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STUDIES ON THE BOTTOM DEPOSITS OF THE EGYPTIAN LAKES.

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ABSTRACT

Sediment samples were collected from six Egyptian lakes and subjected to some physical and chemical investigations. The percentages and amounts of different components of each lake sediments were compared with those of the others in order to illustrate the variations in composition of the Egyptian lake sediments.

Variable amounts of organic matter, calcareous substances, allochthonous materials and diatom-silica were deposited on the bottom of the Egyptain lakes. The distribution of these components in the Egyptain lake sediments was found dependet mainly upon certain factors which were discussed.

INTRODUCTION

Lake Manzalah, Lake Brollus, Lake Edku, Lake Mariut and the Nozha Hydrodrome are situated at the north of the Nile Delta. Lake Qarun, however, is situated in upper Egypt southwest of Cairo (Fig.1). These lakes represent the major part of the Egyptain inland water bodies. The first three lakes are connected to the Mediterranean Sea, and hence their chlorosity varies according to locality and season. All these lakes receive drainage waters, except the Hydrodrome which only feeds from the Nile water. Lake Manzalah, the largest Delta lake, has an area of about 350,000 feddans (one feddan is equivalent to 4200 m^2). Its water depth ranges from 60 to 120 cm. This Lake is also connected to the Suez Canal and the Damietta Branch of the Nile. The area of Lake Brollus, the second largest Delta lake, reaches 146,000 feddans and its depth varies from 70-240 cm. Lake Edku has an area of about 30,000 feddans, and its depth ranges from 50 to 150 cm. Lake Mariut is artificially divided into four parts. The Lake proper, from which the sediment samples were collected, has an area of 6500 feddans and its depth varies from 90-150 cm. The Hydrodrome, which was artificially separated from Lake Mariut, has an area of 1200 feddans, and an average depth of 3 meters. Lake Qarun, an inland closed basin, has an area of about 50,000 feddans and its depth may reach 9 meters.

The total fish production in Egypt depends mainly on the inland water bodies of the country. It was necessary to carry out intensive limnological studies on the Egyptian inland water bodies to evaluate their fertility with regards to their fish production. Consequently, we have started in 1968 a modern limnological program for studying these waters. The results of

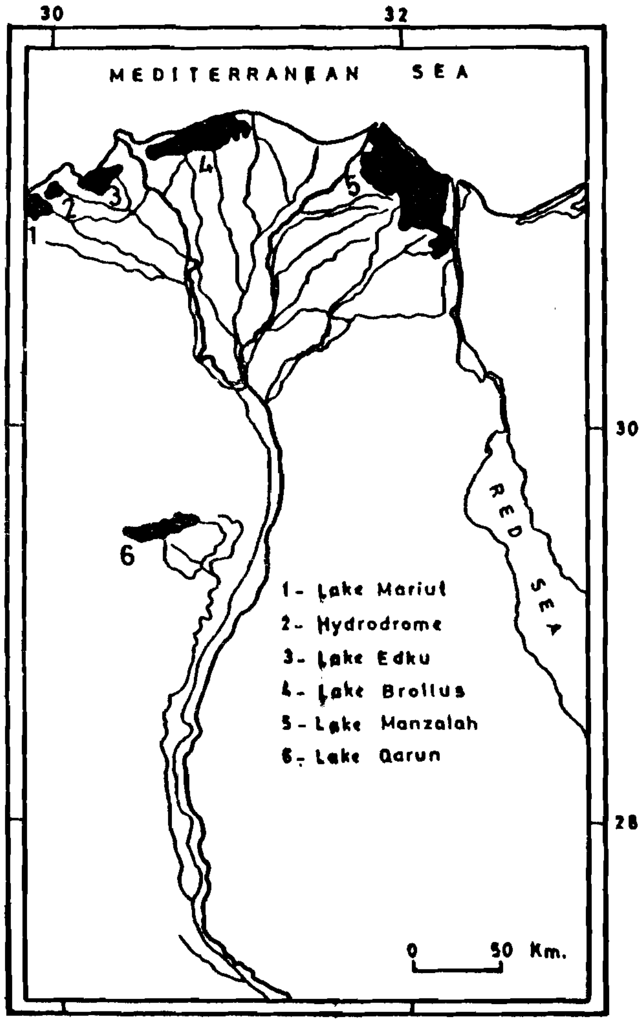

Fig. 1
Relative positions of the Egyptian Lakes.

this program covering several papers have dealt with the limnological characteristics of the Egyptian inland waters, with particular reference to the problems of pollution. The investigations of bottom deposits of these waters were also involved in this program, since the sediments are very important for the production of the lakes.

The present work was undertaken to study the nature and composition of sediments collected from the six Egyptian lakes described above and to compare the results obtained from each lake with those of the other. Such comparison seems to be of particular importance since each lake has its own limnological characteristics.

MATERIAL AND METHODS

Sediment samples were collected from three different localities of each lake using a modified Ekman-bottom sampler. The samples of Lake Manzalah, Lake Brollus, Lake Edku, Lake Mariut, Nozha Hydrodrome and Lake Qarun were mixed to from the composite A_1, A_2, A_3, A_4, A_5, and A_6, respectively.

The density of wet mud was determined, on the same day of collection, using a pyknometer. The density of dry mud was calculated from the density of wet mud and the water content (Saad, 1970). The amount of water was determined by drying the wet sediments in an oven at 105 C°. The organic matter was determined by igniting about 500 mg dry mud in a muffel furnace at 525° C for 4-5 hours (Ungemach, 1960). The HCl-soluble and insoluble fractions of the deposits were determind by adding 12.5% HCl to the remaining inorganic parts of the sediments in conical flasks, which were heated for one hour on a hot plate. Filtration was carried out using ashless filter paper. The dissolved fractions of the sediments were considered as calcareous substances and the undissolwed parts as allochthonous materials plus diatom shells. The carbonate-soluble (diatom) silica was determined photometrically using the method described by Mullin and Riley (1955), and modified by Tessenow (1964).

RESULTS

The data of different constituents of the composites A_1,A_2,A_3,A_4,A_5, and A_6 are represented as percentages per dry mud in order to give a good idea about the percentage distribution of different copmonents of the sediments of the Egyptian Lakes (Table. 1). The data obtained from all Lakes, except those of Lake Manzalah, were also calculated in kg per m^2 wet mud in order to give a good picture for copmaring the amounts of different constituents of the sediments of each Lake with those of the others. The silica content was calculated in g per m^2, due to its value (Fig. 2).

The sediments of Lake Mariut had the maximum value of water content (70.92%) and the minimum value of dry matter (29.08%). On the other hand, the deposits of Lake Edku gave the minimum value of water content (45.63%) and the maximum value of dry matter (54.37%). The water content and dry matter of the Hydrodrome sediments gave relatively high and low values of 67.60 and 32.40%, respectively. On the other hand the deposits of Lake Qarun had a relatively low value of water content (51.67%) and a high value of dry matter (48.33%).

TABLE 1

Density of the wet and dry mud, as well as the percentage of some constituents of the sediments of the Egyptian lakes.

Sample	Lake	wet mud	dry mud	Water %	Dry matter %	Organic matter %	Calc. substances %	Alloch materials %	Si %	SiO_2 %
A_1	Manzalah	-	-	-	-	5.60-	53.58	40.27-	0.54	1.17
A_2	Borollus	1.37	3.17	60.23	39.77	15.01	41.38	42.86	0.75	1.60
A_3	Edku	1.62+	3.16	45.63-	54.37+	7.48	31.82-	60.21+	0.49-	1.06-
A_4	Mariut	1.26-	3.844	70.92+	29.08-	15.21+	53.72+	30.41-	0.66	1.41
A_5	Hydrodrome	1.28	2.89-	67.60	32.40	9.63	39.97	49.59	0.81+	1.73+
A_6	Qarun	1.51	3.09	51.67	48.33	8.97	42.84	47.39	0.81+	1.72

N.B.: The maximum values are designated by (+) and the minimum values by (-).

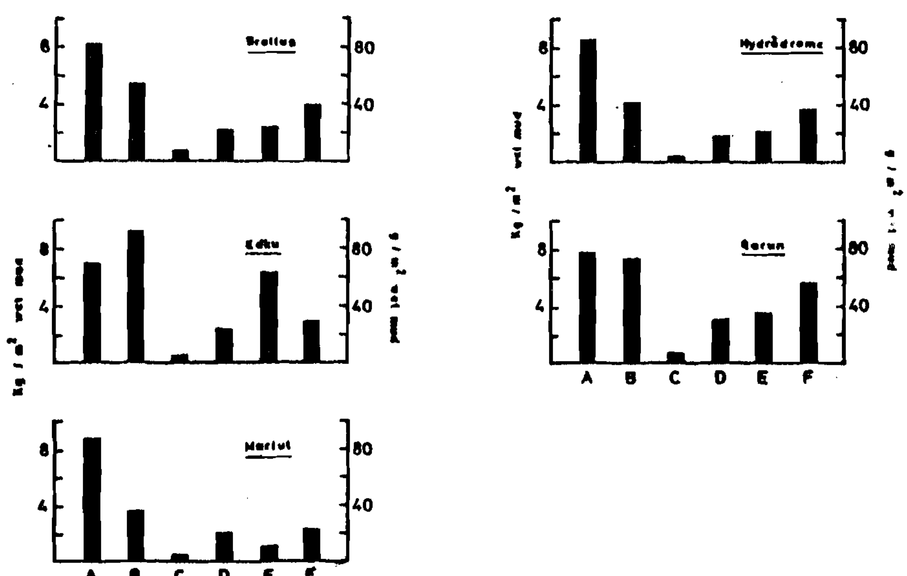

Fig. 2

Amount of different components of the sediments of the Egyptian Lakes.

A = water, B= dry matter, C = organic matter D = Calcareous substances, E = allocthonous materials, F = Si.

The maximum value of organic matter (15.21%) was found in the sediments of Lake Mariut, Whereas the minimum value of 5.60% was recorded from the deposits of Lake Manzalah . The organic content of Lake Brollus sedments also gave a high value of 15.01%. The sediments of Lake Edku, Nozha Hydrodrome and Lake Qarun had relatively low values of organic matter which reached 7.48, 9.63 and 8.97%, respectively.

The maximum value of calcareous substances (53.72%) was found in the sediments of Lake Mariut, whereas the minimum value of 31.82% was recorded from the deposits of Lake Edku. The sediments of Lake Manzalah also had a high value of calcareous substances (53.58%). The deposits of Lake Brollus, Nozha Hydrodrome and Lake Qarun gave nearly similar low values of calcareous substances, which reached 41.38, 39.97 and 42.84%, respectively.

The maximum value of allochthonous materials (60.21%) was found in the sediments of Lake Edku. However, the value of these materials reached a minimum of 30.41% in the deposits of Lake Mariut. Relatively high values of allochthonous material were also recorded from the sediments of Nozha Hydrodrome and Lake Qarun. These values reached 49.59 and 47.39%, respectively. On the other hand, the deposits of Lake Manzalah and Lake Brollus had relatively low values of allochthonous materials of 40.27 and 42.86%, respectively.

The maximum value of diatom-silica (1.73%) was found in the sediments of the Hydrodrome. However, the minimum value (1.06%) was recorded from the deposits of Lake Edku. The sediments of Lake Brollus and Lake Qarun also gave high values of silica, which resched 1.60 and 1.72%, respectively. On the other hand, a relatively low silica value (1.17%) was recorded from Lake Manzalah sediments. The deposits of Lake Mariut gave an intermediate value of silica (1.41%).

The maximum value of wet density (1.62 g/cm^3) was found in the sediments of Lake Edku, whereas the minimum vbalue of 1.26 g/cm^3 was recorded from the deposits of Lake Mariut. The Hydrodrome sediments also gave a low value of wet density (1.28 g/cm^3) which is nearly similar to that of Lake Mariut.

The maximum and minimun values of dry density were found in Lake Mariut and Hydrodrome sediments, 3.84 and 2.89 g/cm^3, respctively. The density of dry mud also gave relatively high values in the sediments of Lake Brollus, Lake Edku and Lake Qarun. These values reached 3.17, 3.16 and 3.09 g/cm^3, respectively.

The amount of water found in the sediments of Lake Mariut reached a maximum of 8.9 kg/m^2, whereas that in the deposits of Lake Edku gave a minimum of 7.00 kg/m^2. The quantities of water found in the sediments of Lake Brollus and the Hydrodrome were relatively high reaching 8.2 and 8.6 kg/m^2, respectively. However, the amount of water in the deposits of Lake Qarun was relatively small (7.3 kg/m^2).

The quantity of dry matter precipitated on a unit area of the Lake bottom (one m^2) rerached a maximum of 9.2 kg in Lake Edku sediments and a minimum of 3.7 kg in Lake Mariut sediments. The amount of dry matter in the deposits of Lake Qarun was relatively high (7.3 kg/m^2). However, the dry matter of Lake Brollus and the Hydrodrome sediments gave relatively small amounts of 5.5 and 4.2 kg/m^2, respectively.

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The amount of organic matter deposited on one m^2 of the bottom of Lake Brollus reached a maximum of 0.8 kg. However, a minimum amount (0.4 kg/m^2) was recorded from Lake Edku and the Hydrodrome sediments. Relatively great quantities of organic matter of 0.6 and 0.7 kg/m^2 were found in the sediments of Lake Mariut and Lake Qarun, respectively.

The quantity of calcareous substances gave a maximum of 3.1 kg/m^2 in Lake Qarun sediments and a minimum of 1.7 kg/m^2 in the Hydrodrome deposits. Intermediate amounts of these substances were obtained from the sediments of Lake Brollus, Lake Edku and Lake Mariut. These amounts reached 2.3, 2.1 and 2.0 kg/m^2, respectively.

The quantity of allochthonous materials precipitated on one m^2 of the lake bottom reached a maximum of 6.4 kg in Lake Edku sediments and a minimum of 1.1 kg in Lake Mariut deposits. A relatively great amount of allochthonous materials (3.5 kg/m^2) was found in Lake Qarun sediments. However, these materials gave relatively small quantities of 2.4 and 2.1 kg/m^2 in the deposits of Lake Brollus and the Hydrodrome, respectively.

The quantity of carbonate-soluble (diatom) silica gave a maximum of 57 g/m^2 in Lake Qarun sediments and a minimum of 23 $g/^2$ in Lake Mariut deposits. Intermediate amounts of diatom-silica were found in the sediments of Lake Brollus, Lake Edku and Hydrodrome, reaching 40, 30 and 37 g/m^2, respectively.

DISCUSSION

The quality and quantity of materials deposited on the bottom of the Egyptian lake are affected by certain internal and external events. The latter have a considerable effect on the nature, composition and distribution of the Egyptian lake sediments (Saad and Arlt, 1977; and Saad, 1987). All Lake receive large amounts of drainage waters, except the Hydrodrome which feeds only from the Nile water. The drainage and the Nile waters, which are enriched with silt and clay particles, continuously transport to the lakes great quantities of allochthonous materials. Lake Manzalah, Lake Brollus and Lake Edku are connected with the Mediterranean Sea by a narrow slit through which the sea water may enter into these lakes and reach a great distance inside them. The sea water may transport to these lakes considerable amounts of sand. Moreover, Lake Brollus and Lake Qarun are bordered at their northern sides by sand dunes. The sand particles are carried away by the effect of the prevailing wind to settle on the bottom of the northern sides of these lakes.

The allochthonous mineral materials entering into the Egyptian lakes are distributed on most areas of their bottom and covered the allochthonous organic sediments or mixed with them. Consequently, the exchange of elements between the sediments of these regions and the upper free water is greatly reduced under this condition (Ohle, 1960, 1962, and 1964; Ungemach, 1960, and Saad, 1970 and 1984).

The maximum density of wet mud found in Lake Edku sediments is mainly due to the great increase in the amount of dry matter, which reached the maximum value, and the decrease in the amount of water content to reach the minimum value. Such increase in the amount of dry matter in the deposits of Lake Edku can be attributed principally to the large quantities of allochthonous minerogenic materials entering into this Lake via drainage and sea waters. These allochthonous materials gave the maximum value in Lake Edku sediments (Table 1, Fig. 2).

The minimum density of wet mud found in Lake Mariut sediments was associated with the maximum density of dry mud. This minimum wet density is mainly due to the great decrease in the amount of dry matter, which reached the minimum value, and the increase in the amount of water content to reach the maximum value (Table 1, Fig. 2). Such increase in the amount of water content is due principally to the change in the nature of Lake Mariut sediments. These deposits were soft and rich in water content, due to the continuous supply of sewage and industrial wastes into this Lake, (Saad, 1972 b). The great decrease in the amount of dry matter in Lake Mariut sediments coincided with great decrease in the amount of allochthonous materials which reached the minimum value in these sediments.

Variable amounts of organic matter were deposited on one m^2 of the bottom of the Egyptian lakes (Fig. 2). The great quantities of organic matter found in the sediments of Lake Brollus and Lake Qarun are mainly due to the increase in the amount of allochthonous and autochthonous organic matter reached the bottom of these lakes (Saad, 1984). The decrease in the rate of decomposition of organic matter in the lake sediments must be also considerad.

The minimum quantities of organic matter found in the sediments of Lake Edku and the Hydrodrome are attributed principally to; 1) the decrease in the amounts of allochthonous and autochthonous organic matter reaching the bottom of these lakes; 2) the increase in the intensity of mineralization of organic matter in the lake sediments; and 3) the increase in the rate of sedimentation of mineral matter in these lakes (Saad, 1972a). The latter factor seems to be the main one, since these two lakes continuously receive considerable amounts of minerogenic materials. Lake Edku receives these materials from the drainage and sea water, whereas the Hydrodrome receives them from the Nile water. According to Saad (1970), the rate of aerobic mineralization of organic matter was found to increase in localities rich in mineral matter.

Lake Mariut receives large amounts of allochthonous organic matter in sewage and industrial wastes, which continuously enter into this Lake as a result of severe pollution. The autochthonous organic production of this Lake was also relatively high. It wuold be expected that the high organic content of Lake Mariut water must be followed by somewhat similar high organic values of its sediments. However, the organic content of Lake Mariut sediments was relatively low, due to the high intensity of decomposition of organic matter favoured by the special environmental conditions in the region (El-Wakeel, 1964a and Saad, 1972b).

The bottom of Egyptain lakes is characterized by great accumulations of calcareous shells and shell fragments of calcareous organisms. Variable amounts of calcareous substances were found in a unit area (one m^2) of the bottom of the Egyptain lakes (Fig. 2). The great amounts of calcareous substances found in the sediments of Lake brollus, Lake Edku and Lake Qarun are due to the abundance of calcareous shells on the bottom of these lakes (El-Wakeel, 1964b; Saad and 1974 and 1984; Saad and Arlt, 1977). This evidence is very clear in Lake Qarun sediments, which gave the maximum amount of calcareous substances, as a result of their enrichment with calcareous shells.

The small quantities of calcareous substances found in the Hydrodrome and Lake Mariut sediments coincided with relative decrease in the amount of calcareous shells on the bottom of these lakes. Such decrease of calcareous shells may be due to; 1) the environmental conditions, which might be unfavourable for the growth of calcareous organisms; 2) the solution of calcium carbonate, which may occur after death of the organisms; and 3) the increase in the rate of supply of noncalcareous substances. The latter factor seem to be the main one, since these two lakes continuously receive great amount of noncalcareous substances. The Hydrodrome receives these substances from the Nile water, whereas Lake Maruit receives them from the drainage waters, sewage and industrial wastes.

Different amounts of shellsdiatom-silica were found in one m^2 of the bottom of the Egyptian lakes (Fig. 2), This is attributed principally to the nature and type of sediments of these lakes. The maximum amount of diatom-silica found in Lake Qarun sediments relects the richness of these sediments with diatom shells (Saad, 1971, 1987 and 1984). It may be concluded that the environmental conditions necessary for the growth of diatoms were favourable at the time of deposition. The diatom frustules in these sediments were also subjected to a high degree of preservation. In other words, the rate of release of silica from these sediments into the free water might be greatly reduced.

The minimum amount of diatom-silica in Lake Mariut sediments coincided with the scarcity of diatom frustules in these sediments. According to Saad (1971), this condition is mainly related to the considerable changes in the nature and composition of Lake Mariut sediments which occurred in the last years as a result of severe pollution. The sludge has deposited on the bottom of Lake Mariut in great amounts. This sludge covered the successively deposited diatom frustules and made them unavailable to the Ekman-bottom sampler. Therefore, the bottom sampler collected the surface sediments with only relatively small amounts of diatom shells.

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