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Determination of radioactive concentrations in Tigris river soil samples in Baghdad province

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Abstract

In this study, the amounts of activity concentrations of naturally occurring in 10 soil samples of the Tigris river and surrounding areas collected from deferent city of Baghdad have been investigated. Tigris river is an important water source for irrigation and drinking in Iraq. This study was done during 2018 in Protection Center of the Iraqi Ministry of Health and Environment using a high purity germanium detector. The resolution of (HPGe) at 2keV and 30% efficiency. The results of soil sample obtained showed that the effective activity concentration of ^{40}K are ranged from 181.4 Bq/kg in sample S6 to 286.4 Bq/kg in S7. For Ra_{eq} values are ranged from 6 Bq/m^3 in sample S5 to 17 Bq/m^3 in sample S3. The obtained data revealed that the mean specific activity for ^{226}Ra, ^{228}Ac and ^{40}k in these samples were less than World average. The artificial radionuclide represented by ^{137}Cs was observed in some samples and vary from minimum value of detector <MDA to 7.5Bq/kg in sample S9 with an average value 3.842857 Bq/kg. Area around the site may attributed to the nuclear activities of this site or may be due to the nuclear accident (Chernobyl Catastrophe) which have been spread throughout a large area of the world including the samples locations were collecting.

Key words
Radioactive concentrations, soil, Tigris river.

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تحديد العناصر المشعة في تربة نهر دجلة في محافظة بغداد

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الخلاصة

في هذه الدراسة، تم قياس تركيز النشاط الاشعاعي الطبيعي لعينات عدد عشرة أخذت من نهر دجلة والمناطق المحيطة بها في مدينة بغداد. ويعد نهر دجلة مصدر مهم للمياه في الري والشرب في العراق. وتمت الدراسة في سنة 2018 في مركز الوقاية من الاشعاع التابع الى وزارة الصحة والبيئة باستخدام كاشف الجرمانيوم عالي النقاوة حيث كانت طاقة الفصل للمنظومة 2keV وذات كفاءة 30%. حيث اظهرت النتائج ان تراكيزالنظير المشع ^{40}K تراوحت من اقل قيمة في العينة S6 181.4Bq/kg الى اعلى قيمة لها في العينة S7 286.4Bq/kg. اما R_{aeq} فكانت قيمه تتراوح بين 6 Bq/m^3 في العينة S3 الى 17 Bq/m^{3}في العينة S5. واخيرا عنصر ^{137}Cs فكانت تتروح قيمه بين الحد الادنى للكشف في العينة S2 الى 7.5Bq/kg في العينة S8. تم عرض النتائج الإجمالية للعينات التي تم فحصها (طيني وجافة) حيث لم يتأثر أبدا بسلامة البيئة والتربة. وان قيم كل من ^{40}K وسلسلة ^{238}U وسلسلة ^{232}Th ضمن المدى المسموح عالميا. اما بخصوص عنصر السيزيوم ^{137}Cs قد تعزى إلى الأنشطة النووية لهذا الموقع أو قد تكون ناجمة عن الحوادث النووية (كارثة تشيرنوبيل) التي انتشرت في أنحاء منطقة واسعة من العالم بما في ذلك مواقع العينات التي تم جمعها.

Introduction

Human has always been exposed to ionizing radiation because of the multiplicity of its sources as found in the soil that we walk up on, the air we breathe, the water we drink, the food we eat and the building that we occupy [1]. Natural occurring radionuclide's are widespread in the earth’s environment and it exists in all of them, e.g. geological formations in soil, water, air, rocks and plants. In world average, 85 % of the annual total radiation dose of any person comes from natural radionuclide of both terrestrial and cosmogenic origin. Natural radioactivity arises mainly from primordial radionuclide's, such as ^{40}K and the radionuclide's from ^{238}U and ^{232}Th series, which occur at trace levels in all ground formations [2]. So, radiation is all around us, it naturally exists in our environment and it has been since the birth of our planet. Exposure to ionizing radiation is generally considered undesirable at all level because even a small amount of a radiation substance may produce a damaging biological effects and that ingested and inhaled radiation can be a serious health risk. The radiological impact is due to the gamma-ray exposure of the body and irradiation of lung tissue from inhalation of radon and its daughters. The ^{238}U and ^{232}Th series and ^{40}K isotope, have very long half-life up to 10^{10} years, include gamma energies greater than 1.022 MeV which is the threshold of pair production (electron-positron) [3]. Also, from the view point of biological effect of radiation protecting, United Nations Scientific Committee on the Effects of Atomic Radiation established that the world mean dose from natural radiation sources of normal area is estimated to be 2.4 mSv/y while for all man-made is about 0.8 mSv/y [4]. The objective of the present study is to measure the radioactivity concentration and gamma-ray absorbed dose of the naturally occurring radionuclides (^{226}Ra, ^{232}Th series and ^{40}K) and man-made radionuclide (^{137}Cs) in the soil samples from the Tigris river In Baghdad Province using gamma-ray spectrometry.

Materials and method

1-Study area

This study was carried out in Baghdad province which is located along the Tigers River and in the center of Iraq. The samples were collected from several sites at 10 sites at Karrada, Bab Al-Sharqi, Al-Kadhimiya, Al-Dawra and Medical City of Baghdad province. On the other hand, the samples were taken during January to March 2018 was taken up to almost one kilogram. Then these samples are left 30 days to reach aquarium. The samples were taken from the bank and from inside river. Table 1 demonstrates the sites of which testing samples were collected from Baghdad city. The measurement were carried out at the Radiation Protection Center of the Iraqi Ministry of Health and Environment in 2018 using high purity germanium detector.

2- Sample collection and treatment

The samples soils preparation depends on type of samples under investigation, clay, dye and max soils sampled cleaning and make one piece with area about by placing each sample in an oven for drying at temperature of 110 ^{o}C for one hour until complete removal of any residual moisture and ensuring that a constant weight was reached. Then, the dried samples were pulverized into a fine powder and passed through a standard 1 mm mesh size. The homogenized samples were filled into 1L Marinelli beakers to measure the radioactivity by HPGe. All samples were weighed using a fine balance ± 0.01g error. For all samples, 1kg of sample mass was used and stored for at least one month prior to measurements in order to attain radioactive secular equilibrium between ^{226}Ra and ^{228}Ac and their short-lived progeny.

Table 1: The local soil samples taken from Tigris river –Bagdad.

Sample No	Sample	Location of sample
S1	bank	Karrada
S2	bank	Bab Al-Sharqi
S3	bank	Kadhimiya
S4	bank	Al-dawra
S5	clay	Bab Al-Sharqi
S6	clay	Karrada
S7	clay	Kadhimiya
S8	clay	Al-Dawra
S9	Bank	Medical City
S10	clay	Medical City

Theoretical concepts

Determining of hazard Indices in soil one important index that may be using to investigate the risk by metals of presenting the exterior exposing and named the exterior risk index using the following Equation [5]

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_k}{4810} \quad (1)$$

where A_{Ra}, A_{Th} and A_k are activation of ^{232}Ra, ^{232}Th and ^{40}K. On the other hand, the interior risk index H_{in} that exposing to radon and written by following Equation [6]

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_k}{4810} \quad (2)$$

The representative level index Iγr used to estimate the level of gamma-radiation hazard associated with the natural radionuclides in specific investigated samples is defined from the following equation [7].

$$I_\gamma = \frac{A_{Ra}}{150} + \frac{A_{Th}}{100} + \frac{A_k}{1500} \quad (3)$$

2-The specific activity A of radiation could be written by following Equation [8]

$$A = \frac{C_E}{\varepsilon_\gamma P_r\, V\ or\ M} \quad (4)$$

where A is the specific activity of the radionuclide in (Bq/kg) or in (Bq/l), C_E is the count of net peak area per second at energy gamma ray, M is the mass soil sample in kg, V is the volume of the sample in L, P_r is the the transition probability of gamma-decay at energy and ε_γ is the detector efficiency atenergy [8]. On the other hand ,the estimation of of ^{232}Ra, ^{232}Th and ^{40}K the risk that connect with, and substance named Radium equivalent activity in (Bq/kg) and given by

$$Ra_{eq}(Bq/kg = A_{Ra} + 1.43A_{Th} + 0.077A_K) \quad (5)$$

The published maximal admissible (permissible) Ra_{eq} is 370 Bq/kg [9, 10].

Due to gamma radiations in air at 1m above the ground surface for the uniform separation of the naturally occurring radionuclide's (^{226}Ra, ^{232}Th and ^{40}K) were calculated based on guidelines provided by (UNSCEAR, 2000) and the effective doses rate D(nGy/h) are evaluated using following Equation [11]

$$D(nGy/h = 0.462A_{Ra}) + 0.621A_{Th} + 0.0417A_k \quad (6)$$

Annual effective dose, annual radionuclide intakes and yearly influential effective doses of Sv/y had been counted for Indoor effective dose

Indoor effective dose is calculated using the fallowing equation [12]

$$E_{ied}(mSv/y) = D(nGy/h * 8760h * 0.8 * 0.7\, Sv/Gy * 10^{-6})) \quad (7)$$

Outdoor effective dose is calculated using the fallowing equation [13]

$$E_{oed}\,(mSv/y) = D(nGy/h * 8760h * 0.2 * 0.7)\, Sv/Gy * 10^{-6} \quad (8)$$

Results and discussion

Tigris river were rich natural area for soil as well as of mix soil surrounding from every side of rivers clay and sediment. The radiological calculations for all soil samples that's collection from rivers, inside and bank rivers in cities at Al- Karrada, Bab Al-Sharqi, Kadhimiya, Al-Dawra and Medical City of Baghdad province are presented in Table 2. The radiological calculation including the measurement of the concentration activity (^{232}Th, ^{137}Cs, ^{238}U ^{40}K). Also calculated the hazard index (H_{ex} and H_{in}), the gamma radio hazard index (I_γ), the radium equivalent hazard index (Ra_{eq}) and the annual effective doses rate D for all soil samples. Table1 shows the radiological calculated corresponding to the effective activation concentration (Bq/kg). The activity concentration for ^{40}K are ranged from 181.4 Bq/kg in sample S6 to 286.4 Bq/kg in S7 with an overall average about 239.96Bq/kg. While the activity concentration of ^{232}Th series are ranged from 7 Bq/kg in S4 to 21.8 Bq/kg in sample S7 with an overall average about 13.46Bq/kg. And the activity concentration of ^{238}U series are ranged from 7.6 Bq/kg in S6 to 16 Bq/kg in sample S7 with an overall average about 29.45Bq/kg, and are the activity concentration of ^{137}Cs are ranged from 0.4 Bq/kg in S2 to 7.5 Bq/kg in S8 sample. According to the UNSCEAR report 2000, the worldwide specific activity of ^{238}U, ^{232}Th and ^{40}K in soil. The results in this work were compared to the worldwide population mean specific activity of the radionuclides ^{226}Ra, ^{232}Th and ^{40}K in soil of 50, 50 and 500 $\mathrm{Bq/kg}$ respectively, (UNSCEAR, 1993). The overall results for the investigated samples are lower than the accepted values. All results are presented in Table1. The artificial radionuclide represented by ^{137}Cs was observed in some samples and vary from <MDA to 7.5Bq/kg in sample S9 with an average value 3.843 Bq/kg. area around the berms of site may attributed to the nuclear activities of this site or may be due to the nuclear accident (Chernobyl accident) which have been spread throughout a large area of the world including the samples locations were collecting [10]. The important indices for calculating the different soil sample such that were estimated to known how can effective on human health. The most important effective index is hazard index (H_{in}) that estimation using Eq.(2) and we show from Table 2 the 0.151 mSv/y was minimum values that calculated in S1 sample and the maximum value was 0.342 mSv/y in S9 sample, whereas the overall average value was 0.261 mSv/y as shown in Figs. 1-3.

Table 2: Results data of radiological testing for soil samples.

Sample No	*U/Ra Bq/kg*		*Th Bq/kg*		*K-40 Bq/kg*	*Cs-137 Bq/kg*	*Ra_{eq}* Bq/m^3	*D (nGy/h)*	*H_{ex}*	*H_{in}*	*Eff_{in} (mSv/y)*	*Eff_{out} (mSv/y)*	*$I_{\gamma r}$*
	Ra-226	*Pb-214*	*Ac-228*	*Pb-212*									
S1	13±2.9	9±0.8	219 .2±13	10±1.4	219 .2±13	-	11.6	20.86	0.116	0.151	0.102	0.256	0.325
S2	16.4±2.1	12.6±2.2	232±9.8	8±0.7	232±9.8	0.4±0.1	11.6	23.34	0.130	0.175	0.114	0.286	0.362
S3	33±4.4	10.8±1.9	251.5±10.6	12.4±0.7	251.5±10.6	-	17	30.70	0.172	0.262	0.151	0.377	0.468
S4	31±2.1	9.8±0.6	226±12.4	10.6±0.9	226±12.4	-	12.5	28.09	0.158	0.242	0.138	0.345	0.427
S5	25.8±3.6	14.6±0.8	273.8±24.9	15.6±1.5	273.8±24.9	6.2±0.5	6	35.88	0.205	0.274	0.176	0.440	0.557
S6	32.2.2±4	7.6±0.6	181.4±20.2	8±1	181.4±20.2	3.8±0.4	9	30.39	0.174	0.261	0.149	0.373	0.464
S7	35.2±4.1	16±0.8	286.4±25.4	13.4±1.4	286.4±25.4	5.4±0.5	11.6	41.74	0.239	0.334	0.205	0.512	0.644
S8	33±6.1	14.6±1.2	251.7±10.7	15±2.1	251.7±10.7	7.5±0.5	11.6	34.81	0.198	0.287	0.171	0.427	0.534
S9	41.3±5.3	15.6±1.2	251±23.9	13.7±1.6	251±23.9	2.8±0.7	11.6	40.23	0.230	0.342	0.197	0.493	0.615
S10	33.6±4.1	11.4±0.7	226.6±22.6	8.4±0.5	226.6±22.6	0.8±0.2	11.6	33.67	0.192	0.283	0.165	0.413	0.515
Average								31.97	0.181	0.261	0.157	0.392	1.167
World average								75	0.43	0.57	0.37	0.09	0.941

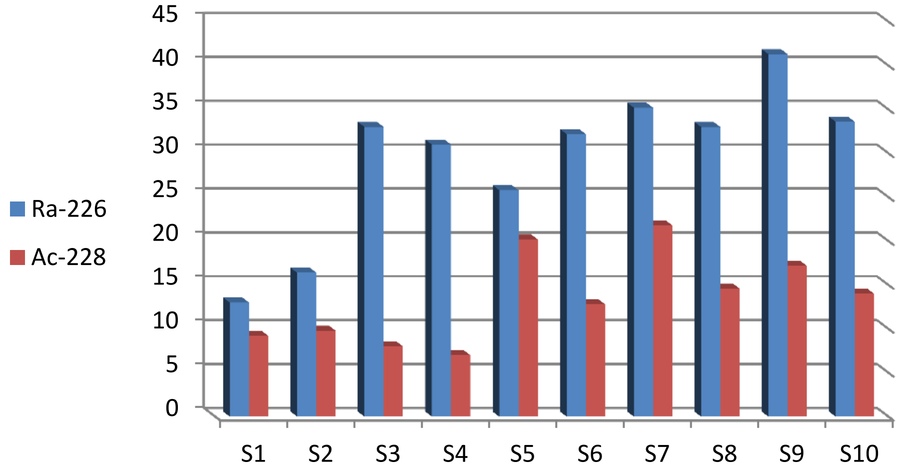

Fig. 1: Activity concentration A of radiation for, ^{226}Ra and ^{228}Ac, soil sample.

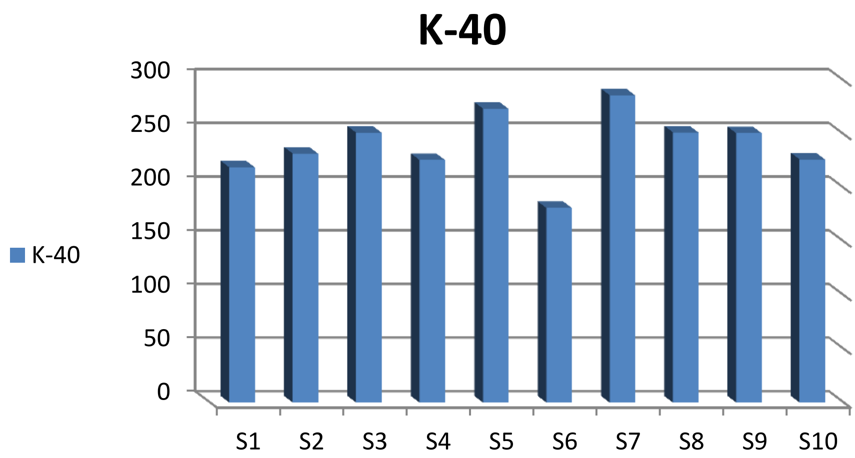

Fig. 2: Activity concentration of ^{40}K in soil sample.

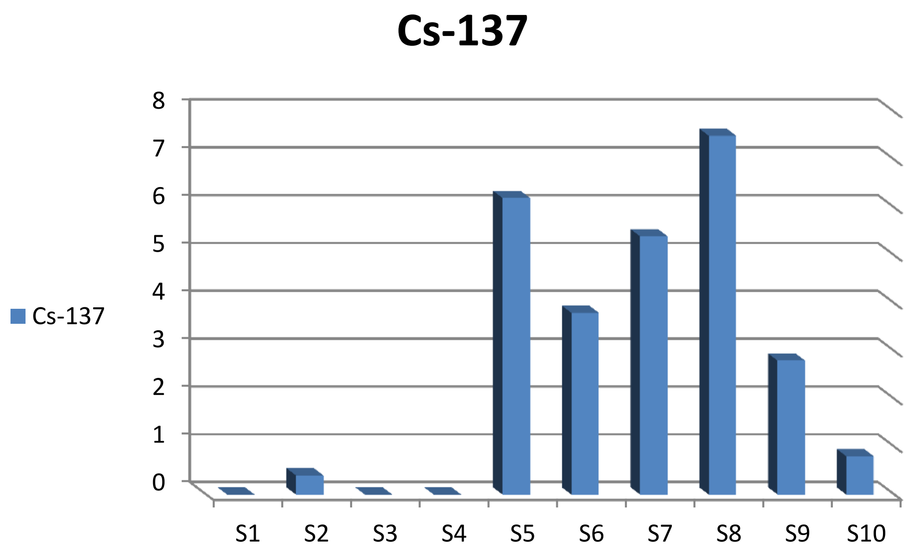

Fig.3: Activity concentration A of radiation for ^{137}Cs at soil sample.

Fig. 4 shows that the Radium equivalent activity and the effective doses rate at soil sample are large for both samples S9 and S7 and lowering for sample S1. The radiological hazard parameters of absorbed dose Dγ, annual effective (AEDE) as shown in Fig. 5.

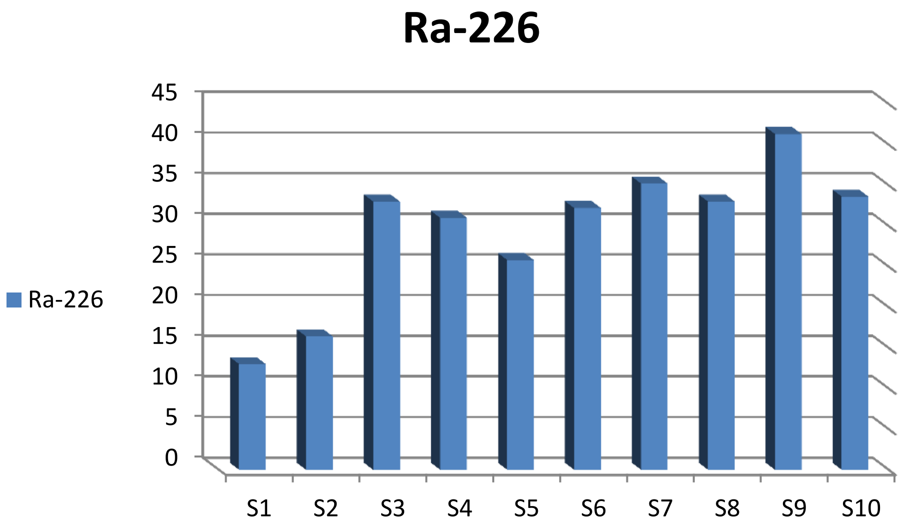

Fig.4: Radium equivalent activity in (Bq/kg) at soil samples.

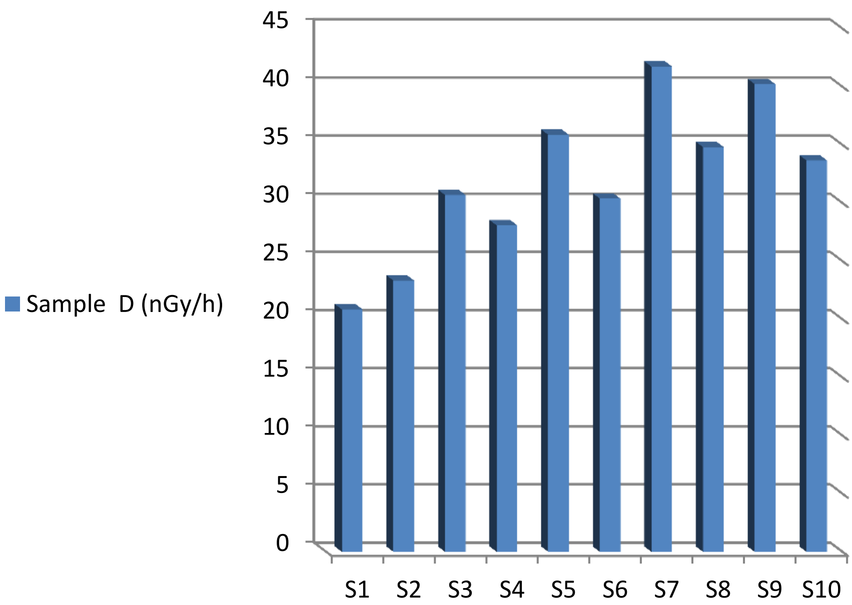

Fig. 5: The effective doses rate D(nGy/h) at soil sample.

Conclusion

Radium equivalent activities (Raeq), external hazard index (Hex) and the internal hazard (Hin) for all samples found to be below than average worldwide.

References

[1] Joga Sigh, Harmanjit Singh, Surinder Singh, B.S. Bajwa, R.G. Sonkawade, Journal of Environmental Radioactivity, 100 (2009) 94-98.

[2] Vikas Duggle, Asha Raaini, Rohit, Roamola, Radiation Protection Dosimetry, 158, 2 (2014) 235-240.
[3] James E. Turner, “Atoms, adiation, and Radiation Protection”, Third, Completely Revised and Enlarged Edition, 2007.
[4] UNSCEAR, United Nations Scientific Committee on the Effects of Atomic Radiation, Sources, effects and risks of ionizing radiation. Report to the General Assembly with Annexes, (New York, United Nations) (1993).
[5] Hadi J.M Al-Agealy, Mohsin A. Hassooni, Ahmed M. Ashweik, Raad H. Mjeed, Abbas K. Sadoon "Determination of radioactive concentrations in Carpio fish Samples In Baghdad Province" Department of Physics–College of Education for pure science –Ibn Al-Haitham - Baghdad of University. The Fifth Scientific Conference of the College of Science University of Kerbala 2017.
[6] H. Diab, S. Nouh, A. Hamdy, S. El-Fiki, Journal of Nuclear and Radiation Physics, 3, 1 (2008) 53-62.
[7] Ali A. Ahmed and Mohammed I. Hussein, International Journal of Geological and Environmental Engineering, 5, 2 (2011) 66-73.
[8] United nations scientific committee on the effects of atomic radiation, 2000. "Sources and effects of ionizing radiation". UNSCEAR 2000 report Vol.1 to the general assembly, with scientific annexes, United Nations sales publication, United Nations, New York.
[9] Abdulla Ahmad Rasheed, Nada Farhan Kadhum, Nadhim Khaleel Ibrahim, International Journal of Physics, 4, 3 (2016) 50-54.
[10] Hussein Jabbar Mugar "Evaluation of Annual Dose for Residents in the Area around the Berms of Al-Tuwaitha Nuclear Site Using RESRAD Software" MSc Thesis University of Baghdad, 2017.
[11] Kamal K. Ali and Shafik Sh. Shafik, Iraqi Journal of Science, 58, 3B (2017) 1464-1476.
[12] Jaafer Jaleel "Determination of Natural Radioactivity and Radiological Rask assessment of Environment for Al-Dora Refinery and Surrounding Area. Al-Nahrain University. M.SC. Thesis, 2013.
[13] Lazim K. Shwayyea "The measurement of the concentration of natural occurring radionuclides and the radiation hazard indices for building materials in Iraq" M.Sc. Thesis Baghdad University, 2013.