Comparison levels of natural radioactivity for some of agriculture and virgin soil in the Najaf governorate

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Abstract

Specific activities of the natural radionuclides ^{238}U,^{232}Th and ^{40}K have been measured by gamma –ray spectrometry NaI(Tl) in twenty virgin and agriculture soil samples from Najaf governorate. The range of specific activity of ^{238}U, ^{232}Th and ^{40}K in the virgin soil samples varies from 16.08±4.71 to 37.79±4.16 $Bqkg^{-1}$, 8.83±3.52 to 42.36±2.33$Bqkg^{-1}$ and 127.91±11.21 to 756.09±11.14 $Bqkg^{-1}$ with average values of 27.39±4.46 $Bqkg^{-1}$, 31.16±3.00 $Bqkg^{-1}$ and 602.77±10.76 $Bqkg^{-1}$ respectively, whereas for agriculture soil samples varies from 29.90±5.99 to 78.58±5.50 $Bqkg^{-1}$, 26.87±2.98 to 59.31±3.41 $Bqkg^{-1}$ and 543.64±10.98 to 1104.61±12.23 $Bqkg^{-1}$ with average values of 51.96±5.04 $Bqkg^{-1}$, 42.48±3.47 $Bqkg^{-1}$ and 847±11.26 $Bqkg^{-1}$ respectively. The radium equivalent activity (Ra_{eq}), the absorbed dose rate (D) and the activity concentration index (I_γ) resulted from the natural radionuclides in soil, were also calculated. All values of Ra_{eq} were lower than the worldwide average. The average values of (D) and (I_γ) in all soil sample were higher than the permissible limit.

الخلاصة:

الفعالية النوعية للنويدات الطبيعية المشعة ^{238}U,^{232}Th and ^{40}K لـ لعشرين نموذج من التربة الصحراوية والزراعية لمحافظة النجف قيست باستخدام مطياف أشعة كاما NaI(Tl) . الفعالية النوعية للنويدات المشعة لنماذج التربة الصحراوية تتراوح من 16.08±4.71 الى 37. 79±4.16 Bq kg^{-1} , 8.83±3.52 الى 42.36±3.41Bq kg^{-1} ومن 127.91±11.21 الى 756.09±11.14Bq kg^{-1} , بمعدل قيم 27.39±4.46 $Bqkg^{-1}$, 31.16±3.00 $Bqkg^{-1}$ و 602.77±10.76 Bq kg^{-1} على التوالي, في حين كانت للتربة الزراعية تتراوح من 29.90±5.99 الى 78.58±5.50 $Bqkg^{-1}$, 26.87±2.98 الى 59.31±3.41 $Bqkg^{-1}$ ومن 543.64±10.98الى 1104.61±12.23 $Bqkg^{-1}$ وبمعدل قيم 51.96±5.04 $Bqkg^{-1}$, 42.48±3.47 $Bqkg^{-1}$ و 847±11.26 $Bqkg^{-1}$. مكافيء النشاط الإشعاعي للراديوم (Ra_{eq}) , معدل الجرعة الممتصة (D) و معامل تركيز الفعالية(I_γ) الناتج من النويدات المشعة في التربة حسبت ايضاً . جميع قيم مكافيء النشاط الإشعاعي للراديوم كانت اقل من المعدل العالمي .معدل قيم (D) و (I_γ) في جميع نماذج التربة كانت أعلى من الحد المسموح به

Introduction

Around 90% of human radiation exposure arises from natural sources such as cosmic radiation, exposure to radon gas, and terrestrial radiation[1]. Terrestrial radiations results from radionuclide sources found in the earth's crust occurring in the different types of rocks and soils. The commonest of these primordial radionuclides are ^{238}U, ^{232}Th and ^{40}K and their progenies [2]. The radiological implication of these radionuclides is due to the gamma-ray exposure of the body and irradiation of lung tissue from inhalation of radon and its daughters. Therefore, the assessment of gamma radiation dose from natural sources is of particular importance as natural radiation is the largest contributor to the external dose of the world population[3]. Natural environmental radioactivity and the associated external exposure due to gamma radiation depends primarily on the geological and geographical conditions, and appear at different levels in the soils of each region in the world [4,5].

It is felt necessary to study the natural radioactivity in soil to assess the dose to the population in order to know the health risks and to have a baseline for future changes in the environmental radioactivity due to human activities, because natural radioactive materials under certain conditions can reach hazardous radiological levels[6].
This study aims to measured the natural radioactivity for different type of soil from Najaf and assess the radiological hazard resulting from them, using NaI(Tl) gamma-ray spectrometers. The absorbed dose rate, radium equivalent activities, activity concentration index have been calculated based on guidelines provided by UNSCEAR (2008).

Experimental

Sampling and sample preparation

In order to measure the natural radioactivity in soil, surface and depth soil samples(virgin and agriculture) are collected from four different districts of Najaf. After collection, the samples were grinded into a fine powder with a particle size less than 1 mm. Before measurement samples are dried in an oven at a temperature of 100 ˚C for 12 h [7]. Each sample is packed and sealed in an airtight plastic container and kept for about 4 week's period to allow radioactive equilibrium among the daughter products of radon (^{222}Rn), thoron (^{220}Rn) and their short lived decay products. An average 1 kg of soil is used per sample. The specific activities were measured by using NaI(TI) detector with crystal of 3"×3" dimensions (Alpha Spectra, Inc.-12I12/3) coupled with a multi-channel analyzer 4096 channel (ORTEC-Digi Base) with range of (0–3000 keV) joined with computer software (MAESTRO-32). The detector was enclosed in a graded lead shield. The standard sources ^{22}Na, ^{137}Cs, ^{54}Mn and ^{60}Co were used to measure the counting efficiency. The activity of ^{238}U was measured by 1764.5 keV gamma rays emitted from ^{214}Bi. The activity of ^{232}Th was determined by 2614 keV gamma rays emitted from ^{208}Tl [8] . whereas ^{40}K activity was measured directly through its gamma ray energy peak of 1460 keV. The resolution of detector was 6.8 keV for 662 keV. [9]. All samples were counted for 18,000s just to obtain the gamma spectrum with good statistics.

Results and discussion

Specific activity measurement

The specific activity of each radionuclide was calculated by the following equation [5, 10].

$$A_s(\mathrm{Bqkg}^{-1}) = \frac{C}{\varepsilon \times p_\gamma \times M_s}, \qquad (1)$$

where, C is the count rate of gamma rays (counts per second), ε is the counting detector efficiency, p_γ is the absolute transition probability of γ-decay and M_s is the mass of the sample (kg). The measured range value of specific activity for ^{238}U, ^{232}Th and ^{40}K radionuclides in virgin and agriculture soil samples were given in Table 1. The specific activity of ^{238}U, ^{232}Th and ^{40}K in the virgin soil samples varies from 16.08±4.71 Bqkg^{-1} to 37.79±4.16 Bqkg^{-1}, 8.83±3.52 Bqkg^{-1} to 42.36±2.33Bqkg^{-1} and 127.91±11.21Bqkg^{-1} to 756.09±11.14 Bqkg^{-1} with average values of 27.39±4.46Bqkg^{-1}, 31.16±3.00Bqkg^{-1} and 602.77±10.76 Bqkg^{-1} respectively, whereas for agriculture soil samples varies from 29.90±5.99 Bqkg^{-1} to 78.58±5.50 Bqkg^{-1} , 26.87±2.98 Bqkg^{-1} to 59.31±3.41 Bqkg^{-1} and 543.64±10.98 Bq kg^{-1} to 1104.61±12.23 Bqkg^{-1} with average values of 51.96±5.04 Bqkg^{-1}, 42.48±3.47 Bqkg^{-1} and 847.225±11.26 Bqkg^{-1} respectively. As can be seen from Table1 ,the minimum values of specific activity for ^{238}U, ^{232}Th and ^{40}K were recorded in virgin soil, while the maximum values noted in agriculture soil sample which are higher than the worldwide average [4] . In general, Figure1 shows the distribution specific activity of ^{238}U,^{232}Th and ^{40}K with depths in virgin soil compared with agriculture soil, also we can note the effect of adding chemical fertilizers to the soil would enhance the values of radioactivity despite of the soil have the same geological origin.

Table 1: Specific activity of ^{238}U ^{232}Th and ^{40}K in soil samples

Type	Sample code	Depth(cm)	Specific activity ($Bqkg^{-1}$) ^{238}U	^{232}Th	^{40}K
Virgin	S1	0 − 5	20.79±4.83	40.79±2.71	685.66±10.66
		5 − 10	37.79±4.16	42.20±3.36	749.42±11.37
		10 − 15	30.16±4.39	40.18±2.84	647.04±10.89
		15 − 20	30.70±3.73	42.36±2.33	668.02±10.90
		20 − 25	32.97±4.35	36.19±2.90	656.50±11.08
	S2	0 − 5	25.07±4.71	22.59±3.47	756.09±11.14
		5 − 10	16.08±4.71	8.83±3.52	127.91±11.21
		10 − 15	19.87±4.89	21.13±3.20	626.37±11.29
		15 − 20	30.82±4.28	28.22±2.82	601.51±9.41
		20 − 25	29.66±4.59	29.14±2.82	509.13±9.65
	Min		**16.08±4.71**	**8.83±3.52**	**127.91±11.21**
	Max		**37.79±4.16**	**42.36±2.33**	**756.09±11.14**
	average		**27.39±4.46**	**31.16±3.00**	**602.77±10.76**
Agriculture	S3	0 − 5	64.58±4.89	59.20±3.41	965.95±13.10
		5 − 10	29.90±5.99	59.31±3.41	905.02±12.39
		10 − 15	34.18±7.52	42.30±4.50	1041.87±12.08
		15 − 20	78.58±5.50	48.53±4.39	1104.61±12.23
		20 − 25	61.58±6.24	51.51±3.52	1024.14±13.65
	S4	0 − 5	77.85±4.28	42.52±2.76	671.62±9.18
		5 − 10	40.36±4.77	27.73±3.03	543.64±10.98
		10 − 15	47.58±3.42	33.91±3.14	634.06±9.10
		15 − 20	44.15±3.34	32.93±3.52	783.69±9.57
		20 − 25	40.85±4.46	26.87±2.98	797.65±10.27
	Min		**29.90±5.99**	**26.87±2.98**	**543.64±10.98**
	Max		**78.58±5.50**	**59.31±3.41**	**1104.61±12.23**
	average		**51.96±5.04**	**42.48±3.47**	**847.225±11.26**

Radium equivalent activity

To compare the specific radioactivities of soil which contain ^{238}U, ^{232}Th and ^{40}K, a common index is generally preferred to obtain the sum of the activities. This index is called the radium equivalent activity (Ra_{eq}). The Ra_{eq} in (Bq kg^{-1}) can be expressed as[11]

$$Ra_{eq} = A_U + 1.43A_{Th} + 0.077A_K , \qquad (2)$$

where A_U, A_{Th} and A_K the specific activity of the three radionuclides ^{238}U, ^{232}Th and ^{40}K respectively. The maximum value of (Ra_{eq}) must be less than 370 $Bqkg^{-1}$ as recommended by the Organization for Economic Cooperation and Development [12]. As can be seen from Table 2, the (Ra_{eq}) values for the soil samples varied from 38.56 $Bqkg^{-1}$ to 233.04 $Bqkg^{-1}$ with average value 148.157 Bq kg^{-1} , which is lower than the internationally accepted value (370 Bq kg^{-1}) [11]. Generally the agriculture soils have(Ra_{eq}) values higher than the virgin soils as shown in Figure 2, these high values may be due to high concentration of Uranium, Thorium and Potassium in agriculture soil samples.

The gamma absorbed does rate in air (D):

The absorbed dose rates (D) due to gamma radiation in air at 1 m above the ground surface, assuming uniform distribution of the naturally occurring radionuclides (^{238}U, ^{232}Th and ^{40}K) have been calculated based on guidelines provided by [4] .

$$D(nGyh^{-1}) = 0.462A_U + 0.621A_{Th} + 0.0417A_K \qquad (3)$$

where A_U, A_{Th} and A_K the specific activity of ^{238}U, ^{232}Th and ^{40}K respectively. It can be observed from Table 2 that the calculated absorbed dose rate due to the presence of ^{238}U,^{232}Th and ^{40}K in soil ranges between 18.1 and 111.68 $nGyh^{-1}$ with an average value of 70.80 $nGyh^{-1}$. The minimum value of (D) was found in virgin soil samples (S2) in depth (5-10) cm and maximum value was found in agriculture soil samples (S3) in depth (15-20) cm. Figure. 2 shows all values of agriculture soil are greater than the permissible limit, while the virgin soil have (D) values oscillated around permissible limit with factor 55 $nGyh^{-1}$ [3,13].

Activity concentration index (I_γ)

Because more than one radionuclide contributes to the dose, it is practical to present investigation levels in the form of an activity index. The European Commission Guidance document proposes the introduction of an activity concentration index (I_γ), use to assess the safety requirement of building materials [14].

$$I_\gamma = \frac{A_U}{300} + \frac{A_{Th}}{200} + \frac{A_K}{3000} , \qquad (4)$$

where A_U, A_{Th} and A_K the specific activity of ^{238}U, ^{232}Th and ^{40}K respectively. The value of (I_γ) must be less than 1 to keep the radiation hazard insignificant to the general population[15]. The calculated (I_γ) values for the soil samples are given in Table 2. The values range from 0.28 to 1.75 with an average of 1.12 which is higher than unity. Figure 2 shows the minimum value recorded in virgin soil sample and the maximum value recorded in agriculture soil sample. The most values in agriculture soil are higher than unity.

Table 2 : radiation hazard indices of soil samples

Type	Sample code	Depth	Ra_{eq}(Bq.Kg^{-1})	D (hGy.h^{-1})	I_{γ}
Virgin	S1	0 – 5	131.91	62.83	1.00
		5 – 10	155.84	74.20	1.17
		10 – 15	137.44	65.18	1.03
		15 – 20	142.71	67.62	1.07
		20 – 25	135.27	64.47	1.02
	S2	0 – 5	115.59	56.76	0.90
		5 – 10	38.56	18.10	0.28
		10 – 15	98.31	48.06	0.76
		15 – 20	117.49	56.37	0.89
		20 – 25	110.53	52.53	0.83
Agriculture	S3	0 – 5	223.62	105.87	1.67
		5 – 10	184.41	87.38	1.40
		10 – 15	174.90	84.79	1.35
		15 – 20	233.04	111.68	1.75
		20 – 25	214.10	102.27	1.61
	S4	0 – 5	190.37	89.65	1.39
		5 – 10	121.88	58.07	0.91
		10 – 15	144.89	68.90	1.08
		15 – 20	151.59	72.97	1.15
		20 – 25	140.69	68.36	1.07

Conclusions:

The radioactivity levels due to natural radionuclides are determined by gamma ray spectroscopy in virgin and agriculture soil samples collected from the najaf governorate. The specific activity due to ^{238}U, ^{232}Th and ^{40}K in agriculture soil is higher than the virgin soil, and hazard indexes of the agriculture soil are higher than the permissible limit because of the increasing usage the chemical fertilizer in this soil. Should be taken into consideration the continuous usage of chemical fertilizer in agriculture soil because it cause radioactive contamination.

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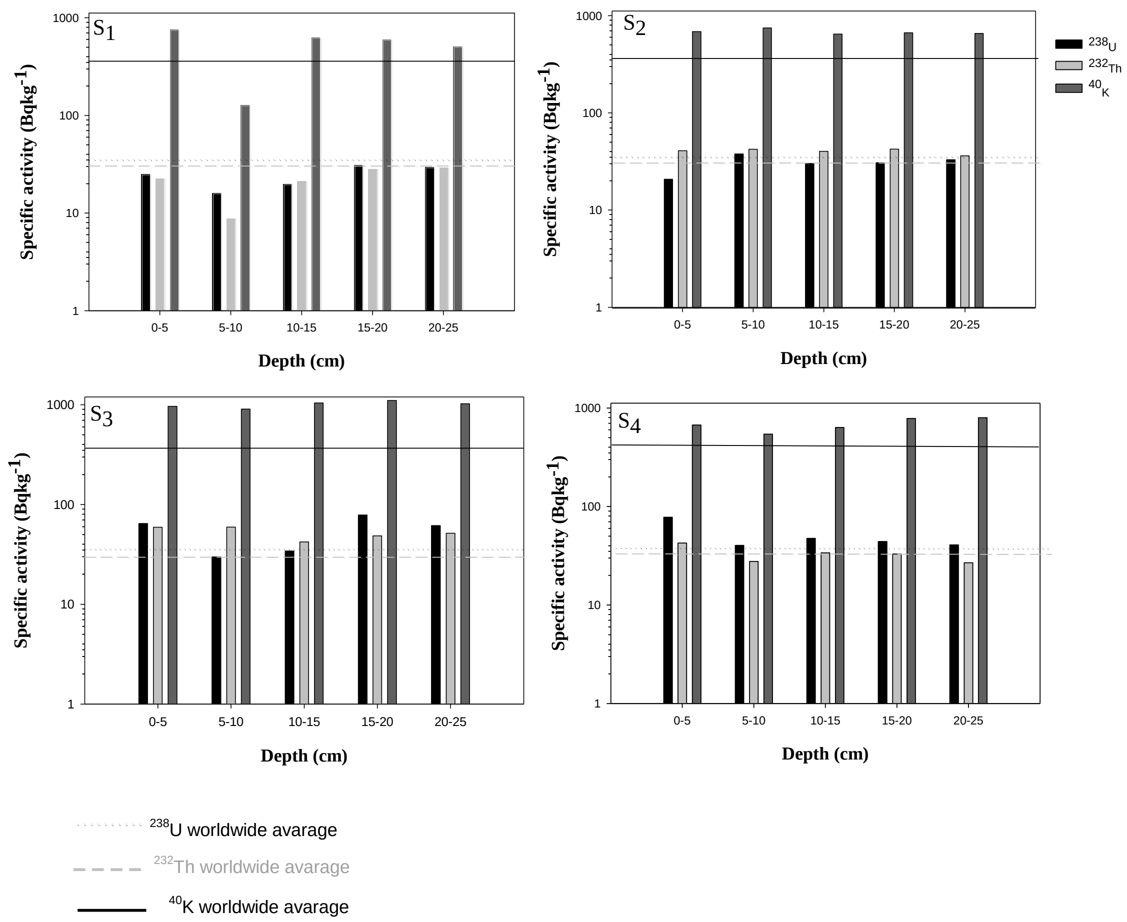

Fig.1 Specific activity of soil samples

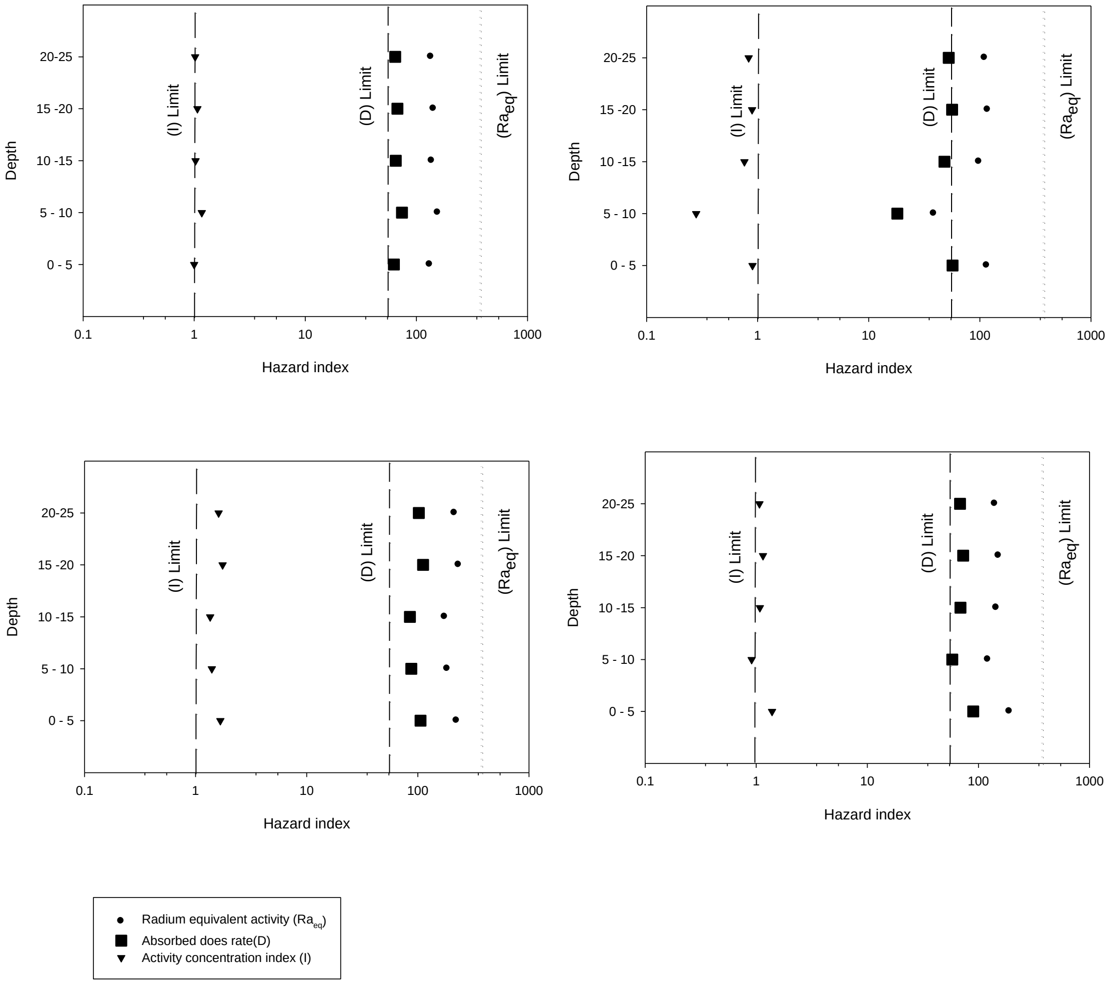

Fig.2 hazard index of soil sample