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Assessment of Natural Radioactivity in the Western Coast of the Red Sea, Egypt

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ABSTRACT

In our work we have investigated the radioactive metals ^{226}Ra (^{238}U) series, ^{232}Th series, ^{40}K and ^{137}Cs radionuclides) were determined in the collected samples. The results of the radiation hazard indices for soil samples that have the values of 72.05±3.41, 40.01±1.76, 0.20±0.01 and 255.78±11.16 for radium equivalent activity (Ra_{eq}) in (Bq/Kg), absorbed dose rate in nSv/h in air (D), external hazard index (H_{ex}) and the annual gonadal dose equivalent (AGDE) (µSv/y), respectively in winter. While that values for summer samples were 91.49±3.66, 49.14±1.88, 0.25±0.01 and 312.78±11.86, respectively. The results of the radiation hazard indices for shore sediment samples have the values of 50.74±2.04, 29.07±1.09, 0.14±0.01 and 186.51±6.91 for radium equivalent activity (Ra_{eq}) in (Bq/Kg), absorbed dose rate in nSv/h in air (D), external hazard index (H_{ex}) and the annual gonadal dose equivalent (AGDE) (µSv/y), respectively in winter. While that values for summer samples were 58.06±2.80, 33.16±1.46, 0.16±0.01 and 212.75±9.23, respectively. The obtained results show that the transfer factor from soil to plant were in the order ^{40}K > ^{226}Ra> ^{232}Th that is consistent with the solubility and mobility of these nuclides in soil.

Keywords: soil, shore sediment, plant, water, natural radioactivity, red sea, radiation hazard indices.

INTRODUCTION

The Egyptian Red Sea coast has a unique environment, which is considered one of its competitive marketing advantages. There are signs of environmental degradation in early-developed red sea destinations in the region. The red sea Suez Canal pathway is one of the most important international marine pathways with highly intensive ship traffic, which is a source of possible accidental contamination. In the Gulf of Suez, the northern part of the red sea,

there are about 90% of the Egyptian oil exploration and production activities, which could be a significant source of environmental contamination with technological enhanced naturally occurring radioactive materials.

The knowledge of the concentrations and distributions of natural radionuclides is of interest since it provides useful information in the monitoring of environmental contamination by natural radioactivity [(1)]. All uses of natural or man-made radionuclides require an understanding of their environmental behavior. Such knowledge is needed for their effective application as in-situ tracers or geo-chronometers and for estimation of human health risks.

In a marine environment, radioactive materials can be attached to particulate matter in water. Some isotopes remain dissolved and are termed conservative within water. Others are scavenged out of solution onto particulate material by biological or chemical processes, e.g., adsorption and co-precipitation. They may become deposited in sediments on the bottom of the sea. Uranium and thorium radionuclides have different behavior in the marine environment. While some uranium compounds remains dissolved in water, thorium compounds are a particularly insoluble in natural waters and are usually found associated with solid matter. [(2)].

Egypt has about 700 km of coastline along the Red Sea proper, which is of great environmental, economical and recreational value. Commercial and subsistence fisheries provide a living for a large sector of the coastal population in Egypt. The eco-tourism infrastructure is continuously developing along the Egyptian Red Sea coast.

On the Red Sea coast, there are two main centers for phosphate ore mining: Safaga and Quseir and three shipping harbours. Mining of the Red Sea coastal ph- osphorites began in 1910, for export to the Far East. The phosphatic deposits in the Quseir–Safaga district of the Red Sea coast are mined at many localities in the Quseir group of mines (Hamadat, Atshan, Duwi, Anz, Abu Tundub, Hamrawein), and at Safaga group of mines (Um El-Howeitat, Gasus, Wasif, Mohamed Rabah). Phosphate ore dust spilled over into the Sea during shipping is considered as a continuous source for contaminating the Red Sea coastal environment [(3)].

In this study, red sea was chosen because of its great importance. Its importance is based on the different use of the sea and surroundings, namely recreation, tourism, fisheries, industrial water source etc. So it was an important

task to determine the classical water quality of sea.

MATERIALS AND METHODS

1 *Sampling and study area*

Soil and shore sediment samples were collected using the template method [4] .Plant samples were collected from the plants spreading on the soil of the red sea coast. The collected soil, shore sediment and plant samples were transferred to labelled polyethylene bags, closed and transferred to the laboratory for preparation and measurement. Table 1 and Fig.1 show the samples locations in the red sea coast.

2 Methodology

The samples were prepared for analysis by dried it in an oven at 105 ^{0}C.The sample is mechanically crushed, and sieved through a 0.8 mm mesh sieve. The sieved portion of the sample was weighed for gamma spectrometry measurement in 100 ml Marinelli beaker and was sealed for about four weeks to reach secular equilibrium between thorium and radium content of the sample and their daughters [4].Samples of 5 liter of surface water were collected at sediment collection sites.

The samples were collected in polyethylene containers. Electrical conductivity and pH were measured in the field after sampling. Then, the samples were acidified with nitric acid to pH less than 2 to avoid micro-organisms growth and to minimize water-walls interaction [4]. One liter water sample was transferred to a marinelli-type beaker for gamma-ray measurement and 50 ml were stored in plastic bottle for chemical analysis and heavy metal detection. Another part of the sediment samples was used for the determination of sediments texture (silt, clay and sand percentages), $CaCO_3$ percentage, and organic matter in soil and shore sediment samples.

2.a. Radiation hazard indices calculations

The distribution of ^{226}Ra, ^{232}Th and ^{40}K in soil is not uniform. Uniformity with respect to exposure to radiation has been defined in terms of radium equivalent activity (Ra_{eq}) in Bq/kg to compare the specific activity of materials containing different amounts of ^{226}Ra, ^{232}Th and ^{40}K. It is calculated through the following relation [5].

$$\mathbf{Ra_{eq} = A_{Ra} + 1.43A_{Th} + 0.07A_K} \quad \mathbf{(1)}$$

Where,

A_{Ra}, A_{Th} and A_K are the activities of ^{226}Ra, ^{232}Th and ^{40}K, respectively, in Bq/kg. Radium equivalent index is determined according to the estimation that 1 Bq.kg^{-1} of ^{226}Ra; 0.7 Bq.kg^{-1} of ^{232}Th or 13 Bq.kg^{-1} of ^{40}K produce the same effect of the gamma ray dose.

While the external hazard index (H_{ex}) is given by the following equation, [5].

$$\mathbf{H_{ex} = C_{Ra}/370_{+} C_{Th}/259_{+} C_k/4810} \qquad \mathbf{(2)}$$

The absorbed dose rate (nSv/h) in air, one meter above the ground level in each location were calculated using the following equation, [6, 7].

$$\mathbf{D\ (nSv/h) = 0.49C_{Ra} + 0.67C_{Th} + 0.048C_k} \qquad \mathbf{(3)}$$

Where;
D is the absorbed dose rate or dose equivalent rate C_K, C_U and C_{Th} are the concentrations of ^{40}K, ^{238}U series and ^{232}Th series respectively, expressed in Bq/kg.

The active bone marrow and the bone surface cells are considered as the organs of interest by [7]. Therefore, the annual gonadal dose equivalent AGDE due to the specific activities of ^{226}Ra, ^{232}Th and ^{40}K was calculated using the following formula [8]:

$$\mathbf{AGDE\ (\mu Sv/y) = 3.09A_{Ra} + 4.18A_{Th} + 0.314A_K} \qquad \mathbf{(4)}$$

2.b Sediment concentration factor

The solid-liquid distribution coefficient, K_d, is generally used to express the exchange of radionuclides between the dissolved and sediment sorbed phases for a given radionuclide under steady state conditions at equilibrium. It is known that plant uptake of a radionuclide largely depends on the K_d value of the corresponding soil[9]. A higher K_d value attributes a lower transfer of radionuclide from soil to plant.

The concentration factor is the ratio of concentration of the heavy element or the radionuclides in the concentrating matrix (e.g., sediment or biota) to the concentration in the ambient matrix (e.g., sea water) under equilibrium conditions.

$$K_d = \frac{\text{Amount of element absorbed by plant}}{\text{Amount of element left in soil}} \qquad \mathbf{(5)}$$

2.c. Transfer factor (TF)

The soil-to-plant TF quantifies: The transfer of radionuclides from soil to plant when uptake by plant root is the only process responsible for the transfer, the TF values were calculated according to the following equation [9]:

$$TF = \frac{\text{Activity in plant part (Bq/kg dry mass weight)}}{\text{Activity in soil (Bq/kg dry mass weight)}} \qquad \mathbf{(6)}$$

Table(1): Site number and locations of samples of Red Sea coast.

Site No.	Locations	Site No.	Locations
1	40 Km north Shalateen	12	Alhamrawin
2	24 Km north Brnise	13	Alkouseir
3	30 Km north Brnise	14	45 Km North Alkouseir
4	Hamatta	15	Safaga
5	45 Km Brnise	16	43 Km North Safaga
6	68 Km north Brnise	17	Hurghada
7	125 Km north Brnise	18	27 Km North Hurghada
8	Mrsa Alam	19	38 Km North Hurghada
9	16 Km North Mrsa Alam	10	73 Km North Hurghada
10	50 Km North Mrsa Alam	21	Shuqeir
11	75 Km North Mrsa Alam	22	Ras-Gharib

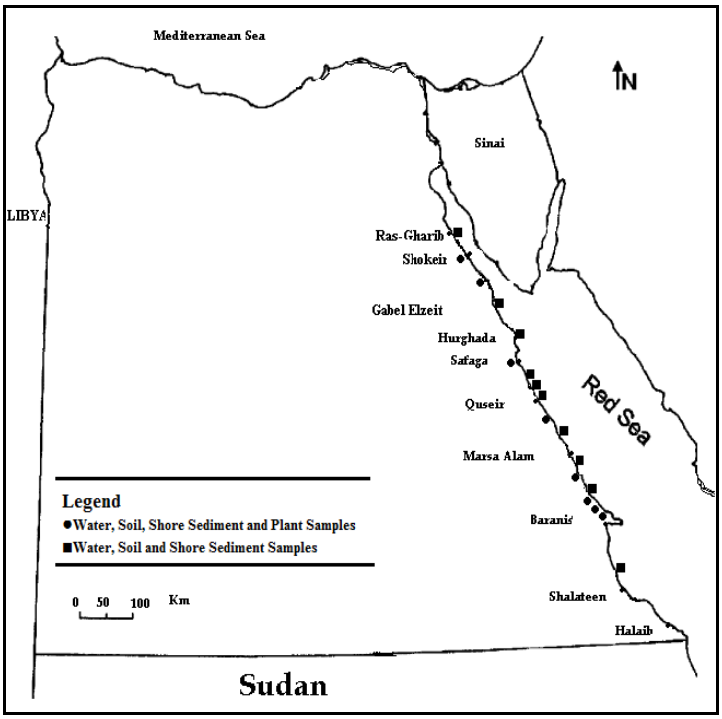

Figure (1): Distribution of water, shore sediment, soil and plant samples of Red sea coast in winter and summer.

RESULTS AND DISSCUSION

Measurements of Natural Radioactivity in Red sea coast:

For soil samples, the specific activities of ^{226}Ra (^{238}U) series, ^{232}Th series, ^{40}K and ^{137}Cs in winter and summer seasons were presented in Figs. 2-A and 2-B, and 2-C.The average activity concentration of ^{226}Ra (^{238}U) series, ^{232}Th

series, ^{40}K and ^{137}Cs along the red sea coast during ***winter season*** were found to be 14.33±1.06 Bq/kg of dry weight, 21.22 ± 1.19 Bq/kg of dry weight, 391.13±9.19 Bq/kg of dry weight and 2.86 ± 0.36 Bq/kg of dry weight that varied from1.34±0.30 to 4.91 ± 0.69 Bq/kg of dry weight, respectively.

The average activity concentration of ^{226}Ra (^{238}U) series, ^{232}Th series, ^{40}K and ^{137}Cs along the red sea coast during ***summer season*** were found to be 16.932±1.09 Bq/kg of dry weight, 33.12±1.36 Bq/kg of dry weight, 388.61±8.93 Bq/kg of dry weight and 4.5±0.37Bq/kg of dry weight, respectively.

The highest radium and thorium activities for soil samples in ***winter season*** were found at the sampling point No. 11, 75 Km North Mrsa Alam where the samples are rich in clay, while the lowest value were found at sampling points No. 2 and 3 which are at 30 Km north Brnise and Hamatta, respectively.

The highest radium and thorium activities in ***summer season*** were found at sampling point 75 Km north Mrsa Alam and Alhamrawin, respectively which indicates the enhanced levels due to the activities of phosphate mining and shipment operations in El Hamraween area, excluding the influence of phosphate mining activities [10].

The lowest value were found at 100 Km north Brnise. Thorium and uranium in beach sand are contained mainly in resistant heavy minerals such as monazite, zircon and xenotime [11]; potassium is present in the light mineral fraction, such as potash–felspar, mica and glauconite, from which it is slowly converted into soluble forms by weathering processes. A slight variation in the radioactivity content of the soil can be observed due to the atmospheric deposition, type of soil, soil formation and the sand transport process and geomorphology. Increased rainfall may result in more effective leaching and/or transport of uranium from soil to sea water.

For shore sediment samples, the specific activities of ^{226}Ra (^{238}U) series, ^{232}Th series, ^{40}K and ^{137}Cs in shore sediment samples were presented in Figs. 2-D, 2-E and 2-F in Bq/kg of dry weight.

The average activity concentrations along the red sea coast in ***winter season*** for ^{226}Ra (^{238}U) series, ^{232}Th series, ^{40}K were found to be 8.78±0.77, 12.91±0.47 and 335.67±4.8 Bq/kg of dry weight, respectively, while the activity concentration of ^{137}Cs is 2.95±0.95 at hamrawin site.

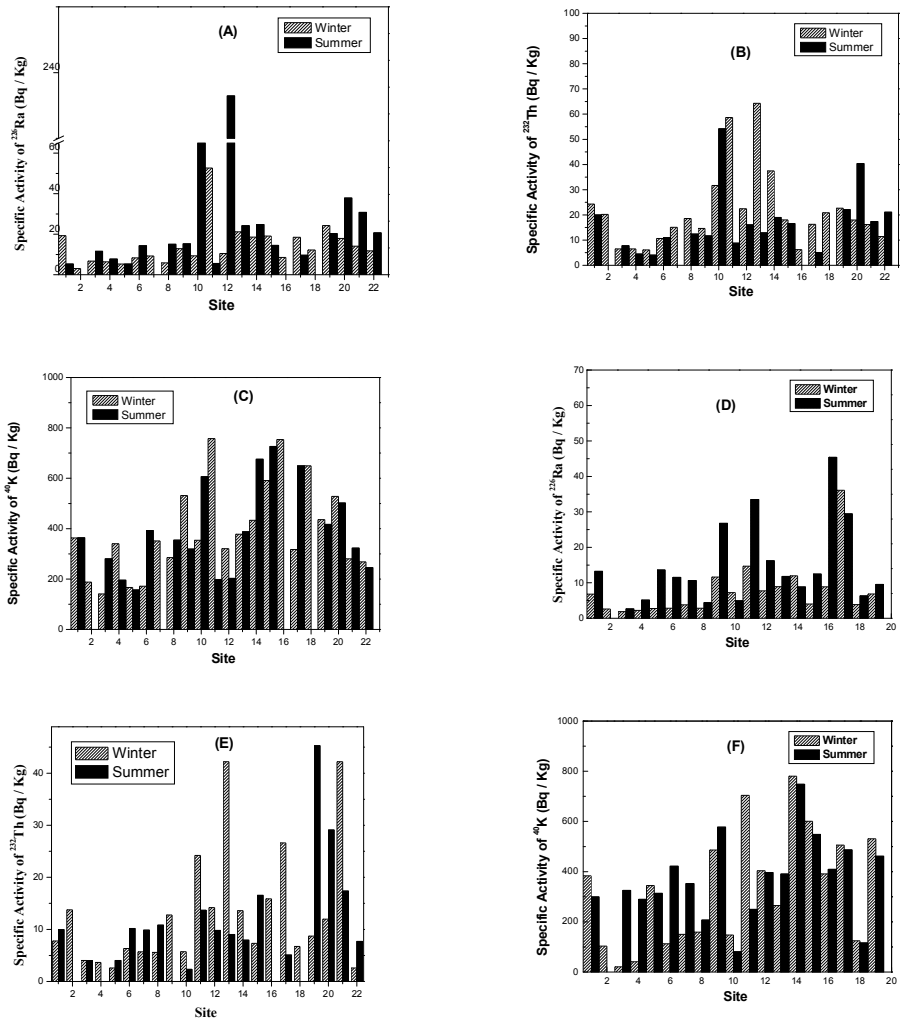

Figure (2): Specific activity (Bq/kg of dry weight) of ^{226}Ra (^{238}U) series, ^{232}Th series and ^{40}K in Red Sea soil (A, B and C) and shore sediment (D, E and F) samples.

The average activity concentrations along the red sea coast in ***summer season*** for ^{226}Ra (^{238}U) series, ^{232}Th series, ^{40}K and ^{137}Cs were found to be 14.80±0.84, 12.10±0.96, 370.81±8.32 Bq/kg of dry weight, respectively, while the activity concentration of ^{137}Cs is 1.77±0.33 Bq/kg of dry weight at hamrawin site.

The highest radium, thorium and potassium activities for shore sediment samples in ***winter season*** were found at Shuqeir which indicates the enhanced levels due to the activities of oil productions areawhile the lowest

radium, thorium and potassium activities for shore sediment samples in ***winter season*** were found at Ras-Gharib and also at Hamatta.

The highest radium and thorium activities in ***summer season*** were found at point 38 Km North Hurghada which also, indicates the enhanced levels due to the activities of oil productions area while the lowest values for radium and thorium were found at Hamatta and at point 50 Km north Mrsa Alam, respectively.

The radioactivity content in the shore sediment depends on the rock type from which the sediment is formed, the atmospheric deposition (dry and wet), and the physical and chemical properties of the sediment. This variation can also be explained by the effects of the climatic parameters, evapotranspiration and the concentration of suitable complexing agents which can increase the solubility of radionuclides especially uranium in addition to the wave-shore interaction.

From the natural radioactivity data and Fgs 3, 4, 5 and 6, it was found that there were strong correlations between activities of ^{226}Ra (^{238}U series) and ^{232}Th series in soil and shore sediments, with correlation coefficients of values *0.80* for soil samples and *0.81* for shore sediment samples in ***winter season*** while in ***summer season*** were *0.87* for soil samples and *0.602* for shore sediment samples.

The correlation between ^{226}Ra (^{238}U) series and ^{40}K was found in soil and shore sediment samples with correlation coefficient *0.58* and *0.52*, in ***winter season*** while the correlation between ^{226}Ra (^{238}U) series and ^{40}K in ***summer season*** in soil was weak. The correlation between ^{232}Th series and ^{40}K was also weak. The correlation between ^{226}Ra (^{238}U) series, ^{232}Th series and ^{40}K is quite logic, as all of them have the same origin. The weaker correlation between ^{226}Ra (^{238}U) series and ^{40}K in shore sediment samples than ^{232}Th series may be due to their different behaviours (chemical properties, mobility, etc) in aquatic ecosystems and the different parameters affecting their concentrations in the coastal sediment.

The correlation between ^{40}K, ^{226}Ra (^{238}U) series and ^{232}Th series may be explained by the competitive chemical behaviour and the concentration of the stable isotopes that could affect the adsorption of these ions on clay particles.

^{137}Cs was found in soil samples which could be explained by the fall-out phenomena. Its specific activity was very low and lower than the detection limit (0.1 Bq/kg) of the HPGe detector along the red sea coast in the rest of the samples. This may be attributed to the chemical behaviour of ^{137}Cs which is soluble in water. Also, the amount of ^{137}Cs is strictly related to the

concentrations of the exchangeable magnesium, calcium and the sum of alkaline exchangeable cations.

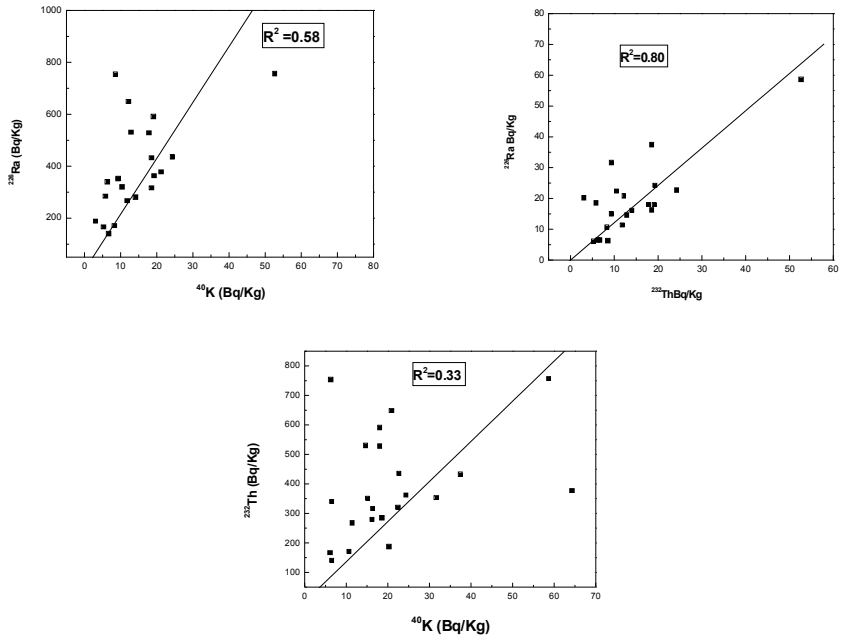

Figure (3): Correlation graphs between ^{226}Ra, ^{232}Th and ^{40}K in soil samples, winter.

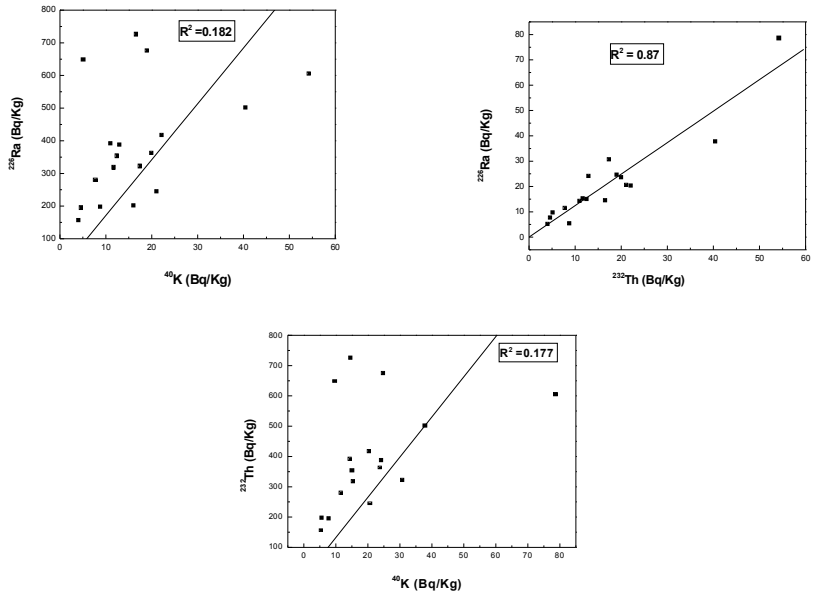

Figure (4): Correlation graphs between ^{226}Ra, ^{232}Th and ^{40}K in soil samples, summer.

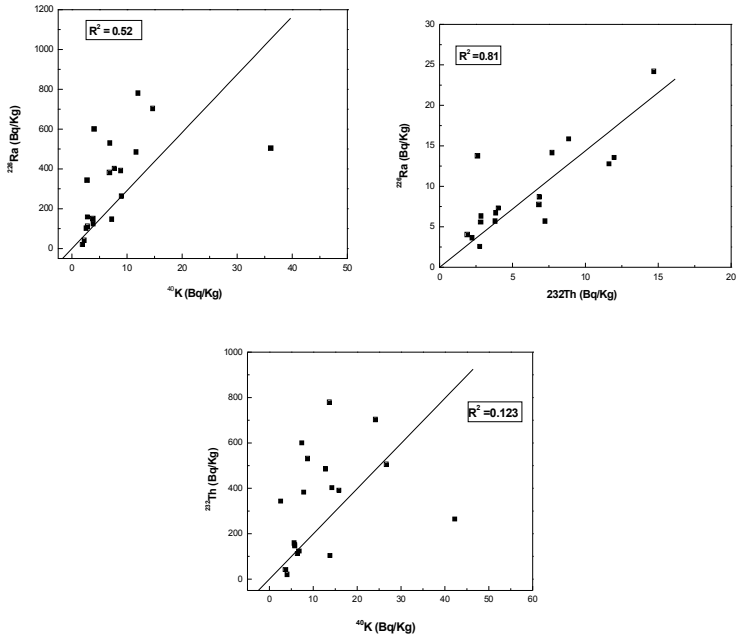

Figure (5): Correlation graphs between ^{226}Ra, ^{232}Th and ^{40}K in shore sediment samples, winter.

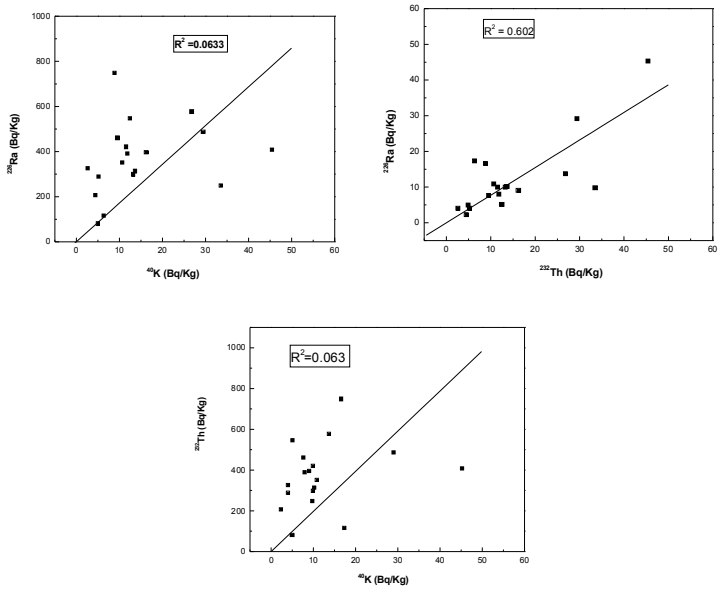

Figure (6): Correlation graphs between ^{226}Ra, ^{232}Th and ^{40}K, in shore sediment samples, summer.

For plant samples, the specific activities of ^{226}Ra (^{238}U) series, ^{232}Th series, and ^{40}K are presented in Fig. 7 in Bq/kg of dry weight. The average activity concentrations in the red sea plants collected in ***winter*** for ^{226}Ra (^{238}U) series, ^{232}Th series and ^{40}K were found to be 8.49±1.34, 6.48±0.61and 466.14±14.28 Bq/kg of dry weight respectively.

While the average activity concentrations along the red sea coast in ***summer*** for ^{226}Ra (^{238}U) series, ^{232}Th series and ^{40}K were found to be 7.30±1.16, 3.94±0.47 and 488.09±13.74 Bq/kg of dry weight respectively.

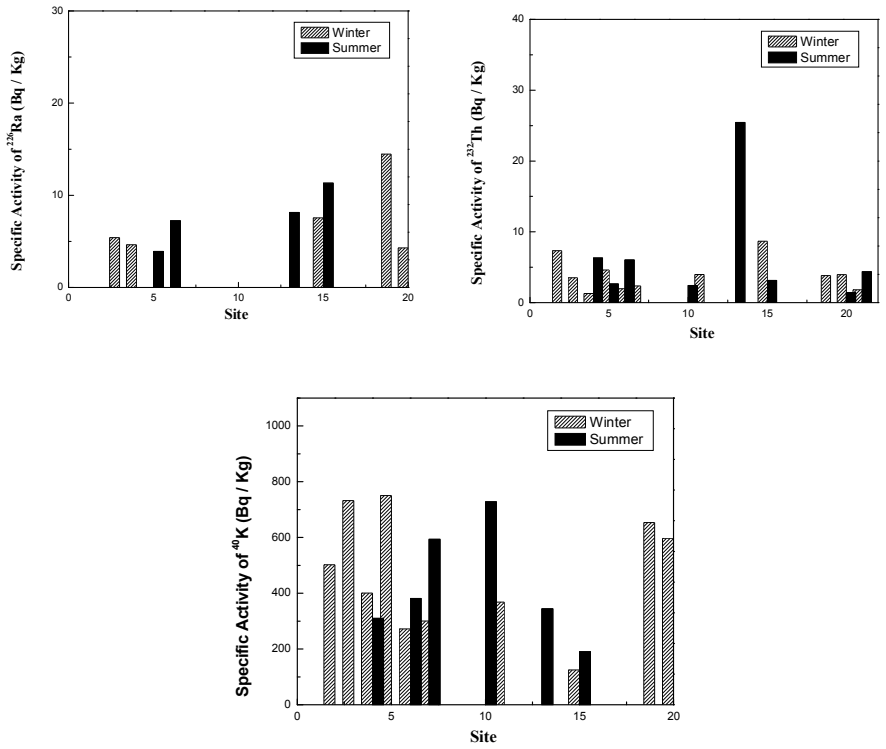

Figure (7): Specific activity (Bq/kg of dry weight) of ^{226}Ra (^{238}U series), ^{232}Th series and ^{40}K in plant samples.

For water samples, the specific activities of ^{226}Ra (^{238}U) series, ^{232}Th series and ^{40}K in water samples are presented in Figs. 8 and 9. The average activity concentration of ^{226}Ra (^{238}U) series, ^{232}Th series and ^{40}K along the red sea coast during ***winter*** were found to be 2.59 Bq/L, 2.29 Bq/L and 22.60 Bq/L, respectively.

While the average activity concentration of ^{226}Ra (^{238}U) series, ^{232}Th series and ^{40}K along the red sea coast during ***summer*** were found to be 2.10 Bq/L, 1.94 Bq/L and 22.89 Bq/L of dry weight, respectively.

From the radioactivity data of water samples it is clear that the mean values of ^{226}Ra (^{238}U) series, ^{232}Th series and ^{40}K were very close to each other in both summer and winter seasons and also that the values along the coast were varied within a narrow range.

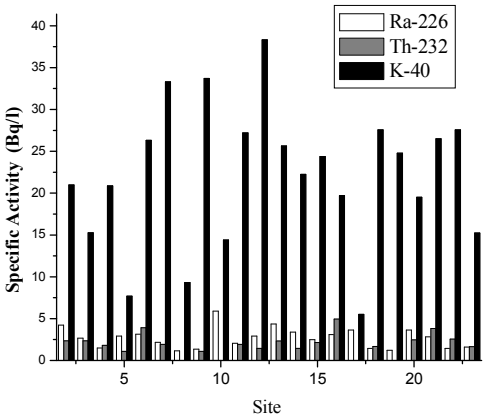

Fig (8): Specific activity of (Bq/L)of ^{226}Ra (^{238}U) series, ^{232}Th series and ^{40}K in Red sea water samples, winter.

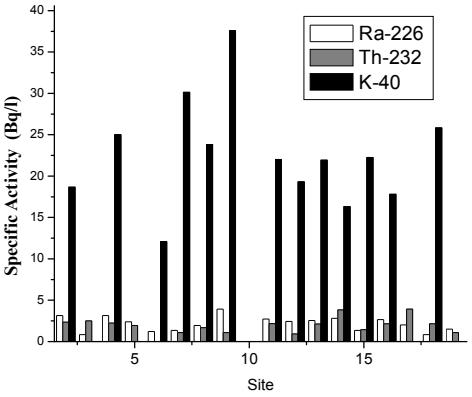

Fig (9): Specific activity of (Bq/L) of ^{226}Ra (^{238}U) series, ^{232}Th series and ^{40}K in Red sea water samples, Summer.

Table (2): Average values of radiation hazard indices (Bq/kg of dry weight) of Red sea soil and shore sediment samples.

Radiation hazard indices	Soil		Shore sediment	
	Winter	summer	Winter	Summer
Ra-eq	72.05	91.49	50.74	58.06
Dose	40.01	49.14	29.07	33.16
Hex	0.20	0.25	0.14	0.16
AGDE	255.78	312.78	186.51	212.75

As shown in tables 2 and 3, and fig. 11.

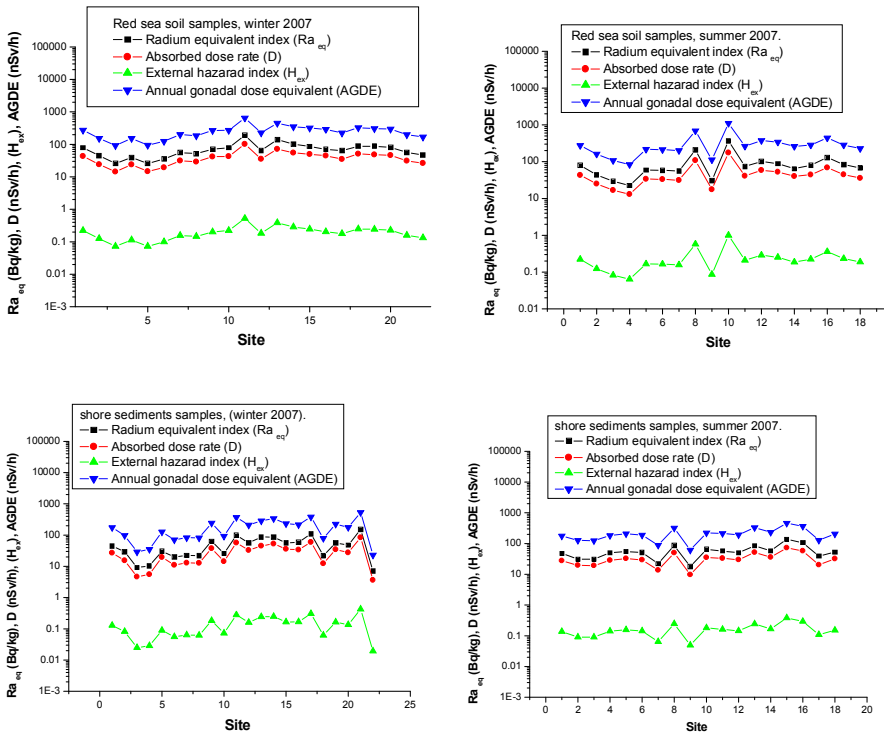

Figure (11): Radiation hazard indices for soil and shore sediment samples of the red sea coast. ***Radiation hazard indices calculations***

The results for the radium equivalent activity (Ra_{eq}) in (Bq/Kg), absorbed dose rate in nSv/h in air (D), external hazard index (H_{ex}) and the annual gonadal dose equivalent (AGDE) (μSv/y) using equations 1, 2, 3 and 4.

The average values for these indices in soil samples in winter were 72.05±3.41, 40.01±1.76, 0.20±0.01 and 255.78±11.16, respectively. In summer

these values were 91.49±3.66, 49.14±1.88, 0.25±0.01 and 312.78±11.86, respectively.The average values for these indices in shore sediment samples in winter were 50.74±2.07, 29.07±1.09, 0.14±0.01 and 186.51±6.91, respectively. In summer, these values were 58.06±2.06, 33.16±1.46, 0.16±0.01 and 212.75±9.23, respectively.

Finally, the mean values of radiation hazard indices (Bq/kg of dry weight) of Red sea soil and shore sediment samples are summarized in table 1, which indicates that these indices in soil samples were greater than that in shore sediment samples, which may be attributed to the leaching of ^{226}Ra, ^{232}Th and ^{40}K from shore sediment by tidal water.

Distribution coefficient and transfer factors

In this study we are concerned with the sediment/water distribution coefficient (K_d) and soil/plant transfer factor (TF) using equations 5 and 6. The distribution coefficient and transfer factors for the collected samples from the Red Sea are summarized in Table 2 and plotted in Fig. 12.The obtained results show that the transfer factor of ^{40}K > ^{226}Ra> ^{232}Th that is consistent with its solubility and mobility in soil. For natural radionuclides, ^{40}K, ^{226}Ra and ^{232}Th were measured in both sediment and water samples.

Table (3): The soil/plant Transfer factor (TF) and sediment/water distribution coefficient (K_d) for red sea samples.

	Transfer factor (TF)		Distribution coefficient (K_d)	
	Winter		Winter	
	Mean	Range	Mean	Range
^{226}Ra	0.63	0.44-0.84	3.39	0.76-24.88
^{232}Th	0.36	0.08-0.97	5.64	0.66-29.1
^{40}K	1.57	0.32-2.22	14.85	0.99-70.96
	Summer		Summer	
^{226}Ra	0.72	0.11-1.2	7.05	1.63-17
^{232}Th	0.28	0.03-0.6	6.24	1.4-21.1
^{40}K	1.71	0.17-3.84	16.20	4.49-45.87

Effect of mechanical properties of samples on the radioactivity distribution

Geochemical phases such as clay minerals, iron oxides and hydroxides, manganese oxides and hydroxides, and organic matter are the principal adsorbents of heavy metals [11]. It's clear from the results that the radioactivity content of soil samples is directly proportional to the silt + clay fraction and inversely proportional to the sand and $CaCO_3$ fractions. In shore sediment

samples the correlations between radionuclides with these fractions have nearly the same behavior. The correlation coefficients for radium were -0.34199, 0.27754 and 0.30984 for sand, $CaCO_3$ and silt + clay fractions, respectively. The correlation coefficients for thorium were -0.10789, 0.09977 and 0.095 for sand, $CaCO_3$ and silt + clay fractions, respectively. The correlation coefficients for potassium-40 were -0.543, -0.036 and 0.55 for sand, $CaCO_3$ and silt + clay fractions, respectively.

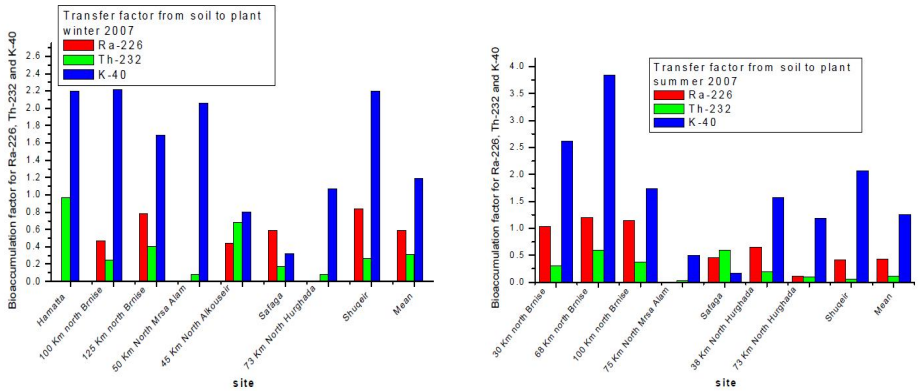

Figure (12): The soil/plant Transfer factor (TF) and sediment/water distribution coefficient (K_d) for red sea samples.

CONCLUSIONS

The results of our study, which is a part of the national program for nuclear safety and radiation control, are a data-base to distinguish any future changes due to non-nuclear industries on the Red Sea coast. The results showed that the natural radioactivity in the coastal zone of the red sea is in the normal range and all of these results indicate that there are no harm effects due to radiation exposure in these areas.

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مجلة البحوث الإشعاعية
والعلوم التطبيقية
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تقييم النشاط الاشعاعي للشاطئ الشرقى المصري للبحر الاحمر

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يهدف هذا البحث الي تقدير تركيزات بعض الأنوية المشعة طبيعيا وهي اليورانيوم-٢٣٨ والثوريوم-٢٣٢ والبوتاسيوم-٤٠ في ١٣٨ عينة من التربة والرسوبيات الشاطئية والمياه والنباتات. تم تجميع عدد ٧٤عينة في فصل الشتاء موزعة كالتالي: (٢٢ عينة مياه تمثل المياه السطحية و٢٢ عينة رسوبيات من نفس أماكن عينات المياه السطحية و ٢٢عينة تربة بالقرب من أماكن الرسوبيات و ٨ عينات نباتية بجوار عينات الرسوبيات). وكذلك تم تجميع عدد ٦٥ عينة في فصل الصيف موزعة كالتالي: (١٨ عينة مياه تمثل المياه السطحية و١٨ عينة رسوبيات من نفس أماكن عينات المياه السطحية و ١٨عينة تربة بالقرب من أماكن الرسوبيات و ١١ عينات نبات بجوار عينات الرسوبيات علي الشاطئ المصري للبحر الأحمر) لمعرفة الخلفية الأشعاعية ومصادرها ومدي تأثر البيئة المحيطة بها وذلك بأستخدام المطياف الجامى المزود بكاشف جيرمانيوم عالى النقاوه. وأوضحت النتائج أن متوسط المستويات الأشعاعية لعينات التربة 14.33 و21.22 و 391.13 بيكريل/كيلوجم في الشتاء وكان متوسط المستويات الأشعاعية في الصيف 16.93 و33.12 و388.61 بيكريل/كيلوجم لليورانيوم-٢٣٨ والثوريوم-٢٣٢ والبوتاسيوم-٤٠ علي التوالي. أما بالنسبة لعينات الرسوبيات فكانت كالاتي في الشتاء 8.78 و12.91 و 335.67 بيكريل/كيلوجم أما في الصيف فكانت 14.80و12.10و370.81 بيكريل/كيلوجم لليورانيوم-٢٣٨ والثوريوم-٢٣٢ والبوتاسيوم-٤٠ علي التوالي. أما بالنسبة لعينات النبات فكانت كالاتي في الشتاء8.49 و6.48 و466.14 بيكريل/كيلوجم أما في الصيف 7.30 و3.94 و488.09 بيكريل/كيلوجم لليورانيوم-٢٣٨ والثوريوم-٢٣٢ والبوتاسيوم-٤٠. أما بالنسبة لعينات المياه في الشتاء2.59 و 2.29 و 22.60 بيكريل/لتر أما في الصيف فكانت 2.10 و1.94و22.89 بيكريل/لتر لليورانيوم-٢٣٨ والثوريوم-٢٣٢ والبوتاسيوم-٤٠ علي التوالي .

ووجد أن الجرعة الأشعاعية المصاحبة لأشعاعات جاما علي بعد واحد متر أعلي سطح الارض في الشتاء ٤٠.٠١ نانوجراى/ ساعه أما في الصيف49.14 نانوجراى/ ساعه وهي في حدود قيمة خلفية منظومة التعرض البيئي دوليا(٥٥ نانوجراى/ ساعه).