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ENVIRONMENTAL FACTORS AFFECTING ABUNDANCE AND DISTRIBUTION OF MACROBENTHIC ORGANISMS IN LAKE MANZALAH, EGYPT.

By

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Key Words: Benthos, Lake Manzalah, Nile Delta lakes, Egypt.

ABSTRACT

The overall sediment distribution pattern indicates that the bottom of lake Manzalah is covered by a predominant type of sediments composed of 38%, 40% and 22% for the sand, silt and clay respectively. The monthly and seasonal abundance (no. of org./m^2) of bottom fauna in Lake Manzalah show pronounced changes with no distinct pattern of variations. Abundance during Spring season was much higher than other seasons. The average number of organisms per square meter of the bottom is 1397, 3141, 799 and 654 organism during Winter, Spring, Summer and Autumn respectively. Tendipes tentans larva and the Oligochaeta Chaetogaster limnaei were found in all stations forming an overall average of 42% for the former and 20.3% for the latter relative to the total abundance. When the distribution of benthic organisms in lake Manzalah was correlated with the prevailing environmental conditions; it became evident that both salinity and the sediment type are the main factors controlling the distribution of macrobenthos in the lake.

INTRODUCTION

Lake Manzalah is the largest and the most productive of the Egyptian delta lakes. The total area of the lake is about 215,440 Feddans with a an average depth of about 140cm. The lake shows gradient in water salinity ranging from 2.03 mg/l in the South and upto 35 mg/l at the outlets in the North. The lake is transversed by a number of small islands of varying sizes dividing the lake into a number of inter-connected basins each of which is known as "Bahr". Each Bahr has to-some extent-a distinctive character in terms of water quality and fish species distribution. The quality of the water in the basins is affected by the location of the drains discharging into the lake and the direction of the prevailing winds.

The lake is considered as a sink for disposing industrial and human wastes. A total amount of about 7500 million cubic meter of untreated industrial. domestic and drainage water as well as agrochemicals (fertilizers and biocides) is discharged annually into the lake. It is estimated that about three million cubic meters of water heavily loaded with organic matter and pollutants outflow daily into the Mediterranean sea. This out-flowing water enriches the coastal waters of the area as well as causing different types of pollution.

The quality of water in the lake basins is affected by many factors; the most significant of which is the location of the drains and the quality of their water inflow. The water level in the lake is subjected to variations during the Mediterranean Sea annual high tides in the early summer. The annual total water-inflow into the lake is equivalent to about six times the volume of the lake. Only 4% of this water is fresh water, while the remainder being supplied from the agricultural and urban waste drains.

As benthic organisms play an important role in the economy of the natural water systems. and as the nature of the benthic communities transformations is triggered by the combined action of various physical, chemical, geological and biological factors. Hence it is of prime importance to correlate the distribution of such communities with the prevailing environmental conditions in the lake.

MATERIALS AND METHODS

The lake was covered by eleven sampling stations. Each of which is located in one of the different basins of the lake (Bahr) as shown in Figure (1). Each station was sampled monthly and/or seasonally during the period from Nov. 1991 to April 1993 for the prevailing environmental parameters such as: surface water temperature which was measured by regular mercury thermometer to 0.5°C, water transparency measured by a 20 cm diameter Sicchi disc, hydrogen ion concentration using a portable PH meter accurate to the nearest 0.5, dissolved oxygen was measured by a portable Oxygen meter, chlorosity was estimate by titration against Silver Nitrate according to Mohr's method as described in Vogel, (1953) and is expressed as g/l. Sediment samples were collected using a modified Ekman bottom sampler covering an area of 0.02 square meter of the upper layer of the bottom sediments. The sediment grain size was determined by air-drying and mechanical analysis of about 15-25 gm of the sediment sample. The sample was subjected to the combined technique of dry sieving and pipette analysis according to the method described in Krumbein and Pettijon, (1938). The determination of organic matter content in the lake was based on the classic method of Walkly and Black (1934).

Quantitative and qualitative sampling were performed on the bottom Fauna collected by the Ekman bottom sampler. The bottom fauna sample was washed thoroughly in a small hand net of bolting silk with 14 mesh/cm or 14X14 cm2 and preserved with 10% neutral formalin solution in polyethylene jars for later laboratory investigations. The bottom fauna was sorted into groups where each group was counted and weighed separately after being left for about five minutes on a paper towel to get rid of external moisture.

Cluster and multivariate analysis of the abundance of the encountered species and their distribution pattern was performed by computing the similarities between every pair of samples using the Brey-Curtis coefficient (Bray & Curtis 1957). These similarity matrices were then subjected to both clustering and ordination analysis. Clustering was carried out according to a hierarchical, agglomerative method employing group-average-linkage. The results are then displayed in the form of a dendrogram. Ordination was carried out by non-metric multi-dimensional scaling (MDS) to construct a "map" of the more similar stations containing more similar samples in terms of species abundance.

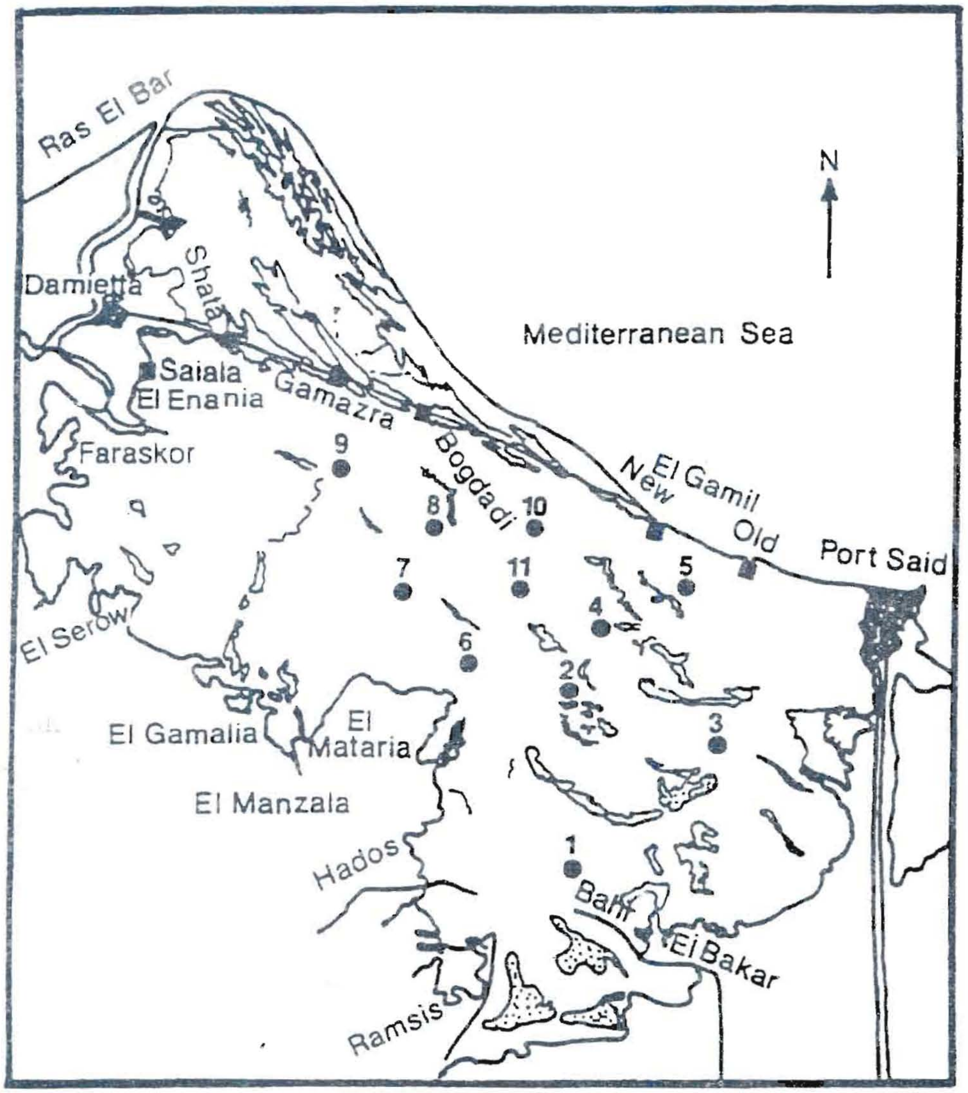

Figure (1): Location map of the sampling stations in Lake Manzalah.

RESULTS AND DISCUSSION

(A) Physical Parameters:

Temperature: Figure (2) shows that water temperature in the lake fluctuates between a minimum of 12.5°C in December/January to a maximum of 29°C in July. Apparent differences between stations were noticed probably due to the different sampling time during the day as a result of sailing time between stations.

Secchi disc readings: As presented in Figure (3) the lake is subjected to changes in turbidity levels both in time and place. It not only changes on daily and seasonal bases due to the wind action and/or ambient water temperature or other factors, but it also changes from station to the other. Station (1) shows the lowest reading due to the particulate matter carried by Bahr El Bakar drain and its discharging in this station. On the other hand, Station (9) showed the maximum reading. As a general observation; it could be noticed that the average monthly water turbidity showed a minimum in June followed by gradual increase to reach a maximum in January. This could be attributed to more suspended matter (in the form of planktonic organisms) in summer than in winter.

(B) Chemical Parameters:

The values of the Chemical parameters such as Oxygen, Chloride content and PH showed marked variations relevant to the site of the station and the time of sample collection. The most out standing features exist in the stations facing the drains and the lake-sea connection.

Hydrogen Ion Concentration (pH):

As shown in Figure (4), the monthly average of the pH values is rather on the alkaline side. It ranges between a minimum of 8.2 in November to a maximum of 8.7 in February. Station (1) showed almost the lowest pH value (8.2). This could be attributed either to low primary productivity as a result of high turbidity as indicated by low Sicchi disc reading and/or to pollutants that may suppress this process. On the other hand the western station (9) showed the highest pH value which may be attributed to the greatest light penetration of the water at this station. This penetration enhances the photosynthetic activity, hence removing CO_2 from the water and increasing the pH value.

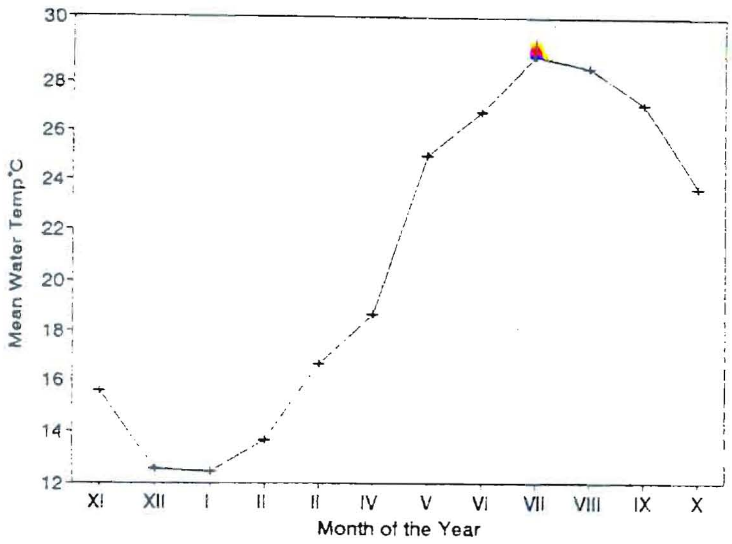

Figure 2: Monthly Temperature Average in Lake Manzala during 1992 - 1993

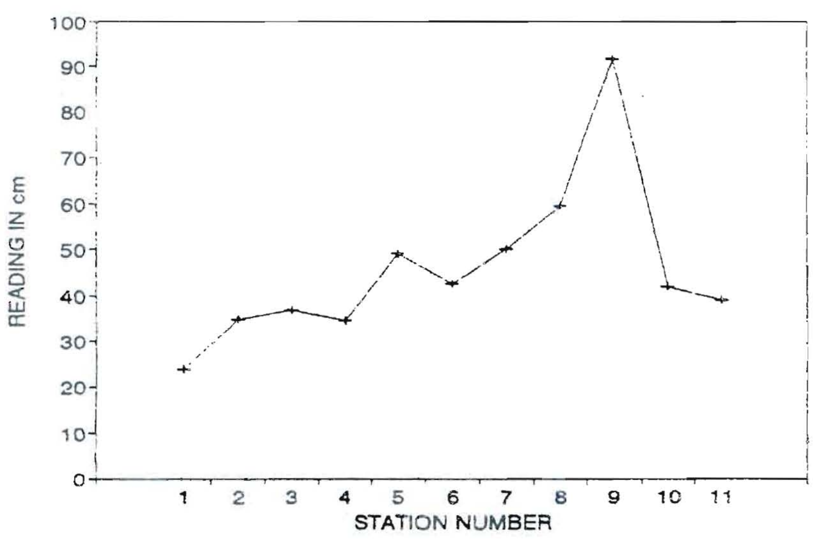

Figure (3): Average Secchi disk reading (cm) in lake Manzalah. during 1992 - 1993

Dissolved oxygen:

The surface water of the lake shows seasonal variation in the oxygen concentration level as conversely correlated with variation in the surface water temperature. Based on Figure (5), it is clear that on the average; the minimum oxygen content in the lake is reached during the hot months especially during June-July, where the surface water temperature reaches it maximum. On the other hand, the maximum oxygen content is reached during December. Individual variation in the oxygen content was also noticed in the different stations. As a rule; station (1) shows the minimum average, while most of the surface waters of the western area is well oxygenated.

Chloride content:

Considerable difference in water salinity between stations was noticed at lake-sea connections due to water movement into or out of the lake (depending on the wind condition and the difference in water levels between the sea and the lake proper). On the average and as based on Table (1). It is clear that station (5) shows the maximum salinity all year round followed by stations (4) and (3) with average annual salinity of 2.64 and 2.15 g/l respectively. In the mean time; stations (9) and (1) show minimum salinity average of about 0.74 and 0.89 g/l respectively. The mid sector stations of the lake, namely stations (2), (3), (4), (6), (7), (8) and (11) show mixed Chloride levels ranging from 1 to less than 2 gm/l.

Table (1): Seasonal salinity variations (g/l) in Lake Manzalah during 1992-1993.

Station / Season	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
Spring Season	0.56	1.04	1.33	1.82	4.95	1.08	0.98	1.16	0.67	1.08	1.29
Summer Season	0.75	1.20	3.40	2.91	7.23	1.00	1.13	1.06	0.82	1.16	2.08
Autumn Season	0.98	1.40	1.34	4.24	9.88	0.91	0.94	0.96	0.86	2.13	1.67
Winter Season	1.28	1.46	2.53	1.59	3.67	1.35	1.00	1.32	0.61	1.34	1.38
Average	0.89	1.28	2.15	2.64	6.43	1.09	1.01	1.13	0.74	1.43	1.61

(C) Geological Parameters:

Grain size analysis: The overall sediment distribution pattern indicates that the bottom of lake Manzalah is covered by a predominant type of sediments

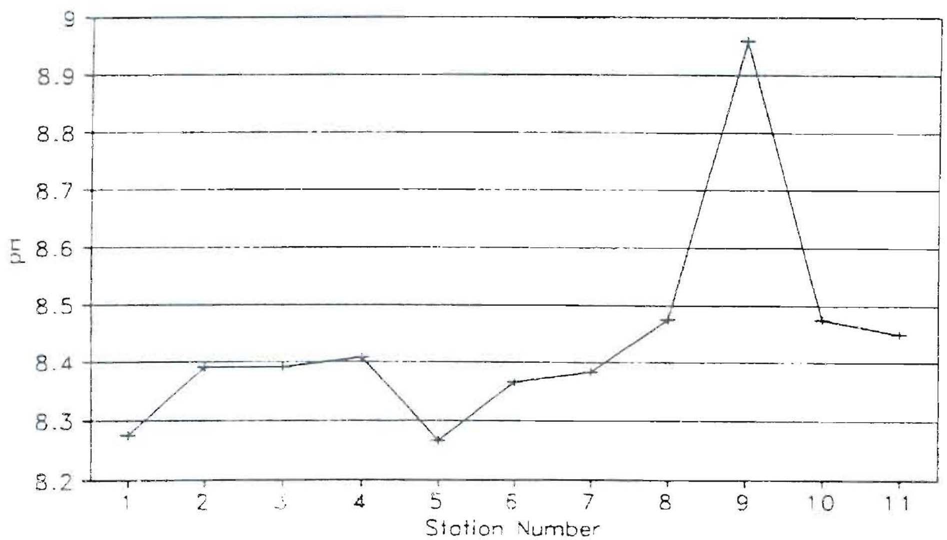

Figure (4): Annual average of pH values in Lake Manzala during 1992-1993.

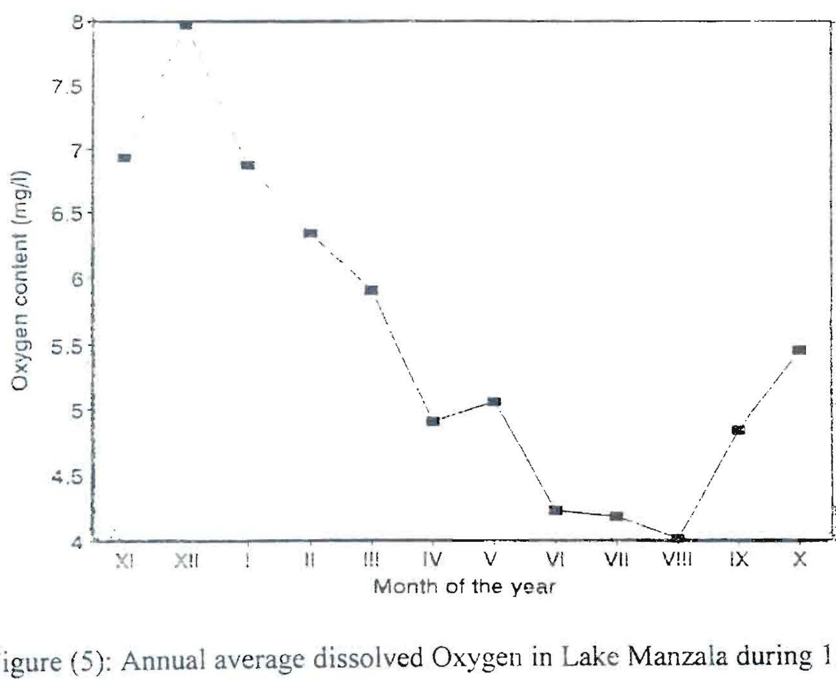

Figure (5): Annual average dissolved Oxygen in Lake Manzala during 1992-1993.

composed of variable amounts of sand, silt and clay. The constituents can be averaged as 38%, 40% and 22% for the sand, silt and clay respectively. The correlation of grain size components to each other revealed an inverse relationship between sand and both of silt and clay. The monthly changes in grain size composition are not significant due to the fact that the water turbulence in such extremely shallow lake always results in agitating the sediments at the surface of the bottom Table (2).

Table (2): Average grain size composition (%) of Lake Manzalah sediments during 1991-1993.

Station No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*Average %*
SAND	19	49	41	15	20	61	41	40	35	54	40	38
SILT	40	39	43	56	46	25	33	40	39	33	45	40
CLAY	41	13	16	29	34	14	26	20	26	13	15	22
Total %	100	100	100	100	100	100	100	100	100	100	100	100

Organic matter: Organic matter in lake Manzalah is one of the important sediment components. Organic carbon ranged between 0.9 and 9.5 % with an overall mean for the lake as 3.72%. Semi-closed areas are characterized by rich organic matter content. The annual average for station (4) was about 5.1%, while in Station (9) it shows 6.67%. Table (3). Monthly variations in organic content was not pronounced because of the high rate of sedimentation. In such environment, the rate of organic matter combustion is almost equal to the rate of accumulation. The study of organic carbon concentrations during the sampling period was not of much help to verify monthly or even seasonal changes. Rather, the observed monthly variations in organic carbon concentrations are accompanying changes in grain size.

The surface distribution of organic matter shows that the sediments of some lake areas are always highly enriched with organic carbon. Meanwhile, others show relative depletion all year round. Concentrations of more than 5% are found in the sediments from Station (4), Station (8) and station (9). Concentrations of 3 - 5% are found in sediments of stations (1), (3), (5), (7) and (10). Concentrations less than 3% are restricted to sediments from stations; (2), (6) and (11). This indicates that no general pattern of distribution can be proposed for the organic carbon contents of the sediments.

Table (3): Monthly variations in % Organic Carbon content of Lake Manzalah sediments during 1992-1993.

Station No. / Month	1	2	3	4	5	6	7	8	9	10	11	Average %
V 1992	2.4	3.9	3.1	5.5	2.7	2.3	5.3	8.6	5.7	5.5	2.3	4.3
VI	2.5	1.2	1.4	5.3	4.8	2.5	5.5	3.8	2.0	3.1	4.0	3.3
VII	3.1	1.8	2.8	6.1	4.7	2.0	6.2	7.3	9.0	1.7	3.1	4.3
VIII	3.1	1.8	3.4	5.0	4.7	1.3	4.5	3.5	2.6	3.1	2.9	3.3
IX	2.5	3.2	2.9	4.9	3.2	1.9	2.5	1.5	6.9	1.5	1.9	3.0
X	3.6	1.8	3.4	2.0	4.2	1.4	2.7	7.9	8.0	6.7	2.2	4.0
XI	2.8	2.0	5.8	4.5	5.1	1.9	3.5	6.7	7.7	3.3	3.1	4.2
XII	4.0	1.1	1.1	5.5	3.9	1.4	5.2	8.4	7.0	1.5	3.9	3.9
I 1993	4.4	1.7	2.5	5.8	3.0	1.3	5.2	5.9	5.9	2.6	1.7	3.6
II	1.3	1.7	2.1	6.2	3.8	2.1	6.7	4.6	8.6	1.2	1.9	3.7
III	4.6	3.5	3.1	4.4	5.2	1.5	1.6	2.6	9.5	2.5	2.0	3.7
IV	3.4	1.6	4.1	6.3	4.0	0.9	1.2	1.8	7.1	4.1	2.3	3.3
Average %	3.14	2.11	2.98	5.12	4.11	1.71	4.18	5.22	6.67	3.07	2.61	3.72

The organic carbon content is correlated to the proportions of sand, silt and clay fractions. A negative correlation was obtained between the organic carbon and the sand ($r = -0.58$). This means that lower concentrations of organic carbon are inherent to areas with sandy substrates. On the contrary, positive correlation were obtained between organic carbon and both of silt ($r = 0.58$) and clay ($r = 0.36$). It became apparent also that the organic carbon associates more with the silt fraction than with the clay one. The same behavior is noticed in the sediments of Lake Edku by Moussa et al., (1994). This result indicates that the silt size particles could be originally as clays that have been subjected to firm cementation by organic matter; or that the organic detritus predominates in the silt size range.

(D)Bottom Fauna:

The general picture of bottom fauna is the presence of empty calcareous forms of Mollusca. barnacles and tube worms. Living benthic organisms were generally represented by few numbers including the red algae ***Ectocarpus conferoides*** in the western area of the lake. The insect larva ***Tendipes tentans*** was found in most stations forming an overall dominant group with a year average of 56.1% of the total abundance. The Amphipoda; ***Palamontes*** sp. was noted in the eastern area, Oligochaeta, polychaetes, crustaceans, Nematoda and

Bryozoan ***Postisella erecta*** were observed in the mosouthern station near Bahr El-Baqar drain. There are also other infrequent forms such as Decapoda. Isopoda. Turbellaria and sea anemones.

Based on Table (4): the highest abundance of the benthic fauna was noticed at station (5) where it showed about 5699 organisms/m^2 represented by 16 different species. This may be attributed to the large numbers of polychaetes and cirripedian groups inhabiting this station. They amount to 54.9% and 24.7% respectively on a year average. Station (5) is characterized by higher salinity values ranging from 4 to 10 g/l. high silt and clay contents 46.0% and 34.0% respectively. and higher organic matter content positively correlated with the clay content of the sediment. This organic source induces settlement by enhancing bacterial and other micro-organisms activities that act as a primary source for the deposit-feeding invertebrates. On the contrary; the lowest numerical abundance of the benthic fauna was observed at station (10) that averaged about 499 organisms/m^2· and showed a relatively lower organic matter 3.1%. lower clay content 13.0% and lower salinity value.

Table (4) : Average annual abundance of bottom fauna in Lake Manzalah as total number of organisms/m^2 during 1992 - 1993.

Station No.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
Annual Average	1278	1733	1891	2439	5699	2000	2335	820	605	499	1488
No. of species or groups	3	3	6	6	16	6	6	5	3	5	7

The similarity of fauna dendrogram between stations. as shown in Figure (6) as obtained from the cluster analysis by the aid of computer program based on Bray-Curtis similarity method using square root(square root) transformation factor revealed a dendrogram that could be divided into three main groups. The first of which includes stations 11. 3 and 4. This group showed a high similarity level of more than 85%. Within this group. stations 4 and 3 showed higher similarity of 88.25% that is caused by the great dominance of *Chironomus* larvae in both stations. The second group showed a similarity level of more than 80% and it included stations 7. 6. 8 and 2 which are dominated by the oligochaete ***Chaetogaster limnaei*** and Chironomus larvae.

The over all annual percent abundance for all of the stations reveals that station #5 showed the maximum average annual number of organisms (5699 org./m^2) as well as the biomass. This value is twice as much as that of stations (4, 7 and 6). They are followed in descending rank by stations 3, 2, 11 & 1 respectively, where each station is having more than 1000 org./m^2. The rest of the stations are having less than 1000 organism/m^2 with station #10 is having the lowest abundance.

The higher annual abundance (5699 org./m^2) of the benthic fauna in station #5 can be attributed not only to the high number of bottom fauna groups encountered in the station (16 spp.), but also to the large number of polychaetes inhabiting this station, where they averaged about 54.9%, followed by cirripedia 24.7%. This station is characterized by having the maximum salinity values in the lake (6.43 g/l as an average), by sediment components as sand, silt and clay (20%, 46% and 34% respectively) and 4% of organic carbon . This means that the present level of organic carbon in this station is not a limiting factor for such organisms. On the other hand the lowest numerical abundance of the benthic fauna (499 org./m^2) was observed at station #10 which showed salinity of 0.74 g/l, sand, silt and clay content of 54%, 33% and 13% respectively, and 3% of organic carbon

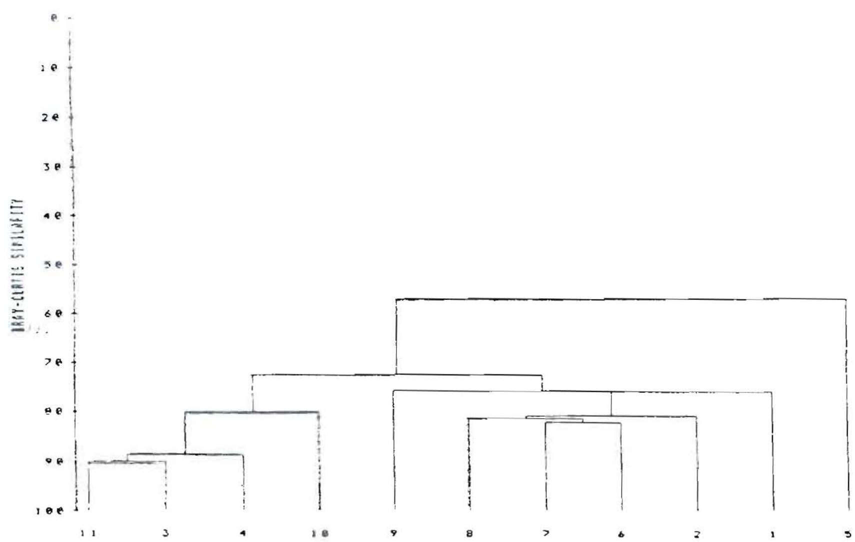

Figure (6): Similarity dendrogram of annual abundance of bottom fauna in LakeManzalah.

The cluster analysis of the grain size components distribution from the different stations as presented in the dendrogram in Figure (7) revealed that, stations (9), (5), and (10) stand alone and have their own sediment component characteristics while, the rest of the stations are clustered into one or more similar groups.

The salinity dendrogram Figure (8) points out that salinity may be one of the most important factors affecting the abundance of the bottom fauna in stations (#5, #1 and #9) ; yet this factor can not be applied alone to the rest of the stations. The mentioned dendrogram reveals also that stations #1 and #9 are about 77% similar to each other with respect to their species abundance. Yet; they are relatively fresh water basins having salinity level of less than (S = 1.0 ‰). For station #1; it is located at the outlet of Bahr El-Bakar drain which carries drain waters of salinity (S = 0.89‰) and is contaminated with industrial pollutants. In the meantime, station #9 is located at the western sector of the lake receiving drain waters from El-Enania area (S = 0.74 ‰). From the mentioned dendrogram it could also be noted that stations (#2, #6, #7 and #8) are clustered between stations #1 and #9.

A closer look at these stations shows that station #2 is a transitional station between Stations #1 and #5 with a salinity of 1.28‰. Stations (#6 & #7) are located at the southern sector of the lake and are not directly affected by neither the saline water from Boghaz El-Gamil nor by Bahr El-Bakar drain. (S = 1.09 and 1.01‰ respectively). For station #8, it is located at the north western sector of the lake and is not directly affected by sea water or drainage water (S = 1.13‰). The stations (#3, #4, #10 and #11) are also clustered as a separate group. A closer look at these stations shows that: station #10 is located at the north sector of the lake and is not directly affected with sea water or drainage water (S = 1.43‰). Stations (#3, #4 & #11) form a strip of water mass extending from within El-Gamil area to the North West corner of the lake. (S = 2.15, 2.64 and 1.61‰ respectively).

The pH, the dissolved oxygen and the organic carbon content similarity dendrograms revealed that there is more than 95% similarity between all the 11 stations. They did not show good clustering presentation to be used as a base for abundance analysis. On the other hand, the tests on the Secchi disk readings showed some vague evidence that station #9 is less similar than the other stations reflecting its less suspended matter load than the rest of the stations.

The bottom sediment distribution dendrogram is in good agreement with the abundance dendrogram in pointing out to the main factors affecting the distribution of the bottom organisms in lake Manzalah. In spite the fact that it is difficult to designate a single factor or few factors as being limiting in controlling the biological processes taking place in the abundance of bottom fauna in lake Manzalah, and such processes are controlled mainly by a combination of factors, acting at different rates throughout the successive months of the year or even during the different years; yet it is evident that both salinity and the sediment type are the main factors acting in this regard.

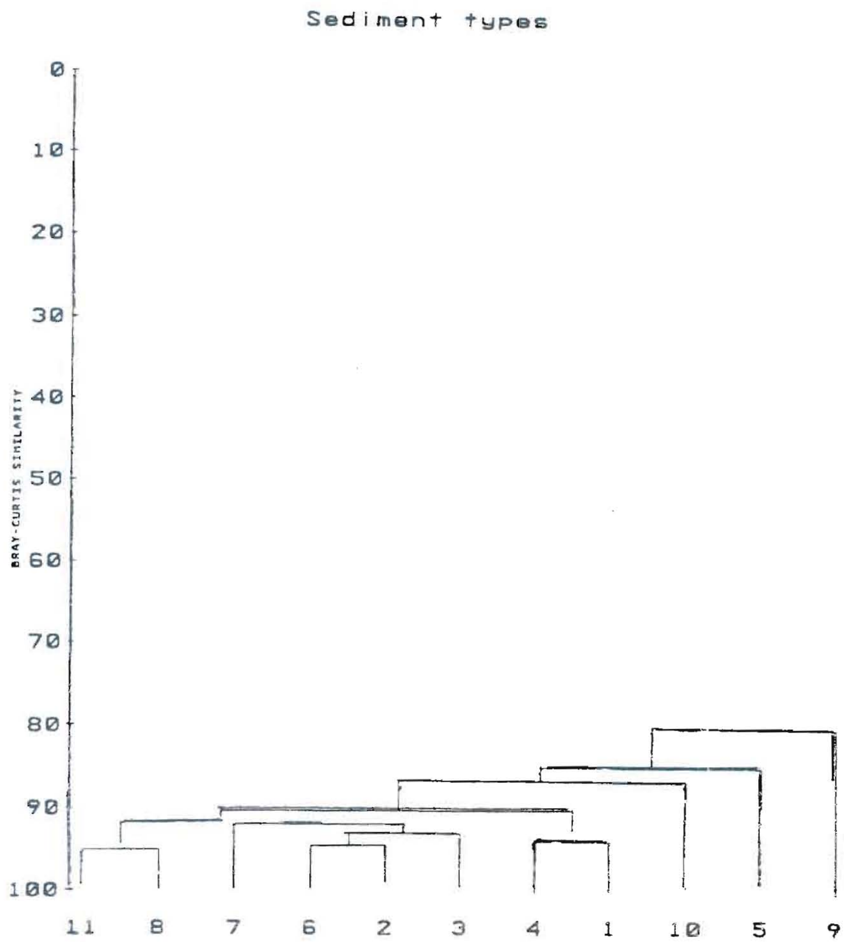

Figure (7): Similarity dendrogram of bottom sediments in Lake Manzalah.

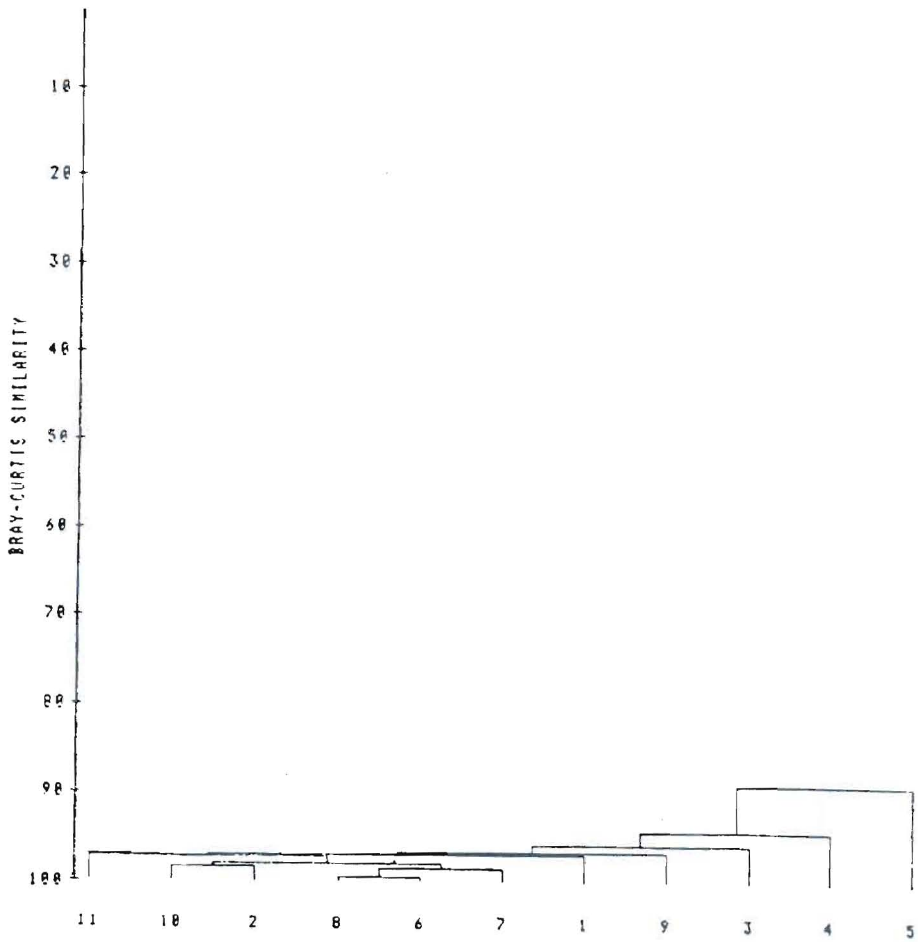

Fig. (8): Similarity dendrogram of annual salinity average in Lake Manzalah.

SUMMARY AND CONCLUSION

Lake Manzalah is a highly dynamic aquatic system. The values of the physical and chemical parameters in the lake showed marked variations relevant to the site of the station and the time of sample collection. The most outstanding features exist in both of the stations facing the drains and those at the lake-sea connection. The constituents of the bottom sediments can be averaged as 38%, 40% and 22% for the sand, silt and clay respectively. The correlation of grain size components to each other revealed an inverse relationship between sand and both of silt and clay.

Water temperature fluctuates between a minimum of 12.5°C in December/January to a maximum of 29°C in July with no significant statistical differences between the mean temperatures of the different sampled stations. The average monthly water temperature showed a minimum in January followed by gradual increase to reach a maximum in June. The values of the dissolved Oxygen. Chloride content and PH showed marked variations relevant to the site of the station and the time of sample collection.

The monthly and seasonal abundance (no. of org./m^2) of bottom fauna in Lake Manzalah showed pronounced changes with no distinct pattern of variations. The maximum annual number of organisms (5699 org./m^2) as well as the maximum number of species (16 species) was noticed at the lake-sea connection area. This area is characterized by maximum salinity values (6.43 g/l), by having sediment components represented by sand, silt and clay in the ratios of 20 %. 46 % and 34 % respectively. as well as 4 % organic carbon. On the other hand the lowest numerical abundance (499 org./m^2) was observed at station (#10). This station has salinity of 0.74 g/l; sand. silt and clay contents of 54%. 33% and 13% respectively. and 3% of organic carbon.

In spite the fact that it is difficult to designate a single factor or few factors as being limiting in controlling the biological processes taking place in the abundance of bottom fauna in lake Manzalah, as such processes are controlled mainly by a combination of factors. acting at different rates throughout the successive months of the year or even during the different years; yet it is evident that both salinity and the sediment type are the main factors acting in this regard.

REFERENCES

Bray, j.r. and J.T. Curtis (1957). An ordination of the upland forest communities of Southern Wisconsin. Ecol. Monogr.. 27: 325-349.

Krumbein. W.C. and Pettijon. F.J. 1938. Manual of sedimentary petrography. Appleton - Century. Grofts Inc.. New York. 252 p.

Maclaren. Planners and Scientists Inc. 1982. Lake Manzalah study, Cairo, ARE/UNDP/EGY/79 Draft Report to A.R.E. Ministry of Development and New Communities and UNDP Scientists, Inc. Toronto, Canada 12 vols.

Moussa A.A.; M.A. El-Sabrouti; O.A. El-Rayis, and M. Kh Khalil, 1994. Phosphorus in sediments of lake Edku, Egypt. The influence of chemical and grain size parameters. Chemistry and Ecology, Vol. 9. pp. 31-40.

Vogel, A.I. (1953). Text Book of Quantitative Inorganic Analysis. Longmans Green and Co. London.

Walkly, A. and Black, I.A. (1934). An examination of the Detjareff method for determining soil organic matter. and a proposed modification for the chromic acid titration method. Soil Sci. 37: pp. 29-38.