Natural Radioactivity in Underground Waters In Tallafar Distract In Iraq

Ashraf Abdulrahman M. Taher, Kareem Mohammad
Al-Nahrain University, College of Science, Department of physics
kareemnerc26@gmail.com
ashfww@gmail.com

Abstract
The purpose of the present study is to measure the level of the natural radioactivity of (underground waters samples) in Tallafar district center, from the Alayadiyah side, and from the Al-Adaya village, determination of specific activities of $^{228}$Ac, $^{226}$Ra, $^{214}$Pb, $^{137}$Cs, $^{40}$K, (0.40716), (0.2321), (0.281), (0.76751), (4.9806) Bq/L respectively using gamma ray spectroscopy technique with NaI(Tl) scintillation detector in 15 samples, also evaluation of radiological hazard indices (radium equivalent Reaq, absorbed dose rate ($D_\gamma$), annual effective dose (AEDE indoor), AEDE(outdoor), hazard induces (Hex and Hin) and gamma index ($I_\gamma$)) . The results showed that the average value of the specific activity are agreement with IAEA publications.
1. Introduction

Radiation is known to be a stream of particles such as electrons, protons, neutrons, alpha particles, or high-energy photons, or a mixture there of [1]. As for the sources of radiation in the environment, they are either natural, which includes cosmic rays and nuclides generated as a result of their interaction with some air components, terrestrial radionuclides such as potassium $^{40}$K, uranium chain $^{238}$U, thorium series $^{232}$Th and uranium chain $^{235}$U, or industrial and the most important ones arising from the nuclear fuel cycle and the waste of the nuclear, agricultural and industrial fields, or by means of nuclear weapons tests such as cesium ($^{137}$Cs and $^{134}$Cs), may constitute a significant source of radiation in the environment [2]. The radioactivity The phenomenon of radioactivity of the elements discovered by the French scientist Henri Becquerel in 1896 is a process of spontaneous decomposition that occurs for the nuclei from the emission of alpha, beta, gamma, ... etc., and it is of two types: either natural radioactivity it occurs for heavy elements whose atomic number is greater than $Z > 82$, except for $^{40}$K and $^{14}$C which are light elements, or either an artificial radioactivity that can be made in the laboratory by bombarding certain nuclei with charged particles or with neutrons [3]. The natural radioactivity resulting from the emission of gamma rays depends on joules Environment, soil quality and geographical conditions of that environment [4]. The Earth appears from the space as a blue ball covered with water, and there are some large and small islands littered in it. Therefore, the earth was called the Blue Planet, which covers the largest part of the globe. Billion square kilometers. Salt water represents about 97% of the total volume of water and is found in seas, oceans, lakes, and waterways. As for fresh water, it represents the remaining part that reaches 3%. This type is concentrated in rivers, ponds, some lakes, and the subsoil of groundwater and hot mineral water, and icebergs form in The polar regions are the largest part of the freshwater available for human use, which represents approximately 1.6% of the total water volume, and this percentage is not fixed, especially with the high percentage of increasing salts in lakes and closed or semi-closed fresh water bodies, i.e., whose water connects with sea water For one-sided navigation[18]. Water sources vary greatly on the surface of the globe due to their very wide area, but they can divide water according to its natural sources into:

1- Oceans and seas.
2- Rain water.
3- River water.
4- Lake water.
5- Ground water.
6- Mineral and hot water.

2. Material And Methods

2.1 Study Area

Tallafar is an Iraqi city located in northwestern Iraq, and it belongs administratively to Nineveh Governorate. An estimated population of about 205,000 thousand peoples, according to 2014 estimates, and the city is located near the Iraqi-Syrian border and is about 70 km away from the city of Mosul, about 38 km south of the Turkish border, and the Syrian border by about 60 km[5]. The city was part of the state of Mosul, which was one of the states of the Ottoman Empire, and in the city a castle was built as a military base, and today the ruins
of the castle can be seen, and after the withdrawal of the Ottomans a garrison was erected in that castle and they were the first residents of the city that borders the castle. In the battle of Mosul (2016-17) against ISIS, the organization transferred what is called the caliphate headquarters to the city of Tallafar, to become the temporary stronghold of the organization[5]. This study is considered the first after the region suffered to break down. The table (1) shows the areas from which the models were chosen, which are ancient water eyes used by the population for the purpose of agriculture and drinking.

Table (1) Name, location, date, and brief summary of each sample.

| SA. CO | Area Name | Coordinate | SA. Na. | History | Notes |
|-------|-----------|------------|---------|---------|-------|
| TA1   | Puoltry   | N36.2139   | Tala'afer1 | 2019/12/25 | This area is close to Tallafar military airport where the sample was taken from a poultry artesian well and this area was affected by liberation operations in Tallafar in 2017. |
|       |           | E42.2715   |          |         |       |
| TA2   | Quarter Alkifah Aljanabi | N36.2129   | Tala'afer2 | 2019/12/26 | A neighborhood Tallafar located on airport road. The sample was taken from artesian well of residential home. |
|       |           | E42.249    |          |         |       |
| TA3   | Quarter Allalia | N36.2224   | Tala'afer3 | 2019/12/29 | A neighborhood Tallafar located on center Tallafar. The sample was taken from artesian well of residential home. |
|       |           | E42.2644   |          |         |       |
| TA4   | Almhikha Village | N36.242    | Tala'afer4 | 2019/12/29 | This village is located on the outskirts of Tallafar where the sample was taken from poultry artesian well. |
|       |           | E42.3125   |          |         |       |
| TA5   | Subashi    | N36.2241   | Tala'afer5 | 2019/12/29 | It is considered an archeology area, as it is the site of the ancient Tallafar fortress built by the ottomans, and in 2015 it was detonated by terrorist ISIS. |
|       |           | E42.2722   |          |         |       |
| TA6   | Quarter Alwahda Alowha | N36.2250    | Tala'afer6 | 2020/1/1 | This district is a bit of actor of the treatment of the criminology terrorists to blow up a car bombing in 2007 in which the led demolished 1km² of housing houses. where the sample was taken from poultry artesian well. |
|       |           | E42.262659 |          |         |       |
| TA7   | Quarter Almucalimin | N36.2175    | Tala'afer7 | 2020/1/1 | A neighborhood Tallafar located on center Tallafar. The sample was taken from artesian well of residential home. |
|       |           | E42.259770 |          |         |       |
| TA8   | Quarter Alkhara’ | N36.2199    | Tala’afer8 | 2020/1/2 | A neighborhood Tallafar located on center Tallafar. The sample was taken from artesian well of residential home. |
|       |           | E42.270985 |          |         |       |
| TA9   | Aqueduct Alayadiyah | N36.2920    | Tala’afer9 | 2020/1/7 | Alayadiyah is one of the aspects of the Tallafar district, where this aqueduct has more than 150 years of water, where the water in it contains sulfur. where the sample was taken from poultry artesian well. |
|       |           | E42.254103 |          |         |       |
| TA10  | Quarter Alwahda Althanaya | N36.2251    | Tala’afer10 | 2020/1/8 | The sample was taken from poultry artesian well market. |
|       |           | E42.257259 |          |         |       |
| TA11  | Aladaya1   | N36.154552  | Tala’afer11 | 2020/1/14 | Aladaya is a village that belongs to the Tallafar district, and this village has many nuclear rumors. The sample was taken from artesian well in the center of the village and the water in it contains a large of sulfur. |
|       |           | E42.426308 |          |         |       |
| TA12  | Aladaya2   | N36.154552  | Tala’afer12 | 2020/1/14 | The sample was taken from the sheep field artesian well |
|       |           | E42.426308 |          |         |       |
| TA13  | Aladaya3   | N36.154552  | Tala’afer13a | 2020/1/14 | The sample was taken from aqueduct village and the water in it contains a large of sulfur. |
|       |           | E42.426308 |          |         |       |
| TA14  | Aladaya4   | N36.154552  | Tala’afer13b | 2020/1/14 | The sample was taken from aqueduct village and the water in it contains a large of sulfur. |
|       |           | E42.426308 |          |         |       |
| TA15  | Aladaya5   | N36.154552  | Tala’afer13c | 2020/1/14 | The sample was taken from aqueduct village and the water in it contains a large of sulfur. |
|       |           | E42.426308 |          |         |       |
2.2 Sample Collection, preparations and measurement

Samples were collected from (15) sites from the Tallafar district center, from the Alayadiyah side, and from the Al-Adaya village, affiliated to the Tallafar district, using polyethylene bottle capacity (2L), where (5) samples were taken from the Al-Adaya village, (3) samples were taken from different locations, while the two samples were taken from the same site on the same day and the same time to compare their results with each other. The water samples were used in measurement standard (1L) polyethylene Marinelli beakers, which also used as a measuring container. Before use the containers were washed with dilute HCl and rinsed with distilled water. Samples were acidified by adding 0.5ml of conc. HNO3 per liter, to avoid any loss of radium isotopes around the container walls [6]. Each container was filled up by water, sealed, and aged one month in order to ensure that radioactive equilibrium was reached between $^{226}$Ra, $^{222}$Rn and its progeny [6]. The time of measuring is 7200s each samples.

2.3 Measuring specific activity of radionuclide

The specific activity of radionuclide’s, (911, 583) keV for $^{228}$Ac, (609, 351.5)keV for $^{214}$Bi and $^{214}$pb respectively, $^{212}$Pb, 1460keV for $^{40}$K respectively with intensity 100%, were used for the laboratory measurement of activity concentration uranium and thorium and potassium. In (Bq/kg) units in sediment samples and in (Bq/L) units in water samples were obtained by using the relation [7]:

$$S.P \left( \frac{Bq}{kg} \right) = \frac{N-B.G}{T.N.\times M.\times V} \times 100\% \quad \text{(1)}$$

Where:
- A: specific activity concentration of radionuclide in (Bq/kg) or (Bq/L)
- N: net gamma counting rate (count per second)
- B: G: back ground
- M: mass of the sample (kg)
- V: the volume the sample(L)
- T: time (S)
- $\epsilon$: The absolute efficiency

3. Result And Discussions

Specific Activities Of Natural Radionuclide In Ground Water Samples collected from (11 location) from inside and outside Tallafar District. A specific activity of natural radionuclide’s($^{228}$Ac, $^{226}$Rn, $^{214}$Pb, $^{137}$Cs and $^{40}$K) in ground water samples collected was given in Table(2),Fig(1).
The range of specific activity concentration for $^{226}$Ra varied from (0 to 4.26) Bq/L with average (0.40716) Bq/L, the highest specific activity levels were found in sample (TA1) is (4.26) Bq/L, which can be referred to as the cumulative of this radionuclide in the water and the minimum activity levels found in (TA5) is zero shows in Fig.(1).

The range of specific activity concentration for $^{214}$Pb varied from (0 to 0.7) Bq/L, with average (0.281) Bq/L, the highest values was found in the sample (TA1) is (0.7) Bq/L, which can be referred to as the cumulative of this radionuclide in the water and the minimum value found in the sample (TA10) is zero shows in Fig.(2). The range of specific activity concentration for $^{228}$Ac varied from (0 to 1.23) Bq/L, with average (0.231) Bq/L, the highest values was found in the sample (TA4) is (1.23) Bq/L, which can be referred to as the cumulative of this radionuclide in the water and the minimum value found in the sample (TA9) is zero shows in Fig.(3). The range of specific activity concentration for $^{40}$K varied from (3 to 6.16) Bq/L, with average (4.9806) Bq/L, the highest values was found in the sample (TA10) is (6.16) Bq/L, which can be referred to as the cumulative of this radionuclide in the water and the minimum value found in the sample (TA9) is 3 Bq/L shows in Fig.(4). The range of specific activity concentration for $^{137}$Cs varied from (0.0057 to 1.22) Bq/L, with average (0.76751) Bq/L, the highest values was found in the sample (TA4) is (1.22) Bq/L, which can be referred to as the cumulative of this radionuclide in the water and the minimum value found in the sample (TA13) is 0.0057 Bq/L shows in Fig.(5).

Table (2) Specific activity in (Bq/L) of radionuclide's in ground water samples and compared with some countries in Table (3). The results showed that the average value of the specific activity are agreement with IAEA publications and UNSCEAR[16,17].

| Sample code | Specific Activity concentration |
|-------------|--------------------------------|
|             | $^{226}$Ra | $^{214}$Pb | $^{228}$Ac | $^{40}$K | $^{137}$Cs |
| TA1         | 4.26       | 0.7        | 0.13       | 4.4     | 0.623     |
| TA2         | 1.73       | 0.246      | 0.12       | 5.81    | 1.1       |
| TA3         | 0          | 0.102      | 0.288      | 5.62    | 1.12      |
| TA4         | 0          | 0          | 1.23       | 5.24    | 0.947     |
| TA5         | 0          | 0.231      | 0.0335     | 4.78    | 1.05      |
| TA6         | 0.021      | 0.4        | 0.382      | 4.64    | 1.22      |
| TA7         | 0          | 0.133      | 0          | 5.9     | 0.8       |
| TA8         | 0          | 0.357      | 0.555      | 4.13    | 0.98      |
| TA9         | 0          | 0.33       | 0          | 4.9     | 1.06      |
| TA10        | 0          | 0          | 0.27       | 6.16    | 0.786     |
| TA11        | 0          | 0.38       | 0.107      | 3.5     | 0.797     |
| TA12        | 0          | 0.48       | 0.126      | 6.03    | 0.413     |
| TA13        | 0.0964     | 0.49       | 0.24       | 5.03    | 0.0057    |
| TA14        | 0          | 0.365      | 0          | 3       | 0.52      |
| Country     | Water source | $^{226}$Ra (Bq/L) | $^{232}$Th (Bq/L) | $^{40}$K (Bq/L) | Reference |
|-------------|--------------|-------------------|------------------|----------------|-----------|
| Saudi Arabia| ground water | 0.05-1.63 (0.558) | 0.52-0.69 (0.204) | 1.47-8.9 (4.581) | [9]       |
| Yemen       | ground water | 2.25-3.45 (2.95)  | 0.3-1.37 (0.72)   | 26.73-43.7 (34.9) | [10]      |
| Saudi Arabia| Drinking water | 0.105-0.568 (0.32) | 0.016-0.382 (0.12) | 2.16-18.84 (10.96) | [11]      |
| Malaysia    | Drinking water | 0.70-7.03 (2.86)  | 0.55-8.64 (3.78)  | 22-53 (15.2)     | [12]      |
| Egypt       | Drinking water | 0.07-0.54 (0.2)   | 0.05-0.5 (0.13)   | 3.25-8.72 (5.29) | [13]      |
| Nigeria     | ground water | 2.89-7.79 (4.54)  | 0.18-4.77 (0.50)  | 1.74-4.69 (2.94) | [14]      |
| Ghana       | ground water | 0.38              | 0.54             | 5.05            | [15]      |

Table (3) Specific activity in (Bq/L) of radionuclide's in ground water samples in some countries[9].

Fig. (1) Specific Activity of $^{226}$Ra in all ground water samples.
Fig.(2) Specific Activity of $^{214}\text{Pb}$ in all ground water samples.

Fig.(3) Specific Activity of $^{228}\text{Ac}$ in all ground water samples.
Fig. (4) Specific Activity of $^{40}$K in all ground water samples.

Fig. (5) Specific Activity of $^{137}$Cs in all ground water samples.
4. Conclusion

The study area is one of the important areas that depend on groundwater. This water is used in agriculture and drinking water. This water needs test continued for the purpose of monitoring. One of these tests is the measurement of natural radiation activity where the soil and environmental factors have a major impact on groundwater.

The results showed that it is within the permissible limits compared to the publications of the International Agency and studies of other countries.

Reference

[1] Bahaa Al-Din Maarouf, “Natural Radioactivity in Iraq,” studies and researches selected from the scientific conference on the effects of the use of depleted uranium weapons on humans and the environment in Iraq, Baghdad - Iraq, issued by the Ministry of Higher Education, pp. 129-145-26-27 March, (2002).

[2] Al-Andawi, Hussein “Factors Affecting Radioactive Contamination of Food and Water,” Corn and Development Bulletin, 13 (1), (1999).

[3] Khalil, Muneeb Adel "Nuclear Physics". Book House for Printing and Publishing, University of Mosul (1994).
[4]. Diab, H.M., Nouh, S.A., Hamdy, A. and El-Fiki, S.A. "Evaluation of natural radioactivity in a cultivated area around a fertilizer factory., Journal of Nuclear and Radiation Physics, 3(1), 53-62(2008).
[5]. H. Assaf, Dr. M. S. Al-Masri “Sources of Groundwater Contamination Department of Protection and Safety”, Atomic Energy Commission of Syria, Damascus P.O.Box 6091, Syria(2007).
[6]. Description of Tallafar Department of Behavioral Sciences & Leadership United States Air Force Academy, Colorado Springs. January 8, 2008. Archived from the original on August 16 (2010). Retrieved April 22( 2011).
[7]. Navratilova, R. D. Greenwell and F. MacAfee “Radioactive waste management and environment restoration Proceedings of the International Congress of Speleology” October 12–16(1997).
[8]. Vosniakos F., Zavalaris K. and Papaligas T., "Indoor concentration of natural radioactivity and the impact to human health", Journal of Environ. Protect. Ecol., Vol.4, No.3, p(733-737), (2003).
[9]. F.A. Alseroury , T. Almeelbi, Aslam Khan, M.A. Barakata, J.H. Al-Zahrani, W. Alali” Estimation of natural radioactive and heavy metals concentration in underground water” Journal of Radiation Research and Applied Sciences 11 (2018) 373–37
[10]. El-Mageed, A. I. A., El-Camel, A. E.-H., Abbacy, A. E.-B., Herb, S., & Sale, I. I. “Natural radioactivity of ground and hot spring water in some areas in Yemen”. Desalination, 321, 28–31(2013).
[11]. Al-Zahrani, J. H. “Risk assessment due to ingestion of natural radionuclides and heavy metals in drinking water” International Journal of Development Research, 06(06), 8039–8044(2016).
[12]. Almayahi, B., Tajuddin, A., & Jaafar, M. “Radiation hazard indices of soil and water samples in Northern Malaysian Peninsula”. Applied Radiation and Isotopes, 70(11), 2652–2660 (2012).
[13]. El-Gamal, H., & El-Mageed, A. I. A. “Natural radioactivity in water samples from Assiut City, Egypt”. International Journal of Pure and Applied Sciences and Technology, 22(1), 44–52. (2014).
[14]. Ajayi, O. S., & Achuka, J. “Radioactivity in drilled and dug well drinking water of Ogun state southwestern Nigeria and consequent dose estimates”. Radiat.Prot. Dosimetry, 135, 54–63 (2009).
[15]. Darko, G., Faanu, A., Akoto, O., Acheampong, A., Goode, E. J., & Gyamfi, O. “Distribution of natural and artificial radioactivity in soils, water and tuber crops”. Environmental Monitoring and Assessment, 187(6), 1–11,(2015).
[16]. UNSCEAR. United Nations scientific committee on the effects of atomic radiation, sources and effects of ionizing radiations. United Nations, New York(2000).
[17]. IAEA. International atomic energy agency. Measurement of radiation in food and the environment. Guidebook. Technical Report series, No. 295Vienna: IAEA (1989).
[18]. Kareem k. Mohammad, . Study of the elements distribution in water and particles of the river Tigris by neutron activation analysis , Iraq J. OF CHEM. 23 (2), 1997.