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Evaluation of Natural Radioactivity Levels and Transfer Factor of Soil and Plant, Siwa Oasis, Egypt

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Abstract

Purpose: The study sought to evaluate natural radioactivity levels and transfer factor of soil and plant, Siwa Oasis in Egypt.

Methodology: In this work, 23 plant samples and 23 soil samples were collected directly from the central and western parts of Siwa oasis for radioactivity analysis. Global Positioning System device (eTrex, Personal Navigator, Garmin Ltd) was used to define the latitudes and longitudes of sampling points. Each plant sample was dried, grind into fine powder and weighed. The activity concentrations of ^{238}U (^{226}Ra) series and ^{232}Th series and ^{40}K in water samples were measured at Egyptian Nuclear and Radiological Regularity Authority (ENRRA).

Results: For plant samples, the maximum activity values of ^{226}Ra (^{238}U) series and ^{232}Th were 35 Bq/kg and 27 Bq/kg, respectively. Most values of activity concentrations of ^{226}Ra (^{238}U) series and ^{232}Th series were under the detection limits (0.7 and 0.6) Bq/kg, respectively. For ^{40}K the activity concentration ranges from 338 to 2102 Bq/kg in the plant samples. For soil samples, the activity concentrations were ranges from <0.7 to 104 Bq/kg, from < 0.6 to 67 Bq/kg, and from 82 to 1969 Bq/kg for ^{226}Ra (^{238}U) series, ^{232}Th series, and ^{40}K, respectively. The total absorbed dose rate in air ranged from 10 to 171nGy/h. The external hazard index was ranged from 0.07 to 0.95, and the annual effective dose ranged from 0.01 to 0.06. The highest value of transfer factors in case of uranium and thorium were 1.41 and 0.40, respectively. While for ^{40}K the highest value of transfer factor was 36.4 and the mean value was equal 7.19.

Unique contribution to theory, practice and policy: Since plant uptake from soil was probably influenced by various factors such as soil characteristics, amount and physico-chemical form of radionuclides in soil, plant species, temperature, rainfall, and agricultural management, these parameters should be further investigated in the future. The results obtained from this study can be considered as baseline data for TFs of natural radionuclides from soil to plants and also serve as a guideline for future monitoring and assessment of naturally occurring radioactive material in Siwa Oasis.

Keywords: *Transfer Factor, Environmental Radioactivity, Radiological Hazards, Siwa Oasis, Egypt*

INTRODUCTION

Natural radionuclides in the environment are classified into cosmogenic and primordial ones. Cosmogenic radionuclides such as ^{22}Na, ^{7}Be,^{14}C, ^{3}H, and ^{24}Nado not contribute significantly in the external gamma radiation dose at ground levels. Primordial radionuclides include ^{87}Rb, ^{40}K and the elements of the three radioactive series headed ^{238}U, ^{235}U, and ^{232}Thbelong to this group as well. As a matter of fact, the radionuclides present in the ^{235}U decay series contribute very little environmental radioactivity by (Renoux, A. 1987). ^{3}H has natural and manmade sources in the environment. The naturally occurring radionuclides present in soil include ^{238}U, ^{235}U and ^{232}Th (Khan, K. et al., 1998).

Gamma radiation emitted from those naturally occurring radioisotopes, represents the main source of irradiation of the human body and contribute to the total absorbed dose via ingestion, inhalation and external irradiation (Steinhausler, F., 1992). Calculations by (Beck, H.L., 1972) suggested that 50-80 % of the total gamma flux at the earth surface arises from ^{232}Th, ^{238}U and ^{40}K series in the topsoil. Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological and geographical conditions and appears at different levels in the soils each region in the world (UNSCEAR, 2000). Since these radionuclides are not uniformly distributed, the knowledge of their distribution in soils play an important role in radiation protection and measurement (Khan, H.M.et al., 1994). Also, the radioactivity of soils is essential for understanding changes in the natural background (Sroor, A. et al., 2001 and Chiozzi, P. et al., 2002).

Generally Radioactive isotopes concentration in soil is an indicator of radioactive accumulation in the environment, which affects humans, plants and animals (El-Khatib, A.M., et al., 1988). Radionuclides in soils are usually transferred to different plant tissues by direct transfer via the root system, as well as radionuclide fallout and resuspension of contaminated soil followed by deposition on plant leaves (Naim M. A. et. al., 1999).

The goal of the present work is to investigate the transfer factor, concentration of natural radionuclides in soil and plants; The annual effective dose and the gamma activity concentration indexes will be evaluated and compared to the average worldwide exposure limits represented in (UNSCEAR 2000) and to the dose criteria recommended European Commission (EC, 1999), respectively (Steinhausler, F., 1992and Beck, H.L., 1972). In addition, the correlations between activity concentration of ^{232}Th, ^{238}U and ^{40}K will be shown in this paper with an aim to correlate the petrographic characteristics of soil with their corresponding dose rates for natural radioactivity (UNSCEAR, 2000).

Site Description

Siwa Oasis (29.12° N, 25.43° E) is an Egyptian oasis, located between the Qattara depression and the Egyptian sand sea (the Western Desert of Egypt), approximately 330 km from Matrouh city situated in the northern Mediterranean coastal zone, nearly 50 km east of the Libyan border, and 560 km from Cairo (Fig. 1)(El-Sayed, S.A.et al., 2017).The climate of Siwa is primarily arid characterized by hot-dry summer and cold winter. The average annual high and low air temperatures, precipitation and relative humidity are 29.32 ^{o}C and 14.12 ^{o}C, 10 mm and 45.3%, respectively (Climate Charts,

2013). The evaporation rate attains about 5.4 mm/day in winter and 16.8 mm/day in summer (Abdel-Mogheeth, 1996).

Land Use

The main land use patterns those could be found in the Oasis are Agriculture, Tourism, Industry and of course Housing, the main land uses found in the Oasis with significant impact on water Demand. It is mainly about the balance between the different land uses that could help avoiding an unwanted environmental degradation of the Oasis.

Agriculture

It is considered as the main economic activity within the oasis. The irrigation water comes mainly from springs. The texture class of the cultivated soil was either loam or sandy loam. The unused saline water of naturally flowing springs and the agricultural drainage water are poured into four main lakes, namely; Siwa, Aghormy, Zeiton and Khamisa. Moreover, the migration of sand dunes from the southern and western directions seriously threaten the agricultural activities, irrigation & drainage constructions, transportation and communications as well as other aspects of socio-economic development in the oasis**.** The main crops in the oasis are dates and olives. Everything else cultivated in the oasis is for local consumption. Other fruits found in abundance are excellent red grapes, figs, apricots, sweet lemons, bitter oranges, limes and pomegranate. For vegetables the following could be also found: Okra, Eggplant, pumpkin, tomato, cress, onion, broad beans, garlic, mint, radish and pepper. Garlic is held in great esteem as a preventive of sickness

Tourism

Siwa oasis commands a great historic interest due to the presence of Romanic monuments such as the temple of Alexander the Great and mountain of the Dead (Gabal El-Mawta). It was a center for Roman civilization, which makes it an attractive tourist site. The Temple of Jupiter Ammon is also about one and a half miles east of Siwa. There is also Shali, which is the old City and means in local language the elevated city.

Industries

The main industry that used to be there in Siwa is the Drying food industry. There are 3 old factories and 5 new ones using more developed techniques. It is the major industry as it depends on dates as the major product of the oasis. Water Bottling is another recent industry in the area Traditional Handcrafts is the main source for preserving the cultural heritage of Siwian handcrafts which attracts tourist and visitor to it (Salheen, M. A., 2013).

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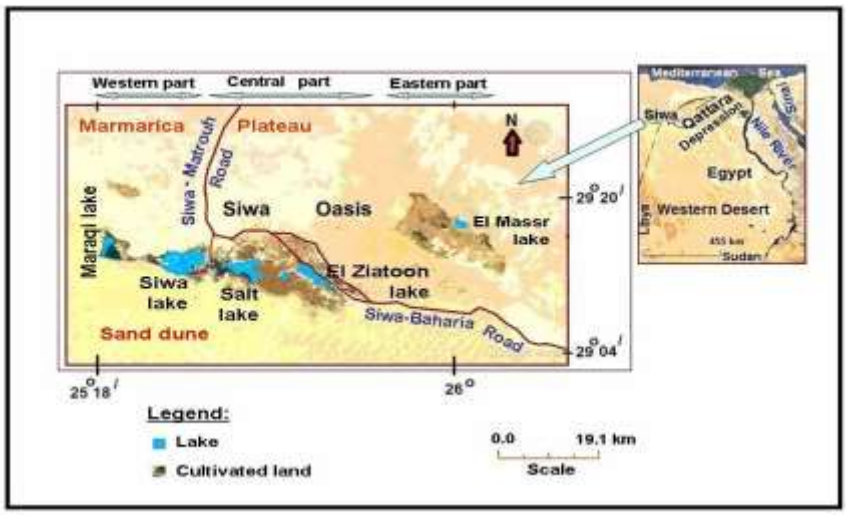

Figure 1: Location map of Siwa oasis, Western Desert, Egypt (El-Sayed, S.A.et al., 2017)

MATERIALS AND METHODS

Sample collection and preparation

In this work, 23 plant samples and 23 soil samples were collected directly from the central and western parts of Siwa oasis for radioactivity analysis. Global Positioning System device (eTrex, Personal Navigator, Garmin Ltd) was used to define the latitudes and longitudes of sampling points. Sampling sites are shown in Figure (2)**.** Each plant sample was dried, grind into fine powder and weighed. The soil and plant samples were then sieved using a fine-aperture mesh (2 mm mesh size) to remove extraneous items, to obtain a fine-grained sample that would present a uniform matrix to the detector. Then the samples were weighed and packed in cylindrical-type container (100 ml capacities) to be analyzed using gamma spectrometers. Samples were carefully sealed and stored for more than 4 weeks for secular equilibrium. The samples were analyzed in the geometries used during the procedure of efficiency determination.

Calibration and measurements by gamma ray Spectrometry

The activity concentrations of ^{238}U (^{226}Ra) series and ^{232}Th series and ^{40}K in water samples were measured at Egyptian Nuclear and Radiological Regularity Authority (ENRRA). The gamma ray spectra of the prepared samples were measured for at least 82,000 sec. using a typical high-resolution gamma spectrometer based on a coaxial type shielded HpGe detector, with a relative photo peak efficiency of 35% and energy resolution of 1.9 keV full widths at half maximum for the 1332 keV gamma ray line of ^{60}Co. The spectrum was collected and analyzed using computer software called Genie 2000 software made by Canberra Industries Inc, USA.

The activity of ^{40}K was measured directly via its 1461 (10.7%) keV peak of the gamma ray spectra. To determine the activity concentration of ^{226}Ra, the average value of gamma ray lines 295.1 (19.2%) and 351.9 (37.1%) keV from ^{214}Pb to 609.3 (46.1%) and 1764.5 (15.9%) keV gamma rays from ^{214}Bi are used. Activity concentration of ^{232}Th is determined using the average value of gamma ray lines238.6 (43.6%) keV from ^{212}Pb, 338.4 (12%), 911.1 (29%) and 968.9 (17.4%) keV from ^{228}Ac, 583.1 (86%) and

2614 keV from ^{208}Tl. The efficiency of detector had calibrated by using ^{226}Ra point source, that to produce a relative efficiency curve followed by standardization using KCl as a standard solution (Farouk and Al Soraya, 1980). Quality control and quality assurance of the measurements using International Atomic Energy Agency (IAEA) reference materials (Soil 6, IAEA no.326). In addition, duplicate samples were added to insure the analyses consistency of the measurements. Blank samples were added to eliminate the cross-contamination occurrence in the samples.

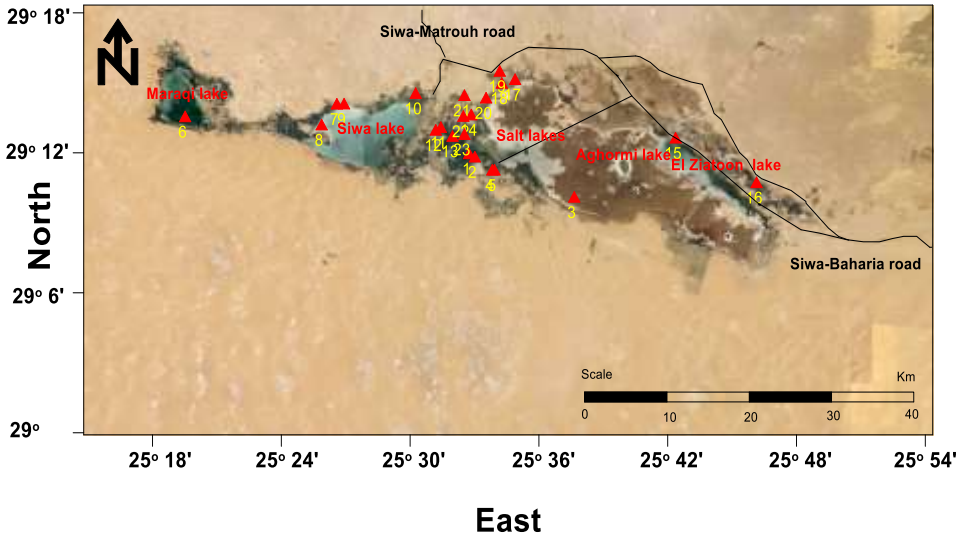

Figure 2: Sampling location map, Siwa Oasis, Egypt. El-Sayed, S.A.et al., 2017

All measurements undertaken have to be underpinned by accurate calibration techniques with traceability to international standards. Quality Assurance and Quality Control programs in radionuclide measurements deal with primary reference materials, standards, techniques and systems, secondary standards and systems, validation and demonstration of equivalence for measurement standards, infra structures for environmental monitoring, nuclear data for applications of ionizing radiation and last but not least, the transfer of knowledge (Spasic, V. 1982 and Spasic-Jokic, V. et al., 2002).

RESULTS AND DISCUSSION

Determination of Activity concentration:

The activity concentrations were calculated using the formula below by (Noordin**,** I., 1999):

$$A = \frac{N}{P_\gamma \times \varepsilon \times W} (Bq\ kg^{-1}) \qquad (1)$$

Where,

N = Net counts per second (C.P.S) = (Sample C.P.S – background C.P.S)

Pγ= Intensity of the radionuclide

ε= Efficiency in %

W = Weight of sample in kilograms

The activities of the parent ^{232}Th nucleus of the thorium decay series and the head of the uranium decay series, ^{226}Ra, were determined by assuming that they were in radioactive equilibrium with their daughter products ^{212}Pb and ^{214}Pb, respectively (Harb, S. 2007). Standard characteristic values of P_γ were used in the present study, (IAEA. 1989).

Table (1) shows the activity concentration of natural radionuclides in plants samples of ^{226} Ra, ^{232} Th and ^{40} K in soil sample, their average value, from different location in siwa oasis, the maximum activity values of ^{238}U was 35Bq/kg in the sample number (4) (Woven). While for ^{232}Th the maximum level was observed in sample number (4) (Woven) 27Bq/kg. But the most value of activity concentration of ^{226}Ra (^{238}U) series and ^{232}Th series were under the detection limit of HPGe detector (0.7 and 0.6) Bq/kg respectively. The value of ^{40}K ranged from 338Bq/kg in the sample number (12) (Grass) to 2102 Bq/kg in the sample number (16) (Olive). Only seven samples show concentrations of ^{40}K above the value of 1000 Bq/kg. Density was taken in consideration for calculating the activity; (Noordijk, K. E. H. et al. 1992).

It is obvious that the activity concentration of ^{40}K was the highest among other radionuclide in all plant sample, followed by ^{226}Ra, and ^{232}Th exhibit the lowest activity concentration. Plant absorb radionuclide from soil in different amount, according to their metabolism. It is also due to the levels of radionuclide in soil where the plant is collected, might vary geographically from one place to another. The high level of potassium due to the use of potassium containing fertilizer to improve crop yields (Eman Al -Absi, et al. 2015). In addition, the concentration of potassium is expected to be higher, as its half -life is longer compared to another radionuclide.

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Table 1: Activity concentration of plants in Bq.kg−1

Sample no.	Lat.	Long.	Plant type	Activity concentration (Bq.kg−1)		
	◦ ″ ′	◦ ″ ′		^{238}U	^{232}Th	^{40}K
1	29 11 275	25 33 831	Grass	‹‹D.L.*	‹‹D.L.*	441.53±23.08
2	29 11 679	25 02 096	Grass	‹‹D.L.	‹‹D.L.	1530.8±48.90
3	29 13 021	25 25 878	Grass	‹‹D.L.	‹‹D.L.	1229.38±42.2
4	29 12 259	25 32 153	Woven	35.09±9.17	27.21±6.57	543.29±41.06
5	29 11 275	25 33 831	Grass	12.59±4.06	‹‹D.L.	521.09±21.92
6	29 11 275	25 33 831	Grass	‹‹D.L.	‹‹D.L.	778.24±33.88
7	29 11 679	25 02 096	Alfalfa	‹‹D.L.	‹‹D.L.	667.83±29.48
8	29 14 104	25 26 588	Woven	‹‹D.L.	‹‹D.L.	914.06±34.33
9	29 13 021	25 25 878	Woven	‹‹D.L.	‹‹D.L.	407.93±21.73
10	29 14 107	25 26 924	Fig tree	‹‹D.L.	‹‹D.L.	450.85±26.63
11	29 14 056	25 30 260	Fig tree	‹‹D.L.	‹‹D.L.	638.9±28.670
12	29 13 100	25 31 434	Grass	‹‹D.L.	‹‹D.L.	338.0±23.010
13	29 12 984	25 31 195	Grass	8.64±3.93	‹‹D.L.	426.78±22.39
14	29 12 720	25 31 975	Mulberry	‹‹D.L.	11.77±4.93	694.93±30.46
15	29 13 064	25 32 849	Olive	‹‹D.L.	‹‹D.L.	573.91±32.57
16	29 12 647	25 42 368	Olive	‹‹D.L.	‹‹D.L.	2102.06±49.3
17	29 10 736	25 46 140	Woven	‹‹D.L.	‹‹D.L.	1032.3±39.20
18	29 15 156	25 34 891	Olive	‹‹D.L.	‹‹D.L.	1136.0±38.00
19	29 14 998	25 34 027	Olive	‹‹D.L.	‹‹D.L.	160.06±26.20
20	29 15 510	25 34 175	Leaf plant	‹‹D.L.	‹‹D.L.	145.33±27.39
21	29 14 364	25 33 539	Grass	‹‹D.L.	‹‹D.L.	1703.38±46.4
22	29 14 047	25 32 530	Woven	‹‹D.L.	‹‹D.L.	1316.3±45.30
23	29 13 577	25 32 048	Henna	10.9±3.57	9.84±4.93	689.67±30.46

(*) Within the low limit of detection.

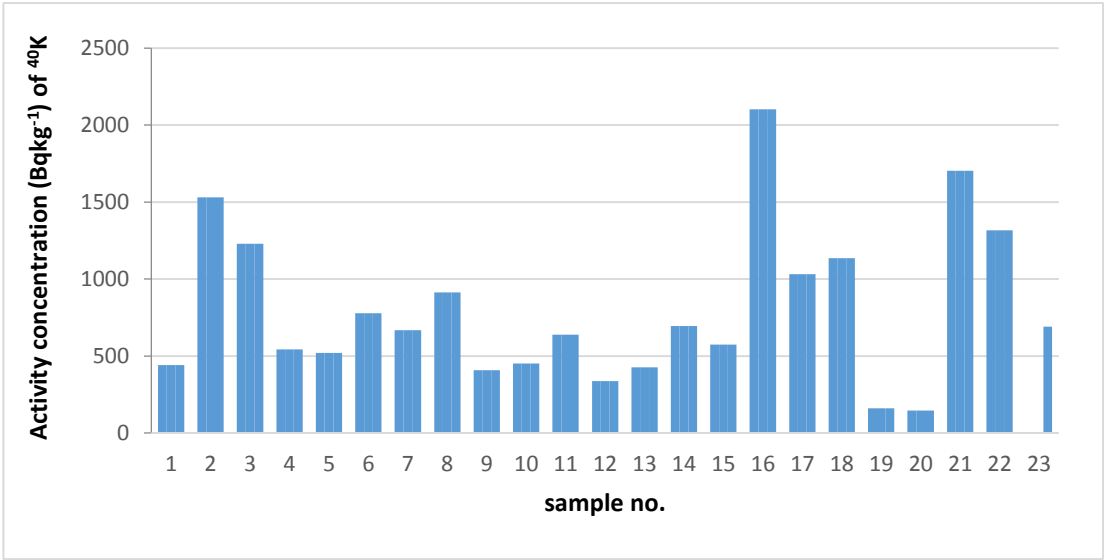

Figure 3: Activity concentration (Bqkg^{-1}) of ^{40}K in plant samples

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Table 2: Activity concentration of soil in Bq.kg^{-1}

Sample no.	Lat.	Long.	Activity concentration ± total error in Bq.kg−1		
	° ′″	° ′″	238U	232Th	40K
1	29 11 275	25 33 831	61.98±2.88	11.77±1.92	250.30±9.97
2	29 11 679	25 02 096	48.64±3.01	11.94±2.07	298.19±12.56
3	29 13 021	25 25 878	8.48±1.49	5.27±0.98	100.25±6.71
4	29 14 107	25 26 924	104.55±16.1	67.83±13.9	1969.36±80.7
5	29 14 056	25 30 260	24.46±2.51	7.46±1.89	230.01±9.83
6	29 13 100	25 31 434	28.25±2.28	6.30±1.57	167.87±8.34
7	29 12 984	25 31 195	18.15±1.05	5.51±1.07	210.6±5.43
8	29 12 720	25 31 975	15.08±1.21	7.41±1.00	93.58±4.20
9	29 13 064	25 32 849	25.67±1.47	9.74±1.21	154.45±5.03
10	29 12 647	25 42 368	17.78±1.71	12.78±1.25	291.65±7.03
11	29 10 736	25 46 140	22.48±1.61	5.86±1.06	113.15±5.57
12	29 15 156	25 34 891	29.15±1.83	11.26±1.55	165.9±9.52
13	29 14 998	25 34 027	7.56±1.47	7.14±1.01	113.79±7.39
14	29 15 510	25 34 175	34.90±2.05	10.64±1.82	255.44±7.60
15	29 14 364	25 33 539	46.15±1.81	9.87±1.40	85.31±4.83
16	29 14 047	25 32 530	17.77±1.27	7.67±1.07	122.72±5.03
17	29 13 577	25 32 048	8.87±1.52	7.11±0.84	118.66±6.92
18	29 12 008	25 32 053	30.85±2.32	6.57±1.61	208.42±9.13
19	29 11 367	25 32 257	15.56±2.40	7.21±1.96	264.46±9.79
20	29 11 345	25 33 040	10.92±1.70	3.84±1.15	87.76±5.91
21	29 11 645	25 33 325	18.73±1.81	6.78±1.96	82.85±6.02
22	29 11 749	25 33 015	14.51±1.81	‹‹D.L.	125.13±6.58
23	29 12 259	25 32 153	73.30±3.19	18.38±2.55	179.03±9.77

The distribution of natural radionuclides in soil samples is presented in Table (2), the Soil texture of all samples is Sandy clay loam, the activity concentrations of ^{238}U ranged from (< 0.7 to 104Bq/kg), ^{232}Th from < 0.6 to 67Bq/kg and 40K from (82 to 1969Bq/kg). The maximum activity value of ^{238}U was 104 Bq/kg in the sample number (4) and the minimum value was 8.48Bq/kg in the sample number (3). While for ^{232}Th the maximum level was observed 67 Bq/kg in samples number (4) and the minimum level < 0.6 Bq/kg in sample number (22). The value of ^{40}K ranged from 82 Bq/kg in the sample number (21) to 1969 Bq/kg in the sample number (4). The activity concentration of radionuclide in soil shows variation as it depends on the soil type, formation and transport characteristics, rainfall levels at sampling locations area, and geological properties of the location (IAEA, 2006 - Umar, A.M. et al. 2012).

Transfer factors

The transfer factor (TF) values are calculated and presented in Table (3), the spatial distribution of radionuclide in soil samples were shown in Figure number (4), according to the equation below, (International Union of Radio Ecologists. 1994).

$$TF = \frac{\text{Activity of radionuclides in plant weight (Bq/Kg dry weight)}}{\text{Activity of radionuclides in soil weight (Bq/Kg dry weight)}} \quad (2)$$

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Soil properties that affect uptake may include mineralogical and granulometric composition, organic matter content, PH and fertility, (Kuhn, W., Handl, J. & Schuller, P. 1984).

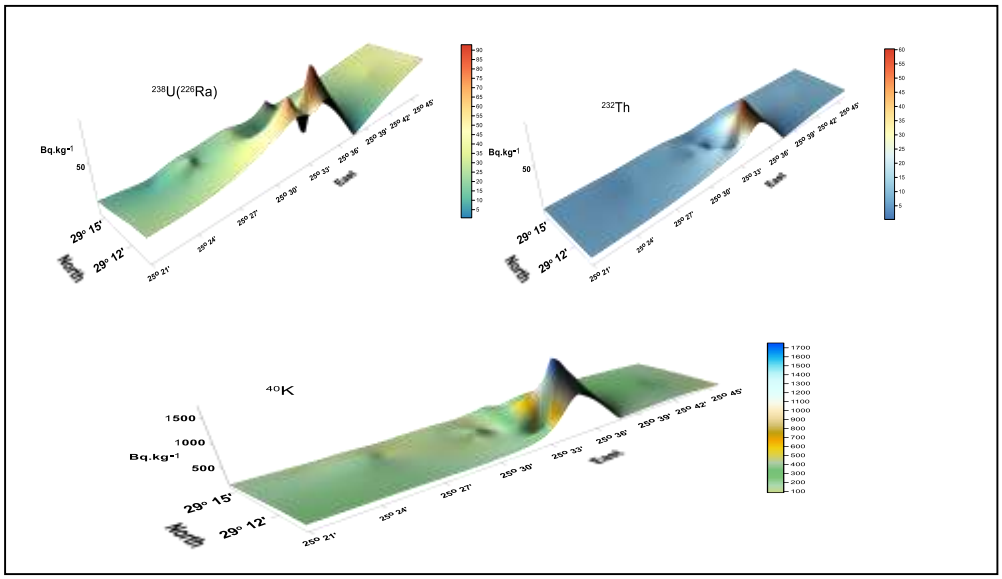

Figure 4: Patterns of ^{226}Ra, ^{232}Th and ^{40}K distributions in soil samples.

Table 3: Transfer factor (TF) of^{226}Ra, ^{232}Th, and^{40}K

Sample no	TF (^{238}U)	TF (^{232}Th)	TF (^{40}K)
1	0	0	1.76
2	0	0	5.13
3	0	0	12.26
4	0.34	0.40	0.28
5	0.51	0	2.27
6	0	0	4.64
7	0	0	7.14
8	0	0	5.92
9	0	0	1.40
10	0	0	5.65
11	0	0	2.04
12	1.14	0	3.75
13	0	0	2.25
14	0	0	36.36
15	0	0	8.41
16	0	0	9.57
17	0	0	0.77
18	0	0	0.55
19	0	0	19.41
20	0	0	15.89
21	0.75	0	5.51
Average			**7.19**

Transfer factors from soil to plants were experimentally estimated. Among the different outcomes; the values of transfer factor for the uranium, thorium and potassium were poles apart to each other. The highest value of TF in case of uranium and thorium was 1.41 and 0.40 respectively. Whereas for potassium the highest values of transfer factor were 36.4 and mean value was equal 7.19.

The result predicted that for all areas, potassium has highest TF. This was due to the fact that potassium is an important element to fertile of the plants. Even though potassium is the radioactive element but it does not harm in aquatic system. Potassium is important to grow plant to adapt the environmental stresses. Therefore, as compare to the uranium and thorium, the potassium had the highest number of transfer factor. The higher transfer factor of potassium at that time was not at-risk streak because that value was not at staid position to harm the body.

Transfer factors are shown to be extremely variable depending on vegetation type, various soil parameter and environmental factors. Also, different parts of the plant and the observed small variations in these values were attributed to the difference in physical and chemical properties of soils along the studied area (transfer factors are low on soils with a high clay content (Lembrechts, J.F. et al. 1989).

Radium equivalent activity (Ra_{eq})

The distribution of natural radionuclides in the samples under investigation is not uniform. Therefore, a common radiological index has been used to evaluate the actual activity level ^{226}Ra, ^{232}Th and ^{40}K in the samples and the radiation hazards associated with these radionuclide (Beretka J, Matthew PJ, 1985).

$$Ra_{eq} = A_{Ra} + 1.43A_{Th} + 0.077\ A_k \quad (3)$$

Where: A_{Ra}, A_{Th} and A_K are the specific activities of ^{226}Ra, ^{232}Th and ^{40}K respectively in Bq/kg. In the definition of radium equivalent, it is assumed that 10 Bq/kg of ^{226}Ra, 7 Bq/kg of ^{232}Th and 130 Bq/kg 0f ^{40}K produce an equal gamma ray dose rate; *(*Krisiuk EM, et al., 1971 and Stranden E. 1976).

The values of calculated Ra_{eq} for collected soil samples are shown in Table 3. The Ra_{eq} was varied in the range of 7.72 – 353.18 Bq kg^{-1} (average = 57.18). These values are far below the allowable limit (370 $Bq.kg^{-1}$) recommended by the International Atomic Energy Agency (IAEA). (EC 1999, Beretka J, Matthew PJ, 1985 and UNSCEAR, 1993).

Dose rate estimation

If naturally occurring radioactive nuclides uniformly distributed in sample environment, dose rates, D, in units of nGy/h can calculate by the following formula: (Stranden E. 1976).

$$\text{Dose rate} = 0.40\ A_{Ra} + 0.57\ A_{Th} + 0.041\ A_k \quad (4)$$

The total absorbed dose rates calculated from the concentrations of the nuclides of the ^{238}U and ^{232}Th series, and of ^{40}K, range from 10 to 171Gy/h. for soil samples.

External hazard index

Soil is used to produce earthen huts, bricks and pottery materials; Consequently, the external radiation hazard index (H_{ex}) due to natural gamma radiation is calculated using the following formula: (Beretka and Mathew 1985).

$$H_{ex} = \left(\frac{A_{Ra}}{370 Bqkg^{-1}} + \frac{A_{Th}}{259 Bqkg^{-1}} + \frac{A_{k}}{4810 Bqkg^{-1}}\right) \leq 1 \qquad (5)$$

There is also a radiation hazard to respiratory organs due to the ^{226}Ra decay product ^{222}Rn and its short-lived decay products. To account for this hazard, the maximum permissible radium concentration must be reduced to half of the normal limit; (Beretka and Mathew 1985). It is observed from Table 3 that the mean value 0.17of H_{ex} is equal the criterion value (1).

Annual effective dose ($A_{ed.}$)

Annual estimated average effective dose equivalent received by a member was calculated using a conversion factor of 0.7 $SvGy^{-1}$, which was used to convert the absorbed rate to human effective dose equivalent with an outdoor occupancy of 20% and 80% for indoors (Krisiuk EM, et al., 1971). The annual effective dose was determined as follows:

$$\text{Annual effective dose rate} = D \times T \times F \qquad (6)$$

Where D is the calculated dose rate (in $nGyh^{-1}$), T is the outdoor occupancy time (0.2x24 h x365.25 d≈1753 hy^{-1}), and F is the conversion factor ($0.7x10^{-6}$ $SvGy^{-1}$). The experimental results of annual effective dose rate are presented in Table 3 The International Commission on Radiological Protection (ICRP) has recommended the annual effective dose equivalent limit of 1 $mSvy^{-1}$ for the individual members of the public and 20 $mSvy^{-1}$ for the radiation workers (ICRP, 1993).

Excess lifetime cancer risk (ELCR):

Excess lifetime cancer risk (ELCR) was calculated using the following equation and presented in Table 3.

$$ELCR = AEDE \times DL \times RF \qquad (7)$$

where AEDE, DL and RF is the annual effective dose equivalent, duration of life (70 years) and risk factor (Sv^{-1}), fatal cancer risk per sievert. For stochastic effects, ICRP uses values of 0.05 for the public (Ramasamy V., et al., 2011). The values were ranged from (0.05 to 0.22) × 10^{-3}, the world permissible value of ELCR is 0.29 × 10^{-3} (Taskin H, et al., 2009).

Table (3): Radium equivalent, the dose rate, hazard index, annual effective dose rate and Excess lifetime cancer risk for soil samples.

Sample No.	Ra_{eq} $Bqkg^{-1}$	D $nGyh^{-1}$	H_{ex} $nGyh^{-1}$	AEDE. $mSvy^{-1}$	ELCR $\times 10^{-3}$
1	19.27	45.89	0.26	0.06	0.20
2	22.96	41.92	0.23	0.05	0.18
3	7.72	11.25	0.07	0.01	0.05
4	353.18	171.19	0.95	0.21	0.74
5	52.84	25.31	0.14	0.03	0.11
6	50.18	23.74	0.14	0.03	0.10
7	42.25	20.45	0.11	0.03	0.09
8	32.88	15.27	0.09	0.02	0.07
9	51.49	24.06	0.14	0.03	0.10
10	58.51	28.04	0.16	0.03	0.12
11	38.34	18.03	0.10	0.02	0.08
12	58.03	27.05	0.16	0.03	0.12
13	26.53	12.52	0.07	0.02	0.05
14	69.78	33.06	0.19	0.04	0.14
15	66.83	30.59	0.18	0.04	0.13
16	38.19	17.88	0.10	0.02	0.08
17	28.17	13.30	0.08	0.02	0.06
18	56.29	26.79	0.15	0.03	0.12
19	46.23	22.54	0.12	0.03	0.10
20	23.17	10.98	0.06	0.01	0.05
21	34.81	16.11	0.09	0.02	0.07
22	24.15	11.89	0.07	0.01	0.05
23	113.37	52.05	0.31	0.06	0.22
Average	**57.18**	**30.43**	**0.17**	**0.04**	**0.12**

CONCLUSION

From this study, the specific activity was measured; and radium equivalent, dose rate, hazard index, annual effective dose equivalent and excess lifetime cancer risk has been calculated to assess the radiological hazards from the soil and plant samples. Our results showed that the average calculation of radium equivalent activity (Ra_{eq}) values are

lower than the recommended levels of 370 Bqkg^{-1}, and the external (H_{ex}) hazard indices were less than the unity.

Also, they showed that the soil and plants samples do not pose any significant radiation hazard. Therefore, there is no immediate radiation health hazard associated with using these samples from the study area.

The distribution of natural radionuclides in soil and plant is valuable information therefore we will carry out this study with various types of plant. Since plant uptake from soil was probably influenced by various factors such as soil characteristics, amount and physico-chemical form of radionuclides in soil, plant species, temperature, rainfall, and agricultural management, these parameters should be further investigated in the future. The results obtained from this study can be considered as baseline data for TFs of natural radionuclides from soil to plants and also serve as a guideline for future monitoring and assessment of naturally occurring radioactive material in Siwa Oasis.

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