Measurement of the natural radiological activity of soil samples of some general education schools in Al-Qadisiyah Governorate

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Abstract
Right now, specific radioactivity of soil chose from Diwaniya Governorate was estimated. Ten samples of this soil were gathered. These samples were from some general education schools, where the samples were taken from diversified sites. to define the specific activity from the radioactivity 232-Th, 238-U and 40-K, Iodide sodium system activated with Thallium 3"×3“ had been used for this aim, finally for Thorium 232-Th ranged between (BLD-14.652) Bq.kg -1, average (5.334) Bq.kg -1. for Uranium 238-U, it is ranged between (BLD-26.187) Bq.kg -1, average (8.364) Bq.kg -1, where the result showed that radio activity of potassium 40-K ranged between (346.823-536.704) Bq.kg -1 with a rate of (450.482) Bq.kg -1. The radium equivalent values ranged between (33.951-68.194) Bq.kg -1, average (50.68) Bq.kg -1, the absorbed dose rate in air ranged between (18.386- 33.995) nGy.h -1, average (25.962) nGy.h -1, External hazard index ranged through (0.091-0.184), average (0.136), Internal hazard index ranged through (0.091-0.226), average (0.159), activity concentration index ranged between (0.293-0.538), average (0.409), the observed results were below the International recommended limits.

Keywords: Radiation, Radioactive contamination, Na reagent (Tl), Effective annual dose.

1 - Introduction
Radioactivity was found out in 1896 by the scientist Henri Beckerle, where it was found that Uranium salt emits a strong radiation in all Time and even in the dark. Where This radiation penetrated paper wrappers and thick silver foil and was affected by photographic plates .This phenomenon radioactivity [1,2], The concentration of radioactive isotopes in a soil were a course for radioactivity to people and is an indicator of radioactive assembling in environment [2]. Naturalist sources of radiation are cosmic radiation and earth radiation (naturally radiation), the approximates of the half life time of a radionuclide found in land stratum asymptotic to the age of the Earth at that point the radionuclide is primordial [3] . it was present from the earliest starting of the earth [4]. Inventories of primordial radionuclides are essentials segment of the normal foundation level of radioactivity in nature. the concentration of the natural nuclides 238-U, 232-Th, and their daughter items and 40-K, existing in the soil and rocks which is a relies upon the local geology of each part on the planet are causes diversity of dosages [5]. A few region are have high natural background in light of
the fact that in these regions levels of Uranium and their decay items in soil and rock, high establishment radiation zones, as a result of places geography, and geochemical activities it, due to arises levels of terrestrial radiation [4].

2 - Material and Method

2.1. Study area

Al-Qadisiyah is an Iraqi governorate. The total area is 8153. The samples were collected from city center of Al-Qadisiyah as shown in figure (1). By picking 10 schools Governmental from the center of Al-Qadisiyah city (i.e Khadija, Al-azhar Al-sharif, Qutibah, Al-zaytoon, Al-markaziah, Baghdad, Al-fajr Al-jadid, Dhat Al-sawari, Al-Rusafi, Altafawuq), as shown in table (1).

![Figure (1) map of Al-Qadisiyah/ Iraq with sampling site](image)

Table (1) Numbers, codes, Names and Locations of the collected samples in Al-Qadisiyah Province

| S of No. | S of code | Schools name          | Locations               |
|----------|-----------|-----------------------|-------------------------|
| 1        | R1        | Khadija               | Al-uruba                |
| 2        | R2        | Al-azhar Al-sharif    | Al-wahduh Al-thania     |
| 3        | R3        | Qutibah               | Um Khayl                |
2.2. Experimental Procedures

In this study, the natural radiation of soil samples was studied in some Diwaniyah schools which were randomly collected. beforehand estimation tests are exsiccated in a broiler at a temperature of 60°C for 72 h, every last one of the example filled and tight in a nearby PVC compartment and it was spared about one month and a half period to Let the radioactive balance between the daughter products of radon (222Rn), thoron (220Rn) and their shorter-lived decay products be allowed. was used 0.5 kg of soil is per sample. These samples are taken from a depth of approximately 10 centimeter. They were estimated by using Gamma spectrometer with scintillation detector NaI(Tl) from SPECTRUM TECHNIQUES, INC.USA. the sample is put vis-à-vis over the detector for 18000 sec(five hours), the contribution of the radiological background is subtract from the peak area of the measured sample [6], because of the accuracy of NaI(Tl) reagent in detecting vanishing gamma energies that did not separate the peak well..hence, the estimating of the activity focuses is accessible at high energies as that secure in our outcomes from gamma beam emitted the series of238U (the gamma line 1765 keV for 214Bi) and 232Th (the gamma line 2614 keV for 208Tl) which are equilibrium together with them, however 40K was assessed directly by means of its gamma line of 1460 keV [7,8].

3 - Calculation of activity

The samples were placed on the detector to calculate the specific activity for each sample, the net area under the corresponding peaks in the energy spectrum was computed by subtracting count due to background sources from the net area of a certain peak using MAESTRO-32 data analysis package. The background spectrum measured by using Empty 1 L polyethylene plastic container in the detector and counting at the same time for the sample measurements. The specific activity of each radionuclide is can be calculated using the following equation [7,8].

\[ Ac = \frac{C - BG}{\varepsilon I_{\gamma} M t} \quad \ldots \ldots (1) \]

where Ac is the specific activity, C is the area under the specified energy peaks, BG is background, \(\varepsilon\) is the efficiency of the detector, \(I_{\gamma}\) the transition probability for emitted gamma ray, \(M\) weight of samples in (kg) and \(t\) the time for collected in (sec)

4 - Calculation of Hazard indices

The specific efficacy of Uranium, Thorium, and Potassium, the Radium equivalent, average dose absorbed in air, and external and internal risk factors as well as the coefficient of effectiveness for the studied models were calculated as following:

4.1. Radium equivalent activity (Ra\text{eq})
Distribution of $^{232}\text{Th}$, $^{238}\text{U}$ and $^{40}\text{K}$ in environment is not orderly, for this regard to exposure for radiation, the radioactivity has been defined in terms of radium equivalent activity ($R_{aeq}$) in Bq.kg$^{-1}$ [9].

$$R_{aeq} = A_U + 1.43 A_{Th} + 0.077 A_K \ldots \ldots (2)$$

Where $A_U$, $A_{Th}$ and $A_K$ are specific activity concentration in (Bq.kg$^{-1}$) of $^{238}\text{U}$, $^{232}\text{Th}$ and $^{40}\text{K}$, respectively. The indexes are important to compare at the specific activity of materials containing various concentrations of $^{238}\text{U}$, $^{232}\text{Th}$ and $^{40}\text{K}$ [10].

4.2. Gamma Dose Rate (D)

The total dose rate $D$ in the air (outdoors) from distribution of commonly the $^{226}\text{Ra}$, $^{232}\text{Th}$ and $^{40}\text{K}$ in the soil 1 meter above sea level was estimated by the following equation [11,12].

$$D = 0.462A_U + 0.604A_{Th} + 0.042A_K \ldots \ldots (3)$$

Where $D$, the dose rate in (nGy.h$^{-1}$) and $A_U$, $A_{Th}$ and $A_K$ are the concentrations each of $^{233}\text{U}$, $^{232}\text{Th}$ and $^{40}\text{K}$ respectively [13].

4.3. Representative level index ($I_{\gamma}$)

To check whether the sample meets the dosage criterion limits, another radiation risk index, level index $I_{\gamma}$ employed to assess the degree of $\gamma$-radiation peril related for the radionuclides in examined samples is characterized as follow [12,13]

$$I_{\gamma} = \frac{A_U}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \ldots \ldots (4)$$

The annual dose was associated with an index $I_{\gamma}$ of excessive external gamma radiation by surface material. Values of index $I \leq 1$ agree to 0.3 mSv.y$^{-1}$, while $I \leq 3$ agree to 1 mSv.y$^{-1}$. Thus, the movement fixation list is important to utilize just as a screening apparatus for portray materials which may be see to use as covering material. As indicated by this portion measure, materials with $I \leq 3$ must be deflect [12].

4.4. External hazard index ($H_{ex}$)

Equation (5) calculate The external hazard index ($H_{ex}$), as following [12,13]

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \ldots \ldots (5)$$

4.5. Internal hazard index ($H_{in}$)

The inner exposure to $^{222}\text{Rn}$ and its radioactive progeny was given from this risk, and given by this equation [10,11]

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \ldots \ldots (6)$$

for the safe utilization of all material, index ($H_{in}$) ought to be less than unity to give safe level to the radiation.

Table (2) Activity Concentration in (Bq.kg$^{-1}$) $^{232}\text{Th}$, $^{238}\text{U}$ and $^{40}\text{K}$ in soil samples investigated in this study
The concentration of $^{238}$U, $^{232}$Th and $^{40}$K in soil samples are compared with other values reported in other countries as shown in Table 3. The comparisons are indicated the activity concentration of $^{238}$U was found to be lower than in other countries, except for Cyprus, Iraq/Basra. On the other hand, the activity concentration of $^{232}$Th was observed to be lower than in other countries, except Cyprus. Whilst, the activity concentration of $^{40}$K was found to be more than in other countries, except for India, Pakistan. in fact we found the concentration of $^{238}$U, $^{232}$Th were less than the world average Except $^{40}$K .The results indicated that the concentration varied from country to country due to the differences in the geological nature of the soil.

Table (3) Comparison of specific activity of soils samples in Iraq and other countries of the world

| Country          | Activity concentration $^{238}$U | Activity concentration $^{232}$Th | $^{40}$K Bq.kg$^{-1}$ | Reference |
|------------------|----------------------------------|-----------------------------------|------------------------|-----------|
| Pakistan         | 20.9                             | 42.6                              | 550                    | [14]      |
| India            | 34.03                            | 90.71                             | 765.35                 | [15]      |
| Cyprus           | 7.1                              | 5                                 | 104.6                  | [16]      |
| Iraq/Basra       | 1.35                             | 10.16                             | 360.5                  | [17]      |
| Saudi Arabia     | 11.3                             | 6.7                               | 153.8                  | [18]      |
| Ghana            | 13.6                             | 24.2                              | 162.1                  | [19]      |
| Turkey           | 17.9                             | 30.7                              | 448.7                  | [20]      |
| Egypte           | 22.3                             | 12.2                              | 158.2                  | [21]      |
| Nigeria          | 8.42                             | 10.28                             | 337.08                 | [22]      |
| Iraq, Ghammas    | 15.780                           | 8.596                             | 393.012                | [23]      |
| Vietnam          | 42.77                            | 59.84                             | 411.93                 | [24]      |
| Iraq, Al-Qadisiyah | 8.3                         | 5.3                              | 450.4                 | Present work |
| World (average)  | 35                               | 30                                | 400                    | [25]      |
Table (4) Radium equivalent activity, absorbed dose rate, external hazard index, internal hazard index, and gamma index for soil samples consumed in this study

| Sample code | Radium equivalent (Bq.kg\(^{-1}\)) | absorbed dose rate (nGy.h\(^{-1}\)) | Internal (H\(_{\text{in}}\)≤1) | External (H\(_{\text{ex}}\)≤1) | Activity concentration index (I\(_{\gamma}\)) |
|-------------|-----------------------------------|-------------------------------------|-----------------------------|-----------------------------|------------------------------------------|
| R1          | 56.761                            | 28.346                              | 0.153                       | 0.167                       | 0.450                                    |
| R2          | 57.637                            | 28.957                              | 0.155                       | 0.226                       | 0.444                                    |
| R3          | 33.951                            | 18.386                              | 0.091                       | 0.091                       | 0.293                                    |
| R4          | 50.224                            | 26.491                              | 0.135                       | 0.159                       | 0.417                                    |
| R5          | 47.140                            | 24.071                              | 0.127                       | 0.161                       | 0.375                                    |
| R6          | 47.751                            | 25.222                              | 0.128                       | 0.141                       | 0.400                                    |
| R7          | 68.194                            | 33.995                              | 0.184                       | 0.207                       | 0.538                                    |
| R8          | 42.537                            | 21.607                              | 0.114                       | 0.139                       | 0.339                                    |
| R9          | 58.384                            | 29.913                              | 0.157                       | 0.180                       | 0.472                                    |
| R10         | 44.185                            | 22.632                              | 0.119                       | 0.119                       | 0.362                                    |
| Low.        | 33.951                            | 18.386                              | 0.091                       | 0.091                       | 0.293                                    |
| Hig.        | 68.194                            | 33.995                              | 0.184                       | 0.226                       | 0.538                                    |
| Ave.        | 50.680                            | 25.962                              | 0.136                       | 0.159                       | 0.409                                    |

So as to demonstrate the state of variation in the rate of specific effectiveness, for thorium-232, Uranium-238 and Potassium-40, the relationship between the specific quality values in Bq.kg\(^{-1}\) see figure (2).

Figure (2) concentrations in soil samples

5 - Discussion and conclusions

Discussion of the results studied in the light of the global standards for the specific efficacy of potassium, uranium and thorium in public education schools, and comparing them with the internationally tolerable results with a presentation of the main conclusions we have reached.

For \(^{232}\text{Th}\), \(^{238}\text{U}\) and \(^{40}\text{K}\) radionuclides, the specific activity values for (10) soil samples are tabulated in table 2 and figure 2 they have been found in the range from (BLD to 14.652) Bq.kg\(^{-1}\) with an average (5.334) Bq.kg\(^{-1}\), from (BLD to 26.187) Bq.kg\(^{-1}\) with an average (8.364) Bq.kg\(^{-1}\) and (346.823 to 536.704) Bq.kg\(^{-1}\) with an average (450.482) Bq.kg\(^{-1}\) for \(^{232}\text{Th}\), \(^{238}\text{U}\) and \(^{40}\text{K}\) separately. The outcome shows that all values of \(^{232}\text{Th}\), \(^{238}\text{U}\) and \(^{40}\text{K}\)
specific activity for all samples are in the world average (30 Bq.kg\(^{-1}\) for \(^{232}\)Th, 35 Bq.kg\(^{-1}\) for \(^{238}\)U and 400 Bq.kg\(^{-1}\) for \(^{40}\)K). [25,26].

Also \(R_{eq}\) values change from (33.951 to 68.194) Bq.kg\(^{-1}\) with average value of (50.680) Bq.kg\(^{-1}\), as shown in table 4 at that point can see the \(R_{eq}\) values for all samples are lower than the recommended values 370 Bq.kg\(^{-1}\) [25,26]. The Absorbed dose rate in air ranged between (18.386 to 33.995) nGy.h\(^{-1}\), average (25.962) nGy.h\(^{-1}\), See table 4.

while \((H_{ex})\), \((H_{in})\) and \((I_{\gamma r})\) for the 10 soil samples index tabulated in table 4, External hazard index \((H_{ex})\) range from (0.091 to 0.184) with an average (0.136) and Internal hazard index \((H_{in})\) range from (0.091 to 0.226) with an average (0.159). Representative level Gamma Dose \((I_{\gamma})\) extend from (0.293 to 0.538) with an average (0.409) External and internal risk and gamma activity concentration were less than unity indicated by the Radiation Protection [26]. The values of the Radium equivalent activity and annual effective dose have been less than world average for \(^{40}\)K It was found that the specific efficacy of \(^{40}\)K takes varying values from one site to another, so it was observed that there is an increase in the Potassium nucleus concentration in some regions, due to its contamination with wastewater, and other wastes that are thrown in the area where the isotope concentration increases (\(^{40}\)K), but Results were higher than internationally allowed limits Bq.kg\(^{-1}\) (400). The values of the Radium equivalent activity and annual effective dose was less than the world average Except \(^{40}\)K. External and internal hazard and gamma activity concentration (representative level index) indexes were lower than unity [27].

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