Lakes, reservoirs and ponds, vol. 10(2): 139-158, 2016

BATHYMETRIC STUDY OF SOME KHORS IN LAKE NASSER, EGYPT

Radwan ABD ELLAH[1], Tarek EL-GEZIRY[2*]

[1] Laboratory of Physical Limnology, National Institute of Oceanography and Fisheries, 101 Kasr El-Ainy Street, Cairo, Egypt; Phone: +20227921341; E mail: Abdellah555@hotmail.com

[2] Laboratory of Physical Oceanography, National Institute of Oceanography and Fisheries, Kayitbey Road, Al-Anfoushy, 21556, Alexandria, Egypt; Phone: +201143946353; Email:**tarekelgeziry@yahoo.com*

Abstract

Lake Nasser is a man-made lake that represents the national freshwater bank of Egypt. The Lake's reservoir is about 300 km long. The Lake is featured by the presence of numerous dendritic inlets, or side extensions of the reservoir, known as khors. While most of these Khors are narrow and extend for long distances into the desert, some other Khors are very wide. The Lake, and consequently its Khors, may have fluctuated in the surface area and the morphometerical features; due to the increasing population, the Ethiopian Renaissance Dam building, in addition to the climate change. A bathymetric survey was conducted, for the first time, on five Khors in Lake Nasser. The bathymetric contours for each Khor were used to produce hypsographic curves relating water level in each Khor to its surface area and volume. The surveyed Khors comprised Khor Toushka (area of 184.8 km^2), Khor Dahmit (area of 12.0 km^2), Khor Abu Askar (area of 36.7 km^2), Khor Batikh (area of 7.1 km^2) and Khor Dahab (area of 13.3 km^2). A large number of scattered islands, of various sizes, can be observed within the Khors. These islands represent the tops of former hills. Fluctuations in the water level in Lake Nasser greatly impact on the number, the location and the size of these observed islands.

Keywords: Lake Nasser; Egypt; khor; bathymetry; water level.

1. INTRODUCTION

Reservoirs are an essential component for the flood control, the production of hydroelectric power, the creation of freshwater stores to be used in the years of extremely low natural discharge, the fish production and they have significant effect on the life style of communities along their shores (CPWF, 2009).

Bathymetric information on lakes is of special importance in Limnology. Beside the determination of water level, area and volume curve relationships, multi temporal comparison between different bathymetries plays a key role in detecting many environmental changes such as lake sedimentation, lake ecosystem functioning, life times, in addition to the derivation of erosion and sedimentation rates of catchments (Dost&Mannaerts, 2008).

Limnologically, Lake Nasser and its Khors are key players in the environmental planning, restoration and management of water resources in Egypt. The knowledge of the Lake's Khors is based on observation of the dimensions of their water basins. Concerning the bathymetric map, the changing conditions in the water body, such as the water level, the rapidly changing of bathymetric chart is obvious. The Lake, and consequently its Khors, may have fluctuated in their total surface areas and morphometerical features; due to the population increase, the Ethiopian Renaissance Dam building (El Bedawy, 2014), in addition to climate change (Elshemy&Meon, 2011; Elsaeed, 2012). As water resources in Egypt are becoming scarce (Abdin&Gaafar, 2009) and as public awareness of the morphometry of the Lake's Khors studies are almost rare, it has become necessary to have a continuous record and a good upgrading of changes in its morphometerical features.

The present study can be considered the first study that targets the establishment of bathymetric maps of some Khors in Lake Nasser aiming at to improving the baseline knowledge of the bathymetry and the fluctuating water levels of the selected Khors.

1.1. Site description

The High Dam Lake, south of Egypt, was formed by the construction of Aswan High Dam, and is considered the second largest man-made basin in the world. The solely water source to the Lake is the River Nile inflow from the south, with a water inflow of the order 84 km^3/year (Mageed&Heikal, 2006). The flood season always takes place from the end of July to November. According to the 1959 treaty, the average natural flow to Egypt is 55.5 km^3/year (van Zwieten *et al.*, 2011). Some 12 km^3/year is

assumed to be lost due to the natural evaporation process (Mutua *et al*., 2005). The total seepage around the Lake is found to be 1.2 $\times 10^{-3}$ km^3/year (Khalil *et al*., 2005).

The reservoir of the High Dam Lake is divided into two basins: Lake Nasser in Egypt and Lake Nubia to the south in Sudan. The mean depth of the High Dam Lake fluctuates between 20.75 m at 160 m level and 25.23 m at 180 m level above the mean sea level (MSL) (Table 1). The mean width changed from 7.36 km to 13.03 km at the two levels, respectively (Entz, 1976). Lake Nasser represents the national freshwater bank of Egypt. It lies between Latitudes 22º 00\ and 23 º 58\ N and Longitudes 30 º 35\ and 33 º 15\ E (Figure 1). Lake Nasser's reservoir length is about 300 km (Hassan, 2013).

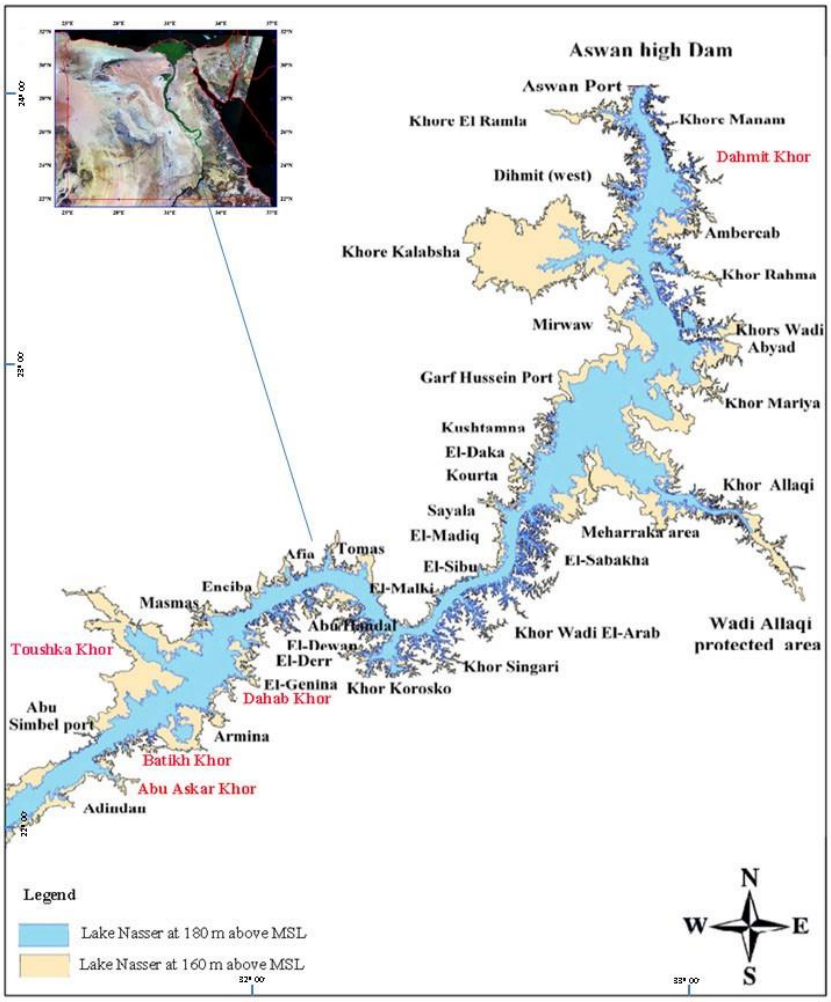

Figure 1. Lake Nasser and its main Khors in east and west shoreline

The deepest part in the basin of Lake Nasser is the ancient bed of the river south to the adjacent cultivated land, forming together the original river valley and known as the main channel of Lake Nasser (Abd Ellah, 2004). The maximum water depth is 120 m, at the Lake's level of 180 m above the MSL near the Aswan High Dam. The Lake's mean depth, on the other hand, fluctuates between 30.53 m at 160 m level and 25.01 m at 180 m level above the MSL, respectively (Table 1).

Table 1. The morphometric features of Lake Nasser and High Dam Lake (Entz, 1976)

Basin	Lake Nasser (Above MSL)		High Dam Lake (Above MSL)	
Water level	160 m	180 m	160 m	180 m
Length (km)	291.8	291.8	419.8	481.8
Surface area (km2)	2562	5237	3084	6276
Water storage (km3)	53	131	64	158
Mean width (km)	8.85	17.95	7.36	13.03
Mean depth (m)	30.53	25.01	20.75	25.23
Shoreline length (km)	4516	7875	5960	8804

The eastern mean slope of Lake Nasser shoreline is generally rocky or stony, and is steeper than its western flatter, more open, wider, often sandy shoreline (El Shahat, 2000). The Lake is featured by the presence of numerous dendritic inlets, or side extensions of the reservoir, known as khors (Mostafa&Soussa, 2006). These are located on both sides of the reservoir. van Zwieten *et al*. (2011) reported that, these Khors impact on the length of the shoreline, which is estimated at 8700 km. Thus, the effects of the fluctuating water level on the boundaries are the source of some conflict among fisher groups. At 180 m above the MSL, the total surface area of the Khors outside of the main valley covered by water is about 4900 km^2, which represents 79% of the total surface area of Lake Nasser. However, the volume of water in these is only 86.4 km^3, which represents 55% of the total Lake's volume (Mostafaa&Soussa, 2006). Each water body in each Khor is characterized by its own ecological natures and environmental conditions that are different than those of the main channel of Lake Nasser (Elba *et al*., 2014). Khors are highly productive, and most of fish landing and catches come out from it. Therefore, local variations in their limnological characteristics are expected to be of considerable importance (Abd El-Monem, 2008). Water flows in the Khors are of lower velocities than the Lake itself. This results in a general reduction in the potential of mixing of

local effluent discharges and, in turn, enhances potential vulnerability to local influences. The environmental conditions in the Khors create an ideal ecosystem for fish spawning (Zaghloul *et al*., 2011). Decreases in Lake's water level results in a general decline in the water quality from the order of good to medium in both the Lake Nasser and its Khors (Heikal, 2010).

2. MATERIAL AND METHODS

A bathymetric survey was conducted on five Khors in Lake Nasser. The surveyed Khors comprised Toushka Khor, Dahmit Khor, Abu Askar Khor, Batikh Khor and Dahab Khor. The survey program commenced in 2016 and data collection was performed as scheduled in Table (2). Khors' Bathymetry charts were produced by using a combined system of a Global Positioning Systems (GPS) and a portable sonar sounder mounted on a small boat. The GPS device (Garmen 76) was used to determine the positions, *i.e.* to record the location coordinates (Latitudes & Longitudes). The water depth was determined using a Portable Eco-sounder device (Navman, fish 4500). The sounder uses a beam frequency transductor of 50 kHz to measure the distance from sensor to Khor's bottom with an accuracy of 10 cm. The depth record density or measurement grid distance is a function of the variation of the Khor bathymetry. As a rule, high variations in depth require high record densities. Factually, data supplied from the bathymetry survey covered two distinct data classes: the Khors' shoreline data and the in-Khor depth readings.

Table 2. Date and number of recording points in Lake Nasser khors

Khor	Date of serves	Number of recording points	
		shoreline	Depths
Toushka	February 28th, 29th , March 1st , 2nd	1147	1377
Dahmit	March 4th , 5th	2271	2199
Abu Askar	Aug 1th	792	556
Batikh	Aug 2th	588	1298
Dahab	Aug 3th	351	676

3. RESULTS AND DISCUSSION

3.1. Toushka Khor

Toushka, also called Toushka west, is one of the southern Lake Nasser's Khors. The Khor is located to the south-west of Lake Nasser between 22° 31' 41.3" and 22° 43' 27.5" N Latitudes, and 31° 32' 19.7" and

31° 47' 08.7" E Longitudes (Table 3). Toushka Khor is separated from the main channel of the Lake with a natural wide opening water channel of 11.25 km width, with no outlet. This Khor with its funnel shape is considered one of the largest Khors in Lake Nasser. It extends for 34.5 km in an east–west direction. The maximum width of this Khor is 12.7 km, and its surface area is 184.8 km^2. Toushka Khor is bordered from its most sides by the desert with many newly reclaimed land established in some southern region of the Khor. The Khor contains 17 islets, some of which are usually air-exposed, and some others are covered by the Khor's water during high flood time.

Figure (2) shows the produced bathymetric map for Toushka Khor; showing its water depth contours. Waters in Toushka Khor are considered of medium depth with regular bottom topography. The depths in the Khor vary between a few centimeters to ≤ 30 m. The lower water depths are usually found close to the shoreline and also along the western bank of the Khor. The higher depths, on the other hand, exist near the inlet of the Khor.

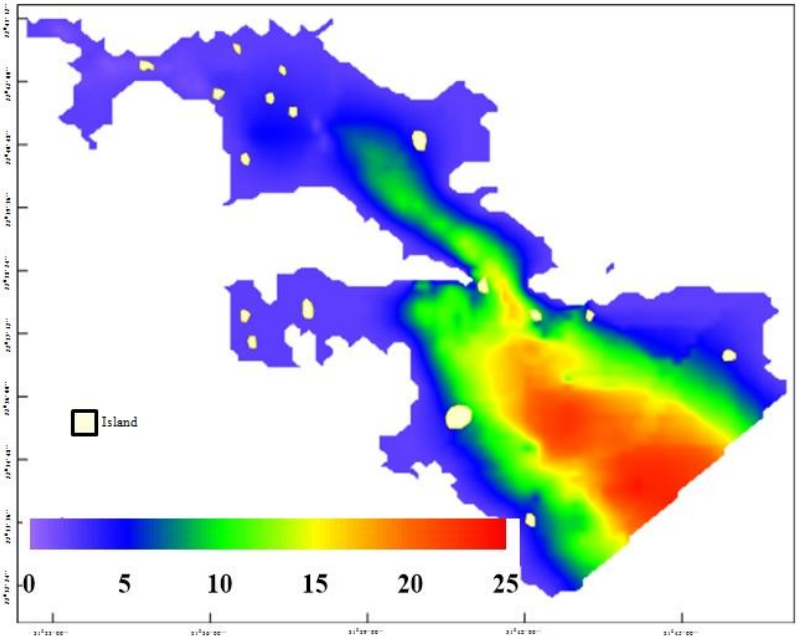

Figure 2. Bathymetric Chart of Toushka Khor

Figure 3 shows the special relationship between the Lake's water level and both the water surface area and water volume in Toushka Khor. The limit of water level ranges between 175.2 and 145.2 m above the MSL, and there is a general increase in the surface area and water volume in the Khor with the increase of the water level above the MSL.

Table 3. General information for five Khors in Lake Nasser

Khor	Location	General shape	Position				Dimensions					
			Latitudes (N)		Longitudes (E)		Opening water (km)	Shoreline (km)	Length (km)	Max width (km)	S.area (km^2)	Volume (Km^3)
			From	To	From	To						
Toushka	South-western	Funnel	22° 31' 41.3"	22° 43' 27.5"	31° 32' 19.7"	31° 47' 08.7"	11.25	125	34.5	12.7	184.8	2.01
Dahmit	North-eastern	Octopus	23° 43' 21.4"	23° 48' 01.4"	32° 57' 22.0"	33° 03' 17.6"	0.45	103.4	12.4	0.9	12	0.22
Abu Askar	South-eastern	Funnel	22° 12' 59.3"	22° 17' 44.7"	31° 36' 17.3"	31° 44' 15.7"	3.04	54.53	14.35	5.65	36.7	0.38
Batikh	South-eastern	Octopus	22° 18' 18.0"	22° 21' 06.7"	31° 43' 42.2"	31° 47' 44.9"	0.75 - 1.55	30.1	6.87	1.13	7.1	0.04
Daha	South-eastern	Funnel	22° 28' 14.2"	22° 31' 50.2"	31° 55' 03.7"	32° 00' 35.6"	5.4	30.1	8.8	5.4	13.3	0.18

Figure 4 displays the histogram distribution of both water surface area and water volume in relation to the water depth and elevation. It can be easily noticed that the notable surface area and volume dominate from 160.2 m above the MSL. Below this level only small depths, and hence small area and volume dominate.

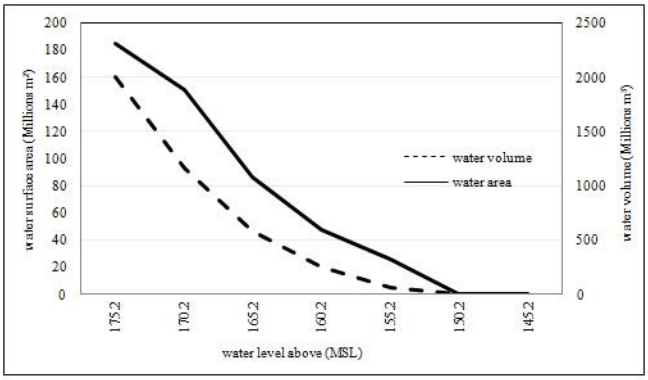

Figure 3. The relationship between water level and both the water surface area and water volume in Toushka Khor

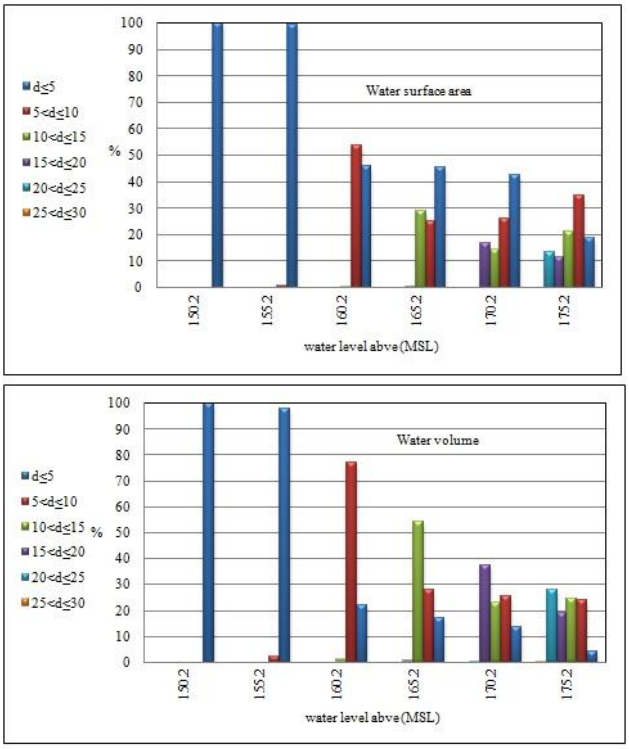

Figure 4. The percentage of both water surface area and water volume at different water levels in Toushka Khor

3.2. Dahmit Khor

Dahmit Khor is located in the north-eastern corner of Lake Nasser (Table 3). The Khor occupies the area between 23° 43' 21.4" and 23° 48' 01.4" N Latitudes, and 32° 57' 22" and 33° 03' 17.6" E Longitudes. Dahmit Khor is connected to the main channel of Lake Nasser by a natural narrow mouth (0.45 km width), with no outlet. This Bay, as Octopus shape, is considered one of the smallest Khors in Lake Nasser. The Khor spreads in the west–east direction, with a total length of 12.4 km, a maximum width of 0.9 km and a surface area of 12.0 km^2. Dahmit Khor is surrounded from its borders by the desert and mountains. The Khor include 10 islets, some of which are usually aerated, and some others are covered by the Khor's water during high flood.

According to the produced bathymetric chart of Dahmit Khor (Fig. 5), the Khor is classified as deep water Khor with no regular bottom topography. The depths in this Khor vary between a few centimeters to 55 m. The lowest water depths are observed near to the shoreline and also along the eastern side of the Khor. The higher depths occur near to the entrance of Dahmit Khor.

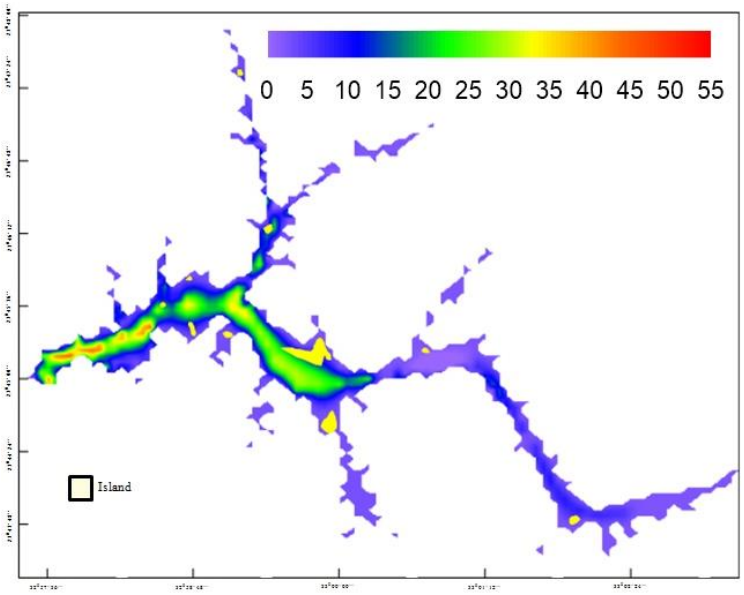

Figure 5. Bathymetric chart of Dahmit Khor

Again, the direct relationship between the Lake water level and both the water surface area and water volume in Dahmit Khor can be easily detected as illustrated in Figure (6). This relationship is limited between 120.1 and 175.1 m above the MSL. Statistically, Figure (7) illustrates the

histogram distributions of both water surface area and water volume of Dahmit Khor. In contrast to the case in Toushka Khor, moderate surface areas and volumes, in accordance to the depth variations, started to appear from the level of 135.1 m.

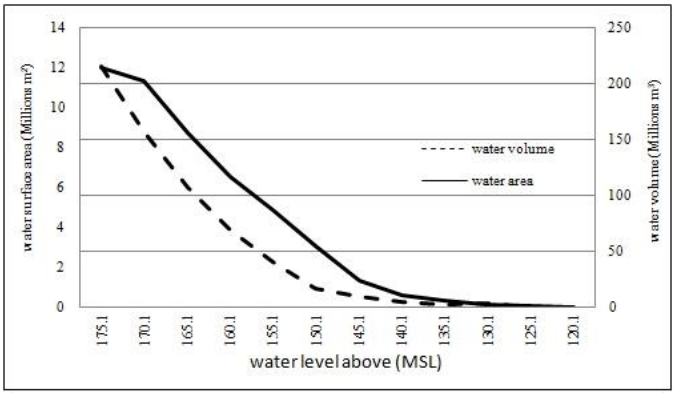

Figure 6. The relationship between water level and both the water surface area and water volume in Dahmit Khor

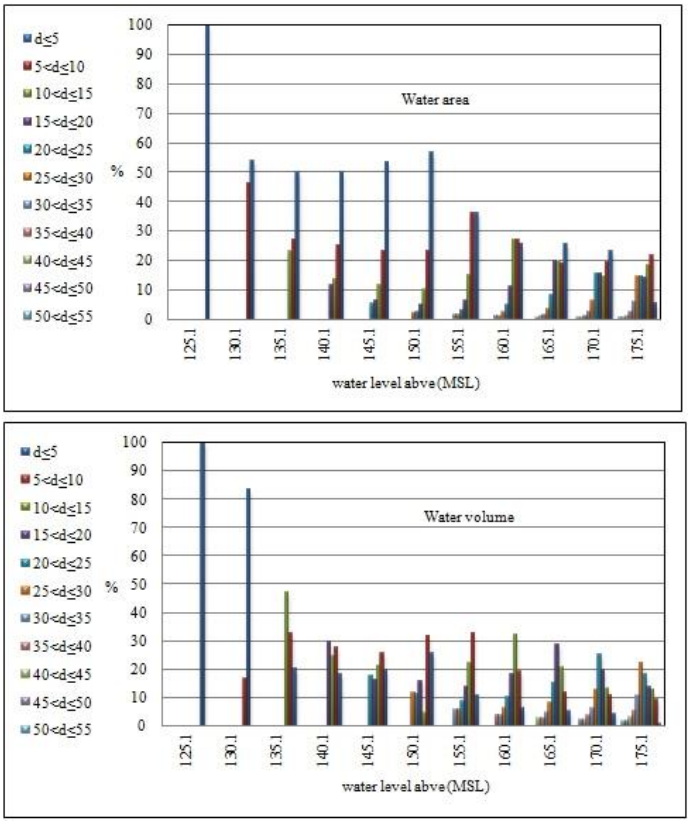

Figure 7. The percentage of both water surface area and water volume at different water levels in Dahmit Khor

3.3. Abu Askar Khor

Abu Askar is an embayment located in the south-eastern side of Lake Nasser (Table 3). The Khor stretches between 22° 12' 59.3" and 22° 17' 44.7" N Latitudes, and 31° 36' 17.3" and 31° 44' 15.7" E Longitudes. Abu Askar Khor is linked to the main channel of the Lake by a natural wide water opening (3.04 km width), with no outlet. This Embayment has a funnel shape and is considered one of the medium Khors in Lake Nasser. It stretches in the west–east direction for 14.35 km length, with a maximum width of 5.65 km and a surface area of 36.7 km^2. Abu Askar Khor is edged from its most sides by the desert and mountains. It encloses 19 islets, some of which are often air-exposed and some others disappear through high flood.

The produced bathymetric map of Abu Askar Khor is shown in Figure (8). The Khor's waters are considered deep with regular bottom topography. The lowest water depths take place close to the shoreline and also at the eastern region of the Khor. The higher depths appear near to the inlet of the Khor. The water depth inhere generally vary from a few centimeters to ≤ 50 m depth.

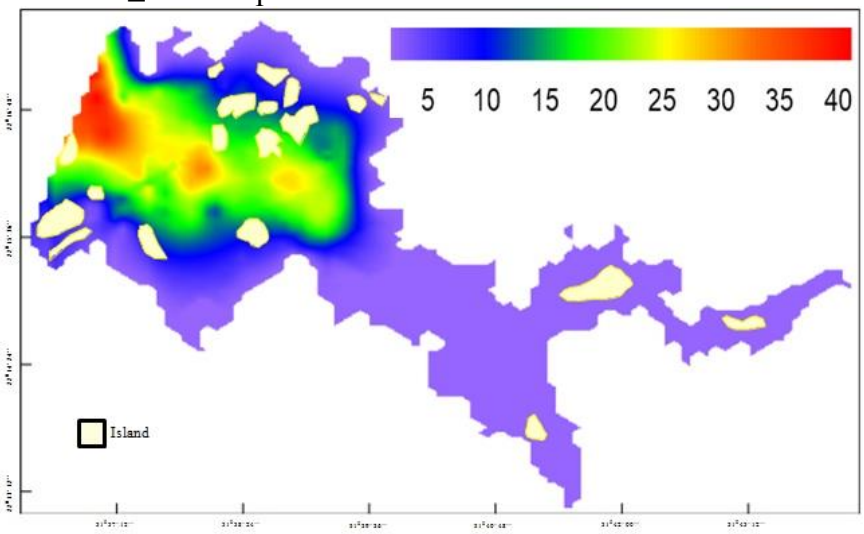

Figure 8. Bathymetric chart of Abu Askar Khor

The relationship between the Lake water level and both the water surface area and water volume is plotted in Figure (9). This function, limit water level ranges between 173.2 and 118.2 m above the MSL. As in the case of Dahmit Khor, moderate surface areas and volumes, in accordance to the depth variations, in Abu Askar Khor started to appear from the level of 135.1 m (Fig. 10).

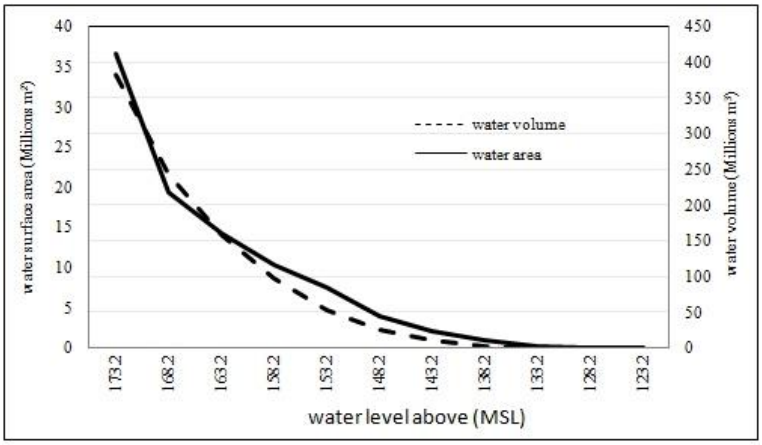

Figure 9. The relationship between water level and both the water surface area and water volume in Abu Askar Khor

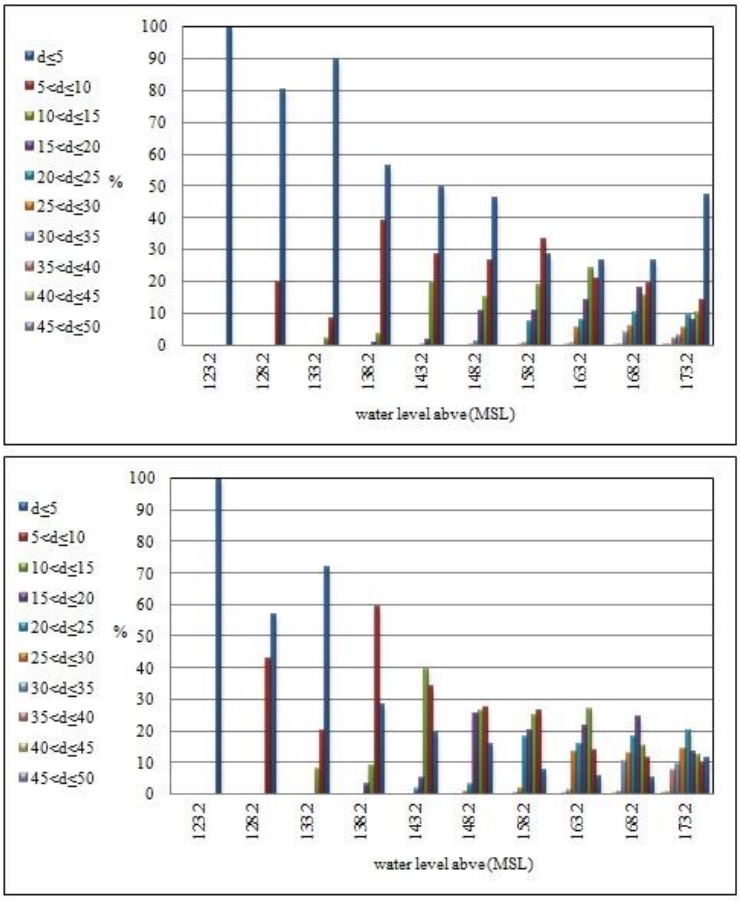

Figure 10. The percentage of both water surface area and water volume at different water levels in Abu Askar Khor

3.4. Batikh Khor

Batikh is one of the southern dendritic side areas in Lake Nasser (Table 3). Batikh Khor is situated at the south-eastern extension of Lake Nasser between 22° 18' 18.0" and 22° 21' 06.7" N Latitudes, and 31° 43' 42.2" and 31° 47' 44.9" E Longitudes. The Khor is coupled with the main channel of Lake Nasser by two natural narrow water openings (0.75 km and 1.55 km width) , with no outlet. This Bay, as Octopus shape, is considered one of the smallest Khors in Lake Nasser. It extends in the west–east direction with 6.87 km length, a maximum width of 1.13 km and a surface area of 7.1 km^2. Batikh Khor is bordered from most of its shoreline by the desert and mountains. Batikh Khor comprises 4 islets, some of which are usually air-exposed, and some are covered by the Khor's water through high flood. Based on Batikh Khor bathymetric survey and the produced chart (Fig. 11), the Khor is classified as a medium water depth Khor with regular bottom topography. As usual, the lowest water depths appear near to the shoreline and also at the eastern region of the Khor. The higher depths are near the entrances of Batikh Khor. The water depths in Batikh Khor generally fluctuate between a few centimeters and ≤ 50 m.

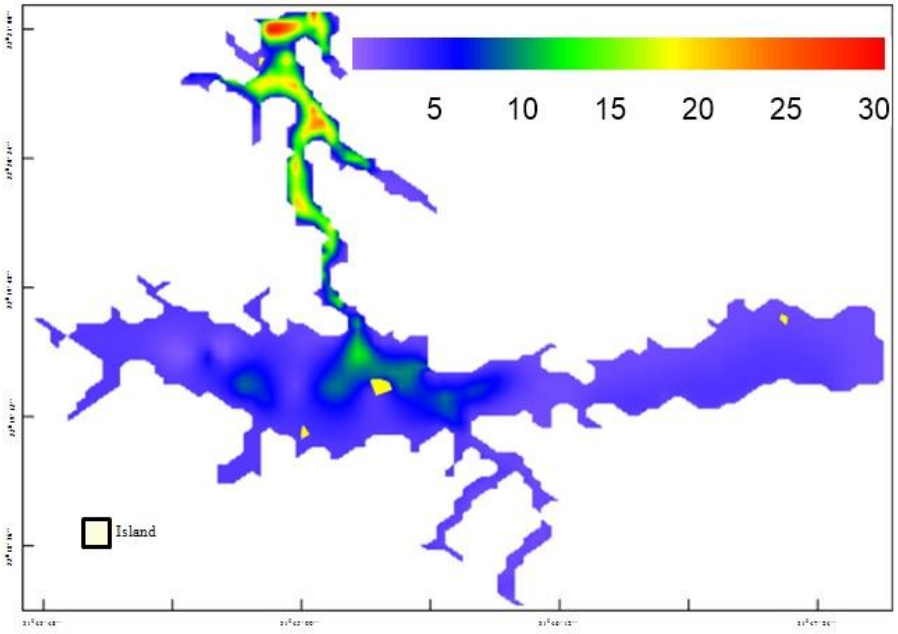

Figure 11. Bathymetric chart of Batikh Khor

In Figure (12), the water surface area and water volume estimated by the bathymetric survey is plotted as a function of the Lake's level. The limit of water level ranges between 123.4 and 173.4 m above the MSL. In the

Batikh Khor case, the variations in water surface area and water volume are almost identical. Mathematically, the Lake water level and both the water surface area and water volume in Batikh Khor are categorised as shown in Figure 13. Following the two above mentioned Khors, Batikh Khor's moderate surface areas and volumes, in accordance to the depth variations, started to be noticed from the level of 138.4 m.

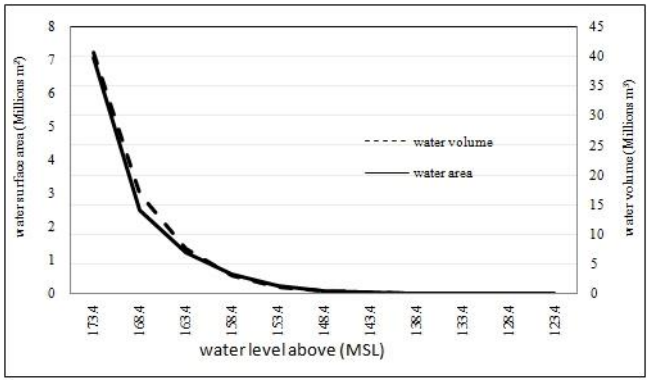

Figure 12. The relationship between water level and both the water surface area and water volume in Batikh Khor

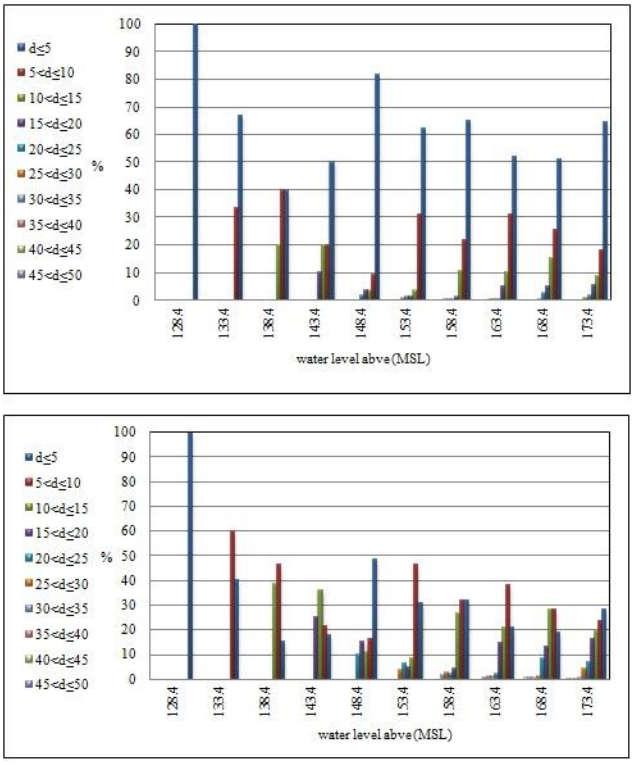

Figure 13. The percentage of both water surface area and water volume at different water levels in Batikh Khor

3.5. Dahab Khor

Dahab Khor, also known as Toushka east Khor, is one of the southern Khors in Lake Nasser (Table 3). Dahab Khor is located to the north of Batikh Khor in Lake Nasser, between 22° 28' 14.2" and 22° 31' 50.2" N Latitudes, and 31° 55' 03.7" and 32° 00' 35.6" E Longitudes. The Khor is connected to the main channel of the Lake by a natural wide water opening of 5.43 km width, with no outlet. This Embayment, as funnel shape, is considered one of the medium Khors in Lake Nasser. Its main axis extends in west–east direction with 8.81 km length. The Khor's maximum width is 5.43 km and its surface area is of 13.3 km^2. Dahab Khor is bordered from its most edgess by the desert and mountains. Dahab Khor contains 12 islets, some of which are appearance, and some of these islets cover by the Khor's water through high flood.

According to the produced bathymetric chart of Dahab Khor, its water is considered as medium deep water with regular bottom topography (Figure 14). The lowest water depths exist near to the shoreline and also along the eastern bank of the Khor. The higher depths are observed near to the inlet of the Khor. The depths in Dahab Khor vary between a few centimeters close to the shore to ≤ 30 m in its deepest parts.

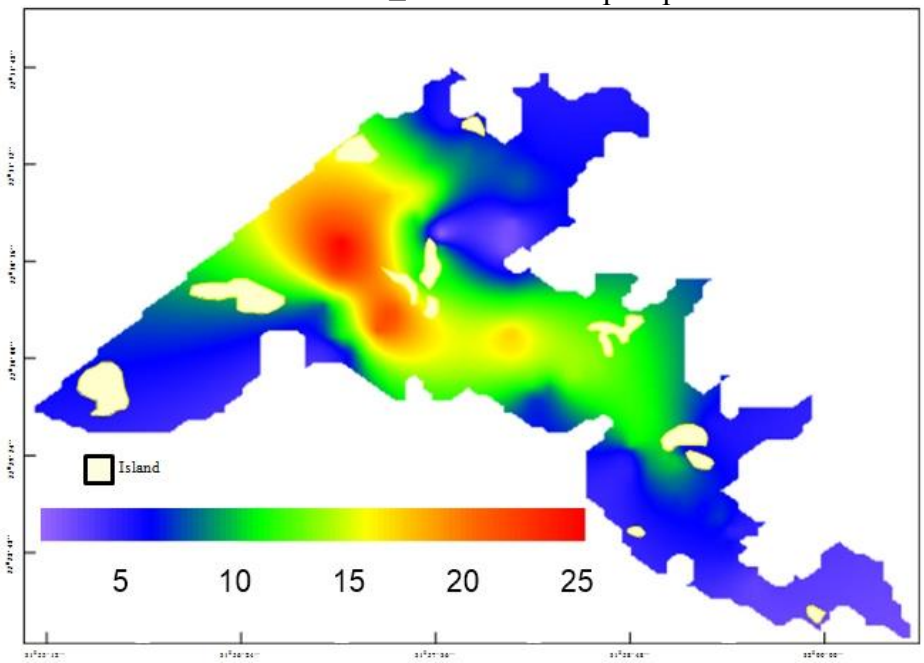

Figure 14. Bathymetric chart of Dahab Khor

The relationship between the Lake water level and both the water surface area and water volume is plotted in Figure (15). The limit water

level ranges between 143.5 and 173.5 m above the MSL. Statistically, the Lake water level and both the water surface area and water volume divided as shown in Figure 16.

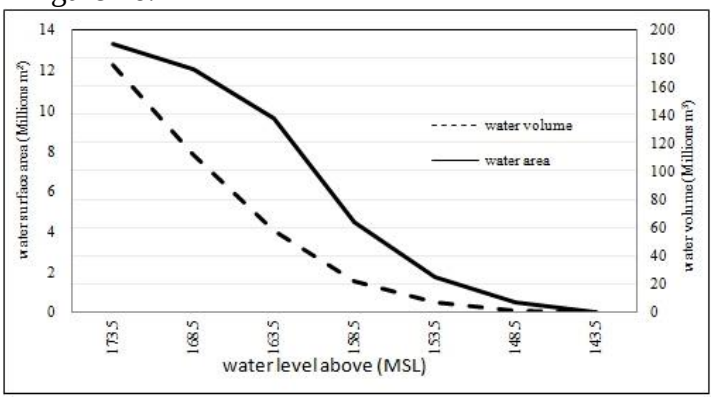

Figure 15. The relationship between water level and both the water surface area and water volume in Dahab Khor

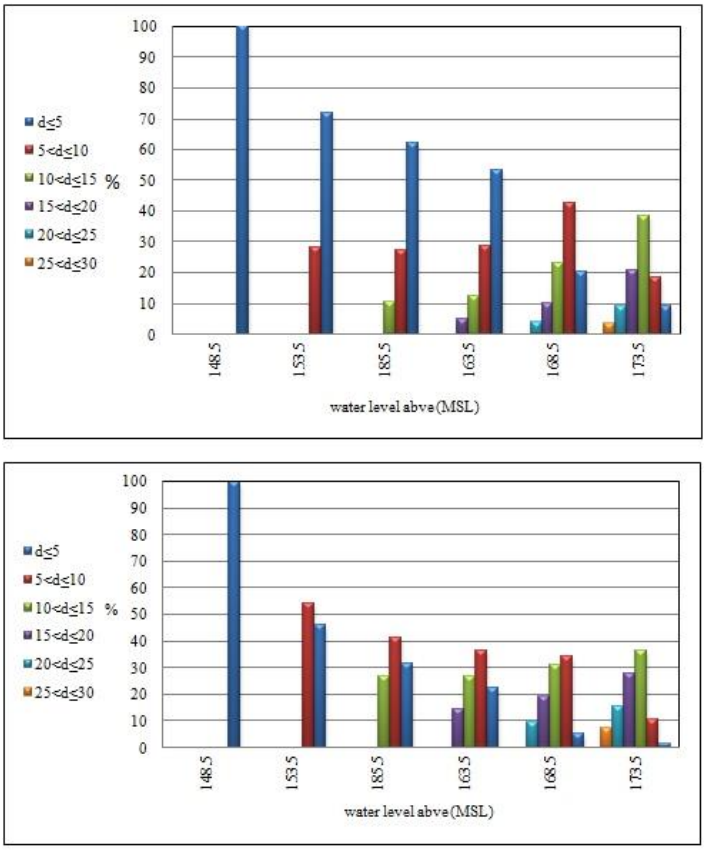

Figure 16. The percentage of both water surface area and water volume at different water levels in Dahab Khor

4. CONCLUSIONS

Spafard&Edmundson (2000) reported that, limnological analyses require a detailed knowledge of the morphometry of a lake basin, consequently its khors, which is best described by a bathymetric map. The most common morphometric parameters measured are depths, surface area, volume, length, and shoreline length. Their parameters ratios have been used to classify or inventory lakes.

The increase in water level causes the inundation of new lands on both sides of the Lake Nasser and their amount depends on the slope. Therefore the extensive areas of the khors having gentle slopes are covered with water with increased storage (Salem, 2010).

Lake Nasser is mainly affected by the climatic change on east Africa (El Gammal, 2010). The implementation of the Renaissance Dam in Ethiopia is a matter of security challenge to Egypt's water security. It is a fact that Egypt's share of water did not change since the fifties despite the growing population and the high rates of population development. Accordingly, this Ethiopian Dam can be considered as a disrupting disaster for the development map in Egypt (El Bedawy, 2014). The reservoir capacity of the Dam is almost the same as the annual flow of the Nile water at the Sudanese-Egyptian borders. Water loss from the dam's reservoir due to evaporation has significant impact on the flow of the Blue Nile (Ferrari et al., 2013).

To the authors' knowledge, no work has dealt before with the bathymetric structure of Khors in Lake Nasser. Therefore, the present work is considered the first trial to configure changes in water depths in five of these Khors and to produce their detailed bathymetric maps.

Lake Nasser, a man- made lake, represents the national freshwater bank of Egypt. The Lake is featured by the presence of numerous dendritic inlets, or side extensions of the reservoir, known as Khors. A bathymetric survey was conducted on five Khors in Lake Nasser. These are Khor Toushka (area of 184.8 km^2), Khor Dahmit (area of 12.0 km^2), Khor Abu Askar (area of 36.7 km^2), Khor Batikh (area of 7.1 km^2) and Khor Dahab (area of 13.3 km^2). A large number of scattered islands, of various sizes, can be observed throughout the Khors. These islands represent the tops of former hills. The number, location and size of these islands are greatly affected by the water level fluctuations in the Lake. The distribution of both water surface areas and water volumes at several Lake level is different.

The morphological elements of the Lake basin are different from those recorded in each of the five examined Khors. Most of the Lake's Khors are narrow and extends for long distances into the desert, although

some other Khors are very wide. Higher depths were recorded near the mouths of the Khors. On Dahmit Khor, the slopes are high, while on other Khors the slopes are gentles. Beside variations in the Khors' water volumes or Khors' surface areas or stage curve relationships, multi-temporal comparisons between bathymetries is a key element to assess environmental changes in these aquatic resources; such as sedimentation, biodiversity and anthropogenic activities, *e.g.* agriculture, fisheries and recreation (Liu *et al.*, 2003).

REFERENCES

Abd Ellah, R.G., 2004, Temperature distributions in Lake Nasser water, Egypt. Asw. Sci. Tec. Bull. **22**: 57-66.

Abd El-Monem, A.M., 2008, Impact of Summer Thermal Stratification on Depth Profile of Phytoplankton Productivity, Biomass, Density and Photosynthetic Capacity in Lake Nasser (Egypt). *Jordan J. Biol. Sci.* **1**(*4*): 173- 180.

Abdin, A. & Gaafar, I., 2009, Rational water use in Egypt. Options Mediterranean, An 88, 2009 - Technological Perspectives for Rational Use of Water Resources in the Mediterranean Region. 11- 27.

CPWF 2009, Improved fisheries productivity and management in tropical reservoirs. No. CP34. 117p.

Dost, R.J. & Mannaerts, C.M., 2008, Generation of lake bathymetry using sonar, satellite imagery and GIS. In, Proceedings of the 2008 ESRI international user conference: GIS, Geography in action. San Diego, Florida. 6p.

El Bedawy, R. 2014, Water Resources Management: Alarming Crisis for Egypt. *J. Manag. and Sustain.* **4**(*3*): 108- 124.

El Gammal, E.A., 2010, Assessment Lake Nasser within the Climatic Change. *J. Amer. Sci.* **6**(*7*): 305- 312.

El Shahat, M.M., 2000, Lake Nasser Overview. Sustainable fish production in Lake Nasser: ecological basis and management policy. *Conf. Proc*. **61**: 10- 13.

Elba, E., Farghaly, D. & Urban, B., 2014, Modeling High Aswan Dam Reservoir Morphology Using Remote Sensing to Reduce Evaporation. *Int. J. Geosci*. **5**: 156- 169.

Elsaeed, G., 2012, Effects of Climate Change on Egypt's Water Supply. H.J.S. Fernando *et al*. (eds.), National Security and Human Health Implications of Climate Change, NATO Science for Peace and Security Series C: Environmental Security, 337- 347.

Elshemy, M. & Meon, G., 2011, Climate change impacts on water quality indices of the southern part of Aswan High Dam reservoir, Lake Nubia. Fifteenth Int. Water Technology Conference, IWTC-15 2011, Alexandria, Egypt, 17p.

Entz, B., 1976, Comparison of the physical and chemical environments of Volta Lake and Lake Nasser. Proceeding of the JBP-UNESCO Symposium on productivity problems of freshwaters. Kasimierz Dolny, Poland, May 6- 12, pp.883- 891.

Ferrari, E., McDonald, S. & Osman, R., 2013, Grand Ethiopian Renaissance Dam: A global CGE model to assess the economic effects on the Ethiopian economy. 16th annual conference on Global Economic Analysis, "New Challenges for Global Trade in a Rapidly Changing World" Information Building, Shanghai Institute of Foreign Trade, 13p.

Hassan, M., 2013, Evaporation estimation for Lake Nasser based on remote sensing technology Evaporation estimation for Lake Nasser based on remote sensing technology. *J. Ain Shams Eng.* **4**(*4*): 593- 604.

Heikal, M.T., 2010, Impact of Water Level Fluctuation on Water Quality and Trophic State of Lake Nasser and its Khors, Egypt. *Egypt J. Aqua. Biol. and Fish*. **14** (*1*): 75- 86.

Khalil, M.A., El-Said, A.A. & Hassaneen, A.G., 2005, Ground/surface water interactions and evaporation loss determined from chloride and stable isotopes in Lake Nasser, *Egypt. J. Appl. Geophys*. **4**: 45–58.

Liu, Y., Anisul, I.M. & Jay, G.J., 2003, Quantification of Shallow Water Quality Parameters. *Prog. Phys. Geogr.* **27**: 24- 43.

Mageed, A.A. & Heikal, M.T., 2006, Factors affecting seasonal patterns in epilimnion zooplankton community in one of the largest man-made lakes in Africa (Lake Nasser, Egypt). *Limnolog*. **36**: 91 – 97.

Mostafa, M. & Soussa, H., 2006, Monitoring of Lake Nasser using remote sensing and GIS techniques. Conference: ISPRS, At the Netherlands. 5p.

Mutua, F.M., Mtalo, I.F. & Bauwens, W., 2005, Challenges of Modeling the Flows of the Nile River. Proceedings of International Conference of UNESCO Flanders Fust Friend/Nile Project Towards A Better Cooperation And The 5th Project Management Meeting And 9th Steering Committee Meeting.12-15p.

Salem, A.H., 2010, General description of lake Nasser. Conservation Ecology of the Nile crocodile" and Community Environmental Education to resolve the conflicts between the Nile Crocodiles and Man, in Lake Nasser –Egypt. 22p.

Spafard, M.A. & Edmundson, J.A., 2000, A morphometric atlas of Alaskan lakes: Cook Inlet, Prince William Sound, and Bristol Bay areas. Alaska

Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 2A00-23, 13p.

van Zwieten, P.A.M., Béné, C., Kolding, J., Brummett, R. & Valbo-Jorgensen, J., 2011, Review of tropical reservoirs and their fisheries- The cases of Lake Nasser, Lake Volta and Indo-Gangetic Basin reservoirs. *FAO Fisheries and Aquaculture Technical Paper*. No. 557. Rome, FAO. 2011. 148 p.

Zaghloul, S., Pacini, N., Schwaiger, K. & Villeneuve, P., 2011, Towards Lake Nasser management plan, Results of a pilot test on integrated water resources management. *Fifteenth International Water Technology Conference, IWTC-15 2011, Alexandria, Egypt*, 13p.