NATURAL RADIOACTIVITY IN SEDIMENTS ALONG THE Middle REGION OF RED SEA COAST, EGYPT

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INTRODUCTION

The measurements of natural radionuclides concentrations (**^{226}Ra, ^{232}Th, and ^{40}K**) in water bodies sediments (sea, rivers or ocean) are significant to protect the seawater ecosystem and to human health from radiation. Red sea coast, Egypt on of the most favorite places in the world. Egypt has about 700 km of coastline along with the Red Sea proper, which is of great environmental, economic and recreational value. Commercial and subsistence fisheries provide a living for a large sector of the coastal population in Egypt. The major industries in the Red Sea region are oil exploration, oil production, oil processing, manufacturing industries (fertilizers, chemicals, cement), tourism, fisheries, and oil-related maritime transport. Because of the rich marine life and favorable climate, tourism has become important for many Red Sea countries, with over 3-5 million tourists per year expected in the future. An extensive area of the coastline was developed to accommodate the increasing flux of tourists, especially in various areas along the Egyptian coastline. On the Red Sea coast, there are two main centers for phosphate ore mining: Safaga and Quseir and three shipping harbors. Phosphate ore dust spilled over into the Sea during shipping is considered as a continuous source for contaminating the Red Sea coastal environment.

The aim of this work is an estimation of the natural radioactivity in different sediments samples collected from four cities (Ras Gharib, Hurghada, Safaga, and Quseir) along the Egyptian red sea coastal. The samples were collected from 3 points in each city. The natural radionuclides activity concentration of **^{226}Ra, ^{232}Th, and ^{40}K** in Bq/kg are investigated with a gamma-ray spectrometer (NaI (Tl) detector). The radiation hazard parameters; radium equivalent activity, annual dose, external hazard, Excess lifetime cancer risk (ELCR) in mSv yr^{-1} and Effective dose rate (D_{organ}) to different body organs and tissues were also estimated and compared with the recommended levels by UNSCEAR reports.

STUDIED AREA

A total of 84 coastal sediment samples (upper 3 cm) were collected from four sampling sites (Figure 1), Ras Gharib 3 sites (18 samples), Hurghada 3 sites (21 samples) Safaga 3 sites (18 samples) and Quseir 3 sites (27 samples).

MATERIALS AND METHODS

Samples, nearly 1 kg, were washed in distilled water and dried at about 110 °C to ensure that moisture is completely removed [9, 10]. The samples were crushed, homogenized and sieved through a 200 mesh. The samples were weighed and placed in a polyethylene beaker. The beakers were completely sealed for 4 weeks to reach a secular equilibrium where the rate of decay of the decay products become equal to that of the parent radium and thorium. This step is necessary to ensure that radon gas confined within the volume and the decay products will also remain in the samples. The sediments textures (gravel sand, mud) and total organic matter (TOM) content in representative sediment samples of each site are presented in Table 1. In general, about 90 % of sediment in these sits is sand. Mud between 0-2 % and Gravel from 4 to 14 %. TOM is varied from 3-25 %.

Activity measurements have been performed by the gamma-ray spectrometer, employing a scintillation detector (3×3 inch). It is hermetically sealed assembly, which includes a NaI (Tl) crystal, coupled to PC-MCA Canberra Accuspec. To reduce gamma-ray background, a cylindrical lead shield (100 mm thick) with a fixed bottom and movable cover shielded the detector. The lead shield contained an inner concentric cylinder of copper (0.3 mm thick) in order to absorb X-rays generated in the lead.

Effective dose rate (D_{organ}) to different body organs and tissues

The effective dose rate delivered to a particular organ can be calculated using the following relation:

$$D_{organ} = AEDE * F$$

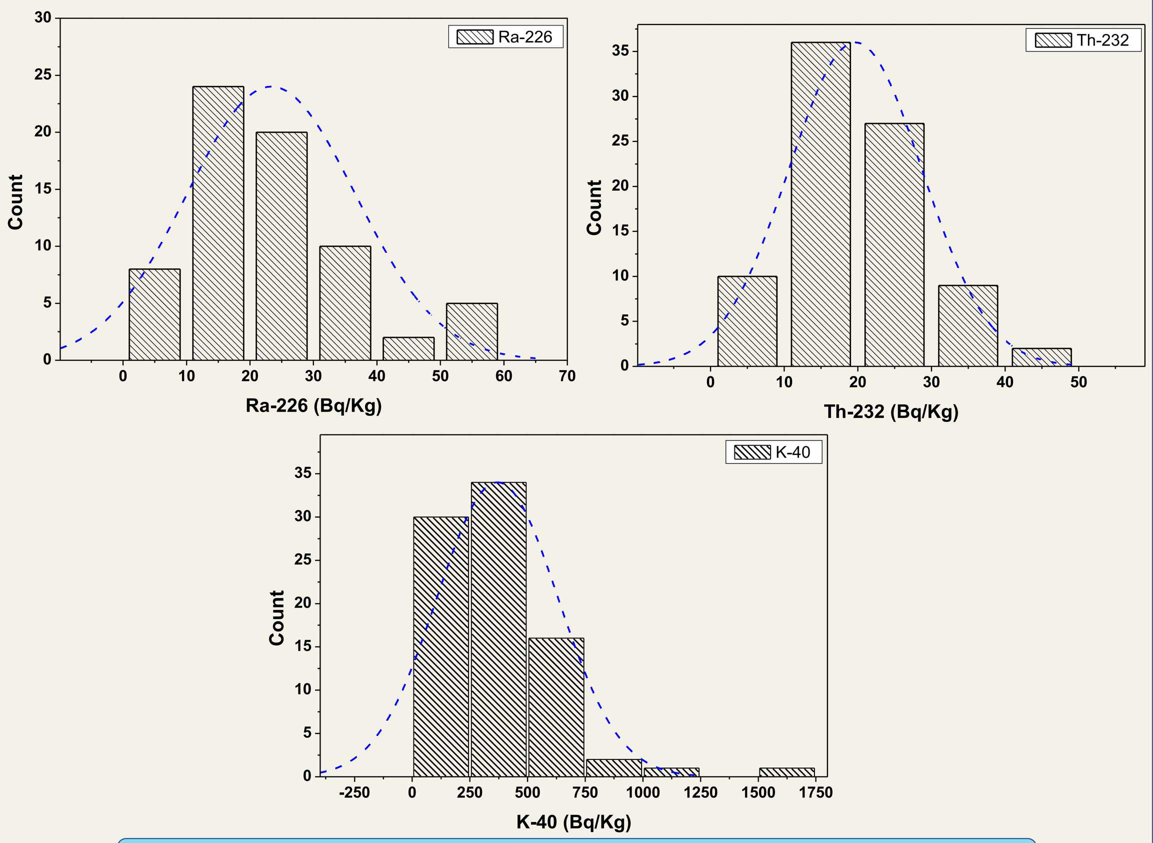
where f is the conversion factor of organ dose from air dose. The energies of interest in the present work is 0.2E+03 MeV f is almost independent of energy. The average values of *f* for various organs and tissues are given in Table 1. Using these f values, D_{organ} can calculated with the above Eq.

Organ or tissue	F
Lungs	0.64
Ovaries	0.58
Bone marrow	0.69
Testes	0.82
Whole-body	0.68

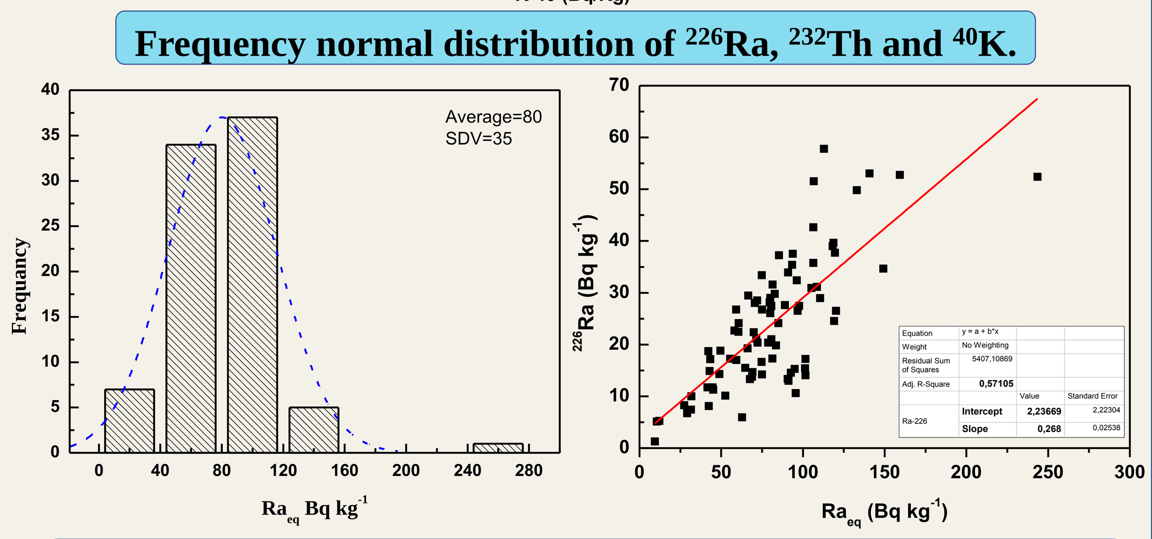
RESULTS AND DISCUSSIONS

Concentration values of ^{226}Ra, ^{232}Th, and ^{40}K (Bq/kg) and the radiological hazard parameters in each city along the red sea coastal.

City		Ra-226	Th-232	K-40	Ra_{eq}	D_{rate} (nGy h^{-1})	H_{ex}	I_γ	AEDE (µSv y^{-1})	ELCR (µSv y^{-1})	AGDE (µSv y^{-1})
Quseir	Min	1.3	3.9	17.8	9.4	4.3	0.0	0.03	5.3	18.6	30.8
	Max	57.8	47.2	627.9	149.3	69.6	0.4	0.50	85.4	298.8	496.6
	Av	25.6	20.7	240.4	73.7	34.2	0.2	0.25	41.9	146.7	241.0
Safaga	Min	7.4	6.3	195.7	31.5	15.3	0.1	0.11	18.7	65.5	110.8
	Max	53.1	33.8	821.0	140.7	65.9	0.4	0.47	80.8	282.8	465.7
	Av	22.2	19.2	477.6	86.5	41.4	0.2	0.29	50.8	177.9	298.9
Hurghada	Min	5.1	1.9	36.3	10.6	5.0	0.0	0.04	6.1	21.4	35.0
	Max	52.8	32.2	1120	159.4	78.9	0.4	0.53	96.8	338.7	574.3
	Av	19.1	15.1	432.0	74.0	35.7	0.2	0.25	43.8	153.2	258.0
Ras Gharib	Min	5.9	7.9	86.3	31.8	14.6	0.1	0.11	17.9	62.6	102.4
	Max	52.4	45.4	1640	243.5	118.8	0.7	0.81	145.7	510.0	866.3
	Av	28.0	23.9	381.4	91.5	43.0	0.2	0.31	52.7	184.6	306.1



Frequency normal distribution of ^{226}Ra, ^{232}Th and ^{40}K.



Frequency normal distribution of Ra_{eq} and Correlation between ^{226}Ra and Ra_{eq} in all measured sites.

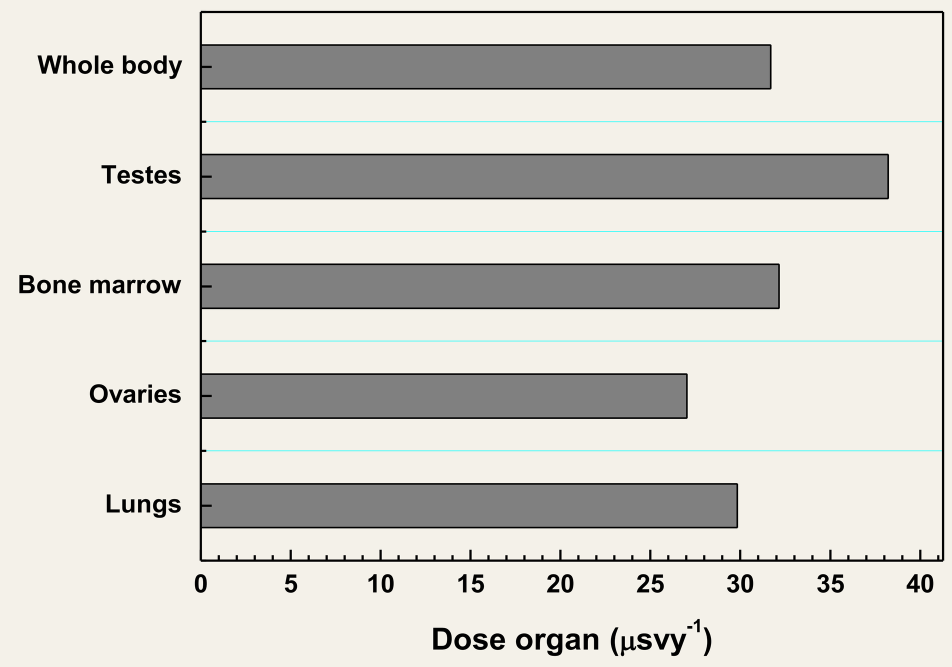
The average activity concentration of ^{226}Ra, ^{232}Th, and ^{40}K (Bq/kg) in sediment samples in different countries around worldwide

Country	^{226}Ra	^{232}Th	^{40}K	Reference
Egypt	23.8	19.6	374.9	This work
Venezuela	11.4	14.5	153.4	(Alfonso et al., 2014)
Korea	65.7	91.1	1,005	(Lee et al., 2009)
USA	21.4	45.3	609	(Powell et al., 2007)
Yugoslavia	71	49	520	(Bikit et al., 2005)
Greece	67	45	691	(Papaefthymiou et al., 2007)
Hong Kong	33	48	625	(Zare et al., 2012)
India	34	75	782	(Tripathi et al., 2013)
Turkey	19	-	387	(Ergül et al., 2013)
Malaysia	30	56	420	(Yii et al., 2011)
Spain	12	15	188	(Fernández et al., 2012)
UK	21	45	609	(Alfonso et al., 2014)
Thailand	9	42	963	(Malain et al., 2012)

The obtained results are considering in the world range of natural radioactivity around the world. These values are below the world average of 35, 30 and 400 Bq/kg respectively for **^{226}Ra, ^{232}Th and ^{40}K**).

In some samples, ^{232}Th concentration is found to be higher than ^{226}Ra concentration. This may be due to the low geochemical mobility and insoluble nature in the water of thorium.

D_{org} values are less than the set limit. Also, we can conclude that the testes have the highest radiation sensitivity while ovaries have the lowest radiation sensitivity. Therefor males more affected than females with radiation.



The effective dose rate delivered to the particular organs (Lungs, Ovaries, Bone marrow. Testes and Whole-body) from air dose outdoor.

Pearson's Correlation Coefficient Analysis

	^{226}Ra	^{232}Th	^{40}K	Ra_{eq}	D	AEDE	Hex	Gravel %	Sand%	Mud%
^{226}Ra	1.00									
^{232}Th	0.83	1.00								
^{40}K	0.54	0.54	1.00							
R_{aeq}	0.54	0.41	0.44	1.00						
D	0.49	0.37	0.47	0.99	1.00					
AEDE	0.49	0.38	0.47	0.99	1.00	1.00				
Hex	0.07	0.03	-0.11	0.25	0.24	0.24	1.00			
Gravel %	0.39	0.12	0.23	0.49	0.46	0.46	0.19	1.00		
Sand %	-0.23	-0.44	-0.47	-0.15	-0.19	-0.19	0.09	-0.30	1.00	
Mud %	0.21	0.04	0.14	0.38	0.40	0.41	-0.32	0.19	-0.05	1.00

The strong positive correlation coefficient was observed between ^{232}Th and ^{226}Ra because ^{232}Th and ^{226}Ra decay series occur together in nature. Positive correlation coefficient was observed between ^{232}Th and ^{226}Ra in all the radiological parameters. However, these radiological parameters have a weak negative correlation with ^{40}K. This implies that there is a very strong relationship between the radionuclides of ^{232}Th and ^{226}Ra in sediments and radiological parameters. Hence this stronger relationship shows that the ^{232}Th and ^{226}Ra radionuclides contribute to the emission of gamma radiation in all the locations. The sandy nature of the soil has negative correlation values for the radiological parameters and

therefore, the reason for the observation of lesser radiation in the study area can be attributed to the sandy nature of the soil.

CONCLUSION

The activity levels and distribution of natural terrestrial radionuclides of 226Ra, 232Th, and 40K were measured by gamma-ray spectrometry system for sediment samples collected from twelves points in four cities along the Egyptian red sea coast. The activity concentrations of 226Ra, 232Th and 40K in the studied sediments are found to be normal. Our results suggest that the variation of grain-size distribution is one of the most important factors influencing the spatial variations of 226Ra, 232Th and 40K in sediments. The extracted values are, in general, comparable to the corresponding ones obtained from other countries and they all fall within the average worldwide ranges. All measured radiological parameters are less than the permissible limit. Hence harmful radiation effects are not posed to the public and tourists going to the beaches for recreation or to the sailors and fishermen involved in their activities in the area as a result of the natural radioactivity of beach sediments. This study can be used as a baseline for future investigations and the data obtained in this study may be useful for natural radioactivity mapping and also be used as a reference data for monitoring possible radioactivity pollutions in future.

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