

**VERTICAL DISTRIBUTION OF IRON, PHOSPHORUS AND
OTHER ELEMENTS IN TWO SEDIMENT CORES
FROM LAKE EDKU.**

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ABSTRACT

Lake Edku is the smallest of the Nile Delta brackish water coastal lakes. It is connected with the Mediterranean Sea through a short and shallow channel. The lake receives at its eastern and southern margins considerable amounts of agricultural drainage water. Two short cores in the recent sediments were collected on October 1983, one near the vicinity of the lake - sea connection and the other far east near the eastern agricultural drain. The sediments were sectioned at 10 cm intervals and analyzed for total iron and phosphorus in addition to calcium, magnesium, sulphate, organic matter and water content. The results showed remarkable differences between the surface and deep sediments of the eastern part of the lake when compared with those near the mixing area. Average percentages for all samples were: iron 3.0, phosphorus 0.04, water content 55.5, organic matter 6.4, sulphate 2.0, calcium 1.8, magnesium 1.9 and calcium-magnesium carbonate 15.5. These different constituents could be arranged in a certain order according to their abundance. Different degrees of correlations between the studied variables were also given.

INTRODUCTION

Lake Edku, the smallest of the Nile Delta brackish water coastal lakes has a direct connection with the Mediterranean Sea through a shallow and narrow outlet. The lake covers about 126 km² and has an average depth of one meter. It stretches east-west by the side of Abu-kir bay for about 19 km and has an average breadth of 6 km. The lake bottom is found at a depression little below the sea level (110 cm). The lake receives considerable amounts of drainage water at its eastern and southern margins fluctuating between 39.4 and 206.3 million cubic metres per month (El-Sarraf, 1976). The exchange of water between the lake and the sea depends mainly on the wind stress and the rate of inflowing drainage water.

The chlorosity of the lake water increased gradually seawards and varied between 0.48 g cl/L (surface) and 17.7 g cl/L (bottom). The pH values of its water range between 8.00 and 9.45. Oxidizable organic matter in the water showed a wide variation between 21.2 and 65.4 mg O/l (Samaan, 1974). The lake water is well aerated with dissolved oxygen except during summer when oxygen depletion caused by the decomposition of the hydrophytes in the eastern area could be happen.

The hydrophytes, *Potamogeton pectinatus* and to a less extent *Ceratophyllum demersum* cover about 50% of the lake area, particularly in the eastern region besides the drains and also around the lake margins. The lake sediments have a characteristic composition, which is found in most of the Nile Delta coastal lakes. These sediments are composed of nearly equal amounts of sand-silt and clay, the fine particles increase, as expected, towards the drains (El-Sarraf, 1976). They also contain significant amounts of empty mollusca shells and shell fragments (El-Sarraf, 1976 and Soliman, 1983).

The present work is intend to study the vertical distribution of iron and phosphorus as well as calcium, magnesium, sulphate, organic matter and water content. Our purpose is to elucidate the effect of both sea and drainage waters on the mobilization of these variables downwards in the core sediments.

MATERIALS AND METHODS

Two sediment cores were collected from the lake during October 1983. One core of 70 cm length was taken in the bare area near the lake sea connection (core N). The other one (core D) of 60 cm length was sampled at the eastern area which represents the plant belt and drainage area (Fig. 1). These two cores were divided immediately after collection to subsamples of 10 cm interval and stored deep frozen until analysis.

To determine the water content, one part of each subsample was dried at 105°C. The carbonates then were released by means of strong acid (HCl) and the dried samples were ignited at 525°C for four hours to estimate the loss on ignition or organic content (Ungemach, 1960 and Schlungbaum et al., 1981). For chemical analysis a representative part of each fresh sample was dried at 105°C, grinded to pass 200 mesh sieve and stored in well stoppered ampules. Dried powdered samples were digested with a hot concentrated nitric-perchloric acids mixture, taken up in solutions and the filtered extracts were diluted to a constant volume. These solutions were used for the determination of total iron, phosphorus, calcium, magnesium and sulphate content.

The analysis of total iron and phosphorus were carried out colorimetrically. Iron is reduced to ferrous state by hydroxy ammonium chloride and a red colour is developed by using 2,2' dipyridyl (Jeffery,

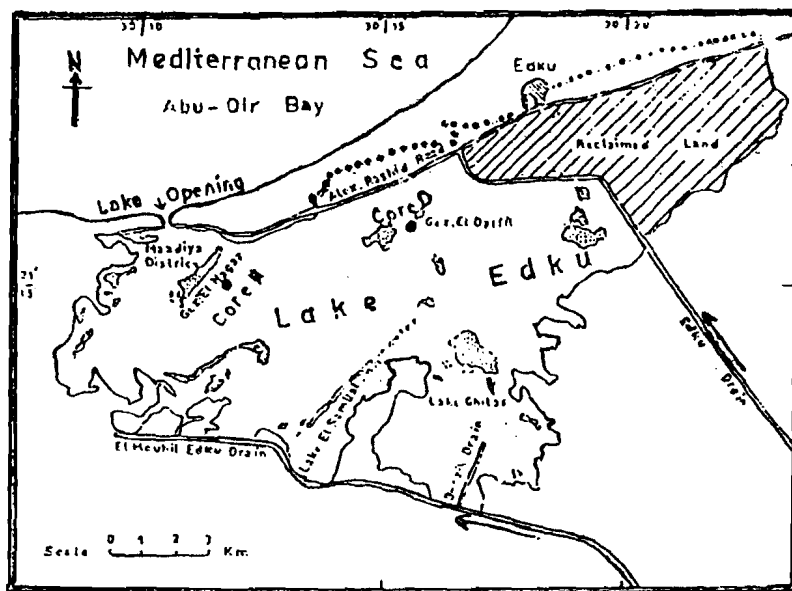


Fig. (1)
Lake Edku
Position of sampling cores.

1975). Total phosphorus is determined using the molybdate method according to Murphy and Riley (1958). The intensity of produced colours was measured against distilled water at recommended wave lengths using a Shimadzu-double beam Spectrophotometer UV - 150 - 2.

Calcium and magnesium were determined according to Heron and Makerath (1960) by titration against EDTA Solution using Eriochrome black-T as indicator. Calcium is also titrated alone using another indicator (murexide). Magnesium is then calculated by deduction.

Sulphate was determined gravimetrically as barium sulphate according to the method mentioned by Grasshoff (1976).

Total carbonates were calculated from the equivalent amounts of calcium and magnesium. These different constituents were expressed in percentages on dry weight basis.

RESULTS AND DISCUSSION

The percentages of total iron, Phosphorus, calcium, magnesium and sulphate as well as the interstitial water and organic matter in 13 subsamples of two sediment cores were given in Table (1). The calculated Ca-Mg carbonate and the order of abundance of the different constituents in each sample were also represented in this table. Correlation coefficients of pair groups of these variables were summarized in Table (2).

The amount of interstitial water showed its maximum percentage in the surface sediments. It decreased gradually downwards as the sediment tends to compact reaching its minimum in the deepest cored layer. However, the difference in water content between the surface and bottom sediments at the eastern area was extremely higher (2.25 times) than that near lake-sea connection. This regional variation may be due to the considerable amount of marine sand that introduced into the lake through its opening which in turn reduced the water content of the sediment column at the mixing area. El-Sarraf (1976), found that the sand fraction in the "Boghaz" region amounts to 92.69% of the total sediments.

In the lake sediment, the upper 20 or 30 cm layer showed a gradual increase in organic content, followed by a marked decrease reaching its minimum percentage at 40 or 50 cm depth, below which the sediment tends to be enriched again with organic substances, (Fig. 2).

The extra-cellular products exuded by the hydrophytes and the precipitated planktonic organisms are expected to be as the main autochthonous sources of organic matter in the lake (Samaan, 1974).

The drainage water, which is loaded with considerable amounts of dissolved and particulated elements as well as organic detritus and algal flora, has probably enriched the surface sediment with different constituents. The sharp drop in the amount of accumulated organic substances below the enriched surface sediment reflects their decaying and strong oxidation. The rate of degradation of the organic matter is mainly affected by redox-potential, aeration, temperature, water content and other factors.

Calcium and magnesium were more or less uniformly distributed in the two sediment cores with slight deviations from the mean values. Magnesium was approximately two times as abundant as calcium in the sediment of the mixing area. The sediment in the eastern area of the lake, which receives only drainage water, were considerably enriched with calcium in comparison with that near the lake - sea connection.

The increase in the Mg/Ca ratio seawards is due to the relatively high abundance of magnesium oxides in the marine water than calcium oxides.

TABLE (1)

Different constituents and their averages expressed as percentages (2 on dry wt. basis) to the total subsample sediments of Lake Edou as well as the order of their abundance (Core H, near the Lake-sea connection and Core D in the drainage area).

Sample	depth	H ₂ O	Org. sub	Ca	Mg	Fe	P	SO ₄	Ca Mg CO ₃	Order of abundance
1. Core H										
0-10	62	9.6	1.3	2.8	3.3	0.042	2.0	14.8	CO ₃ > Fe > Mg > SO ₄ > Ca > P	
10-20	61	13.9	1.4	2.5	4.1	0.042	1.9	14.8	CO ₃ > Fe > Mg > SO ₄ > Ca > P	
20-30	58	11.4	1.3	3.71	3.1	0.040	2.0	18.5	CO ₃ > Mg > Fe > SO ₄ > Ca > P	
30-40	48	2.7	1.9	2.8	3.2	0.050	2.0	16.3	CO ₃ > Fe > Mg > SO ₄ > Ca > P	
40-50	43	2.3	1.7	2.9	3.1	0.049	2.0	14.5	CO ₃ > Fe > Mg > SO ₄ > Ca > P	
50-60	42	2.3	1.3	2.5	3.3	0.043	2.0	13.6	CO ₃ > Fe > Mg > SO ₄ > Ca > P	
60-70	43	5.7	1.3	2.5	3.1	0.046	2.0	13.6	CO ₃ > Fe > Mg > SO ₄ > Ca > P	
Average	51	7.0	1.5	2.8	3.3	0.045	2.0	15.2		
2. Core D										
0-10	79	6.5	1.5	3.0	3.5	0.047	2.1	16.2	CO ₃ > Fe > Mg > SO ₄ > Ca > P	
10-20	76	7.7	2.5	2.4	1.8	0.046	2.0	16.2	CO ₃ > Ca > Mg > Fe > SO ₄ > P	
20-30	73	8.1	3.2	2.0	4.0	0.030	2.0	16.2	CO ₃ > Fe > Ca > SO ₄ > Mg > P	
30-40	64	4.3	2.1	3.3	3.1	0.039	2.1	18.4	CO ₃ > Mg > Fe > SO ₄ > Ca > P	
40-50	56	1.6	2.2	3.5	2.0	0.035	1.9	19.6	CO ₃ > Mg > Ca > Fe > SO ₄ > P	
50-60	34	6.4	1.5	1.2	2.0	0.030	1.9	8.8	CO ₃ > Fe > SO ₄ > Ca > Mg > P	
Average	64	5.8	2.2	2.6	2.7	0.035	2.0	15.9		

TABLE (2)

Correlation coefficients between the different variables analysed
in the two sediment cores from Lake Edku.

Core A		Core B							
n = 7		H ₂ O	Org. Sub.	Ca	Mg	Ca-Mg Co ₃	SO ₄	Fe	P
H ₂ O									
Org. Sub.		0.99 ^{**}							
Ca		0.14	-0.17						
Mg		0.33	0.29	0.19 ^{**}					
Ca Mg Co ₃		0.43	0.36	0.03	0.90 ^{**}				
SO ₄		-0.49	-0.65 [*]	-0.48	0.31	0.10			
Fe		0.52	0.63 [*]	0.41	0.42	-0.10	-0.99 ^{**}		
P		-0.35	0.65 [*]	0.39	-0.30	-0.32	0.40	-0.36	

Core C		Core D							
n = 6		H ₂ O	Org. Sub.	Ca	Mg	Ca-Mg Co ₃	SO ₄	Fe	P
H ₂ O									
Org. Sub.		0.25							
Ca		0.25	0.31						
Mg		0.45	-0.72 [*]	-0.05					
Ca Mg Co ₃		0.61	-0.39	0.37	0.91 ^{**}				
SO ₄		0.70 [*]	0.26	0.00	0.41	0.36			
Fe		0.51 [*]	0.25	0.34	0.09	0.22	0.41		
P		0.89 ^{**}	-0.02	-0.16	0.73	0.75	0.67	0.20	

n No. of observations
 * Significant at 10 %
 ** Significant at 1 %

El-Sayed et al (1980), found that Mg-carbonate was about 6 times as abundant as Ca-Carbonate in the surficial sediments of Alexandria eastern harbour. The subsamples taken from the mixing area showed no great differences in their Ca Mg-Carbonate contents from the mean value (15.2%), while the values at the drainage zone had wide variations. A linear correlation between calcium and magnesium was found only in the sediment of the mixing area ($r = + 0.99$). On the contrary to calcium, magnesium gave strong positive correlations with total carbonate in both sediment cores ($r > \text{or} = + 0.90$).

The Vertical distribution of iron in the sediment core near the mixing area was more or less uniform where the variations among the subsamples were within very narrow limits. Except a subsample between 10 and 20

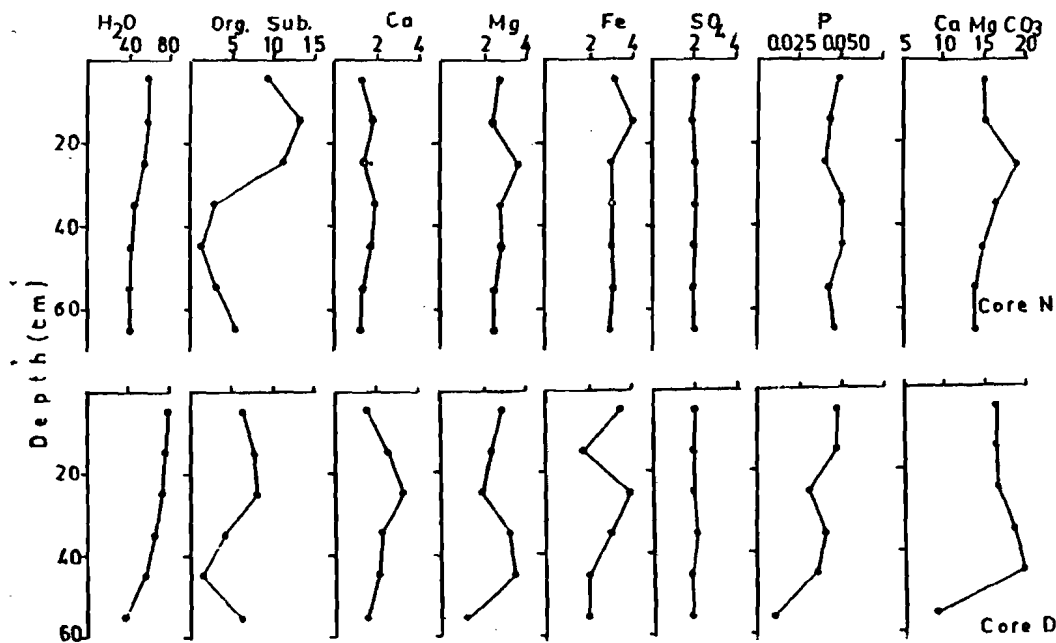


Fig. (2)
Vertical distribution of different constituents (% dry weight)
in the two studied sediment cores from lake Edku.

cm depth below the sediment interface, which reflects a maximum percentage of 4.1 associated with a higher value of arganic content, all the other percentages were very close to its core average (3.3). The distribution of iron in the eastern core, on the other hand, was characterized by wide variations, similar to the condition of the water content and total carbonates. The percentages of iron and organic matter in the lake sediment, in general, were relatively higher than those obtained by Saad et al, (1980) for the adjacent Abu-kir Bay sediment. Transportation of these constituents from the lake to the sea could be probably occurred after their resuspension in the out flowing water. The amount of interstitial water in all subsamples as well as the organic content in core N (Table 2) showed positive correlations with iron, ($r > + 0.50$). Sulphate, on the other hand, was strongly negative correlated with iron in the latter core N ($r = -0.99$).

Near the lake - sea connection the concentration of phosphorus reflects slight variations not exceeding $\pm 0.005\%$ from their average (0.045%). The vertical distribution of phosphorus in the eastern sediment, on the other hand, showed wide variations similar to the other parameters except of sulphate conditions.

The regeneration and leaching of phosphate from the sediment in the eastern region during turbulence of water and its consumption by the roots of the growing hydrophytes are mainly responsible for the marked decrease in the percentage of phosphorus. It is also noticed that the dropping in the phosphorus concentration in the deepest sediment layer of this core was associated with a marked increase in organic content, a decrease in the iron percentage and a sharp decrease in Mg - Ca - carbonate concentration too.

The concentration of sulphate in the different subsamples is nearly constant (2.0) with very slight variations of $\pm 0.1\%$. The weak or insignificant negative correlation ($r = 0.26$ and -0.65 for cores D and N, respectively) between sulphate and organic content can be explained as a result of partial reduction of sulphate by bacteria in the presence of higher organic content (Schlungbaum et al., 1931). Hydrogen sulphide was also produced and could be sometimes smelt.

According to the relative abundance in sediments, the studied constituents are decreased in the following orders:

$\text{CO}_3 > \text{Fe} > \text{Mg} > \text{SO}_4 > \text{Ca} > \text{P} \dots \dots \dots$ for core N,

and, $\text{CO}_3 > \text{Fe} > \text{Mg} > \text{Ca} > \text{SO}_4 > \text{P} \dots \dots \dots$ for core D.

The relative abundance of these variables in the surface 10 cm sediment of both cores follows the same order as for core N. This arrangement was found in a good agreement with that for sediment of brackish lagoons connected to the Baltic Sea (Nessim, 1980).

SUMMARY AND CONCLUSIONS

Precipitation as well as regeneration processes or consumption of the different ions by hydrophytes are controlled by different factors such as pH, temperature and dissolved oxygen content. These factors are changeable in the eastern part of the lake and consequently the percentages of the studied constituents showed wide gradients. The minimum value recorded in the deepest sediment (core D) for iron is nearly 55% lower than the surface concentration. For the other studied constituents, the gradient does not exceed more than 50% for carbonate, 40% for magnesium and 20% for phosphorus content.

At the mixed area, the sediment core tends to be much coarser.

homogenous and the drop of concentration of most constituent down core never exceeds 15% of their surface values.

The dropping in organic content of the sediment downwards along both cores are less than 25% of its surface value. The increase in the amount of organic substances may result either in a decrease, e.g. in the phosphorus content, or an increase, e.g. in the iron content, in the sediment.

Calculation of correlation coefficients of the studied constituents concentrations in the two sediments cores (Table 1) confirms these results:

A significant positive correlation coefficients ($r > \text{or} = 0.90$), between magnesium and total carbonates contents cores noticed in the two sediments cores, showing that the predominant carbonate in the lake sediment is magnesium carbonate.

In the eastern core, a strong positive correlation between the percentage of interstitial water and phosphorus content was calculated and showed the adsorption efficiency of the fine sediment to these ions.

The strong negative correlation ($r = - 0.99$) between iron and sulphate concentrations at the mixed area explains the inverse relationship between these ions and hence iron in the lake sediment can not be present in the sulphate fraction.

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