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Estimation the Radiological Hazard Effects for Soil Samples of Nineveh Province

Laith A. Najam[1,*], Fouad A. Majeed[2], Malik H. Kheder[3], Shaher A. Younis[1]

[1]Department of Physical, College of Science, University of Mosul, Mosul, IRAQ
[2]Department of Physics, College of Education for Pure Sciences, University of Babylon, Hilla, IRAQ
[3]Department of Physics, College of Education, Hamdania Univ., Mosul, IRAQ
*Corresponding author: prof.lai2014@gmail.com

Abstract The specific activities of ten soil samples has been measured with HPGe detector in order to evaluate the radiological hazard effects of the natural radioactivity, the activity utilization index(AUI), alpha index (Iα) and the radiation exposure rate (I) have been measured. The activity utilization index values ranged from 0.275 in SS9 (Al-Medan) location to 0.735 in SS2 (Rebeaa) location with an average value 0.593, alpha index(Iα) values ranged from 0.081 in SS9 (Al-Medan) location to 0.194 in SS1(Sinjar) location with an average value of 0.162, while the radiation exposure rate(I) values ranged from 107.20μR/h in SS9 (Al-Medan) location to 260.37μR/h in SS2 (Rebeaa) location with an average value of 186.88 μR/h.

Keywords: *HPGe detector, natural radioactivity, alpha index, radiation, exposure rate*

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1. Introduction

Natural radionuclides have been the components of the earths' since its existence. It is widely spread in earth environment and exists in soil, sediment, water, plants and air. There are many naturally occurring radionuclides in environment, containing uranium and thorium series radioisotopes and natural ^{40}K [1,2]. The natural radioactivity in soil comes from U and Th series and natural K. Natural environmental radioactivity and associated external exposure due to gamma radiation depend primarily on the geological conditions of soil and sediment formations of each region in the world [3]. The study of natural radioactivity in marine and coastal environments is of significant importance for better understanding of oceanographic and sediment logical processes. The distribution of natural radionuclides in the seabed can be used as a tracer for both sediment sand dredged soil dispersal and accumulation mechanisms [4]. The radionuclides are associated with heavy minerals, whereas ^{40}K is concentrated within clay minerals [5]. Radioisotopes that are present in soil significantly affect terrestrial gamma radiation levels. In the last decade, several studies were carried out to assess the average outdoor terrestrial gamma dose rate in air at 1 m from the ground. The effective gamma radiation levels were generally in the range of 10–200 nGy /h with a mean of 60 nGy/h [6,7]. Human beings are exposed to background radiation that stems both from natural and man-made sources. Natural background radiation, which is equivalent to 2.4 mSv per person, makes up approximately 80% of the total radiation dose a person is exposed in a year [8]. In addition to the natural sources, soil radioactivity is also affected from man-made activities. Caesium-137 (^{137}Cs) is a fission product which is formed through nuclear tests and accidents. The deposition of ^{137}Cs in soil is important since its half-life is 30.2 years and it has a gamma emission of 661 keV [9].

The aim of the present work is determine the activity utilization index (AUI), alpha index (I_α) and radiation exposure rate (I) for soil samples in different areas of Nineveh province.

2. Materials and Methods

2.1. Study Area

This study was carried out at Nineveh province, ten districts has been selected from the center of Mosul city (i.e. Al-Medan, Camp of Gazlany and College of Agriculture at University of Mosul) and other locations from some small towns outside the city center of Mosul like (Sinjar, Rabeaa, Telfar, Al-Koosh, Telkaif, Al-Hamdanea and Bacheeka) as shown in Table 1.

The specific activities of ^{226}Ra, ^{232}Th and ^{40}K and were calculated using the following relation [10,11]:

$$A = Net\ Count / I.\varepsilon.m.t \quad (1)$$

where A is the specific activities in (Bq/kg), I is line intensity of γ- line in a radionuclide, ε is the measured efficiency of each γ- line observed, m is the weight of each sample and t is the sample counting time in (sec.).

Table 1. Names and codes of collected soil samples from Nineveh province

Sample No.	Sample code	Sample name
1	SS1	Sinjar
2	SS2	Rabeaa
3	SS3	Telfar
4	SS4	Al-Koosh
5	SS5	Telkaif
6	SS6	Al-Hamdanea
7	SS7	Bacheeka
8	SS8	Camp of Gazlany
9	SS9	Al-Medan
10	SS10	College of Agriculture at Univ. of Mosul

2.2. Sample Preparation

Ten soil samples were collected from all of the districts in the selected study area, every one of these samples weigh about 1.5 Kg , and the stones organic matter were removed from these samples, then the samples dried by placing it in the oven of 110°C for period of 24 hours, then crushed to pass through 2 mm sieve to be homogenized in size. The homogenized soil samples were sealed in plastic containers and left for at least one month to attain secular equilibrium, before gamma spectrometer consisting of vertical HPGe setup and multichannel analyzer (8192) channel, with the following specifications: resolution (FEHM) at 1.33 MeV 60Co is 2.0 keV, relative efficiency at 1.33 MeV 60Co is 40%. The detector shield are with activity adequate to accommodate large samples. Shield has walls 10 cm lead, thick lined inside with graded absorber of Cd ~ 1.6 mm, Cu~ 0.4mm. This shield serves to reduce different background radioactivity. To minimize the effect of the scattered radiation from the shield, the detector is located in the center of the chamber.

3. Results and Discussion

3.1. Radiological Parameters

The Radium Equivalent Activity (R_{aeq}), Absorbed Gamma Dose rate (D), External and Internal Hazard Indices (H_{ex} and H_{in}) and Gamma index(I_γ) were calculated and mentioned in [10].

3.1.1. Activity Utilization Index (*AUI*)

In order to facilitate the calculation of dose rates in air from different combinations of the three radionuclides in sediments and by applying the appropriate conversion factors, an activity utilization index (*AUI*) is constructed that is given by the following expression [12]:

$$AUI = \left(A_{Ra} / 50 \frac{Bq}{Kg} \right) f_{Ra} + \left(A_{Th} / 50 \frac{Bq}{Kg} \right) f_{Th} + \left(A_K / 500 \frac{Bq}{Kg} \right) f_K \quad (2)$$

where A_{Ra}, A_{Th} and A_K are activity concentrations in (Bq/Kg) of ^{226}Ra, ^{232}Th, and ^{40}K taken from [7],($f_{Ra} = 0.462$), ($f_{Th} = 0.604$) and ($f_K = 0.041$) (0.462) are the fractional contributions to the total dose rate in air due to gamma radiation from the actual concentrations of these radionuclides. In the NEA-OECD Report, typical activities per unit mass of ^{226}Ra, ^{232}Th, and ^{40}K in sediments A_{Ra}, A_{Th} and A_K are referred to be 50, 50 and 500 Bq/Kg, respectively [13]. The activity utilization index of the soil samples is calculated by using eq.(2). The calculated values from Table 2, vary from 0.275 in SS9 (Al-Medan) location to 0.735 in SS2 (Rebeaa) location with an average value of 0.593. This value shows that AUI is less than 2, which corresponds to an annual effective dose of < 0.3 mSv/y [14]. The values of *AUI* are shown graphically in Figure 1 and listed in Table 2.

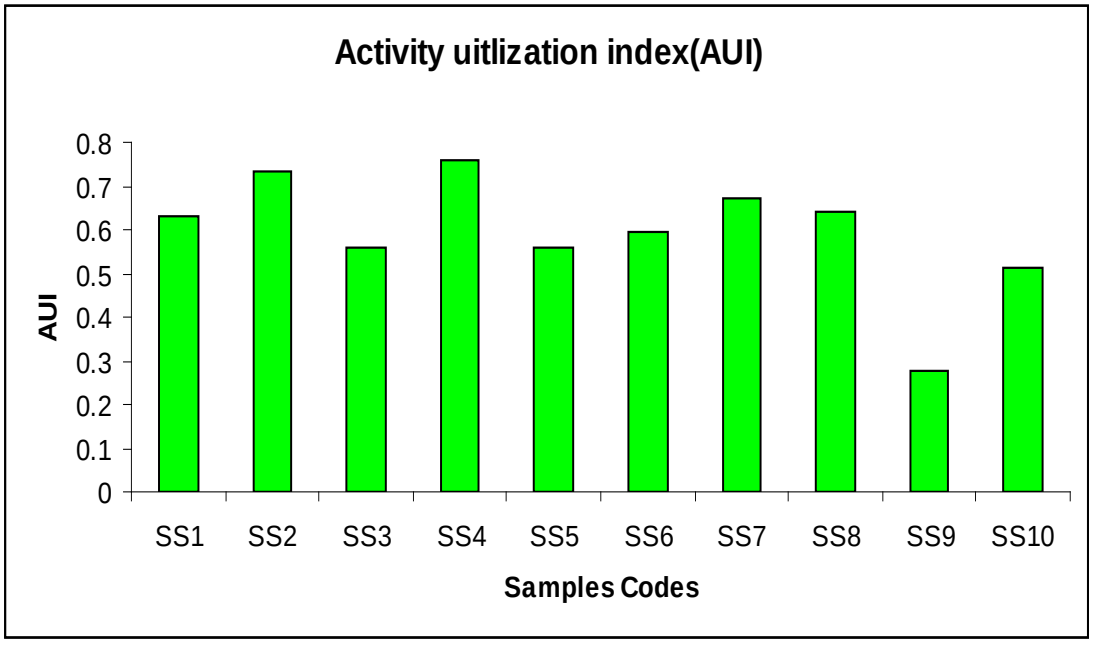

Figure 1. The values of AUI for soil samples in different areas of Nineveh province

Table 2. The value of activity utilization index (AUI) of soil samples of different areas in Nineveh Province

Samples codes	*AUI*
SS1	0.631
SS2	0.735
SS3	0.559
SS4	0.758
SS5	0.557
SS6	0.593
SS7	0.672
SS8	0.641
SS9	0.275
SS10	0.515
Range	**0.275-0.735**
Average	**0.593**

3.1.2. Alpha Index (I_α)

The excess alpha radiation due to radon inhalation originating from building materials, such as soil, was estimated using the following relation [15]

$$I_\alpha = A_{Ra} / 200 \frac{Bq}{Kg} \leq 1 \quad (3)$$

where:
I_α: is the alpha index
A_{Ra}: is the specific activity concentrations of ^{226}Ra assumed in equilibrium with ^{238}U.

The recommended upper limit of specific activity concentration is (200 *Bq*/*Kg*), for which alpha index (I_α) is equal to 1. The values of alpha index shown graphically in Figure 2 and listed in Table 3.

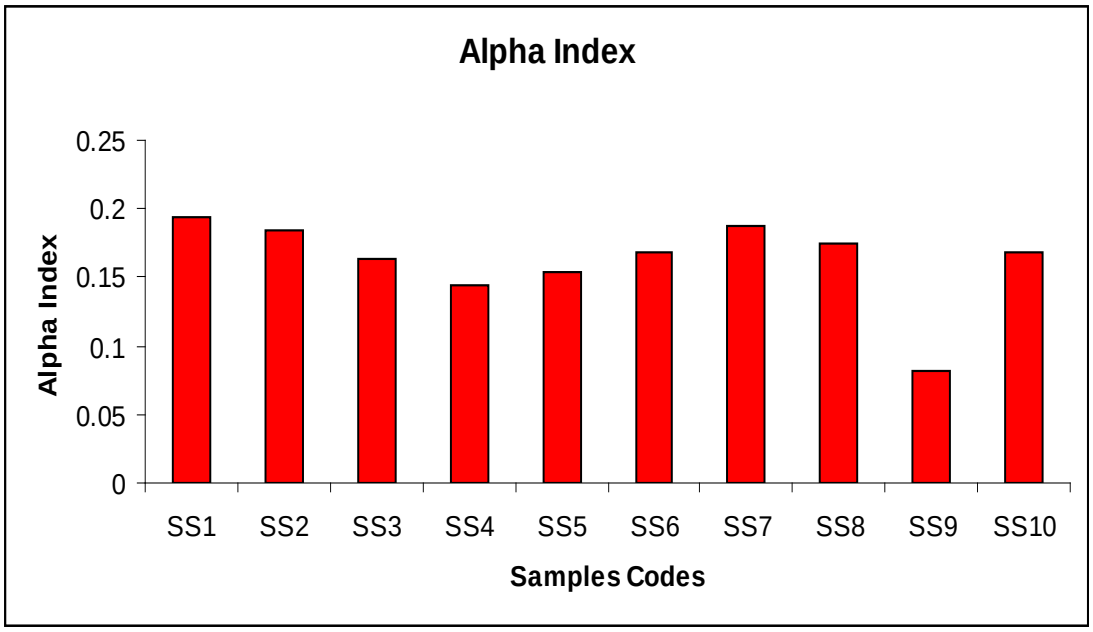

Figure 2. The values of Iα for soil samples in different areas of Nineveh province

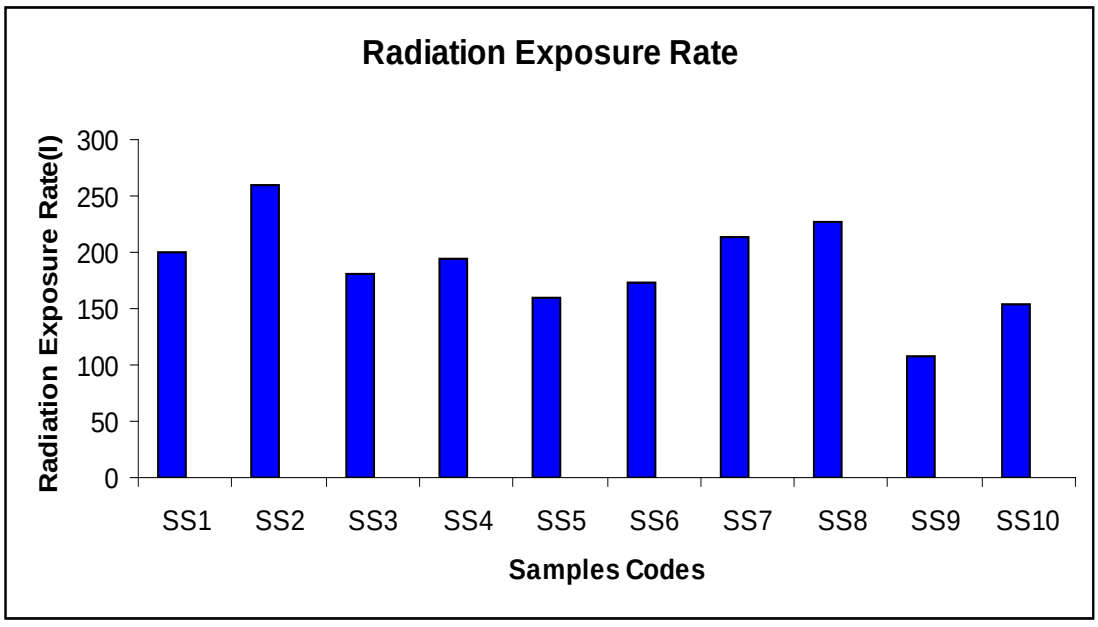

Figure 3. The values of radiation exposure rate for soil samples in different areas of Nineveh province

Table 3. The values of alpha index(Iα) and radiation exposure rate of soil samples of different areas in Nineveh Province for ^{226}Ra, ^{232}Th and ^{40}K

Samples Codes	Iα	I(μR/h)
SS1	0.194	199.32
SS2	0.185	260.37
SS3	0.163	180.18
SS4	0.145	194.44
SS5	0.154	159.97
SS6	0.168	172.83
SS7	0.188	214.38
SS8	0.175	226.34
SS9	0,081	107.20
SS10	0.168	153.78
Range	0.081-0.194	107.20-260.37
Average	**0.162**	**186.88**

3.1.3. Radiation Exposure Rate (*I*)

An index, *I*, in μR/hr, was selected to estimate the radiation exposure rate potential due to the combined radionuclide concentrations, in pCi/g, of the ^{238}U progeny, ^{232}Th progeny and ^{40}K in a material. This index was taken to be the exposure rate measured 1 m above an infinite hemisphere or slab with respect to the y-rays emitted by the radionuclides. The following relation, with the first coefficient modified on the basis of more recent decay information, is given by [16,17,18].

$$I = 1.90A_{Ra} + 2.82A_{Th} + 0.179A_K . \quad (4)$$

Concentrations of ^{226}Ra and ^{228}Ra can be substituted for those of ^{238}Uand ^{232}Th, respectively, because X- and y-rays in the chains before radium contribute little to the total exposure rate.

The values of radiation exposure rate (I) ranged from 107.20 μR/h in SS9 to 260.37 μR/h in SS2 with an average value of 186.88 μR/h. The values of *I* is shown graphically in Figure 3, and also listed in Table 3.

4. Conclusions

It is important to determine background radiation level in order to evaluate the health hazards. This study determined the values of activity utilization index, alpha index and the radiation exposure rate, have been found to be lower than their corresponding allowed limits, hence they will pose relatively no serious health risk.

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