment, although exposure to natural radiation is more significant than the threat posed by industrial radioactive sources [2, 3]. Naturally occurring radionuclide series, such as ^{238}U, ^{232}Th, and ^{40}K, can be found all across the earth's crust. These radionuclides are crucial because they offer valuable data, and they are even more dangerous due to their high solubility and quick transportability. It's crucial to monitor environmental pollution caused by natural radioactivity and understand its quantities and dispersion in order to protect human health [4,5].

Rocks, soil, sand, and sediments in rivers and oceans are frequently radioactive, as are building materials because they include naturally occurring radioactive materials. Generally speaking, it contains any lingering primordial radionuclides from the Earth's formation [6]. Most people's radiation exposure comes from natural sources. Many locations around the world, including Brazil, China, Iran, and Japan, have excessive natural radiation levels [7]. The previous years, the study of naturally occurring radioactivity in soils across all nations has become more crucial for determining the threat that radiation poses to human health at low doses for an extended period of time. After homes, government departments are probably the biggest source of background radiation exposure. Because many people spend the majority of their time there. Therefore, those government departments are required to check the background radiation levels in residences as well. The natural radioactivity in many structures, including universities and schools, needs to be studied.

The goal of this study was to determine the radiological parameters brought on by exposure in these government departments by calculating the radioactivity levels brought on by ^{238}U, ^{40}K, and ^{232}Th in soils of government departments in Al- Nasiriya city, southern Iraq. Also, the anticipated outcomes can be utilized because there hasn't been any previous research of this kind conducted in the area.

MATERIALS AND METHODES

Samples collection

Al- Nasiriya city is where this study is being conducted. Fifteen government departments were selected. From Al- Nasiriya city southern Iraq. Table 1 shows the coordinates of location samples for the present study.

Table 1. Coordinates of location samples for the present study.

Sample code	Locations	Coordinates	
		Latitude (N)	Longitude (E)
S1	Al-Shahid Health Center-ASSADAR city	31°04^' 49.21"	46°14^' 17.95"
S2	Foundation and Directorate shahada - 30. Street	31°04^' 20.08"	46°14^' 50.11"
S3	Water Directorate - Teachers' neighborhood	31°04'18.67"	46°14^' 55.73"
S4	Appellate court - Iridoo neighborhood	31°04^' 29.38"	46°14^' 52.36"
S5	Directorate of Municipalities – Teachers' neighborhood	31°03^' 37.90"	46°14^' 57.69"
S6	Anti - crime department - Iridoo neighborhood	31°43^' 22.88"	46°06^' 45.02"
S7	Sunduq Alaskan - Alaskan neighborhood	31°03^' 27.07"	46°14^' 54.75"
S8	Directorate of Immigration and Displacement - Al-Thawra neighborhood	31°02^' 02.91"	46°13^' 44.56"
S9	Shamiya Police Center - Mansourieh neighborhood	31°01^' 58.17"	46°13^' 36.32"
S10	Hassan health center -Al-Shumukh neighborhood	31°02^' 23.51"	46°13^' 58.98"
S11	Environment directorate - Salhia neighborhood	31°03^' 27.17"	46°10^' 37.00"
S12	Dental hospital - Sumer neighborhood	31°03^' 30.47"	46°10^' 24.38"
S13	Al Hussein Health Center - Ur neighborhood	31°03^' 35.89"	46°14^' 40.90"
S14	Civil Defense Directorate - MansourIeh neighborhood	31°02^' 07.20"	46°13^' 33.08"
S15	Euphrates Electricity Circuit - Fida neighborhood	31°03^' 36.21"	46°16^' 33.46"

Experimental method

15 soil samples were taken from government departments in the city of Nasiriya, southern Iraq, collected from a depth of 10 cm. They are marked with special symbols in table 1. After that, the samples were delivered to the Advanced Nuclear Physics Laboratory at the University of Kufa's College of Science. Each sample was dried in an electric oven at 100 °C for 2-3 hours to remove all moisture from it. Then, the samples were ground using an electric mill and sifted using a 2 mm mesh. The samples were then placed inside a cylindrical plastic container with a tight-fitting lid to prevent the leakage of radon gas. Before being placed in a container, each sample was accurately weighed using an electronic scale. Each sample had a mass of 1 kg and to achieve a secular equilibrium, each sample was held for at least one month (8).

Gamma-ray spectrometer

Using and outfitting the electronic counting and analysis system for the detection of nuclear radiation by (Alpha Spectra, Inc.-12I12 / 3) and consists of a NaI (Tl) scintillation detector with crystal dimensions of "3 × 3" in addition to a multi-channel analyzer (MCA)(ORTEC - Digi Base) contains 4096 channels, connected to an ADC unit, which translates the main amplifier's pulse into digital numbers before sending the spectral data directly to the personal computer, in the laboratory (9). The detector was kept vertical and protected by an ORTEC cylindrical chamber to reduce background radiation. To calibrate the NaI (Tl) detector, IAEA radioactive sources were used (model RSS-8) consisting of ^{137}C, ^{54}Mn, ^{60}Co, ^{22}Na, and ^{152}Eu as energy and efficiency calibration sources for the detector. The working current accuracy value was 7.9% for a standard ^{137}C source with an energy of 661.66 kV.

Calculations

Equation 1 was used to estimate the specific activity (A_s)(9):

$$A_s(\frac{Bq}{Kg}) = \frac{C_n}{\varepsilon \times I_\gamma \times T \times m} \quad (1)$$

where is A_s the specific activity in Bq/kg, C_n is the net count rate under peak per second, ε is detector efficiency, I_γ is the probability of gamma-ray emission at each energy; T seconds for counting, m is sample mass (kg).

Eq. 2 is used to calculate Radium Equivalent Activity (Ra_{eq}), a widely used danger index (9):

$$Ra_{eq}\left(\frac{Bq}{Kg}\right) = A_U + 1.43\, A_{Th} + 0.077\, A_K \quad (2)$$

Where A_U, A_{Th}, and A_K are the specific activity of ^{238}U, ^{232}Th, and ^{40}K, respectively.

Eq. 3 is used to calculate the Absorbed Dose Rate in Air (D_γ) (10):

$$D_\gamma\left(\frac{nGy}{h}\right) = 0.462\, A_U + 0.604\, A_{Th} + 0.0417 A_K \quad (3)$$

The following equations give The annual Effective Dose Equivalent (AEDE), and External and internal hazard index for the investigated samples(11):

$$AED_{Eout\ door}(\mu Sv/y)=D_\gamma\times 8760\times 0.2\times 0.7 \quad (4)$$

$$AEDE_{In\ door}(\mu Sv/y)=D_\gamma\times 8760\times 0.8\times 0.7 \quad (5)$$

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \quad (6)$$

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \quad (7)$$

RESULTS AND DISCUSSION

Table 2 and figure 1, show the results of the activities identified in the soil samples of the government departments of the city of Nasiriya, southern Iraq, for radionuclides ^{238}U, ^{232}Th, and ^{40}K. It

[DOI: 10.61186/ijrr.22.1.219]

was found that the radioactivity of ^{238}U ranges between 1.19±0.15 and 10.24±0.45Bq/kg, at an average of 5.37±0.30Bq/kg. The lowest value was in the sample (S6), and the highest value was in the sample (S11).

By comparing the value of the specific activity rate of U-238 of the soil samples of the current study, it was found to be less than the internationally permitted rate, which is (35 Bq / kg) [12]. The specific effectiveness values ranged for Th-232 from 1.58 ± 0.10 Bq/kg in the sample (S14) to 4.15 ± 0.17 Bq/kg in the sample (S8) at an average of 2.24 ± 0.12 Bq/kg, which is less than the internationally permissible limits (30 Bq/kg) [12].

As for the specific effectiveness of ^{40}K, it ranged between 50.54 ± 1.05 and 257.40 ± 2.36 Bq/kg for the samples (S12) and the samples (S2), at a rate of 189.41 ± 1.98 Bq/kg, which is lower than the global average (400 Bq/kg) [11].

Table 2. Specific activity for gamma emitters (^{238}U, ^{232}Th and ^{40}K) in the Soil samples.

Sample No.	Activity Concentration (Bq/kg)		
	^{238}U	^{232}Th	^{40}K
S1	3.18±0.25	2.97±0.14	252.25±2.34
S2	9.02±.42	3.17±0.15	257.40±2.36
S3	2.34±0.21	2.34±0.13	215.08±2.16
S4	7.23±0.38	2.03±0.12	236.93±2.26
S5	8.38±0.40	2.08±0.12	255.56±2.35
S6	1.19±0.15	LDL	57.09±1.11
S7	6.08±0.34	1.97±0.12	93.41±1.42
S8	9.04±0.42	4.15±0.17	240.81±2.28
S9	7.17±0.37	1.76±0.11	106.61±1.52
S10	4.36±0.29	2.47±0.13	216.75±2.17
S11	10.24±0.45	3.15±0.15	181.16±1.98
S12	LDL	LDL	50.54±1.05
S13	4.34±0.29	2.71±0.14	235.29±2.26
S14	4.26±0.29	1.58±0.10	223.91±2.20
S15	3.69±0.27	3.24±0.15	218.37±2.17
Ave.	5.37±0.30	2.24±0.12	189.41±1.98
worldwide(11)	35	30	400

Through table 3, it can be seen that the radium equivalent activity values (Ra_{eq}) in samples for the current study ranged from 3.89 to 33.52 Bq/kg, with an average value of 23.16 Bq/kg, which is less than the international permissible limit of 370 Bq/kg [7]. Equations [6,7] were also used to calculate the risk indicator values (external and internal indicators) for the collected samples. , The rate value was for H_{ex} and H_{in} (0.063 and 0.077) respectively which are less than unity which represents the maximum value of acceptable safety level recommended by UNSCEAR [7]. As for the results of other radiation hazards such as D_γ, $AEDE_{indoor}$, and $AEDE_{outdoor}$ also, the results of the D_γ absorbed dose ranged from 2.18 nGy/h to 17.07 nGy/h with an average value of 11.96 nGy/h, which is lower than the global average, which is 55 nGy/h. The calculated values of annual outdoor and indoor equivalent effective doses (AEDEoutdoor and AEDEindoor) for soil samples varied from 0.003 µSv/y to 0.021 µSv/y with an average of 0.015 µSv/y, and from 0.01 µSv/y to 0.084 µSv/y). With an average of 0.059 µSv/y, respectively. The values of (AEDEoutdoor and AEDEindoor) were less than the global permissible limit which is (0.08, 0.42 µSv/y respectively) [11].

Table 3. Radiological parameters of the radionuclides (^{238}U, ^{232}Th, and ^{40}K) for soil samples of government departments of the city of Nasiriya, Iraq.

Sample No.	Ra_{eq} (Bq/kg)	D (nGy/h)	$AEDE_{Out}$ (µSv/y)	$AEDE_{In}$ µSv/y)	H_{ex}	H_{in}
S1	26.86	14.22	0.0174	0.069	0.073	0.081
S2	33.37	17.07	0.021	0.084	0.09	0.115
S3	22.25	11.84	0.015	0.058	0.06	0.066
S4	28.37	14.66	0.018	0.072	0.077	0.096
S5	31.04	15.99	0.019	0.078	0.084	0.106
S6	5.59	2.98	0.004	0.015	0.015	0.018
S7	16.09	7.94	0.009	0.039	0.043	0.059
S8	33.52	17.01	0.021	0.083	0.091	0.115
S9	17.89	8.83	0.011	0.043	0.048	0.068
S10	24.58	12.86	0.016	0.063	0.066	0.078
S11	28.69	14.28	0.018	0.07	0.078	0.105
S12	3.89	2.18	0.003	0.01	0.011	0.01
S13	26.33	13.81	0.017	0.068	0.071	0.083
S14	23.76	12.54	0.015	0.062	0.064	0.077
S15	25.13	13.15	0.016	0.065	0.068	0.078
Ave.	23.16	11.96	0.015	0.059	0.063	0.077
worldwide (11)	370	59	0.08	0.42	≤1	≤1

CONCLUSION

The electronic counting and analysis system was used to measure the spectrum of gamma rays (NaI (Tl)) to analyze soil samples of government departments in the city of Nasiriyah, southern Iraq, to consider the effects of natural radioactivity in soil samples on employees from 15 government departments. The activity concentrations of ^{238}U, ^{232}Th, and ^{40}K were below the global permissible limits. Also, it was found that all the radiological hazards of the samples examined for the current study were within the recommended safe ranges. As a result, employees in these establishments are not exposed to radiation danger from their immediate surroundings.

I'd like to express my gratitude to the University of Kufa, College of Sciences. Department of Physics for their assistance.

ACKNOWLEDGMENTS

I would like to thank the employees at the official institutes in Dhi Qar Governorate for their support. I would also like to extend my thanks to the University of Kufa / College of Science / Department of Physics for their assistance in conducting laboratory tests for this research, noting that this work was self-financing by the researcher himself.

REFERENCES

1. El-Ghossain MO and Saleh RMA (2015) Radiation measurements in soil in the middle of Gaza-Strip using different type of detectors.

[DOI: 10.61186/ijrr.22.1.219]

IUG J Nat Stud, ***15****(1)*.
2. Rose C, Parker A, Jefferson B, Cartmell E (2015) The characterization of feces and urine: a review of the literature to inform advanced treatment technology. *Crit Rev Environ Sci Technol,* ***45****(17): 1827–79*.
3. Elsaman R, Ali GAM, Uosif MAM, *et al.* (2020) Transfer factor of natural radionuclides from clay loam soil to sesame and Cowpea: radiological hazards. *Int J Radiat Res,* ***18****(1): 157–66*.
4. Hamoo ZN and Najam LA (2022) Natural radioactivity for soil samples of different sites of ancient Mosul. *Technology Reports of Kansai University,* ***62****(3): 979-987*.
5. Daaeim JS and Obayes KH (2022) Measurement of radon concentration levels at the official institutes of Al-Rifai City, Dhi Qar Governorate, Iraq. *Statistics (Ber),* ***1****: 2*.
6. Obayes KH and Oudah ON (2022) The measurement of radon concentration in the buildings of the college of education, Al-Qadisiyah University, Iraq using CR-39 detector. *Nat Environ Pollut Technol,* ***21****(2): 669–74*.
7. Radiation UNSC on the E of A. Sources and effects of ionizing radiation. UNSCEAR 1996 report to the General Assembly, with scientific annex. 1996.
8. Lippmann M and Leikauf GD (2009) Introduction and background to environmental toxicants, edited by M. Lippmann, 1–38. Hoboken. NJ: Wiley; 2009.
9. Mahdi KH, Nassif RM, Obayes KH (2015) Radionuclides concentration and radiological risk in the dust rising in Some Streets of Diwaniyah city due to the movement of wheels and cars. *Int J Sci Res (IJSR),* ***2015****: 2319-7064*.
10. Obayes KH, Mahdi KH, Nassif RM, Mansour HL (2019) Determination of radionuclides and heavy elements in the rising dust in the small side of Diwaniyah City due to the movement of wheels and cars. In Conference Series. IOP Publishing; 2019. bl *Conf. Ser. Journal of Physics,****1234****: 12046*.
11. Maphoto KP (2004) Determination of natural radioactivity concentrations in soil: a comparative study of Windows and Full Spectrum Analysis. University of the Western Cape; 2004.
12. Maphoto KP (2000)UNSCEAR Report 2000: Sources and effects of ionizing radiation. 2001.

[DOI: 10.61186/ijrr.22.1.219]