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Estimation of Radiation Hazards of Natural Radionuclides in Archaeological Site (Tanis), Egypt

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Natural radionuclides of ^{238}U (^{226}Ra), ^{232}Th and ^{40}K contained in the earth crust (soil) of Archaeological Site (Tanis, San Al-Hagar, Sharqai, Egypt) were measured using γ-ray spectroscopy system equipped with High pure germanium detector (HPGe). 20 soil samples were collected from the ground surface of tomb rooms, roads among tombs and the outer empty space of Tanis. Arithmetic mean values of radionuclides concentrations in the studied samples were 5.96 ± 1.46 Bq kg^{-1} for ^{226}Ra, 3.78 ± 1.60 Bq kg^{-1} for ^{232}Th and 70.34 ± 7.20 Bq kg^{-1} for ^{40}K, respectively. All the studied natural radionuclides had concentration values less than worldwide recommended value of 35, 30, 400 Bq kg^{-1} for ^{226}Ra, ^{232}Th and ^{40}K, respectively. Furthermore, the radiation dose in that site was measured using Digilert100 radiation survey meter and its mean value was of 0.52 ± 0.13 µSv h^{-1} which is much lower than safety limit. Moreover, radiological hazards indices of radium equivalent activity (Ra_{eq}), external (H_{ex}) and internal hazard indices (H_{in}), alpha and gamma radiation indices and annual effective dose due to the presence of those radionuclides were calculated and their values were less than worldwide limit. These results implied that the Tourists can safely visit and stay in this site (San Al-Hagar) as long as they wish.

Keywords: *Natural radionuclides, HPGe, hazard indices, Radiation dose, Soil, Archaeological site, Egypt*

Introduction

Human beings are exposed to ionized radiation emitted from natural radionuclides in the earth's crust, rocks, and soils which resulted from the weathering of the different type of rocks. The level of those radionuclides varied according to the type of rocks. Igneous rocks contained high levels of radinuclides while sedimentary rocks contained low levels. The soil (upper layer of the earth's crust) is one of the most important sources of naturally occurring radioactive materials (NORM), i.e. uranium series, thorium series and potassium [1-4]. UNSCEAR, 2000 [5] reported that the main contributor of human beings' exposure comes from natural radiation, and the worldwide average annual effective dose is 2.4 mSv. Thus, the high level of ionizing radiation above the earth is mainly due to the increase of the concentration of natural radionuclides of uranium (^{238}U), thorium (^{232}Th), their daughter products and potassium (^{40}K), NORM, in earth's crust, rock and soil [6]. Hence, the evaluation of natural radionuclides concentrations is very important from the point of view of environmental radiation protection.

The radiological implications of those radionuclides are the result of γ-ray exposure of the human body and irradiated of its inter tissue (lung, stomach, bone marrow, …) by the inhalation or digestion of radon and its progenies [7]. Consequently, the most important sources of external and internal exposure are the gamma radiation and alpha particles emitted from uranium (^{238}U) series, thorium (^{232}Th) series and ^{40}K present

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within soil. External exposure occurs directly by gamma-rays, whilst, internal exposure to α-particles results from the inhalation of radon and its progenies [8-10]. Therefore, the exposure to NORMs has a theoretical potential to cause cancers in individuals exposed at significant levels. Therefore, the measurement of specific activity concentration natural radionuclides in soils is of a prime importance from the environmental radiation protection point of view [11].

San Al-Hagar (Tanis) is the most important archaeological site in Egypt's northern Delta, about 150 km northeast of Cairo, (Figure. 1). It is characterized by an eclectic reuse of materials that were usurped from other locations and earlier reigns. Tanis was actually its Greek name. It contains several temples of Ramses II, royal tombs and a sacred lake. Tourists from different countries of America, Belgium, Italy, Poland, Spain, etc. visited Tanis, and about 2180 tourists visit that place yearly. In the present work, the concentrations of ^{238}U, ^{232}Th, and ^{40}K in architecture site (Tanis) were measured using high-purity germanium detector (HPGe). Based on the radionuclides concentrations values, the hazard indexes of radium equivalent activity (Ra_{eq}), external (H_{ex}), internal (H_{in}) hazard indices, alpha and gamma radiation indices and annual effective dose associated with those radionuclides were calculated and compared with worldwide limit according to UNSCEAR equations. Moreover, the radiation dose in the architecture site was measured with Digilert100 radiation survey meter.

Materials and Methods

Sample preparation

A total 20 samples of soil were collected from different locations of San Al-Hagar, Egypt; ground surface of tomb rooms, roads among tombs and the outer empty space, as shown in Figure. (1). The selected samples were crushed into a fine powder. They were than sieved through a 1 mm mesh size to remove the larger grains size from sample to be more homogenous. The sample were then dried in an oven of controlled temperature at 110 oC for 24 hours to ensure that moisture is completely removed. After moisture removal, the samples were cooled down to room temperature in a desiccator [4,11].

The prepared samples were packed into airtight plastic containers, (6 cm diameter and 8 cm height) made from polyethylene. The containers were carefully sealed with adhesive to prevent any possibility of radon escaping (222Rn) or thoron (220Rn) and stored for one month to achieve radioactive secular equilibrium between radium and radon. At the same time, an empty container with the same geometry of that used for samples, was also sealed and left for the same time in order to be used for background [7].

Measurement of radionuclide concentrations

Natural radionuclides concentrations of ^{226}Ra, ^{232}Th, and ^{40}K were measured using HPGe detector of vertical coaxial closed-end manufactured by Canberra. The HPGe detector majored efficiency is 100% and the energy resolution is 2.1 keV at 1.33 MeV of γ-ray line of ^{60}Co (EAEA, Cairo, Egypt). It was shielded with a cylindrical lead container of thickness 5 cm, which contains an inner concentric cylinder of Cu with a thickness of 10 mm, in order to reduce the effects of background. It was connected to a personal computer based data acquisition system which has a Multi-Channel-Analyzer (8192 channels). The data analysis was carried out via gamma spectroscopy program of Genie 2000.

HPGe detector's peak efficiency was carried out using standard point source package (RSS-8) of 8 radionuclides of Cs-137, Ba-133, Cd-109, Zn-65, Co-60, Co-57, Mn-54, and Na-22 supplied by International Atomic Energy Agency (IAEA) and bulk standard soucre. For bulk measurement, the ^{40}K in KCl form was used as a normalizing factor. Bulk source was packaged in the same container geometry as those used for samples. The samples were left for measurement overnight; so, the measurement time for each sample was around (24 h). Since radium (^{226}Ra) and its progenies produced about 98.5% of the radiological effects of uranium series, the contribution of ^{238}U and the precursors of ^{226}Ra were ignored. Thus, radium (^{226}Ra) was considered to be the reference of ^{238}U series instead of ^{238}U [11]. The radium (^{226}Ra) specific activity concentration was measured from the γ-rays of energies of 351.9 keV (36.6 %) and 295.2 keV (18.5%) associated with the decay ^{214}Pb, 609.3 keV (46.1%) and 1120 keV (15%) γ-rays of associated with the decay ^{214}Bi. The thorium (^{232}Th) specific activity concentration was estimated from the γ-rays of energies of 911.1 keV (29%) associated with the decay of ^{228}Ac, 583.1

keV (84.5%) associated with the decay of ^{208}Tl and 238.6 keV (43.6%) associated with the decay of ^{212}Pb. The potassium (^{40}K) specific activity concentration was estimated from the γ-ray of energy of 1460.9 keV (10.67%) associated with the decay ^{40}K itself, [2,7] as shown in Figure. (2). The specific activity concentration of those natural radionuclides, A, (Bq kg^{-1}) were calculated from Eq (1) [1,7].

$$A = \frac{C}{pwt\varepsilon} \quad (1)$$

where, C is the net count above the background, p is the absolute emission probability of the gamma ray (mentioned in brackets after γ-rays energies), w is the net dry sample weight (kg), t is the measurement time, and ε is the absolute efficiency of the detector.

Results and Discussion

Soil is the main source of the radiation dose received by individuals from natural radionuclides which is the main source of external and internal radiation exposures due to γ-rays and α-particles emitted from uranium series (^{238}U), thorium series (^{232}Th), and radioactive potassium nucleus (^{40}K). Therefore, evaluation the concentration of those radionuclides is very important from view of environmental radiation protection. The specific activities concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in San Al-Hagar soil samples ranged from 3.90 ± 0.78 to 9.44 ± 1.59 Bq kg^{-1} for ^{226}Ra, 1.09±0.43 to 9.50±2.65 Bq kg^{-1} for ^{232}Th, and 43.77 ± 1.59 to 106.69 ± 11.89 Bq kg^{-1} for ^{40}K, with mean values of 5.96 ± 1.46 Bq kg^{-1}, 3.78 ± 1.60 Bq kg^{-1} and 70.34 ± 7.20 Bq kg^{-1}, respectively, as shown in Table (1) and Figure. (3). UNSCEAR, 2000 [5] reported that the worldwide limit of ^{226}Ra, ^{232}Th, and ^{40}K in soil samples should be in the range of 35, 30 and 400 Bq kg^{-1} which implies that all the measured samples maintained radionuclides concentrations much lower than the worldwide average value. It was noticed that specific activity concentration of ^{40}K was much higher than that of ^{226}Ra and ^{232}Th in soil samples. This is a common occurrence in most of the geological materials [1,4]. These variations in radionuclides concentration may be attributed to the soil samples geological formation, physical geological characteristics, topographical differences, geomorphology, and meteorological conditions of the region [12]. When the present results are compared with the values of the soil originating in different courtiers of the world (in literature), it can be noticed that the radionuclides level in the present study were much lower than the literature values of other countries, as seen in Table (2).

Radium equivalent (Ra$_{eq}$) index can be defined on the assumption that 370 Bq kg^{-1} of ^{226}Ra, 259 Bq kg^{-1}of ^{232}Th and 4,810 Bq kg^{-1} of ^{40}K produce same γ-rays radiation dose of 1.5 mSv y^{-1}. It was calculated from Eq. (2), [2, 12].

$$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.077C_K \quad (2)$$

Where, C_{Ra}, C_{Th}, and C_K are the concentrations of ^{226}Ra, ^{232}Th and ^{40}K, respectively. Radium equivalent of the studied samples varied from 8.98 ± 1.77 Bq kg^{-1} (OET1) to 25.68 ± 6.89 Bq kg^{-1} (TT1) with a mean value of 16.76 ± 3.97 Bq kg^{-1}, respectively, as shown in Table (3) and Figure. (3). Since UNSCEAR, 2000 [5] reported that for the sake of safety, the radium equivalent concentration of soil samples should be less than 370 Bq kg^{-1} to maintain the γ-rays dose less than 1.5 mSv y^{-1}. This implies that Radium equivalent of all the selected soil samples were much lower than recommended value of 370 Bq kg^{-1}.

External radiation exposure of γ-rays emitted from natural radionuclides in soil can be calculated from Eq. (3), [1]. For the sake of safety, external hazard index (H_{ex}) should be less than unity in order to a γ-rays radiation dose value less than 1.5 mSv y^{-1}.

$$H_{ex} = \frac{C_{Ra}}{370} + \frac{C_{Th}}{259} + \frac{C_K}{4810} \quad (3)$$

Where, C_{Ra}, C_{Th} and C_K are the specific activities concentration of ^{226}Ra, ^{232}Th, and ^{40}K, respectively, in Bq kg^{-1}. External hazard index (H_{ex}) of the studied samples varied from 0.02 ± 0.01 for (OET1) to 0.07 ± 0.02 for (TT1) with a mean value of 0.05 ± 0.01, as seen in Table (3). Therefore, all of the studied samples had an external hazard index less than unity which implies that the received γ-ray radiation dose is less than 1.5 mSv y^{-1}. In addition, the internal hazard index was calculated from Eq. (4) and it should be less than unity [10-13].

$$H_{in} = \frac{C_{Ra}}{185} + \frac{C_{Th}}{259} + \frac{C_K}{4810} \quad (4)$$

Internal hazard index was less than unity for all samples, as shown in Table (3).

Table 1 Concentrations of natural radionuclides of ^{226}Ra, ^{232}Th and ^{40}K in selected soil samples

Location	Code	Activities Concentrations (Bq/Kg)		
		^{226}Ra	^{232}Th	^{40}K
Monee Nilometer	MN1	5.11 ± 3.25	7.63±3.11	88.24 ± 11.37
Poetry Nilometer	PN1	7.80 ± 2.17	3.38±2.16	88.76 ± 5.98
Nilometer for 22,30th Dynasties	ND1	7.24 ± 1.71	2.62±1.06	72.33 ± 10.53
NRT I Tomb	NT1	4.40 ± 1.08	2.73±1.30	66.91 ± 5.03
NRT II Tomb	NT2	4.91 ± 1.19	2.90±1.46	65.12 ± 5.33
NRT IV Tomb	NT3	7.00 ± 3.05	2.93±3.01	70.86 ± 10.79
Osorkon II East Tomb	OET1	4.05 ± 1.05	1.09±0.43	43.77 ± 1.59
Osorkon II West Tomb	OWT1	4.71 ± 2.92	6.43±3.86	106.69 ± 11.89
Sheshonq II Tomb	ST1	6.36 ± 1.33	1.95±1.01	52.21 ± 5.11
Sheshonq III Tomb	ST2	6.53 ± 0.97	3.21±1.23	52.47 ± 6.39
Sheshonq IV Tomb	ST3	3.90 ± 0.78	2.00±0.35	56.18 ± 3.84
Psusennes I Tomb	PT1	5.31 ± 1.61	4.33±1.41	68.84 ± 9.71
Takelot I Tomb	TT1	6.55 ± 2.14	9.50±2.65	72.04 ± 12.44
The Sacred Lake	SL1	9.44 ± 1.59	4.24±1.73	63.53 ± 7.05
Temple Holy of Holies	THH1	8.35 ± 0.99	1.57±1.31	61.72 ± 6.34
Temple Of Horus	TH1	6.17 ± 1.88	3.14±1.50	74.34 ± 7.01
East Of Amun Temple	EAT1	5.52 ± 1.14	4.56±0.81	69.24 ± 7.07
West Of Amun Temple	WAT1	5.54 ± 0.22	2.41±0.61	88.97 ± 0.27
The East Temple	ET1	5.07 ± 1.68	5.23±2.36	77.91 ± 9.88
Mut Temple	MT1	5.27 ± 2.47	3.66±1.70	66.63 ± 5.97

Alpha index, (I_α), Alpha radiation due to the inhalation of radon released from soil, was calculated using Eq. (5), [21,22]. It should be less than unity to reflect radium concentration less than 200 Bq kg^{-1} (the upper recommended value) and consequently the release radon concentration will be less than 200 Bq m^{-3}.

$$I_\alpha = A_{Ra}/200 \quad (5)$$

Alpha index for all the studied samples varied from 0.02 ± 0.01 (OET1) to 0.05 ± 0.01 (SL1) with a mean value of 0.03 ± 0.01, as seen in Tables (3). These values indicate that the studied samples contain a radium content much lower than 200 Bq kg^{-1}(agree with measured values). Moreover, the γ-ray radiation hazards associated with the natural radionuclides in soil can be assessed by means of radioactivity level index (I_γ) which was calculated from Eq. (6) (European Commission, EC) [21,22]. According to the European Commission guidelines, it should be less than unity for radiation dose of 1 mSv y^{-1}.

$$I_\gamma = \frac{C_{Ra}}{300} + \frac{C_{Th}}{200} + \frac{C_K}{3000} \quad (6)$$

The radioactivity level index (I_γ) of all studied samples had values much lower than unity, as given in Table (4), which implies the received radiation γ-ray dose to individual (visitor) in San Al-Hagar will be less than 1 mSv y^{-1}.

The absorbed dose rate of γ-rays emitted from radionuclides of ^{226}Ra, ^{232}Th and ^{40}K maintained in soil of San Al-Hagar at 1 m above the ground can be calculated from the following from Eq. (7) [2,16].

$$D\left(\frac{nGy}{h}\right) = (0.46C_{Ra}) + (0.62C_{Th}) + (0.042C_K) \qquad (7)$$

Where, C_{Ra}, C_{Th} and C_K are the specific activities of ^{226}Ra, ^{232}Th and ^{40}k, respectively. The calculated absorbed dose varied from 4.38 ± 0.81 nGy h^{-1} (OET1) to 11.93 ± 3.15 nGy h^{-1} (EM8) with a mean value of 8.04 ± 1.82 nGy h^{-1}, as seen in Tables (4). UNSCEAR, 2008 [23] reported that the worldwide average limit value of the absorbed dose should be 59 nGy h^{-1}. All the studied samples had absorbed dose less than worldwide average value, as given in Tables (4).

The annual effective dose (E) due to γ-rays emitted from earth crust due to the presence of natural radionuclides of ^{226}Ra, ^{232}Th and ^{40}k was calculated using Eq. (8) [12,16].

$$E = D(nGy\ h^{-1})\ x\ 8760(hy^{-1})\ x\ O\ x\ C(mSv/nGy) \qquad (8)$$

Where, *O* is the occupancy factor and *C* is the absorbed to effective dose conversion factor (0.7 × 10^{-6} Sv per Gy). The annual effective dose varied from 5.37 ± 0.99 μSv y^{-1} (OET1) to 14.63 ± 3.86 μSv y^{-1} (TT1) with an average value of 9.86 ± 2.24 μSv y^{-1}, respectively, as shown in Tables (4). The annual effective dose of all samples was less than 480 μS y^{-1} [23] which implies that this architecture site of San Al-Hagar (Tanis) could be very safely to be visited for long durations.

Finally, the radiation dose received or delivered to individuals (visiting tourists) from the ionized radiation (α-particle, β-particle and γ-rays) was measured in different locations in San Al-Hagar (in-situ) using Digilert100 radiation survey meter (factory calibrated). The dose varied from 0.30 ± 0.12 μS h^{-1} to 0.80 ± 0.15 μS h^{-1} with a mean value of 0.52 ± 0.13 μS h^{-1}, respectively, as seen in Table (4). It was noticed that the values of the measured radiation dose in site is much higher than the calculated annual effective dose. This could be attributed to α-particle, β-particle and γ-rays emitted from radon, radon progenies and from natural radionuclides emitted from the walls of Tomb and Pharaonic statues themselves which composed of granite.

Conclusion

Natural radionuclide concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in soil samples collected from the ground surface of Tomb rooms and roads among them in Tanis, Egypt, were measured using high purity germanium detector. The average specific activities of ^{226}Ra, ^{232}Th, and ^{40}K in those soil samples were 5.96 ± 1.46 Bq kg^{-1}, 3.78 ± 1.60 Bq kg^{-1} and 70.34 ± 7.20 Bq kg^{-1}, respectively. Perhaps the high ratio of ^{40}K in some samples is due to the decomposition of human bodies for many years; as the region is a cemeteries area and old landfills. Based on the radionuclides concentrations results, the radiological hazards, of radium equivalent activities (Ra_{eq}), external and internal indices, alpha and gamma indices, the absorbed dose and annual effective dose were calculated and the values of all of them were much lower than the safety value. Moreover, the radiation dose in that architecture site was measured using the Digilert 100 survey meter varied from 0.30 ± 0.12 μS h^{-1} to 0.80 ± 0.15 μS h^{-1} with a mean value of 0.52 ± 0.13 μS h^{-1}, respectively. The present results imply that the architecture site of Tanis, Egypt is so safe from radiation hazards and can be visited for short or long durations by tourists from the entire world

Table 2 Comparison of radionuclides concentrations in the present studied soil samples and their obtained values in literatures for various countries all over the world.

Country	Activity Concentration in soil (Bq/Kg)			Reference
	^{226}Ra	^{232}Th	^{40}K	
India	33.78 ± 1.99	77.44 ± 2.37	791.58 ± 5.78	[13]
Pakistan	49 ± 1.7	62.4 ± 3.2	670.6 ± 33.9	[2]
Nigeria	32.52 ± 4.56	56.23 ± 2.3	403.63 ± 7.2	[6]
Saudi Arabia	4.35 ± 0.028	3.3 ± 0.033	71 ± 7.21	[14]
Iraq	33.55 ± 5.61	21.52 ± 5.37	326.74 ± 70.26	[15]
Turkey	37 ± 18	40 ± 18	667 ± 281	[16]
Qatar	23.2 ± 1.82	4.5 ± 0.18	127.1 ± 6.62	[17]
Kenya	21.2 ± 9.7	27 ± 11.8	61.1 ± 13	[18]
Algeria	47.01 ± 7.3	33 ± 7	329.4 ± 19.7	[19]
Yemen	48.2 ± 4.4	41.7 ± 4.5	939.1 ± 36	[20]
Malaysia	79 ± 3	84 ± 3	545 ± 55	[1]
Sudan	7.54 ± 4.91	20.74 ± 11.29	111.87 ± 136.84	[12]
Egypt	5.96 ± 1.46	3.78 ± 1.6	70.34 ± 7.20	Present study

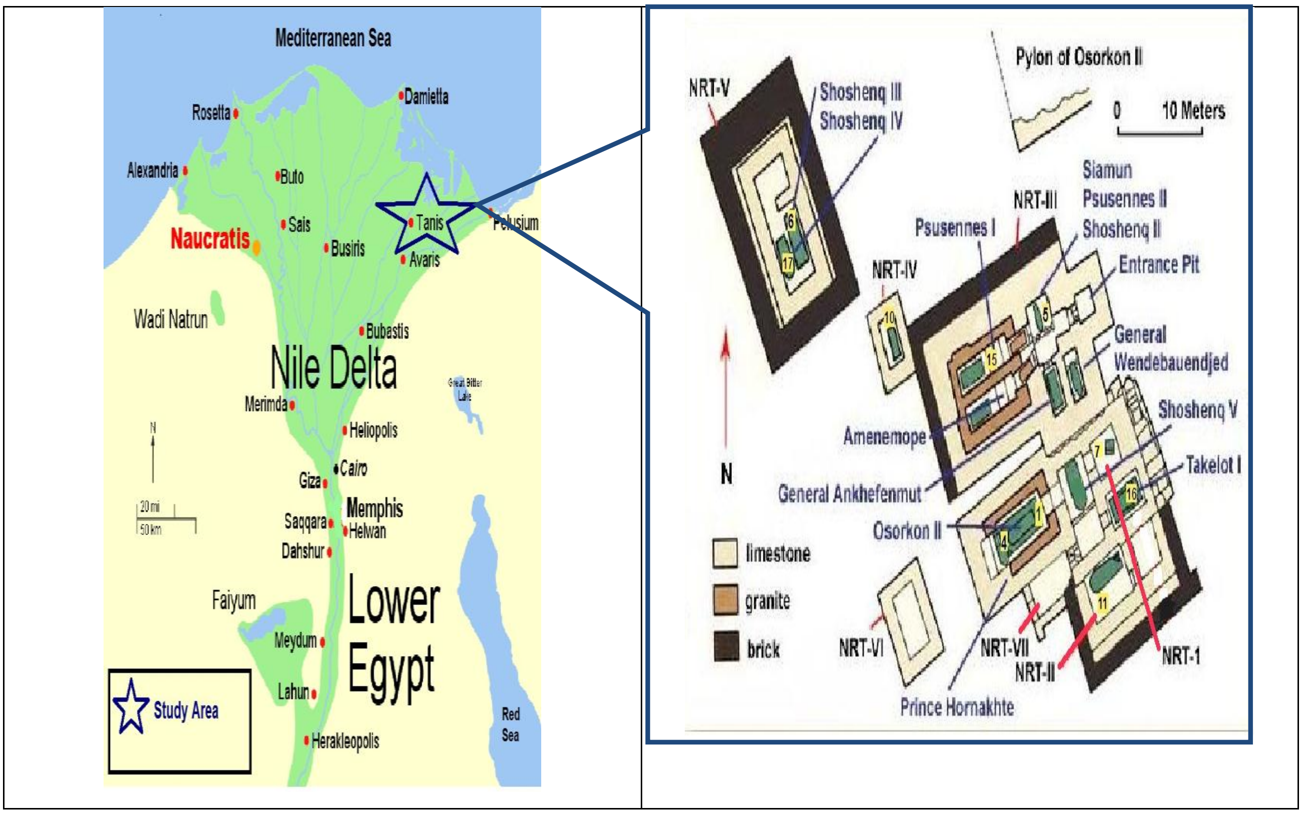

Fig. 1 A simple map showing the location of Tanis in Egypt and the studied area in Tanis

Table 3 Radium equivalent, external and internal hazard indices and Alpha index of soil samples.

Sample Code	Radium Equivalent (Bq/Kg)	External hazard Index (H_{ex})	Internal hazard index (H_{in})	Alpha index (I_{α})
MN1	22.82 ± 8.57	0.06 ± 0.02	0.08 ± 0.03	0.03 ± 0.02
PN1	19.48 ± 5.72	0.05 ± 0.02	0.07 ± 0.02	0.04 ± 0.01
ND1	16.56 ± 4.03	0.05 ± 0.01	0.06 ± 0.02	0.04 ± 0.01
NT1	13.45 ± 3.32	0.04 ± 0.01	0.05 ± 0.01	0.02 ± 0.01
NT2	14.06 ± 3.68	0.04 ± 0.01	0.05 ± 0.01	0.03 ± 0.01
NT3	16.64 ± 8.18	0.05 ± 0.02	0.06 ± 0.03	0.04 ± 0.02
OET1	8.98 ± 1.77	0.02 ± 0.01	0.04 ± 0.01	0.02 ± 0.01
OWT1	22.12 ± 9.36	0.06 ± 0.03	0.07 ± 0.03	0.02 ± 0.01
ST1	13.17 ± 3.16	0.04 ± 0.01	0.05 ± 0.01	0.03 ± 0.01
ST2	15.16 ± 3.22	0.04 ± 0.01	0.06 ± 0.01	0.03 ± 0.01
ST3	11.09 ± 1.57	0.03 ± 0.01	0.04 ± 0.01	0.02 ± 0.01
PT1	16.79 ± 4.38	0.05 ± 0.01	0.06 ± 0.02	0.03 ± 0.01
TT1	25.68 ± 6.89	0.07 ± 0.02	0.09 ± 0.02	0.03 ± 0.01
SL1	20.39 ± 4.61	0.06 ± 0.01	0.08 ± 0.02	0.05 ± 0.01
THH1	15.35 ± 3.36	0.04 ± 0.01	0.06 ± 0.01	0.04 ± 0.01
TH1	16.38 ± 4.57	0.04 ± 0.01	0.06 ± 0.02	0.03 ± 0.01
EAT1	17.38 ± 2.84	0.05 ± 0.01	0.06 ± 0.01	0.03 ± 0.01
WAT1	15.83 ± 1.10	0.04 ± 0.01	0.06 ± 0.01	0.03 ± 0.01
ET1	18.54 ± 5.82	0.05 ± 0.02	0.06± 0.02	0.03 ± 0.01
MT1	15.64 ± 5.36	0.04 ± 0.01	0.06 ± 0.02	0.03 ± 0.01

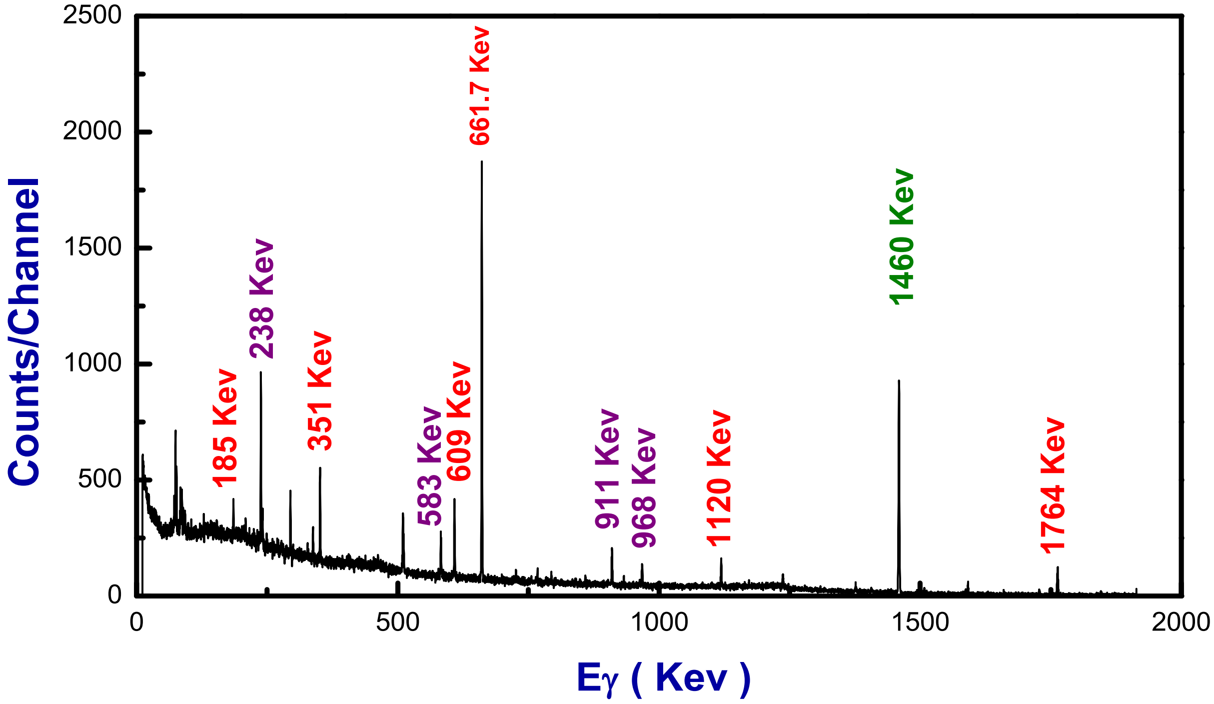

Fig. 2 **Typical γ-ray lines spectrum of natural radionuclide's maintained in soil sample**

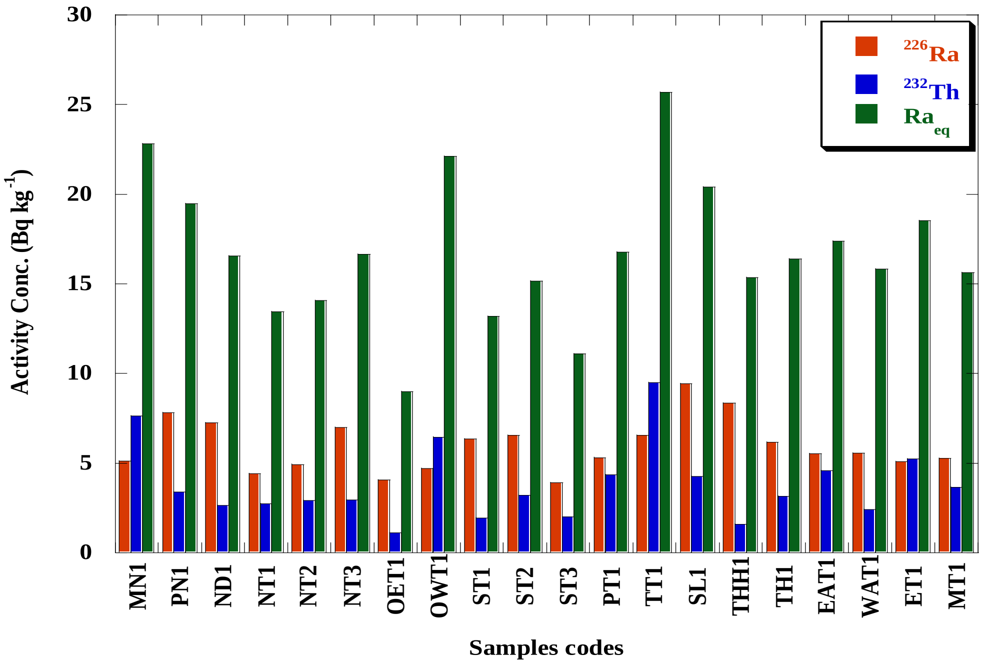

Fig. 3 The concentrations of natural radionuclides of ^{226}Ra, ^{232}Th, and Ra$_{eq}$ in studied soil samples

Table 4 Gamma index (I_γ), absorbed and annual effectives doses of studied soil samples and the actual radiation dose in the architecture site.

Samples Codes	Gamma index (Iγ)	Absorbed dose (nGy/h)	Annual effective dose (μSv/y)	radiation dose in-situ (μSv/h)
MN1	0.09 ± 0.030	10.79 ± 3.90	13.23 ± 4.7835	0.53 ± 0.13
PN1	0.07 ± 0.02	9.42 ± 2.59	11.55 ± 3.18	0.67 ± 0.13
ND1	0.06 ± 0.02	8.00 ± 1.88	9.81 ± 2.31	0.70 ± 0.14
NT1	0.05 ± 0.01	6.53 ± 1.51	8.01 ± 1.86	0.42 ± 0.14
NT2	0.05 ± 0.01	6.79 ± 1.67	8.33 ± 2.05	0.40 ± 0.15
NT3	0.06 ± 0.03	8.01 ± 3.72	9.83 ± 4.56	0.80 ± 0.15
OET1	0.03 ± 0.01	4.38 ± 0.81	5.37 ± 0.99	0.38 ± 0.14
OWT1	0.08 ± 0.03	10.63 ± 4.24	13.04 ± 5.20	0.36 ± 0.15
ST1	0.05 ± 0.01	6.33 ± 1.45	7.76 ± 1.78	0.51 ± 0.13
ST2	0.06 ± 0.01	7.20 ± 1.48	8.83 ± 1.81	0.56 ± 0.13
ST3	0.04 ± 0.01	5.40 ± 0.73	6.62 ± 0.89	0.43 ± 0.14
PT1	0.06 ± 0.02	8.01 ± 2.03	9.83 ± 2.48	0.52 ± 0.13
TT1	0.09 ± 0.03	11.93 ± 3.15	14.63 ± 3.86	0.54 ± 0.14
SL1	0.07 ± 0.02	9.64 ± 2.10	11.82 ± 2.57	0.42 ± 0.13
THH1	0.06 ± 0.01	7.41 ± 1.54	9.08 ± 1.89	0.30 ± 0.12
TH1	0.06 ± 0.02	7.91 ± 2.0894	9.69 ± 2.56	0.33 ±0.13
EAT1	0.06 ± 0.01	8.28 ± 1.32	10.15 ± 1.62	0.40 ± 0.14
WAT1	0.06 ± 0.01	7.78 ± 0.49	9.54 ± 0.60	0.38 ± 0.15
ET1	0.07 ± 0.02	8.84 ± 2.65	10.85 ± 3.25	0.44 ± 0.14
MT1	0.06 ± 0.02	7.49 ± 2.44	*9.19 ± 2.99*	0.49 ± 0.15

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