Measurement of radioactive contamination in some oil sites in Nineveh

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Abstract
Five locations have been chosen within the oil field of the oil wells area at the Qayyarah region in Iraq. Soil samples were collected from the surface of the earth up to a depth of 10 cm. Radiation levels in the samples were measured by the Gamma spectroscopy technique using the NaI (Tl) detector applying the measurement procedure used by Yousuf and Abdulla (1, 2).
Results in this research include the radiation levels of \( ^{226}\text{Ra} \), \( ^{232}\text{Th} \), \( ^{40}\text{K} \) and \( ^{137}\text{Cs} \) such that the results include specific activity, \( \text{Ra}_{eq} \), dose rate \( D(\text{Gy h}^{-1}) \), absorption dose in air \( D(\mu \text{Sv h}^{-1}) \), External hazard Index \( (H_{ex}) \), Internal risk index \( (H_{in}) \), Level index of Gamma \( (I_{\gamma}) \) and Level index of alpha radiation hazard \( (I_{\alpha}) \).

Key words:
Natural Radioactivity, soil, Kama spectroscopy, oil pollution.

1- Introduction

Man has known oil since ancient civilizations, as mentioned in the Holy Books and the books of travelers. Since the nineteenth century, oil has become a distinguished place in human civilizations, and it has relied on it as a primary source of energy, heat and lighting. People have benefited from the leaching oil to the surface of the earth naturally, then people began extracting oil from the ground, where the first oil well was successfully drilled at 1859 in United States of America. Because of the presence of radioactive isotopes within the natural radiation chains (radiation series) in the Earth’s components, the oil industry is highly likely to be associated with radioactive contamination at various work sites.

There are several techniques available for measuring radiation and determining the quantity and quality of radioactive materials, such that each technique has characteristics which distinguish it from others in terms of diagnostic ability and efficiency. The Gamma ray spectroscopy technique using the NaI (Tl) detector is among the distinguished techniques in diagnosing the type of radioactive isotope, as well as it has high efficiency in determining the amount of radioactive isotope in the examined sample.

The interaction of radiation with mater associated with the process that involves this absorption of radiation energy within the components of the material causing the effect of ionization and
excitation of the atoms and molecules in the medium that the radiation interacts with, all of this causes damage to the composition of the mater and health risks in the materials that make up living tissue.

From here emerges the importance of conducting this research, and the need to determine the levels of radiation accompanying the oil industry, five sites were selected to collect samples from the oil field and some oil wells in the Qayyarah region in Iraq.

2- Experimental:

For the purpose of carrying out this research, the samples of the Earth's surface soil were collected in five elected sites within the Qayyarah oil fields site as shown in Figure No. 1, and the coordinates of the sample collection sites themselves were shown in Table 1 as well.

![Figure 1: The five elected sampling sites at the Qayyarah oil site.](image-url)
Table 1: the locations of the soil samples.

| Sample Code | Latitude (N) | Longitude (E) |
|-------------|-------------|--------------|
| S1          | 35.8131     | 43.2550      |
| S2          | 35.8116     | 43.2569      |
| S3          | 35.8122     | 43.2590      |
| S4          | 35.8115     | 43.2606      |
| S5          | 35.8111     | 43.2630      |

The soil samples were collected, prepared then the measurement process was performed using the same procedure that was used by the research at reference (1, 2). Also, the specific activity in soil samples were detected for each elected site. The measurements were repeated three times and their rate was adopted to ensure accuracy of the achieved results.

The technique of Gamma ray spectroscopy was used to measure and determine the type of radioactive element in the soil samples, in terms of the diagnostic Gamma radiation related to each radioactive isotope in this research, including (\(^{226}\text{Ra}\), \(^{232}\text{Th}\), \(^{40}\text{K}\) and \(^{137}\text{Cs}\)), as shown in Table 2.

Table 2: Characteristic data of the detected radioactive isotopes. (3)

| Isotope     | \(E_\gamma\) (keV) | \(I_\gamma\) (%) |
|-------------|--------------------|------------------|
| Bi\(^{214}\) (\(^{238}\text{U}\) series) | 609.3              | 46.9             |
| Ac\(^{228}\) (\(^{232}\text{Th}\) series) | 911.2              | 22               |
| K\(^{40}\) (Natural) | 1460.8             | 10.7             |
| Cs\(^{137}\) (Fission) | 661.62             | 85               |

Also seven parameters related to (radiation risk indicators) were calculated and included each of them in equations (a - g) as follows:

a- (Equivalent activity to radium Ra\(_{eq}\)) using the relation (4, 5):

\[
Ra_{eq} = A_{Ra} + 1.43 A_{Th} + 0.077 A_{K} \tag{1}
\]

Where:
ARa = Specific activity of Radon gas.
ATh = Specific activity of Thorium.
AK = Specific activity of Potassium.

The radium equivalent (Raeq) represents the sum of the radioactivity concentration of the three radioisotopes (\(^{226}\)Ra, \(^{232}\)Th, \(^{40}\)K), it is based on the assumption that (370 Bq kg\(^{-1}\) of \(^{226}\)Ra) or (259 Bq kg\(^{-1}\) of \(^{232}\)Th) or (4810 Bq kg\(^{-1}\) of \(^{40}\)K) produces a dose rate equal to that of the Gamma ray, such that the substance with (Raeq > 370 Bq kg\(^{-1}\)) is radioactive hazardous substance (6,7).

b- (Average absorbed dose rate \(D_1\) (n Gy h\(^{-1}\))) using the relation (5):

\[
D_1 (\text{n Gy h}^{-1}) = 0.462 \text{ARa} + 0.621 \text{ATh} + 0.0417 \text{AK} \quad \text{--- (2)}
\]

Where:
\(D_1\) = Radiation Dose rate in (n Gy h\(^{-1}\))

\(c\)- The rate of absorption dose in the air can be calculated at a height of one meter from the Earth's surface in units D (µSv h\(^{-1}\)) using the following relation (6):

\[
D_2 (\text{µSv h}^{-1}) = (0.462 \text{ARa} + 0.621 \text{ATh} + 0.0417 \text{AK}) \times 0.001 \times 0.7 \times 0.34 \quad \text{--- (3)}
\]

Where:
(0.7 Sv Gy\(^{-1}\)) is conversion factor of absorbed dose to effective dose.
(0.034 µSv h\(^{-1}\)) is the cosmic ray term.

d- (Hazard Index) as (External hazard Index \(H_{ex}\)) using the relation (5,8):

\[
H_{ex} = 0.002702 \text{ARa} + 0.003861 \text{ATh} + 0.000207 \text{AK} \quad \text{--- (4)}
\]

e- Likewise, calculating (internal risk index \(H_{in}\)), which shows the effect of radon on respiratory organs, using the relation (5,8):

\[
H_{in} = 0.005405 \text{ARa} + 0.003861 \text{ATh} + 0.000207 \text{AK} \quad \text{--- (5)}
\]

f- Level index for Gamma radiation hazard associated with natural radionuclide can be calculated by the relation (5,8):

\[
I_\gamma = 0.0067 \text{ARa} + 0.01 \text{ATh} + 0.00067 \text{AK} \quad \text{--- (6)}
\]

g- Level index for alpha radiation hazard given by the relation (9):
\[ I_a = \frac{A_{Ra}}{200} \] 

3- Results and discussion :

The results of the measurements on the soil samples taken from the five sites selected at this study indicated that the values of specific radioactivity \( A_s \) for each of the radioisotopes \( ^{226}{Ra} \), \( ^{232}{Th} \), \( ^{40}{K} \) and \( ^{137}{Cs} \) are as shown in Table 3.

It is clear that the results are within the range of accepted values given by ( UNSCEAR - 2008) for the corresponding items (10).

| Sample Code | \( A_{Ra} \left(^{226}{Ra}\right) \) Bq/kg | \( A_{Th} \left(^{232}{Th}\right) \) Bq/kg | \( A_{K} \left(^{40}{K}\right) \) Bq/kg | \( A_{Cs} \left(^{137}{Cs}\right) \) Bq/kg |
|-------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| 64.8 ± 8.0  | 20.2 ± 4.5                      | 403 ± 20.1                      | 72.1 ± 8.5                      |
| 73.4 ± 8.6  | 22.6 ± 4.7                      | 461 ± 21.5                      | 58.6 ± 7.7                      |
| 65.7 ± 8.1  | 20.9 ± 4.6                      | 290 ± 17.0                      | 62.8 ± 7.9                      |
| 56.2 ± 7.5  | 16.2 ± 4.0                      | 342 ± 18.5                      | 29.9 ± 5.5                      |
| 57.5 ± 7.6  | 15.9 ± 4.0                      | 310 ± 17.6                      | 36.1 ± 6.0                      |

( UNSCEAR 2008 ) Ref. (10)

| Av (32) | Av (45) | Av (412) |
|---------|---------|----------|
| 11 - 60 | 11 - 64 | 140 - 850 |
Table 4 shows data of the results that include (seven indicators), and important evidence to describe the degree of radiation risk and the amount of radiation doses that were recorded in the five selected sites in this study.

The accepted value of the average absorbed dose rate $D_1 \text{ (n Gy h}^{-1})\text{ ) is given by ( UNSCEAR -2000 ) in the range } (0.034 - 0.0685) \text{ with average 0.057 (5), so the dose results in table 4 are in good agreement with the UN range.}

Table 4: Radium equivalent ( $Ra_{eq}$ ), Average absorbed dose rate $D_1 \text{ (n Gy h}^{-1})\text{ ) , The rate of absorption dose in the air } D_2 \text{ (µSv h}^{-1})\text{ ) , External hazard Index } H_{ex} \text{ , Internal risk index } H_{in} \text{ , Level index for Gamma radiation hazard } I_{\gamma} \text{ and Level index for alpha radiation hazard } I_{\alpha} \text{ .}

|       | Bq/kg | (n Gy h$^{-1}$) | (µSv h$^{-1}$) | $H_{ex}$ | $H_{in}$ | $I_{\gamma}$ | $I_{\alpha}$ |
|-------|-------|----------------|----------------|---------|---------|-------------|-------------|
| Ref.  | 370   | ≤ 1            | ≤ 1            | ≤ 1     | ≤ 1     | ≤ 1         | ≤ 1         |
| 124.72| 59.287| 0.0141         | 0.336          | 0.512   | 0.906   | 0.324       |
| 141.22| 67.169| 0.0159         | 0.381          | 0.574   | 1.027   | 0.367       |
| 117.92| 55.425| 0.0132         | 0.318          | 0.496   | 0.843   | 0.328       |
| 105.70| 50.286| 0.0119         | 0.285          | 0.437   | 0.768   | 0.281       |
| 104.11| 49.365| 0.0117         | 0.281          | 0.436   | 0.752   | 0.287       |

4- Conclusion:

The radiation levels that were measured in this work, also the results of radiation doses related to their dangerous levels, as well as the amount of radiological evidence in the five sites under study, have all shown values that fall within the acceptable limits compared to the relevant global determinants, although these sites have been chosen based on being contaminated by oil, as well as fire accidents previously occurred close to them, a matter that justifies follow-up and monitoring.

5- acknowledgment:

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