

Regional Water Resources Management - Lake Qarun Restoration, Egypt

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ABSTRACT

Lake Qarun is one of the closed saline lakes located in the North of the Western Desert of Egypt. Lake Qarun is situated in the lowest part of the Fayum Depression with an elevation of ≈ 43 m below sea level. It is located between the latitudes of $29^{\circ} 24'$ & $29^{\circ} 33'$ N and longitudes of $30^{\circ} 24'$ & $30^{\circ} 49'$ E. The lake covers 230 km² in surface area. Qarun area was declared as a natural protectorate according to the provisions of Law 102/1983, by Prime Ministerial Decree Number. (943 / 1989). Lake Qarun is under environmental pressure which cause series of problems related to the lake's ecological and aquatic life. Thus, there is a pressing need to form accurate understanding of the many environmental factors. The lake suffering from several problems such as, Increasing evaporation rate and absence of fresh water inflow, Receiving a huge amounts of sewage water and irrigation water moreover the Wind-blown sands attack the lake from north and northwest...etc. Lake restorations are usually attempted not only to improve water quality and aquatic life but also to improve aesthetic and recreational needs. In lake restoration techniques, depending on the nature and extent of the problem. There are many approaches for lake restorations. This paper presents the physical and chemical methods for Lake Qarun restoration.

Keywords: *environmental pressure; lake Qarun; lake restoration; water budget; water resources management.*

1. Introduction

Environmental and climate changes play an extremely important role in water basin management [1]. The climate changes can result in great hydrology changes in Qarun Lake. Increasing global warming causes an increase in the evaporation rate from the lake which causes to convert lake to dead lake in the future. It could be said that Lake Qarun is under environmental pressure which caused a series of problems related to the lake's ecological and aquatic life. Thus, there is a pressing need to form an accurate understanding of the many environmental factors, particularly the water budget components that affected the main service function of the lake. Lake Qarun suffers from many problems as mentioned in the next sections. Additionally, several solutions are presented in this paper.

2. Study area

Lake Qarun is one of the closed saline lakes located in the North of the Western Desert of Egypt. It is the merely significant natural lake in Middle Egypt. It is situated in an arid region occupying the lowest part of the Fayum Depression (Figure (1,2)).

Lake Qarun is one of the most important inland-aquatic ecosystems in Egypt. It is a distinctive

landform lying in the El-Fayum area situated approximately 80 km southwest of Cairo. Besides its significance as a natural discharge area for the El-Fayum region, Lake Qarun is situated in the lowest part of the Fayum Depression with an elevation of ≈ 43 m below sea level. It is located between the latitudes of $29^{\circ} 24'$ & $29^{\circ} 33'$ N and longitudes of $30^{\circ} 24'$ & $30^{\circ} 49'$ E [2]. It is bordered from its northern side by the desert and by cultivated land from its south and southeastern side. The lake covers 230 km² in surface area. The climate is generally warm and dry in Lake Catchment. The mean minimum and maximum temperatures are 14.5 °C and 31 °C, respectively. And the annual mean relative humidity varies between 50 % and 62% [2]. In addition, it is characterized by low seasonal rainfall and a high rate of evaporation. Rainfall is extremely less than 15 mm annually. The total area of El-Fayum depression is around 6000 km². Approximately 1800 km² of the depression is filled with rich alluvial sediments and more than 1580 km² is cultivated. This area presents more than 5% of the total cultivated land of Egypt

[3]. It is an area of heavy agriculture, it depends on irrigation from the Nile. El-Fayum depression has a special nature of its land which slopes from south to north. The drainage water flows from south to north by two main drains (El-Batts and El-Wadi), finally, it

flows into Qarun and Wadi Al Rayan Lakes. The population of El-Fayum was about 3.8 million according to the population of the Arab Republic of Egypt for the year 2020.



Figure 1- Satellite image of El-Fayum depression.



Figure 2- Satellite image of the lake Qarun and El-Fayum depression.

3. The Importance of Lake Qarun

Lake Qarun is one of the most important inland-aquatic ecosystems in Egypt. The lake is an important place for fishery, salt production, tourism and migratory birds in the autumn and winter seasons.

Therefore, Qarun area was declared as a natural protectorate according to the provisions of Law 102/1983, by Prime Ministerial Decree Number. (943 / 1989) [4].

Healthy lakes and their shores not only provide us

with a number of environmental benefits but they influence our quality of life and they strengthen our economy. Proper lake function can ease the impact of floods and droughts by storing large amounts of water and releasing it during shortages. Lakes also work to replenish groundwater, positively influence the water quality of downstream watercourses, and preserve the biodiversity and habitat of the area. When the ecological puzzle pieces of a lake come together and the lake is able to work as it should, the big picture is clear, we all stand to benefit from this important resource.

Lakes can provide us with prime opportunities for recreation, tourism, and cottage or residential living. They are also respected by many people for their historical and traditional values and maybe a source of raw drinking water for a municipality. Lakes can also be used as a water supply for industry and an irrigation source for agriculture.

So you see lakes are more than just a simple body of water used by many people to enjoy recreational activities. They are important ecosystems that, when respected and cared for, can sustain a healthy balance of aquatic life, provide us with much enjoyment, and help support our socio-economic needs. It is our responsibility to continue to practice stewardship in our lakes by keeping them healthy for all, especially those who depend on them.

4. Lake Qarun suffers from many problems

Increase the water level from year to year

It could be mention that, Lake Qarun is under environmental threaten which causes several problems influence the lake's ecological and aquatic life. Thus, there is a pressing need to form accurate understanding of the many environmental factors, particularly the water budget components. The hydrologic water balance for lakes can be expressed as

$$\Delta S = P + R + Q_i - E \pm Q_{gw} - Q_o \quad (1)$$

Where P: the precipitation over a lake surface, R: the runoff to a lake from its drainage basin, Qi: the inflow water into the lake (e.g drainage water), Qgw: the ground water, Qo: the outflow water from the lake, E: the amount of water evaporated, ΔS: the change in water body storage.

The residual amount of the water balance equation is 29.65 million m3/year. In the beginning of the simulation period, the lake stage is 43.00 m below sea level and in the final simulated lake stage is 42.87 m below sea level. Therefore, the increasing in the water level annually by 13.17 cm and increasing the surface water area consequently. Figure (3) shows the danger area which will be affected by the annual

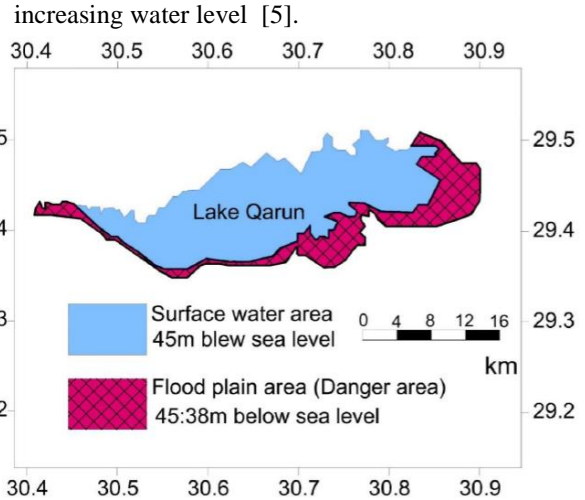


Figure 3- The danger area will be affected by flood

In this section, many problems that lake Qarun suffered from are presented. Lake Qarun suffer from many problem as mentioned in Table (1).

Table 1- The Main Problems Of Lake Qarun,

| Problem | Cause | Result in |
|--|--|---------------------------------|
| The annual discharge of inflow water is greater than the annual discharge of outflow water | Increase the water level from year to year | Inundation of contiguous lands |
| Increase evaporation rate and absence of fresh water inflow | Increase salinity | Dead lake |
| Receive a huge amounts of sewage water and irrigation water | Increase pollutant and pesticides and heavy metals | Deterioration of lake ecosystem |
| Wind-blown sands attack the lake from north and northwest | Sand dune | continuous shallowness |

After showing the great problem that lake Qarun suffering from, Great efforts should be directed to keep the lake function as a drainage reservoir, a fishery and also as a touristic place. There are many proposals will offer safe preservation and protection of one of the oldest lake all over the world since its historical heritage and natural resources should be under sustainable development programs in order to maintain its continuous development and restoration.

5. Results and dissection

Lake Qarun Restoration.

Generally, Lake Restorations concept is usually attempted not only to enhance the water quality and the aquatic life but also to improve aesthetic and recreational needs. In lake restoration techniques, depending on the nature and extent of the problem. There are many approaches for lake restorations such as physical, chemical and biological. For example, Dredging is the most common method of the restoration methods. In this technique, there are a physical removal of sediments from water body's bed. This study presents the physical and chemical methods for Lake Qarun restoration (See Figure (4))

6. Physical Methods

Dredging techniques

Dredging is a digging activity conducted underwater particularly in shallow basins with the aim of collecting the sediments from basins' beds and getting rid of them at another site. The dredging technique is usually aimed to conserve waterways navigable. Moreover, it is applied as an approach to fill up sand on many public beaches, wherever sand has been wasted as of coastal erosion process. Sometimes, the Fishing dredge is used as a tool for hooking many certain species of crabs and clams. Several of these ways are carried out particularly for use in small reservoirs and lakes.

The removal of pollutant

The removal of pollutant from lake especially phosphorous because it is considered one of the main harmful substance which affects the water quality and aquatic system when it found in high concentrations. Finally, reducing the contaminants inflowing the system from external sources is frequently referred to as continued removal of the sediment from the lake. The removal of phosphorus is very important action to alleviate the pollutant load in the water body. In most cases, phosphorus is very harmful to the aquatic life and water quality, when the phosphorus concentration excess the allowable values. It is limiting nutrient for aquatic systems. Phosphorus is found in the lake water when external inputs are inflowing the water body as wastewater. In lakes, Phosphorus can be found in a high ratios in

vegetation and bottom sediments. This phosphorus can be removed by two restoration approach (chemical and physical). The chemical approach is carried out by treating inflowing water to get rid of the phosphorus. The physical approach can be done by dredging to remove sediment from the lake bed which contains a high concentration of phosphorus. Dredging reduces phosphorus concentration by getting rid of the part that is contained in the sediments. Some researchers have shown that some bodies of water can reach up to 66% of their total phosphorus loading from sediment input [6]. Lake Ontario sediments have been found to contribute phosphorus concentrations equal to 10 % of the total lake's external loading [7].

Types of dredging equipment

The common types of dredging equipment are grab bucket, pneumatic, and hydraulic(see Figure (5,6 and7) .

Sediment removal techniques have been used as a Regional water resources management tool for many years, with much data collected on its surrounding environmental effects. The required Data for lake restoration by dredging is as follows:-

- 1) Information about the past ecology and the future prediction to determine the target removal depth.
- 2) .Sediment accumulation rates
- 3) Actual water depth for different parts of lake
- 4) Bottom contour for the lake bed.
- 5) Determine the location for disposal site.
- 6) Take samples of water and sediment at the dredging area.
- 7) The physical composition of dredged materials.
- 8) Surveys (by using lead-line or echo-sounding) are applied to confirm the adequate depth of water and the volume of sediments to be removed.
- 9) Choosing the most appropriate method or equipment of dredging.
- 10) The approval or appropriate licenses from environmental agencies.

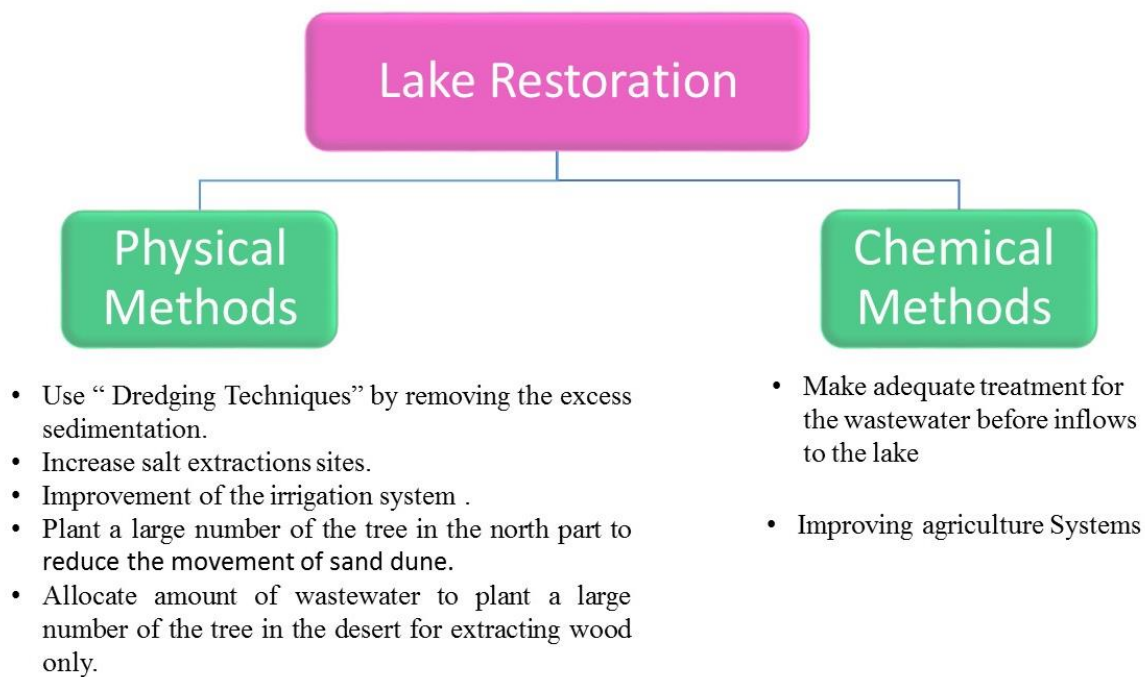


Figure 4- Physical and chemical methods for Lake Qarun restoration.

The disposal places

The disposal place needs to have an adequate area that has a high infiltration ability to cope with the amounts of water and sediments. also, it needs to have built basins wherever materials can be stored, dried, and subsequently spread on the ground surface (according to the Waste Management Regulations).according to the rules in the Sediment Management Strategy (2007) sediments should be recycled where available in flood embankments, or reused on agricultural lands. Removal of $284 \times 10^3 \text{ m}^3$ of wet sediment (To minimize the inflowing phosphorus loading from nutrient-rich sediment) from Barton Broad removed about 50 ton of P from the lake [8]. [9] studied many dredging projects Trout Lake, in Florida, 3 ha. Of 41 ha. The lake was dredged to a sand bed. The consequents of this experimental restoration were that benthic fauna diversity was raised in the dredged regions. Long Lake, in Michigan, was dredged to enhance fish

habitats. The average depth was raised from 0.75 m to 2 m, and bass average length grew by about 5 cm. Lake Trummen, in Sweden, was dredged to minimize Phosphorus load in this lake. After the dredging process, the lake no longer gave periods of phosphorus concentrations near 1 mg/l but held steady around 0.2 mg/l.

Increase salt extractions sites.

Salt extraction companies play important role in lake restoration by extracting a huge amount of salt and abstracting amount of water from the lake. Extracting salt reduces the salinity of the lake water for improving the aquatic life. In addition, abstraction water reduces the water surface level in order to alleviate the flood event. Thus, new evaporation basins with purposes of salt extractions are highly recommended to cope with the growing rate of salts in the lake waters by adding annual agricultural wastewater.



Figure 5- Excavator on a pontoon loading a barge



Figure 6- Storage dredged material in barge



Figure 7- Dredged material being pulled out

Improvement of the irrigation system.

The improvement of the irrigation system would lead to conserving the water resources. Therefore, the infiltrated water through the ground will be reduced. Consequently, the amount of wastewater which reach the lake via ground water will be also reduced.

Plant a large number of the tree in the north part to reduce the movement of sand dune.

The lake is bordered from the northern part by desert which causes movement of sand by winds. This amount of sand deposit in the lake bottom causing a noticed rise in the bottom level. Thus this problem reduces the capacity of the lake to receive more of wastewater.

Allocate amount of wastewater to plant a large number of the tree in the desert for extracting wood only.

plant an especially trees (which are called woody plants) which have a wide cross section for extracting wood only by using untreated water for irrigation process. In addition, the various woods have been used as source of paper and natural glue. Also, the reusing of waste water as an irrigation water for landscaping instead of using fresh water.

7. Chemical Methods

The improving agriculture Systems

The improving agriculture Systems by reducing the use of pesticides and fertilizers would lead to reduce the amount of recharge polluted water to aquifer which have a direct impact on the water quality of the lake. The Coordination with the Ministry of Agriculture plays an important role to control and

rationalize the use of agricultural pesticides, as well as non-use of pesticides that remain in soil and water for a long time without decomposition.

Make adequate treatment for waste water

It is extremely important to make reasonable treatment for the wastewater before inflows to the lake to reduce the negative impacts and pollution level of inputs wastes to water body for water quality, aquatic life and whole lake ecosystem.

8. Conclusion

Lake restoration techniques can play a major role to obtain safe, clear, and navigational lakes. It is needed particularly under the continuous environmental changes, such as water level fluctuations, pollution, climate change, and threatened ecological balance. However, the majority of this study has focused on reaching solutions to the problems of Lake Qarun. therefore, we had to study the water and salt balance of the lake and find out the causes of these problems so that we can develop possible scenarios and solutions, not only to eliminate the current problems but also to cope with the expected effects of future expansions, such as the inundation of contiguous lands, the deterioration of lake ecosystem, Increase the salinity, and continuous shallowness. Finally, restoration technics prevent lakes from losing their functions.

Therefore, it can be concluded that the restoration technics for Lake Qarun was proposed for the following purposes:

- 1) Give the lake sufficient water depth for flood hazardous prevention.
- 2) Reduce the concentration of phosphorus loading from nutrient-rich sediment.
- 3) Contour adaptation for navigational purposes

- 4) Remove harmful substances in sediment.
- 5) To conservation many aquatic species diversity (biological diversity).
- 6) Reduce the concentration of contaminants in the water column.
- 7) Make lake water valid for the irrigation process.
- 8) Improve the social and economic life.
- 9) Protect the long-lasting jobs as fishermen.
- 10) Promote the touristic and recreational activities

9. References

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