Al-Azhar Bulletin of Science Vol. 30, No. 1, (June) 2019, pp. 37-47

NATURAL RADIOACTIVITY ASSESSMENT AND THE ASSOCIATED RADIOLOGICAL HAZARDS FOR BEACH SAND, BALTIM AREA, EGYPT.

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ABSTRACT

Natural radioactivity of ^{238}U, ^{232}Th series and ^{40}K of black sand samples collected along El-Fanar and El-Nargess Beaches in Baltim area, north of the Nile Delta in Kafr El-Sheikh Governorate, were measured using a gamma-ray spectrometer with a high purity germanium (HPGe) detector. Results showed that the average activity concentrations of ^{238}U and ^{232}Th in El-Fanar Beach was significantly higher (73.22±5.1 and 70.8 ± 4.9 Bq kg^{-1}) than El-Nargess Beach (31.91±2.2 and 25.95 ±1.8 Bq kg^{-1}) respectively. The average activity concentrations of ^{40}K in El-Fanar Beach was lower (67.47±4.7 Bq kg^{-1}) than that in El-Nargess Beach (80.75±5.6 Bq kg^{-1}). The hazard indices due to these radionuclides have been calculated. The obtained results from this study indicate that the average activity concentrations of ^{238}U, ^{232}Th and^{40}K at El-Nargess Beach are within world median ranges while average activities of ^{238}U and^{232}Th in El-Fanar Beach are higher than the world mean (33and45) Bq kg^{-1} respectively. This study aimed to establish a baseline map of radioactivity background levels in the aforementioned region to assess any change in the radiological background levels due to any artificial effects attributed to any radiation activities.

Keywords: Natural radioactivity, radionuclides, radiation hazard, Baltim Area; Egypt, beach sand samples.

1. INTRODUCTION

From the beginning of time all living creatures have been, and are still being, exposed to radiation (cosmic rays, radionuclides produced by cosmic ray interactions in the atmosphere, and radiation from naturally occurring substances). Measurement of natural radioactivity is very important to determine the amount of change in natural background with time as a result of any radioactive decay. Humans should be aware of their natural environment with regard to the radiation effects due to the naturally occurring and induced radioactive elements. (Sutcliffe & Parks,1999) [1] .The Egyptian black sand occurs especially along the beaches of northern part of the Nile Delta. The loaded sands are concentrated as deposits at both of the mouths of the two Nile branches, near Rosetta and Damietta at the northern coast of Egypt, where the condition are most favorable for their accumulation as detrital beach deposits. This beach sand contains heavy minerals such as garnet and monazite. Many of these heavy minerals, zircon and monazite, contain radionuclides of the ^{238}U and ^{232}Th series. The concentration of ^{238}U and ^{232}Th in these minerals are much greater than the worldwide average concentration in soils and rocks. (Abdel-Razek Y.A &Bakhit A.F, 2009) [2].This study attempts to understand the occurrence and distribution of natural radionuclides ^{226}Ra, ^{232}Th and ^{40}K in black sand samples collected from El-Fanar and El-Nargess Beaches located in the north of the Nile Delta in Egypt (Baltim area) and to estimate the radiation doses received by humans living in this area. The calculated radiation doses are compared to the limits proposed by United Nation Scientific Committee on the effect of atomic radiation (UNSCEAR).

2. EXPERIMENTAL TECHNIQUE

2. 1. Sample collection and preparation

Thirty six sand beach samples were collected from Baltim area which lies to the north of the Nile Delta in Kafr El-Sheikh Governorate between latitudes 31^{0} 37' 25"and 31^{0} 56' 19"N and longitudes 31^{0}1'12", and 31^{0} 26' 7" E and about 25 km of the Egyptian

Coast. The covered area was about 500 km^2, with a length of 25 km and a width of 18.75 km. It's located nearly in midway between Rosetta and Damietta promontories (Mohamed Abdel-Fattah & Ahmed Tawfik, 2015) [3].

For radiometric analysis, black sand samples were classified according to their sites of extraction, El-Fanar and El-Nargess beaches, weighted, dried at 105^0 C for 24 hours, mechanically crushed, and sieved to 2 mm grain size. Each sample placed in polyethylene container of 100 cm^3 volume and marked individually. These containers sealed tightly for impeding the possibility of moisture contamination for 4 weeks to reach secular equilibrium (Mohamed Amin Mahmoud Uosif, 2011) [4].

2. 2. Gamma ray measurements

Gamma ray spectrometry technique was applied for measuring radioactivity concentrations in investigated samples. The system consists of high purity germanium (HPGe) detector with 40% efficiency and 2.0 keV resolution at 1.33 MeV photons, shielded by 4" Pb, 1 mm Cd and 1 mm Cu linked up to a multichannel analyzer was used for gamma measurements. The system was calibrated for energy and efficiency using different gamma emitters. These included cesium-137 (661.66 keV), cobalt-60 (1173.23 keV, 1332.5 keV), and potassium-40 (1460.8 keV).The radium-226 spectrum covers a wide energy range from 0.186 MeV to 2.45 MeV.

The gamma ray line energies of 295.2, 351.9 keV from (^{214}Pb), 609.3 keV, 1120.3 keV and 1764.5 keV from(^{214}Bi) were used to represent activity concentration of ^{226}Ra series. ^{232}Th activity has been calculated using gamma ray line energies of 338.4 keV, 911.1 keV and 968.9 for (^{228}Ac), 583 keV from (^{208}Tl). The activity of ^{40}K has been calculated from its γ-ray line of energy 1460.8 keV(Nataša B. Sarap et al, 2014)[5].

1. RESULTS AND DISCUSSION

3. 1. Concentration of natural radionuclides

The activity concentration of ^{226}Ra, ^{232}Th and ^{40}K radionuclides in the samples was measured using HPGe system and calculated using the following equation **(Jibiri, N.N. and Emelue, H.U.,2008) [6];**

$$C_i = \frac{1}{B.R_Y \times \eta_Y \times t \times M} \times N_{sY}$$

Where

C_i is the ctivity concentrations of the sample in Bq kg^{-1}.

N_{sY} is the net count under the peak area of the selected gamma line for the measured sample.

$B.R_Y$ is the emission probability of the gamma line corresponding to the peak energy

(Y) of the radionuclide (i).

η_Y *is* the spectrometer's efficiency corresponding to the peak energy (Y) at the specific geometry

t is the real counting time

M is the mass of the sample (kg)

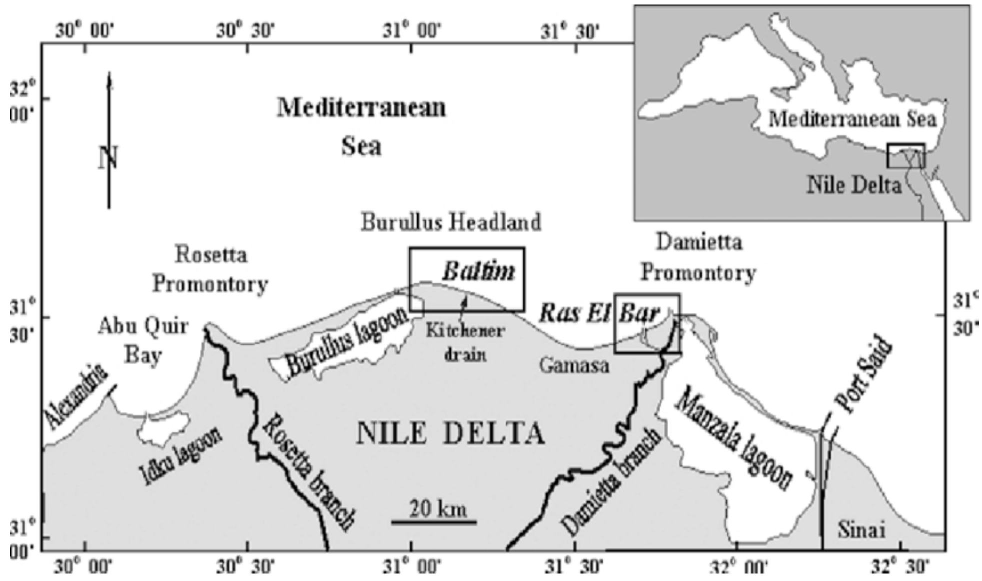

Figure (1): Map of the Nile delta coast showing the location of Baltim area

Results of the activity concentrations for 24 samples from El-Fanar and 12 samples from El-Nargess beaches were shown in Tables (1 and 2). For El-Fanar, ^{226}Ra concentration ranged from 5.4±0.38 Bq kg^{-1} to 353.3±24.73 Bq kg^{-1} with mean average value 73.22±5.1 Bq kg^{-1}. While ^{232}Th was ranged from 4.2±0.29 Bq kg^{-1} to 399.5±27.97 Bq kg^{-1} with an average of 70.8± 4.9 Bq kg^{-1}, for ^{40}K the activity ranged from 3.7±0.26Bq kg^{-1} to 120.55±8.44 Bq kg^{-1} with an average of 70.4±4.9 Bq kg^{-1}. For El-Nargess beach the activity concentrations were ranged from 12.7±0.89 to 53.25±3.73 Bq kg^{-1} with mean value of 31.9±2.23 Bq kg^{-1}, 8.7±0.61 to 47.8±3.35 Bq kg^{-1} with mean value 26±1.82 Bq kg^{-1} and 67.7±4.74to 110.8±7.76Bq kg^{-1} with mean value 80.8±5.65Bq kg^{-1} for ^{226}Ra, ^{232}Th and ^{40}K respectively.

The obtained results showed that the activity concentration of ^{226}Ra,^{232}Th having maximum values at shore near sea, the average activity concentrations of ^{226}Ra and ^{232}Th in El-Fanar Beach which is nearly twice the permissible maximum value while average activity concentrations of ^{40}K lower than permissible maximum value. While the average value of ^{226}Ra - and ^{232}Th series and from ^{40}K in El-Nargess beach which is lower than world median ranges.

3. 2. Hazards indices

3.2.1. Radium equivalent Activity (Ra_{eq})

The distribution of radionuclides ^{226}Ra, ^{232}Th and ^{40}K in soil is not homogeneous. The inhomogeneous distribution of naturally occurring radionuclides is due to disequilibrium between ^{226}Ra and its decay products. For uniformity in exposure estimates, the radionuclide concentrations are defined in terms of radium equivalent activity (Ra_{eq}) in Bq kg^{-1}. This allows comparison of the specific activity of materials containing different amounts of ^{226}Ra, ^{232}Th and ^{40}K according to the following relation (Beretka, J., & Mathew, P. J. ,1985)[7];

$$\mathbf{Ra_{eq}\ (Bq\ kg^{-1}) = C_{Ra} + 1.43\ C_{Th} + 0.077\ C_K}$$

From Tables (1 and 2), the obtained results show that the mean value of Ra_{eq} for El-Fanar 179.9 Bq kg^{-1} was higher than those for El – Nargess beach75.2 Bq kg^{-1}, mean values of Ra_{eq} for both beaches are below the recommended value of 370 Bq kg^{-1} **(UNSCEAR 2000)[8]**

3.2.2. External hazard index (H_{ex})

Soil from the investigated area is used for the construction of houses and for agricultural purposes, which may contribute to the external gamma dose rates to the public. The external hazard index (H_{ex}) can be examined according the following equation **(Oktay et. al., 2011)[9];**

$$\mathbf{H_{ex} = C_{Ra} / 740 + C_{Th} / 520 + C_K / 9620}$$

Where C_{Ra}, C_{Th} and C_K are the specific activities of ^{226}Ra, ^{232}Th and ^{40}K, respectively in Bq kg^{-1}. The value of H_{ex} must be lower than unity in order to keep the radiation hazard insignificant . The obtained values of external hazard index (H_{ex}) are show in Tables (1and2) for El-Fanar and El–nargess beaches with mean values of 0.24 and 0.1 Bq kg^{-1} respectively. Mean values of H_{ex} are lower than the recommended value **≤1** (Hewamanna et al., 2001)[10].

3.2.3. Internal hazards index (H_{in})

In addition to the external radiation hazard they pose, radon and its short-lived daughters are also hazardous to the respiratory organs. The internal exposure caused by radon and its daughter products is quantified by the internal hazard index H_{in}, which has been defined as given below (Righi & Bruzzi 2006)[11];

$$\mathbf{H_{in}=C_{Ra}/185+C_{Th}/259+C_K/4810}$$

The values of internal hazard index H_{in} as shown in Tables (1and2) have mean values of 0.68 and 0.29 Bq kg^{-1} for El-Fanar and El nargess Beaches respectively. These mean values are lower than the recommended value **≤1**. While the values of internal hazard index (H_{in})for F7,F13 and F19 are higher than the recommended value.

3.2.4. Gamma index (I_γ)

It is a hazard index for external gamma radiation proposed by the European Commission (EC) to verify whether the guidelines of EC for building material usage are met. The representative gamma index (I_γ) is calculated using the following equation **(Hesham Zakaly et al,2016) [12];**

$$I_{\gamma} = C_{Ra} / 300 + C_{Th} / 200 + C_{K} / 3000$$

The obtained values of representative gamma index (Iγ) are shown in Tables (1and2) for El-Fanar and El-Nargess beaches with mean values of 0.62 and 0.26 Bq kg^{-1} respectively which are lower than the recommended value ≤1 that corresponds to 0.3 mSv y^{-1} (NEA-OECD, 1979)[13];

3.2.5. Alpha index (I_{α})

Alpha index is another important index dealing with the assessment of the excess alpha radiation due to radon inhalation originating from building materials. The index is defined as (El-Galy, 2008)[14];

$$I_{\alpha} = C_{Ra} / 200$$

I_{α} should be lower than the maximum permissible value of $I_{\alpha} = 1$, which corresponds to 200 Bq kg^{-1}. It should be noted that building material with activity concentration lower than 200 Bq kg^{-1} dose not cause indoor radon concentration higher than 200 Bq m^{-3} [15]. The obtained mean values of Alpha index are shown in Tables (1 and 2) for El-Fanar El-Nargess Beaches, the corresponding mean values are 0.37and 0.16 respectively..

3.2.6. Activity utilization index (AUI)

The activity concentrations of natural radionuclides in samples collected from the studied area mainly affect the indoor absorbed dose by elevation dose rates in air indoors. This index has been calculated using the following relation (Orgun et al., 2007)[15];

$$AUI = (C_{Ra} / 33\ Bq\ kg^{-1})\ f_u + (C_{Th} / 45\ Bq\ kg^{-1})\ f_{Th} + (C_K / 420\ Bq\ kg^{-1})\ f_k$$

where C_{Ra}, C_{Th} and C_K are the actual values of the activities per unit mass (Bq kg^{-1}) of ^{238}U, ^{232}Th, and ^{40}K respectively in the considered building materials; f_u (0.462), f_{Th} (0.604) and f_k (0.041) are the fractional contributions to the total dose rate in air due to gamma radiation from the actual concentrations of these radionuclides.

The activity utilization index is unity by definition and is deemed to imply a dose rate of 80 nGy h^{-1}). Tables (1 and 2) shows that the average values of AUI for El-Fanar and El-Nargess beach are 2 and 0.8 respectively. For AU I < 2, this corresponds to an annual effective dose of < 0.3 mSv y^{-1}. So, El- Fanar beach sand can't be used as a safe building material (El-Gamal et al., 2007) [16].

3.2.7. Absorbed gamma dose rate (D_R)

The outdoor absorbed gamma dose rate in air (D_{out}) resulting from the natural specific activity concentration of ^{238}U, ^{232}Th and ^{40}K in Bq kg^{-1}, at a height of 1 m above the ground was calculated after applying the conversion factors (in nGy h^{-1} per Bqkg^{-1}) using the formula provided by (Oktay et. al., 2011)[9] which have the following form ;

$$D_{out}\ (nGy\ h^{-1}) = 0.462\ C_{Ra} + 0.621\ C_{Th} + 0.0417\ C_K$$

Minimum and maximum values for external outdoor doses resulted from ^{238}U, ^{232}Th and ^{40}K in beaches samples was 5.3 and 420.5 nGy h^{-1} in El-Fanar beach samples, Table (3). The average value was 81.8 nGy h^{-1} which is higher than world's average level of 59 nGy h^{-1}. From Table (3) the minimum and maximum gamma dose rates were 15 and 58.1 nGy h^{-1} at El-Nargess beach samples with an average value of 34.8 nGy h^{-1} which is lower than world's average of 59 nGy h^{-1}. (**UNSCEAR 2000**).

The present indoor gamma ray dose (D_{in}) imparted by ^{238}U, ^{232}Th and ^{40}K was calculated using the following equation (Laith Najam et. al., 2013) [17];

$$D_{in}\ (nGy\ h^{-1}) = 0.92\ C_{Ra} + 1.1\ C_{Th} + 0.081\ C_K$$

From Table (3), it is shown that, calculated D_{in} for El-Fanar was higher than those for El-Nargess beach samples, the corresponding mean values are 150.7 and 64.5 nGy h^{-1} respectively. According to the world average of 84 nGy h^{-1}, D_{in} for El-Fanar beach was higher than the recommended value.

Table (1): Specific activities (Bq kg^{-1}) of ^{226}Ra, ^{232}Th, and ^{40}K and the radiological parameters for El-Fanar beach sand samples.

Sample ID	Specific activity Bq kg^{-1}			Ra_{eq} Bq kg^{-1}	The hazard indices		The level indices		Activity utilization index
	^{226}Ra	^{232}Th	^{40}K		H_{ex}	H_{in}	Iγ	Iα	AUI
F1	101.2±7.08	105.0±7.35	71.1±4.98	256.7	0.35	0.97	0.89	0.51	2.8
F2	23.7±1.66	25.9±1.81	90.2±6.32	67.7	0.09	0.25	0.24	0.12	0.7
F3	24.4±1.70	22.6±1.58	73.1±5.11	62.4	0.08	0.23	0.22	0.12	0.7
F4	50.6±3.54	47.5±3.33	95.6±6.69	125.9	0.17	0.48	0.44	0.25	1.4
F5	29.9±2.09	25.5±1.79	75.3±5.27	72.2	0.10	0.28	0.25	0.15	0.8
F6	27.0±1.89	21.6±1.51	70.1±4.5	63.3	0.09	0.24	0.20	0.14	0.7
F7	136.8±9.57	99.7±6.98	41.6±2.91	282.4	0.38	1.13	0.97	0.68	3.3
F8	17.0±1.19	17.1±1.20	120.5±8.4	50.7	0.07	0.18	0.18	0.08	0.5
F9	35.0±2.45	31.3±2.19	79.3±5.55	85.9	0.12	0.33	0.30	0.17	0.9
F10	31.2±2.18	25.9±1.81	84.9±5.94	74.7	0.10	0.29	0.26	0.16	0.8
F11	44.1±3.09	40.9±2.86	86.7±6.07	109.3	0.15	0.41	0.38	0.22	1.2
F12	33.2±2.33	21.7±1.52	90.0±6.30	71.2	0.10	0.28	0.25	0.17	0.8
F13	313.2±21.92	311.8±21.83	38.0±2.66	761.9	1.03	2.90	2.62	1.57	8.6
F14	12.5±0.88	12.4±0.87	61.3±4.29	35.0	0.05	0.13	0.12	0.06	0.4
F15	58.5±4.09	61.0±4.27	57.4±4.02	150.1	0.20	0.56	0.52	0.29	1.6
F16	75.8±5.31	76.0±5.32	65.8±4.60	189.5	0.26	0.72	0.65	0.38	2.1
F17	5.4±0.38	4.2±0.29	3.7±0.26	11.7	0.02	0.05	0.04	0.03	0.1
F18	80.7±5.65	74.9±5.24	57.5±4.02	192.1	0.26	0.74	0.66	0.40	2.1
F19	353.3±24.73	399.5±27.97	53.4±3.74	928.7	1.25	3.46	3.19	1.77	10.3
F20	64.8±4.54	58.4±4.09	61.8±4.32	153.1	0.21	0.59	0.53	0.32	1.7
F21	37.8±2.64	35.1±2.45	94.2±6.59	95.2	0.13	0.36	0.33	0.19	1.0
F22	85.6±5.99	82.4±5.77	70.1±4.91	208.8	0.28	0.80	0.72	0.43	2.3
F23	49.2±3.45	47.0±3.29	68.7±4.81	121.7	0.16	0.46	0.42	0.25	1.3
F24	66.4±4.65	52.1±3.64	79.5±5.56	146.9	0.20	0.58	0.51	0.33	1.6
Min	**5.4±0.38**	**4.2±0.29**	**3.7±0.26**	**11.7**	**0.02**	**0.13**	**0.04**	**0.03**	**0.1**
Max	**353.3±24.73**	**399.5±27.97**	**120.5±8.4**	**928.7**	**1.25**	**3.46**	**3.19**	**1.77**	**10.3**
Average	**73.2±5.1**	**70.8± 4.9**	**70.4±4.9**	**179.9**	**0.24**	**0.68**	**0.62**	**0.37**	**2.0**
Permissible	**33**	**45**	**420**	**370**	**≤1**		**≤1**	**≤1**	**≤2**

3.2.8. Annual effective dose equivalent (AEDE)

The annual effective dose equivalent was calculated using conversion factor recommended by the (UNSCEAR 2000) of 0.7 Sv Gy^{-1} and outdoor occupancy factors of 0.2 by considering that the people on the average spent 20% of their time in outdoors. Therefore, (AEDE) can be determined according the following equation (UNSCEAR, 2000)[8].

$$\textbf{AEDE (mSv yr}^{-1}\textbf{) = D (nGy h}^{-1}\textbf{) x T (hs in 1 yr) x Q (C.coeff.) x Qf x 10}^{-6}$$

Where T = 8760 h, Q = 0.7 SvGy^{-1} Qf = Occupancy factor for outdoor = 0.2 and for indoor effected dose indoor = 0.8. Both $AEDE_{in}$ and $AEDE_{out}$ indice measure the risk of stochastic and deterministic effects in the irradiated individuals. Table (3) shows the mean annual indoor and outdoor effective dose rates of 0.7, 0.1 and 0.32, 0.04 for El-Fanar and El-Nargess beach sand samples respectively. The obtained results show that El-Fanar beach is higher than the recommended limit (UNSCEAR 2000) of 0.41 and 0.07 mSv yr^{-1} for indoor and outdoor respectively.

Table (2): Specific activities (Bq kg^{-1}) of ^{238}U (^{226}Ra), ^{232}Th, ^{40}K and the radiological parameters for El-Nargess beach sand samples.

Sample ID	Specific activity Bq kg^{-1}			Ra_{eq} Bq kg^{-1}	The hazard indices		The level indices		Activity utilization index
	^{226}Ra	^{232}Th	^{40}K		H_{ex}	H_{in}	I_γ	I_α	AUI
N1	33.8±2.37	35.2±2.46	71.1±4.98	89.6	0.12	0.33	0.31	0.17	0.95
N2	13.8±0.97	8.7±0.61	69.0±4.83	31.5	0.04	0.12	0.11	0.07	0.32
N3	31.5±2.2	28.1±1.97	110.8±7.76	80.2	0.11	0.30	0.28	0.16	0.83
N4	47.0±3.29	27.0±1.89	67.7±4.74	90.9	0.12	0.37	0.31	0.24	1.03
N5	42.7±2.99	26.0±1.82	72.8±5.09	85.5	0.12	0.35	0.30	0.21	0.95
N6	32.7±2.29	18.5±1.29	74.5±5.21	64.9	0.09	0.26	0.23	0.16	0.71
N7	53.3±3.73	47.8±3.35	71.4±5.0	127.1	0.17	0.49	0.44	0.27	1.39
N8	12.7±0.89	12.2±0.85	89.6±6.27	37.0	0.05	0.13	0.13	0.06	0.35
N9	17.5±1.22	17.2±1.20	95.4±6.68	49.4	0.07	0.18	0.18	0.09	0.48
N10	46.7±3.27	44.7±3.13	74.8±5.24	116.3	0.16	0.44	0.40	0.23	1.26
N11	35.9±2.51	34.6±2.42	96.7±6.77	92.8	0.13	0.35	0.32	0.18	0.98
N12	15.5±1.08	11.5±0.80	75.2±5.26	37.7	0.05	0.14	0.13	0.08	0.38
Min	**12.7±0.89**	**8.7±0.61**	**67.7±4.74**	**31.5**	**0.04**	**0.12**	**0.11**	**0.06**	**0.32**
Max	**53.3±3.73**	**47.8±3.35**	**110.8±7.76**	**127.1**	**0.17**	**0.49**	**0.44**	**0.27**	**1.39**
Average	**31.9±2.23**	**26.0±1.82**	**80.8±5.65**	**75.2**	**0.1**	**0.29**	**0.26**	**0.16**	**0.80**
Permissible	**33**	**45**	**420**	**370**	**≤1**		**≤1**	**≤1**	**≤2**

3.2.9. Annual gonadal dose equivalent (AGDE)

AGDE is a genetic significance of the dose equivalent received each year by the reproductive organs (gonads) of the exposed population to natural radioactivity. Within this context, the activity bone marrow and the bone surface cells are inclusive by (UNSCEAR 2000) as organs of interest. The annual gonadal dose equivalent (AGDE) resulted from the specific activities of ^{226}Ra, ^{232}Th and ^{40}K in studied samples was estimated using the following equation: **(Mamont Ciesla et al., 1982)[18].**

$$\textbf{AGDE } (\mu Sv\ y^{-1}) = 3.09\ C_{Ra} + 4.18\ C_{Th} + 0.314\ C_K$$

Calculated AGDE values for El-Fanar and El-Nargess beaches are presented in Table (3) and ranged from 35.4 to 2778.5 µSv y^{-1} with an average of 544.3 µSv y^{-1} and from 100.6 to 386.9 µSv y^{-1} with an average of 232.46 µSv y^{-1} respectively. The obtained AGDE value for El-Fanar is 81.4 % which is higher than the world permissible level (300 µSv y^{-1}). For El-Nargess beache, the calculated value is 22.5 % less than world recommended level.

3.2.10. Excess lifetime cancer risk (ELCR)

Another radiological parameter, is the excess lifetime cancer risk (ELCR), was calculated on the bases of the calculated annual effective dose using the following equation (Arafa ,2004)[19];

$$\textbf{ELCR = AEDE x DL x RF (0.05)}$$

Where AEDE is annual effective dose, DL is the average duration of life (72.7 year for Egyptian), RF is the risk factor and defined as the fatal cancer risk per sievert.

The average values of excess lifetime cancer risk (ELCR) obtained for El-Fanar and El-Nargess beaches are presented in Figure (4). It clear that the ELCR for El-Fanar beach is higher than the recommended limit of 1.16 x 10^{-3}.

3.2.11. Effective dose rate to different body organs and tissues (D_{Organ})

The effective dose rate delivered to a particular organ can be calculated using the following relation (O'Brien K., & Sanna R. 1976)[20];

$$D_{organ}\ (mSv\ yr^{-1}) = AEDE \times f$$

Table (3) Indoor and outdoor absorbed gamma dose rate, annual effective dose equivalent (AEDE), exposure rate (E_R) , excess lifetime cancer risk (ELCR) and effective dose rate to different body organs and tissues (D_{organ}) for El-Fanar and El-Nargess beach sand samples.

		El- Nargess	El- Fanar
D(nGy h^{-1}) Indoor	Range	27.8-107.4	9.9-768.8
	Mean	64.5	150.7
D(nGy h^{-1}) Outdoor	Range	15.0-58.1	5.3-420.5
	Mean	34.8	81.8
AEDE (mSv yr^{-1}) Indoor	Range	0.14-0.53	0.1-3.8
	Mean	0.32	0.7
AEDE (mSv yr^{-1}) Outdoor	Range	0.02-0.07	0.01-0.5
	Mean	0.04	0.1
ELCR	Range	0.3-1.3	0.1-9.1
	Mean	0.8	1.8
AGDE (μSv y^{-1})	Range	100.6-386.9	35.4-2778.5
	Mean	232.46	544.3
D_{organ} (mSv yr^{-1})			
Lungs indoor	Range	0.05-0.18	0.02-1.28
	Mean	0.11	0.25
Lungs outdoor	Range	0.01-0.04	0.004-0.32
	Mean	0.03	0.06
Ovaries indoor	Range	0.04-0.16	0.01-1.16
	Mean	0.1	0.23
Ovaries outdoor	Range	0.01-0.04	0.004-0.29
	Mean	0.02	0.06
Bone marrow indoor	Range	0.05-0.19	0.02-1.38
	Mean	0.11	0.27
Bone marrow outdoor	Range	0.01-0.05	0.004-0.34
	Mean	0.03	0.07
Testes indoor	Range	0.06-0.23	0.02-1.64
	Mean	0.14	0.32
Testes outdoor	Range	0.01-0.06	0.005-0.41
	Mean	0.03	0.08
Whole body Indoor	Range	0.05-19	0.02-1.36
	Mean	0.11	0.26
Whole body outdoor	Range	0.01-0.05	0.004-0.34
	Mean	0.03	0.07

Table (4) Comparison of effective radiation doses from diagnostic X-Ray single exposure and natural radiation dose rates from El-Fanar and El-Nargess beaches.

X-Ray Procedure	Resulted effective radiation dose (mSv)	Comparable for NORM from El-Fanar beach	Comparable for NORM from El-Nargess beach
CT - Abdomen & Pelvis	10.0	4.2 month	11.1 month
CT – Body	10.0	4.2 month	11.1 month
Lower GI Tract Radiography	8.0	3.3 month	8.9 month
Upper GI Tract Radiography	6.0	2.5 month	6.7 month
Spin Radiography	1.5	18 days	24 days
Extremity Radiography	0.001	19 min	29 min
CT – Head	2.0	0.8 month	2.2 month
CT – Spine	6.0	2.5 month	6.7 month
Myelography	4.0	1.7 month	4.4 month
CT – Chest	7.0	2.9 month	7.8 month
Radiographic Chest	0.1	1.3 month	0.1 month
Bone Densitometry	0.001	19 min	29 min
Mammography	0.7	9 days	12 days

Where f is the conversion factor of organ dose from air dose and is almost independent of energy. The indoor and outdoor average values of (D_{organ}) are presented in Figures (2 and 3) for El-Fanar and El-Nargess beaches respectively. The calculated (D_{organ}) for the investigated beaches were compared with estimated radiation doses for some common diagnostic X-ray, computed tomography (CT) and mammography procedures as shown in Table 4.

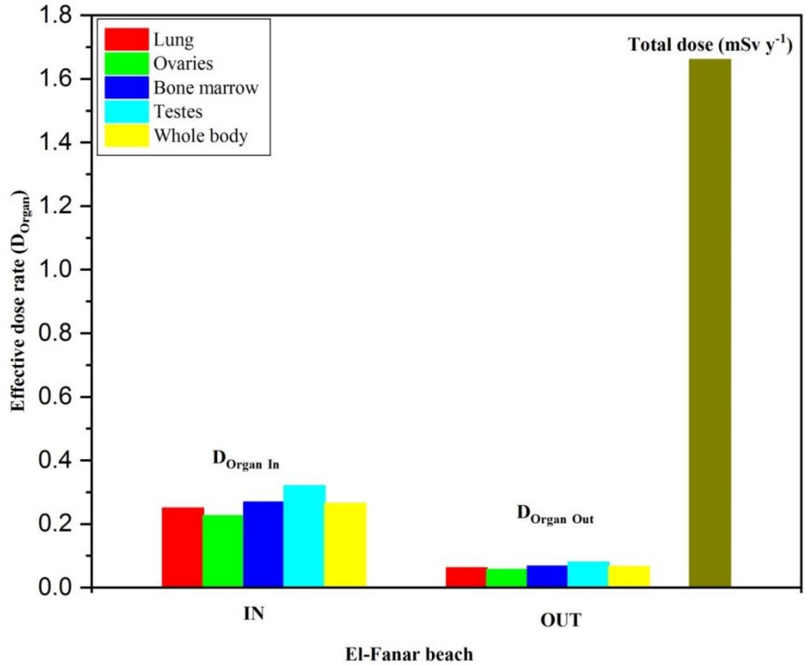

Figure (2): Effective dose rate for different body organs and tissues ,Total dose ($mSv\ y^{-1}$) for El-Fanar beach.

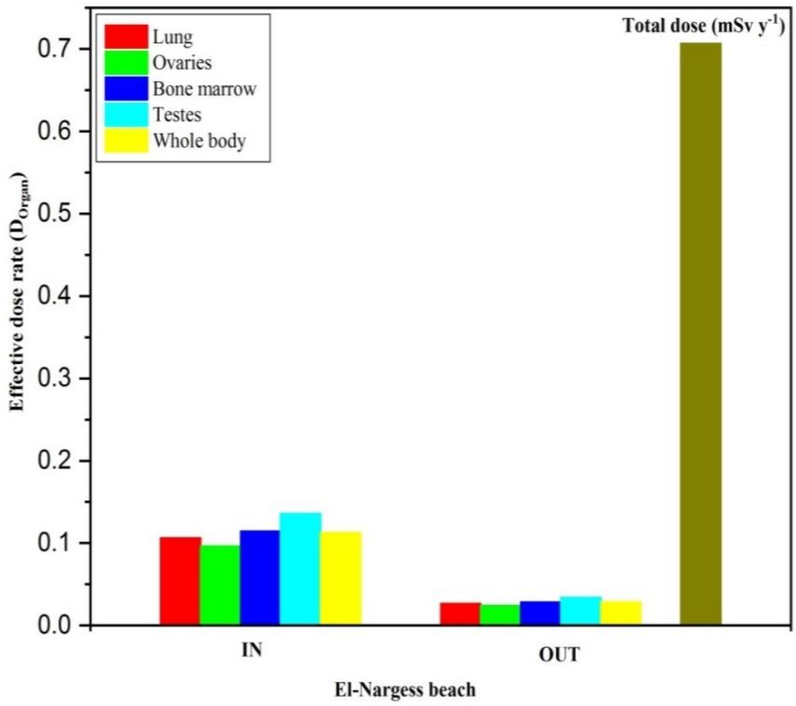

Figure (3): Effective dose rate for different body organs and tissues ,Total dose($mSv\ y^{-1}$) for El-Nargss baach.

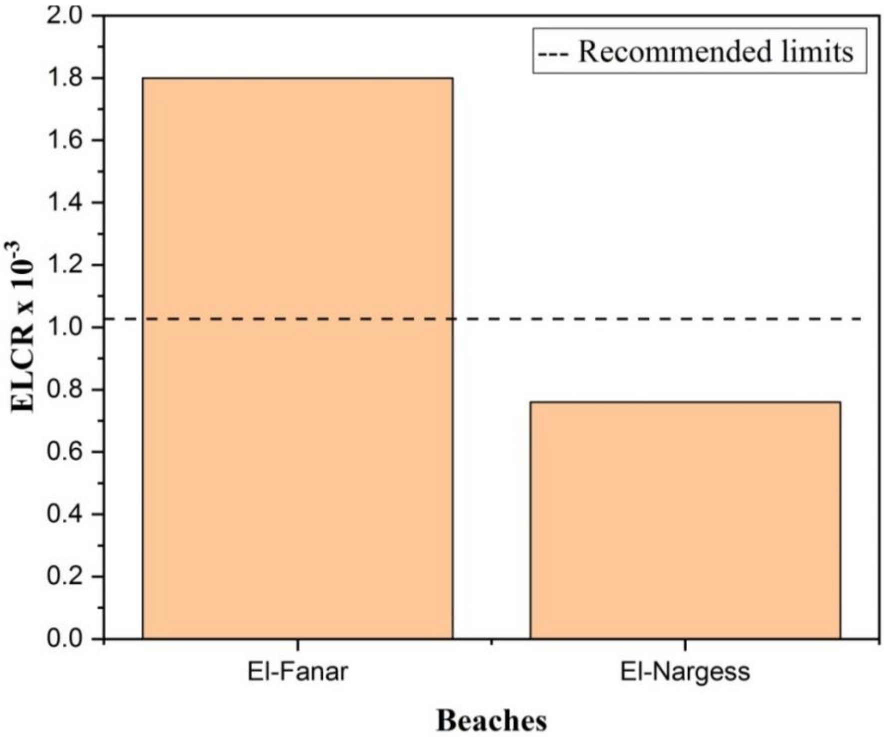

Figure (4).Excess lifetime cancer risk (ELCR) for El-Fanar and El-Nargess beach sand samples.

2. CONCLUSION AND RECOMMENDATIONS:

The conclusion of our study can be summarized in the following points:

- The specific activity concentration of natural radionuclide ^{226}Ra,^{232}Th and ^{40}K at El-Fanar and El-Nargess beaches in Baltim area were measured using HPGe gamma ray spectrometer.
- The average activity concentrations of ^{238}U, ^{232}Th and^{40}K at El-Nargess beach are within the world median ranges while average activities of ^{238}U ,^{232}Th in El-Fanar beach exceeded the permissible value
- It is important to determine the background radiation level in order to evaluate the health hazards.
- Separation of heavy mineral elements from El–Fanar beach Sand is recommended to decrease the highly background radioactivity due to the presence of monazite and zircon.
- The measurement of radionuclides ^{238}U, ^{232}Th and^{40}K in the sediments of El- Narges revealed that the specific activity of EL-Narges beach sand is within the limit for public, this permits the use of these beach sand as building materials in any probable development projects .But for EL-Fanar beach a removal of the radioactive minerals (monazite and zircon) is very necessary.
- The present study was carried out to give a baseline reference data about the natural radioactivity levels arising from natural radionuclides along El-Fanar and El-Nargess beaches in Baltim area.

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الملخص العربي :

أجري التقييم الاشعاعي المتسبب عن وجود المواد المشعة المتواجده طبيعيًا في منطقة بلطيم الواقعة على ساحل البحر الأبيض المتوسط (شمال الدلتا). وقد تم جمع العينات من شاطئي (الفنار و النرجس) وتم تصنيف العينات وفقا لمواقع استخراجها وتم تحضير وقياس العينات فى مركز الأمان النووي والرقابة الإشعاعية بهيئة الطاقة الذرية بالقاهرة. تم قياس النشاط الاشعاعي للراديوم-226 والثوريوم-232 والبوتاسيوم-40 بواسطة منظومة تحليل أطياف جاما المستندة إلى كاشف الجرمانيوم عالي النقاوة ذي الكفاءة 40 %. أوضحت النتائج أن متوسط تركيزات نشاط الراديوم -226 والثوريوم-232 في شاطيء الفنار(4,9±70,8،5,1±73,22بيكريل/كغم) على التوالي وهى أعلى بكثير من شاطيء النرجس(1,8±25,95،2,2±31,91بيكريل/كغم)على التوالي بينما كان تركيز البوتاسيوم-40 في شاطيء الفنار(4,7±67,47 بيكريل/كغم) وهى أقل من شاطيء النرجس(80,75 5,6±بيكريل/كغم) . ومن تلك النتائج وجد أن متوسط التركيز الإشعاعي للرديوم-226 والثوريوم-232في شاطيء الفنار أعلى من المتوسط العالمي كما ورد فى لجنة الأمم المتحدة للوقاية من آثارالإشعاعات الذرية (33-45 بيكريل/كغم) بينما كان متوسط التركيز الإشعاعي للراديوم -226 واللثوريوم- 232 لشاطيء النرجس أقل من المتوسط العالمي. تم تقدير المخاطر الإشعاعية وأشارت النتائج الى أن قيم معاملات الخطورة الإشعاعية لأغلب العينات أقل من القيم المسجلة عالميًا ماعدا بعض عينات شاطيء الفنار .ومن ثم هدفت هذه الدراسة إلى وضع خريطة مرجعية لمستويات خلفية النشاط الإشعاعي في البيئة المحيطة لتقييم أي تغير في مستويات الخلفية الإشعاعية.