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BENTHIC ASSEMBLAGES FOR ECOLOGICAL EVALUATION OF LAKE BOROLLUS, MEDITERRANEAN SEA, EGYPT

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ABSTRACT: Lake Borollus is one of the largest and oldest Egyptian lakes, whereas it is located in the far north of the Delta and mediates between the two branches of Rosetta and Damietta. It is connected to the Mediterranean Sea through Boghaz El Borollus and to the Nile through the Bermbal Canal, which was established in 1926 to feed the lake with abundant quantities of Nile water and Nile fish. Central coordinates: latitude 31°30' N and longitude 30°49' E with an area has decreased from 160,000 acres to 108,000 acres. The present work provides an ecological study on the regional and temporal distribution of benthic communities in particular along the wetlands lakes waters. Indicated that, the effective sediment and water variables which significantly correlated with the distribution and abundance of the identified benthos assemblages of vegetation and animal's groups include sediments structure, water quality (pH, S%, DO, BOD, temperature. Overall, 10 taxa and 27 species of macroinvertebrates were identified. They were exclusively associated with submerged vascular plants *Potamogeton pectinatus* while only 10 were alive forms and the rest were represented by calcareous shells of molluscs. The benthic flora and fauna were estimated in the Lake Botollus, Egypt is subjected to the influx of sewage effluents, agriculture drainages and industrial wastes. Also considerable amounts of drain water are constantly discharged along the southern drains. Quantitative hauls were performed at the different habitats during winter and summer, 2017 covering 12 sampling sites and 9 drains discharged directly to the lake which bottom sampling was collected by grab sampler were selected to represent the covering the different environments. The dredged area per each station was 225 cm^2 per haul. Results illustrated that the distribution of benthos in the estimated area is greatly affected by the degree of pollution as well as the prevailing hydrological conditions. The aquatic submerged vascular plants *Potamogeton pectinatus* appeared as the most common species in the lake in addition the bottom animals appeared more- sensitive to pollution than submerged vascular; thus, their lowest counts were recorded at the most sites and the fauna was mainly represented by the Nematoda, Oligochaeta, Polychaeta, Insects larvae, Ostracoda, Amphipoda, Barnacles, and juvenile larvae of Mollusca. Sediments in some areas consist of organic materials (sludge) is composed of waste sewage and agricultural and industrial and others of sandy silt (silt), calcareous shells are mainly of molluscs' and therefore it can determine some environments prevailing in the lake. Results indicated for examining configuration qualitative benthic macro during the study period were recorded 27 species, including 9 species of living benthic macro organisms include one type of aquatic submerged vascular plants of species *Potamogeton pectinatus*. Although higher values of taxonomic richness, the Shannon and index (H`) and evenness (J`) were obtained with the water *Potamogeton pectinatus* habitat as well as Ostracoda *Sclerochilus contortus* were most abundant.

KEYWORDS: benthic assemblages; environmental evaluation; biodiversity; dominance species; Lake Borollus

INTRODUCTION

During the previous 50 years many scientific studies were carried out in lake Borollus mainly on hydrodynamic-ecological model analyses of the water quality (Rasmussen *et al.,* 2009); on heavy metals pollution in water and sediments northern delta lakes, Egypt; on the environmental assessment of the spatial distribution of zooplankton and on algal diversity of the Mediterranean lakes (Khairy, *et al.,* 2015); the properties of the ecosystem variables changes are the reliable forecast on qualities of ecosystem functions (Suding*et al.*, 2008). The physicochemical properties (Mohsen *et al.*, 2021 and Elmorsi, (2017) *Potamogeton pectinatus*; dynamics is due to the consequent changes in the interactions between species functions (Garnier *et al.,* 2004) will affect the community change ecosystem processes through changes in the representation of the ecosystem impact qualities (Diaz *et al.*,2004; Kremen, 2005). Lake Borollus is one of the largest and oldest Egyptian lakes, whereas it is located in the far north of the Delta and mediates between the two branches of Rosetta and Damietta. It is connected to the Mediterranean Sea through Boghaz El Borollus and to the Nile through the Bermbal Canal, which was established in 1926 to feed the lake with abundant quantities of Nile water and Nile fish. Impact of drainage water inflow on the environmental conditions and fishery resources of Lake Borollus was studied by Al Sayes *et al.*, (2007).

The fishermen of the lake also complained about the pollution of some parts of the lake with industrial and agricultural drainage, especially the “Kitchener” drain, which is one of the most important causes of pollution and pours its waste into some of its waters. It is considered the second natural lake in Egypt in terms of area. The lake has many biological sources and many types of aquatic plants. It enjoys a diversity of natural life due to the diversity of environments. Sanitary and industrial sewage flowing into the lake, which is estimated at 652 million cubic meters annually, should be prevented.

It is the second largest natural lake in Egypt and considered the oldest lakes which are connected to the Mediterranean Sea through the Borollus Boughaz inlet and the River Nile by the Permbal Canal, to supply the lake with abundant quantities of water from the Nile and Nile fish. Recently the lake area has been reduced by about 60,000 acres and 25,000 acres of grass and reeds and the high silt content of many islands, which increases the height of the lake level from the Mediterranean level by 35 cm; this hinders the flow of salt water to it. The increase in pollution rates exceeding the permissible limits by stages, as a result of dumping more than 30 billion cubic meters annually in the lake consists of agricultural and sewage water and the fish farms existing on the southern edges of the lake are discharged. Water sources and outlets in Lake Borollus from East Borollus Drains; Al Gharbia Drain; Drain Tira No.7; Drain No.8; Nashart Drain; Al Hoxa Drain (No.11); West Borollus Drain; Zaghloul Drain; Treatment plant Borg Al-Borollus; Boughaz Borg Al Borollus and Permbal Canal (fresh water of River Nile). It is bounded by numerous fish farms, villages and farmlands. The lake has many biological sources and many species of hydrophyte plants whereas, it enjoys a diversity of natural life due to the diversity of environments.

As well as preserving the diversity of fish species by maintaining an environment suitable for breeding, preventing overfishing and numerous encroachments, and continuous disinfection of the lake bottom and the removal of weeds and dense submerged hydrophytes as *Pomatogeton pectinatis* and Floating Hyancinth *Eichhomia crassipes*. As listed by Saeed and Shaker, (2008) the concentration of heavy metals in surficial sediments had the trend Fe > Mn > Zn > Cu > Pb > Cd. But each of Elghobashy *et al.*, (2001), Ibrahim and ElNaggar, (2006) cited that iron appears in the Lake sediments as an essential component of clay minerals which is the major one in the Lakes whereas, it can be concluded that the heavy metals are more highly accumulated in sediments than water due to its acts as a reservoir for all contaminants and dead organic matter descending from the ecosystem above as was mentioned by Hamed, (1998). He also added that the sandy sediments showed low concentrations of heavy metals than clayey sediments. On the other side, Saeed and Shaker, (2008) the concentration of heavy metals in surficial sediments had the trend Fe > Mn > Zn > Cu >Pb > Cd. But each of Elghobashy *et al.*, (2001), Said and Abdel-Moati, (1997) and Ibrahim and ElNaggar, (2006) cited that iron appears in the Lake sediments as an essential component of clay minerals which is the major one in the Lakes. It can be concluded that the heavy metals are highly accumulated in sediments than water due to its acts as a reservoir for all contaminants and dead organic matter descending from the ecosystem above as was mentioned by Hamed, (1998). They also added that the sandy sediments showed low concentrations of heavy metals than clayey sediments. By comparing the accumulation of heavy metals in water and sediments.

The total area of the Lake Borollus is about 114,000 acres (ca 460 km^2), with maximum width of 6-21 km, maximum length ca 54 km, with hydrophytes covering a proportion of 46% of the total area of the lake, while the open water represents the remaining part of the total area 54% of the lake has a shallow water basin depth varied between 75 -100 cm. The lake is a reservoir for agricultural wastewater and sewage for the Central Delta Region whereas, many drains poured directly 61 major drains flow into the lake especially Kafr El Sheikh Governorate. Lake Borollus was declared a protectorate to conserve its biological diversity and also to provide endangered species a natural habitat whose endangerment was a result of human activities. Also, making the lake a protectorate helped in monitoring environmental changes and in encouraging natural or ecotourism in Egypt. Its protectorate status also helps in conducting applied scientific research. The lake helps in protecting natural resources especially those that are of economic significance.

Dumont and El-Shabrawy (2007) mentioned that lake Borollus is considered one of the central situation Nile Delta lakes due to the preexisting salt marsh by fluviatile deposition of sand dunes north of the lake subsidence of the preexisting tidal swamp behind this barrier. Due to this control, lake`s fauna and flora contains a mix of marine, freshwater, and brackish-water species and subsequently after the constructor of the High Aswan Dam-1964 the yearly flood fully was under control. The Result of draining irrigation water of agriculture directly into the lake became a constant evacuation to the Mediterranean Sea and nearly freshwater fish were replaced by marine fish species. High amounts of delta crops increased the rate of nutrients discharged into the lake causing eutrophication and hyper- trophication because of the low residence time of its water.

Yearly sediment layer of mud deposited into the sea leading to erosion continues and consumes the sand bar that separates the lake from the sea.

Previous studies conducted in the north Delta Lakes included the Northern of Delta Lakes of Egypt (Lake Borollus, Manzala and Bardawil) connection to Mediterranean Sea during the years the current study for the 8th year 2017 reflect some changes in the qualitative diversity of benthic and numerical density of equal distribution between species and between study areas due to different environments, depending on the type and physical and chemical properties of aqueous than direct and indirect impact on the qualitative composition of benthic (El-Komi, 2016, 2017a, 2019, 2021). The objective of biological studies includes estimating biodiversity by knowing the difference in the qualitative composition of benthic organisms and evaluating some organisms with biological and economic efficiency and biological indicators resulting from the impact of pollution from various pollutants and climatic variables in water areas of the northern lakes, including Lake Pearls, as their environmental condition is gradually deteriorating in particular. The lake is also characterized by a large area, a shallow, medium-salinity lake, and is the second largest natural lake in Egypt after Lake Status, estimated at about 460,000 square meters and located in the north of the Nile Delta along the coast about 10 km and the depth of water ranges from half to 1.6 meters. tt extends between latitudes 31° 23` 26`` to 31° 34` 48`` N and longitudes 31° 02` 48`` to 31° 07` 30`` E and the lake connects to the Mediterranean Sea on the north side during the tower bugs, and as a result of increased rates of nutritious salts Organic matter, especially in the south-eastern, western and southern regions, where it flows directly from some sources of pollution, such as sanitation and agricultural activity, the lake suffers from an increase in fertility (Eutrophication).

One of the main objectives of the project is to study the distribution of benthic organisms in Lake Borollus and to know the relationship between the groups and types of benthic organisms as a food environment and as an important food source for some other organisms, especially fish and crustaceans in the study stations and link this to chemical, sedimentary and natural changes statistically. It also estimates and studies changes in species abundance and the different formative structure of the lake's different biological clusters, starting with primary producers (phytoplankton), secondary consumer aquatic plants and zooplankton, and higher consumers such as fish, molluscs, crustaceans, worms, etc. All these communities, including larvae stages, are as far as possible to indicate whether pollutant concentrations have a negative or positive impact on increasing biodiversity from the abundance of aquatic organisms, both qualitatively and estimating the numerical density in the various designated areas, where the Egyptian coastal region has recently experienced significant fluctuations in environmental conditions, which has a fundamental impact on fisheries in coastal waters off Egyptian coastal waters to a large extent. To achieve various types of knowledge, is depending on our databases and provide various consistent information for all network users and encouraging comparisons science and query tool allows the user to search for information about the range of the species selected, and can explore patterns and relationships, and learn how to develop or to answer scientific questions, long -term goal-create database rich enough to explore some of the basic concepts of user controls and conservation biology. The main goal of this work is to ensure the integration of biodiversity through the regional and temporal distribution of benthic communities in particular along the wetlands, lakes and waters. In addition, this project works towards the correct interpretation and implementation of environmental laws, which are of great importance in order to halt the loss of biodiversity and a good assessment for "Monitoring Tool of Benthic Organic Pollution" as "Bio indicator" for other pollutants or those is very important economically and ecologically concepts.

MATERIAL AND METHODS

Materials and methods of study during the study period February and September 2017 the semi-annual journey representing the summer and winter seasons. Samples for the study were collected in the benthic biology of Lake Borollus and sediment samples were taken by grab sampler Van veen size 15 cm X 15 cm (equivalent to 0.02 m^2 from 12 stations and were selected to cover and represent the environments in the lake in addition to 7 main drains were selected from drains from 61 major drains that poured directly and flow into the lake as shown in the map; Lake Borollus locates between the coordinates, latitude (31° 29′ 0″ N) and longitude (30° 52′ 0″ E) as shown in Fig. 1 and their sites locations in Table 1.

The pattern of the study sampling sites in Lake Borollus can be divided into three main sectors namely:

1- Eastern Sector (included 3 sites, B1- front of the mouth of East Borollus Drain I; B2 - in front of Al-Boghaz in front of the mouth of East Borollus Drain, and B3 – (El Bulaq),
2- Middle Sector (included 5 sites, B4 - in front of the mouth of the drain No.7, B5, Al-Zanqa (in the middle of the lake, the farthest station from the sources of pollution); B6 - Tawila (middle of the lake north of drains no.8 and 9; B7 - Al Shakhaliya (mediating drains No.8 and 9, B8 - Mistroo (North of the lake) and
3- Eastern Sector (included 4 sites, B9 - Abu Amer (northwest of the lake); B10 - Al-Baraka and in the middle of the western sector in the lake; B11- In front of the mouth of the drain No.11 - Aloxa bank, and B12 - In front of the Bermbal canal estuary (the mouth of the Nile waters in the lake).

In the laboratory, the sample was washed through a network with 100 micron slots and another 300 microns, where samples are examined and sorted into their types using an anatomical microscope of 20 x 40x. The numerical density of macro organisms is estimated per square meter, and nonliving organisms from calcareous molluscs shells, floats and limestone tubes of many worms have been estimated to be the most common, predominant, hesitant, present (abundant common- frequent present).

Locality of study sampling sites: Borollus Wetland is located along the Mediterranean Sea coast in the north part of Nile Delta. It is bordered from the north by Mediterranean Sea and from south by the agricultural lands of the north Nile Delta. It lies in a central position between the two branches of the Nile: Damietta to the east and Rosetta to the west. Its coordinates are 31°36' N and 30°33' E in north - west, 31°36' N and 31°07' E in the north –east, 31°22' N and 30°33' E in the south –east, 31°22' N and 31°07' E in the south – east. It has a total area of 460 km2, which includes the entire area

	Eastern Sector			Middle Sector					Western Sector			
Stations	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12

Fig. 1. Northern part of EGYPT Map shows the North River Nile Delta Lakes and the sampling sites in Lake Borolo's during 2017.

of Lake Borollus with numerous islets inside it, as well as the sand bar separating the lake from the Mediterranean Sea, with a shoreline of about 65 km (Shaltout and Khalil, 2005).

1-Area of Study

a) **The nature of the benthic sediment**: Lake Borollus lies between the coordinates, latitude (31° 29′ 00″ N) and longitude (30° 52′ 00″ E) as shown in Fig. 1 and their sites locations in Table 1. The pattern of the study sampling sites in Lake Borollus can be divided into three main regions namely: the eastern sector (sites B1, B2, B3); Middle Sector (B4, B5, B6, B7, B8); and the western sector (B9, B10, B11, B12). Lake Borollus is the 2nd largest natural lake in Egypt connected to the Mediterranean Sea through the Borollus Boughaz inlet and the River Nile by the Permbal Canal Lake Borollus is connected with the Mediterranean Sea. This work was done during 2017 covering 12 sampling sites and 7 drains at the southern region and they discharged directly to Lake Borollus. Sediments in a few zones are organic materials (sludge) is made out of waste sewage and agricultural and industrial particularly in the southern region and others of sandy silt, sands, and shells in most sites. Consequently, it can decide a few conditions prevailing in lake environments. The nature of bottom sediment as illustrated in Table 1 is characterised by some deposits of organic material (sludge) and is composed of sewage waste of agricultural, industrial, and others of sandy silt and shells.

b) **Sampling collection**: Bottom sediments samples were collected by using a grab sampler which were selected to represent the covering the different environments. Also, bottom sediments were collected from seven main drains as shown in Fig. 1 and Table 1. Sampling was carried out during two periods, the 1st during February 2017 representing the winter season and the 2nd during September representing the summer season 2017. Benthos and bottom sediment samples were collected from 12 sites representing the different habitats in Lake Borollus. The positions of the selected sites, as well as the nurture of the bottom sediments, are shown in Fig. 1. The location of the sampling sites is detected by using GPS off B1, B2, B3, B4, B5, B6, B7, B8, B9, B10, B11 and B12. At each site, the bottom sediment sample was collected by Van veen grab sampler size 15cm x 15cm (an equivalent area to 0.02 m2) where each sample was placed in plastic containers, labelled, and preserved in 8-10 % diluted formalin solution. Also, bottom sediments were collected from 7 main drains (El Borollus Drain, Nasser drain, Drain No.7, Drain No.8, Drain No.9, Hoksa drain, and Bermbal Drain. At each station, each sample was placed in a 2-litre plastic jar and kept in a 5-8 percent diluted formalin solution.

c) **Sediments structure** in some areas consist of organic materials (sludge) is composed of waste sewage and agricultural and industrial and others of sandy silt, calcareous shells are mainly of molluscs' and therefore it can determine some environments prevailing in the lake. Monthly inflows of drainage discharges to Lake Borollus was estimated at about one million cubic meters (Shaltout and Khalil, 2005). The pollution rate has increased at rates exceeding the permissible limits as a result of meeting more than 30 x109 m3 yearly in the lake. This is from untreated sewage and agricultural water, as well as the drainage of fish farms on the edges of the south lake. Transparency of the water in the lake ranges between 10-40 cm with an average of 28 cm. High silt resulting in the formation of many islands in the lake, which increases the lake level above the Mediterranean level, which hinders the flow of salt water to it.

Sediments in a few zones are organic materials (sludge) made out of waste sewage and agricultural and industrial particularly in the southern basin and others of sandy silt, sands, and shells in the northern basin. Consequently, it can decide a few conditions prevailing in lake environments. The nature of bottom sediment as illustrated in Table 1 is characterized by some deposits of organic material (sludge) and is composed of sewage waste of agricultural, industrial, and others of sandy silt and shells.

d) **Water depths of the lake: (**EEAA, 2017**)** were mainly varied among the study sampling sites which ranging from low depth 60 cm – 80 cm depth (B2, in front of Al-Boghaz El Borollus, B4, in front of the mouth of the drain No.7, B5, Al-Zanqa (in the middle of the lake, the farthest station from the sources of pollution) and B11, in front of the mouth of the drain No.11 - Aloxa bank) and the maximum depth at the rest sites ranged from 100 cm to 125 cm depth.

Degree of transparency of lake water: ranges from 15 cm to one meter with an average of 45 cm therefore the transparency is relatively moderate except in southern sites and the drains.

Laboratory Analyses (El-Komi, 2017c, 2019, 2021): Bottom sediment samples in the Borollus and its drains in the laboratory were washed through 100 and 300 µm mesh-size sieves thoroughly with fresh water to remove the formaldehyde and other fine sediments (lesser than 300 µm). During sorting, stained matter or organisms identified were placed into broad taxa, including Polychaeta's, molluscs, and to the species level using a binocular stereo microscope has a power magnification of 20x and 40x. Acceptable taxonomic keys were used from different branches of taxonomical sources.

Table 1. shows the type of sediment formation observed in the different samples collected from the study stations in Lake Borollus during 2017.

Sectors	Sampling sites	Locality	Nature of bottom
Eastern Sector	B1	In front of the mouth of East Borollus Drain	plant fragments
	B2	In front of Al-Boghaz	empty shells
	B3	El Bulaq	empty shells
Middle Sector	B4	In front of the mouth of the drain no.7	plant fragments
	B5	Al-Zanqa (in the middle of the lake, the farthest station from the sources of pollution)	empty shells
	B6	Tawila (middle of the lake north of drains no.8 and 9	empty shells
	B7	Al Shakhaliya (mediating drains no. 8 and 9	plant fragments
	B8	Mistroo (North of the lake)	empty shells, plant fragments
Western Sector	B9	Abu Amer (northwest of the lake)	plant fragments
	B10	Al-Baraka and in the middle of the western sector in the lake	empty shells
	B11	In front of the mouth of the drain no.11 - Aloxa bank	plant fragments
	B12	In front of the Bermbal canal estuary (the mouth of the Nile waters in the lake)	fine sands

Data analysis: The following descriptive measurements were computed at each site B is the biomass of individuals and it is expressed as the wet weight of individuals in g/m^2 the ratio S is the species number per sample A is the abundance of individuals and it is expressed as some ind/ m^{2}B/A and A/S were plotted for the samples at the different sites Hydro-chemical properties: (EEAA 2017) as shown in Table 2 and Fig. 2 Temperature of the water is one of the most important factors affecting the aquatic environment as a whole, the temperature ranged from 27℃ to 30℃ with an average of 28.78 ℃.

Transparency of the water: reflects the ability of light to penetrate during the water, ranging from 25cm to 35 cm with an average of 31.25 cm.

Depth of the water: is low, ranging from 60 cm to 125 cm with an average of 99.58 cm.

Water salinity: (total dissolved salts in water) recorded at low salinity reached between 3.63‰ to 21.73‰ with an average year of 10.17‰. It attained high values at sites B2 (In front of Al-Boghaz), B3 (Bulaq), B4 (In front of the mouth of the Drain No.7), and B5 (Al-Zanqa in the middle of the lake) which ranged from 21.7 ‰ to 14.05 ‰ and moderate values 8.14‰ (B6, Tawila (middle of the lake north of drains No.8 and 9) and 9.89 (B8, Mistroo north of the lake) and the rest sites ranged from 3.63‰ (B1, in front of East Borollus Drain) to 5.46‰ (B9, Abu Amer northwest of the lake).

Hydrogen ion (pH) has an important role in the installation or melting of heavy metals in the water bodies. It ranged from 8.28 to 9.09 with an average of 8.72. It is located on the alkaline side.

Dissolved oxygen (DO) has an important role in the survival of aquatic organisms. The results indicated that it was regularly varying from a low value of 4.55 mg/l and high value of 15.44 mg/l with an average of 8.8 mg/l.

Biology oxygen levels (BOD) absorbed is the amount of oxygen used to decompose the microorganisms of organic matter and in the current study, the amount of oxygen consumed by e.g. (6.6 -25.5 mg/l) ranged from an average year in the lake (13.5 mg/l).

Oxygen consumed (COD) is the amount needed to oxidise organic substances in the water and turn them into carbon dioxide and water, and in this study ranged from the amount of oxygen consumed as a percentage of 100% (43.02 – 108.14 mg/l) with an average 70.15 mg/l). The high values were recorded at sites B4, in front of the mouth of the drain no. 7 and B5 Al-Zanqa (in the middle of the lake, the farthest station from the sources of pollution reaching 108.14 mg/l.

By comparing the results of some of the hydro chemical properties of the water lake with the levels allowed internationally during the current study. It was found that the levels of the hydrogen ion (pH) were found within the levels allowed internationally (6.0 – 9.0) by the average of 8.28 years. Dissolved oxygen's (DO) were found within the internationally permitted levels (12.6 - 4.0 mg/l in all lake sites at this time of year, except for site B6 (Tawila (middle of the lake north of Drains No.8 and Drain No.9) and an average of 10.24 mg/l). The biology oxygen levels (BOD) absorbed is higher than the internationally permitted levels (6.0 - 3.0 mg/l) in all lake sites with a general average (24.13 mg/l).

The quality of water is rated by the Oregon Water Quality Index, which is rated as a valid water quality for organisms or as a fish designer, which is based on an integrative calculation of a number of characteristics. The water and nature of the lakes include

Table 2. Abundance of the annual averages (no. ind/m^2) and relative abundance (%) of the main groups of benthic species recorded in bottom sediments collected from Lake Borollus during 2017.

A-Abundance 2017		Eastern Sector			Middle Sector					Western Sector				Ave	%
Groups	Species	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12		
Hydrophytes	*Potamogetonpectinatus*	0	0	0	861	0	0	0	420	0	0	0	0	107	4.4
Nematoda	*Enoplismersdionalis*	0	0	0	0	672	672	0	0	0	0	0	0	112	4.6
Oligochaeta	*Chaetogasterlirnnaei*	0	0	0	0	0	0	252	0	0	0	0	420	56	2.3
Polychaeta	*Capitella capitata*	357	0	0	0	1155	0	546	0	0	0	0	210	189	7.7
Insecta larvae	*Tendipestentans*	0	0	126	378	0	672	0	0	0	42	63	294	131	5.4
Ostracoda	*Sclerochiluscontortus*	567	1491	1470	1155	1575	2856	2058	2016	966	1617	840	882	1458	60
Amphipoda	*Corophiumvolutator*	0	0	0	0	0	0	399	588	0	0	0	231	102	4.2
Barnacles	*Amphibalanusimprovisus*	0	168	588	0	42	0	0	0	0	0	0	0	67	2.7
Bivalves	Juviniles of bivalves	0	0	0	0	0	0	2646	0	0	0	0	0	221	9
	(A) Abun. no.ind./m2	924	1659	2184	2394	3444	4200	5901	3024	966	1659	903	2037	2441	100
	% Abundance	3.2	5.7	7.5	8.2	11.8	14.3	20.1	10.3	3.3	5.7	3.1	7		
	Sector abundance		1589				3793				1391				
	% Sector abundance		23.5				56				20.5				
B- Biomass	**Species**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**	**B11**	**B12**	**Ave**	**%**
Vascular plants	*Potamogetonpectinatus*	0	0	0	205.1	0	0	0	92.4	0	0	0	0	24.8	33.1
Nematoda	*Enoplismersdionalis*	0	0	0	0	0.183	0.189	0	0	0	0	0	0	0.03	0.0
Oligochaeta	*Chaetogasterlirnnaei*	0	0	0	0	0	0	0.334	0	0	0	0	0.385	0.06	40.0
Polychaeta	*Capitella capitata*	0.48	0	0	0	1.53	0	0.73	0	0	0	0	0.285	0.25	80.3
Insecta larvae	*Tendipes tentans*	0	0	0.63	1.76	0	3.12	0	0	0	0.21	0.315	1.365	0.62	40.8
Ostracoda	*Sclerochilus contortus*	0.01	0.02	0.02	0.02	0.03	0.03	0.01	0.02	0.03	0.02	0.02	0.02	0.02	20.0
Amphipoda	*Corophium volutator*	0	0	0	0	0	0	3.55	5.255	0	0	0	2.88	0.97	31.3
Barnacles	*Amphibalanus improvisus*	0	121.6	425.5	0	30.55	0	0	0	0	0	0	0	48.1	64.3
Bivalves	Juviniles of bivalves	0	0	0	0	0	0	0.26	0	0	0	0	0	0.02	0.03
	Biomass g/m2	0.5	121.6	426.2	206.9	32.3	3.3	4.9	97.7	0.03	0.2	0.3	4.9	75	100
	B/A ratio	0.001	0.073	0.195	0.086	0.009	0.001	0.001	0.032	0	0	0	0.002	0.033	
	A/S	462	830	874	798	984	1400	1311	1210	966	1106	602	679	935.09	
	%	0.05%	13.00%	45.70%	22.20%	3.50%	0.40%	0.50%	10.50%	0.00%	0.02%	0.04%	0.53%		
	Sector Biomass		183				69				1.38				
	% Sector Biomass		72.3				27.3				0.5				

Continued…….

	A-Abundance 2017	Eastern Sector			Middle Sector					Western Sector				Ave
C- Water - Quality		B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	
	Depth (cm)	100	80	100	60	80	125	125	125	100	125	75	100	99.6
	Trans (cm)	30	30	35	30	35	30	25	30	30	35	30	35	31.3
	Temp	27	27.6	28	29	30	29.6	29.5	28	29.5	28.5	29.4	29.2	28.8
	pH	8.62	8.32	8.28	8.58	8.73	8.91	9.09	8.6	8.82	8.93	8.92	8.89	8.72
	Salinity ‰	3.63	21.73	19	19.12	14.05	8.14	5.75	9.89	5.46	5.07	5.36	4.78	10.2
	Do (mg/l)	7.15	4.55	4.88	6.18	9.75	9.26	12.35	7.31	5.85	10.73	12.19	15.44	8.8
	BOD (mg/l)	15	6.6	6.9	8.1	10.5	18.0	25.5	9.3	6.9	11.1	25.5	18	13.5
	COD (mg/l)	43.02	31.18	43.02	108.14	108.14	84.46	90.38	84.46	60.78	60.78	54.86	72.6	70.15
D- Diversity	Indices	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	
	d Richness	0.146	0.135	0.26	0.257	0.368	0.24	0.461	0.25	****	1350.	0.147	0.525	
	J`Evenness	0.962	0.473	0.714	0.92	0.791	0.772	0.785	0.785	0	0.17	0.365	0.9	
	H` Shannon	0.667	0.328	0.784	1.011	1.097	0.849	1.264	0.863	0	0.118	0.253	1.448	
	Simpson index	0.475	0.182	0.471	0.613	0.64	0.487	0.662	0.499	0	0.049	0.13	0.726	

Where: d (Richness) Margalef`s index = (S-1) / log N -- J'(Evenness) Pielou`s index = H` / Hmax-- H` (Shannon and Weaver index) species diversity = - ∑ Pi log Pi
Simpson index D = 1 - ∑ (Pi)2 --- S = No. of species A = abundance no. ind. / m2 B = Biomass g/m2

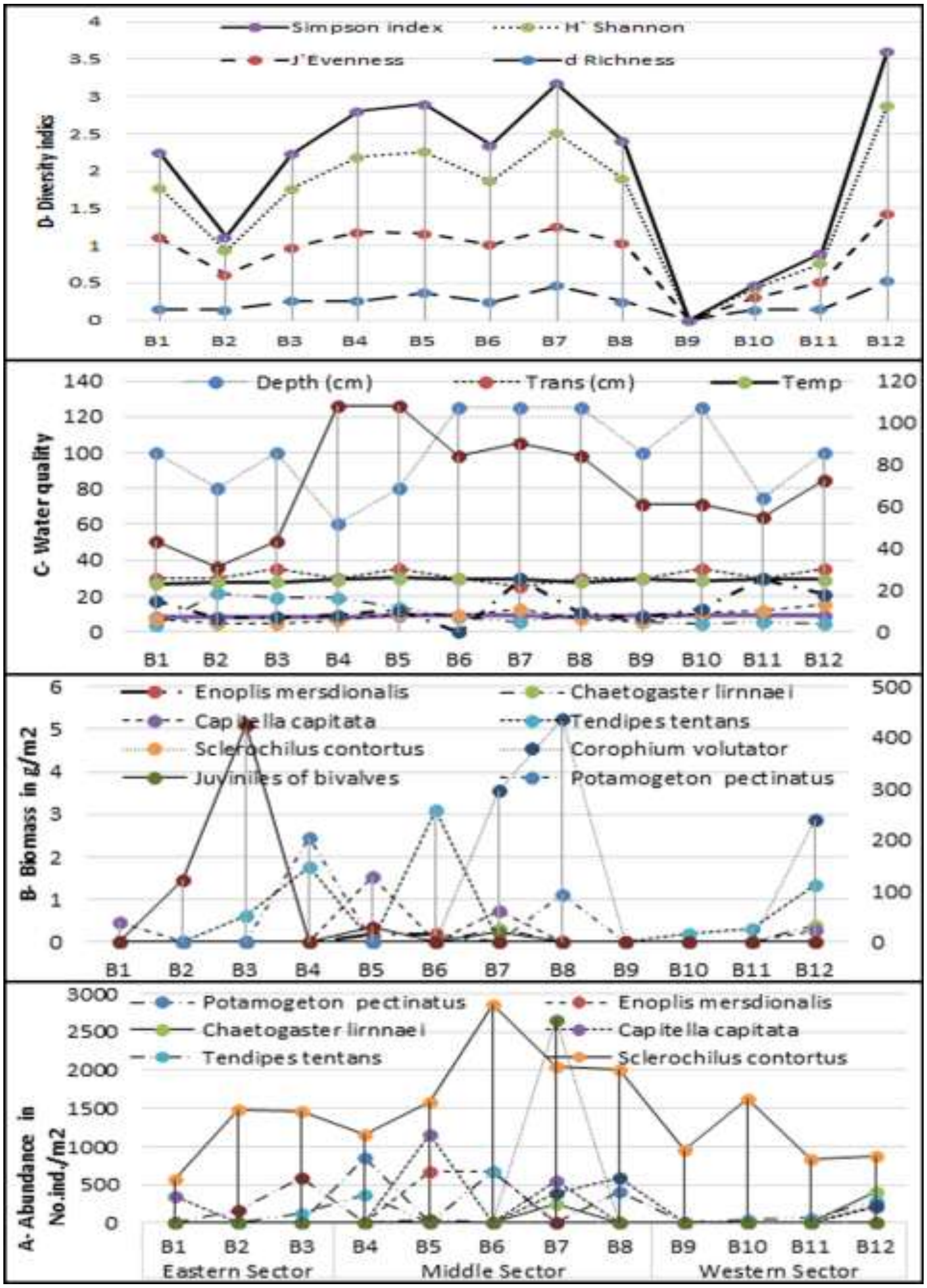

Fig. 2. Regional changes: A- Benthos abundance; B- Benthos biomass; C- Water quality and D- Diversity indices were calculated for benthic constituents at the study sampling sites in Lake Borollus during 2017.

temperature, pH-ion, dissolved oxygen (DO), bio-dependent oxygen (BOD), total ammonia and nitrates as nitrogen, total phosphorus, as well as Faecal Coliform.

The Oregon Water Quality Index (OWQI) on the water of the lake found that the condition of water as large as good in some stations and poor at other stations.

Pesticides the total concentration of phenyl poly chloride (PCBs) reached 0.357 ng/l) and the value of total pesticide reached 0.919 ng/l).

The heavy metals in lake water showed from the results as:

- Iron is ranged from 6.12 to 45.11 mg/l with an average of 18.25 mg/l
- Manganese is ranged from (4.01 - 9.66 mg/l with an average of 5.29 mg/l.
- Copper is ranged from 2.44 to 6.12 mg/l with an average of 3.16 mg/l.
- Zinc is ranged from 4.00 and 18.81 mg/l with an average of 10.06 mg/l.
- Nickel is ranged from 1.54 to 6.51 with an average of 4.31 mg/l.
- Cadmium is ranged from 0.03 to 1.32 mg/l with an average of 0.43 mg/l.
- Lead is ranged from 0.42 to 2.3 mg/l with an average of 0.98 mg/l.
- Mercury is ranged from 0.0097 to 0.0389 mg/l with an average of 0.0196 mg/l.
- Chrome is ranged from 4.88 to 34.32 mg/l with an average of 11.35 mg/l.

d- Data analysis

1- Diversity Indices: Diversity indices which serve as an indication of community health on spatial and temporal scales can be measured using several indices (Magurran, 2004). However, diversity indices including Margalef's species richness, Pielou's (Pielou, 1966) Evenness index, Shannon-Weaver and Simpson's diversity index were applied in this study.

• **Margalef's species richness (d)**

Species richness which refers to the total number of different species present (without taking into account the proportion and distribution of each species) within the sample. Margalef index (Margalef, 1958) is represented by the equation: $d=(S-1)/lnN$

where'S = the total number of species, and N = the total number of individuals in the sample.

• **Pielou's evenness (J')**

Pielou (1966) used the ratio of expected number of species against the recorded number of species as an index of evenness, with the assumption that all species were accounted for in the sample. This aids in qualifying organism distribution among sampled assemblages. The higher the obtained value, the more evenly individuals are spread among the species. Species evenness is dependent on species richness and species diversity. The evenness measure is a ratio of the observed diversity to the maximum possible in a sample having the same number of species. The equation used was:

$J'= H'/H'max= H'/\log S$

where H' = the Shannon-Weaver diversity index

S = the total number of species

• **Shannon-** Weaver**'s diversity index (H')** (Shannon, and Weaver, 1949)

The Shannon-Weaver diversity index (also referred to as the Shannon diversity), characterises the state of an assemblage per the species richness and species abundance. It assumes all species are represented in the sample and that individuals are randomly sampled from an independently large population. The community diversity is defined by the obtained value; 0 to 1.5 for poor, 1.5 to 2.5 for moderate and > 2.5 for highly diverse. The Shannon-Weaver diversity value often falls between 1.5 and 3.5 but can exceed 4. The index increases as the community richness and evenness increases (Magurran, 2004).

The equation used is: S

$H' = -\Sigma pi$ ln pi

i=1

where pi = the proportion of individuals found in species i

ln = natural logarithm

s = the total number of species

• **Simpson's diversity index (D):** Simpson, (1949) introduced this measure to determine the degree of concentration when species are classed. Values of Simpson's diversity index range from 0 to 1, where 0 represents no diversity and 1 represents infinite diversity. The index is directly related to species evenness and richness. The Simpson index gives more weight to common or dominant species; therefore, a few rare species with only a few representatives will not affect the diversity.

The equation used to measure it was: $D=\Sigma(n(n-1)/N(N-1))$

where n = the total number of organisms of a particular species

N = the total number of organisms of all species

D is a measure of dominance, so as D increases, diversity (in the sense of evenness) decreases. Thus, Simpson's index is usually reported as its complement 1-D. This provides an intuitive proportional measure of diversity that is much less sensitive to species richness.

1- Statistical analyses: Statistical tools used in Univariate and Multivariate analyses were MICROSOFT EXCEL Tool PCA and PRIMER (Plymouth Routines in Multivariate Ecological Research) version 5 respectively. The analysis of variance (ANOVA) using simple linear regression (FAO, 1991) was calculated. This method is based on determining the significant differences at the 95% confidence limits between the variables of sites (abundance, biomass, and groups of benthos) and physic-chemical variables.

1. The triangular matrix of similarities between samples leading to hierarchical classification (cluster analysis) (FAO, 1991). This is based on a Bray-Curtis similarity matrix of appropriately transformed species abundance or biomass data.

2. Principal component and factor analyses PCA are multivariate techniques, which generate a sequence of varieties known as components of factors in a correlation matrix. These analytical methods have been successfully used in marine ecology. It is based on extracting information on the regional patterns of species from complex correlation matrices. The basic difference between PCA and factor analyses FA is that the PCA is assumed that all the variance is common and its orthogonal components can be extracted, whereas in the FA the variance common in all variables is separated from the specific and error (residual) variances. The analysis is based on the data of the abundance (no. ind/m2) of the most common species or the main high taxa groups of benthos using the numerical data.

RESULTS AND DISCUSSION

Part 1- Distribution of Macrobenthos in the Lake Borollus

1- Species composition of benthos structure:

1.1 Species Composition: The results of the benthic structure and their regional distribution in Lake Borollus are shown in Table 3. During this study at the different sampling sites over a period one year (winter and summer, 2017), nine species were recorded as living macrobenthic assemblages in addition to many un-living composed mainly from empty shells of bivalves, gastropods, barnacles, and fragments of aquatic plants. These include nine species belonging to 10 main higher taxonomic levels namely;

- Submerged aquatic plants included one species namely *Potamogeton pectinatus*.

- Phylum Nematoda (class Enoplea, *Enoplus meridionalis*);

- Phylum Annelida (class - Oligochaeta, *Chaetogaster Chaetogaster limnaei* and class Polychaeta, *Capitella capitata*); -Sub Phylum Crustacea, Class - Ostracoda, Order Myodocopida, *Sclerochilus contortus*), (class Malacostraca, Order Amphipoda, Order Isopoda, *Corophium volutator*, Order Cirripedia, *Amphibalanus improvisus*); Phylum Insecta; insect larvae Pupa larvae.

- Phylum Mollusca (class Bivalvia, keniles of bivalves).

- Kingdom: Plantae Clade: Tracheophytes - Angiosperms - Monocots; Order: Alismatales; Family: Potamogetonaceae; Genus: Stuckenia / Binomial name *Stuckenia pectinata* (L) Böerner Synonyms/*Potamogeton pectinatus* Linnaeus, 1758.

- Kingdom: Animalia Subkingdom: Eumertazoa Clade: Para Hoxozoa – Bilateria – Nephrozoa Phylum: Nematoda Diesing, 1861 Class: Enoplea / Synonyms *Nematoidea sensu stricto* Species: *Enoplus meridionalis*

- Phylum: Annelida Class: Clitellat Subclass: Oligochaeta Order Lumbriculidae Species: *Chaetogaster limnaei*

- Family: Capitellidae Genus: Capitella: Species: *Capitella capitata* / Binomial *Capitella capitata* (Fabricius, 1780)

- Calcareous tube worms **

- Phylum: Arthropoda Class: Insecta: Order: Diptera Superfamily: Culicoidea Family: Chironomidae Genus: Chironomid (L), Pupa larvae.

- Subphylum: Crustacea Superclass: Malacostraca Class: Ostracoda Order Podocopida.

- Suborder Podocopina Family Bythocytheridae Genus: Sclerochilus Sars, 1866
Species *Sclerochilus (Sclerochilus) contortus* (Norman, 1862)

- Class: Malacostraca Order: Amphipoda Family: Corophiidae Genus: Corophium Species *Corophium volutator* (Pallas, 1766).

- Class: Maxillopoda Infraclass: Cirripedia Order: Sessilia; Family: Balanidae Genus: *Amphibalanus Pitombo*, 2004
Species: *Amphibalanus improvisus* (Darwin, 1854).

- Phylum: Mollusca Class: Gastropoda Clade: Sorbeoconcha Superfamily: Cerithidea Family: Thiaridae Genus: Melanoides Olivier, 1804
Species: *Melanoides fasciolata* Olivier, 1804 **

- Superfamily: Cerithiodea Family: Potamididae Genus: Cerithideopsilla Species: *Cerithium conicum* Blainville, 1829 ** Superfamily: Viviparoidea Family: Bellamyinae Genus: *Bellamya*

Species: *Bellamya unicolor* (Olivier, 1894)

- Superfamily: Nderitoidea Family: Neritidae Tribe: Theodoxini Genus: *Theodoxus*

Species: *Theodoxus niloticus* (Reeve, 1856) **

- Superfamily: Lymnaeoidea Family: Lymnaeidae Genus: *Lymnaea* Species: *Lymnaeanatalensis* Krauss, 1848** Superfamily: Planorboidea Family: Planorboidae Subfamily: Planorboidae Tribe: Planoribini Genus: *Planorbis*

Species: *Planorbis planorbis* (Linnaeus, 1758) **

- Family: Planorboidae Subfamily: Cleopatrinae Genus: Cleopatra

Species: Cleopatra bulimoides** (Olivier, 1804).

- Family: Physidae Subfamily: Physinae Tribe: Physellini Genus: *Physa* Species: *Physa acuta* Draparnaud, 1805 **

- Family: Planorbidae Genus: Helisoma

Species: *Helisoma duryiis*

- Superfamily: Ampullariidae Family: Ampullariidae Subfamily: Ampullariidae Tribe: Ampullariini Genus: Lanistes Montfort, 1810

Species: *Lanistes carinatus* (Olivier, 1804) **

- Family: Hydrobiidaae Subfamily: Hydrobiinae Genus: *Hydribia (Hydrobia)* Hartmann, 1821

Species: *Hydrobia ventrosa* (Montagu, 1803) **

- Class: Bivalvia Order: Veneridae Family: Cyrenidae Genus *Corbicula*:

Species: *Corbicula consobrina* (Caillaud, 1823)

- Subclass: Heterodonta Order: Sphaeriidae Superfamily: Sphaerioidea Family: Sphaeriidae Genus: *Pisidium* Pfeiffer, 1821

Species: *Pisidium pirothi* Jickeli, 1881.

- Order: Mytilidae Family: Mytilidae Genus: *Mytilus*

Species: *Mytilus galloprovincialis* Lamarck, 1819.

- Subclass: Heterodonta Order: Cardiida Family: Cardiidae Genus: *Ceratodrma*

Species: *Cerastoderma edule* (Linnaeus, 1758).

- Family: Donacidae Genus: *Donax* (Linnaeus, 1758) **

1.2 Structure of species number: The benthos groups at the different sites is shown in Table 4 & Fig. 2 emphasized that two groups from a total of 9 were relatively low, namely each group was represented by only one species. At each sampling site their occurrence varies by one to 5 species.

1.3 Regional Distribution of Macrobenthos Constituents

1.3.1 Abundance of benthic communities (A):

- As shown in Table 2 & Fig. 2 emphasized that the data analysis of the average annual abundance of benthic groups was the highest predominate benthic at sites of middle sector (from site B4- In front of the mouth of the drain No.7, B5- Al-Zanqa (in the middle of the lake, the farthest station from the sources of pollution), B6- Tawila (middle of the lake north of drains No.8 and 9, B7- Al Shakhaliya (mediating drains no. 8 and 9, and B8- Mistroo (North of the lake) attaining respectively annual average of 2394 (8.20%). 3444 (11.80%), 4200 (14.30%), 5901 (20.10%) and 3024 ind/m^2 (10.30%). This may be related to the water quality (Table 2) where the water salinity ranged from 9.89 ‰ to 19.12‰, dissolved oxygen DO vary between 6.18 mg/l to 12.35 mg/l and BOD reached 8.1 to 25.5 mg/l. Whereas, at the rest sites the average annual abundance ranged from 903 ind/m^2 (3.2%) to 2073 ind/ m^2 (7.0%).

Table 3. List of benthic assemblage recorded at different sampling in Lake Borollus during 2017.

Groups	Species	Groups	
Vascular plants	*Potamogeton pectinatus*	Gastropoda	*Melanoides tunculata* **
Nematoda	*Enoplus meridionalis*		*Pirenella conica***
Oligochaeta	*Chaetogaster limnaei*		*Bellamya unicolor***
Polychaeta	*Capitella capitata*		*Theodoxus niloticus***
	Calcareous tube worms**		*Lymnaea natalensis***
Insecta larvae	*Tendipes tentans*		*Planorbis planorbis***
Ostracoda	*Sclerochilus contortus*		*Cleopatra bulimoides***
Amphipoda	*Corophium volutator*		*Physa acuta***
Barnacles	*Amphibalanus improvisus*		*Bulinus truncatus*
			*Helisoma duryiis***
			Lanistes carinatus **
			*Hydrobia ventrosa***
			Corbicula consobrina
			*Pisidium pirothi***
		Bivalves	*Mytilus galloprovincialis*
			Cerastoderma edule
			Donax sp.**
			Juveniles of bivalves

** Empty shells

- Benthic meiofauna Ostracoda (*Sclerochilus contortus*) constituent representing 1st highest abundant (1458 ind/m^2, representing 36.1% of the total annual average of 2441 ind/m^2) which recorded at the most sampling sites in the Lake Borollus and living among the sand bottom sediments particular predominated at the middle sector B4-B8. This class of small crustaceans inhabiting the different aquatic environments occur as calcified “shells”. They have a "seed"-like appearance and therefore are also known by the term "seed shrimps" or "mussel shrimps". They were the highest predominate benthic meiofauna Ostracoda constituent reprinting 1st highest abundant (1010 ind/m^2, representing 45.4% of the total annual average of 2224 ind/m^2) which recorded at the most sampling sites in the lake and living among the sand bottom sediments.
- The 2nd highest abundance rather which was recorded at the most sampling sites in the lake was the juvenile of bivalves molluscs averaging to 221 ind/m^2, representing

9% and recorded only at site B7- Al Shakhaliya (mediating drains No. 8 and 9 (2646 larvae/m^2).

- The 3rd group were represented by class Insect larvae which showed low density of individual numbers in which lived on bottom sediment estimated by an annual average of 131 ind/m^2, representing 5.4%.

- Phylum Nematoda (class Enoplea, is represented by species *Enoplus meridionalis* which recorded only at site B6. The submerged vegetation plants (*Potamogeton pectinatus*) reached an averaged density of 107 tuft/m^2, and representing 4.4% and it was recorded only at site B4 (861 tuft/m2) and at site B8 (420 tuft/m^2).

- Class Crustacea, was represented by order Amphipoda (*Corophium volutator*) which recorded at the saline and brackish sites reaching 399 ind/m^2 (at B7), 588 ind/m^2 (at B8) and 231 ind/m^2 (at site B12- In front of the Bermbal canal estuary (the mouth of the Nile waters in the lake).

Table 4. Yearly annual averages of abundance (no.ind/m^2), biomass (wet weight in g/m^2) and the number of species recorded in benthos groups in bottom sediments collected from Lake Borollus during 2017.

Abundind/m^2	No. spp.	Abundance ind/ m^2	d (Margalef`s richness	J` Pielou`s evenness	H`(loge) Shannon diversity	Simpson's diversity
B1	2	924	0.146	0.962	0.667	0.475
B2	2	1659	0.135	0.473	0.328	0.182
B3	3	2184	0.260	0.714	0.784	0.471
B4	3	2394	0.257	0.920	1.011	0.613
B5	4	3444	0.368	0.791	1.097	0.640
B6	3	4200	0.240	0.772	0.849	0.487
B7	5	5901	0.461	0.785	1.264	0.662
B8	3	3024	0.250	0.785	0.863	0.499
B9	1	966	****	0.000	0.000	0.000
B10	2	1659	0.135	0.170	0.118	0.049
B11	2	903	0.147	0.365	0.253	0.130
B12	5	2037	0.525	0.900	1.448	0.726

- Phylum Annelida, Subclass Oligochaeta group recorded in relatively high numbers especially in polluted sites and represented as an indicator polluted species and estimated by an annual average of 56 ind/m^2, representing 2.3% which it recorded only in two sampling sites B7 (252 ind/m^2) and B12 (420 ind/m^2). They live inside muddy building tubes and attach to any submerged objects. They can tolerate the increase of polluted sediment and represent an indicator of pollution species.

Errant Polychaete *Capitella capitata* was relatively abundant (7.7%, 131 ind/m^2) and lived inside muddy building tubes and attached to any submerged objects. They can tolerant the increase of polluted sediment and represent an indicator of pollution species were recorded at B1- In front of the mouth of East Borollus Drain (357 ind/m^2), B5- Al-Zanqa (in the middle of the lake, the farthest station from the sources of pollution (1155 ind/m2), B7 (546 ind/m^2) B12 (210 ind/m^2).

- The cirriped barnacle *Amphibalanus improvisus* was recorded in a lower annual average of 2.7% (annual average 67 ind/m2) was recorded at sites B2- In front of Al-Boghaz (168 ind/ /m^2), and B3 (588 ind/m^2).

- The annual density of benthos was highest at B7-Al Shakhaliya (mediating drains No.8 and 9) yielding 5901 ind/m^2 in average (corresponding 20.1 % of the total numerical abundance of benthos, was estimated by 2441 ind/m^2. It was followed by site B6-Tawila (middle of the lake north of drains No.8 and 9, B5-Al-Zanqa (in the middle of the lake, the farthest station from the sources of pollution)) and B8-Mistroo (North of the lake)) which corresponding respectively to the annual density of benthos was moderate at the study sites B4 (In front of the mouth of the drain No.7), B3 (El Bulaq), and B12 (in front of the Bermbal canal estuary (the mouth of the Nile waters in the lake)) reaching percentage of the annual average of abundance of 8.2%, 7.5% and 7.0% attaining annual average of benthic abundance of 2394, 2184 and 2037 ind/m^2. At the rest sites yielding low density of benthic assemblage corresponding to the average of the annual average percentage of benthic that varied between 5.7% to 3.1% of total abundance varied from 1659 to 903 ind/m^2.

The abundance of macro-benthos organisms at the middle sector of Lake Borollus (B4, B5, B6, B7, B8) as shown in Table 1 contributed the greatest annual average reached 3793 ind/m^2 (23%) with biomass 60 g/m^2 (27.3%). Whereas, at the eastern sector it sustained 1589 ind/m^2 while the relatively low density was recorded at the western sector yielding 1301 ind/ m^2(20.5%) and a biomass of 1.38 g/m^2 (0.5%).

The abundance of macro benthos organisms at different sectors of Lake Borollus can be arranged in the following sequence: middle sector (56%) > eastern sector (23.5%) > western sector (20.5%) of the annual average density 2441ind/m^2. The biomass of benthic assemblages at the different sectors can also be ranked as follows: eastern sector (72.3%) > middle (27.3%) > western sector (0.5%) of the annual average biomass 75 g/m^2. The percentages 14.3%, 1.8% and 10.3% and yielding the following average annual of abundance 4200, 3444, and 3024 ind/m^2.

These variations in the constituents of bottom structure of the density and biomass related due to the impact of chemical properties on the sediments and water quality affection of components of benthic organisms and the tolerance of species to these changes in the nature of benthic sediments resulting from pollutants dumped in the lake from sources of pollution from agriculture, sanitation, agricultural and industrial, limestone health and fish farming.

1.3.2 Biomass g/m^2 (B): The wet weight in grams of the different benthic constants were recorded in Table 2 and illustrated graphically in Fig. 2 & 3 emphasized that the data analysis of the average annual biomass of benthic groups was the highest predominate benthic at sites B3 and B4 attaining respectively annual average of 426 g/m2 (75.7%) and 206 g/m^2) of the total annual average in wet weight of benthos, was estimated by 75 g/m^2. Whereas, at the sites B2 and B8 the average annual biomass was relatively moderate reaching 122 g/m^2 and 98 g/m^2 representing 13% and 10.5% respectively. At the rest sites the average annual biomass of benthic was low ranging from 32.3 to less than 0.01 g/m^2 representing 3.5% to less than 0.001%.

• The 1st annual average wet weight was the barnacle species *Amphibalanus improvisus* attaining the highest weights of 88.1 g/m^2, 64.3% whereas, it was recorded only at sites B2 (1216 g/m^2) and at site B3 (4255 g/m^2) at the eastern sector.

• The 2nd annual average wet weight was the submerged vegetation plants (*Potamogeton pectinatus*) reached an average density of 24.8 g/m^2, representing 33.1% of the average annual biomass. It was recorded only at site B4 attaining 2051 g/m2 and at site B8 sustained 92.4 g/m^2.

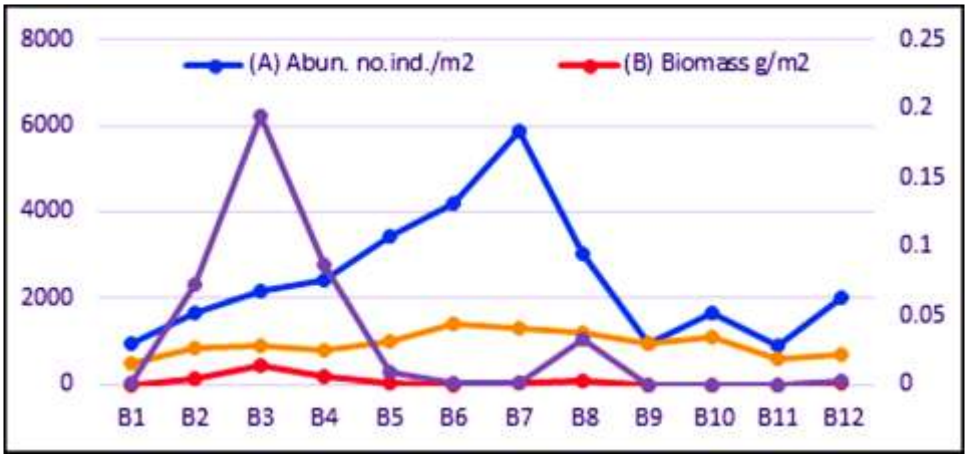

Fig. 3. Yearly annual average of abundance (no.ind/m^2), biomass (wet weight in g/m^2) A/S ratio and B/A ratio benthos groups in bottm sediments collected from Lake Borollus during 2017.

• The other benthic groups were less frequent, ranging from 0.1% to less than 1.0 % of the total annual average biomass of individuals whose biomass ranged from 1.0 g/m^2 to less than 0.01 g/m^2. On the other side, the percentage of biomass of benthic groups at higher taxonomic levels at the different sampling sites can also be ranked as following: Cirripedia (64.3%) > submerged aquatic plants (33.1%) > rest groups ranged 0.1% to less than 1.0 %.

1.3.4 A/S Ratio for The Samples at The Different Sites.

• As shown in Table 2 and illustrated graphically in Fig. 3 which A/S ratio was plotted for the samples at the different sites. The ratio indices which serve as an indication of community health on spatial and temporal scales can be measured using several indices. However, the shape showed how the appropriate medium is for the growth of the bottom organisms as the increase in the ratio A/S indicates that the medium is not suitable for the growth of benthic organisms. It is suitable for benthic growth when the abundance and the number of species has decreased.

• However, the B/A ratio Indic indicating increases when the value of benthic Biomass increases concerning the increase in biomass yield, and consequently it increases when the value of Abundance decreases. It is also clear from the table and shape how the appropriate medium is for the growth of the bottom organisms as the increase in the ratio B/A indicates that the medium is not suitable for the growth of benthic organisms.

1.4 - Diversity Indices (as shown in Table 2 & 4 and Fig. 2): Diversity indices served as an indication of community health on area scales. It can be measured using several indices as Magurran, (2004), Goodall, (1973), Magurran and McGill, (2011) El-Komi, (2017b). Also, DIVERSE-Univariate diversity indices can use PRIMER 5 (Plymouth Routines in Multivariate Ecological Research). Margalef's species Richness, Pielou's Evenness index, Shannon-Weaver species diversity, and Simpson's diversity index will apply in this study.

1.4.1 Margalef's species richness (d): Species richness refers to the total number of different species present (without taking into account) the proportion and distribution of each species) within the sample. The calculated values species richness (d) were low of species richness of values less than one at all sites ranging from 0.135 to 0.525.

1.4.2 Pielou's evenness (J'): Pielou's evenness is used as the ratio of the expected number of species against the recorded number of species as an index of evenness. According to the assumption that all species accounted for in the sample. The higher value of the attaining values of 0.962, 0.920 and 0.900 respectively at sites B1, B4 and B12. The evenness measure is a ratio of the observed diversity to the maximum possible in a sample having the same number of species, meaning the more evenly individuals spread among the species.

1.4.3 Shannon-Weaver's diversity index (H`): The Shannon-Weaver diversity index refers to the state of an assemblage per the species richness and species abundance. The estimated values attained 1.011, 1.097. 1.264, and 1.448 were moderately diverse at B4, B5, B7 and B12 respectively. At the rest sites low diversity ranged from 0.000 (B9) to 0.962 (B1).

1.4.4 Simpson’s diversity index (D): Simpson's diversity indexes aimed to measure and determine the degree of concentration of species classes. Simpson's diversity values as the index at the different sites ranging from the low value of 0.613, 0.640, 0.662, and 0.726 and at sites B4, B5 and B12 respectively. That provides an intuitive proportional measure of diversity that is much less sensitive to species richness. At the rest sites low diversity ranged from 0.000 (B9) to 0.499 (B8).

- Cumulative sites count over samples are shown in Fig. 4, A indicating four clusters groups: the 1st class is B12, B7 and B1 has low similarity about 50%; the 2nd and 3rd classes are B8 and B4; class 3 is B3, B2, B11, B9 and B8 has high similarity of about 83%; the 4th class is B6 and B5 has moderate similarity 65%.

Cumulative species count over samples are shown in Fig. 5, indicating three clusters groups: the 1st class is *Tendipes tentans*, Enoplus meridionalis and *Sclerochilus contortus*, and Amphibalanus improvisus has low similarity 20%; the 2nd group included *Corophium volutator*, *Chaetogaster limnaei* and *Capitella capitata* and Juveniles of bivalves reaching low similarity about 38% and the 3rd group included only *Potamogeton pectinatus* has low similarity 10%. Figure 6 indicates the Euclidean distance between clusters - distance below diagonal Squared distances above diagonal distance Table Descriptive Statistics for Cluster contains 25 variables which were maximum at sites B6 and B7 and minimum at site B1.

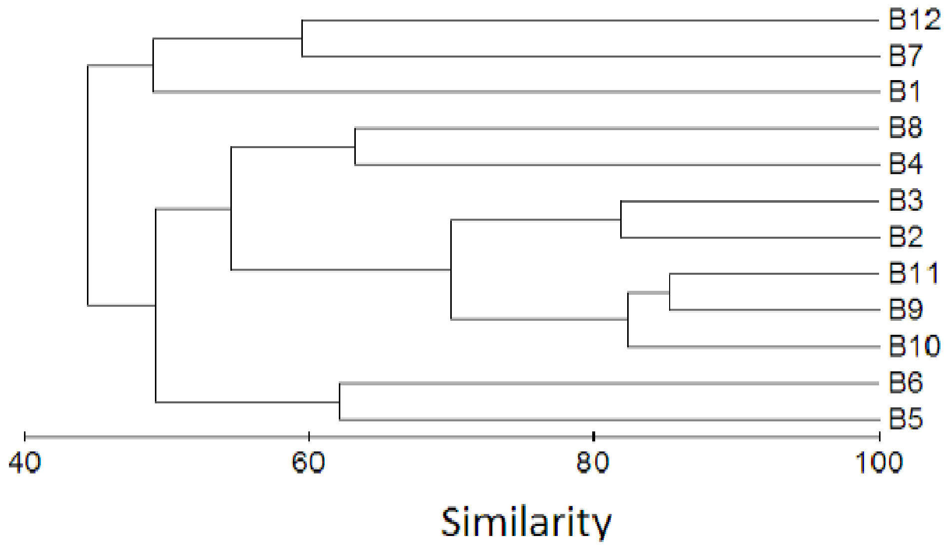

Fig. 4. Bray-Curtis similarity (%) dendrogram within benthic groups and diversity indices at different studied sites.

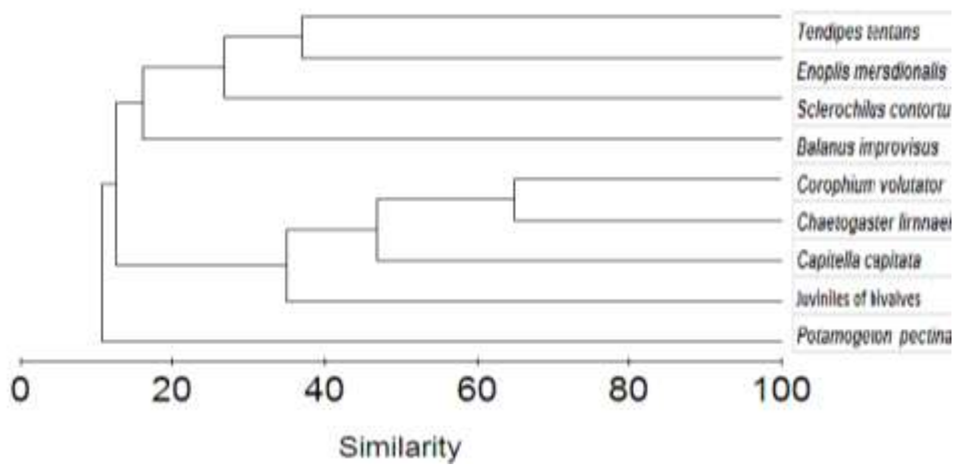

Fig. 5. Bray-Curtis similarity (%) dendrogram within benthic groups and diversity indices at different studied sites.

1.4.5 Cumulative Sites and Species Count Over Samples:

1.4.6 PCA principal component analysis: Fig. 7 & Table 5 revealed PCA ordination between all variables and samples which the Eigenvalues Eigenvectors and (Coefficients in the linear combinations of variables making up PC's) and Principal Component Scores indicating one main of highly score at sites B2, B3, B4, B7, B9 and

B10 (as shown in Table 5). While, the pattern of PCA values suggest the influence of surrogate abiotic water conditions in Tables 7 & 8. A Bray-Curtis similarity cluster assessment between- species (Fig. 7) are displayed as dendrograms.

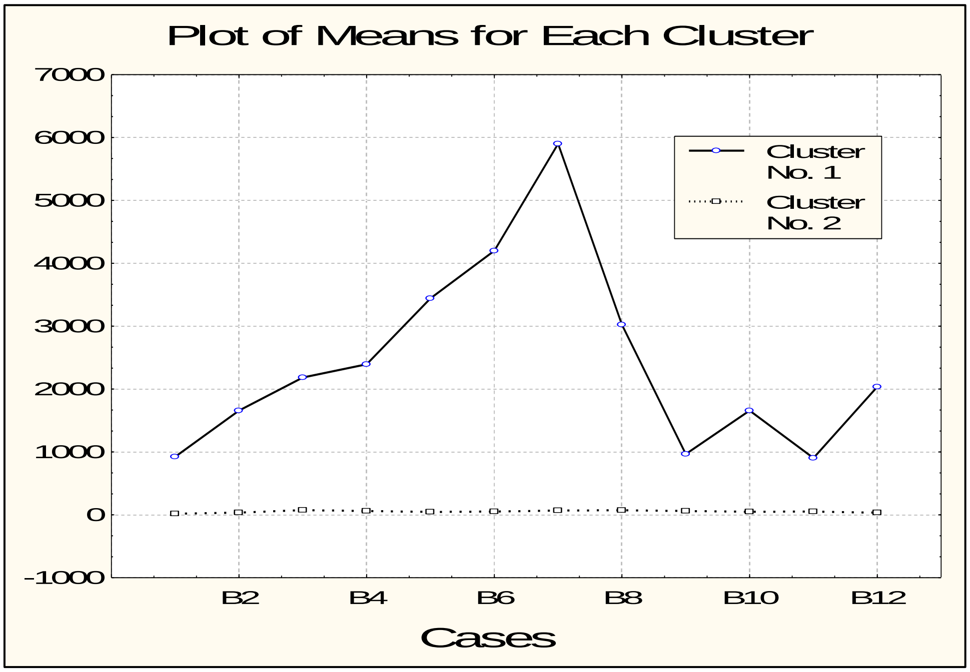

Fig. 6. Euclidean distance between clusters - distance below diagonal Squared distances above diagonal distance Table Descriptive Statistics for Cluster contains 25 variables.

Table 5. Factor Scores Rotation: Varimax normalized Extraction: Principal factors (comm.=multiple R-square).

	Factor 1	Factor 2		Factor 1	Factor 2
B1	-0.3006	-0.45	B7	1.48133	1.70405
B2	-0.66106	-1.24579	B8	0.38852	-0.12106
B3	0.26405	-1.85407	B9	-1.94769	0.61724
B4	0.84228	-1.08834	B10	-1.16426	0.5521
B5	0.92437	-0.06763	B11	-0.96188	0.77788
B6	0.36249	0.5519	B12	0.77243	0.62372

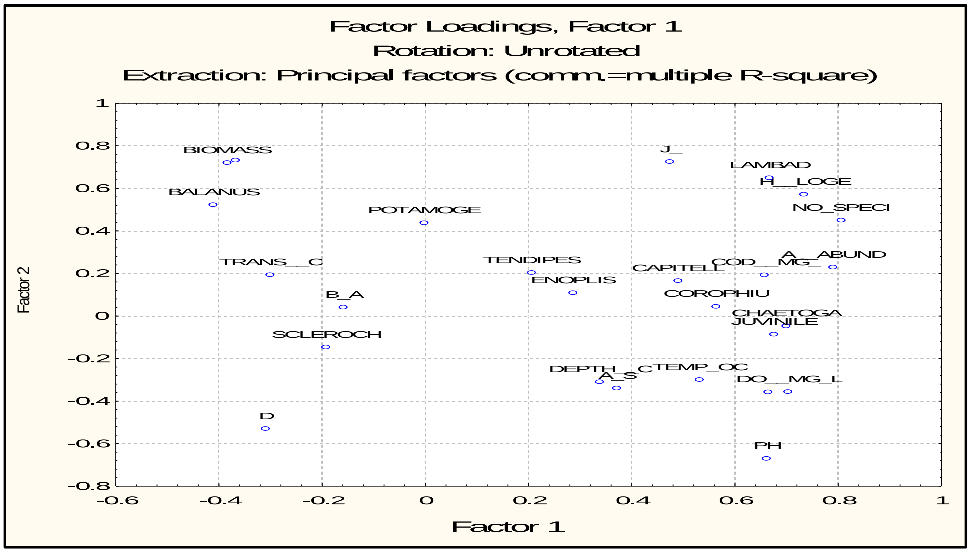

Fig. 7. Factor Loadings (Varimax normalized) Extraction: Principal factors (comm.= multiple R-square) (Marked loadings are > .700000).

Table 6. Factor Loadings (Varimax normalized) Extraction: Principal factors (comm.=multiple R-square) (Marked loadings are > .700000)

	Factor	Factor		Factor	Factor
	1	2		1	2
Potamogeton pectinatus	0.290353	-0.326989	Depth (cm)	0.045509	0.456242
Enoplus meridionalis	0.285868	0.110367	(cm)Trans	-0.095043	-0.343792
Chaetogaster limnaei	0.489916	0.502289	Temp	0.196865	0.577878
Capitella capitata	0.475692	0.203594	pH	0.046396	0.940794
Tendipes tentans	0.289663	-0.01366	Salinity ‰	0.214432	-0.790044
Sclerochilus contortus	-0.241093	-0.019056	Do (mg/l)	0.286451	0.734603
Corophium volutator	0.449746	0.342713	BOD (mg/l)	0.256557	0.709766
Balanus improvisus	0.042435	-0.663019	COD (mg/l)	0.618484	0.295149
Juviniles of bivalves	0.446078	0.515296	d richness	-0.58393	0.188531
(B) Biomass g/m2	0.194484	-0.792517	J`evenness	0.836999	-0.223764
(A) Abundance no.ind./m2	0.741694	0.356476	H` diversity	0.928469	0.063839
B/A	-0.091178	-0.136118	Simpson	0.929824	-0.03862
A/S	0.050363	0.501114	Expl.Var	5.984459	5.693111
S-pecies	0.900945	0.20268	Prp.Totl	0.230171	0.218966

Table 7. Correlations Casewise deletion of MD N=12

	POTA-MOGE	ENOP-LIS	CHAE-TOGA	CAPIT-ELL	TENDI-PES	SCLE-ROCa	CORO-PHIU	BALA-NUS	JUVI-NILE	BIO-MASS	A__ABUND	B_A	A_S	NO_SP-ECI
POTAMOGE	1.00													
ENOPLIS	-0.18	1.00												
CHAETOGA	-0.18	-0.20	1.00											
CAPITELL	-0.23	0.50	0.24	1.00										
TENDIPES	0.26	0.46	0.05	-0.29	1.00									
SCLEROCH	-0.05	0.64	-0.38	0.02	0.35	1.00								
COROPHIU	0.15	-0.25	0.56	0.05	-0.16	-0.33	1.00							
BALANUS	-0.17	-0.12	-0.18	-0.15	-0.07	-0.02	-0.22	1.00						
JUVENILE	-0.12	-0.13	0.61	0.32	-0.20	-0.51	0.44	-0.12	1.00					
BIOMASS	0.33	-0.21	-0.25	-0.26	0.07	-0.05	-0.13	0.88	-0.17	1.00				
A__ABUND	0.04	0.43	0.43	0.42	0.25	-0.06	0.47	-0.09	0.73	-0.05	1.00			
B_A	-0.12	-0.13	-0.14	0.15	-0.20	-0.51	-0.17	-0.12	-0.09	-0.18	-0.32	1.00		
A_S	0.14	0.01	0.11	-0.12	-0.01	0.22	0.43	-0.16	0.44	-0.07	0.47	-0.67	1.00	
NO_SPECI	0.10	0.33	0.52	0.60	0.12	-0.23	0.47	0.04	0.67	0.10	0.89	-0.22	0.28	1.00
DEPTH__C	-0.37	0.07	0.25	-0.10	0.03	-0.12	0.50	-0.09	0.36	-0.26	0.44	0.00	0.36	0.19
TRANS__C	-0.17	0.18	-0.13	0.10	0.05	0.38	-0.29	0.37	-0.63	0.27	-0.38	-0.13	-0.34	-0.17
TEMP_OC	-0.04	0.51	0.28	0.35	0.32	0.55	-0.01	-0.34	0.24	-0.34	0.42	-0.60	0.57	0.35
PH	-0.24	0.18	0.48	0.21	0.14	0.01	0.22	-0.70	0.46	-0.78	0.35	-0.13	0.47	0.22
SALINITY	0.40	0.06	-0.35	-0.06	0.07	0.17	-0.25	0.59	-0.21	0.76	0.03	-0.31	-0.18	0.12
DO__MG_L	-0.29	0.10	0.71	0.29	0.13	-0.14	0.35	-0.47	0.33	-0.58	0.27	-0.15	0.19	0.37
BOD__MG	-0.31	0.06	0.54	0.18	0.14	-0.36	0.24	-0.39	0.55	-0.52	0.35	0.07	0.22	0.37
COD__MG_	0.52	0.48	0.20	0.46	0.33	0.27	0.30	-0.44	0.25	-0.16	0.63	-0.34	0.44	0.64
D	-0.12	-0.13	-0.13	-0.17	-0.20	0.43	-0.16	-0.12	-0.09	-0.18	-0.31	-0.09	0.28	-0.52
J_	0.33	0.22	0.31	0.36	0.34	-0.36	0.33	0.04	0.15	0.21	0.43	0.33	-0.34	0.63
H__LOGE	0.23	0.25	0.64	0.48	0.33	-0.21	0.51	-0.02	0.37	0.11	0.64	-0.04	-0.04	0.83
LAMBAD	0.28	0.28	0.52	0.50	0.33	-0.23	0.44	0.01	0.31	0.16	0.61	0.08	-0.12	0.80

Continued…..

DEPTH_C	TRANS_C	TEMP_°C	pH	SALINITY	DO_MG_L	BOD_MG_	COD_MG_	D	J_	H_LOGE	LAMBAD
1.00											
-0.12	1.00										
-0.06	-0.02	1.00									
0.40	-0.25	0.66	1.00								
-0.52	0.15	-0.21	-0.80	1.00							
0.24	0.09	0.51	0.80	-0.64	1.00						
0.21	-0.41	0.37	0.73	-0.62	0.77	1.00					
-0.02	-0.09	0.66	0.40	0.00	0.30	0.13	1.00				
0.01	-0.13	0.25	0.12	-0.23	-0.27	-0.30	-0.11	1.00			
-0.07	-0.06	-0.15	-0.17	0.18	0.12	0.17	0.39	-0.64	1.00		
0.05	0.00	0.23	0.11	0.08	0.41	0.28	0.59	-0.49	0.86	1.00	
0.00	-0.01	0.14	0.01	0.13	0.29	0.21	0.59	-0.51	0.93	0.98	1.00

Table 8. Correlations Marked correlations are significant at p < .05000 N=12 (Casewise deletion of missing data)

	No. sp.	Depth Cm	Transp. Cm	Temp ^oC	pH	SALI-NITY	DO mg/l	BOD mg/l	COD mg/l	D	J_	H_LOG E	LAMBA D
POTAMOGE	0.1	-0.37	-0.17	-0.04	-0.24	0.4	-0.29	-0.31	0.52	-0.12	0.33	0.23	028
ENOPLIS	0.33	0.07	0.18	0.51	0.18	0.06	0.1	0.06	0.48	-0.13	0.22	0.25	028
CHAETOGA	0.52	0.25	-0.13	0.28	0.48	-0.35	0.71	0.54	0.2	-0.13	0.31	0.64	0.52
CAPITELL	0.6	-0.1	0.1	0.35	0.21	-0.06	0.29	0.18	0.46	-0.17	0.36	0.48	0.5
TENDIPES	0.12	0.03	0.05	0.32	0.14	0.07	0.13	0.14	0.33	-0.2	0.34	0.33	0.33
SCLEROCH	-0.23	-0.12	0.38	0.55	0.01	0.17	-0.14	-0.36	0.27	0.43	-0.36	-0.21	-0.23
COROPHIU	0.47	0.5	-0.29	-0.01	0.22	-0.25	0.35	0.24	0.3	-0.16	0.33	0.51	0.44
BALANUS	0.04	-0.09	0.37	-0.34	-0.7	0.59	-0.47	-0.39	-0.44	-0.12	0.04	-0.02	0.01
JUVENILE	0.67	0.36	-0.63	0.24	0.46	-0.21	0.33	0.55	0.25	-0.09	0.15	0.37	0.31
BIOMASS	0.1	-0.26	0.27	-0.34	-0.78	0.76	-0.58	-0.52	-0.16	-0.18	0.21	0.11	0.16
A__ABUND	0.89	0.44	-0.38	0.42	0.35	0.03	0.27	0.35	0.63	-0.31	0.43	0.64	0.61
B_A	-0.22	0	-0.13	-0.6	-0.13	-0.31	-0.15	0.07	-0.34	-0.09	0.33	-0.04	0.08
A_S	0.28	0.36	-0.34	0.57	0.47	-0.18	0.19	0.22	0.44	0.28	-0.34	-0.04	-0.12

1.5 Linear regression as shown in **Tables 7 & 8 and Fig. 7:**

Correlations Casewise deletion of MD N=12 <0.05

1) *Potamogeton pectinatus* shows weak positive correlation with abundance
2) Temperature indicates weak negative correlation with *Potamogeton pectinatus*
3) A/S ratio shows strong positive correlation with *Enoplus meridionalis*
4) *Potamogeton pectinatus* indicates strong positive correlation with *Capitella capitata*
5) A/S ratio shows strong negative correlation with *Tendipes tentans*
6) Depth indicates moderate positive correlation with *Tendipes tentans*
7) *Amphibalanus improvisus* shows strong negative correlation with *Sclerochilus contortus*
8) pH strong shows positive correlation with *Sclerochilus contortus*
9) Temperature indicates strong negative correlation with *Corophium volutator*
10) No. of species shows weak positive correlation with *Amphibalanus improvisus*
11) J` Palou's evenness shows weak positive correlation with *Amphibalanus improvisus*
12) H` diversity indicates strong negative correlation with *Amphibalanus improvisus*
13) Simpson value indicates strong positive correlation with *Amphibalanus improvisus*
14) Salinity shows moderate positive correlation with abundance
15) Depth indicates strong positive correlation with B/A ratio
16) H` diversity indicates weak negative correlation with B/A ratio
17) Simpson value shows strong positive correlation with depth
18) Temperature shows strong negative correlation with transparency
19) H` diversity indicates strong positive correlation with transparency
20) COD strong shows positive correlation with salinity

Table 9. Showing the sampling sites and the nature of bottom\sites at sampling sites in Lake Borollus drains during, 2017.

Drains	Nature of bottom
El Borollus drain	plant fragments
Nasser drain	plant fragments
Drain No.7	empty shells, plant fragments
Drain No.8	plant fragments
Drain No.9	empty shells
Hoksa drain	plant fragments
Bermbal drain	plant fragments

Part 2- Distribution of Macrobenthic Structure in the Lake Borollus Drains:

1- Nature of bottom sediments: Table 9 shows the nature of sediments, as noted, is mainly composed of organic sediments and remnants of water plants and pollutants from sanitation, agricultural and industrial, and limestone. The sediments consist mostly of organic matter, sludge calcareous empty shells, and plant fragments in addition to the remainder of sewage, agricultural and industrial waste. It was composed mainly of sludge at sites of El Borollus drain, Nasser drain, Drain No.7, Drain No.8, Drain No.9, Hoksa drain, and Bermbald Drain as shown in Fig. 1 these bottom samples sites were selected from many drains (61 major drains) poured directly into the lake especially.

- Water depths of the drains are shallow and not exceed 50 cm.
- Degree of transparency of water drains is low depth.

2-1 Hydro-chemical properties in Lake Borollus Drains: (EEAA, 2017) as shown in Table 11 & Fig. 2.

- Temperature of the water ranged from 26℃ to 30℃ with an average of 28.07 ℃.
- Depth of the water is low, ranging from 60 cm to 125 cm with an average of 99.58 cm.
- Water salinity (total dissolved salts in the drains water is in general ranged from 2.52‰ to 4.87 ‰to 3.61 with an average of 3.61‰.
- Hydrogen ions (pH) ranged from 7.87 to 8.78 attained an average of 8.39. It is located on the alkaline.
- Dissolved oxygen (DO) was regularly varying from low value of 2.6 (at site Borollus
- Drain El Borollus Drain) and 3.58 mg/l (at site Hoksa drain; it was moderate at sites Nasser Drain, Drain No.7 and Drain No.8 (ranged from 7.31, 7.8 and 8.6 mg/l) and it was high value at sites at Drain No.9 and Bermbal Drain reaching 18.4 and 13.81 mg/l, respectively.
- The biology oxygen demand Drain 8 (BOD) in the lake drains ranged from low amount 12 mg/l to 16.5 mg/l at site El Borollus Drain, Hoksa Drain, and Bermbal Drain as the effect of pollution and has moderate at site Nasser Drain (24 mg/l), Drain No.7 (24 mg/l), and Drain No.9 (25.5 mg/l) with an average of 18.64.

4.2 Structure of Benthos in Lake Borollus Drains species number of benthos

4.2.1 Specie number (S): The structure of species number of benthos groups at the different sites (as shown in Table 4 and Figure were represented by 10 species were relatively low namely each group was represented by two species at Nasser Drain; 3 species at El Borollus Drain; 4 species at site drain No.7 and drain No.9; 5 species at sites drain 8 and Hoksa drain and 6 species at site Bermbal drain.

4.2.2 Regional Distribution of Macrobenthos Constituents

4.2.2.1 Abundance of benthic communities (A): As shown in Table 10, and illustrated graphically in Fig. 8 emphasized that the data analysis of the average attaining respectively annual average of 3045 ind/m2 (15.12% at El Borollus drain), 3087 ind/m^2 (15.33% at Drain 7), 4053 ind/m^2 (20.13% at Drain No.8), and 3465 ind/m^2ind/m^2 (17.21% at Drain No.9) of the total annual average of 2877 ind/m2) whereas, at the rest sites the average abundance of benthos varied from 861 ind/m^2 (4.28% at site Nasser Drain), 2982 ind/m^2 (14.81% at Hoksa Drain) and 2646 (13.14 % at Brembal Drain). This may be related to the water quality (Table 10 and Figure 8) due to the increase of water quality values of 735 and 945 ind/m^2.

Table 10. List of benthic assemblage recorded at different sampling in Drains of the Lake Borollus during 2017.

Groups	Species	Groups	Species	Groups	Species
Vascular plants	*Potamogeton pectinatus*	Gastropoda	*Melanoides tuberculata* **	Bivalves	*Mytilus galloprovincialis*
Nematoda	*Enoplus meridionalis*		*Pirenella conica***		*Cerastoderma edule*
Oligochaeta	*Chaetogaster linnaei*		*Bellamya unicolor***		*Donax* sp.**
Polychaeta	*Capitella capitata*		*Theodoxus niloticus***		
	Calcareous tube worms**		*Lymnaea natalensis***		
Insecta larvae	*Tendipes tentans*		*Planorbis planorbis***		
Ostracoda	*Sclerochilus contortus*		*Cleopatra bulimoides***		
Amphipoda	*Corophium volutator*		*Physella acuta***		
Barnacles	*Amphibalanus improvisus*		*Bulinus truncatus*		
			*Helisoma duryi***		
			Lanistes carinatus **		
			*Hydrobia ventrosa***		
			Corbicula consobrina		
			*Pisidium pirothi***		

Empt shells **

Table 11. Abundance of the annual averages (no. ind/m^2) and relative abundance (%) of the main groups of benthic species recorded in bottom sediments collected from Lake Borollus drains during 2017.

Abundance 2017	no.ind./m^2	El Borollus Drain	Nasser Drain	Drain No.7	Drain No.8	Drain No.9	Hoksa drain	Bermbal Drain	Ave	%
Vascular plants	***Potamogeton pectinatus***	0	0	0	0	0	0	840	120	4.2
Nematoda	***Enoplus meridionalis***	0	0	147	441	693	441	126	264	9.2
Oligochaeta	***Chaetogaster linnaei***	0	0	420	945	525	714	0	372	12.9
Polychaeta	***Capitella capitata***	0	525	882	861	882	504	0	522	18.1
Insecta larvae	***Tendipes tentans***	777	0	0	798	0	588	399	366	12.7
Ostracoda	***Sclerochilus contortus***	1575	0	1638	1008	1365	735	945	1038	36.1
Amphipoda	***Corophium volutator***	693	336	0	0	0	0	0	147	5.1
Bivalves	***Corbicula consobrina***	0	0	0	0	0	0	210	30	1.0
	Mytilus galloprovincialis	0	0	0	0	0	0	126	18	0.6
	Abundance no.ind./m2	3045	861	3087	4053	3465	2982	2646	2877	100
	%	15.12	4.28	15.33	2013	17.21	14.81	13.14		
	No species	3	2	4	5	4	5	6		

Continued……..

Biomass 2017	**Species**	**El Borollus Drain**	**Nasser Drain**	**Drain No.7**	**Drain No.8**	**Drain No.9**	**Hoksa drain**	**Bermbal Drain**	**Ave**	**%**
Vascular plants	***Potamogeton pectinatus***	0	0	0	0	0	0	329	47.1	45.2
Nematoda	***Enoplus meridionalis***	0	0	0.04	0.13	0.2	0.13	0.04	0.08	0.07
Oligochaeta	***Chaetogaster linnaei***	0	0	0.55	1.23	0.71	0.92	0	0.49	0.47
Polychaeta	***Capitella capitata***	0	0.64	1.08	1.05	1.08	0.61	0	0.64	0.61
Insecta larvae	***Tendipes tentans***	3.89	0	0	3.32	0	2.83	2	1.72	1.65
Ostracoda	***Sclerochilus contortus***	0.01	0	0.01	0.01	0.01	0.01	0	0.01	0.01
Amphipoda	***Corophium volutator***	5.49	2.78	0	0	0	0	0	1.18	1.14
Bivalves	***Corbicula consobrina***	0	0	0	0	0	0	205	29.3	28.1
	Mytilus galloprovincialis	0	0	0	0	0	0	165	23.6	22.7
	Biomass g/m^2	9.4	3.4	1.7	5.7	2	4.5	701	104	100
	%	1.3	0.5	0.2	0.8	0.3	0.6	96.3		
	No species	3	3	3	5	4	5	5		

Continued…….

Water quality	Stations	El Borollus Drain	Nasser Drain	Drain No.7	Drain No.8	Drain No.9	Hoksa drain	Bermbal Drain	Ave
	Temp ^{o}C	26	28.5	29.5	28.5	30	26	28	28.07
	pH	7.87	8.05	8.5	8.43	8.78	8.66	8.44	8.39
	Salinity ‰	5.4	3.2	3.07	2.52	3.57	2.66	4.87	3.61
	DO mg/1	2.6	7.31	7.8	8.61	18.04	3.58	13.81	8.82
	BOD mg/1	12	24	24	15	25.5	13.5	16.5	18.64
	Stations	**El Borollus Drain**	**Nasser Drain**	**Drain No.7**	**Drain No.8**	**Drain No.9**	**Hoksa drain**	**Bermbal Drain**	**Ave**
	Abundance	3045	861	3087	4053	3465	2982	2646	
	Biomass g/m^2	9.4	3.4	1.7	5.7	2	4.5	701	104
	Species no.	3	2	4	5	4	5	6	
	d	0.249	0.148	0.373	0.482	0.368	0.5	0.634	
	J'	0.934	0.965	0.801	0.979	0.954	0.988	0.842	
	H'	1.026	0.669	1.111	1.576	1.323	1.591	1.508	
	Simpson	0.616	0.476	0.616	0.788	0.717	0.793	0.738	

Where: d (Richness) Margalef`s index = (S-1) / log N -- J'(Evenness) Pielou`s index = H` / Hmax-- H` (Shannon and Wiener index) species diversity = - ∑ Pi log Pi
Simpson index D = 1 - ∑ (Pi)2 --- S = No. of species A = abundance no. ind. / m^2 B = Biomass g/m^2

- Ostracoda (*Sclerochilus contortus*) benthic meiofauna composed the main constituent representing 1st highest abundant (1038 ind/m^2, representing 36% of the total annual average of 2877 ind/m^2) which recorded at the most sampling sites of the lake drains and living among the sand bottom sediments particular predominated at the Drain No.7 reached 1638 ind/m^2 and at the El Borollus Drain attaining annual average of 1575 ind/m^2, 1008 ind/m^2 at Drain 8 and 1365 ind/m2 at Drain 8. It was not recorded at Nasser Drain whereas, and at the rest sites Haska Drain and Bermbal Drain its abundance varied from 735 and 945 ind/m^2.

- The 2nd is the class Polychaeta *Capitella capitata* was the highest abundance rather which was recorded at the most sampling sites at the drains of Borollus averaging to 522 ind/m^2, representing 18.1% and recorded at the most sites except El Borollus drain and Bermbal drain. Its density fluctuated between 882 ind/m2 and 504 ind/m^2, it is generally expressed as a biological indicator for pollution areas that can tolerate the concentration of non-treatment deranged waste products.

- The 3rd group were represented by Phylum Annelida, Subclass Oligochaeta, *Chaetogaster limnaei* which represented respectively by 420, 945 ind/m^2, 525 ind/m^2 and 714 ind/m^2 at the Drain No.7, Drain No.8, and Drain No.9. In fauna Oligochaeta can tolerate the increase of polluted sediment and represent an indicator of pollution species recorded at areas suffering from increase in the level of pollution. It was recorded at the most sampling sites at the drains of Lake Borollus averaging to 372 ind/m^2, representing 12.9% of the total abundance of the annual average estimated Borollus drains in present work of 2877 ind/m^2.

- The 4th group of phylum Insecta larvae is represented by *Tendipes tentans* showed increase in the density of individual numbers in which lived on bottom sediment or floating on water surface as pupa of insect was estimated by an annual average of 366 ind/m2, representing 12.7% of the total abundance of the annual average 9.2 % (2877 ind/m^2). It was recorded in the most sites except at site Nasser Drain, Drain 7, and Drain 9 attaining of the annual average representing by12.7%.

- The 5th Nematoda *Enoplus meridionalis* was estimated by an annual average of 264 ind/m^2

attaining percentage of 9.2% it was not recorded at site El Borollus Drain and Nasser Drain which at rest sites representing by 126 ind/m^2 to 693 ind/m^2.

- The 6th Amphipoda *Corophium volutator* was estimated by an annual average of 147 ind/m^2, representing 5.1% were presented only at sites El Borollus and Nasser Drain attaining 693 ind/m2 and 336 ind/m^2.

The 7th Vascular plant *Potamogeton pectinatus* was estimated by an annual average of 120 ind/m2, representing 4.2% were recorded only at site Bermbal Drain.

- The 8th Bivalves were represented by two species *Corbicula consobrina* and *Mytilus galloprovincialis* whereas, they were estimated by an annual average of 30 ind/m^2 and 18 ind/m^2 representing 1.0% (210 ind/m^2) and 0.6% (126 ind/m^2), respectively, and were recorded only at site Bermbal Drain reached.

These variations in the constituents of bottom structure of the density and biomass related due to the impact of chemical properties on the sediments and water quality affection of components of benthic organisms and the tolerance of species to these changes in the nature of benthic sediments resulting from pollutants dumped in the lake from sources of pollution from agricultural, sanitation, agricultural and industrial, limestone health and fish farming.

4.2.2.2 Annual abundance (no. ind/m2) of benthic groups constituents: Ostracoda *Sclerochilus contortus* 1038 ind/m2 (36.1%) >Polychaete*Capitella capitata* 522 ind/m2 (18.1%) > Oligochaeta *Chaetogaster limnaei*372 ind/m2 (12.9%) > Insects larvae *Tendipes tentans* 366 ind/m2 (12.7%) > Nematoda Enopleameridionalis 264 ind/m2 (9.2%) > Amphipoda *Corophium volutator*147 ind/m2 (5.1%) > Vascular plants *Potamogeton pectinatus* 120 tufts/m2 (4.2%) > Bivalves *Corbicula consobrina* 30 ind/m2 (1.0%) >*Mytilus galloprovincialis* 18 ind/m2 (0.6%).

- Regional annual abundance (no. ind/m2) of benthic groups constituents: Drain No.8- 4053 ind (20.13%) > Drain No.9- 4053 ind/m2 (17.21%) Drain No.9 - 3465 ind/m2 (17.21%) > Drain No.7- 3087 ind/m2 (15.33%) > El Borollus Drain- 3045 ind/m2 (15.12%) >Hoksa Drain 2982 ind/m2 (14.81%) >Bermbal Drain 2646 ind/m2 (13.14%) > Nasser Drain 861 ind/m2 (4.28%).

- Annual biomass of benthos (wet weight g/m2): As shown in Table 10 and Fig. 8 the average annual of the benthic biomass (wet weight g/m2) species estimated at different Borollus drains attaining Vascular plants *Potamogeton pectinatus* attaining the maximal biomass of 47.1 g/m2which corresponding to 45.2% of the total annual average (104 g/m2), Bivalves *Corbicula consobrina* attaining the biomass of 29.3 g/m2(28.1%) and *Mytilus galloprovincialis* attained biomass of 23.6 g/m2(22.7%) whereas, the rest benthic groups on the other side reaching low percentage (0.07% to 1.65%) and biomass (0.01 – 1.72 g/m2).

- The annual benthic biomass at the different drains was estimated at an average weight of 701 g/m2 Bermbal Drain representing by 96.3% of the total annual of the benthic biomass attained 104 g/m2 and the biomass was followed by relatively low density with wet weight of 0.6% to 9.4% and biomass of 0.2 g/m2 to 1.3 g/m2.

5 - Diversity Indices (as shown in Table 11 & 12 and Fig. 8): Diversity indices served as an indication of community health on area scales. It can be measured using several indices as Magurran (2004), Goodall (1973), Magurran and McGill (2011) El-Komi (2017b). Also, DIVERSE-Univariate diversity indices can use PRIMER 5 (Plymouth Routines in Multivariate Ecological Research). Margalef's species Richness, Pielou's Evenness index, Shannon-Weaver species diversity, and Simpson's diversity index will apply in this study.

5.1 Margalef's species richness (d):

d (Richness) Margalef's index = (S-1) / log N: Species richness refers to the total number of different species present (without taking into account) the proportion and distribution of each species) within the sample. Table 12 indicates the calculated values species richness (d) were low of species richness of values less than one at all sites ranging from 0.148 to 0.500.

5.2 Pielou's evenness (J'): J'(Evenness) Pielou's index = H` / Hma: Pielou's evenness is used as the ratio of the expected number of species against the recorded number of species as an index of evenness. According to the assumption that all species accounted for in the sample. The higher value of the attaining values of is ranged from 0.842 to 0.988 at all sites. The evenness measure is a ratio of the observed diversity to the maximum possible in a sample having the same number of species, meaning the more evenly individuals spread among the species.

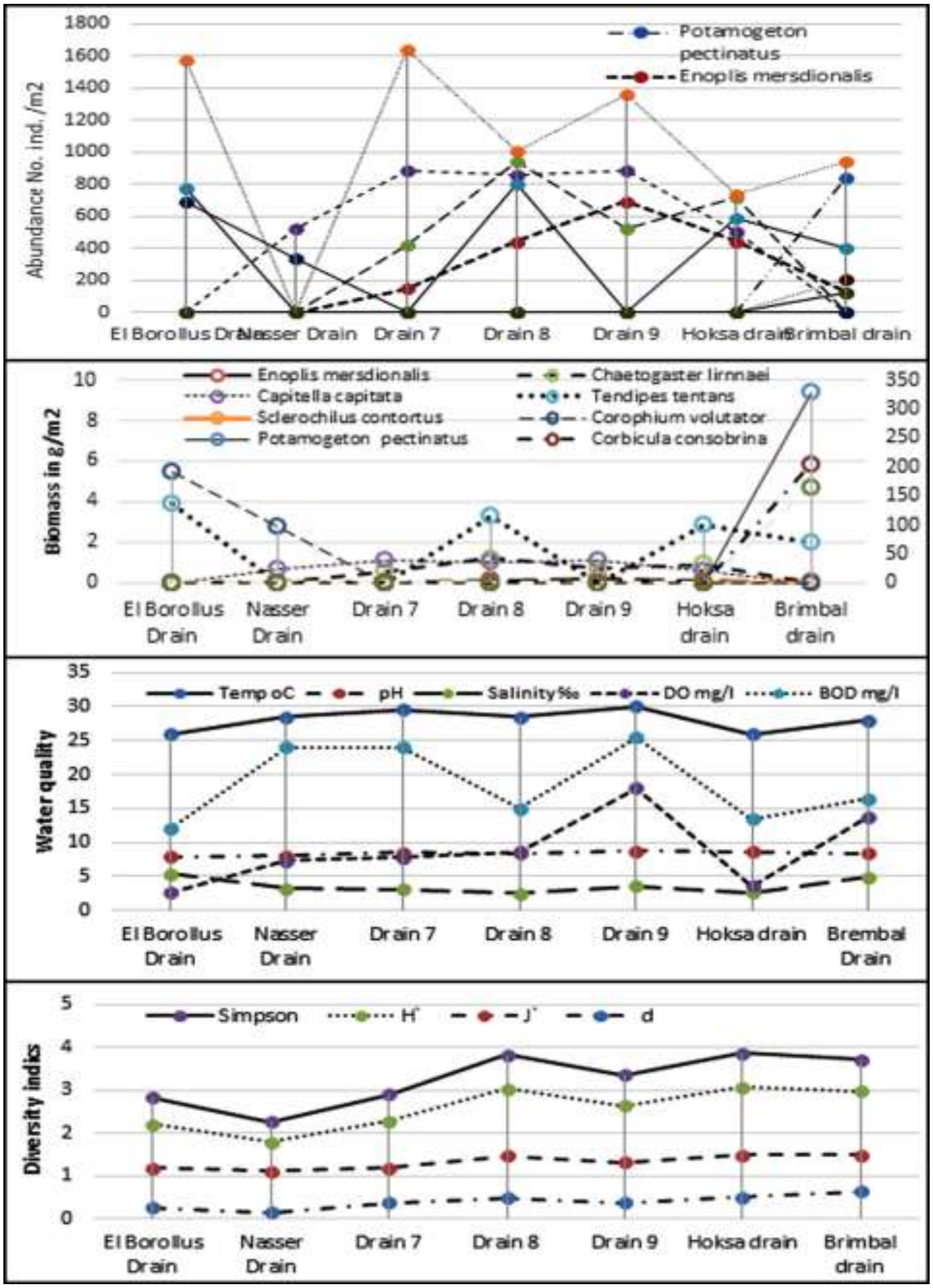

Fig. 8. Regional changes: A- Benthos structure; B- Chemical parameters and C- Diversity indices were calculated for benthic constituents at the study sampling sites in drains of Lake Borollus during 2017.

**5.3 Shannon-Weaver's diversity index (H`):** H` (Shannon and Weaver index) species diversity = - ∑ Pi ln Pi

The Shannon-Weaver diversity index refers to the state of an assemblage per the species richness and species abundance. The estimated values attained less than one at Nasser drain (0.669) and at the rest sites were moderate diver's values of 1.026 (El Borollus Drain) to 1.591 (Hoksa Drain).

5.4 Simpson's diversity index (D): Simpson's diversity indexes aimed to measure and determine the degree of concentration of species classes. Simpson's diversity values as the index at the different sites ranging from the low value of 0.616 to 0.793. So that provides an intuitive proportional measure of diversity that is much less sensitive to species richness.

Table 12. Yearly annual averages of abundance (no.ind/m2), biomass (wet weight in g/m2) and the number of species recorded in benthos groups in bottom sediments collected from Lake Borollus drains during 2017.

stations	species no.	abundance	d	J`	H`	Simpson
El Borollus Drain	3	3045	0.249	0.934	1.026	0.616
NasserDrain	2	861	0.148	0.965	0.669	0.476
DrainNo.7	4	3087	0.373	0.801	1.111	0.616
Drain No.8	5	4053	0.482	0.979	1.576	0.788
Drain No.9	4	3465	0.368	0.954	1.323	0.717
Hoksadrain	5	2982	0.5	0.988	1.591	0.793
Bermbal drain	6	2646	0.634	0.842	1.508	0.738

Where: d (Richness) Margalef`s index = (S-1) / log N – J'(Evenness) Pielou`s index = H` / Hmax
H` (Shannon and Wiener index) species diversity = - ∑ Pi ln Pi Simpson index D = 1 - ∑ (Pi)2
S = No. of species A = abundance no. ind/m2 B = Biomass g/m2

DISCUSSION: Lake Borollus is the 2nd largest natural lake in Egypt connected to the Mediterranean Sea through the BorollusBoughaz inlet and the River Nile by the Permbal Canal. It is a shallow lake that reaches a depth of about one metre. The main aim of this study is to evaluate the ecology of the benthic assemblages and knowledge of the relationship between the types and aggregates of benthic as main source food especially fish and economic crustaceans. Sediments in some areas consist of organic materials (sludge) is composed of waste sewage and agricultural and industrial and others of sandy silt (silt), calcareous shells are mainly of molluscs and therefore it can determine some environments prevailing in the lake. Results indicate for examining configuration qualitative benthic macro during the study period were recorded 27 species, including 9 species of living benthic macro organisms include one type of aquatic submerged vascular plants of species *Potamogeton pectinatus*. Owing to improve and conservation the biodiversity of the aquatic environments and increasing the fish production quantity and quality. The state aims to increase fish production wealth by increasing fish farming projects. Especially in the lakes north of the Nile Delta connected to the Mediterranean

Sea (Mariot – Edku - Borollus – Manzala - Bardawil). This is to increase self-sufficiency and encourage the establishment of modern model fisheries farms that rely on deep well water after conducting an analysis of water quality, the appropriate degree of salinity, salts and the quality of the soil suitable for fish farming. In addition to studying the validity of these areas for agriculture that suits him with logic around lakes, and increasing the agricultural area which needs a lot of labor.

Lake Borollus is separated from the sea by a broad, dune-covered sandbar, which varies in width from a few hundred meters in the east to 5 km in the west. There are some 50 islands scattered throughout the lake with a total area of 0.7 km². On average, 50–70 million m³ of slightly saline, nutrient-rich water enters the lake annually from the south via six drains. Bughaz El Borollus, located in the north-east corner of the lake, is the only direct connection between Borollus and the Mediterranean. Salinity in the lake decreases towards the south and west as the distance from the Boughaz increases, becoming fresh near the outflows of drains and canals that flow into the lake from the south. Consequently, the north shores of the lake are dominated by salt marshes and mudflats, while the southern shore is bordered by an extensive fringe of reed-swamps (mainly Phragmites and Typha), which currently covers more than 25% of the lake area. Lake Borollus has abundant submerged vegetation, dominated by Potamogeton, which is densest in the southern portion of the lake. Borollus is by far the least disturbed and damaged of the delta wetlands and its environs still retain some aspects of wilderness, which have been lost throughout most of the delta. The concentrations of some heavy metals (Fe, Mn, Zn, Cu, Pb and Cd) in water of the largest Delta wetlands (Lake Manzala; north of Egypt), in relation to some water quality characteristics were investigated. The obtained results declared that the agricultural and domestic sewage drained into the lake from urban and rural lands have an adverse effect on water quality characteristics of the lake. According to Ali (2008) the contamination of natural environment components such as soil, sediment, water and biota by heavy metals is a major, the concentrations of Zn, Cd, Cu, Mn and Pb in water and bottom sediments of the Eastern Lake Manzala indicated that the sediments and water an ultimate sink for heavy metals in the aquatic system. The contaminated water body with heavy metals greatly affected the lake food, organisms, and hence, humans. On the side, Elshemy and Khadr (2015) considered Lake Borollu’s is the most important coastal lake in Egypt, as supporting high amounts of fish yield in Egypt which it is considered as a vulnerable lake, since it is subjected to significant environmental changes caused by various anthropogenic activities.

Lake Borollus is considered an important coastal lake in Egypt, and produces a high fish production in spite of being subjected to significant environmental changes caused by various anthropogenic activities and increase in deterioration of its water quality status (Mohsen *et al.*, 2021). Benthos is an important its lies in the position as then 2nd producer in the food web whereas any change in the benthos structure and constituent is reflected on the growth and production of fish and these assemblages of benthic can be used as a good indicator for monitoring which can help in management and conservation of the lake water (Fishar and Abdel-Gawad, 2009). As cited by Abdel Gawad, (1993) water temperature degrees of water lake have a direct effect on aquatic organisms and indirect effect through its influence on other environmental factors such as solubility of gases including oxygen. The lowest benthic density of macrobenthic invertebrates was recorded in summer and the highest one was recorded in winter. Hammerton, (1972) and Payne, (1986) reported that changes in the water temperature can be effective in completely inhibiting the normal growth and spawning activities of some organisms. Insects chironomid larvae disappeared during summer, spring, autumn. This may be due to the increase of water temperature which accelerates the development of larval stages, difference in salinity of water as recorded in the sampling study sites influenced on spatial and temporal benthic constituent of some species such as

- The 2nd is the class Polychaeta *Capitella capitata* was the highest abundance rather which was recorded at the most sampling sites at the drains of Borollus averaging to 522 ind/m^2, representing 18.1% and recorded at the most sites except El Borollus drain and Bermbal drain. Its density fluctuated between 882 ind/m2 and 504 ind/m^2, it is generally expressed as a biological indicator for pollution areas that can tolerate the concentration of non-treatment deranged waste products.

- The 3rd group were represented by Phylum Annelida, Subclass Oligochaeta, *Chaetogaster limnaei* which represented respectively by 420, 945 ind/m^2, 525 ind/m^2 and 714 ind/m^2 at the Drain No.7, Drain No.8, and Drain No.9. Infauna Oligochaeta can tolerate the increase of polluted sediment and represent an indicator of pollution species recorded at areas suffering from increase in the level of pollution. It was recorded at the most sampling sites at the drains of Lake Borollus averaging to 372 ind/m2, representing 12.9% of the total abundance of the annual average estimated Borollus drains in present work of 2877 ind/m^2.

- The 4th group of phylum Insecta larvae is represented by *Tendipes tentans* showed increase in the density of individual numbers in which lived on bottom sediment or floating on water surface as pupa of insect was estimated by an annual average of 366 ind/m2, representing 12.7% of the total abundance of the annual average 9.2 % (2877 ind/m^2). It was recorded in the most sites except at site Nasser Drain, Drain 7, and Drain 9 attaining of the annual average representing by12.7%

- The 5th Nematoda *Enoplus meridionalis* was estimated by an annual average of 264 ind/m^2 attaining percentage of 9.2% it was not recorded at site El Borollus Drain and Nasser Drain which at rest sites representing by 126 ind/m^2 to 693 ind/m^2.

- The 6th Amphipoda *Corophium volutator* was estimated by an annual average of 147 ind/m^2, representing 5.1% were presented only at sites El Borollus and Nasser Drain attaining 693 ind/m2 and 336 ind/m^2.

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Chaetogaster limnaei which is a freshwater oligochaete that were recorded in sites, where salinity was too low (between 2.81 and 4.05 g /l). This agrees in the present study and agrees with Khalil (1990), Ahmed (1991), and El-Komi (2015, 2016, 2017a, d, 2019 and 2021) and who stated the diversity and distribution of organisms in Manzala Lake are largely determined by salinity and reported also that the mean abundance of benthic fauna ranged from 1494 to 2820 organisms/m2. Coull, (2009) mentioned meiobenthic invertebrate's (Ostracoda, *Sclerochilus contortus*) community plays an important role in the lake's food web. It serves as food for a variety of higher trophic levels and its high sensitivity to anthropogenic inputs making them excellent monitors for the study of pollution. Ostracoda in the present study Ostracoda, *Sclerochilus contortus* showing its abundance at all sites of lake stations (attaint an annual average abundance of 1452 ind/m2, representing 60% of annual abundance of 2441 ind/m2) and in drain sampling sites reaching 1038 ind/m2 representing by 36% of annual abundance of 2877 ind/m2 sites increased in the summer sampling sites as was recorded by Rudnick *et al.,* (1985), Smol *et al.,* (1994), Abdel Gawad (2001 and 2007).

During the previous 50 years many scientific studies were carried out in lake Borollus mainly on hydrodynamic-ecological model analyses of the water quality (Rasmussen *et al.*, 2009); on heavy metals pollution in water and sediments northern delta lakes, Egypt; on the environmental assessment of the spatial distribution of zooplankton and on algal diversity of the Mediterranean lakes (Khairy, *et al.* 2015); the properties of the ecosystem variables changes are the reliable forecast on qualities of ecosystem functions (Suding *et al.*, 2008). The physicochemical properties (Elmorsi *et al.*, 2017); Dynamics is due to the consequent changes in the interactions between species functions (Garnier *et al*., 2004) will affect the community change ecosystem processes through changes in the representation of the ecosystem impact qualities (Diaz *et al.*, 2004; Kremen, 2005). Khairy *et al.*, (2015) noted that the diversity of species in the five lakes can be arranged as follows: Manzala (383 spp.) >Mariut (376 spp.) >Bardawil (333 spp.) >Borollus (247 spp.) >Edku (183 spp.). The species diversity of the five lakes can be arranged descending as follows: Manzala (383 spp.) >Mariut (376 spp.) >Bardawil (333 spp.) >Borollus (247 spp.) >Edku (183 spp.). The highest number of unique species was recorded in Bardawil (208 spp.) followed by Manzala (128 spp.), then Mariut (85 spp.), Borollus (76 spp.) and Edku (6 spp.).

Natural and anthropogenic is considered another factor affecting disturbance and influence on the disturbances of the system's stability particularly in closed and semi enclosed environments as in lagoons. These reflected the variable of the benthic organism's distributions. According to Raffaelli and Hawkins (1996) anthropogenic stresses are superimposed on stresses caused by natural environmental factors and the aquatic biodiversity changes may be directly resulted from habitat structure, pollution, exploitation, or indirectly through climate change and related bio-geochemistry changes. Stress can be any factor that negatively affects the physiology, growth, reproduction, and survival of an organism or that has consequences affecting populations or communities (Shiel, 2009).

Stress at one level of organization (e.g. individual, population) may also have an impact on other levels, for example, causing alterations in community structure. Therefore, it may be detected the effects of anthropogenic stress at the low level of taxa, and impacts are more often investigated at a population or community level (Crowe *et al.*, 2000). There is little doubt that anthropogenic disturbance has extensively altered the global environment, leading to a decrease in biodiversity. In Lake Borollus 1st annual average wet weight was the order cirripedia *Amphibalanus improvisus* attaining the highest weights of 88.1 g/m2, 64.3% whereas, it was recorded only at sites B2 (1216 g/m^2) and at site B3 (4255 g/m^2) at the eastern sector. The 2nd annual average wet weight was the submerged vegetation plants (*Potamogeton pectinatus*) reached an average density of 24.8 g/m^2, representing 33.1% of the average annual biomass. It was recorded only at site B4 attaining 2051 g/m^{2}and at site B8 sustained 92.4 g/m2. Whereas, the abundance of macro benthos organisms at different sampling sites in the lake can be arranged in the following sequence: Ostracoda (crustaceans) 60% > Juvenile of bivalves 9.0% >Capitellidae (polychaetes) 7.7% > insect larvae 5.4% > Nematoda *Enoplea meridionalis* 4.6 > Vascular plants *Potamogeton pectinatus* 4.4% >*Corophium volutator* (crustaceans) 4.2% > Barnacles *Amphibalanus improvisus* 2.7% > oligochaetes *Chaetogaster limnaei* 2.3% of the total numerical abundance of benthos, was estimated by 2441 ind/m^2. Whereas, the results of macrobenthic assemblages in Lake Borollus indicate an average annual stocking 2441 ind/m^2 density is in terms of numerical density and the number of species is relatively small compared with previous studies of the lake during the successive monitoring yearly studies from 2010 to 2017 (El-Komi 2015, 16, 2017a, c, d). Numerical density is relatively higher than in Lake Manzala (El-Komi 2021) where the annual average numerical density ranged between 525 to1827 ind/m^2 and a percentage between 2.4%-8.4% of annual stocking average of 1968 ind/m^2. The occurrence of the bottom living organisms of both the infauna and epifauna providing well information about the feeding habits of other members of living organisms as a food source for fishes in particular, and to enlarge our knowledge of trophic interaction in the lake. The data analyses of their species composition, density abundance, and biomass will be compared with the available parameters of the water quality and the sediment structure. It is obvious, the increase in fresh water of irrigation water of agriculture affects directly on the water quality of the lake and consistently became a constant evacuation to the Mediterranean Sea and nearly freshwater fish replaced by marine fish species. Also, the increasing land areas of the Nile Delta lead to increase the rate of nutrients that are discharged into the lake leading to eutrophication and hyper-trophication due to the low residence time of lake water budges. It is obvious to the increasing sediment layer of mud deposited into the sea leading to erosion continuing and consuming the sand bar that separates the lake from the sea. El-Komi, (2021) reported that some Physic-chemical parameters are affected by the increase in nitrogen concentrations of mineral salts (in Lake Manzala) and generally on the benthic flora and fauna in particular fisheries and temperature variation is a clear factor affecting the aquatic distribution in terms of qualitative and qualitative of the number of dominant species and numerical density and quantity and seasonally in the study areas of the lagoon for its location in the moderate tropical region. Hydrogen ion pH concentration is known as and as important factor affecting the aquatic environment where participation in all dynamic processes within aquatic surveys focus also it has an important role in precipitation or melting metals in-water surveys. The results in Lake Borollus showed it located on the alkaline side where the average concentration values ranged between 8.28-9, 0 and an average of 8.72 and it is located in alkanes. Also, the sediments nature occurred as mud (silt and clay), sludge materials that recorded in high concentration in the bottom sediments that collected from the different study sites in the sampling sites in the lake and its drains. The area of study is exposed to the entrance of freshwater or drainage untreated water from different polluted drainage from the human sewage, agriculture drainage, fish farming, and industrial waste material. From a public health point of view with the result especially when applying international mentions of water quality found that at all stations located within the limits.

CONCLUSION AND RECOMMENDATIONS

From the previously mentioned discussion, based on the results of biological investigation and water quality index and using diversity indices and benthos distribution at the different sampling sites, we can conclude that: Biological monitoring revealed that Lake Borollus drains and western sector included the main sources of pollution leading to a decrease in density and number of species despite the eastern sector located around its connection of El Boughaz to the Mediterranean Sea. The frequent presence of the families such as Ostracoda, Polychaetes, Oligochaetes and aquatic submerged are bio-indicators of moderate and good water quality. They are the most resistant species to pollution and the recommendation is the necessity of the continuous monitoring of any ecosystem and following up its status at a period, which should be repeated over time. Biological monitoring revealed that the western bank included the main sources of pollution leading to a decrease in density and number of species. The frequent presence of the families such as Neritidae and Unionidae are bio-indicators of moderate and good water quality. Studying water quality parameters and calculation WQI revealed that surface water quality was in a medium status and the eastern bank was better than the western bank of Damietta branch of the River Nile. (ii) Investigation of the macro-benthic community in the Damietta region revealed that pollutants and surface water quality affect their biodiversity, especially in the eastern bank. The mean values of most measured parameters of the water quality were within the threshold limits in comparison for the EESR. Constant ecological and hydrological monitoring using WQI is needed to record any alteration in the quality and outbreak of health disorders. Discharging of irrigation effluents must be limited leading to better remediation of this important ecosystem. We recommended the necessity of the continuous and regular monitoring of any ecosystem and follow up its status at a period of time. And it is important to maintain pollution levels within the permissible values. Environmental quality control should be enforced to prevent or decrease the entrance of wastewater from agricultural, domestic, industrial, or other sources to the Northern Delta Lakes System that it is essential to approve critical sources in the lakes and maintain pollution levels within the permissible values so the biodiversity of macro-invertebrate can be monitor and reflect the surface water quality. The present study stated that the ecological status of surface water quality along the lake region was in a medium status of water quality based on both WQI and diversity indices of macro-invertebrates which reflected the actual conditions of the water quality.

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