Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 23(4): 167- 179 (2019)
www.ejabf.journals.ekb.eg

Hydrography and plankton community structure of Marina El-Alamein, Egypt

Howaida Y. Zakaria*, Ahmed Radwan and HalaTaha
National Institute of Oceanography and Fisheries, Alexandria, Egypt
*Corresponding Author: howaidazakaria@hotmail.com

ARTICLE INFO

Article History:
Received: June 26, 2019
Accepted: Sept. 28, 2019
Online: Oct. 2019

Keywords:
Hydrography
Phytoplankton
Zooplankton
Marina El-Alamein
Egypt

ABSTRACT

Marina El-Alamein is one of the biggest tourist summer resorts at the north coast of Egypt. This was the first tourist project in the northern Sahel region bordering the Mediterranean Sea in Egypt. The present study is the first attempt to provide data on hydrography and plankton community structure of the coastal and lake waters of Marina El-Alamein tourist resort. Samples were collected seasonally from 10 stations in the study area during 2017.

Forty five phytoplankton taxa included within five groups were identified during the present survey. Bacillarophyceae was the most diversified phytoplankton group (28 taxa) followed by Dinophyceae (7 taxa), Chlorophyceae (5 taxa), Cyanophyceae (3 taxa), and Euglinophyceae (2 taxa). The highest phytoplankton abundance was 4.44×10^3 unit/l in summer and the lowest value was 3.55×10^3 unit/l in winter with an annual average of 4.03×10^3 unit/l. Zooplankton community in the study area comprised 14 species; 4 Protozoa, 4 Copepoda, 3 Rotifera, besides one species of cnidarian, one ostracod and one of molluscs. The meroplanktonic larvae of polychaetes, decapods and molluscs were also recorded. The lowest zooplankton abundance was recorded during winter (aver. $0.9\times10^3 ind.m^{-3}$) while the highest abundance was recorded during autumn (aver. $27.6\times10^3 ind.m^{-3}$). Copepoda was the highest abundant group (81.77% of the total zooplankton crop) followed by Rotifera, the meroplanktonic larvae of Mollusca and Polychaeta.

Finally, it would be concluded that the plankton community structure in Marina El-Alamein area represents a balanced and stable marine ecosystem. This is probably due to the exchange of waters between the Sea and lagoon and good environmental management of the lagoon by the concerning authorities.

INTRODUCTION

Tourism is one of the main sources of national income for Egypt and the success of coastal tourism projects is measured by the extent of their impact on the marine ecosystem (Gharib *et al.*, 2011). Marina El-Alamein resort was the first tourist project in the northern Sahel region bordering the Mediterranean Sea in Egypt. It is one of the biggest tourist summer resorts in the northern coast of Egypt. It lies about 94 km west of Alexandria City and is owned by the New Urban Communities Authority. It has the first international yacht marina in the eastern part of North Africa. The area has an artificial lake separated from the Egyptian Mediterranean waters by a narrow passage (Fig 1). The lake extends to about 10 km E-W and occupies an area of about 3.5 km^2,

its depth range 0.5m-8m with an average of 4m. Its continuous existence is made possible by maintaining many outlets from the Mediterranean by dredging.

Few studies were carried out on plankton community in the western part of the Egyptian Mediterranean Coast, Shams El-Din and Abdel-Halim (2008) studied variations in phytoplankton community structures in the coastal water of three touristic villages in the western Alexandria City. Meanwhile, Gharib *et al.* (2011) assess the impact of physicochemical parameters on the diversity and distribution of phytoplankton community in the coastal water of Matrouh. On the other side, zooplankton studies were mainly deal with the abundance, distribution and diversity of certain zooplankton groups (Zakaria, 2004; Zakaria *et al.*, 2016 and 2018). The spatial and temporal variations of zooplankton community in Matrouh beaches were studied by Aboul Ezz *et al.* (2014). No studies have been carried out in Marina El-Alamein tourist resort. The present work is the first attempt to provide data on hydrography and plankton community structure of the coastal and lake waters of Marina El-Alamein tourist resort.

MATERIALS AND METHODS

Sampling was performed seasonally from 10 stations covered the coastal and lake water of Marina El-Alamein tourist resort during 2017. It was not possible to obtain samples from St. 2 due to its continuous cover with sand during the sampling period. Fig. 1 illustrates Marina El-Alamein area and locations of the sampling stations. Temperature and salinity measured using HydroLab YSI model ProDSS with GPS with an accuracy of ±0.10°C for temperature and ±0.05 psu for salinity.

Fig.1: Marina El-Alamein coastal area and the artificial lake.

Phytoplankton samples were collected by 2 liter plastic container from the surface water of the study area. Water samples were preserved in 4% neutral formalin solution. The number of phytoplankton was estimated by the sedimentation method applied by Utermöhl, 1958 and expressed as unit per liter (the unit includes cells, colonies and strands). The phytoplankton taxa were identified according to Cupp (1943), Sournia (1986), Mizuno (1990) and Al-Kandari *et al.* (2009).

Zooplankton samples were collected by standard plankton net of 55µm mesh size. Vertical hauls (from near bottom to the surface) were towed at each station in the study area. The collected samples were preserved in 4% neutral formalin solution and their volumes were concentrated to 100ml. Zooplankton abundance was estimated in

number per cubic meter. The identification of zooplankton taxa were done according to Rose (1933), Tregouboff and Rose (1957), Edmondson *et al.* (1959) and Marshall (1969). A cluster analysis carried out on data of phytoplankton and zooplankton communities at the sampling stations using MINITAB 12 under Windows.

RESULTS

Hydrographic characteristics

The water temperature of Marina El-Alamein area had a wide range of variations seasonally. The lowest value was observed in winter (February) where it varied between 14 at St.3 and 15.26°C at St. 8 with an average of 14.52±0.44°C (Fig. 2). It increased with increasing air temperature to reach an average of 19.45±0.66°C in spring (April). It reached its maximum value (30.1 at St.5 and 31°C at St.1) with an average of 30.60±0.25°C in summer (July). During autumn the average water temperature decreased to 22.33±0.17^{o}C.

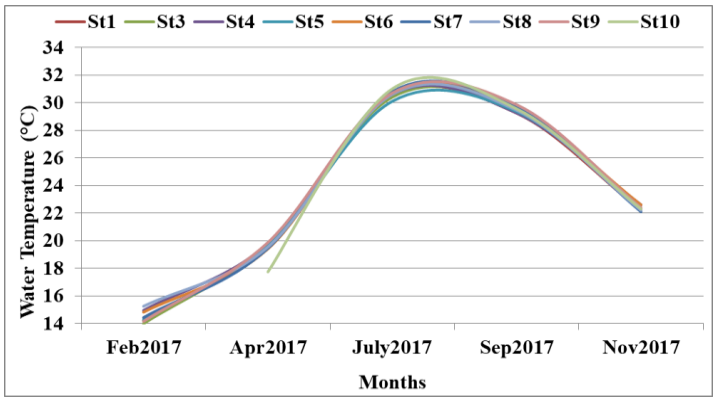

Fig. 2: Spatial and seasonal variations of water temperature (^{0}C) in Marina El-Alamein during 2017.

The spatial and seasonal variations of salinity values in Marina El-Alamein area were small. The average salinity values varied between 39.573±0.29psu in summer and 40.754±0.25psu in winter. These values were higher than salinity values of the Egyptian Mediterranean waters.

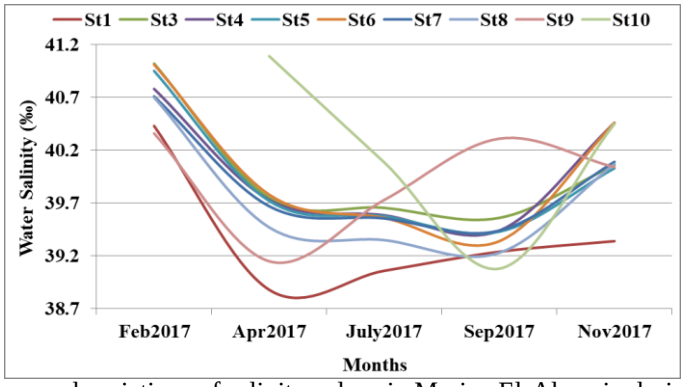

Fig. 3: Spatial and seasonal variations of salinity values in Marina El-Alamein during 2017.

Phytoplankton community structure

Forty five phytoplankton taxa included within five groups were recorded in Marina El-Alamein area (Table 1).

Table 1: Average count (unit/L) of phytoplankton taxa recorded at the different seasons in Marina El-Alamein area during 2017.

Phytoplankton Taxa	Seasons				Average
	Winter	Spring	Summer	Autumn	
Bacillariophyceae					
Amphiphora paludosa	0	44	39	33	**29**
Amphora cymbifera	78	94	83	72	**82**
Amphora marina	117	150	144	122	**133**
Bacillaria paxillifer	155	217	217	172	**190**
Campylodiscus hibernicus	89	111	117	83	**100**
Chaetoceros decipiens	33	22	39	33	**32**
Coscinodiscus centralis	89	89	100	78	**89**
Cyclotella kütziginiana	44	33	61	50	**47**
Diploneis didyma	44	44	61	50	**50**
Guinardia flaccida	39	44	44	39	**41**
Gyrosigma acuminatum	217	261	244	222	**236**
Hemiaulus hauckii	0	22	22	17	**15**
Leptocylindrus danicus	55	72	72	61	**65**
Licmophora abbreviate	39	55	61	50	**51**
Naviculadistans	111	111	105	105	**108**
Naviculapla centula	78	111	100	100	**97**
Navicula gracilis	105	128	111	105	**112**
Navicula viridula	100	117	105	94	**114**
Nitzschia kütziginiana	94	122	122	111	**112**
Nitzschia longissima	122	144	133	111	**127**
Nitzschia palea	111	117	111	100	**110**
Nitzschia sigma	89	111	117	105	**105**
Odontella sp.	28	0	33	28	**22**
Pleurosigma sp.	161	211	189	172	**183**
Rhizosolenia sp.	22	22	33	28	**26**
Skeletonema costatum	100	128	144	128	**125**
Surirella sp.	33	0	33	28	**23**
Thalassiosira sp.	211	283	283	239	**254**
Total	**2364**	**2863**	**2923**	**2537**	**2672**
Dinophyceae					
Alexandrium ostenfeldii	0	55	61	50	**41**
Gonyaulax spinifera	39	61	55	50	**51**
Gymnodinium sp.	78	94	89	83	**86**
Prorocentrum micans	28	0	33	22	**21**
Protoperidinum ovatum	89	100	111	83	**96**
Pyrophacus sp.	72	72	78	67	**72**
Scrippsella sp.	39	44	44	39	**41**
Total	**345**	**426**	**471**	**394**	**409**
Euglenophyceae					
Euglina sp.	44	72	83	78	**69**
Phacus sp.	0	67	67	50	**46**
Total	**44**	**139**	**150**	**128**	**115**
Cyanopphyceae					
Chroococcus turgidus	55	55	72	72	**64**
Oscillatoria agardhii	139	161	167	150	**154**
Oscillatoria limosa	167	200	189	161	**179**
Total	**361**	**416**	**428**	**383**	**397**
Chlorophyceae					
Ankistrodesmus falcatus	50	44	50	33	**44**
Chlorella vulgaris	111	111	105	100	**107**
Coelastrum microsporum	55	55	67	50	**57**
Oocystissolitaria	94	100	100	100	**98**
Scendesmus bijuga	122	139	144	128	**133**
Total	**432**	**449**	**466**	**411**	**439**
Total phytoplankton	**3546**	**4293**	**4438**	**3853**	**4032**

The Bacillarophyceae was the most diversified phytoplankton group (28 taxa) followed by Dinophyceae (7 taxa), Chlorophyceae (5 taxa), Cyanophyceae (3 taxa), and Euglinophyceae (2 taxa). Bacillariophyceae (diatoms) was the most abundant group comprising 66.12% of the total phytoplankton count. *Thalassiosira* sp. and *Gyrosigma acuminatum* were the most common species (contributed 9.47% and 8.84% of the total Bacillariophyceae count respectively).

Chlorophyceae was the second group (contributed 10.83 % of the total phytoplankton crop). *Scendesmus bijuga* and *Chlorella vulgaris* were the most common species. Dinophyceae was the third abundant group (contributed with 10.30 % of the total phytoplankton count) and was represented by seven species *Alexandrium ostenfeldii*, *Gonyaulax spinifera*, *Gymnodinium* sp., *Prorocentrum micans*, *Protoperidinum ovatum*, *Pyrophacus* sp. and *Scrippsella* sp. Cyanophyceae was the fourth abundant group (contributed 9.75% of the total phytoplankton count) and contributed three species *Oscillatoria limosa*, *Oscillatoria agardhii* and *Chroococcus turgidus*. On the other hand, Euglenophyceae formed 3.00 % of the total phytoplankton count and represented by two species *Euglina* sp. and *Phacus* sp.

The spatial variations of phytoplankton abundance in the investigated area showed that, St. 3 attained the highest phytoplankton count (19.70×10^3 unit/l) followed by St.4 and St.9 (18.50 and 18.20×10^3 unit/l respectively) while the lowest count was recorded at St.10 (10.75×10^3 unit/l) (Fig. 4). Spatial variations of phytoplankton groups showed that diatoms were dominated at all stations of the study area due to the co-dominance of *Thalassiosira* sp., *Gyrosigma acuminatum*, *Bacillaria paxillifer* and *Pleurosigma* sp.

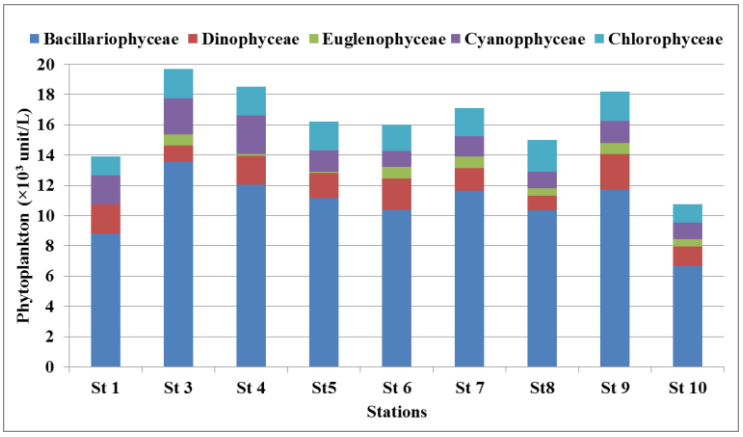

Fig. 4: Spatial variations of the phytoplankton groups (10^3unit/l) recorded in Marina El-Alamein area during 2017.

The seasonal variations of phytoplankton abundance in the investigated area illustrated that, the highest value (4.44×10^3 unit/l) was observed during summer while the lowest one (3.55×10^3 unit/l) occurred in winter. There were no clear seasonal differences in phytoplankton diversity, winter and spring had 41 and 42 species respectively while summer and autumn attained the same number of species (45 species). Bacillariophyceae (diatoms) predominated at all seasons and reached its highest relative abundance during winter and spring (66.76%) followed by Chlorophyceae and Cyanophyceae which were accounted for their highest percentage during winter (12.21% and 10.17% respectively). Dinophyceae reached its highest relative abundance (10.63%) during the summer (Fig. 5).

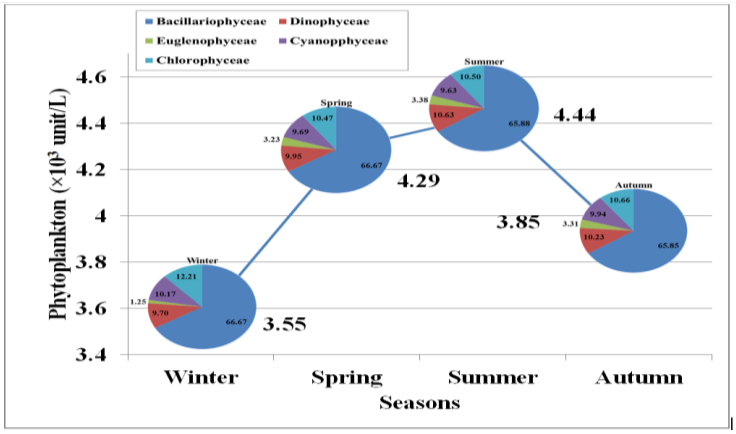

Fig. 5: Seasonal variations of the different phytoplankton groups (10^3unit/l) in Marina El-Alamein area during 2017.

A degree of similarity between the sampling stations, seasonal phytoplankton abundance and phytoplankton groups were determined using a cluster analysis (Fig. 6a, b, c, d). The similarity level of >99.90% delineated two groups of stations. The first group comprised stations 5, 6, 7, 8, 9 and 10. The second group comprised stations 1 and 4. The phytoplankton abundance had high similarity between spring, autumn and summer seasons and the degree of similarity decreased in winter. The spatial and seasonal variations of phytoplankton groups had the same level of similarity (Fig. 6c, d). Dinophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae were in a high degree of similarity. The lowest similarity was found between Bacilliariophyceae and the other groups.

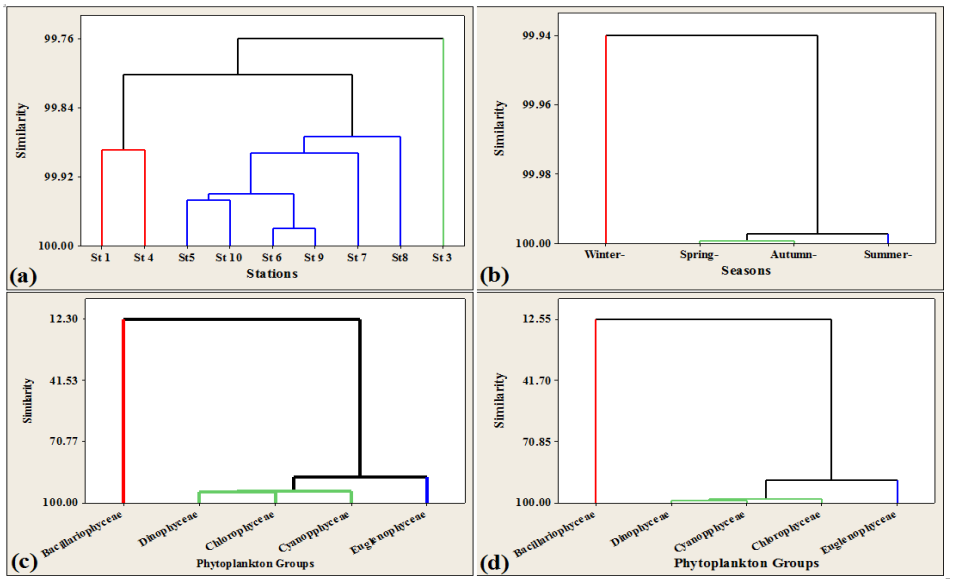

Fig. 6: Dendrogram showing similarity between (a) stations, (b) seasons, (c) spatial and (d) seasonal variations of phytoplankton groups recorded in Marina El-Alamein area during 2017.

Zooplankton community structure

Zooplankton community in Marina El-Alamein area comprised 14 species; 4 Protozoa species, 4 Copepoda species, 3 Rotifera species beside one species of cnidarian, one species of ostracods and one species of molluscs (Table 2). The meroplanktonic larvae of polychaetes, decapods and molluscs were also recorded. Based on the numerical density, Copepoda (adults, nauplii and copepodite stages) was

the highest abundant group (81.77% of the total zooplankton crop) *Eucalanus crassus*, *Paracalanus parvus*, *Oithona nana* and *Euterpina acutifrons* represented copepod population in the study area. Rotifers followed copepods in order of abundance (8.71% of the total zooplankton crop).

Table 2: Average count (ind.m^{-3}) of zooplankton species recorded at the different seasons in Marina El-Alamein area during 2017.

Species \ Seasons	Winter	Spring	Summer	Autumn	Average
Protozoa					
Tintinnida:					
Codonella nationalis Brandt, 1906	0	222	0	0	55
Proplecatella ovata Jorgensen, 1924	0	0	111	111	55
Tintinnopsis beroida Stein, 1867	0	111	0	0	28
Foraminifera:					
Globigerina bulloides (Orbigny, 1826)	111	0	0	0	28
Total	111	333	111	111	166
Cnidaria					
Aglaura hemistoma Mayer	0	111	0	0	28
Rotifera					
*Brachionus angularis*Gosse	0	111	0	0	28
Brachionus calyciflorus Pallas	111	0	0	0	28
Keratella quadrata O.F. Muller	0	5000	778	0	1444
Total	111	5111	778	0	1500
Nematoda					
Free living nematods	0	0	0	111	28
Annelida					
Polychaete larvae	111	1556	556	333	639
Ostracoda					
Cypridina mediterranea Costa	0	111	111	111	83
Copepoda					
Calanoida:					
Eucalanus crassus Giesbrecht, 1888	0	0	333	334	167
Paracalanus parvus (Claus, 1863)	0	0	111	111	55
Cyclopoida:					
Oithona nana Giesbrecht, 1893	0	3333	3778	6000	3278
Harpacticoida:					
Euterpina acutifrons Dana, 1847	333	112	111	111	167
Copepod nauplii	223	13667	6444	18111	9611
Copepodite stages	0	1444	778	1000	805
Total	556	18556	11555	25667	14083
Decapoda					
Mysis larvae	0	111	0	0	28
Mollusca					
Limacina inflata Orbigng	0	0	0	110	28
Lamellibranch veligers	0	889	556	1112	639
Total	0	889	556	1222	667
Total zooplankton	889	26778	13667	27555	17222

Brachionus angularis, B. calyciflorus and *Keratella quadrata* were the recorded rotifer species in the investigated area. The meroplanktonic larvae of Mollusca and Polychaeta were less frequent constituting 3.87% and 3.71% of the total zooplankton crop respectively. Molluscs were represented by one planktonic species (*Limacina inflata*) as well as the meroplanktonic larvae of benthic forms. Other groups such as Protozoa, Cnidaria, Ostracoda and the meroplanktonic larvae of decapods were rare and contributed collectively 1.94%of the total zooplankton count.

Spatial distribution of zooplankton community in the investigated area illustrated that the highest zooplankton abundances were recorded at St.3, St.4, St.7 and St.9 (aver. 22.75×10^3, 28.25×10^3, 23.00×10^3 and 23.75×10^3 ind.m^{-3} respectively) while the lowest abundance was found at St.10 (aver. 5.00×10^3 ind.m^{-3}) (Fig. 7). Copepods and their larval stages (nauplii and copepodite stages) dominated at nearly all stations except at St.10 where rotifers dominated (Fig. 7). Rotifers ranked the second importance at St.1, St.4, St.6 and St.7 while at St.3 and St.5, the meroplanktonic larvae of polychaetes occupied the second order of abundance (Fig. 7).

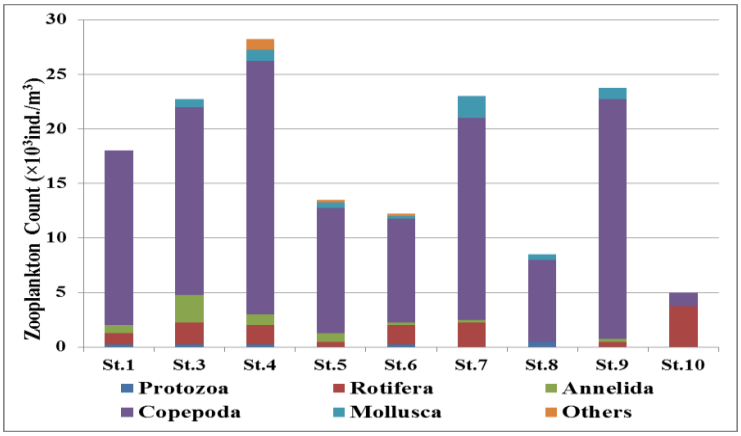

Fig. 7: Spatial distribution of the different zooplankton groups (10^3 ind./m^3) recorded in Marina El-Alamein area during 2017.

Seasonal variations of the numerical density of the total zooplankton and the different groups are shown in Fig. 8. The lowest zooplankton abundance was recorded during winter (aver. 0.9×10^3ind.m^{-3}). Copepoda was the highest abundant zooplankton group in winter (62.53% of the total zooplankton count). Protozoa, Rotifera and the meroplanktonic larvae of polychaetes follow Copepoda in order of abundance.

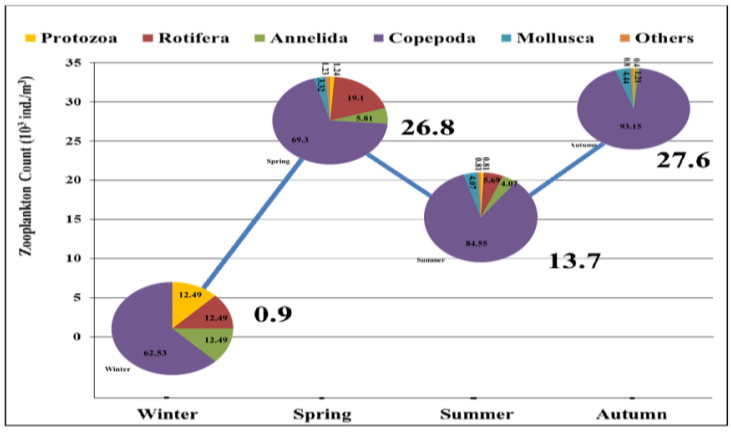

Fig. 8: Seasonal distribution of the different zooplankton groups (10^3ind./m^3) recorded in Marina El-Alamein area during 2017.

Zooplankton abundance increased during spring (aver. 26.8×10^3ind.m^{-3}). The percentage frequencies of Copepoda and Rotifera increased during spring (69.30% and 19.10% of the total zooplankton count respectively) while the percentage frequencies of Protozoa and meroplanktonic larvae of polychaetes decreased (1.24% and 5.81% of the total zooplankton count respectively). However, the meroplanktonic

larvae of Mollusca were represented by 3.32% of the total zooplankton count. During summer, zooplankton abundance decreased (aver. $13.7x10^{3}ind.m^{-3}$).The percentage frequencies of Copepoda and the meroplanktonic larvae of Mollusca increased during summer (84.55% and 4.07% of the total zooplankton count respectively) while the percentage frequencies of Protozoa, Rotifera and meroplanktonic larvae of polychaetes decreased (0.81%, 5.69% and 4.07% of the total zooplankton count respectively). The highest zooplankton abundance was recorded during autumn (aver. $27.6\times10^{3}ind.m^{-3}$). Copepoda was by far the most dominant zooplankton group during autumn (93.15% of the total zooplankton count). The meroplanktonic larvae of Mollusca follow Copepoda in order of abundance while Protozoa and the meroplanktonic larvae of polychaetes were rare (0.40% and 1.21% of the total zooplankton count respectively).

By applying a cluster analysis on zooplankton community in the study area (Fig. 9a, b, c, d), the highest similarity of >80% was observed between stations 1, 4, 5 and 9 while the lowest one (66%) was found between St. 10 and the others stations. The zooplankton abundance had a similarity >99% during summer and autumn and the similarity value decreased in the other seasons. The spatial and temporal variations of zooplankton groups have the same level of similarity (Fig. 9 c, d). Protozoa, Mollusca and Annelida were in high degree of similarity. The lowest similarity value was found between Copepoda and the other groups.

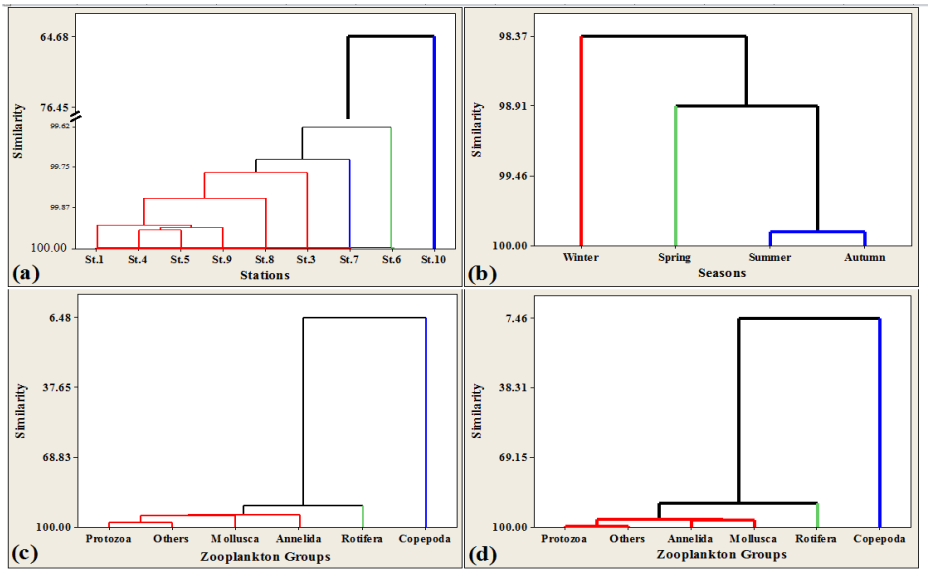

Fig. 9: Dendrogram showing similarity between (a) stations, (b) seasons, (c) spatial and (d) temporal variations of the different zooplankton groups recorded in Marina El-Alamein area during 2017.

DISCUSSION

The present study provides information on hydrography and plankton community structure of the coastal and lake waters of Marina El-Alamein tourist resort for the first time. The water temperature of Marina area has a wide range of variations seasonally. It varied from 14°C in winter (February) to a maximum value of 30.1°C in summer (July). The average salinity values varied between 39.573±0.29psu in summer and 40.754±0.25psu in winter. These salinity values were higher than those previously recorded in the Egyptian Mediterranean waters (Hussein *et al*., 2011). This may be attributed to the study area was shallow (4m depth), closed and connected to the sea through a very narrow passage.

The phytoplankton community in Marina El-Alamein area comprised a total of 45 taxa. The study area was low diversified compared to the inshore waters of El Mohandessin tourist village, Marakia tourist village and Marabella tourist village where the phytoplankton community composed of 90 taxa, 83 taxa and 54 taxa, respectively (Shams El-Din and Abdel Halim, 2008). On the other hand, some of the identified phytoplankton taxa recorded during the present study were previously recorded from different coasts of the Mediterranean Sea (Polat and Isk, 2002; Gharib, 2006; Gharib and Dorgam, 2006; Shams EL Din and Dorgham, 2007). Consequently, the study area sustained relatively low phytoplankton abundance (4.03x and 10^3 unit/L) compared to other sites in the Egyptian Mediterranean Coast (Abdel-Aziz *et al.* 2006, Gharib and Dorgham 2006, Shams El-Din and Abdel Halim 2008). The visualization of data revealed that the number of species of the different phytoplankton groups showed a pattern of Diatom > Dinoflagellates > Green algae > Cyanophytes > Euglinophytes. This trend was previously confirmed by several authors (Gharib *et al*. 2011; Zaghloul and Hussein, 2017). Despite there are many species that have been recorded in Marina El-Alamein area, there were few species prevailed. *Thalassiosira sp., Gyrosigma acuminatum*, *Scendesmus bijuga*, *Chlorella vulgaris*, *Protoperidinum ovatum*, *Gymnodinium*, *Oscillatoria limosa* and *Oscillatoria agardhii* constituted the main component during the present survey. Bacillariophyceae was the most abundant group at all stations and seasons followed by Chlorophyceae and Cyanophyceae. Diatoms and green algae performed better trend at lower temperatures while Cyanobacteria showed strong response with increased temperatures (Schabhüttl *et al*., 2012). However, Dinophyceae was represented the highest percentage in summer season at all stations in the study area. These results were coincide with Eker and Kideys (2000) who reported that, there is a positive relationship between dinoflagellates and water temperature thus, dinoflagellates may be better adapted to the high temperatures. Most dinoflagellates are found in temperate waters, are most prevalent in summer months (Taylor, 1987) and dominate the phytoplankton in warm seasons (Tait, 1981).

Zooplankton abundance in Marina El-Alamein area was very low (aver. $17.2x10^3 ind.m^{-3}$) when compared to that recorded in Matrouh beaches (aver. $36.0x10^3 ind.m^{-3}$) (Aboul-Ezz *et al.,* 2014). Zooplankton community in the study area was less diversified. It comprised 14 species; 4 Protozoa species, 4 Copepoda species, 3 Rotifera species beside one species of cnidarian, one species of ostracods and one species of molluscs. The meroplanktonic larvae of polychaetes, decapods and molluscs were also recorded. All these previous groups were commonly presented in the neritic waters of the southeastern Mediterranean Coast off Egypt (Zakaria, 2006, 2007; Aboul-Ezz *et al.,* 2014).The annual cycle of zooplankton abundance in the study area was bimodal with two conspicuous peaks in spring and autumn seasons where the environmental conditions are optimum for the growth and breeding of many zooplankton organisms as well as the abundance of suitable food (Zakaria, 2004). On the other side,the lowest zooplankton abundance in the study area was recorded during winter (aver. $0.9x10^3 ind.m^{-3}$) as with the decreasing temperature, a great proportion of assimilated energy by marine organisms was directed into growth not reproduction (Sheader, 1978). Copepoda was the highest abundant zooplankton group in the study area. The percentage frequency of copepods increased from 62.53% during winter to 69.30% during spring, 84.55% during summer and reached its maximum (93.15% of the total zooplankton count) during autumn. On the contrary, the percentage frequency of Protozoa decreased from 12.49% during winter to 1.24% during spring, 0.81% during summer and reached its minimum (0.40% of the total

zooplankton count) during autumn. The same trend of seasonal variations of both groups was previously recorded by Zakaria 2006 and 2007. *Eucalanus crassus*, *Paracalanus parvus, Oithona nana* and *Euterpina acutifrons* represented the copepod population in the study area. Of them, *Paracalanus parvus, Oithona nana* and *Euterpina acutifrons* are neritic, cosmopolitan, eurythermal and euryhaline species (Hussein and Abdel-Aziz, 1997, Aboul-Ezz *et al.*, 2014, Zakaria *et al.*, 2016).

A cluster analyses had been applied to determine the level of similarity between phytoplankton and zooplankton abundances with stations, seasons, spatial and temporal distributions (Fig.10a, b, c, d). The similarity level of >98% delineated two groups of stations. The first group comprised stations 1, 4, 9 and 7. The second group comprised stations 3, 5, 6 and 8. The lowest similarity was found between St. 10 and the others stations as this station lies out of the lake area and was directly affected by open sea water. The plankton abundance had high similarity values during spring, summer and autumn seasons and the similarity value decreased in winter. The spatial and temporal variations of plankton groups have the same trend of similarity with different levels (Fig. 10 c, d). Protozoa, Mollusca, Englenophyceae, Annelida, Dinophyceae, Chlorophyceae, Cyanophyceae and Rotifera were in a high degree of similarity. Meanwhile, the lowest similarity values were found between Copepoda, Bacilliariophyceae and the other plankton groups as they were the most dominant groups during all seasons at all stations sampled in the study area.

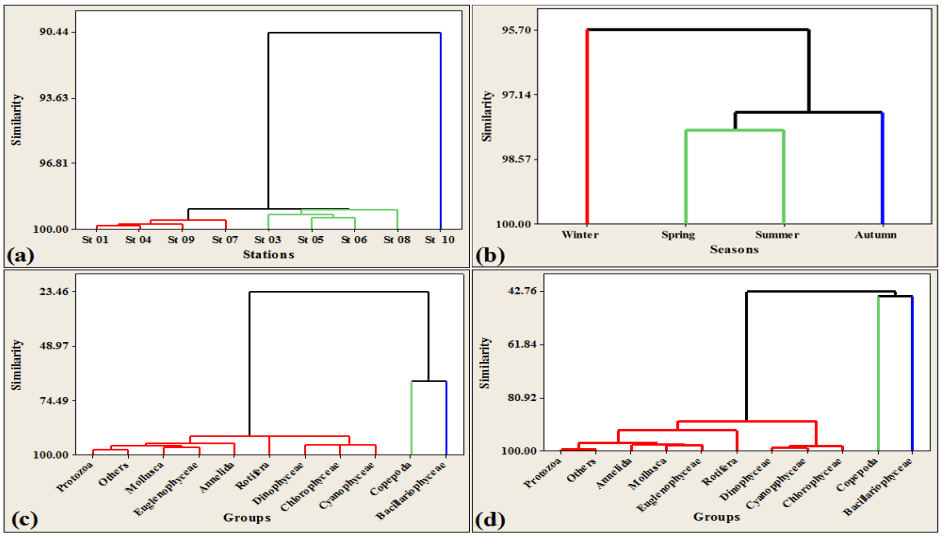

Fig. 10: Dendrogram showing similarity between (a) stations, (b) seasons, (c) spatial and (d) temporal variations of the different phytoplankton and zooplankton groups in Marina El-Alamein during 2017.

CONCLUSION

The lake area is very small, well designed and is connected to the open sea through many outlets causing good exchange of waters between the Sea and lagoon. It is not expected, therefore, to find extreme variation in water quality, or phytoplankton communities between inside the lake and the open sea. It could be also due to the proper environmental management within Marina El-Alamein tourist resort. This includes prohibiting disposal of oil from boat maintenance in the lagoon water, sewage collection and disposal in a separate wastewater treatment plant, and good management practices for solid waste disposal generated from Marina inhabitants. Finally, it would be concluded that the plankton community structure in Marina El-Alamein area represents a balanced and stable marine ecosystem. This is probably due

to the exchange of waters between the Sea and lagoon and good environmental management of the lagoon by the concerning authorities.

ACKNOWLEDGEMENT

The present study is a part of the cooperative research plan between the Marine Environment Division (NIOF) and New Urban Communities Authority, Tourist Villages Authority. The authors wish to express their thanks to Eng. Hatem Mahmoud (Chair of New Urban Communities Authority), Eng. Mohamed Khalil (Vice Chair of New Urban Communities Authority) and Eng. Assem Osman (Director General of Environment and Agriculture Administration) for their helpful cooperation.

REFERENCES

Abdel-Aziz N. E.; Gharib S. M. and Dorgham M. M. (2006). The interaction between phytoplankton and zooplankton in a Lake-Sea connection, Alexandria, Egypt. Int. J. of Ocean & Oceanogr., 1 (1): 151–165.

Aboul-Ezz, S. M.; Heneash, A. M. M. and Gharib, S. M. (2014). Variability of spatial and temporal distribution of zooplankton communities at Matrouh beaches, South- eastern Mediterranean Sea, Egypt. Egypt. J. of Aquat. Res., 40: 283-290.

Al-Kandari, M.; Al-Yamani, F. and Al-Rifaie, K. (2009). Marine Phytoplankton Atlas of Kuwait's Waters. Kuwait Institute for Scientific Res., ISBN 99906-41-24-2.351 pp.

Cupp, E. E. (1943). Marine plankton diatoms of the west coast of North America. Berkely and Los Angeles, California: Univ. California Press. 238 pp.

Edmondson, W.T.; Ward, H.B. and Whipple, G.C. (1959). Fresh water biology, 2nd ed. John Wiley and Sons Institute New York and London, XX, 1248pp.

Eker, E. and Kideyş, A. E. (2000). Weekly variations in phytoplankton structure of a harbor in Mersin Bay (north–eastern Mediterranean). Turk. J. of Bota., 24: 13–24.

Gharib, S. M. (2006). Effect of freshwater flow on the succession and abundance of phytoplankton in Rosetta Estuary, Egypt. Int. J. of Ocean & Oceanogr., 1(2): 1-19

Gharib, S. M. and Dorgham, M. M. (2006). Eutrophication stress of phytoplankton community in the western Harbour of Alexandria, Egypt. Int. J. of Ocean & Oceanogr., 1(2):261-273.

Gharib, S. M.; El-Sherif, Z. M.; Abdel Halim, A. M. and Radwan, A. A. (2011). Phytoplankton and environmental variables as a water quality indicator for the beaches at Matrouh, south-eastern Mediterranean Sea, Egypt: an assessment. Oceanolo., 53 (3): 1–18.

Hussein, M. M. and Abdel-Aziz, N. E. M. (1997). Biometrics method for biomass determination of the dominant copepods in the neritic zone of Alexandria (Egypt). Bull. Nat. Inst. of Oceanogr. & Fish., A.R.E., 23: 83-101.

Hussein, M. A.; Said, M. A. and Radwan, A.A. (2011). Estimation of salinity profiles in the southeastern Mediterranean off the Egyptian Coast. J. King Abdulaziz Univ., Mar. Sci., 22 (1): 79-95.

Marshall, S. M. (1969). Protozoa, order Tintinnida. Fiches d'indentification de Zooplancton. Conseil Internat. Pour l'Exploration de la Mer, Copenhagen, pp. 117-127.

Mizuno, T. (1990). Illustrations of the freshwater plankton of Japan. Japan: ninth Printing Hoikush Publishing Co. Lt. 353.

Polat, S. and Isik, O. (2002). phytoplankton distribution, diversity and nutrients at the north-eastern Mediterrenean coast of Turkey (Karatas- Adana). Turk. J. of Bota., 26: 77-86.

Rose, M. (1933). Copepods pelagiques. Faune de France. Paris: Le Chevalier, 374 p.

Schabhüttl, S.; Hingsamer, P.; Weigelhofer, G.; Hein, T.; Weigert, A. and Striebe, M. (2012). Temperature and species richness effects in phytoplankton communities. Oceanolo., 171(2): 527–536.

Shams El Din, N. G. and Dorgham, M. M. (2007). Phytoplankton community in Abu-Qir Bay as a hot spot of the southeastern Mediterranean coast. Egypt. J. Aquat. Res., 33(1): 163-182.

Shams El Din N. and Abdel Halim A.M. (2008). Changes in phytoplankton community structure at three touristic sites at western Alexandria Beach. Egypt. J. Aquat. Biol. Fish., 12 (4): 85–118.

Sheader, M. (1978). Distribution and reproductive biology of *Corophium insidiosum* (Amphipoda) on the north-east coast of England. J. Mar. Biol. Ass. U.K., 58:585-596.

Sournia, A. (1986). Atlas Du Phytoplankton Marin: Introduction, Cyanophyceés, Dictyochophyceés, Dinophyceéset Radiophyceés, 21 pp.

Tait, R. V. (1981). Elements of Marine Ecology. London: Butterworths. 272 p.

Taylor, F. J. R. (1987). The Biology of Dinoflagellates. Botanical Monographs. Oxford: Blackwell Scientific Publications., 785p.

Tregouboff, G. and Rose, M. (1957). Manuel de planctologie Mediterraneenne. C.N.R.S., Paris. I- (Texte), 587pp. II- (Fig.), 207pl..

Utermöhl, H. (1958). Zur Vervollkommnung der quantitativen phytoplankton Methodik. Mitt. Int. Ver. Theor. Angew. Limnol., 9: 1 -38.

Zaghloul, F. A. and Hussein, N. R., (2017). Comparative study of phytoplankton community structure in Lake Edku, Southern Mediterranean Coast, Egypt. Asia. J. Adv. Basi. Sci., 5(2): 1-13.

Zakaria, H. Y. (2004). Pelagic coelenterates in the waters of the western part of the Egyptian Mediterranean Coast during summer and winter. Oceanolo., 46 (2): 253-268.

Zakaria, H. Y. (2006). Zooplankton community in the Eastern Harbour of Alexandria, Egypt. Egypt. J. of Aquat. Res., 32 (Special Issue): 196- 209.

Zakaria, H. Y. (2007). On the distribution of zooplankton assemblages in Abu Qir Bay, Alexandria, Egypt. Egypt. J. Aquat. Res., 33 (1): 238- 256.

Zakaria, H. Y.; Hassan, A. M.; Abo-Senna, F. M. and El-Naggar, H. A. (2016). Abundance, distribution, diversity and zoogeography of epipelagic copepods off the Egyptian Coast (Mediterranean Sea). Egypt. J. Aquat. Res., 42 (4): 459-473.

Zakaria, H. Y.; Hassan, A. M.; El-Naggar, H. A. and Abo-Senna, F. M. (2018). Planktonic protozoan population in the Southeastern Mediterranean off Egypt. Egypt. J. Aquat. Res., 44 (2): 101-107.