NATURAL RADIOACTIVITY LEVELS IN ENVIRONMENTAL SAMPLES IN NORTH WESTERN DESERT OF EGYPT

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ABSTRACT

Soil and sediment samples were collected from North western desert of Egypt. Gamma spectroscopy was used to determine the concentration of naturally occurring radionuclides ^{238} U, ^{232} Th and ^{40} K. The hazard index due to these radionuclides has been calculated. The measurement results obtained from this study indicate that the region has background radioactivity levels within natural limits.

Keywords*: *Natural radioactivity, Gamma spectroscopy.

INTRODUCTION

A comprehensive study was conducted to determine Thorium, uranium and potassium in element concentrations in surface soils and sediments through out the north western coast in Egypt (El Dabaa area). This study aimed to establish a baseline map of radioactivity background levels in surrounding environment. This map will be used as reference information to assess any change in the radiological background levels due to any artificial effects of radiation measurements.

The natural radioactivity is wide spread in earth's environment and its exists in various geological formation soil, rocks, plants, water and air (1, 2.,3,4,5,6).

The radiological implication of these radionuclides due to the international exposure originating from radionuclides in diet and from inhaled radon gas and external exposure generated by cosmic ray and γ-rays emitted by radioactive element. Therefore, the assessment of gamma radiation dose from natural sources in of particular importance as natural radiation is the largest contributor to external dose of the world population (7).

In order estimate the possible radiological hazards to human health, considerable attention has been paid in the last two decades to low level exposure arising from members of uranium and thorium decay chains and by potassium-40 soils.

Sample collection and preparation

In this paper, fifty representative soil and marine sediment samples have been collected form different localities in area under investigation. Fig. (1) shows location map of El Dabaa site. Samples were collected at the angle of an equilateral triangle approximately two meter long and forth sample was collected at the middle of the

selected triangle, four samples were mixed thoroughly in order to obtain a representative sample. Soil and marine samples wee dried in oven at temperature between 90-105 ^{O}C and sieved in 1mm mesh sieve.

The samples were stored in 1 liter Marinelli beaker for a period of time not less than 28 days for secular equilibrium of naturally radioactive decay series.

Sample counting

Marinelli beaker 1 L were placed to high purity germanium (HPGe) detector with efficiency 30 % and measured for accounting time 18 h.

The system was calibrated for energy calibration by using sources from Cs-137, Co-60, Ba-133 with energy line 661.67 KeV for Cs-137, 1173.21, 1332 KeV for Co-60 and 356, 305, 384, 276, 81 Kev for Ba-133. For efficiency calibration, Ra-226 point sources in two geometry (Top and side) was used to give broad spectrum (186 KeV up to 2.450 MeV). Then relative efficiency normalizing by K-40 (8).

To determine specific activity concentration of Ra-226 (of the U-238) The γ-ray lines 295.21, 351.9 KeV (Pb-214), 609.3, 1120 and 1764.1 KeV of Bi-214 were used. To determine the specific activity concentration of the Th-232, the γ-lines 238.63 KeV (Pb-212), 338.4 KeV (Ac-228), 583.1 KeV (Tl-208), 911, 969.11 KeV (Ac-228) were used. The environmental γ-ray background of the laboratory site was determined using an empty Marinelli beaker under identical measured conditions. Background subtract from the measured γ-ray spectrum of each samples.

Results and discussion

The results for the activity concentration of natural radionuclides ^{226}Ra, ^{232}Th and ^{40}K in soil and marine samples of different locations of El Dabaa area are reported in Tables (1,2)

The radioactivity levels of Ra-226 (U-238) for soil samples, as shown in table (1), ranged from 14.82 Bq/kg to 26.56 Bq/kg with mean average value 22.12 Bq/kg meanwhile in Th-232 the highest value was 20.99 Bq/kg and the lowest value was 3.91 Bq/kg with average value10.27 Bq/kg, for K-40 the activity ranged from 382.98 Bq/kg to 58.02 Bq/kg with average value 180.04 Bq/kg. By comparing the activity concentration for soil samples with those in different locations in world as illustrate in table (3), its clarify that, the activity levels for Ra-226, Th-232 and K-40 for concerning area is lower than activity levels in other countries. Fig. (2) shows comparison between Ra-226, Th-232 and K-40 for soil samples in different locations in El Dabaa area

In case of marine sediment, the concentration of uranium-238, Th-232 and K-40 in table (2) shows variations in activities, which range from 9.80 Bq/kg to 2.34 Bq/kg for Uranium-238 with average range 5.47Bq/kg and range from 2.13 Bq/kg to 0.6 Bq/kg for Th-232 in detected samples with average 0.92 Bq/kg, as well as, K-40 which vary with range from 4.5 Bq/kg to 25 Bq/kg with average 11.43 Bq/kg. Comparison between Ra-226, Th-232 and K-40 for different marine samples in area under investigation is show in Fig.(3) .

Table (3) Comparison of average values for Ra-226, Th-232 and K-40 in soil

Radionuclide activity Bq/kg dry			Region	reference
Ra-226 (U-238)	Th-232	K		
22.12	10.01	180.04	present study	
119	146	352	Hong Kong	Yu et al, 1992
37	26	350	Ireland	MC-Aulay and Moran., 1988
32	54	794	Japan	Ching-jiang Chen et al., 1993
17	19	316	Egypt, Nile Delta	Ibrahiem et al., 1993
30	44	431	Taiwan	Yu-Ming Lin et al., 1987
38.8	41	653	Spain	Baeza et al., 1994
29.2±19.5	47.8±37.3	704±437	Brazil	Alberto et al., 1996
25	25	370	World average	UNSCEAR., 1988

The γ-radiation hazards associated with these samples were assessed according to different indices. The most widely used radiation hazard index, the radium equivalent activity.

Radium equivalent activity.

It's calculated through the following relation (9):

$$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.07C_k \quad (1)$$

Where C_{Ra}, C_{Th} and C_k are the activities concentration of Ra-226, Th-232 and K-40 in Bq/kg, respectively. The values of radium equivalent for different soil samples in area under investigated were calculated by using equation above these values presented in table (4) and values ranged from 33.58 to 85.61 Bq/kg with average value 50.71 Bq/kg which is lower than the recommended maximum value 370 Bq/kg (10)

Absorbed dose rates

The outdoor air-absorbed dose rates due to terrestrial gamma rays at 1 m above ground are calculated from ^{226} Ra, ^{232}Th and ^{40}K concentration values in soil

The conversion factors used to compute absorbed gamma dose rate (D) in air per unit activity concentration in (1 Bq/kg) in soil corresponds to 0.662 nGyh^{-1} for ^{232}Th, 0.427 nGyh^{-1} for ^{238}U, and 0.043 nGyh^{-1} for ^{40} K are given in equation below:

$$D=(0.427C_U+0.662C_{Th}+0.043C_K)\ nGyh^{-1} \quad (2)$$

Where, C_U, C_{Th} and C_K are the average concentration of ^{238}U, ^{232}Th and ^{40}K in Bq/kg, respectively. It can be observed from table (4) that the calculated total absorbed gamma dose rate due to the presence of ^{238}U, ^{232}Th and ^{40}K in soil carried between 15.53 nGyh^{-1} to 41.51 nGyh^{-1} with average range ˉ24 nGyh^{-1}. The computed mean dose rate 24 nGyh^{-1} Was found to be about 0.44 from the world average (55 nGyh^{-1}) as reported in UNSCEAR (7)

Effective dose

To estimate the annual effective dose rates, the conversion coefficient from absorbed dose in air to effective dose (0.7 Sv Gy^{-1}) and outdoor occupancy factor (0.2) proposed by (11) were used. The effective dose rate in units of Sv μyr^{-1} was calculated by the following formula:

Effective dose rate (μSv yr^{-1})=

dose rate (nGyh^{-1}) x 8760 h x 0.2 x 0.7 Sv Gy^{-1} x 10^{-3}) (3)

This calculation takes into account that the people spend 20% of their time outdoors. From table (4),the highest observed annual effective dose are 50.91 μSv and the lowest value 19.04 μSv with a mean average value 29.43 μSv this value is lower than the world-wide average annual effective dose which is approximately 70 μSv (11).

Conclusion

- These results can be considered as base line monitoring for natural background radioactivity levels, this facilitate comparative study between these results and those, which might occur after construction the nuclear power plant
- Generally, the soil and sediment samples show low levels of radioactivity for different measured radionuclides
- The 238 U, Th-232 and 40 K activity concentration for soil samples much high than those of sediment samples
- The results show that activity levels for all samples are lower than international levels.
- Activity of ^{40}K are much higher than that of ^{238}U and ^{232} Th

Table (1) Radioactivity levels of uranium238 and thorium-232, in soil samples from different area within El Dabaa

Sample code	Concentration of radionuclides in (Bq/)			
	Ra-226(U-238)	Th-232	K-40	Cs-137
S.1	25.23±2.11	6.88±0.9	81.70±2.1	1.23±0.1
S.2	26.11±1.18	20.99±1.1	382.98±3.0	< DL*
S.3	24.18±2.20	14.59±1.2	252.72±2.5	3.44±0.1
S.4	23.57±2.17	12.00±1.2	180.77±2.1	2.37±
S.5	23.18±0.98	7.82±1.0	237.00±1.6	<DL
S.6	26.56±3.20	5.52±1.0	68.81±1.8	< DL
S.7	19.84±1.50	13.53±1.1	172.25±1.9	< DL
S.8	14.82±1.4	10.85±1.1	185.80±2.0	< DL
S.9	18.35±2.2	12.45±1.3	214.82±2.0	< DL
S.10	19.08±3.2	15.47±1.8	382.97±2.5	< DL
S.11	23.52±1.2	11.77±1.5	190.07±2.1	< DL
S.12	25.32±2.03	4.57±1.0	58.02±1.9	< DL
S.13	25.86±1.01	11.61±1.0	132.35±1.9	4.41±0.2
S.14	23.99±1.1	7.84±1.0	111.76±2.5	< DL
S.15	24.37±1.8	16.14±1.2	294.17±3.1	< DL
S.16	24.31±1.0	8.85±1.0	102.89±2.5	1.48±0.1
S.17	18.30±0.50	8.59±1.0	191.17±1.4	< DL
S.18	20.49±0.5	3.91±1.0	97.49±1.7	< DL
S.19	23.04±.0.89	8.00±1.2	188.99±1.8	< DL
S.20	20.89±0.41	12.78±1.4	322.72±2.0	0.64±0.1
S.21	23.40±0.68	8.12±1.5	136.27±3.2	< DL
S.22	17.35±0.99	9.02±1.2	171.26±3.2	1.47±0.1
S.23	24.9±0.65	6.15±1.0	96.61±1.9	1.05±0.1
S.24	16.64±0.65	7.53±1.0	160.05±1.4	1.42±0.2
S.25	23.660±1.3	5.28±1.0	87.48±1.5	0.99±0.1

Table (2) Radioactivity levels of uranium238 and thorium-232, in marine sediment samples from different area within El Dabaa

Sample code	Concentration of radionuclides in (Bq/kg)		
	Ra-226(U-238)	Th-232	K-40
Ms.1	2.88±0.30	0.9±0.30	6.10±0.48
Ms.2	3.72±0.38	<DL	9.58±4.12
Ms.3	2.34±0.18	<DL	8.74±0.96
Ms.4	5.60±0.20	<DL	5.32±0.40
Ms.5	4.92±0.45	<DL	10.21±0.52
Ms.6	4.07±0.48	<DL	10.69±0.66
Ms.7	4.54±0.63	<DL	9.83±1.23
Ms.8	3.80±0.10	0.70±0.10	5.70±0.20
Ms.9	3.70±0.15	<DL	6.90±0.60
Ms.10	5.40±0.3	<DL	9.20±0.80
Ms.11	4.00±0.10	0.60±0.10	4.50±0.20
Ms.12	4.20±0.1	0.70±0.10	7.20±0.40
Ms.13	2.68±0.46	2.13±0.42	9.13±0.96
Ms.14	4.13±0.54	0.84±0.41	9.75±0.74
Ms.15	3.45±0.43	<DL	8.43±0.81
Ms.16	7.20±2.10	<DL	14.90±2.10
Ms.17	8.20±0.50	<DL	15.60±1.90
Ms.18	5.01±0.43	<DL	9.12±0.51
Ms.19	7.20±0.00	0.70±0.40	17.50±1.80
Ms.20	8.20±0.50	<DL	13.60±1.60
Ms.21	7.90±0.90	<DL	20.80±2.50
Ms.22	7.60±0.40	<DL	13.60±2.00
Ms.23	7.50±0.50	0.80±0.30	13.60±1.60
Ms.24	9.80±0.90	<DL	20.80±2.20
Ms.25	8.70±0.80	<DL	25.00±1.70

Table (3) Absorbed dose rate & the radium equivalent and effective dose in soil samples within El Dabaa area

Samples code	Absorbed. dose (nGy/h)	Radium. equivalent (Bq/kg)	Annual effective dose μSv y^{-1}
Samples			
S-1	18.84	41.35	23.10
S-2	41.51	85.61	50.91
S-3	30.85	64.50	37.83
S-4	25.78	54.65	31.62
S-5	28.41	59.20	34.84
S-6	17.95	39.75	22.01
S-7	24.83	52.45	30.45
S-8	21.50	44.64	26.37
S-9	25.31	52.69	31.04
S-10	34.85	70.69	42.74
S-11	26.01	54.98	31.89
S-12	16.33	36.32	20.03
S-13	24.42	52.65	29.95
S-14	20.24	43.81	24.82
S-15	33.74	70.10	41.37
S-16	20.66	44.88	25.34
S-17	21.72	45.30	26.63
S-18	15.53	33.59	19.04
S-19	23.26	49.03	28.53
S-20	31.25	64.01	38.32
S-21	21.23	45.50	26.04
S-22	20.74	43.43	25.43
S-23	18.88	41.20	23.15
S-24	18.89	39.55	23.17
S-25	17.36	37.95	21.29

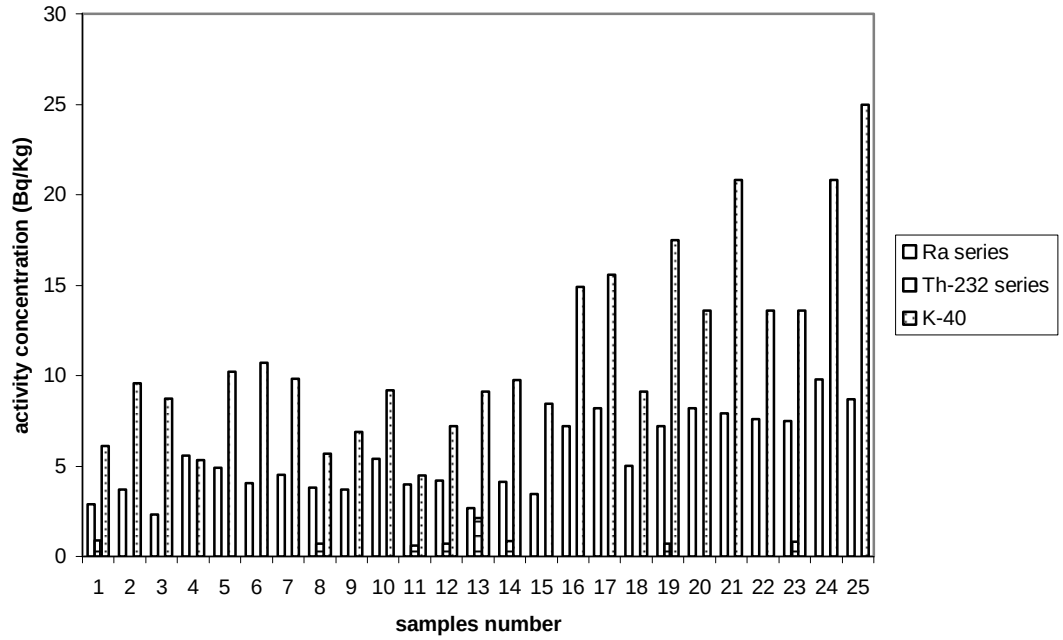

Fig. (1) Bar diagram showing correlation between ^{226}Ra, ^{232}Th and ^{40}K specific activity at marine sediment samples in El Dabaa area

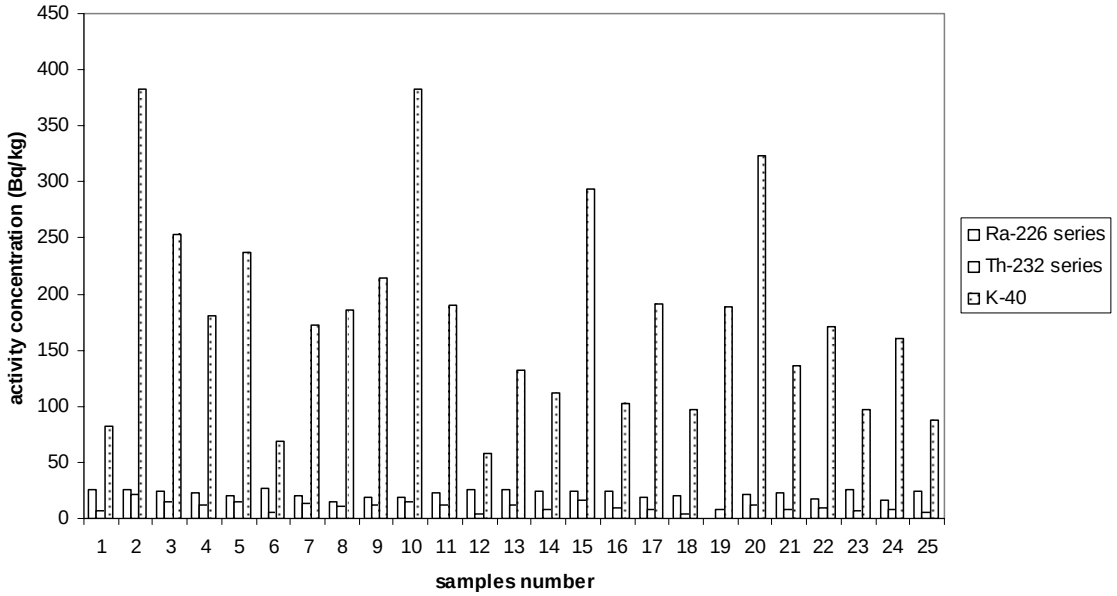

Fig. (2) Bar diagram showing correlation between ^{226}Ra, ^{232}Th and ^{40}K specific activity at soil samples in El Dabaa area

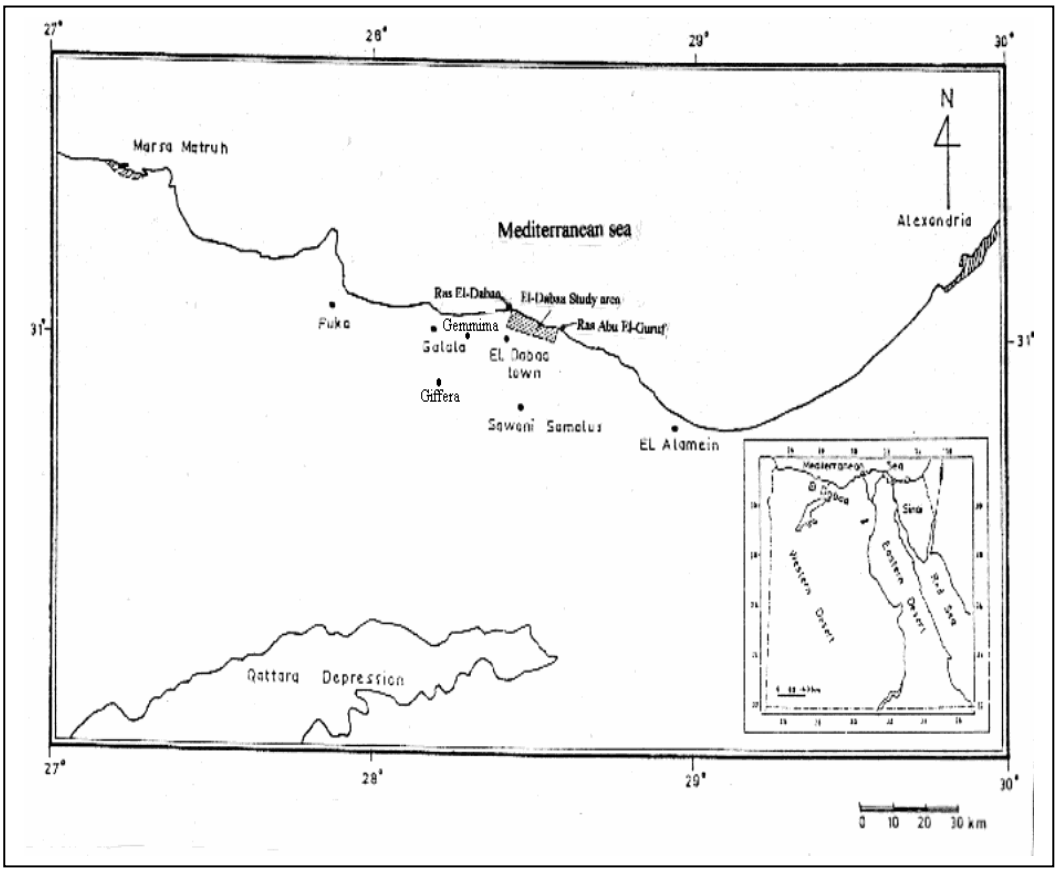

Fig. (3) Location of El Dabaa site

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