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Test of the Null Hypothesis on the Radiation Hazards of the Random Public Uses of the Black Sand Dunes at Baltim Area

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Abstract: *The sand dunes at Baltim area are consumed by the local public in three main activities; manufacturing of building bricks, fill-up of buildings and roads and uplifting the agricultural areas. The expected high concentrations of the terrestrial radionuclides; ^{238}U, ^{232}Th and ^{40}K in these sands lead to the null hypothesis:*

H_0: The random uses of the sand dunes at Baltim area cause high radiation hazards to the local public.

Physically, the effective doses received by the public at Baltim area due to the three proposed activities were estimated and found to be less than the worldwide effective doses arising from the terrestrial radionuclides.

Accordingly, no argument to enforce the local public to stop consuming the sand dunes at Baltim area in the studied activities depending on the expected radiation hazards. Alternatively, enlightenment and education programs to the local public at Baltim area in the scope of the sustainable development may be more effective to save this important resource.

Keywords: *Baltim, Black sands, Effective dose, Public exposures*

1. Introduction

The Egyptian black sands occur along the northern coastal plain from Abu Qir in the west to Rafah in the east. They consider one of the important minerals resources in Egypt. The detritus of these deposits were originally derived from the metamorphic rocks composing the Ethiopian plateau, beside the minor contribution from the igneous rocks of the south Sudan and the Red Sea mountains range. They consist of heavy economic minerals such as magnetite, ilmenite, hematite, zircon, rutile, monazite and garnet beside other gangue minerals called the green silicates. Magnetite and ilmenite is the main constituent in the heavy economic part. Minor traces of heavy economic minerals like casseterite, gold and sillimanite are present.

The sand dunes at Baltim area contains two radioactive minerals; monazite and zircon which have high concentrations of the radioactive nuclides ^{238}U and ^{232}Th with the members of their decay chains beside the non-series radioactive nuclide ^{40}K. The activity concentration of ^{238}U may be as high as 8 and 13 kBq/kg in zircon and monazite, respectively, while ^{232}Th may go up to 32 kBq/kg in monazite (El Afifi et. al., 2006). However, the percentage concentration of monazite and zircon in the raw sands at Baltim area is only 0.1% (Bakhit, 2004). The resultant activity concentration of ^{238}U and ^{232}Th in the sands at Baltom dunes may reach 260 and 411 Bq/kg, respectively (El Afifi et. al., 2006). These concentrations are higher than the worldwide average of both ^{238}U and ^{232}Th which were reported to be 32 and 40 Bq/kg respectively.

Some studies concerning the radioactive emanation of these sands and its impact on the inhabitant through air were done on Abu Khashaba beach where the main heavy mineral concentrations as well as the physical dressing pilot plant of the beach sands were studied (Barakat, 2008, Abdel-Razek et. al., 2012, Nasr, 2012, Abdel-Razek et. al., 2013, Abdel-Razek et. al., 2014).

It has been proven statistically that the sand dunes at Baltim area are consumed by the local public in three main activities; manufacturing of building bricks, fill-up of buildings and roads and uplifting the agricultural areas (Abdel-Razek et. al., 2013).

The high activity concentration of the terrestrial radionuclides in the sand dunes at Baltim area along with the greedy random activities of the local public that consume these sands lead to a null hypothesis H_0 which states that these activities result in higher radiation hazards in the area. Accordingly,

H_0: The random uses of the sand dunes at Baltim area cause high radiation hazards to the local public.

The null hypothesis about the radiation hazards due to the random uses of the sand dunes at Baltim area will be tested physically by evaluating the radiation exposures arising from these uses at the studied area.

2. Experimental Methods

2.1. Field Works

To test the null hypothesis H_0 that the regular uses of the sand dunes at Baltim area cause high radiation hazards to the local public, ten locations over the studied area were chosen to carry out the test. However, these locations covered roads filled with the blac sands and agricultural areas uplifted with these sands, Fig. (1). Three building bricks were collected from each location. All bricks were ground and splitted by quartering using Jon's splitter to get a representative samples for different investigations.

The outdoor effective dose rates received by the members of public from γ-rays were measured next to the same locations. Also, the outdoor concentrations of radon and thoron gases were measured. Indoor effective dose rates from γ-rays were measured inside the ground level of then buildings at Baltim resort along with the indoor concentrations of radon and thoron gases, Fig. (2).

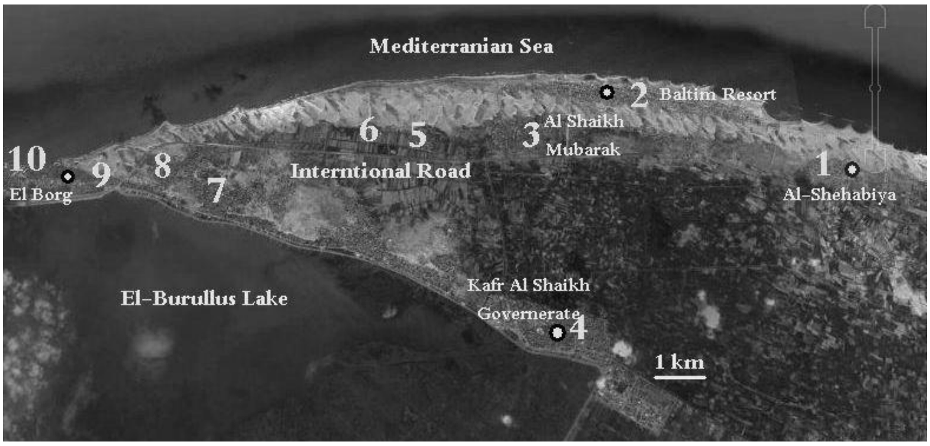

Fig1. *Baltim Area. The Numbers Declare the Location of the Collected Brick Samples and the Outdoor Measurements*

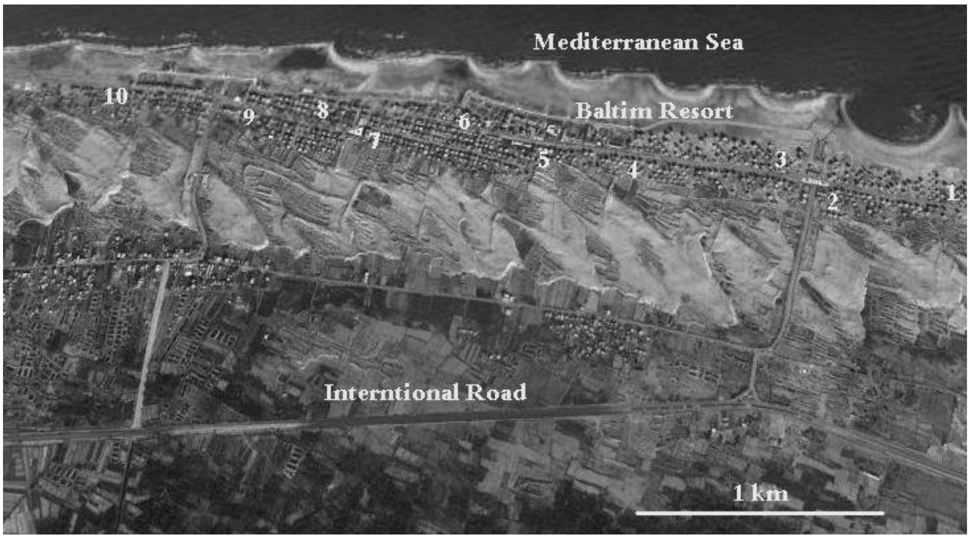

Fig2. *Location of 10 Buildings at Baltim Resort Chosen to Estimate the Indoor Radiation Exposures*

2.2. Activity Concentrations of the Terrestrial Radio Nuclides in the Building Bricks by Radiometric Measurements

About 300-350g from each sample was packed in a plastic container, sealed well and stored for about 30 days before analysis. This prevents the escape of radiogenic gases ^{222}Rn and ^{220}Rn and allows the in-growth of uranium ^{238}U and thorium ^{232}Th decay products to reach secular equilibrium. After attainment of secular equilibrium, each of the prepared samples was measured in the laboratory for their U, Th, Ra and K contents using a high efficiency multichannel analyzer of γ-ray spectrometer (NaI detector). Each sample was counted for 1000s. The radiometric measurement for the studied radionuclides was carried out through four energy regions of interest (ROIs). Since uranium and thorium are not γ-emitters, they were measured indirectly through the γ-ray photons emitted from their decay products, ^{234}Th (81-108keV) for ^{238}U, ^{212}Pb (221-273keV) for ^{232}Th, and radium was measured from the γ-ray photon emitted by ^{214}Pb (327-390keV) whereas potassium was measured directly from the γ-ray photon emitted by ^{40}K (1319-1471keV). Consequently, they are expressed as equivalent U (eU), equivalent thorium (eTh) and equivalent radium (eRa). The chosen energy regions for U, Th, Ra and K were determined from the indicated energy lines of the spectra generated by means of laboratory uranium, thorium, radium and potassium reference standard samples provided by the IAEA.

This technique was carried out at laboratory of γ-ray spectrometry of the Egyptian Nuclear Materials Authority (ENMA). Its probable measurement error was about 10% (Matolin, 1991).

The values of eU and eTh in ppm as well as K in percent were converted to activity concentrations, (Bq/kg), using the conversion factors given by the International Atomic Energy Agency (IAEA, 1989). The activity concentration of a sample containing 1 ppm by weight of ^{238}U is 12.35 (Bq/kg), 1 ppm of ^{232}Th is 4.06 (Bq/kg) and 1 % of ^{40}K is 313 (Bq/kg).

2.3. Check of the Heavy Minerals in the Building Bricks at Baltim Area

To check the existence of heavy minerals in the building bricks as an evidence that the members of public at Baltim area use the black sands at the studied area in the building materials, 50g sample was put in a carrot shape funnel (250cm^3). Bromoform (sp. Gr. 2.85 gm/cm^3) was added to the sample in a quantity enough to make the solid/liquid ratio suitable to give a complete freedom for all the particles to sink or float. After a suitable time at rest, the sample was separated into a float layer and a sink layer with clear liquid layer in-between. The sink of the total heavy fraction was taken on filter paper in a precipitating funnel and the float or the light fraction was taken on another filter paper in another precipitating funnel. After complete filtration, the remaining bromoform in the bore spaces of mineral grains and the thin film coating the grains of both heavy and light fractions was washed with acetone. Both light and heavy fractions were dried and weighed. Mineral grains were investigated under microscope at magnification 40X (Bakhit, 2004).

2.4. Measurements of External Effective Dose Rate

The effective dose rates (μSv/h) due to γ-ray exposures were directly measured at 1m over the road or the agricultural area or inside the building, using ALNOR RDS-100 gamma survey meter. This device was calibrated against a ^{60}Co γ-source of activity 7.4 x10^8 Bq at the National Institute of Standards and Technology (NIST). The annual external effective dose is calculated using an occupancy factor of 0.2 outdoors (out) and 0.8 indoors (in) (UNSCEAR, 2000).

2.5. Concentration of Radon and Thoron Gases

Radon and thoron gases were measured at 1m over the road or the agricultural area or inside the building. At each of these locations, an air sample was withdrawn though a filter by a SARAD radon monitor. The concentration of radon gas C_{Rn} and thoron gas C_{Tn}, (Bq/m^3), in the air at this location is displayed on the radon monitor after one hour.

The annual effective doses due to the inhalation of radon and thoron gases and their decay products are calculated as follows (UNSCEAR, 2000):

$$E_{Rn,\,out}\ (\text{mSv/y}) = C_{Rn,\,out}\ (\text{Bq m}^{-3}) \times 0.4 \times 8760\ \text{h} \times 0.2 \times 9\ \text{nSv}\ (\text{Bq h m}^{-3})^{-1} \quad (1)$$

$$E_{Tn,\,out}\ (\text{mSv/y}) = C_{Tn,\,out}\ (\text{Bq m}^{-3}) \times 0.01 \times 8760\ \text{h} \times 0.2 \times 40\ \text{nSv}\ (\text{Bq h m}^{-3})^{-1} \quad (2)$$

$$E_{Rn,\,in}\ (\text{mSv/y}) = C_{Rn,\,in}\ (\text{Bq m}^{-3}) \times 0.6 \times 8760\ \text{h} \times 0.8 \times 9\ \text{nSv}\ (\text{Bq h m}^{-3})^{-1} \quad (3)$$

$$E_{Tn,\,in}\ (\text{mSv/y}) = C_{Tn,\,in}\ (\text{Bq m}^{-3}) \times 0.03 \times 8760\ \text{h} \times 0.8 \times 40\ \text{nSv}\ (\text{Bq h m}^{-3})^{-1} \quad (4)$$

3. Results and Discussion

3.1. Zircon Mineral in the Building Bricks

The grains of the grounded building bricks were investigated under microscope. Figure (3) shows zircon grains separated from the grounded bricks. Since zircon doesn't appear in the ordinary white sands, this represents evidence that the sands consumed to make the studied building bricks are originated from the black sands.

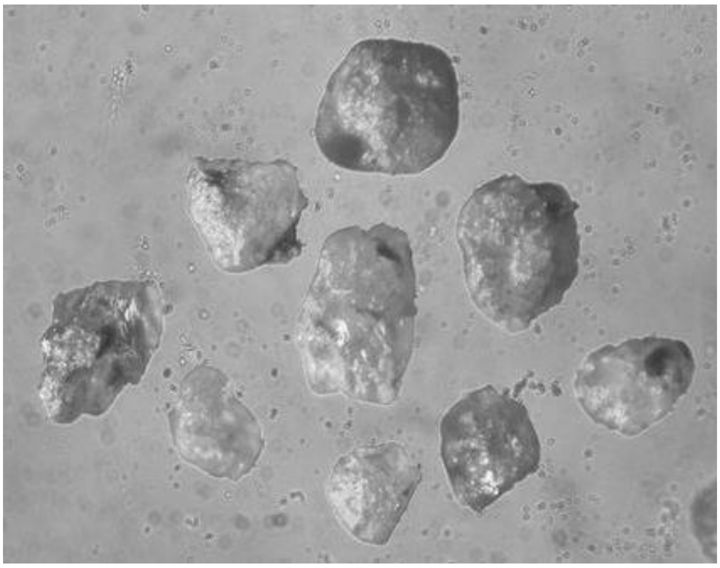

Fig3. *Zircon Grains Separated from Building Bricks at Baltim Area*

3.2. Activity Concentration in Building Bricks

It is reported that the activity concentrations of 32, 40 and 400 Bqkg for ^{238}U, ^{232}Th and ^{40}K, respectively, in the building materials result in an average total effective dose of 1.5 mSv/y for the public (UNSCEAR, 2000).

Table (1) represents the activity concentration of the terrestrial radionuclides ^{238}U, ^{232}Th and ^{40}K (Bq/kg) in the studied building bricks. The table clarifies that the activity concentrations of the studied radionuclides in the building bricks are lower than the reported worldwide concentrations. Accordingly, the expected effective doses from the investigated building bricks will be lower than 1.5 mSv/y.

Table1. *Activity Concentration of the Radionulides; ^{238} U, ^{232} Th and ^{40} K (Bq/kg) in the Building Bricks Collected from 10 Locations at Baltim Area*

No.	^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)
1	12.35	36.54	172.2
2	37.05	20.3	175.3
3	24.7	20.3	153.4
4	BDL	20.3	237.9
5	49.4	20.3	212.8
6	49.4	28.42	68.86
7	61.75	28.42	137.7
8	BDL	24.36	BDL
9	49.4	28.42	316.1
10	37.05	16.24	BDL
Ave.	32.11	24.36	147.4

3.3. Exposures Due to Fill-Up of the Roads and Uplifting the Agricultural Areas

This exposure is an outdoor one. Table (2) represents the outdoor exposures from the different terrestrial sources. It is clear that the average activity concentration of ^{222}Rn in the outdoor air is 3 Bq/m^3 and the associated internal effective dose is 0.019 mSv/y, while the average activity concentration of ^{220}Rn was 2 Bq/m^3 with an effective internal dose of 0.001 mSv/y.

Table2. *Outdoor Concentration of ^{222}Rn, C_{rn} and ^{220}Rn, C_{tn} (Bq/M^3), Outdoor External Effective Dose Rate (µsv/H) and the Total Outdoor Effective Doses due the Random Uses of Black Sand Dunes at Baltim Area*

No.	$C_{Rn, out}$ (Bq/m^3)	$C_{Tn, out}$ (Bq/m^3)	$E_{ex, out}$ (µSv/h)	$E_{Rn, out}$ (mSv/y)	$E_{Tn, out}$ (mSv/y)	$E_{ex, out}$ (mSv/y)	E_{out} (mSv/y)
1	6	8	0.032	0.038	0.006	0.056	0.100
2	BDL	BDL	0.03	0.000	0.000	0.053	0.053
3	BDL	BDL	0.03	0.000	0.000	0.053	0.053
4	6	BDL	0.028	0.038	0.000	0.049	0.087
5	6	6	0.028	0.038	0.004	0.049	0.091
6	BDL	BDL	0.032	0.000	0.000	0.056	0.056
7	6	BDL	0.03	0.038	0.000	0.053	0.090
8	BDL	BDL	0.031	0.000	0.000	0.054	0.054
9	6	6	0.028	0.038	0.004	0.049	0.091
10	BDL	BDL	0.032	0.000	0.000	0.056	0.056
Ave.	3	2	0.0301	0.019	0.001	0.053	0.073

The average external effective dose outdoor at Baltim area due to the exposure to terrestrial gamma rays was found to be 0.05 mSv/y. The corresponding worldwide average of the effective dose due to each source of exposure is 0.065, 0.008 and 0.07 mSv/y for ^{222}Rn, ^{220}Rn and the external gamma rays, respectively (UNSCEAR, 2000).

The total annual outdoor effective dose E_{out} (mSv/y) is obtained according to the equation:

$$E_{out} = E_{ex, out} + E_{Rn, out} + E_{Tn, out} \quad (5)$$

From Table (2), E_{out} has an average value of 0.073 (mSv/y) which is almost half the worldwide average of 0.142 (mSv/y). Indeed, this leads to the fact that the hypothesis that the use of the sand dunes at Baltim area in the fill-up of the roads and uplifting the agricultural areas cause high radiation hazards has no significance.

3.4. Exposures Due to Fill-Up of the Buildings

Radon gas diffuses through the cracks in the floors of the ground levels in the buildings that use filling materials of high radium content and increases the radon concentration in the air at these ground levels. In this study, the effective doses indoors of the ground level in ten buildings at Baltim resort were estimated, Fig. (2). Table (3) represents the indoor activity concentration of both radon and thoron gases, $C_{Rn, in}$ and $C_{Tn, in}$, Bq/m^3, respectively. Table (3) also represents the external effective dose rate µSv/h in the ground level inside the chosen buildings at Baltim area. These buildings were considered to have used the black sands as fill-up.

Table3. *Indoor Concentration of ^{222}Rn and ^{220}Rn (Bq/M^3), Indoor External Effective Dose Rate (µsv/H) and the Total Effective Doses Due the Random Uses of Black Sand Dunes at Baltim Area*

No.	$C_{Rn, in}$ (Bq/m^3)	$C_{Tn, in}$ (Bq/m^3)	$E_{ex, in}$ (µSv/h)	$E_{Rn, in}$ (mSv/y)	$E_{Tn, in}$ (mSv/y)	$E_{ex, in}$ (mSv/y)	E_{in} (mSv/y)	E_{Tot} (mSv/y)
1	32	10	0.05	1.21	0.084	0.35	1.64	1.72
2	27	BDL	0.05	1.02	-	0.35	1.37	1.44
3	8	10	0.04	0.30	0.084	0.28	0.66	0.74
4	13	BDL	0.05	0.49	-	0.35	0.84	0.91
5	8	BDL	0.05	0.30	-	0.35	0.65	0.72
6	5	6	0.06	0.19	0.050	0.42	0.66	0.73
7	25	BDL	0.04	0.95	-	0.28	1.23	1.30
8	10	BDL	0.05	0.38	-	0.35	0.73	0.80
9	10	BDL	0.05	0.38	-	0.35	0.73	0.80
10	13	10	0.05	0.49	0.084	0.35	0.92	1.00
Ave.	15.1	3.6	0.05	0.57	0.030	0.34	0.94	1.02

From Table (3), the average indoor radon and thoron concentrations in the ground levels at Baltim resort are 15.1 and 3.6 Bq/m^3, which are lower than the worldwide concentrations of 40 and 10, respectively. Accordingly, the annual indoor effective doses due to radon and thoron gases are below the worldwide values of 1.0 and 0.084 (mSv/y).The indoor average effective dose due the external exposure is 0.34 mSv/y which is lower than the worldwide average for public, 0.41 mSv/y.

The total annual indoor effective dose E_{in} (mSv/y) is obtained as follows:

$$E_{in} = E_{ex, in} + E_{Rn, in} + E_{Tn, in} \quad (6)$$

The total annual effective dose E_{Tot} (mSv/y) received by the members of public due to the modes (out and in) and from all terrestrial radiation sources is calculated as follows:

$$E_{Tot} = E_{out} + E_{in} \quad (7)$$

E_{out} is the average value in Table (2), 0.073 (mSv/y). Table (3) represents the values of E_{in} and E_{Tot} inside the studied buildings.

Table (3) indicates that the total effective doses E_{Tot} received by the public at Baltim area due to the random uses of the black sand dunes range from 0.8 to 1.72 mSv/y with an average of 1.02 mSv/y. This average effective dose is lower than the worldwide average effective dose of 1.5 mSv/y (UNSCEAR, 2000).

As a result, the random public uses of the black sand dunes at Baltim area are safe. Accordingly, no argument to enforce the local public to stop consuming these sands in the studied activities depending on the expected radiation hazards. Alternatively, since it was shown that the audience in the study area accepts establishing economic projects to utilize the sand dunes in this area (Abdel-Razek et. al., 2013), enlightenment and education programs to the local public at Baltim area in the scope of the sustainable development may be more effective to save this important resource.

4. Conclusions

The null hypothesis that the random uses of the sand dunes at Baltim area cause high radiation hazards to the local public is rejected. Besides, the random public uses of the black sand dunes at Baltim area were proven to be safe. Accordingly, no argument to enforce the local public to stop consuming these sands in the studied activities depending on the expected radiation hazards. Alternatively, enlightenment and education programs to the local public at Baltim area in the scope of the sustainable development may be more effective to save this important resource.

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References

Abdel-Razek,Y.A., Abu-Diab, A.A. and Bakhit, A.F. (2013): Correlation between the Concentrations of the Heavy Minerals and the Terrestrial Radioactivity at El Massaid and El Kharrouba, Sinai, Egypt. XI Radiat. Phys. And Protect. Conf. Cairo, Nov. 25-28, 2012, Arab J. Nucl. Sci. & Applicat., Vol. 46, 393-404.

Abdel-Razek,Y.A., Abu-Diab, A.A. and Bakhit, A.F. (2014): Effect of Some Physical Properties of The Black Sands On The Radiation Exposures At Mastarouh, North Nile Delta, Egypt. Nucl. Sci. Sci. J., 3, 139-148.

Abdel-Razek , Y.A., El-Kassas, H. I., Al-Mobaid , A.M. and Bakhit, A. A. (2013): Evaluation of the environmental management system of the uses of the black sand dunes at Baltim area J. Env. Res., (2013) Ain Shams Univ., In Press.

Abdel-Razek,Y.A., Said, A.F., Hassan, S.F. and Elsayed, M. A. (2012): On The Occupational Radiation Exposures During Mineral Separation Processes At Rasheed And Abu Khashaba Facilities. Nuclear Materials Authority, NMA-IRS-1/2012, Cairo, Egypt.

Bakhit, A.F., (2004): Mineralogy and Concentration of Economic Heavy Minerals, Northern Delta. Ph.D. Thesies, Cairo University. Cairo, Egypt. 189p.

Barakat, M.S.A. (2008): Radioactivity and Radon Emanation Measurements in Some Natural Samples. M.Sc Thesis, Faculty of Science, Menoufia University, Menoufia, Egypt. pp.86.

El Afifi E.M, Hilal M.a, Khalifa S.M, and H.F. Aly (2006): Evaluation of U, Th, K and emanated radon in some NORM and TENORM samples. 41, 627.

IAEA (1989): Construction and use of calibration facilities for radiometric field equipment. International Atomic Energy Agency, IAEA Technical Reports Series No. 309, IAEA, Vienna.

Matolin, M. (1991): Construction and use of spectrometric calibration pads for laboratory γ-ray spectrometry, NMA, Egypt. Report on Project EGY/4/030- IAEA to the Government of the Arab Republic of Egypt, 14p.

Nasr, Amal S. (2012): Environmental and Biophysical Consideration of Radioactive Elements in Processes of Separation and Concentration of Black Sand Products in Egypt. M.Sc.Thesis, Faculty of Science, Cairo University, 85p.

UNSCESR, (2000): Exposures from natural sources of radiation. United Nations Scientific Committee on the Effects of Atomic Radiation, Report to the General Assembly, Vol. I, Annex B, pp. 83-156.