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Evaluation of Natural Radioactive Concentration Levels in a Selection of Some Fauqi Oil Drilling Wells in Maysan Governorate, Iraq

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Abstract: *From the FQCS-80H and FQCS-86D wells in southern Maysan, Iraq, the concentrations of 226Ra, 232Th, and 40K radionuclides were measured for soil and rock at various depths. Utilizing an HPGe detector with energy resolution and a high-resolution gamma spectrometry system of (≤1.8 keV) for the 133 MeV gamma transition of 60Co. The soil and rock samples were collected at a depths range of 150–2800 m. Formation and the depths for the samples were determined. Comparable measurements from other countries were used to compare the natural radionuclide activity concentrations. The average activity for the isotopes 226Ra, 232Th, and 40K was 12.17 Bq/kg, 11.06 Bq/kg, and 373.42 Bq/kg, respectively. The average radium equivalent activities and gamma dose rate were 56.75 and 27.81 nGy/h, respectively. All measurements were determined to be below their respective allowed limits (226Ra, 232Th, and 40K).*

Keywords: *Norm, Buzurgan oil field, Hazard Indices, different depths, HPGe.*

1. Introduction

Naturally occurring radioactive materials (NORMs) of the uranium series, the thorium series, and potassium-40 are present throughout the earth's crust. The concentration of these radionuclides is influenced by the makeup of the soil and rocks. From these nuclides, radiation doses are received by all people. Trace amounts of naturally occurring uranium, thorium, and their radioactive children are present in reservoir rock in oilfields [1-3] . The daughter radioisotopes of ^{238}U and ^{232}Th that are produced as a result of their radioactive decay exhibit a wide range of physical characteristics, such as varied half-lives, decay modes, and radiation types and energy[3-5] . A variety of radioactive wastes are produced by the oil and gas industry. Sludge, drilling mud, and other materials that can be reused if NORM and radioactive materials migrate from one location to another[6, 7].

2. Study Area: According to Fig. 2. 1 [8], the Maysan oil fields are situated in the Maysan province in southeast Iraq, not far from the border with Iran. It is located approximately 175 kilometers north of Basra. The Abu Ghirab, Buzurgan, and Abu Ghirab oilfields are three of the region's active oilfields. The Buzurgan oilfield is structurally divided into two domes, one in the north and the other, along a NW-SE axis anticline that spans around 353.4 km2 [9].

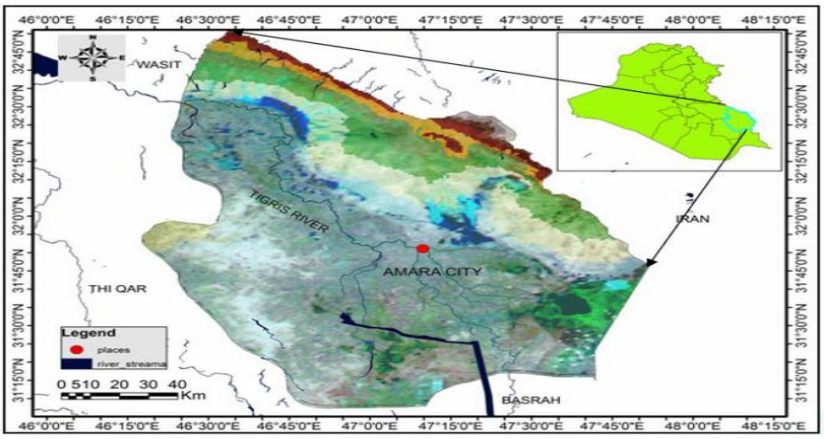

Figure 1. The location of Maysan City[10]

Fauqi field or jabal Fauqi is located in Maysan province about 50 km north-east of Amara city, southeast Iraq(Fig2. 2). It's shared with Iran especially north part of field. Where extend part of it inter Iranian land. Fauqi field products from Asmari Reservoir belongs to (Oligocene- Lower Miocene), it represents the second reservoir products after Mishrif Reservoir in field. Lithologic ally, Asmari reservoir characterizes very complex lithology, it consistence from some formations. One of it represent Buzrgun member is basically consist of sand with high porosity and good reservoir characterization in field, which method applied on it [11].

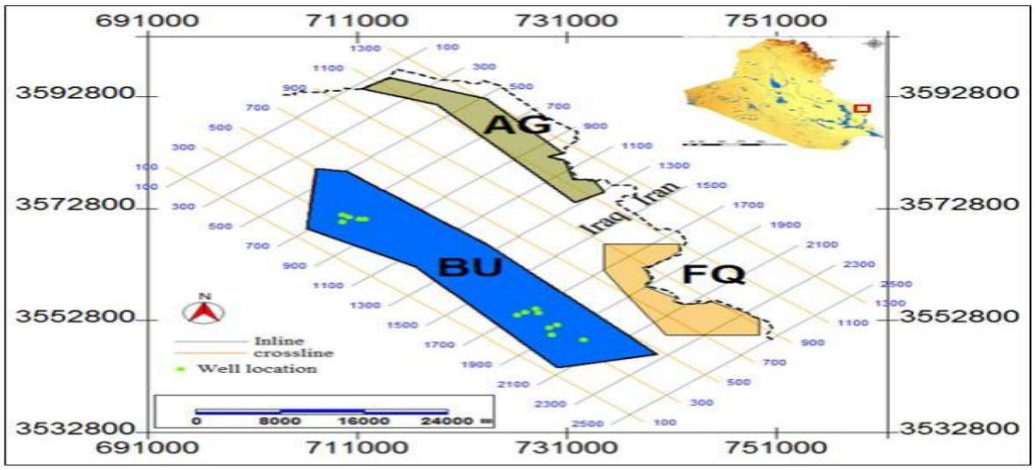

Figure 2. Maysan oil fields shown the study area

3. Sample preparation

Thirty-four soil and three crude oil samples from different depths (different formations) were collected from Faugi and Buzurgan oil wells in Maysan Governorate, including BUCN-157D, FQCS-86D, and FQCS-80H, which are located in southern Iraq with different depths ranging from 1900 to 4500 m. Formation and the depths from which the samples were collected are shown in Fig2. 3. These collected samples were then air dried to eliminate moisture, crushed and milled to a fine powder, and then sieved with a 0.3 mm mesh size. For gamma measurements, the solid samples were weighed, packed in Marinelli beakers, and sealed.

4. Activity Concentrations

Gamma spectrometry is a rapid and convenient method for the identification and quantitative analysis of gamma-emitting radionuclides. This is a non-destructive radiometric technique that is commonly used to measure gamma-emitting radionuclides directly using the discrete gamma energy lines of various radionuclides. The gamma spectrometry system that was used in this study is a comprehensive data collection and computation system that comprises the following [12, 13]:

1. High-purity germanium (HPGe): This is used as a detector.

2. Preamplifier: This is an integral part of the detector unit and is located very near the detector because it is necessary for the operation of the detector with low noise.
3. Linear amplifier: This is usually built into the multichannel analyzer (MCA) to amplify the pulse by a factor of several hundred. It has a voltage of several volts, and it also shapes the pulse for more accurate analysis.
4. Bias high-voltage power supply: This is used to supply high voltage to the detector with a range of 0-5000 D.C. volts, and it must be increased slowly to avoid damaging the detector.
5. Sample preparation

Thirty-four soil and three crude oil samples from different depths (different formations) were collected from Faugi and Buzurgan oil wells in Maysan Governorate, including BUCN-157D, FQCS-86D, and FQCS-80H, which are located in southern Iraq with different depths ranging from 1900 to 4500 m. Formation and the depths from which the samples were collected are shown in Figure 3. These collected samples were then air dried to eliminate moisture, crushed and milled to a fine powder, and then sieved with a 0.3 mm mesh size. For gamma measurements, the solid samples were weighed, packed in Marinelli beakers, and sealed.

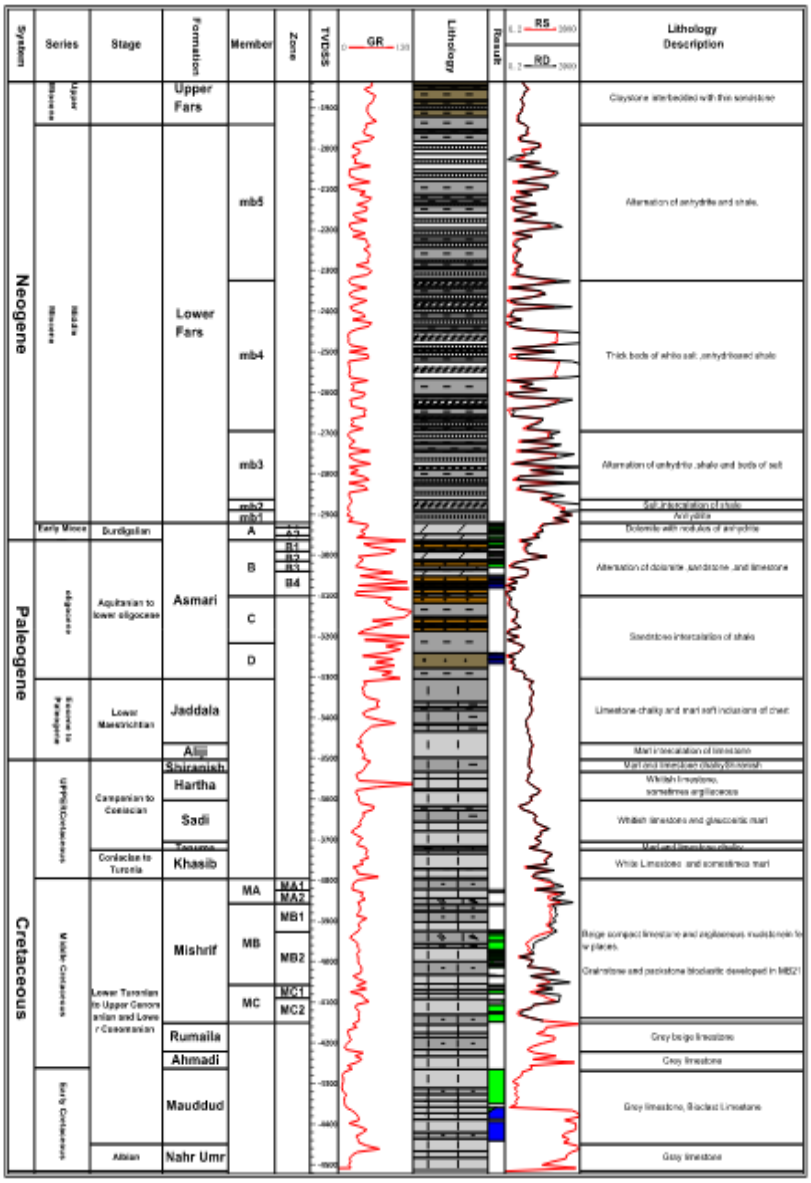

Figure 3. Stratigraphic column of south Iraq, Maysan region, with hydrocarbon generation parameters.

5. Estimation of the Radiological Hazard Indices

1. Radium Equivalent Activity Concentration Index (Raeq)

A useful index to match the distinct activity of materials with various concentrations of 226Ra, 232Th, and 40K is the radium equivalent (Raeq) index in Bqkg-1. It was defined under the presumption that the gamma dose rates produced by 10 Bqkg-1 of 226Ra, 7 Bqkg-1 of 232Th, and 130 Bqkg-1 of 40K were equal. The radium equivalent activity index is given as [14, 15]:

$$Ra\_{eq}=C_{Ra}+1{\cdot}43C_{Th}+0{\cdot}077C_k\leq 370 \quad (1)$$

where C_{Ra}, C_{Th} and C_k are the activity concentrations of ^{238}U, ^{232}Th, and ^{40}K, respectively. To reduce radiation risks, it is not recommended to utilize materials with Ra_{eq} concentrations higher than 370 Bq/kg [16].

2. Gamma Dose Rate

The radiological risk resulting from external exposure to radiation resulting from naturally occurring radionuclides in the human environment was measured using the dose rate due to the concentrations of the radionuclides in the samples. The dose conversion factors for converting the activity concentrations of ^{238}U, ^{232}Th, and ^{40}K into doses (nGyh-1 per Bqkg-1) are 0.427, 0.662, and 0.043, respectively [17]. Gamma dos rate is determined using the following equations [18]:

$$D(nGy/h)=0{\cdot}462C_{Ra}+0{\cdot}621C_{Th}+0{\cdot}0417C_k \quad (2)$$

6. Results and Discussion

The activity concentrations of the primordial radionuclides ^{26}Ra, ^{232}Th and ^{40}K in the samples were calculated. The sample type, formation, depth, and well name are listed in Table 1 and the measured activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in Bq/Kg for the soil and rocks are shown in this table .and the minimum value of the specific activity was below the level of detection in sample 22 of the FQCS-86D.

Table 1. FQCS-80H and FQCS-86D wells properties and the activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K for soil and rock samples

SC		sample Type	Formation	Depth (m)	Ra-226 (Bq/kg)	Th-232 (Bq/kg)	K-40 (Bq/kg)	Raeq (Bq/kg)	D (nGy/h)
S1	Well name	**Soil**	NF*	**150**	**14.6**	**19.4**	**389.5**	**72.33**	**34.76**
S2	FQCS-80H	**Soil**	NF	**500**	**12.9**	**16.6**	**398.7**	**67.34**	**32.62**
S3	FQCS-80H	**Rock**	NF	**1000**	**15.2**	**24.1**	**517.6**	**89.52**	**43.21**
S4	FQCS-80H	**Rock**	Upper Fars	**1500**	**15.4**	**17.2**	**394**	**70.33**	**33.95**
S5	FQCS-80H	**Rock**	Upper Fars	**2000**	**13.7**	**15.8**	**428.7**	**69.3**	**33.72**
S6	FQCS-80H	**Rock**	Upper Fars	**2300**	**7.5**	**4.1**	**399.7**	**44.14**	**22.4**
S7	FQCS-80H	**Rock**	Lowerer Fars	**2500**	**12.1**	**7.4**	**493.8**	**60.7**	**30.43**
S8	FQCS-80H	**Rock**	Lowerer Fars	**2700**	**8.5**	**3.4**	**338.4**	**39.42**	**19.91**
S9	FQCS-80H	**Rock**	Lowerer Fars	**2800**	**6.2**	**1.04**	**216.9**	**24.39**	**12.4**
S10	FQCS-80H	**Rock**	Jeribe-Euphrate	**3000**	**6.1**	**3.3**	**274.4**	**31.95**	**16.12**
S11	FQCS-80H	**Rock**	jaddala	**3400**	**12.1**	**7.9**	**269.4**	**44.14**	**21.54**
S12	FQCS-80H	**Rock**	Aaliji	**3500**	**25.5**	**6.6**	**198.8**	**50.25**	**24.03**

S13	FQCS-80H	**Rock**	NF	**150**	**15.5**	**17.1**	**372.6**	**68.64**	**33.06**
S14	FQCS-86D	**Rock**	NF	**500**	**17.9**	**17.4**	**456.1**	**77.9**	**37.78**
S15	FQCS-86D	**Rock**	NF	**1000**	**16.5**	**21**	**447**	**80.95**	**38.99**
S16	FQCS-86D	**Rock**	Upper Fars	**1500**	**15.4**	**20.7**	**406.1**	**76.27**	**36.62**
S17	FQCS-86D	**Rock**	Upper Fars	**2000**	**15.4**	**13.4**	**371.7**	**63.18**	**30.68**
S18	FQCS-86D	**Rock**	Upper Fars	**2300**	**5.5**	**1.5**	**108.5**	**16**	**7.92**
S19	FQCS-86D	**Rock**	Lowerer Fars	**2500**	**3.5**	**8.4**	**476.7**	**52.22**	**26.38**
S20	FQCS-86D	**Rock**	Lowerer Fars	**2700**	**14.3**	**9.9**	**511.9**	**67.87**	**33.74**
S21	FQCS-86D	**Rock**	Lowerer Fars	**2750**	**13.5**	**7.17**	**383.4**	**53.27**	**26.41**
S22	FQCS-86D	**Rock**	Lowerer Fars	**2800**	**0.56**	**BDL**	**361.6**	**28.4**	**15.08**
Max			Formation		**25.5**	**24.1**	**517.6**	**89.52**	**43.21**
Min					**0.56**	**BDL**	**108.5**	**16**	**7.92**
Average					**12.17**	**11.06**	**373.42**	**56.75**	**27.81**

*.Not Found

The maximum value for the specific activity of the radioactive isotope of ^{226}Ra was 25.5 Bq/kg in sample 12 of FQCS-80H for the Aaliji formation due to the nature of the rocks, while the minimum value was 0.56 Bq/kg in sample 22 of the FQCS-86D well for the Lower Fars formation. For ^{232}Th isotope the maximum value of the specific activity was 24.1 Bq/kg in sample 3 of the FQCS-80H well, which lies within the depth(1000m) and is characterized by rock samples as shown in Figure 4.

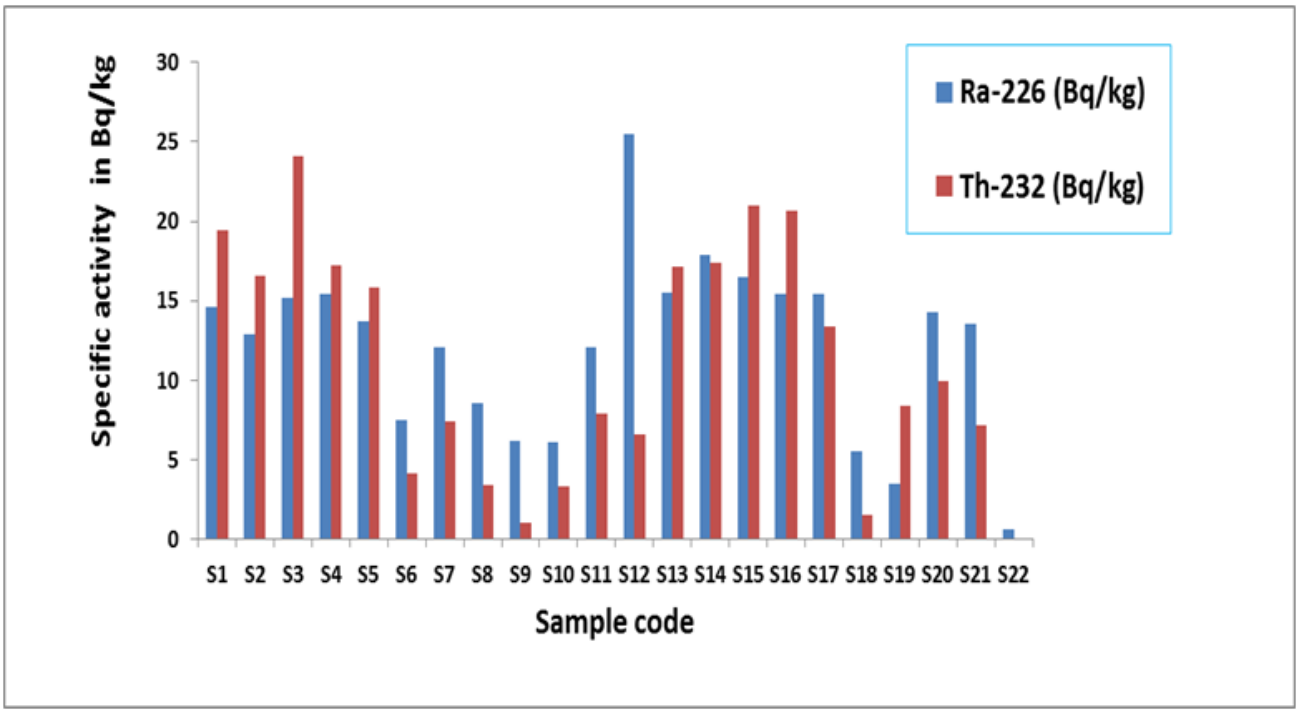

Figure 4. Specific activity of natural radionuclides ^{226}Ra, and ^{232}Th for each soil and rock sample in Fauqi Oil's Field

The results showed that the maximum value of the specific activity of ^{40}K was 517.6 Bq/kg in sample 3 of FQCS-80H, while the minimum value of the presence of ^{40}K was 108.5 Bq/kg in sample 18 of the FQCS-86D. The activity of ^{40}k can be seen in Figure 5

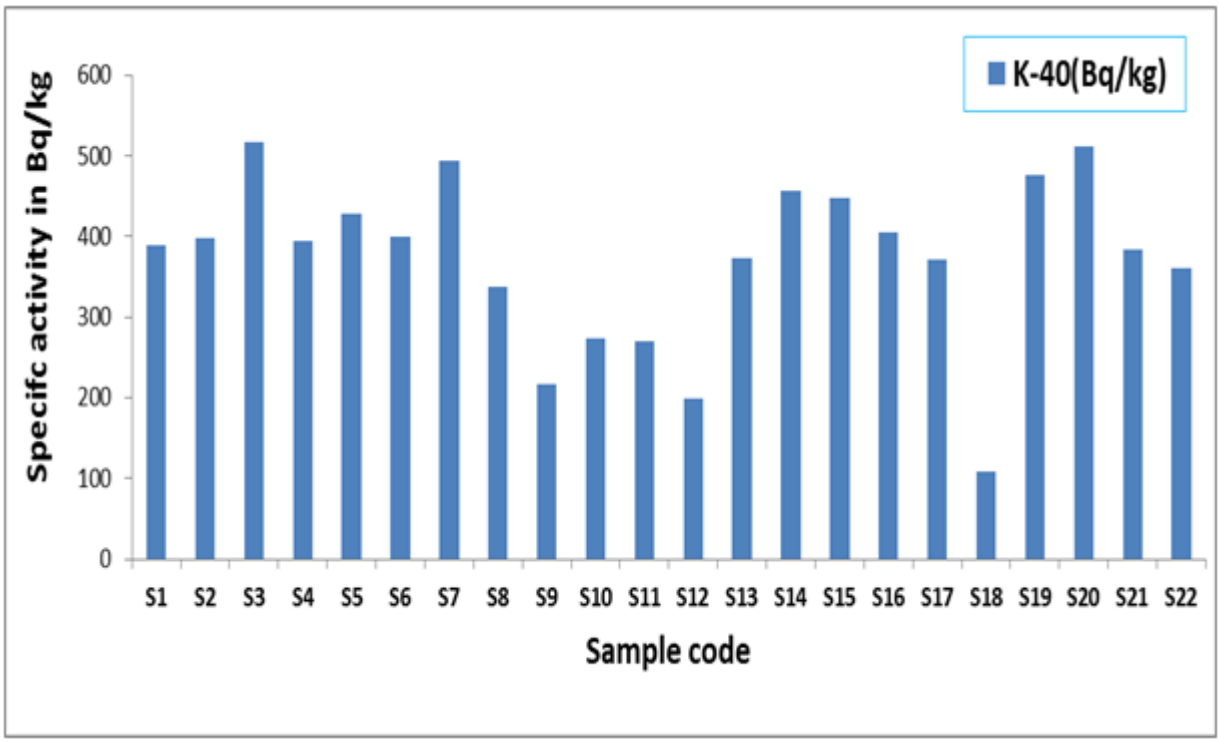

Figure 5. Specific activity of natural radionuclides ^{40}k Bq/kg for each soil and rock samples of Fauqi Oil's Field

However, the overall average value of radium equivalent activities (Raeq) of gamma dose rate for the full soil and rock samples set were determined using equation (1) to be 56.752 Bq/kg . This value is also considered to be normal, while the maximum value of Raeq was 89.518 in sample 3 and the minimum value of Raeq was 16 Bq/ kg in sample 18. The overall average value of the gamma dose rate (D) for the entire sample set was found to be 27.807 nGyh, which was calculated using eq. (2). The maximum value was 43.21 nGyh for sample 3 of the FQCS-80H, which is the permissible value, and the minimum value was 7.921 nGyh in sample 18 of the FQCS-86D as shown in Figure 6 .

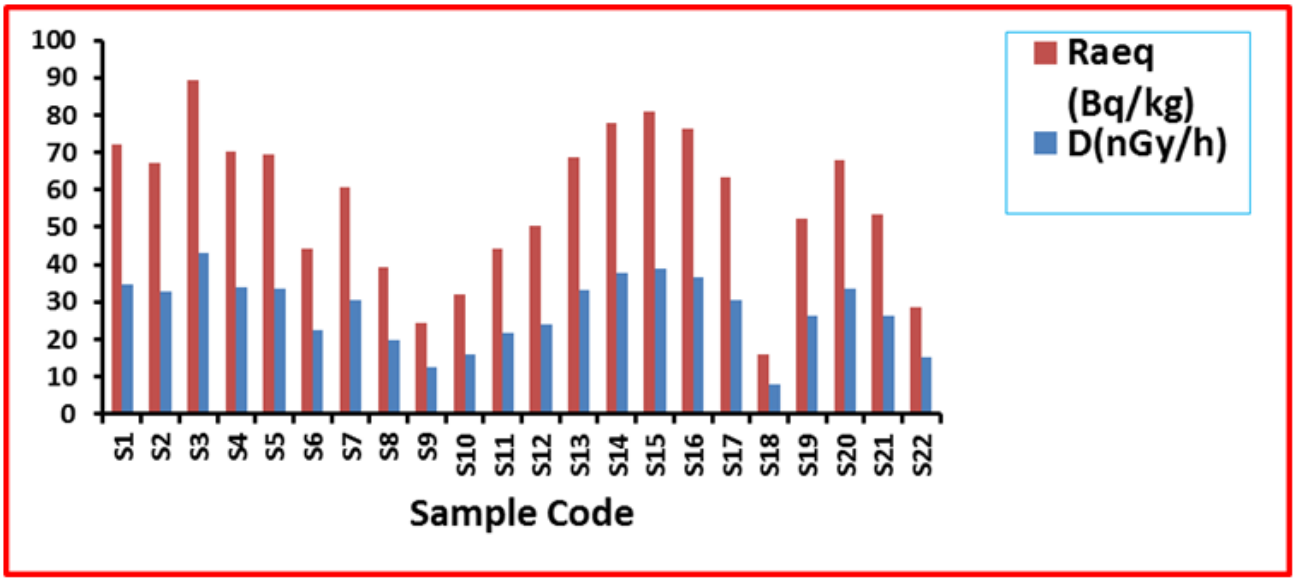

Figure 6. Histogram shows the R_{eq}(Bq/kg) and D(nGy/h) of Fauqi Oil's Field

7. Conclusion

The present work used a gamma ray spectroscopy system with an HPGe detector to estimate the primordial radionuclides ^{238}U, ^{232}Th, and ^{40}K in soil and rock samples from FQCS-80H and FQCS-86D petroleum well situated in Fauqi Oil's Field, Maysan Governorate, southern Iraq. The average values of ^{238}U, ^{232}Th, and ^{40}K that were measured were lower than the average world values that UNSCEAR 2008 reported. The estimated, analyzed, and discussed variables included the radium equivalent (Raeq), absorbed dose rates (D). Comparison data with other countries listed in Table 3 shows that in the present study, the activity is lower compared with the other countries.

Table 2. Comparison of natural radioactivity levels in the samples to other countries.

Country	Ra-226 (Bq/kg)	Th-232 (Bq/kg)	K-40 (Bq/kg)	Reverence
Erbil-Iraq	11.77-91.31	5.75-53.80	3.71-502.30	[19]
Zubair-Iraq	47.72-2214.01	22.49-464.37	184.4-23364.6	[20]
Egypt	NA**	3.99 -42.13	88.68-762.49	[21]
Egypt	17	18	320	[22]
USA	35	40	370	[22]
Malaysia	67	82	331	[22]
Spain	32	33	470	[22]
Fauqi -Iraq	0.56-25.5	BDL-24.1	108.5-517.6	Present study

**.Not Analysis

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