"Natural Radionuclides Distribution in the black sand –North Coast of Egypt"

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ABSTRACT

The aim of this work is to estimate the effective dose to public in Rasheed (Abu Khashba).The obtained results were compared to IAEA safety Standard and this will be contribute in the establishment of Safety Criteria in the field of mining and milling process. Systematic studies on gamma radiation level and the distribution of natural radionuclides were carried out for the establishment of baseline data on background radiation level and the distribution of radionuclides in the environment of Rasheed seashore, in the north of Egypt, where the black sand cover most of the seashore. The external gamma absorbed dose rates prevailing in the region were measured using (TLD-200). Sixty black sand samples were collected from different locations covers three kilometers of the seashore. Radioactivity of terrestrial radionuclides (^{238}U,^{232}Th,^{226}Ra and ^{40}K) was measured in these samples using gamma ray spectrometry system with an HPGe detector. The activity of ^{238}U was found to vary between 244.6-3660.19 Bq/kg, with a mean value 1509.6, while ^{232}Th varies between 258.02-8294.02Bq/Kg,with a mean value 3274.3. ^{226}Ra varies between 265.05-3906.16 Bq/Kg with a mean value 2085.15Bq/Kg and ^{40}K varies between 233.7-789.36 Bq/Kg with a mean value 603.9Bq/Kg. The contributions of ^{238}U,^{232}Th,^{226}Ra and ^{40}K to the total gamma absorbed dose rate were calculated. The gamma absorbed dose rate estimated using the results of activity concentration of ^{238}U,^{232}Th,^{226}Ra and ^{40}K are found to compare well with that of TLD-200 chips. Personal dosimetry (TLD-100) chips were used to evaluate the dose rate to public (fishers).

Key words: Environment; Natural Radionuclides; TLD; Effective Dose; Black Sand

INTRODUCTION

Environmental radiation exists as a consequence of cosmic radiation, terrestrial radiation, and radiation originating from manmade source. Cosmic radiation reaches the earth from outer space. On its way to the earth's surface, the intensity of this radiation is successively reduced by the atmosphere; hence, its intensity depends on altitude. Terrestrial radiation depends on geological structure and mineral content of the location. Uranium and thorium occur naturally in minute and variable quantities in the earth's crust. They produce a series of daughter products which are present in the surrounding materials in trace amount [1]. These daughter products emit alpha, beta, and gamma radiations contribute significantly to the natural background radiation like cosmic rays, fallout from explosions, etc [2]. Human beings are exposed to these natural radiations
internally and externally [3, 4]. There are few regions in the world known to be high background radiation areas due to local geology and geochemical effects that cause enhanced levels of terrestrial radiation [5, 6]. Very high background radiation areas are found at Guarapari, the coastal region of Espirito Santo and the Morro Do Ferro in Minas Gerais in Brazil [5, 7, 8]; Yangjiang in China [9, 10]; the southwest coast of India [11-14]; Ramsar and Mahallat in Iran [15,16]; in the United State and Canda and in some other countries [6].
The gamma emitting decay products of uranium and thorium series can easily be measured by gamma-ray spectrometry. High Purity Germanium (HPGe) detection systems can resolve and measure the naturally occurring background gamma radiation present in the surrounding materials. Thermoluminescent Dosimeter (TLD-200) used to measure the gamma dose component of environmental radiation. Assessing environmental background radiation is essential to determine the population exposure due to direct radiation. Therefore, with the help of Thermoluminescent dosimeters (TLD), environmental radiation levels at Rasheed seashore were estimated. Thermoluminescent Dosimeter (TLD-100) used to measure the personnel dose rate because its density nearly to the density of human tissue.
This study aimed establishing the baseline data on radiation levels and radionuclide distribution in various environmental matrices of a region are important because such studies would help to assess, in the future, the impact of our scientific and technological activities on the environment. This paper deals with the results of external gamma radiation dose rate measurements, distribution of ^{238}U,^{232}Th,^{226}Ra and ^{40}K and their horizontal profiles (3Km) cover the seashore of Rasheed beach sand. It deals also with the results of outdoor exposure dose to public (fishers).

MATERIALS AND METHODS

Study area

Rasheed area is situated on the bank of the delta Nile river (Nile delta) in the north district of Domyaat government, Egypt. The average annual rainfall in the area during 2000-2007 was 5.5 mm. The climate is humid. The total duration of the rain season is about 6.1 mm, from November to March. The Rosetta black sands have been the subject of many articles [17, 18] and dissertations, as well as technical reports by private firms.

The area surveyed is mostly waved posited beach sands of monazite that emit gamma rays owing to their content of thorium [19]. Monazite crystals are monoclinic and are generally a dull, opaque reddish brown, with hardness about 5.5 and density between 5.1 and 5.2. [19]. The crystals usually separated for commerce are between 0.1 and 0.2 mm in size and are most frequently found with ilmenite and rutile, both of which produce so-called “black sand”. Thus monazite deposite often appear as black streaks on the beach.

Sampling Collection

Samples of black sand were collected from three sampling area following standard techniques (EML 1983). The sampling area covers 3 km. The reasons for selecting this are due to the highly public density during the summer season because the people use the beach for swimming, relaxation, and fishing. The first sampling area (area A) is 5 m from the seashore in the water, the second area (area B) is 10 m from the seashore in the beach, and the third one (area C) is 20m from the seashore in the beach as shown in fig.(1). For sampling from the beach, about 0.5 m^2 area was marked and the top layer of the black sand was taken and weathered surface is removed. A total of 60 samples were collected from three area (A, B, C) all during May 2005 – June 2008.

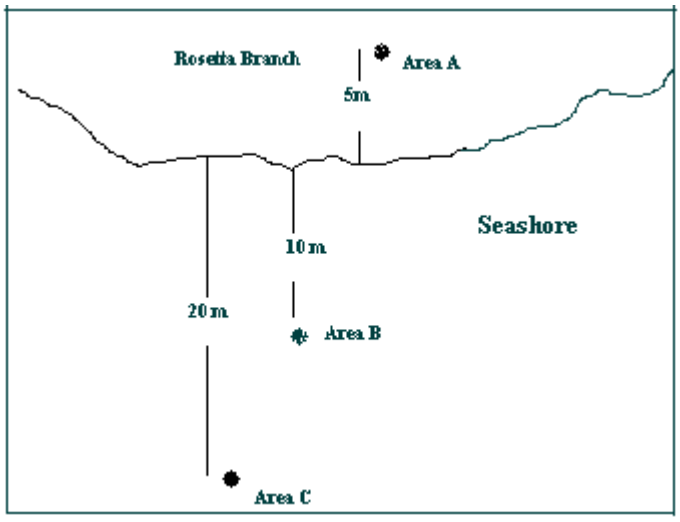

Figure 1. Map of Rosetta Branch showing the collection point of sand samples

Sampling Preparation

All samples were prepared following the standard procedure (EML 1983). Samples were air-dried. After removing the stone and grass, the sampling was shaken in a sieve shaker and particle sizes of < 250 micron factions were obtained. One sample from each area washed using distilled water. Sieved samples were sealed in 100 ml plastic container and carefully sealed for 8 weeks to reach secular equilibrium between ^{232}Th and ^{238}U progeny [20].

Gamma absorbed dose rate measurements

TLD-200 was used in the present study to carry out the gamma radiation level survey. TLD-200 chips were chosen because of their better degree of accuracy, sensitivity and energy independence [21]. Calibration and the determination of TL response per mR ,was done by the batch method [22].An entire batch of dosemeters was annealed together for 1 hour at 400 ^{o}C followed by 2 hours at 100 ^{o}C. Each environmental dosemeters consists of three annealed TLDS chips encased in an opaque plastic capsule. The TLD_s are permanently placed at the surface selected samples. All TLD chips were read out using a TLD reader (Model 4000, victoreen) with a flow of nitrogen at a constant rate. Just before reading, the chips were post-annealed for 10min. at 100 ^{o}C to reduce fading.

RESULT AND DISCUSSIONS

Activity Concentration

The activity concentrations of radionuclides ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in the 60 sand samples considered are presented in Table 1. The values are given in Bq/kg on a dry weight basis. From this table it is clear that, in general, for the first sampling area (area A) the mean average concentration in case of unwashed sand samples are greater than that of washed samples for ^{226}Ra, ^{232}Th and ^{40}K with the exception of ^{238}U the concentrations are nearly equal. For the second sampling area (area B) the mean average concentration of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K (unwashed sand sample) were 1241.5±4.9, 1599.6±5.3, 1465.9±5.1 and 462.7±3.1 Bq/Kg respectively. For the third sampling area (area C) the mean average concentration of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K (unwashed sand sample) were 366.19±6.7, 3906.16±6.9, 8294±8.3 and 721±4.4 Bq/Kg respectively. Generally, the concentration of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in the sampling area C are greater than that for the area A and B.

The interpretation of these results may be due to the area surveyed is mostly waved posited beach sands of monazite that emit gamma rays owing to their content of thorium[(5)] and also some areas in Roseta coast composed of continuous beach sand flat of limestone bedrock with medium sand particles size. Therefore, the region under investigation is pervious to the flow of water, since the sand samples for the areas B and

C were collected from locations mostly in the reach of rapidly spreading water due to the breakage of wave front at the shore. The relatively high radioactivity concentration of ^{226}Ra in the area C is attributed to the existence of dark colored heavy minerals that contain ~2.5 orders of magnitude compared to the area B.

Table 1. The average activity concentration (Bq/Kg) for Rosetta sand samples

Samples Code	Uranium series		Th-232 Bq/Kg	K-40 Bq/Kg
	U-238 (Bq/Kg)	Ra-226 (Bq/Kg)		
I area A	244.6 ± 2.1	265.05 ± 2.6	258.02 ± 2.5	789.38 ± 4.1
II area A	245.8 ± 2.1	304.45 ± 3.1	293.88 ± 3.4	760.2 ± 4.3
III area B	737.5 ± 4.3	1174.03± 4.6	1201.81± 4.3	233.7± 2.1
IV area B	1241.5 ± 4.9	1599.6± 5.3	1456.9± 5.1	462.7± 3.1
V area C	2928.1± 6.3	3851.2± 6.8	8141.19± 8.1	656.19± 4.1
VI area C	3660.19± 6.7	3906.16± 6.9	8294.02± 8.3	721.8± 4.4

Where: I is the washed sand sample from the bottom of the sea (area A)
II is the unwashed sand sample from the bottom of the sea (area A)
III is the washed sand sample 10m from the seashore in the beach (area B)
IV is the unwashed sand sample from 10 m of the seashore in the beach (area B)
V is the washed sand sample 20 m from the seashore in the beach (area C)
VI is the unwashed sand sample 20 m from the seashore in the beach (area C)

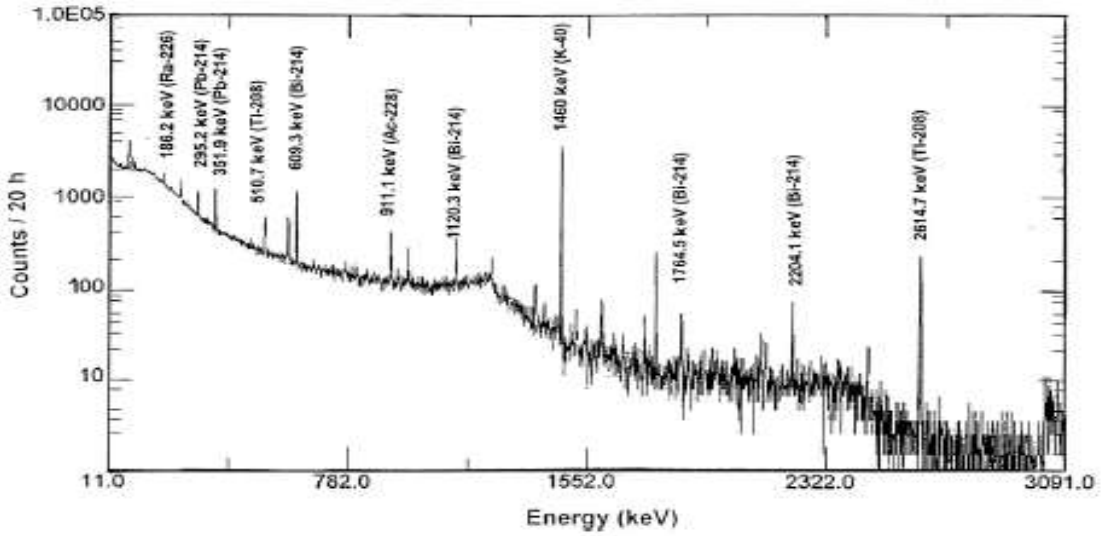

Figure 2. The spectrum of a sample for Rasheed sand

Radium equivalent activity (Ra_{eq}.)

The distribution of ^{226}Ra, ^{232}Th, and ^{40}K in different types of sand is not uniform, so that with respect to exposure to radiation, the radioactivity has been defined in terms of radium equivalent activity Ra_{eq} in Bq/kg to compare the specific activity of materials containing different concentration of radionuclides. Radium equivalent activity (Ra_{eq}), a widely used hazard index, is calculated by:

$$Ra_{eq}(Bq\ kg^{-1}) = A_{Ra^{226}} + 1.43A_{Th^{232}} + 0.077A_{K^{40}}$$

Where A_{Ra} is the specific activity of ^{226}Ra (which is the same as that of ^{238}U) in Bq kg^{-1}, A_{Th} is the specific activity of ^{232}Th in Bq kg^{-1}, and A_K is the specific activity of ^{40}K in Bq kg^{-1}.

The average value of radium equivalent in Bq/kg, dose rate in nGy/h, external hazards in mGy/y are shown in table 2.

Table 2. The average activity concentration (Bq/Kg) and Dose rate for Rosetta sand samples

Samples Code	Ra_{eq} (Bq/Kg)	Dose rate(nG/h)	External hazards (mGy/y)
I area A	673.92	309.197	1.821
II area A	724.11	332.192	1.957
III area B	2472.34	1120.56	6.680
IV area B	3358.38	1514.48	9.770
V area C	14608.85	6667.983	39.483
VI area C	15564.31	7084.58	42.066

TLD Reading

TLD – 200 chips were put 30 days with unwashed and washed black sand samples area A, B and C in small boxes sealed. The conversion factor to convert the TLD reading from (nC) to (uSv/h) is 0.029 mSv/nC.

Table (3): TLD-200 reading and the dose rate which reaching to people from black sand in 3 monthes.

Samples	TLD -200 readings (nC) in 3 monthes	Dose in mSv in 3 monthes	Dose rate in µSv/h
I area A	179.79	5.214	1.744
	171.05	4.960	1.659
	182.48	5.292	1.770
II area A	142.1	4.121	1.378
	171.28	4.967	1.661
	139.12	4.034	1.349
III area B	160.58	4.657	1.558
	141.66	4.108	1.374
	178.18	5.167	1.728
IV area B	151.24	4.386	1.467
	132.11	3.831	1.281
	145.18	4.210	1.408
V area C	161.25	4.676	1.564
	151.37	4.390	1.468
	167.93	4.869	1.629
VI area C	132.21	3.834	1.282
	150.14	4.354	1.456
	143.12	4.150	1.388

The average TLD-100 cards with 3 chips in nCi, reading for 30 days and the dose rate which reaching to people from black sand is shown in table 4. The conversion factor is 0.03 mSv/nCi. From this table it is clear that the dose rate ranged from 1.985 to 2.468 µSv/h while the dose within 30 days ranged from 1.429 to 1.777 mSv/month.

Table 4. Dose and dose rate reaching to people from exposure to the black sand.

The averageTLD-100 cards readings with 3 chips in (nC) in 30 days	Dose in mSv in 30 days	Dose rate (µSv/h)
47.623	1.429	1.985
49.131	1.474	2.047
48.879	1.466	2.036
51.286	1.539	2.138
49.726	1.491	2.071
54.511	1.635	2.271
59.235	1.777	2.468

CONCLUSION

In this study the radioactivity concentrations of radionuclides ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in the 60 sand samples were measured from Rasheed sand using gamma spectroscopy. It was observed that the activity of ^{238}U was found to vary between 244.6-3660.19 Bq/kg, with a mean value 1509.6. ^{232}Th varies between 258.02-8294.02Bq/Kg,with a mean value 3274.3. ^{226}Ra varies between 265.05-3906.16 Bq/Kg with a mean value 185.8 Bq/Kg and ^{40}K varies between 233.7-789.36 Bq/Kg with a mean value 603.9 Bq/Kg. The doses rates were measured for people and environment by using doimeters TLD-100 and TLD-200 respectively. The average doses were 2.041µSv/h and 1.531µSv/h respectively. These results mean that activity level is high in Rasheed (Abu khshaba).

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