

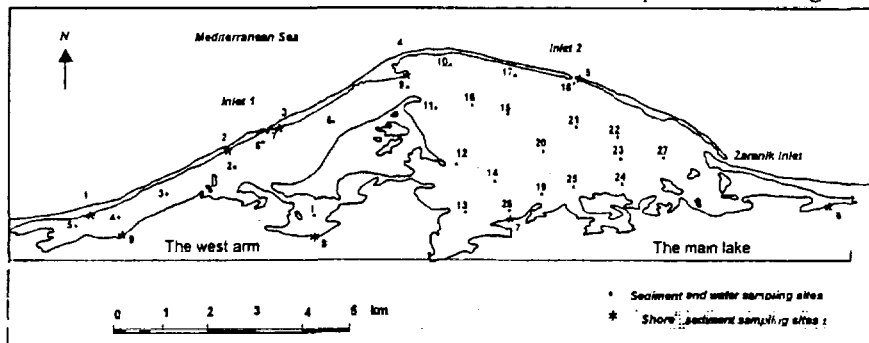
RADIOLOGICAL STUDY OF BARDAWIL LAKE IN EGYPT

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Bardawil lake is one of the five northern lakes which are originally bodies of the Mediterranean sea water and located at the very north of Egypt (map on fig.1) Bardawil lake is located in the northern part of Sinai peninsula between $31^{\circ} 02$ and $31^{\circ} 14$ N longitude ; and $32^{\circ} 40$ and $33^{\circ} 37$ E logoon This lagern covers an area of about 600 km^2 . It is about 80 km long and its maximal width is about 18 km. The water depth ranges from few centimeters to about 2.9 m in the western arm. It is connected with the sea through three inlets, two of which are kept artificially open by periodical dredging, while the third is natural. The lake water is actually a mixing of local groundwater with the sea water. The salinity ranges from 46.6 to 81.1 g/l [1]. The annual fish production is about 2500 tons (65% Bream, 20% Mulletts, 6% seabass, 5% Sole and 3% others). Fishing is banned yearly for four months in order to allow fish to reproduce and to grow reaching marketable size.

Fig.1
Sampling sites
for bottom and
shore sediments
and water in
Bardawil lake.



Sampling & Sample Preparation: Twenty six bottom sediment (BS) samples, twenty six water samples, nine shore sediment (SS) samples (see the map with the sampling site locations) and 36 fish samples of all above mentioned types of fish were collected.

For Gamma-spectroscopy Analysis (GA) the bottom and shore sediment samples were dried at 115°C , crushed, sieved through 1 mm mesh size, homogenized and transferred to Marinelli beakers. The beakers with samples were sealed for 4 weeks to reach secular equilibrium between Radium-226 (of the U-238 series) and daughters.

The water samples were acidified (with nitric acid to avoid micro-organisms' growth and to minimize water-walls interaction), stored in polyethylene containers for transportation to the laboratory.

The fish samples obtained from the professional fishers were washed thoroughly and filleted. The head with the bone (HB) and the flesh (F) were dried separately at 80°C . Every dried sample was milled and transferred to air tight polyethylene container of 100 or 250 ml/capacity.

For Alpha - spectroscopy Analysis (AA) some bottom sediment samples with 60-100 mBq U-232 tracer is dissolved. For uranium separation, the dissolved sample goes through steps of chemical extraction, coprecipitation, ion-exchange and electrodeposition on stainless steel disk [3].

Gamma-Spectroscopy Analysis: Using γ -spectrometers based on HPG-detector in a lead shield with two internal cadmium and copper cylinders, the bottom sediment and shore sediment samples, water samples, fish flesh samples and head & bone samples were analyzed after absolute efficiency calibration of the spectrometer [4]. The average specific activity of Ra-226 (of the U-238 series), Th-232 series, K-40 and Cs-137 in Bq/kg (dry weight) for 26 bottom sediment (BS) and 9 shore sediment (SS) samples is given in table (1). In brackets the range of specific activity variation is given.

Table (1)

Type of Samples	Total Number of Samples	Ra-226	Th-232	K-40	Cs-137
BS	26	6.79 (3.36-13.16)	4.46 (2.32-9.11)	185.6 (94.9-258.8)	2.51 (0.10-6.50)
SS	9	3.82 (2.49-7.45)	2.40 (1.65-4.81)	108.4 (67.8-197.6)	0.19 (0.10-0.55)

For the analyzed water samples, the K-40 radionuclide was the only one with concentration higher than the detection limit of the spectrometer. The average K-40 concentration of the analyzed 26 samples is 18.3 Bq/l and the values of individual concentration ranged between 11.7 and 30.5 Bq/l. The same concentration was measured using flame fluorimeter and was found to have average value of 19.9 Bq/l (14.9-26.6 Bq/l).

The average values (and the range of variation) of the concentration of Ra-226 (U-238), Th-232, K-40 and Cs-137, in Bq/kg (dry weight) in the analyzed 36 fish flesh (F); and 30 fish head and bone (HB) samples are given in table (2)

Table (2)

Type of Samples	Total Number of Samples	Ra-226	Th-232	K-40	Cs-137
F	36	3.03 (0.6 ⁰ -5.58)	1.43 (0.5 ⁰ -2.69)	320.7 (129.7-470.9)	0.42 (0.1 ⁰ -1.43)
HB	30	3.90 (0.6 ⁰ -7.65)	2.07 (0.50 ⁰ -4.73)	219.3 (94.6-450.1)	0.43 (0.1 ⁰ -1.37)

Alpha Spectroscopy Analysis

Using an Alpha spectrometer based on surface- barrier detector, six bottom sediment (BS) samples collected from different sectors of the lake were analyzed. The specific activity of U-238,U-235, total uranium (Bq/Kg dry weight) and the ratio of U-234/U-238 are given in table (3).

Table (3)

Sample code	U-238	U-235	Total U	U-234/U-238
BS 4	61.6±	4.90±0.59	128.8±6.9	1.01±007
BS 9	9.8±1.1	0.34±0.20	17.9±2.2	0.79±0.13
BS14	49.8±6.3	1.12±0.66	114.2±14.5	1.27±0.22
BS18	49.5±3.3	1.72±0.45	104.0±7.3	1.07±0.10
BS21	45.7±2.7	0.62±0.21	90.9±5.5	0.97±0.08
BS27	55.9±5.9	2.36±0.81	107.6±12.1	0.88±0.13

The absorbed dose equivalent in $\mu\text{Sv} / \text{y}$ due to the ingestion of Ra-226(of the U-238),Th-232 and K-40 resulting from flesh consumption of 7 Kg/y of fish was calculated [5] for the 36 collected fish samples. The average equivalent absorbed dose is found to be 25.8 $\mu\text{Sv/y}$ with range of variation from 9.9 to 43.1 $\mu\text{Sv/y}$. The contribution from Ra-226, Th232 and K-40 to the average dose is 7.5, 7.1 and 11.2 $\mu\text{Sv/y}$ respectively

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