Journal of Mechanical Engineering Research and Developments
ISSN: 1024-1752
CODEN: JERDFO
Vol. 44, No. 7, pp. 19-26
Published Year 2021

The determination of the natural radioactivity of ^{238}U, ^{232}Th, and ^{40}K in sediments of Bahr Al-Najaf Reservoir wetland /Iraq

Ahmed Qasim Ubaid[†], Ahmed Mohammed Ali Savore[‡], Nadia Mohammed Majeed[‡†], Mohammed Jawad Salih Al-Haidarey[‡‡]*

[†] College of Education for pure sciences
[‡] Education Directorate of Wasit Province
[‡†]Department of Basic Science, College of Dentistry, University of Wasit, Iraq
[‡‡]Department of Ecological Sciences, University of Kufa-Iraq

*Corresponding Author Email: mohammedj.alhayderi@uokufa.edu.iq

ABSTRACT

Soil is one of the most significant natural sources of ionizing radiation to which humans are exposed, as natural radionuclides (such as uranium-238 nuclear series and thorium-232) are present in soil which affects human health by one way or another. Therefore, this study aimed to studied the natural radioactivity of ^{238}U, ^{232}Th, and ^{40}K in ten sites of Bahr Al-Najaf reservoir-Iraq sediments, to determine the concentration of ^{238}U, ^{232}Th, and ^{40}K in using NaI(Tl) 3"×3" system. The results showed that the radioactivity of ^{40}K ranged between (428±4.83 - 309±4.1) Bq/Kg, ^{238}U ranged between (8.45±0.36 - 3.7±0.24) Bq/Kg, ^{232}Th ranged between (4.61±0.26 - 0.01±0.002) Bq/Kg, and Radium equivalent ranged between (39.62±0.71 - 30.2±0.6) Bq/Kg. The Absorbed dose rate in air ranged between (20.892±0.354 - 16.000±0.300) nGy.h-1. By comparing the experimental results with the globally standard, results found that effectiveness of radiation concentrations of the samples studied within the globally range.

KEYWORDS

NaI(Tl), Bahr Al-Najaf, ^{238}U, ^{40}K, ^{232}Th

INTRODUCTION

Bahr Al-Najaf is located at the western edge of the holy city of Najaf and overlooks its plateau, and its basin extends towards an area of about 750 km2 and the height of its lowest point is 11 m above sea level. As geological view, it is floor covered with modern sediments that reach a thickness of about 38m with sedimentary rocks surrounding it from different edges [1]. Radioactive contamination is one of the most harmful forms of physical pollution, which means that radioactive contaminants are leaked into one of the elements of the environment (e.g. water, soil, air etc.). Radioactive materials are classified into two major categories of materials, the 1st is wave-like (electromagnetic radiation such as gamma rays and x-rays that are common in research applications, and this type of radioactive material has a high potential to penetrate body tissues for a long distance, while the 2nd is radiation with particle nature, such as alpha and beta rays. This type of radioactive material has a lower potential to enter the human body than the first type, but inhaling dust which containing alpha or beta rays could cause significant harm to the cells that absorb it. Radiation is one of the most harmful forms of environmental pollutants, and when toxic contaminants enter the body's cells, they cause noticeable and unseen harm that also destroys human life [2].

Radioactive emissions may occur from natural sources, such as outer space rays and radioactive gasses from the earth's crust. Radioactive particles do not have colors, smells, and feel, and they could easily reach, move and penetrate the living bodies without any opposition, without any evidence of their existence, and without leaving any trace in workers related to nuclear power stations, nuclear reactors and radioisotopes, agriculture or medicine. As a result, the chances of nuclear pollution are getting worse over time. Mehra *et al* [3] measured the efficacy concentration of natural radionuclides, namely radium (^{226} Ra), thorium (^{232}Th), and potassium (^{40}K) for soil samples which collected from different sites in India using a high-purity germanium (HPGe) detector, the results indicate that the concentration of thorium was higher than the international limitation of the United Nations Committee of scientific effects of atomic radiation, the concentration of radium was very close, and the potassium was less than those global figures.

Mehra [4] also studied the radiological hazards of the population in soil samples from western Haryana in India by determining the concentration of natural radionuclides using the nuclear trace detector (LR-115), he was found that the concentrations of radium ^{226} Ra, thorium ^{232}Th and potassium ^{40} K were change from 13.37 - 24.67 Bq/m^3, 34.67 - 67.34 Bq/m^3, and 298.78 - 405.67 Bq/m^3 respectively. The results showed that the concentration of thorium ^{232}Th in soil was higher than the global values mentioned by United Nations Scientific Committee on the effects of atomic radiation. He was also found that the concentration of potassium ^{40} K was very close to those of global values, while the concentration of radium ^{226}Ra was normal and less than the global permissible values. In Egypt, Harb *et al* [5] found that the average of radium ^{226} Ra was (27.3 Bq / kg, 11.4, 10.6 and 11.4), while the concentration of thorium ^{232}Th was about 15.1 Bq / kg (11.1, 10.8 and 11.1) and finally the potassium ^{40}K was about Bq/kg (521, 436, 488.9 and 344) for soil models in the northern, southern, eastern and western regions of those two regions, respectively.

Muhammad and Hassoun [6] studied the concentration of radioactive nuclides in six different types of soil in the Al-Ruhban area in the province of Najaf, they used HPGe, they found that the average of specific radioactivity of the nuclides of Bismuth ^{214} Bi, Radium ^{226} Ra, Actinium ^{228} Ac, Thorium ^{232} Th, ^{40}K and cesium ^{137} Cs were (47.93, 81.87, 5.03, 1.63, 126.3 and 3.5) Bq/kg respectively. In Kurdistan of Iraq, Dashty and Ali [7] used the NaI (Tl) flash detector to measure the concentration of radioactivity of radium ^{226}Ra for 20 soil samples, the results found that the concentration was ranged between 8.11 Bq/kg to 22.42Bq/kg. The results were with the rest of the countries in the world and with the global average of 32 Bq/kg and were within the permissible range, so the soil in that area is suitable for building construction. Hassan and Mahdi [8] collected 16 soil sample from the Rusafa side of Baghdad to detect nuclides and measure the radioactivity of these samples using HPGe. They found that the specific activity rate of ^{238}U was 13.84. Bq / kg and for ^{232}Th was 15.76 Bq / kg, while the specific activity rate for 40 K was 288.39 Bq / kg and for 137Cs was 1.56Bq / kg. The results showed that the specific activity rate was within the international normal range.

Al-Gazaly *et al* [9], determine the specific radioactivity value of ^{238}U, ^{232}Th and ^{40}K in 60 soil samples collected from different sites around a uranium-contaminated area in Abu-Sakhir region in Najaf-Iraq. The results showed that the concentration of uranium and potassium was higher than the global average mentioned in the United Nations Committee of Effects. Almayahi [10] assessed the amount of radiation hazard in soil samples from the city of Kufa -Iraq by determining the value of the radioactivity concentration of natural radionuclides (^{238}U, ^{232}Th and ^{40}K) using the NaI (Tl) flash detector, which was equal to about (78, 78 and 286) Bq/kg. Also, he was found that the value of the equivalent radium was equal to 246Bq/kg, which is less than the globally permissible value of 370 Bq/kg, and found that the rate of the absorbed dose ratio was equal to 112nGy / h, which is about twice higher than Global tolerable value of 51nGy/h, The aim of the current study is to determine the level of the radiation background in ten sites of Bahr Al-Najaf reservoir-Iraq sediments-Iraq, by measuring the concentrations of radionuclides in those areas, and comparing them with a number of other cities and countries and the permissible global values, as well as determining the values of some of the indicators of radioactive pollution in them. To estimate the radiation risks resulting from the level of radioactivity in these sites, we have used for this purpose the gamma ray spectroscopy with the NaI (Tl) flash detector.

METHODOLOGY

Study sites description

The Bahr al-Najaf portion of the Najaf governorate has been chosen to analyze radioactivity because it is uncontaminated land surrounded by dense orchards and watered by the river Euphrates, and is also considered a hub for religious tourism in a densely populated city. In addition, a significant number of arrivals from the governorate communities are coming to work. Ten study sites were chosen for the collection of sediments using the Ekman grab system (Fig. 1). Samples have been processed at-4 ºC in polyethylene bags until analyzed.

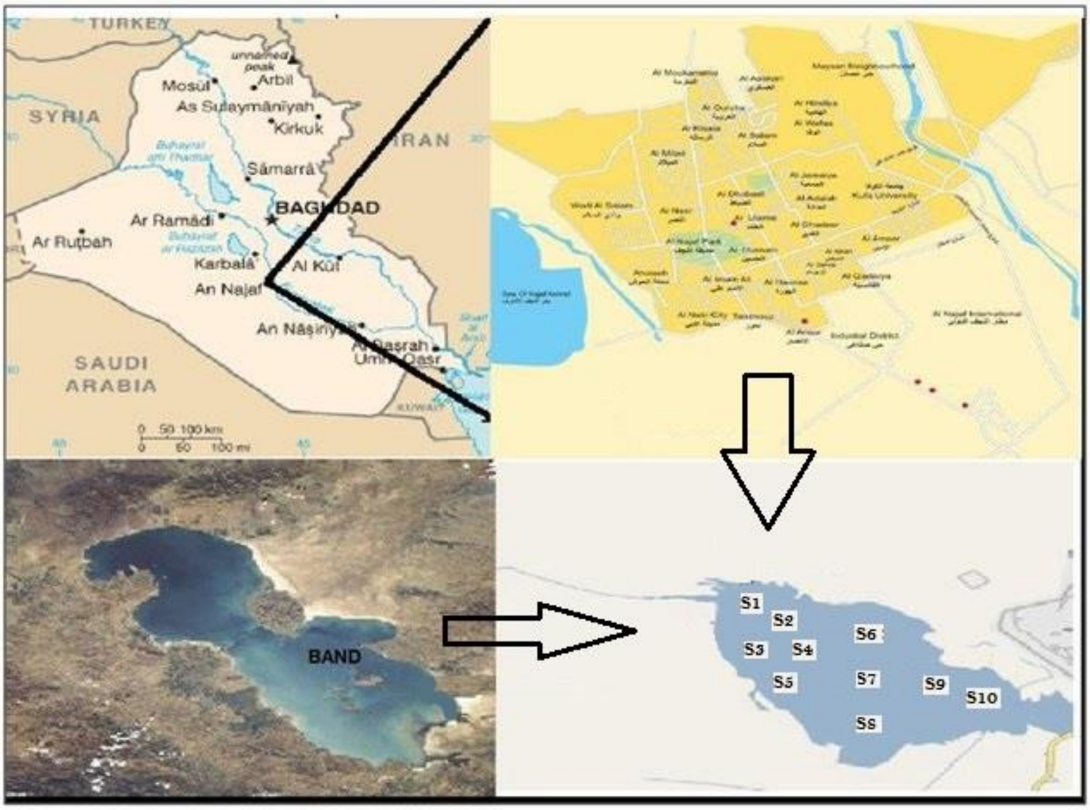

Figure 1. Shows the sediment sampling sites of Bahr Al-Najaf depression reservoir

Preparation of samples

Triplicate samples of ten location of study sites were collected, then dried them using an oven (Bashan Iab-Italy) for two hours to obtain moisture-free samples, the samples were grinded and then sifted using a 1 mm mesh sieve to obtain homogeneous samples. Then 1kg of the dried samples was taken and placed in a 1-liter Marnelli container after washing it well with 0.01 N hydrochloric acid then with distilled water, here the samples became ready to next step.

Sampling Spectrum

The natural radioactivity of the studied samples was measured using a "3" x 3 sodium iodide detector system after calibrated the system using standard sources (Table 1) within 18000 seconds. The radionuclides in samples were determined by the photoelectric emission peaks resulting from the U-238 series, and thorium Th-232 series, and potassium nuclide K-40 single, as well as the detection efficiency of the energy of the radionuclides in soil models was calculated through the following equation:

$$Efficiency = 0.0704 \times e^{-0.0023X} \quad \text{--------------------}(2\text{-}5)$$

Where X is energy (KeV).

Table 1. The radionuclides energy and detection efficiency

Radionuclides	Energy	Efficiency (E%)
234Pa	1001.03	0.7
214Bi	609.31	1.7
212Bi	727.3	1.3
228Ac	968.97	0.75
40K	1460.82	0.24

Measuring qualitative effectiveness

The specific activity of the ^{238}U sequence was determined by measuring the specific activity of the bismuth nuclide (214Bi) with an energy of 1764 keV, as well as the specific activity of the ^{40}K energy, 1460 keV radionuclide and the ^{232}Th chain. Relevant behavior of thorium, ^{232}Th, in that it is possible to quantify the radioactivity of any element in the radioactive chains identified as being in delayed balance in terms of radioactivity of another element in order to research the efficacy of radionuclides in the samples, so that the gamma emitting method was used on the basis of high penetration intensity For gamma rays in materials using gamma rays The net area under the curve for each radionuclide after which the precise radioactivity of these radionuclides was determined by means of the following equation:

$$A = \frac{N_{net}}{\varepsilon . I_{\gamma} . mt} \pm \frac{\sqrt{N_{net}}}{\varepsilon . I_{\gamma} . mt} [Bq.kg^{-1}] \quad (1)$$

N: The net area under photo-peak curve; ε: the calculated efficiency of the gamma line at a given power; I_y: Effectiveness concentration factor; M: mass of the sample (Kg); t: the measurement time.

While, the risk factors were calculated based on the activity concentrations of ^{238}U, ^{232}Th, and ^{40}K by calculating the rate of absorbed dose in air (Equation 2) and radium equivalent (Equation 3).

$$AD\ (nGy/h) = 0.427A_U + 0.662A_{Th} + 0.043A_K \quad (2)$$

$$Raeq\ (Bq/kg) = AU + 1.43ATh + 0.077AK \quad (3)$$

Whereas, Au, ATh, and Ak represent the activity concentration of uranium, thorium and potassium respectively, the highest value of Raeq should be less than the global permissible limit (370 Bq/Kg; 11)

RESULTS AND DISCUSSION

Fingers (2, 3, and 4) showed that the specific effectiveness values for ^{232}Th, ^{238}U, and ^{40}K for the sediment samples which taken from Bahr Al-Najaf depression reservoir. The highest value of ^{232}Th was site 1 (0.810±0.031 Bq/Kg), while the lowest value was in site 6 (0.0059±0.002 Bq/Kg). The lowest value of ^{238}U was in site 10 (3.730±0.237 Bq/Kg), and the highest value was in site 4 (8.446±0.357 Bq/Kg). The lowest value of ^{40}K was in site 9 (308.517±4.099 Bq/Kg), while the highest value was at site 1 (427.806±4.827 Bq/Kg).

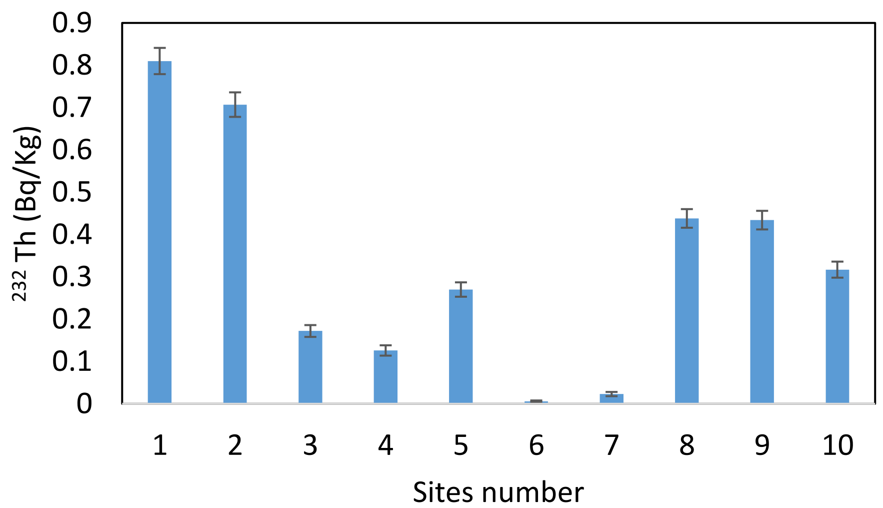

Figure 2. The rates of ^{232}Th activity for the sediment samples.

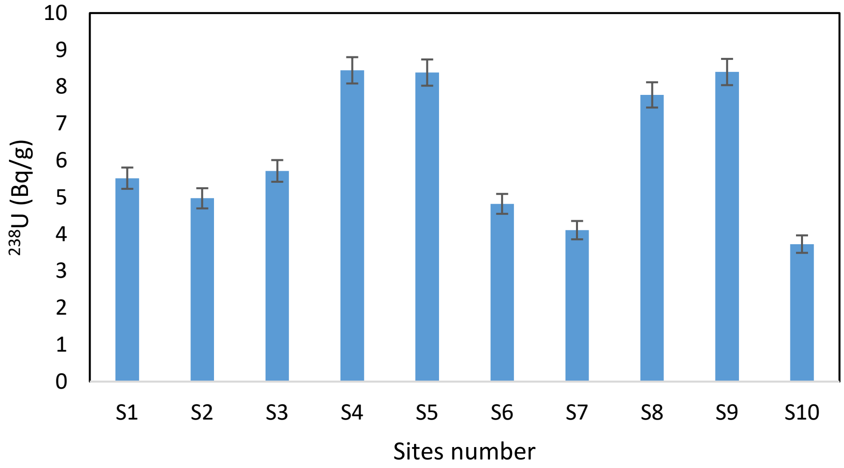

Figure 3. The rates of ^{238}U activity for the sediment samples.

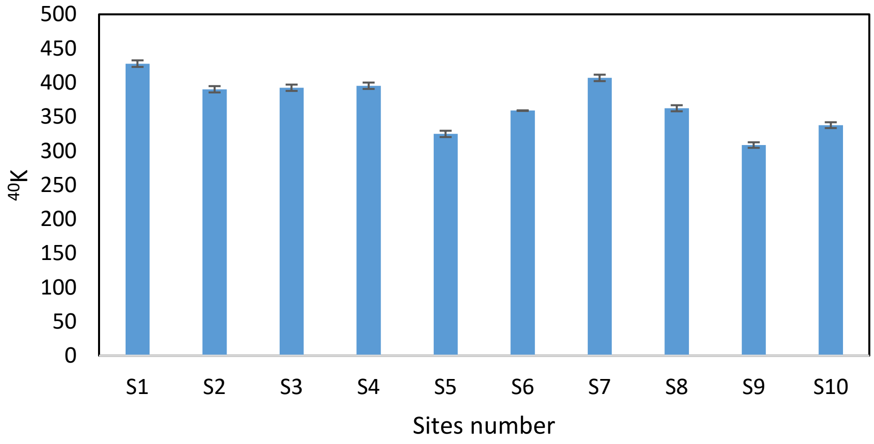

Figure 4. The rates of ^{40}K activity for the sediment samples.

Also, it was found that the highest value of the radium equivalent is 39.618±0.705 nGy.h^{-1} in site 1, while the lowest value (32.470±0.307 nGy.h^{-1}) was at site 6 (Figure 5). The lowest value of the absorbed dose was 16±0.3 nGy.h^{-1} in site 10, while the highest rate of the absorbed dose was 20.892±0.354 nGy.h^{-1} in site 1(Figure 6).

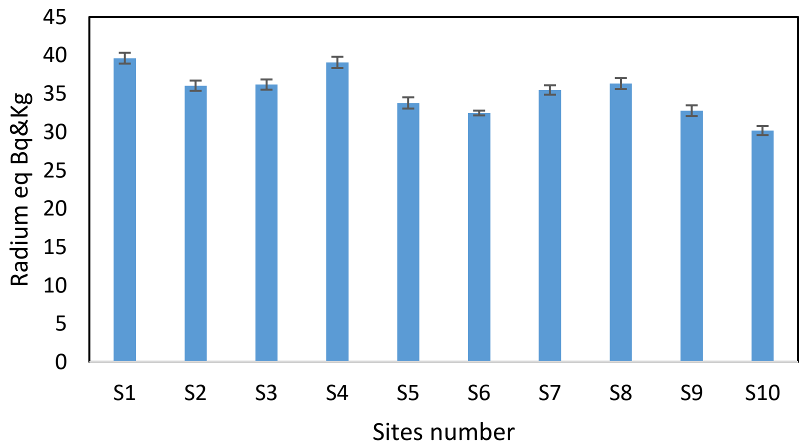

Figure 5. The rates of radium equivalent activity for the sediment samples.

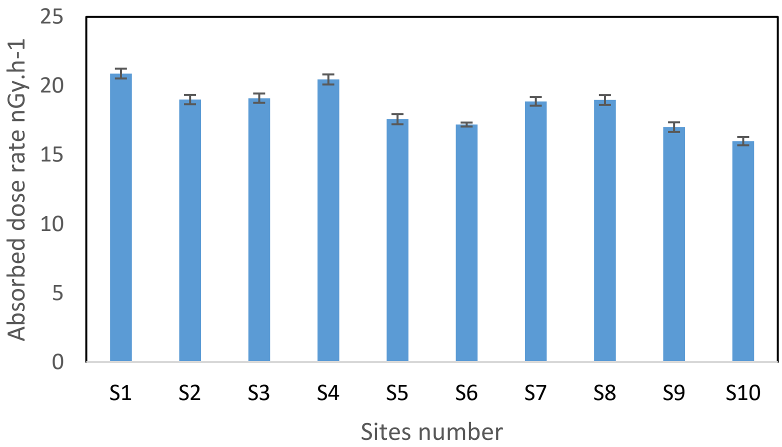

Figure 6. The rates of the absorbed dose activity for the sediment samples.

It is evident from this work that the specific activity values of ^{238}U, ^{232}Th, and ^{40}K were distributed in varying proportions for all the measured samples, and the reason for this may be due to the geological nature of the soil in that region, and despite this disparity it is noticed that it was within the permissible limit globally [12] and less than some locals and internationals countries (Table 1). And the specific activity of potassium ^{40}K takes values varying from one site to another. It has been observed that there is an increase in the concentration of potassium nuclide in some areas is due to the presence of agricultural lands containing phosphate fertilizers in which the concentration of potassium isotope increases (40K), but all results were within the internationally permissible limits (400 Bq/Kg; 11). The study proved all the results of the absorbed dose and the effective dose of the environmental sites were within the globally permissible limit, and despite the high values of specific effectiveness in some sites, were all within the permissible limit globally and locally, so they do not pose a threat to living organisms. These results was agree with Hassan & Mahdi [8], Almayahi [10] and Dashty & Ali [7], but they were disagree with Al-Gazaly *et al* [9] in closed area.

Table 2. Shows the specific effectiveness of the uranium chain - 238, the thorium chain - 232, and the potassium - 40 units (Bq/Kg) for some previous studies.

Land	**Absorbed dose activity rat**			**References**
	^{232}Th	**^{238}U**	**^{40}K**	
Egypt	35	35	370	[13]
USA	92	77	817	[14]
Indonesia	15	13	111	[15]
Brazil	58	44	131	[16]
Iraq	44	18	173	[17]
India	87	57	143	[18]
Cyprus	5	7.1	105	[19]
Bangladesh	52	63	20	[20]
Jordan	21	22	138	[21]
Iraq	7.32	18	142	[22]
Iraq	5.03	48	126	[23]
Iraq	25	23	127	[24]
World rate	45	33	420	[25]
Current study	0.7	5.98	378.161	Current study

CONCLUSION

The study showed that the natural radioactivity was within the globally permissible locally limits and it is not posing a danger to living organisms.

ACKNOWLEDGEMENT

We would like to thankful Head Department of Ecological Sciences-Faculty, University of Kufa to funding this work and supporting the field trips.

REFERENCES

[1] M.J. Al-Haidarey, M.C. Abbas and I.A. Abdulmunem, "Primary productivity in Bahr Al-Najaf Depression Reservoir/Iraq", Kufa Journal of Agricultural Sciences, Vol. 10, No. 3, Pp. 121-135, 2018.

[2] Y. Lu, J. Yuan, D. Du, B. Sun, and X. Yi, "Monitoring long-term ecological impacts from release of Fukushima radiation water into ocean", Geography and Sustainability, Vol. 2, No. 2, Pp. 95-98, 2021.

[3] K. Inoue, M. Fukushi, and T. Van Le, "Distribution of gamma radiation dose rate related with natural radionuclides in all of Vietnam and radiological risk assessment of the built-up environment", Sci Rep., Vol. 10, Pp. 12428, 2020. https://doi.org/10.1038/s41598-020-69003-0.

[4] M. Imani, M. Adelikhah, and A. Shahrokhi, "Natural radioactivity and radiological risks of common building materials used in Semnan Province dwellings, Iran", Environ Sci Pollut Res., 2021. https://doi.org/10.1007/s11356-021-13469-6

[5] E.S. Joel, O. Maxwell, and O.O. Adewoyin, "Investigation of natural environmental radioactivity concentration in soil of coastaline area of Ado-Odo/Ota Nigeria and its radiological implications", Sci Rep., Vol. 9, 4219, 2019. https://doi.org/10.1038/s41598-019-40884-0

[6] K.K. Mohammed and S.A. Hasson, "Measurement of the natural radioactivity of soil samples from Al-Rheban area in Najaf city – Iraq", Journal of Physics, Vol. 3, No. 1, Pp. 38-44, 2011.

[7] T.A. Dashty, and H.A. Ali, "Measurement of Radioactivity for ^{226}Ra Radionuclide in Soil Samples from Bekhma region using Gamma Ray Spectrometry", Pure and Applied Science, 1 (1), Pp. 44-48, 2013.

[8] A.K. Hassan and M.I. Mahdi, "Measuring the natural radioactivity of soil samples from the official departments of the Rusafa side of Baghdad", Al-Nahrain Journal of Science, Vol. 16, No. 3, Pp. 14-19, 2013.

[9] H.H. Al-Gazaly, M. Al-Ulum, A.A. Al--Hamidawi, and A.M. Al-Abbasi, "Natural radioactivity in soil at regions around the uranium mine in Abu-Skhair Najaf Province, Iraq", Pelagia Advances in Applied Science Research, Vol. 5, No. 1, Pp. 13-17, 2014.

[10] B.A. Almayahi, 2014. Gamma spectroscopic of soil samples from Kufa in Najaf Governorate, Iraq. World Applied Sciences Journal, Vol. 31, No. 9, Pp. 1582-1588.

[11] K.M. Thabayneh and M.M. Jazzar, "Natural radioactivity levels and estimation of radiation exposure in environmental soil samples from Tulkarem Province – Palestine", Open Journal of Soil Science, Vol. 2, Pp. 7-16, 2021.

[12] M. Zubair, and Shafiqullah, "Measurement of natural radioactivity in several sandy-loamy soil samples from Sijua, Dhanbad, India", Heliyon, Vol. 6, No. 3, Pp. e03430, 2020. https://doi.org/10.1016/j.heliyon.2020.e03430

[13] S. Harb, A.H. El-Kamel, A.I. Abd El-Mageed and H.H. Negm, "Natural Radioactivity Measurements in Soil and Phosphate Samples from El-Sabaea, Aswan, Egypt», IX Radiation Physics & Protection Conference19-15، November (2008), Nasr City-Cairo, Egypt, 2008.

[14] T.E. Myrikk, B.A. Berven and F.F. Haywood, "Determination of concentrations of selected radionuclides in surface soil in the U.S", Health Physics., Vol. 45, No. 3, Pp. 631-642, 1983.

[15] H. Ryuta and S. Kiyoshi, "Environmental assessment of natural radioactivity in soil samples from the LUSI Mud Volcano, Indonesia", Environment Asia, Vol. 2, Pp. 45-49, 2009.

[16] De Moraes and Daltro, "Environmental gamma radiation and natural radioactivity in soils in Centro Experimental Aramar (CTMSP-Brazil) and Region", Radiation Protection Dosimetry, Vol. 87, No. 3, Pp. 207-211, 2000.

[17] N.A. Abdureda, R.A. Jabur, H.E. Dawood, and M.S. Aswad, "Measuring the radioactivity of water and sediments samples in Al-Qadisiyah governorate using the gamma ray spectroscopy technique", Al-Qadisiyah Journal of pure science, Vol. 15, No. 4, Pp. 87-97, 2010.

[18] E. Menshikova, R. Perevoshchikov, P. Belkin, and S. Blinov, "Concentrations of Natural Radionuclides (40K, 226Ra, 232Th) at the Potash Salts Deposit", Journal of Ecological Engineering, Vol. 22, No. 3, Pp. 179-187, 2021. https://doi.org/10.12911/22998993/132544

[19] R. Mehra, S. Singh, and K. Singh, "Analysis of ^{226}Ra,^{232}Th and ^{40}K in soil samples for the assessment of the average effective dose", Indian J. Phys., Vol. 83, No. 7, Pp. 1031-1037, 2009.

[20] R. Mehra, "Radiological risk assessment in soil samples of western Haryana, India", World academy of science Engineering and Technology, Vol. 3, No. 6, Pp. 448-452, 2009.

[21] S. Harb, K. Salahel Din, A. Abbady, and M. Mostafa, "Activity concentration for surface soil samples collected from Armant, Qena, Egypt", Proceedings of the 4th Environmental Physics Conference, Hurghada, Egypt, Pp. 49-57, 2010.

[22] A. Mussa, "Measuring and studying the levels of natural radioactivity of soil at the Madloum area in the province of Najaf", MSc Thesis. University of Kufa-Iraq, 2011.

[23] K.K. Mohammad, "Measurement of the natural radioactivity in AL-Rohban soil samples from AL-Najaf AL-Ashraf-Iraq", Journal of Kufa – physics, Vol. 3, No. 1, Pp. 37-43, 2011.

[24] A.A.Z. Salih, "Measuring the radioactivity and some physiochemical properties of selected soils from Al-Diwaniyah city-Iraq", MSc Thesis. University of Kufa-Iraq, 2014.

[25] United Nation Scientific Committee on the Effects of Atomic Radiation. Sources and Effects of Ionizing Radiation. United Nations, No.E.10.XI.3, 2008.