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THE DISTRIBUTION OF PHOSPHORUS, IRON AND MANGANESE IN RECENT MARINE SEDIMENTS OFF THE NILE DELTA

RASPODJELA FOSFORA, ŽELJEZA I MANGANA U RECENTNIM MORSKIM SEDIMENTIMA IPRED DELTE NILA

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The distribution of non-detrital phosphorus, iron and manganese was studied in some sediment samples from the Mediterranean Sea shelf off the Nile Delta. On average, the sediments contained 0.422 mg phosphorus/g, 5.860 mg iron/g, and 0.426 mg mangenese/g. The distribution of the three elements was very similar, suggesting a certain degree of geochemical association. The area distribution of the elements, the tendency of their concentrations to decrease as we moved farther away from the Nile mouths and the Lakes' openings, and the relative richness of the sediments in the cones before the two major estuaries of the river, suggested that the River Nile water was the major source of these elements' ions to the area. Adsorption of P ions on to Fe and Mn oxides may have taken place during transportation before it reached the sea.

INTRODUCTION

Phosphorus may be present in marine sediments either as inorganic phosphate mineral grains, i. e., detrital, or it may be present as phosphate ions in association (sorbed) with various sediment components, like alumino-silicate minerals, ferric oxides, manganese oxides and organic matter, i. e., non-detrital. The non-detrital fraction of the element could make an important source for phosphate ions in the water column if equilibrium conditions change, thus enriching the water and increasing biological productivity. Halim and Morcos (1966) suggested that phosphate ions are absorbed during transportation before reaching the Mediterranean Basin. On entering the marine environment, de-sorption takes place until equilibrium is reached between dissolved reactive phospate in sea water and phosphate ions sorbed into sediment particles.

However, Berner (1973) pointed out the importance of iron oxides in the removal of phosphate ions from sea water. He estimated the rate of deposition of phosphorus absorbed on iron oxides to be 0.16×10^6 tons annually in an area of 7.5×10^6 km^2 in the eastern Pacific. Furthermore, chemical analysis of Fe-Mn oxides from different marine environments indicated the presence of high phosphorus in association with the oxides (Manehiem, 1965). Thus, the geochemical association between the three elements in different parts of the dep ocean seems to be evident.

Hence, the present study was undertaken in order to find out how the distribution of both Fe and Mn affect the distribution of P in the recent sediments off the Nile Delta.

MATERIAL AND METHODS

Area Investigated: The area under investigation occupies the south eastern part of the Mediterranean Sea off the Nile Delta. It extends from Sidi-Kreir, west of Alexandria, to Port Said to the east, between longitude 29° 30' and 32° 30'. It extends seawards till latitude 32° 00' with a depth ranging between 10 m and 115 m (Fig. 1). According to Sistini (1975), the slope of the continental shelf of this aera is gentle but not uniform. The thickness of the off-shore delta sediments is not yet known. However, Harrison (1955) estimated a maximum thichness of 3,000 m near Alexandria.

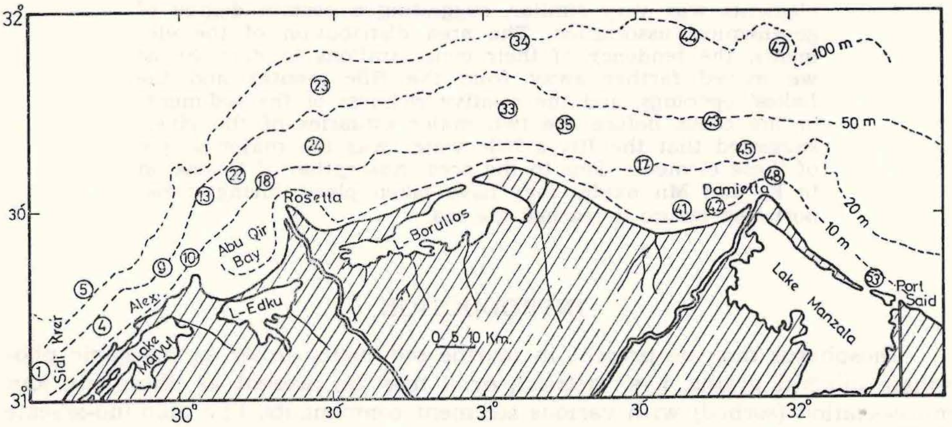

Fig. 1. Area of study and locations of sediment samples

Samples Collection: Sediment samples used in the present study were kindly provided by Dr. M. A. Mohamad of the Geology Dept., Institute of Oceanography and Fisheries. These bottom samples were collected from the area between Sidi-Kreir, west of Alexandria, and Port Said on cruises made to the area by the Russion R/V »Ichthyolog« and the Egyptian R/V »Faras Al-Bahr.« Sediments were collected by means of the Peterson grab sampler, of 0.2 m^2 capacity, from depths ranging between 10 m and 115 m. Representative samples were transferred into labeled plastic jars with screw caps. The samples were air dried and then kept in clean and dry plastic bottles. Out of these air dried samples, 22 samples were subsampled for the present work. Table 1 gives the locations of the samples, type of sediments and other data related to their chemical and mineralogical composition.

Table 1. Samples location, water depth and type of sediments

Stn. No.	Longitude			Latitude			Depth of water m	Type of sediment
	°	'	"	°	'	"		
1	29°	30'	8"	31°	03'	5"	27	sand
4	29	35	7	31	12	5	37	sandy-silt
5	29	41	4	31	16	8	100	sandy-silt
9	29	53	5	31	12	4	50	sandy-silt
10	30	02	0	31	23	2	37	sand
13	30	05	0	31	28	8	30	sand
17	31	30	0	31	37	5	20	sandy-silt
18	30	17	7	31	33	8	15	clay-silt
22	30	11	0	31	35	0	30	silty-sand
23	30	28	2	31	52	4	85	bry.-sand
24	30	26	2	31	40	7	28	sand
33	31	04	3	31	46	0	40	sandy-silt
34	31	06	0	31	57	0	80	bry.-sand
35	31	14	8	31	42	8	27	sand-silt clay
41	31	34	8	31	29	3	13	sandy-silt
42	31	43	5	31	30	0	10	sand-silt clay
43	31	43	8	31	43	1	36	clay-sand
44	31	33	0	31	57	8	96	silty-sand
45	31	49	0	31	38	6	22	silt
47	31	55	8	31	57	0	90	sand
48	31	54	0	31	35	0	10	silt
53	32	12	2	31	20	7	10	sand-silt

* From Mohamad (1972)

Samples Preparation: About 20 gm of the air dried sample were washed several times with distilled water until chloride free, and then samples were oven dried at 95° C over night.

The dried samples were ground gently in a porcelain mortar in order to break down lumps, but gently enough so that change in the particle size composition would not occur. Samples were then sieved to pass 125 standard mesh sieve. The fine fraction of the sediment samples were used for the chemical analysis.

Chemical Treatment: About 3 gm of each prepared sample were leached for 24 hours with 50 ml 2% HCl. The dilute acid would remove sorbed ions from the different components of the sediment without affecting the lattice structure of most clay minerals. The leached sediments were then separated by filtration. The filtrate was made up to 150 ml using re-distilled water, and then used for chemical analysis.

Chemical Analysis: Reactive phosphate was measured colorimetrically following the method described by Murphy and Riley (1962). Iron and manganese were measured colorimetrically using the Ortho-phenantroline method and the periodate method respectively. Both methods are described in the »Standard Methods for the Examination of Water and Waste Water« (1965), American Pub. Health.

RESULTS AND DISCUSSION

Reesults of the chemical analysis are given in Table 2. The distributional patterns of the elements studied are also shown in Figures 2, 3 and 4.

Table 2. Concentration of non-detrital phosphorus, iron and manganese in the sediment samples

Stn. No.	Phosphate mg/g	Iron mg/g	Manganese mg/g	Organic* C wt. %
1	0.325	4.723	0.416	—
4	0.506	7.935	0.407	—
5	0.543	8.689	0.228	—
9	0.048	0.387	0.110	1.34
10	0.662	8.748	0.504	1.22
13	0.325	4.877	0.485	—
17	0.169	1.084	0.296	1.22
18	0.712	9.251	0.491	1.89
22	0.653	9.400	0.739	0.47
23	0.621	8.709	0.395	0.91
24	0.189	1.587	0.325	0.29
33	0.693	9.754	0.999	1.72
34	0.109	0.426	0.281	0.53
35	0.606	7.806	0.262	1.55
41	0.361	5.458	0.548	1.22
42	0.537	8.922	0.341	1.36
43	0.349	3.561	0.207	1.60
44	0.211	0.968	0.076	0.88
45	0.380	6.425	0.627	—
47	0.567	9.837	0.792	0.47
48	0.543	9.038	0.606	0.88
53	0.155	1.358	0.253	0.86
Average	0.422	5.860	0.426	1.08

* From Mohamad (1972)

From these figures, it is evident that phosphorus, iron and manganese have very similar area distributions. Each element has its highest concentration near the Nile mouths and Lake openings; the concentration decreases towards the open sea, and to the west and east of the area.

The highest phosphorus concentration (0.71 mg/g) was measured in the area at Station 18, which was located in front of the Nile mouth of Rosetta. The lowest phosphorus concentration (0.05 mg/g) was recorded at Station 9 to the west of Alexandria. However, non-detrital phosphorus appeared to increase at Stations 4 and 1 where it reached 0.51 mg/g and 0.33 mg/g respectively. This increase may be due to the discharge of water of high phosphate content from the highly polluted Lake Maryut (average PO_4 content of the lake water is ca. 32 μg-at/1, Abdul-Moneim p. c.).

Towards the Nile mouth of Damietta, the highest phosphorus concentration of 0.54 mg/g was reported at Station 48 opposite the Nile mouth. Phosphours concentration tends to decrease both to the east and to the west of Damietta, and it was found to be 0.16 mg/g at Station 53 to the east, and 0.17 mg/g at Station 53 to the east, and 0.17 mg/g at Station 17 to the west of the Nile mouth.

In the area of Lake Borullos off the Nile Delta, non-detrital phosphorus has high concentrations. However, the area distribution of non-detrital phosphorus shows a general decrease towards the open sea. This can be seen at Stations 34 and 44 where the phosphorus concentrations recorder were 0.11 mg/g and 0.21 mg/g respectively. Sediments of the Nile cone before Rosetta and Damietta mouths however, have high phosphorus concentrations. These sediments extend far off shore into the sea.

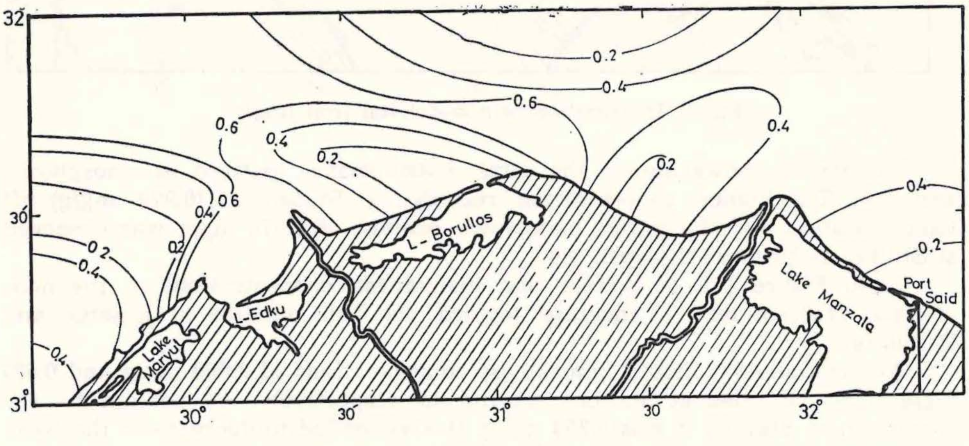

Fig. 2. Distribution of non-detrital phosphate (mg/g)

The highest iron concentration found in the area was 9.84 mg/g, which was recorded at Station 47. The lowest concentration of 0.387 mg/g was recorded at Station 9. The area distribution of non-detrital iron is very similar to that of phosphorus. From Figure 3, it can be seen that the concentration increases from the east and the west towards the Nile mouths at Rosetta and Damietta. In the Damietta area, the highest iron content (9.04 mg/g) was recorded at Station 48. The concentration decreased both to the east, where it reached 1.36 mg/g at Station 53, and to the west, where it reached 1.08 mg/g at Station 17.

The iron concentration was slightly higher in front of the Rosetta mouth; samples collected from Stations 18 and 22 gave 9.25 mg/g and 9.4 mg/g respectively. The concentration decreases towards the east and west where it was 1.6 mg/g at Station 24 to the east, and 0.33 mg/g at Station 9 to the west. In the area off Lake Maryut, the iron showed high concentrations, and this may be attributable to the polluted water discharged from the lake.

Like phosphorus, high iron concentrations were observed in Borullos region (9.75 mg/g at Station 33). The iron concentration also shows noticeable decrease towards the open sea. However, the sediments still maintained a relatively high concentration in front of the Nile mouths (9.84 mg/g and 8.70 mg/g at Stations 47 and 23 respectively).

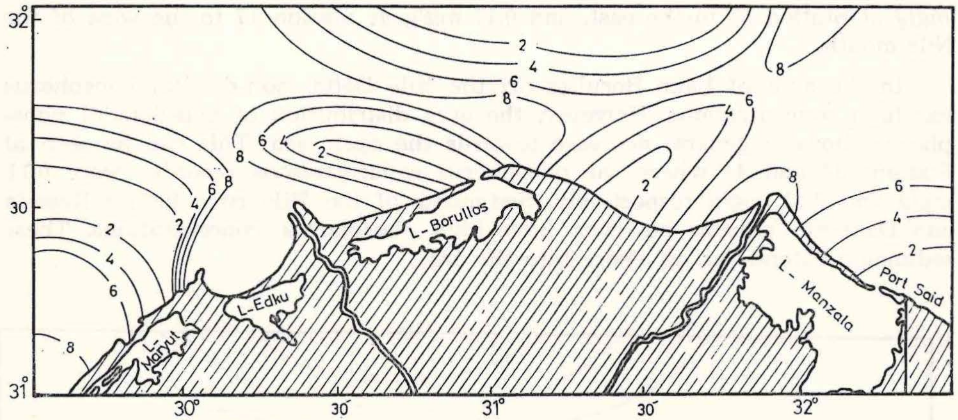

Fig. 3. Distribution of non-detrital iron (mg/g)

Manganese shows almost the same distributional pattern as phosphorus and iron. The highest concentration recorded at Station 33 (0.999 mg/g) off Lake Borullos, and the lowest manganese content of 0.078 mg/g was observed at Station 44 towards the open sea.

From Figure 4 it is evident that manganese concentrations in the non-detrital fraction tend to increase toward the Nile mouths at Rosetta and Damietta.

At the Damietta mouth, manganese concentrations of 0.606 mg/g and 0.627 mg/g were recorded at Stations 48 and 45 respectively. At Station 53, the eastern most Station, it was 0.253 mg/g. It also tended to decrease to the west, where a concentration of 0.33 mg/g was found at Station 17.

In the area of Rosetta mouth and Abu-Qir Bay, manganese concentrations of 0.49 mg/g and 0.74 mg/g were recorded at Stations 18 and 22. The manganese content tends to decrease to the east (0.325 mg/g at Station 24 and 0.11 mg/g at Station 9).

The manganese distribution in the area shows a general tendency to decrease towards the open sea, where manganese concentrations recorded at Station 34 and 44 were 0.281 and 0.078 mg/g respectively. However, this was not the case infront of the Nile mouths; where manganese still showing high concentration levels, for e. g. at Station 47 and 23 manganese content was 0.792 and 0.400 mg/g.

Thus, the area distributions of phosphorus, iron and manganese are very similar. High concentrations are invariably observed before the Nile mouths and the Lakes openings, which are the main source of both dissolved and particulate matter to the area. Such similarity suggests that the association of these three elements originates from their common source, and also during transportation and/or post depositional reactions. Both iron and manganese are known to be closely associated in the geochemical cycle (Krauskopf, 1965; Beltagy, 1973). Phosphorus also shows high affinity towards iron and to a lesser degree towards manganese (Berner, 1973). The correlation coefficient between the elements in the non-detrital fraction may be taken as an indication of the degree of their geochemical association during the oxogenic cyche. In the sediments off the Nile Delta, the correlation coefficient between phosphorus and iron is very high (0.969) Fig. 5. On the other hand, the correlation coefficient between manganese and phosphorus is only 0.668 (Fig. 6). This may indicate a lesser degree of association. This is supported by the fact that manganese correlated very well with iron (c. c. 0.848, see also Fig. 7), thus the relatively high correlation between phosphorus and manganese may have resulted indirectly due to the close association between iron and manganese on one hand and between iron and phosphorus on the other. However, laboratory experiments (El-Sayed, 1977) showed that manganese absorbs more phosphate ions than iron does i. e. correlation coefficient between phosphours and manganese should have been higher than between iron and phosphorus. However, this may have been correct if we are dealing with simple two component system, and if the nature and composition of the manganse oxides in nature were the same as the oxides used in the absorption experiments. There is also th possibility that phosphorus in sea water does not exist in the same form that has been used during the absorption experiments.

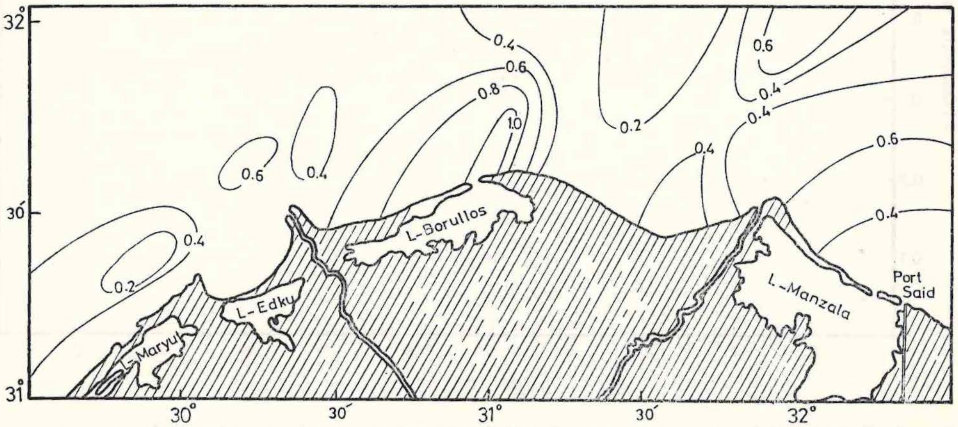

Fig. 4. Distribution of non-detrital manganese (mg/g)

Compared with sediments from other environments of the ocean, the sediments off the Nile delta has a high P/Mn, P/Fe ratios (Table 3), and lower P/C ration; nevertheless, the actual P, Mn, and Fe are lower. This may indicate

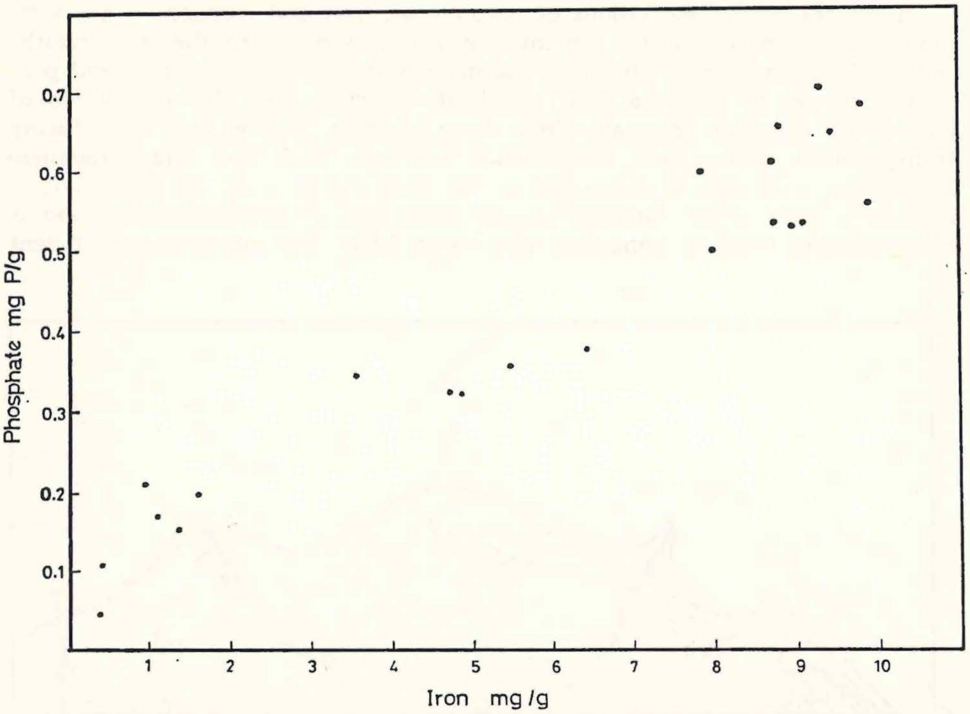

Fig. 5. Relationship between non-detrital phosphate and non-detrital iron in the sediments

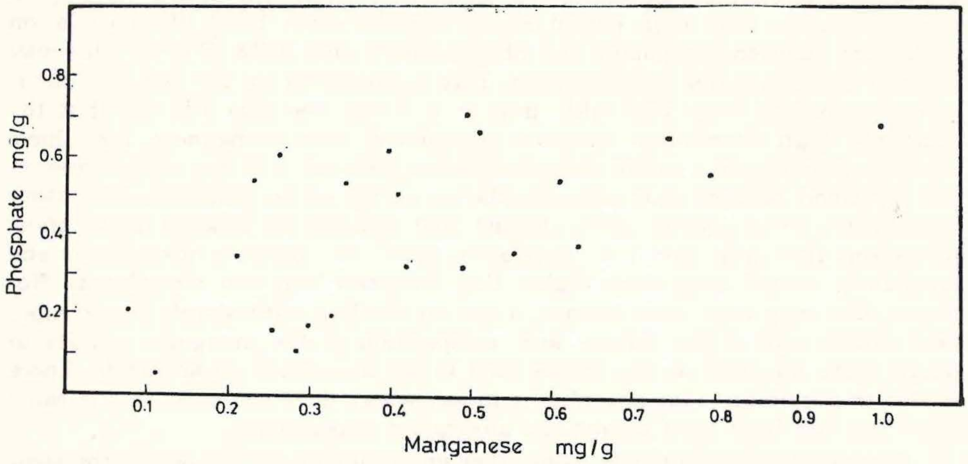

Fig. 6. Relationship between non-detrital phosphate and non-detrital manganese in the sediment

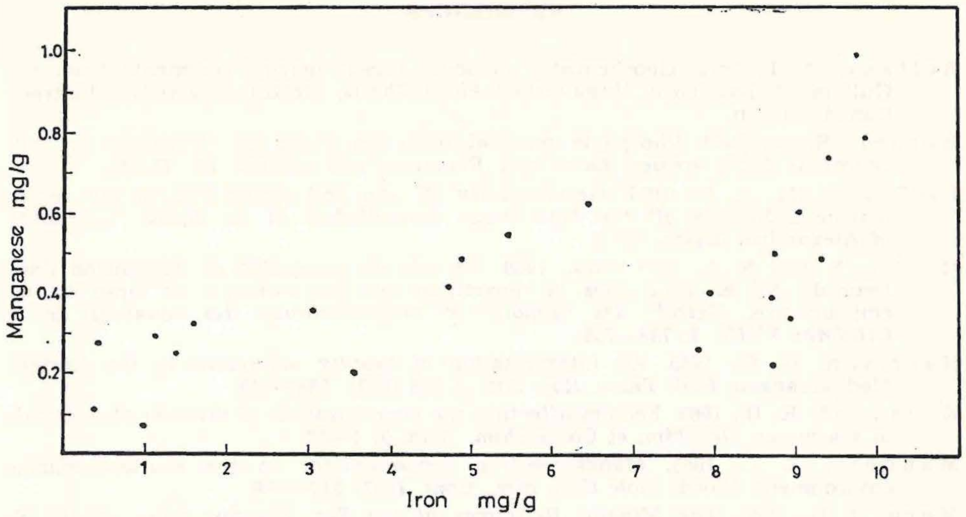

Fig. 7. Relationship between non-detrital manganese and non-detrital iron in the sediments

that in that area Fe and Mn are active agents in the process of removing phosphate ions from sea water, but they are present in relatively small concentrations, so that their contribution to the total non-detrital phosphate does not seem to be significant. Organic carbon which is present in the sediments in much higher concentrations may add significantly to the non-detrital phosphate. This is indicated by the ligher P/C in the Nile sediments compared with other sediments.

Table. 3. P/Mn, P/Fe and P/C ratio in the area compared with other Marine Sediments.

Sediment	P/Mn	P/Fe	P/C
Medit. shelf sediments	0.99	0.070	0.039
Low latitude shallow water sediments	0.83	0.06	0.47*
Deep sea sediments	0.4	0.065	1.4**

* Beltagy (1973)
** Mero (1965)

CONCLUSIONS

In the area in front of the Nile Delta, the distribution of non-detrital phosphorus, iron and manganese are in agreement with the assumption that the major source of these elements to the area is the River Nile and the drainage water from the Delta. The distribution and the close correlation between the three elements studied indicate their close association. In this area however, there are little amounts of iron and manganese to contribute all the phosphours in the sediments. Organic matter in the sediments may have contributed to the phosphorus released during chemical treatment.

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RASPODJELA FOSFORA, ŽELJEZA I MANGANA U RECENTNIM MORSKIM SEDIMENTIMA ISPRED DELTE NILA

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KRATKI SADRŽAJ

Proučavana je raspodjela nedetritalnog fosfora, željeza i mangana u uzorcima sedimenata Mediteranskog priobalnog područja ispred delte Nila. U prosjeku, sedimenti su sadržavali 0,422 mg P/g, 5,860 mg Fe/g i 0,526 mg

Mn/g. Sva tri elementa su slično raspodjeljena, što sugerira izvjestan stupanj geokemijske povezanosti.

Područje raspodjele elemenata, tendencija opadanja njihovog sadržaja s udaljenošću od delte Nila i relativno obogaćenje sedimenata s ispitivanim metalima na samim estuarima, navodi na zaključak da je rijeka Nil glavni izvor, odnosno donosilac ovih iona u ispitivano područje.

Adsorpcija fosfornih iona na željezo-manganske okside vjerojatno se odvija za vrijeme njihova transporta rijekom, tj. prije nego dođu u kontakt s morskom vodom.