Suez Canal University
Faculty of Science
Botany and Microbiology Department

Characterization of Functional Groups of Microalgae in Lake Manzala and their Potentiality for Bioremediation and Biomonitoring of Pollutants

Thesis Submitted for the Ph.D. Degree of Science in Botany
(Non-Flowering Plants)

BY

Mohammed Moukhtar Salama Ibrahiem

M. Sc. (Botany) - Benha University (2015)

Supervised by

Prof. Dr.
Islam M. EL-Manawy
Professor of Phycology
Faculty of Science
Suez Canal University

Prof. Dr.
Ibrahiem M. Shaker
Professor of Limnology
Department of Limnology
(CLAR)

Prof. Dr.
Mona Hamed Ahmed
Professor and Head of Limnology
Department
(CLAR)

2021

CONTENTS

List of Tables

List of Figures

List of plates

Summary

Lake Manzala is one of the largest northern Egyptian lakes, which is ocated in the northeastern part of the Nile Delta, with a maximum length of about 50 km, a maximum width of about 30 km, and an area of about 700 km 2 that includes open water and a large number of islands, which reduces the water area to less From 500 km^2. Lake Manzala is one of the shallow lakes, with an average depth of 1.3 m, where it is fed by the waters of the Nile River and groundwater in addition to sea water. The Mediterranean Sea supplies Lake Manzala with salt water through the new and beautiful Bogaz, in addition to the New Damietta Bogaz, while the lake is connected to the Suez Canal through the Kabouti Canal.

There are three main channels connecting the lake with the Damietta branch, which are the Al-Sufra, Al-Tarma and Ananiyah canal, which were established to reduce the salinity percentage in the western part of the lake, in addition to that there are five main drains that supply the lake with sanitary, agricultural and industrial wastewater which are Bahr Al-Baqar drainage, Hadous, Ramses, Al-Sarw and Farskur . Lake Manzala suffers from its exposure to large quantities of industrial, agricultural and sanitary wastewater, which amount to about 7500 million km2, especially the southern part of it, where Bahr Al-Cow and Haddous drain about 75% (estimated at about 3.3 billion cubic meters annually for the Sea of Cow, while Haddous is estimated at about 1.7 billion cubic meters). Which in turn leads to an increase in the concentrations of heavy elements that were detected in both water and fish, in addition to the reclamation process, which led to a reduction of about 60% of the volume of the lake's water between 1900 and 2000, as the rate of reclamation in the lake was estimated at about 5 km 2 annually in The period from 1922 to 1995.

This study included two experiments:

1- **The first experiment**: a study to characterize the functional groups of microalgae in Lake Manzala and their potential potential as evidence for pollutants in the lake

2- **The second experiment**: a study of the ability of two types of wild algae: *Chroococcus*, as an example of blue-green algae and *Chlorella* as one of the green algae isolated from the Ginkgo area in Manzala lake for the biological treatment of heavy metals, cadmium and lead from aqueous solutions containing different concentrations of heavy elements (Cd^{+2} and Pb^{+2}) for algae.

(1) Field experience:

Samples:

The lake was divided into 4 regions, where 12 sites were chosen, all of which represent these four regions, the first region includes two sites (1 and 2), the second region two sites (11, 12), the third region sites (7, 8, 9, 10), and the fourth region (3, 4, 5, 6).

The results that were reached can be summarized as follows:

A- Water Quality Measurements:

1- Temperature: The water temperature changed from one season to the other, as it ranged from 17 C^{o} recorded in the winter to 31 C^{o} recorded in the summer season, but there was no noticeable change between the sites during one season as the water temperature was affected by the air temperature .

2- pH: The pH values of Manzala lake ranged between 7.45 - 8.9 with slight regional and seasonal variations. The lowest pH values were recorded in the two regions (2 and 3) facing most of the lake drains.

3- Dissolved oxygen: The lowest values of the dissolved oxygen readings were recorded in the sites of the two regions (2 and 3) due to the increase in the microbial content of consuming oxygen as a result of the richness in the

organic content resulting from the sanitary and agricultural drainage in these two regions, while the highest values were recorded in the region (1) in winter.

4- Sicck disk: measuring the transparency of water is an important way to measure the fertility of water and the amount of its containment of zooplankton and plankton from the soil. In general, the values of the transparency disk have been found low in the sites of both regions (2, 3) and this is due to the sewage in these areas beside the plankton of mud And silt from the soil, while the scale of the transparency disk increased in the first and fourth regions

5- Salinity, electrical conductivity and dissolved salts: The salinity readings in the lake varied, as the highest value (31.5 g / l) was recorded during the summer season at site No. (1), while the lowest value (1.2 g / l) was recorded during the winter and autumn seasons at site No. 9) consequently, it becomes clear that the salinity values show their highest values in the northern part of the lake, and these values decrease in the direction of the southern part of the lake. The highest values of electrical conductivity (53.5 µm S. / cm) were recorded during the summer season at site No. (1), while the lowest reading (2.1 µm S. / cm) was recorded during the autumn season at location No. (9). The highest reading (29.5 g / l) of dissolved salts was recorded during the fall season at site No. (1), while the lowest reading (1.1 g / l) was recorded during the winter season at site No. (9).

6- Total alkalinity: The alkalinity reading ranged between 245 mg / l (during the summer season at site No. 1) and between 370 mg / l during the fall and spring seasons at site No. (11).

7- Dissolved phosphorous and total phosphorous: dissolved phosphorous and total phosphorous take an opposite direction to salinity, electrical conductivity, and total dissolved salts, as it decreases in the northern region

of the lake at site 1 and increases in the rest of the sites, as a result of the increase of phosphorus in the wastewater pouring into the lake.

8- Total nitrogen: The results showed a clear increase in the total nitrogen readings, as the highest reading was recorded in the third region during August (1.26 0.1 mg / l), while the lowest reading was recorded during January in the first region (0.36 ± 0.02 mg / l).

9- Nitrates: The results showed a clear difference in the nitrate readings, as the highest reading was recorded in the third region during the month of August (0.74 ± 0.08 mg / l), while the lowest reading was recorded during the month of January in the four regions, where it ranged between (0.39 ± 0.04 and 0.47 ± 0.04). mg / l).

10- Nitrite: Nitrite readings ranged from (0.012 ± 0.001 mg / l) to (0.023 ± 0.002 mg / l) at the sites of the first two regions.

And the fourth, while from (0.015 ± 0.002 mg / l) to (0.04 ± 0.005 mg / l) in the second and third regions.

11- Ammonia: The lowest reading of ammonia was recorded in the first region, i.e both sites (1 and 2). It ranged between 0.13 ± 0.01 and 0.14 ± 0.01 mg / l, while the highest reading was in the third region during the month of August.

B- Biological properties

1- Chlorophyll (a): The values of chlorophyll A took the same direction as phosphorus, so the lowest values were at site (1), while the highest values were at site (9). The highest values of chlorophyll a were recorded during summer and autumn and the lowest were in winter. Chlorophyll a is used as an indicator of the fertility of water and its containment of zooplankton. In general, increasing the nutrients in the water leads to an increase in the proportions of phytoplankton and zooplankton and chlorophyll a. Also, an increase in chlorophyll a is accompanied by an increase in the proportion of

dissolved oxygen in the water as a result of an increase in the rates of photosynthesis.

2- Phytoplankton and their density

The number of phytoplankton is positively affected by diatoms, which represent the largest number, followed by green algae and blue-green algae group, followed by flagellated algae, which represent the smallest number. Moreover, the number of phytoplankton increases monthly. It was evident that the numbers of this group of phytoplankton from diatoms were significantly different ($P < 0.05$) between the basins of the second and third regions and the first and fourth regions. It is worth noting that the temperature season has a great impact on the distribution of diatoms, as the largest number of this group was recorded during September and October. Otherwise, the fewest numbers were recorded during August. The most abundant species during the study period were *Cyclotella meneghiniana* and *Navicula angusta*. *Navicula angusta*.

The results showed that there were clear significant monthly differences in the numbers of green algae group in different locations. On the other hand, the numbers of green algae in the sites of the second and third regions are higher than their counterparts in the first and fourth. The highest value of Chlorophyta was recorded during August in the second and third regions (6351.5 and 9553 cells $\times 10^3$/ l, respectively). Otherwise, its minimum values were recorded during January in the four regions. Among the most common types of green algae were Chlorella vulgaris, *Pediastrum* sp., *Scenedesmus denticulatus*, *Ankistrodesmus falcatus*, and *Oocystis* sp.

The results showed monthly differences in the numbers of blue-green algae in the studied regions. On the other hand, we find that the number of blue-green algae increases in the second and third regions, while their numbers decrease in the first and fourth regions. The largest number of

Cyanophyta was recorded during the month of September for the second and third regions (1379.4, 1266.2 cells × 10^3 / l, respectively) and during the month of August (885.3, 857.4 cells × 10^3 /l, respectively). On the other hand, the minimum values were recorded during the month of January. *Microcystis* sp. And *Anabaena* sp. They were the predominant races among the blue-green algae.

The results showed that Euglenophyta represented the least contributor to a number of phytoplankton. It showed that the number of Euglenophyta increased with time, and the highest numbers were recorded during August for the second and third regions (803 and 935.6× 10^3 cells / l, respectively). The lowest numbers recorded during January for the first and fourth regions were the *Euglena* sp. and *Phacus longicauda* are dominant among the rest of the species.

Understanding phytoplankton functional groups and their relationships with the environment is critical to sustainable lake management. Therefore, phytoplankton and water samples were collected and analyzed from July 2016 to June 2017 to discover these relationships, with a total of 14 phytoplankton functional groups identified; A, B, C, D, F, H1, J, K, Lo, M, P, S1, X1, W1. Biomass of seven phytoplankton functional groups (C, F, H1, J, Lo, P and X1) was predominant. The biomass of the phytoplankton functional groups in the lake showed seasonal variation with the highest biomass value being recorded in the fall and the lowest in the winter. The P and C functional groups were predominant in the winter when temperatures were very low. The H1 group was predominant in summer corresponding to higher temperatures. In the fall groups Lo and X2 were predominant corresponding to high levels of total phosphorous (TP). The results showed that changes in dissolved oxygen (DO), water temperature (WT), total phosphorous (TP), electrical conduction (EC), transparency (SD)) And total nitrogen (TN) were key

influencing factors associated with changes in the composition of PFGs in Lake Manzala.

3- Zooplankton and its density

- About 37 species of zooplankton, represented by three groups, are Rotifers and copepods and Cladocera addition to some rare species such as protozoa and insect larvae.The second and third regions sites maintained the highest zooplankton densities at 394 org. / l. The results showed that Rotifers predominate over the rest of the zooplankton species, about 36 and 39% of the total number of zooplankton in the second and third regions, respectively, and *Keratella cochlearis- Brachionus angularis- Brachionus calyciflorus- Polyarthra vulgaris* were predominant. Copepoda represented in second position in terms of importance to the second and third regions. Only two had been recorded: *Thermocyclops neglectus and Acanthocyclops americanus*. Cladocera was represented by 30 and 26% of the total number of zooplankton at the sites of the second and third regions, respectively. *Diaphanosome excisum, Moina micrura and Ceriodaphia quadrangula* were the dominant species.

Heavy metals in water and fish tissue:

- Elevation Concentration of all heavy elements in the water in the sites in the southern region of Lake [7, 8, 9, 10] than the rest of the sites due to their proximity to the mouths of the main drains.

- The rise of lead and cadmium elements in the sites [1, 2] near Al-Bughaz, due to its proximity to the highway and the presence of fishing port stations.

-The higher concentration of elements in the liver than in the rest of the organs, followed by the gills, then the meat.

-The high concentration of all elements in catfish tissues, followed by mullet and tilapia.

- The higher concentration of elements in water and fish tissues during the summer than in the rest of the year.

B- Laboratory experiment:

The most important results were that the decrease in the amount of cadmium Cd^{+2} by *Chlorella* 12 days after the start of the experiment was 53.26%, 78.33%, 85.87% and 87.95% for the concentrations 2.0, 4.0, 6.0 and 8.0 ppm; Respectively. *Chlorella* was also shown to remove Pb^{+2} lead at 48.23%, 67.08%, 72.94 and 84.98% at concentrations of 3, 6, 12 and 18 ppm, respectively, 12 days after the start of the experiment. This means that the absorption capacity of heavy metals by *Chlorella* can be exploited to detoxify solutions and environmental cleaning processes. In the case of *Chroococcus*; It was observed that the Cd^{+2} clearance was 54.43 and 48.05% at the highest concentrations of 0.4 and 1.0 ppm, which the algae were exposed to until the last day of the experiment. While the Pb^{+2} lead removal percentage (51.44 and 38.98%) was recorded at the end of the experiment for concentrations of 10 and 20 ppm and decreased to 30.98 and 29.43% for concentrations; 30 and 40 ppm, respectively.

Recommendations

According to our findings:

1- The importance of studying the physical and chemical variables, both spatial and seasonal, in determining the functional groups of phytoplankton, and thus in assessing the environmental status of the lake.

2- It is important to understand how human activities change the concentrations of potentially toxic metals, what processes affect this change and which activities have the greatest impacts

3- The study recommends the necessity of disposing of the internal guts of fish before cooking.

4- The study recommends the necessity and utilization of Bahr Al-Cow drainage water after treating it and using it in planting woody trees and others or establishing wastewater treatment plants before dumping it into the lake.

5- The necessity of creating channels to deliver the waters of the Mediterranean Sea to mix the water and reduce pollution.

6- We recommend the possibility of using algae species isolated from polluted sites for biological treatment of heavy metals, as the ability of algae to remove elements varies according to the element, time period and element concentration. Therefore, the study sheds light on the need to choose algae to remove certain elements and the study recommends the need to work on the use of algae to remove pollutants On a large scale to overcome the problems of water scarcity in Egypt.