Natural radionuclides and heavy metal concentrations in marine sediments in view of tourism activities in Hurghada city, northern Red Sea, Egypt.

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ABSTRACT

The natural radioactivity concentration of ^{40}K, ^{232}Th and ^{226}Ra was measured in marine sediment samples collected from coastline of National Institute of Oceanography and Fisheries (NIOF) and Safier Hotel area in Hurghada city using NaT (Tl) spectrometry. The values of activity concentrations in the collected sediment samples varied from 7±1 to 53±4, 6±1 to 32±6 and from 167±11 to 1120±63 Bqkg-1for ^{226}Ra, ^{232}Th and ^{40}K respectively. The results have been compared with the other radioactivity measurements in literature in different cities. The average activity of ^{226}Ra and ^{232}Th were lower than the permissible activity levels, while the average activity of ^{40}K were higher than the permissible activity levels in the samples from NIOF area but, lower than in the samples from Safier Hotel area. The total organic matter (TOC), carbonates (CaCo3) and Heavy metals distribution have been measured. Also, the concentration frequency distribution and the ratio of (^{232}Th/^{226}Ra), (^{232}Th/^{40}K) and (^{226}Ra/^{40}K) for all measured samples were presented. Additionally, the radiological hazards were evaluated and diagramed with Surfer program in maps.

INTRODUCTION

The Red Sea is a deep semi-enclosed and narrow basin connected to the Indian Ocean by a narrow sill in the south and to the Suez Canal in the north.

There are non-nuclear pollution sources tourism activities, landfilling, dredging, oil pollution, water pollution, like solid waste disposal, navigation activities, phosphate shipment pollution and fishing activities All of this have serious radiological impacts on the marine environment and the coastal ecosystems of the Red Sea. Radiology pollution has a negative effect of marine living organisms.

The main aim of the radiation protection view point is to study the activity concentrations of naturally occurring radionuclides and the extent of their exposure to population. Radionuclides present in the environmental media are generally found in low concentration. Detection and intensity measurements of weak gamma activities are more and more playing a vital role in physics experiments and industrial investigation. The most important naturally occurring radionuclides present in sediment are not uniformly distributed; the knowledge of their distribution in sea sediments plays an important role in radiation protection and measurement. In minerals, the incorporation of uranium and thorium into the crystal lattice depends on the abundance of these elements in the sediments during crystallization and on the matching of the chemicals properties and the atomic radii of hosts and substitutes.

DESCRIPTION OF THE STUDIED AREAS

Study Area divided into two stations

Station I: National Institute of Oceanography and Fisheries (NIOF) located at about 5 km north of Hurghada city, between (27° 17\ 07\\ N and 33° 46\ 30\\ E) (Table 1; Fig. 1). it is distinguished by highly sedimentation rate. This site is characterized by a long patchy reef, representing the front edge of a wide and shallow reef flat with many depressions and lagoons. Seaward of the reef edge was a shallow mostly sandy bottom area extending a long distance with few coral patches. The depth ranged from about 3m at the reef front with gentle slope towards deep water.

Station II: Safier Hotel area is one of Hurghada resorts which located 8 Km south of Hurghada at (27º 12' 14"N, and 33º 51' 07"E) (Table 1; Fig, 2). Most of the activities that took place in the area are, landfilling, dredging and reclamation of the intertidal zone. The filling operations has been carried out above the setback line area and around the dredged lagoon in the intertidal zone and violated two small channels have been dredged in the intertidal zone for water circulation inside lagoon. The sea bed in the area is covered by patches of seagrasses and algae with coral fragments. The bottom facies is characterized by many patches of seagrasses, algae and coral reefs.

MATERIALS AND METHODS

Sample collection and preparation

Eighteen samples of sediment have been collected from Ras Ghareb city coastline, Red sea, Table 1. The location and description of bottom characteristics of the collected samples are given in (Figures 1 and 2). Sediment samples were collected by hand, grab sampler and scuba diving. Three different environmental zones such as (i) beach, (ii) intertidal zone and (iii) offshore zone until 5 m water depth represent these localities. Scuba diving was used in areas rich in corals where grab sampler failed to collect samples

For gamma spectroscopic analysis, the samples were prepared as follows. Each sample (about1 kg) was washed in distilled water and dried at about 110◦ C to ensure that moisture is completely removed. The samples were crushed, homogenized and sieved through a 200 mesh, the optimum size to be enriched in heavy minerals. Weighted samples were placed in a polyethylene beaker of 350 cm^3 volume. The beakers were completely sealed for 4 weeks to reach secular equilibrium where the rate of decay of the progency becomes equal to that of the parent (radium and thorium) (IAEA 1989 & Uosif et al 2014). This step is necessary to ensure that radon gas confined within the volume and the progeny will also remain in the sample

Instrumentation

Activity measurements were performed by 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 Accuspes.

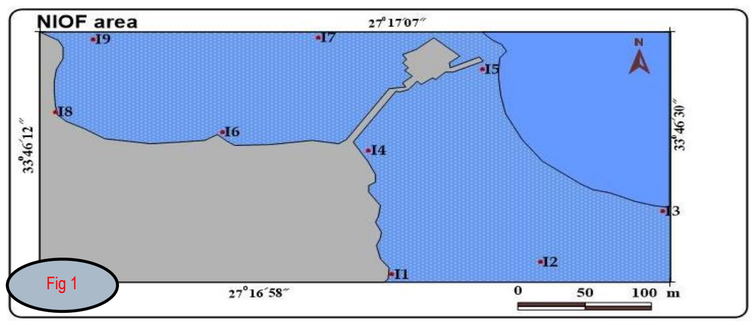
A dedicated software program Genie 2000 from Canberra has carried out the online analysis of each measured gamma ray spectrum.

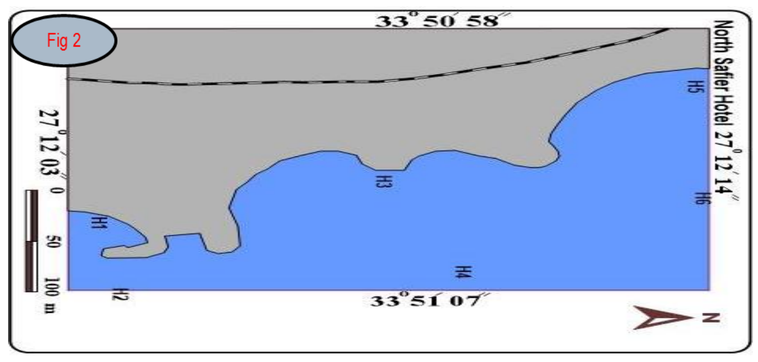
SPECTROMETER ADJUSTMENT

Before using the spectrometer for measurement, it's important to take into account the following considerations:

1-Energy calibration,
2-Detection efficiency ,
3-Background measurements and
4-Detection limit

Importing Photographs





Studied Station	position Lat. ° ' " N	position Long. ° ' " E	Sa. No.	Depth (m)	Tem (°C)	Sal. (%)	PH	SPC ms\cm	TDS (ppt)
North Safier Hotel	27°17'07"	33°46'40"	h1	30cm	22.1	42.3	8.62	62.7	31.3
			H2	5.0m	22.1	42.3	8	62.7	31.4
			H3	35cm	21.8	42.3	8.64	62.7	31.3
NIOF area	27°12'14"	33° 51'07"	H4	1.0m	21.6	42.5	8.5	62.9	31.4
			H5	0.5m	21.5	42.3	8.49	62.8	31.4
			H6	0.8m	21.6	42.5	8.5	62.9	31.4

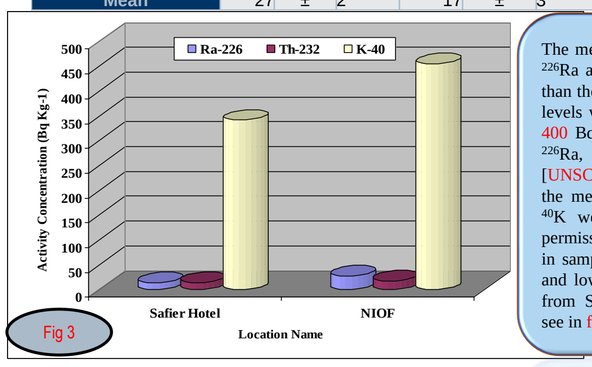
Table 1. The hydrographic parameters of water mass in the studied areas

RESULT AND DISCUSSION

Specific activity (Bq Kg^{-1})

Table 2: Activity concentrations (BqKg^{-1}) of ^{226}Ra, ^{232}Th and ^{40}K in marine sediment samples.

Location	Sample Code	Activity(BqKg^{-1}) ^{226}Ra	^{232}Th	^{40}K
Safier Hotel	H1	7 ± 1	7 ± 1	167 ± 11
	H2	12 ± 1	10 ± 2	240 ± 13
	H3	27 ± 2	26 ± 3	431 ± 24
	H4	13 ± 1	22 ± 3	598 ± 34
	H5	11 ± 1	6 ± 1	323 ± 20
	H6	10 ± 1	14 ± 2	287 ± 16
Mean		13 ± 1	14 ± 2	341 ± 20
NIOF	I1	21 ± 2	15 ± 3	384 ± 22
	I2	20 ± 2	21 ± 4	293 ± 17
	I3	8 ± 1	11 ± 2	247 ± 14
	I4	39 ± 3	32 ± 6	431 ± 25
	I5	53 ± 4	14 ± 2	1120 ± 63
	I6	15 ± 1	12 ± 1	410 ± 23
	I7	38 ± 3	30 ± 3	498 ± 28
	I8	22 ± 2	6 ± 1	376 ± 21
	I9	22 ± 2	16 ± 3	329 ± 19
Mean		27 ± 2	17 ± 3	454 ± 26



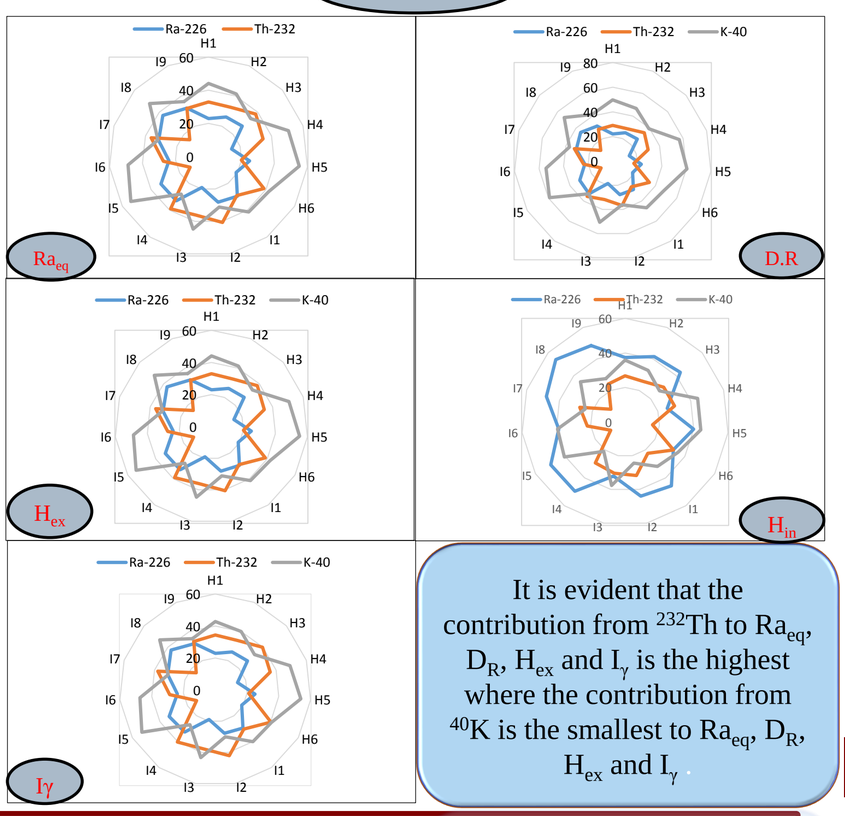
The mean concentrations of ^{226}Ra and ^{232}Th were lower than the permissible activity levels which are 35, 35 and 400 Bqkg^{-1} respectively for ^{226}Ra, ^{232}Th, and ^{40}K [UNSCEAR,2000], while the mean concentrations of ^{40}K were higher than the permissible activity levels in samples from NIOF area and lower than in samples from Safier Hotelas as we see in fig 3 and table 2.

RADIOLOGICAL HAZARDS

Table 3. The equivalent radium (Ra_{eq}), dose rate (D), annual effective dose (AED), external hazard (H_{ex}), internal hazard (H_{in}) γ radiation hazard index (I_γ) and excess lifetime cancer risk (ELCR) for the studied samples

Location		Ra_{eq} (BqKg^{-1})	D (nGy h^{-1})	AED (μSv y^{-1})	H_{ex}	H_{in}	I_γ	ELCR× 10^{-6}
Safier Hotel	Max	97	46	56	0.3	0.3	0.3	**196**
	Min	29	14	17	0.1	0.1	0.1	**60**
	Mean	60	28.7	35.2	0.2	0.2	0.2	**123.3**
NIOF	Max	159	79	97	0.4	0.6	0.5	**339**
	Min	42	20	25	0.1	0.1	0.1	**87**
	Mean	**86.44**	**41.33**	**51**	**0.23**	**0.30**	**0.27**	**177.89**

Fig 4



It is evident that the contribution from ^{232}Th to Ra_{eq}, D_R, H_{ex} and I_γ is the highest where the contribution from ^{40}K is the smallest to Ra_{eq}, D_R, H_{ex} and I_γ .

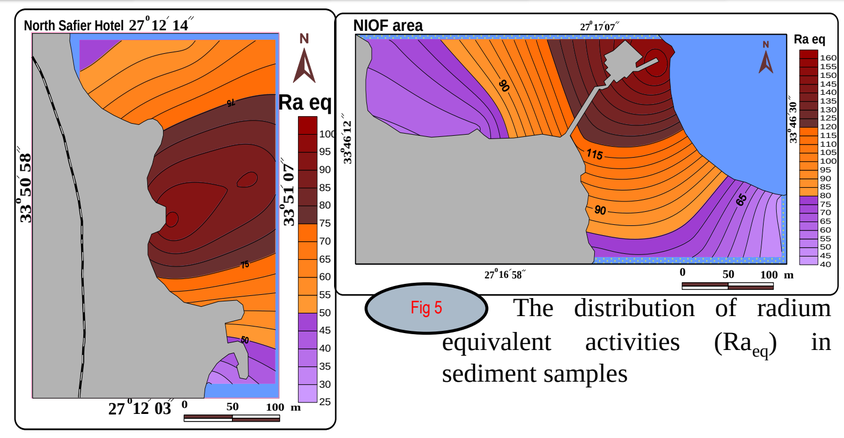
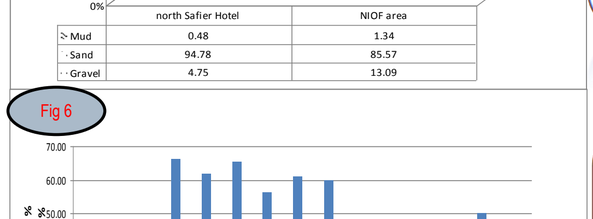


Fig 5 The distribution of radium equivalent activities (Ra_{eq}) in sediment samples

Sediment Types, Carbonates (CaCo3), Total Organic Matter (TOC) and Heavy Metals Concentrations



	north Safier Hotel	NIOF area
Mud	0.48	1.34
Sand	94.78	85.57
Gravel	4.75	13.09

Fig. 5: The distribution of gravel, sand and mud fractions in sediment samples

Fig 6: The distribution of carbonate cmatterontent and total organic in sediment samples from Safier Hotel and NIOF.

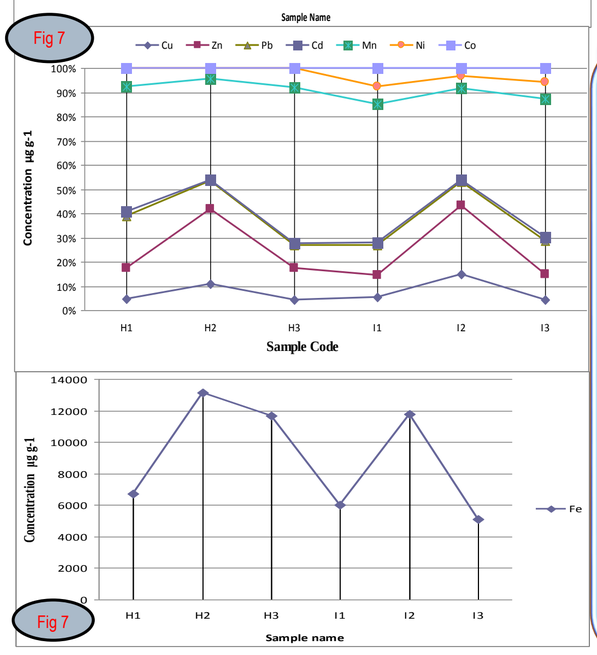


Fig 7: The highest concentration of Cu, Zn, Cd and Co was found in sediment samples from **NIOF** area. As expected the highest concentration of Pb, Fe, Mn and Ni in samples from **Safier Hotel** as shown in figures (4 and 5). The high concentration of iron (Fe) and manganese (Mn) in sediment samples may be due to human activation like sewage, shipment and navigation

CONCLUSIONS

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

- In this study, the results showed that, the activity levels natural radionuclides of ^{226} Ra, ^{232} and Th, in the samples under investigation are lower than the world average (35, 35 and 400 Bq kg^{-1}) fro ^{226}Ra, ^{232}Th and ^{40}K respectively**.** While the average activity of ^{40}K were higher than the permissible activity levels in samples from NIOF area and lower than in samples from Safier Hotel area**.**
- The highest concentration of Cu, Zn, Cd and Co was found in sediment samples from **NIOF** area. As expected the highest concentration of Pb, Fe, Mn and Ni in samples from **Safier Hotel** area. All measured radiological hazards are less than per- miscible limit. Hence harmful radiation effects are not posed to the public going to (NIOF), or tourists going to (Safier Hotel) 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.
- The external and internal hazard indices (H_{ex}, H_{in}), representative level index (Iγr) for all samples investigated are below unity. The annual effective dose (D_{eff}) is well below the recommended value (1 mSv/y). Therefore, the use of these materials for all purposes of human needs is considered to be safe.
- 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 pollution in future.

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