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Natural Radioactivity and Radiological Hazards of Sharm El Loul Beach, South of Marsa Alam City, Egypt

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Abstract: The natural radionuclides of ^{238}U, ^{232}Th, ^{226}Ra, and ^{40}K have beeninvestigated in sand samples collected from Sharm El Loul beach using gamma-ray spectrometry by a High Purity Germanium (HPGe) detector. The detector was connected with a computer based high resolution multi-channel analyzer. The radioactive activities in the surface studied samples (Es) are ranged from 13.456 to 22.45 Bq/kg for ^{238}U; 2.0449 to 16.245 Bq/kg for ^{232}Th; 43.776 to 79.197 Bq/kg for ^{226}Ra and 162. 302 to 416.111 Bq/kg for ^{40}K with the average values of 17.531, 8.888, 63.265 and 342.289 Bq/kg, respectively. While at the deep studied sample (Eb), they are ranged from 10.888 to 20.714 Bq/kg for ^{238}U; 4.427 to 16.347 Bq/kg for ^{232}Th; 47.163 to 68.373 Bq/kg for ^{226}Ra and 252.568 to 402.706 Bq/kg for ^{40}K with the average values of 15.415, 10.034, 58.174 and 345.636 Bq/kg, respectively. The radium equivalent activity (Ra_{eq}), external hazard indices (H_{ex}) have average values of 161.93 Bq/kg, and 0.437, respectively. The average values of indoor and outdoor absorbed dose rate in air were found 70.58 nGy.h-1 and 0.086 nGy.h-1, respectively. The reordered important minerals in the studied area are; feldspar, quartz, Ilmenite, Rutile, Magnetite, zircon, monazite, Uranothorite, and Apatite. In the present work, ^{40}K was the significant radionuclide detected in Sharm El loul beach. The concentrations of radionuclides in the studied samples of Sharm El loul beach during the present investigations were normal and do not produce any harmful health effects to the local residents.

Keywords: Sharm El Loul, Radionuclides, Marsa Alam, Doze rate, Hazards.

1 Introduction

The Red sea virgin beaches like Sharm El Loul south of Marsa Alam City have grown into prosperous resorts that offer beautiful beach and nearly year-round warm water temperatures. Several simple coral reefs and many species of fishes make lovers of scuba diving to try diving in this beach.

The distribution of primordial radionuclides ^{238}U series, ^{232}Th series and ^{40}K that is present in the earth's crust reveal to understanding the radiological implication of those elements due to the γ-ray exposure of the body and irradiation of lung tissue from inhalation of radon and it`s daughters. These exposures may depend on the local geology of each region in the world. The natural radioactivity is usually done in order to gain information about the levels of harmful pollutants discharged to the environment itself or in the living creatures [1].

The natural radioactivity is very important to determine the amount of change in natural background with time as a result of any radioactive decay. Human have always been exposed to natural radiation, so they should be aware of their natural environment with regard to the radiation effects due to the naturally occurring and induced radioactive elements.

This study attempts to understand the occurrence and distribution of natural radionuclides ^{238}U, ^{232}Th and ^{40}K in beach sand samples of Sharm El Loul. The radiological hazards were determined, and compared with the United Nation Scientific Committee on the Effect of Atomic Radiation (UNSCEAR).

2 Materials and Methods

2.1 Study Area

Sharm El Loul beach is shallow water with a maximum depth of 7m covering an area about 2km^2. It is situated on

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the Red sea coastal plain about 60km south of Marsa Alam city between latitudes, 24º 36´ 18˝ to 24º 36´ 54˝ and longitudes, 35º 06´ 18˝ to 35º 07´ 30˝ (Fig. 1). It is easily accessible through asphaltic Marsa Alam – Shalatin Highway. Sharm El Loul beach is characterized by natural features of tourist resources, and a nice climate along a year seasons. Sharm El Loul beach is bordered by a narrow sand coastal plain on the west, following by Wadi deposits and finally by the Red Sea mountains. It is bordered by Miocene–Recent sediments on the southern side (Fig. 2).

2.2-Sample Collection and Preparation

Through (7) stations, covered the Sharm El Loul beach (Fig. 1), number of (14) bulk samples were collected. Each station contains two samples, one from the surface (Es) and the other from depth about 40cm (Eb) at the same station. Each sample weighting about 1kg. (Fig. 2), and was air-dried for several days.

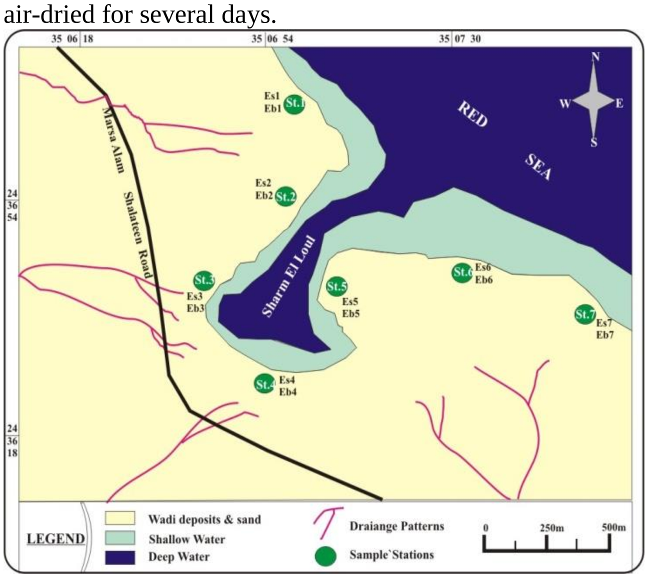

Fig. 1: Location map of Sharm El Loul area showing the beach and drainage patterns of adjacent Wadies.

Fig.2: General view of Sharm El Loul area, notice the Red Sea Mountain chains at the west side and the Miocene and Recent Sediment at the south side.

The collected samples were grounded, and sieved to about 200 mesh by crushing, where each sample placed in polyethylene container ($250cm^3$). The bottles were sealed for more than one month to allow radioactive equilibrium, where this step is necessary to ensure that radon gas is confined within the volume and the daughters will also remain in the sample. Then the samples were being taken for gamma-spectrometric analysis, using high germanium detector (HPGe).

2.3 Radioactivity Gamma Ray Measurements

High germanium detector (HPGe) was coupled to a PC-computer with a special electronic card to make it equivalent to a multichannel analyzer. The system also contains the usual electronic components of preamplifier and power supply. The detector has resolution (FWHM) of 1.85KeV for the 1332.5KeV γ-ray line of ^{60}Co.

The calibration of HPGe detector was performed using the following gamma standard sources: ^{60}Co (1173.2 & 1332.5 Kev), ^{241}Am (59.5 KeV) and ^{226}Ra (185.7, 241.92, 351.99 & 609.70 KeV) respectively. In carrying out any measurement, attention has to be given to the fact that the source strength of the sample under investigation is comparable with that of the standard sources, in order to avoid errors due to shift in amplification.

The efficiency calibration in this work was performed using three well – known reference materials obtained from the International Atomic Energy Agency for uranium (U), thorium (Th) and potassium (K) radioactivity measurements: RGU^{-1}, $RGTh^{-1}$ and RGK^{-1} [2], [3]. The samples were placed on top of the detector for counting and reference materials samples [4].

3 Results and Discussion

3.1Concentration of Natural Radionuclides

The activity concentration of ^{238}U, ^{232}Th, ^{226}Ra & ^{40}K in the studied samples was measured using HPGe system and calculated using the equation [6].

$$\mathbf{A} = \frac{\textbf{Net area (CPS)}}{\mathbf{I_\gamma \times \xi . M}} \ldots\ldots\ldots\ldots \quad (\mathbf{1})$$

Where; A = Activity concentration of the gamma spectral line in Bq/Kg,

Net area (cps) = the net detected counts per second Corresponding to the energy.

ξ = Counting system efficiency of the energy.

M = Mass of sample in Kg.

I_γ = Intensity of the gamma spectral.

The results of the activity concentrations for (14) studied samples from Sharm El Loul beach as shown in table (1) and figures (3, 4 & 5).

Table 1: The activity concentrations in (Bq/Kg) ^{238}U, ^{232}Th, ^{226}Ra, and ^{40}K of the studied sand samples of Sharm El Loul beach.

Samples at the Surface (Es)				
S.no.	^{238}U	^{232}Th	^{226}Ra	^{40}K
Es1	17.97	8.76	43.78	343.12
Es2	16.93	7.64	79.20	344.44
Es3	17.56	7.74	68.49	395.51
Es4	17.51	9.68	68.62	416.11
Es5	16.84	10.10	59.86	390.81
Es6	22.45	16.25	62.08	343.74
Es7	13.46	2.05	60.84	162.30
Min.	13.46	2.05	43.78	162.30
Max.	22.45	16.25	79.20	416.11
Aver.	17.53	8.89	63.27	342.29
Samples at the depth (40cm.) (Eb)				
S.no.	^{238}U	^{232}Th	^{226}Ra	^{40}K
Eb1	12.63	4.43	62.66	252.57
Eb2	13.88	8.94	60.63	318.65
Eb3	10.89	5.32	50.31	310.30
Eb4	17.57	12.92	64.10	373.18
Eb5	20.71	16.35	68.37	402.71
Eb6	16.93	11.12	47.16	375.58
Eb7	15.29	11.17	53.99	386.47
Min.	10.89	4.43	47.16	252.57
Max.	20.71	16.35	68.37	402.71
Aver.	15.42	10.03	58.17	345.64

The surface samples reflect concentrations ranged from 13.456 to 22.450 Bq/Kg. with an average content 17.531 Bq/Kg for ^{238}U; 2.045 to 16.245 Bq/Kg. with an average content 8.888Bq/Kg. for ^{232}Th, 43.776 Bq/kg to 79.197 Bq/Kg. with an average content 63.265 Bq/Kg for ^{226}Ra; and 162.302 to 416.111 Bq/Kg. with an average content 342.289 Bq/Kg. for ^{40}K.

At the depth (40cm) the studied samples showed that ^{238}U ranged from 10.888 to 20.714 Bq/kg., with an average content 15.415 Bq/Kg.; ^{232}Th ranged from 4.427 to 16.347 Bq/kg with an average 10.034 Bq/Kg.; ^{226}Ra ranged from 47.163 Bq/Kg to 68.373 Bq/Kg with an average 58.174 Bq/Kg., and ^{40}K ranged from 252.568 Bq/Kg to 402.706 Bq/Kg with an average 345.636 Bq/Kg.

3.2Hazard Indices

The calculated of the absorbed dose rates, annual effective dose equivalent, radium equivalent calculation, external hazard index and gamma index are illustrated in table (2) and figure (6).

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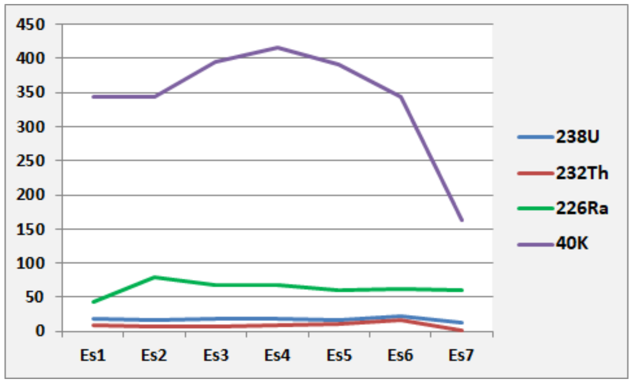

Fig.3: Linear diagram showing the distribution of ^{238}U, ^{232}Th, ^{226}Ra and ^{40}K in the surface studied samples of Sharm El Loul beach.

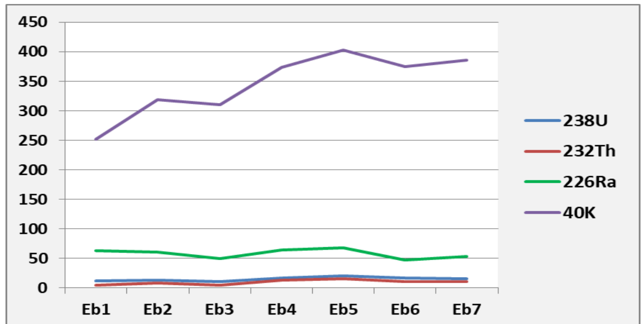

Fig. 4: Linear diagram showing the distribution of ^{238}U, ^{232}Th, ^{226}Ra and ^{40}K in the deep studied samples of Sharm El Loul beach.

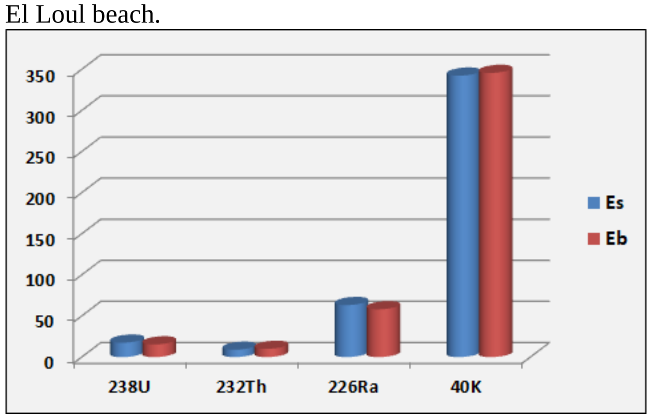

Fig. 5: Bar diagram showing the comparison in activity concentrations between surface and deep studied samples of Sharm El Loul beach.

Table 2: The values of absorbed doses rate (D_{out}), the annual effective doses (E_{out}), Radium equivalent activity (Ra_{eq}), external hazard index (H_{ex}) and radioactivity level index ($I\gamma$) for the studied samples of Sharm El Loul beach.

Samples at the Surface (Es)					
S.no.	$D_{(out)}$	$E_{(out)}$	Ra_{eq}	H_{ex}	I_{γ}
Es1	76.782	0.0941	168.65	0.455	1.169
Es2	86.117	0.1055	192.015	0.518	1.31
Es3	81.463	0.0998	181.12	0.489	1.245

Es4	64.547	0.0791	144.42	0.390	0.99
Es5	60.938	0.0747	136.04	0.367	0.93
Es6	76.331	0.0935	168.29	0.454	1.158
Es7	55.487	0.068	153.305	0.414	1.043
Min.	55.487	0.068	136.040	0.367	0.93
Max.	86.117	0.1055	192.015	0.518	1.31
Aver.	71.666	0.0878	163.406	0.441	1.121
Samples at the depth (40cm.) (Eb)					
S.no.	$D_{(out)}$	$E_{(out)}$	Ra_{eq}	H_{ex}	I_Y
Eb1	84.844	0.1040	187.53	0.506	1.295
Eb2	78.188	0.0958	173.44	0.468	1.194
Eb3	73.701	0.0903	162.94	0.440	1.124
Eb4	62.618	0.076	139.91	0.377	0.960
Eb5	64.573	0.079	144.55	0.390	0.990
Eb6	69.962	0.0857	161.45	0.436	1.112
Eb7	52.565	0.0644	153.31	0.414	1.043
Min.	52.565	0.0644	139.91	0.377	0.960
Max.	84.844	0.1040	187.53	0.506	1.295
Aver.	69.493	0.0850	160.45	0.433	1.103

3.2.1The Absorbed Dose Rates (D_{out} (nGy/y))

The absorbed dose rate in air due to terrestrial gamma rays at 1m above the surface of the earth was calculated, for the studied stations according to the following equation [7].

$$D_{out} = C_{Ra}\,A_{Ra} + C_{Th}\,A_{Th} + C_k\,A_k \; \dots\dots\dots \quad (2)$$

Where: C_{Ra},C_{Th} and C_k, are conversion factors (μGy/h) of ^{226}Ra, ^{232}Th and ^{40}K., while, A_{Ra}, A_{Th} and A_K are the activity concentrations in Bq/kg.

The calculated values of absorbed dose rate of the studied samples are ranged from 55.487 to 86.117 with an average 71.666 (μGy/h) for the surface samples and they are ranged from 52.565 to 84.845 with an average 69.493(μGy/h) for the deep samples.

3.2.2 Annual Effective Dose Equivalent (E_{out})

It was calculated using conversion factor recommended by the UNSCEAR 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, the annual effective dose equivalent (AEDE) can be calculated according the following equation [1].

*A*EDE (mSv yr^{-1}) = D_{out} (nGy h^{-1}) x T (hs in 1 yr) x Q (coff.) x Qf x 10^{-6} …..(3)

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 E_{out} indices measure the risk of stochastic and deterministic effects in the irradiated individuals [8].

The annual effective dose equivalent (E_{out}) is ranged from 0.068 to 0.1055 with an average 0.0878 (mSv yr^{-1}) for the surface samples, while it is ranged from 0.0644 to 0.1040 with an average 0.0850 (mSv yr^{-1}) for the deep samples.

3.2.3 Radium Equivalent Calculation (Ra_{eq})

It is a widely hazard index used when comparing the specific activity of the samples which containing different amounts of ^{226}Ra, ^{232}Th and ^{40}K. It is supposed that 370 Bq kg^{-1} of ^{226}Ra, 259 Bq kg^{-1} of ^{232}Th, and 4810 Bq kg^{-1} of ^{40}K produce the same γ-radiation dose rate [9], [7], by the following equation;

$$\mathbf{Ra_{eq}} = \left(\frac{\mathbf{C_{Ra}}}{\mathbf{370}} + \frac{\mathbf{C_{Th}}}{\mathbf{259}} + \frac{\mathbf{C_K}}{\mathbf{4810}}\right) \times \mathbf{370} \dots.. \quad (\mathbf{4})$$

Where; C_{Ra}, C_{Th} and C_K are the activity concentrations (Bq/Kg) of ^{226}Ra, ^{232}Th and ^{40}K, respectively.

The radium equivalent calculation (Ra_{eq}) is ranged from 136.040 to 192.015 with an average 163.406 for the surface samples, while it is ranged from 139.91 to 187.53 with an average 160.45 Bq kg^{-1} for the deep samples.

3.2.4 External Hazard Index (H_{ex})

To limit the annual external gamma-ray dose from materials to1.5 μSv/y for the studied samples, the external hazard index (H_{ex}) is given by the following equation [10].

$$H_{ex} = \left(\frac{C_{Ra}}{370} + \frac{C_{Th}}{259} + \frac{C_K}{4810}\right) \le 1 \quad \dots\dots\dots \quad (5)$$

The external hazard index (H_{ex}) is ranged from 0.367 to 0.518 with an average 0.4415 for the surface samples, while it is ranged from 0.377 to 0.506 with average 0.443 (mSv/y) for the deep samples.

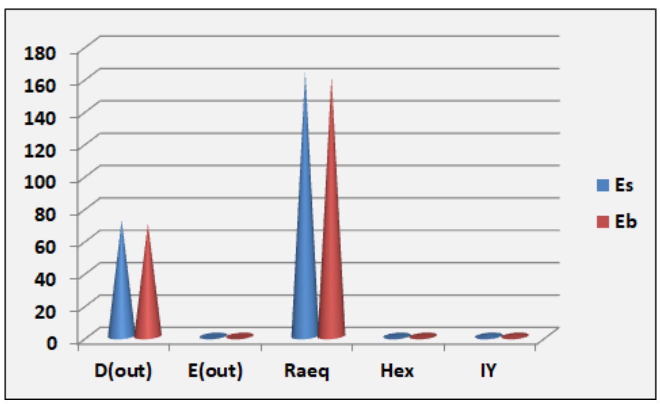

Fig. 6: Bar diagram showing the distribution of D_{out}, E_{out}, Ra_{eq}, H_{ex} and I_y for the studied samples of Sharm El Loul beach.

3.2.5 Gamma Index (I_γ)

The other indices were suggested by a group of experts of OECD'S Nuclear Energy Agency for the external γ–radiation due to different combination of specific natural activities in a sample. A gamma index was used as proposed by the European Commission equation [11].

$$I_\gamma = \frac{C_{Ra}}{150} + \frac{C_{Th}}{100} + \frac{C_K}{1500} \ldots\ldots\ldots\ldots\ldots (6)$$

The Gamma Index (I_γ) is ranged from 0.93 to 1.31 with an average 1.121 for the studied surface samples, while it is ranged from 0.960 to 1.259 with an average 1.103 (μSv/y) for the deep samples.

The concentrations of the NORM in various types of sand from different region of the world for comparison with the present work are listed in Table (3).

3.3 Mineralogy

The reminder of the all collected bulk samples were mixed to be one sample and soaked in water and treated with a mixture of stannous chloride and hydrochloric acid to cleaning of the grains from any coating of carbonates or oxides, or even oxyhydroxides (Milner, 1962). Using one kilogram (1kg) weight sample (Table 4) to be sieved into three parts; > 0.5mm, 0.50-0.125mm & < 0.125mm, and weighting for further treatments.

The fraction (0.5-0.125mm) was subjected to heavy minerals separation using the bromoform liquid (sp.gr.=2.85gm/cm^3) to separate the heavy mineral fraction from the light mineral fractions. The obtained data are listed in table (5).

Table 3: Concentrations of ^{232}Th, ^{226}Ra, ^{40}K, D_{out}, E_{out}, Ra_{eq}, H_{ex}, and I_y in sand samples from Sharm El Loul beach and other studies in different beaches of the world.

Location	^{232}Th Bq.kg^{-1}	^{226}Ra Bq.kg^{-1}	^{40}K Bq.kg^{-1}	D_{out} μGy/h	E_{out} μSvy^{-1}	Ra_{eq} Bq.kg^{-1}	H_{ex} μSv/y	I_y μSv/y	Ref.
Sharm El Loul beach, Egypt	9.461	60.72	343.963	70.58	0.086	161.93	0.437	1.11	Present work
Safaga beach, Egypt	106.3	87.5	33.9	-	251	501	0.85	-	[13]
Dois Rios beach, Southeastern Brazil	12–87	6 –78	269 – 527						[14]
Northeast Coast, Spain	5 – 44	5 –19	136 – 1087						[15]
Ullal, India	1842	374	158						[16]
Costal sand, Egypt	44–96	32–64	96–102						[17]
Beach sand, Al-Maidan, North Sinai, Egypt	146	108	77						[18]
Beach sand, Al-Massaid, North Sinai, Egypt	32.7	27.6	87.9						[18]
Seabed sand, Tuen Mun Hong Kong	29.8	27.7	1210						[19]
Coastal Karnataka	489.6	249	55						[20]
Global average soil (UNSCEAR)	32	45	420	59	0.07	370	≤1	0.3	[1]

Table 4: Weight of heavy concentrates (1kg) after sieving and separation by bromoform of the studied sand beach at Sharm El Loul, Southeastern Desert.

Weight of heavy concentrates (gram) after sieving of 1kg (>0.50mm)	Weight of heavy concentrates (gram) after sieving of 1kg(0.50-0125mm)	Weight of heavy concentrates (gram) after sieving of 1kg (<0.125-mm)	Weight of heavy concentrates (gram) after separation by bromoform (0.50-0.125mm)
875	50	43	2.9
875	50	43	2.9

Table 5. Percentages of light and heavy minerals of the studied heavy concentrates (0.50-0.125mm), of the studied sand beach at Sharm El Loul, Southeastern Desert.

Light concentrates %	Heavy concentrates %
94	5.8

The heavy fractions were subjected to magnetic separation by using a Frantz isodynamic separator, which separate the heavy fraction into; magnetic and nonmagnetic minerals. The loose sediments consist of light and heavy constituents, but the light mineral constituents are feldspar, quartz, and lithic fragments, while the heavy minerals contain Ilmenite, Rutile, Magnetite, zircon, monazite, Uranothorite, and Apatite. The heavy minerals reflect the nature of source rock area because different rock types contain different heavy mineral associations.

The following results (Table 6) about the identified important minerals in the studied samples at Sharm El Loul beach which they are seen by the binocular microscope.

Table 6: Summarized reordered minerals of the studied sand beach at Sharm El Loul, Southeastern Desert.

Minerals	Some characteristics
Ilmenite ($FeTiO_3$)	Represents the major mineral constituent of the total mineral assemblages of the studied area. Under binocular stereomicroscope, ilmenite grains appear to be sub-angular to angular due to the short-distance transportation.
Rutile (TiO_2)	Occurs as tetragonal prisms with rounded pyramidal terminations, it is constitutes about 0.25 wt% of the original raw sand (reaching 3 % of the total minerals of Sharm El Loul beach sands.
Magnetite (Fe_3O_4)	Is a second abundant mineral constitutes about 15% of the total minerals. Magnetite is a black to fine-medium grained with cluster aggregates of angular to sub-angular grains.
Zircon ($ZrSiO_4$)	Is colorless with internal shades of reddish brown, orange, rosy, brown and deep red color due to iron oxide stains. Another zircon crystal reflects metamictic and zoned zircon grains due to radioactive decay.
Monazite **[(LREE, Th) PO_4]**	Occurs as reddish brown prismatic crystals. Thorium is usually exists in monazite in substitution for the REE.
Uranothorite **$(U,Th,Y)SiO_4$**	Is a dark brown grains with a resinous or greasy luster and it is non-magnetic but recovered from the weakly magnetic fraction due to its iron content.
Apatite **$\{Ca_4[(Ca,F,Cl,OH])(PO_4)^3\}$**	Exists as a minor constituent, colorless to pale yellow, transparent, and rounded grains.

4 Conclusions

The average of the activity concentrations at Sharm El Loul beach are 9.461& 343.963 for ^{232}Th and ^{40}K, respectively, this mean they are lower than the permissible values of Global average soil. The ^{232}Th concentration lower while the ^{40}K concentration is higher than Safaga beach, Egypt.

The average concentration of ^{226}Ra (60.7195) is higher than the permissible value of Global average soil, and lower than Safaga beach, Egypt.

The average calculated value of D_{out} (70.58 nGy/h) is higher than permissible value of Global average soil.

The obtained average concentration of E_{out} (0.086 mSv/yr) show that the studied samples of Sharm El Loul beach is higher than the permissible value of Global average soil and it is lower than Safaga beach, Egypt.

The average value of Ra_{eq} (161.93 Bq/kg) for the studied samples are lower than the permissible limit of Global average soil, and OECD safe limit (370 Bq/kg), as well as than Safaga beach, Egypt.

The obtained average value of H_{ex} (0.437) is lower than the permissible value of Global average soil and then Safaga beach, Egypt.

The average value of I_γ (1.112 mSv/y) in the studied samples is higher than the permissible value of Global average soil.

Sharm El Loul beach is a safe area for tourist activities and the obtained results may be used to collaborate in the development of reference levels of natural radioactivity at the Red Sea coast.

References

[1] UNSCEAR "United Nations Scientific Committee on the Effect of Atomic Radiation", Effects of atomic radiation to the general assembly. New York, United Nations (2000).

[2] IAEA, "International Atomic Energy Agency" "Preparation and Certification of IAEA Gamma Spectrometry Reference Materials, RGU-1, RGTh-1 and RGK-1"International Atomic Energy Agency. Report-IAEA/RL /148 (1987).

[3] Anjos, R. M., Veiga, R., Soares, T., Santos, A. M. A., Aguiar J. G., Frascá, M. H. B. O., Brage, J. A. P., Uzêda, D., Mangia, L., Facure, A., Mosquera, B., Carvalho, C. and Gomes, P. R. S. " Natural Radionuclide Distribution in Brazilian Commercial Granites", Radiation Measurements, **39**, 245-253 (2005).

[4] Turhan, S. and Gunduz, L. "Determination of Specific Activity of 226Ra, 232Th and 40K for Assessment of Radiation Hazards from Turkish Pumice Samples", Journal of Environmental Radioactivity., **99**, 332-342 (2008).

[5] Technical Reports Series, No.295 (1989): "Measurement of Radionuclides in Food and the Environment", A Guidebook, IAEA, Vienna -Austria.

[6] Tsoulfanidies, N. "Measurement and Detection of Radiation", (MC Graw-Hill Book Company, Chap), ch. 16 (1983).

[7] Wedad Rayif Alharbi, Adel G. E. Abbady and A. El-Taher., Radon Concentrations Measurement for groundwater Using Active Detecting Method American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)., **14(1)**, 1-11(2014).

[8] Hany A., Shousha, M. R., Atta, A. A., Bakhit, H. M., Diab, A. A. El Hagg and Samah Dahy "Natural Radioactivity Assessment and the associated radiological Hazards for Beach Sand, Baltim Area, Egypt" Al-Azhar Bulletin of Science., **30(1)**, 37-47 (2019).

[9] J. Beretka & P.J Mathew Natural radioactivity of Australian building materials, industrial wastes and byproducts. Health Physics., **48**, 87-95(1985).

[10] S Alashrah and Atef El-Taher., Assessing Exposure Hazards and Metal Analysis Resulting from Bauxite Samples Collected from a Saudi Arabian Mine. Polish Journal of Environmental Studies., **27 (3)**, 959-966(2018).

[11] European Commission of Radiation Protection RP112. EC Radiological protection principles concerning the natural radioactivity of building materials (1999).

[12] OECD, "Organization for Economic Cooperation and Development" "Exposure to Radiation from the Natural Radioactivity in Building Materials", Report by a Group of Experts, of OECD Nuclear Energy Agency, Paris, France (1979).

[13] M. A. M. Uosif. A. El-Taher, A. and Adel G.E Abbady, Radiological significance of beach sand used for Climatotherapy from Safaga, Egypt, Radiation Protection Dosimetry., **131(3)**, 331–339 (2008).

[14] Abdulaziz Alharbi and A. El-Taher., Measurement of Natural Radioactivity and Radiation Hazard Indices for Dust Storm Samples from Qassim Region, Saudi Arabia. Life Science Journal., **11(9)**, 236-241(2014).

[15] F Alshahri, Atef El-Taher and AEA Elzain., Measurement of radon exhalation rate and annual effective dose from marine sediments, Ras Tanura, Saudi Arabia, using CR-39 detectors. Romanian Journal of Physics., **64**, 811, (2019).

[16]- Radhakrishna, A. P., Somashekarappa, H. M., Narayana, Y. and Siddappa, K. A new natural background radiation area on the southwest coast of India. Health Phys., **65(4)**, 390–395(1993).

[17]- Ibraheim, N. M., A., El Ghani, A. H., Shawky, S. M., Ashraf, E. M. and Farouk, M. A. Measurement of radioactivity levels in soil in the Nile Delta and Middle Egypt. J. Health Phys., **64(6)**, 620– 627(1993).

[18] Seddeek, M. K., Badran, H. B., Sharshar, T. and Elnimr, T. Characteristics, spatial distribution and vertical profile of gamma-ray emitting radionuclides in the coastal environment of North Sinai. J. Environ. Radioact., **84**, 21–50 (2005).

[19] F. Alshahri, Atef El-Taher and Abd Elmoniem Ahmed Elzain., Characterization of Radon Concentration and Annual Effective Dose of Soil Surrounding a Refinery Area, Ras Tanura, Saudi Arabia. Journal of Environmental Science and Technology., **10(6)**, 311-319 (2017).

[20] Narayana, Y., Somashekarappa, H. M., Radhakrishna, A. P., Balakrishna, K. M. and Siddappa, K. External gamma radiation dose rates in coastal Karnataka. J. Radiol. Prot., **14**, 257–264 (1994).