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Qualitative and Quantitative Variability of Flora and Fauna along Rosetta Branch of the River Nile, Egypt

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ABSTRACT

During the last decades, the Rosetta branch of the River Nile received a great number of drainage wastes (domestic, agricultural, and industrial) that affected different aquatic organism's life. Accordingly, characterizing the biological aspects of this water body is necessary. The current study aims to survey the biodiversity of flora and fauna along the Rosetta branch to assess the environmental status of this area. Eight sites were selected along the Rosetta branch during 2018 for samples collection. Results indicated the presence of seven macrophyte species, dominated by the free-floating and emergent species *Eichhornia crassipes* and *Echinochloa stagnina*, respectively. Bacillariophyceae had the highest number of species compared with other groups of attached algae and occupied the first and the greatest predominance position. Epiphytic microinvertebrates associated with the floating plant *Eichhornia crassipes* recorded the highest numbers of species and groups during summer and the diversity was affected by the heavy load of pollution discharged to the Nile (especially at El-Rahawy region). Five groups of zooplankton (Rotifera, Copepoda, Cladocera, Meroplankton, and Protozoa) were documented and identified based on their morphological characters. High numbers of bacterial indicators of pollution exceeding the permissible limits were obtained, inferring the harmful effects of drains discharge on the water quality at the Rosetta branch. Physico-chemical parameters showed a great correlation between different biological aspects. The current study confirmed the effects of environmental factors on surveyed aquatic organisms, which could be used as a guide for evaluating water quality in the evaluated area.

INTRODUCTION

Nile River is the lifeline supplying water to millions of people. It extends into the Mediterranean Sea by its two main branches, the Rosetta and the Damietta, which are flowing through the Nile delta wetland **(Badr *et al.*, 2006)**. The Rosetta branch is receiving wastes discharged by agricultural, industrial, and domestic activities. A total of two pollution sources affecting the water quality at the Rosetta branch, firstly are the

agricultural drains such as (El-Rahawy, Sabal, El-Tahreer, Tala, and Zawiet El-Bahr drains) and secondly are the direct continuous discharge of industrial wastes into the Rosetta branch. Therefore, it is important to make regular monitoring programs for the Rosetta branch **(Donia, 2005).**

Aquatic macrophytes are aquatic plants that remove toxic compounds from water and provide aquatic organisms with food, shelter, and substrates. Moreover, It is a source of some biologically active substances that have antimicrobial and anti-algal effects. **(Fareed *et al.*, 2008; Shaltout *et al.*, 2010; Haroon and Abdel-Al, 2016; Haroon and Daboor, 2019; Haroon, 2020a, 2020b).** Epiphytic microalgae determine the trophic status of aquatic ecosystems **(Cook, 2007).** It is considered as a good bioindicator because of fast reproduction rates and high sensitive responses to chemical variations and eutrophication **(Larson *et al.*, 2012)**. It is considered as a source of food for invertebrates and fish in the coastal zones **(Abe *et al.*, 2007**). It is presence was depends on aquatic macrophytes as a host (**Cattaneo *et al.*, 1998)**. Epiphytes, with aquatic macrophytes, may utilize dissolved organic products released by their hosts.**(Allen, 1971).**

Microinvertebrates are the main source of the food for many fishes, it is responding rapidly to environmental changes because of the short generation times for most species. Different environmental factors affect the pattern of their distribution **(Kimmel *et al.*, 2006)**. It is served as bioindicators of water pollution **(Mola, 2011; Ahmad *et al.*, 2012**). Rotifers, such as *Brachionus* species (as a food for many fish larvae), comprise a link in the food chains of inland water (**Guerguess, 1993**). Zooplankton species is playing as avital component of the aquatic biota, it is considered as an informative tool for exploring ecological changes in water. Also, it can transfer energy (from the producers to the consumers) constitutes the economic values of these biological resources in aquatic environments **(Benítez-Díaz *et al.*, 2014; EL-Sebaie *et al.*, 2014).** The total, fecal coliforms and fecal streptococci bacteria are used as bacterial indicators for estimating water pollution **(Anufriieva *et al.*, 2020).**

Investigation of the biological aspects in the Rosetta branch will reflect the status of the water body. Documentation and characterization of the biological resources in the Rosetta branch will enable managing of this strategic Egyptian area properly in the future. Accordingly, the present study aimed to evaluate the flora and fauna communities structure (macrophytes, epiphytes, zooplankton, microinvertebrates, and bacteria) at the Rosetta branch, as well as monitoring the variations in these communities with the environmental conditions.

MATERIALS AND METHODS

Area of investigation:

The Rosetta branch (the main freshwater stream extending northwards, for about 236 km on the western boundary of the Nile Delta) is the central water source for several areas in the Nile Delta.

Sampling:

Eight sampling locations, distributed along the Rosetta branch of the River Nile, were selected to collect samples during winter and summer 2018 (Table 1 & Fig.1).

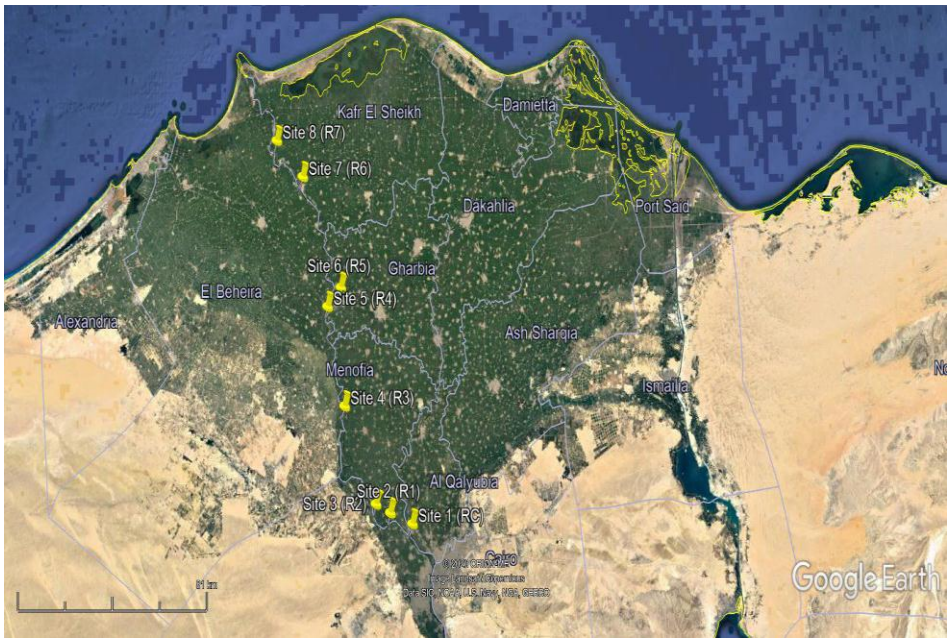

Fig.1. The map of selected sites at the Rosetta branch (Nile River).

Table 1: Sampling sites at the Rosetta branch.

Site No.	Sations	Station code	Coordinates
Site 1	Al-Qanater Al-Khiria (Upstream El-Rahawy drain)	RC	30° 12′ 48.79″ N 31° 2′ 39.26″ E
Site 2	El-Rahawy drain outfall	R1	30° 12′ 26.53″ N 31° 1′ 57.84″ E
Site 3	Al-qata (downstream El-Rahawy drain)	R2	30° 13′ 12.93″ N 30° 58′ 33.77″ E
Site 4	Tamalay	R3	30° 30′ 32.32″ N 30° 49′ 57.29″ E
Site 5	Kom Hamada	R4	30° 42′ 52.91″ N 30° 45′ 44.28″ E
Site 6	Kafer Al-Zayat	R5	30° 49′ 22.64″ N 30° 48′ 38.93″ E
Site 7	Dosouq	R6	31° 08′ 05.09″ N 30° 38′ 01.26″ E
Site 8	Fowah (Kafer Al-Sheikh)	R7	31° 12′ 00.67″ N 30° 33′ 11.18″ E

Macrophytes collection and identification:

At each location, a quadrate of 50×50 cm was used and the macrophytes inside each quadrate were collected. The emergent macrophytes were translocated in polyethylene bags (without water), whereas the submerged and free-floating species were saved in water. Based on **Boulos (2005),** macrophytes were identified and separated into different taxa. The macrophyte samples were weighted (to estimate their biomass

production). The results were expressed as kilogram per square meter wet weight (kg/m^2 ww) (**Misra, 1968**).

Epiphytic algal collection and identification:

Eichhornia crassipes (Mart.) Solms-Laubach was chosen for sampling as it was the most dominant macrophyte. After macrophyte collection, submerged parts of *Eichhornia crassipes* were cut near the bottom -just above the roots-, gently left out from the water, and were divided into about six sections. In the laboratory, the periphytons -on the macrophyte sections- were scraped off many times with a toothbrush in the same day or one day after. Subsequently, the plant segments were washed with tap water. The periphyton algae-water suspension was poured into 1-liter glass cylinder and passed through a 300 µm mesh, for avoiding contamination by small macrophyte fragments **(Cattaneo *et al.*, 1997)**, till the volume of 1000 ml. To facilitate sedimentation and stain of algal cells, Lugol's iodine solution was added (until the color changed to faint tea color). The preserved samples were lifted for 5 days to settle **(APHA, 2012**). The supernatant was carefully siphoned off with a small plastic tube ending with a fine net, 20 µm mesh diameter until the samples were concentrated to about 50 ml. The remaining volume was adjusted to 50 ml and kept at 4ºC in a dark plastic vial until microscopic examination. Epiphytic algal counts were done using a wild inverted microscope (Zeiss, Axiovert 25 C), where 5 µL of the reduced volume was placed in a counting chamber and examined at 10X eyepiece and 40X objective. The drop method (**APHA, 2012**) was applied for both counting and identifying different algal species from different samples. **Cleve- Euler,1952; Bourrelly, 1968; Starmach, 1968; Prescott, 1978; Mizuno, 1990** were used for epiphyte identification.

Microinvertebrates collection and identification:

To collect microinvertebrates, *Eichhornia crassipes* were collected, placed in polyethylene bags (with filtered water), and fixed with neutral formalin solution (10%). The submerged parts of *Eichhornia crassipes* were placed (separately) in a plastic bottle (containing filtered water). The bottle was closed and shacked to detach all animals from *Eichhornia crassipes*. The epiphytic microinvertebrates were separated with a net of 500-µm mesh size, placed into a labeled plankton bottle, and fixed with 10 % neutral formalin solution. By using a Trinuclear microscope, the microinvertebrates were separated into groups. Specimens were investigated, classified and counted as described by **Edmondson, 1966; Pennak, 1978; Shehata *et al.*(1998 a; 1998 b); Dang *et al.*, 2015.** The plants were dried (at 60 °C) in the oven for three days and weighted. The densities of the animal attached to plants were expressed as the number of individuals per gram dry weight plant (org./g plant dw) of the macrophytes (**Arora and Mehra, 2003; Sakuma *et al.* 2002).**

Zooplankton Sampling, counting and characterization:

Samples were collected as described by **Saad *et al.*, 2013.** Zooplankton samples were immediately preserved and counted according to **Mageed (2005).** All the organisms

in each sample were characterized to species level as possible. Samples were made up to (100 ml) standard volume. 1ml was used to count the organisms (using a binocular microscope) according to **Shiel and Koste (1992); Einsle (1996); Smirnov (1996)** with some modifications as described by **Saad *et al.* (2013).** Shannon-Winner diversity, species richness, evenness, and similarity index were calculated using Primer (Vs5) program (**Saad *et al.*, 2013**). Also, the PAST software was used for constructing the clustering analysis among the evaluated stations.

Bacteriology:

Total bacterial count (enumerated at 22°C and 37°C) were detected using the pour plate technique on the nutrient agar media according to **APHA, 2012**. Total and fecal coliforms bacteria (TC and FC) were enumerated by MPN technique (the Most Probable Number). MacConkey broth media was used for standard presumptive test. tubes were incubated at 37 °C for 48 hrs (for total coliform bacteria) and at 44 °C for 24 hrs (in water bath for fecal coliform bacteria). Confirmation for positive tubes by streaked on EMB media (Eosin Methylene Blue agar) then incubated at 37 °C for 24 hrs according to (**APHA, 2005**). Fecal streptococci bacteria (FS) were also enumerated by the MPN technique using ADB media (Azide Dextrose Broth) for presumptive test and a positive tubes showing turbidity after 2 days at 37 °C. Confirmation by transferring positive tubes to ethyl violet azide broth media and a positive tubes showing turbidity and sedimentation on the bottom within 48 hrs at 37 °C (**APHA, 2005**).

Escherichia coli and *Staphylococcus aureus* were enumerated by the Membrane filtration (MF) technique, a suitable volume was filtered through 0.45 µm membrane filter. Filtrates were transferred into EMB agar medium (Eosin Methylene Blue) for *E. coli* and MSA agar medium (Mannitol salt agar) for *S. aureus*. Plates were incubated at 44.5 °C for 24 hrs (for *E. coli*) and 37 °C for 24-48 hrs (for *S. aureus*). Positive results for *E. coli and S. aureus* colonies were enumerated (green metallic sheen and yellow colonies respectively). (**APHA, 2012)**. *Pseudomonas aeruginosa* was enumerated by MPN method using L.asparagine broth medium and the green fluorescent pigment indicated a positive result, then plates of Cetrimide agar media were inoculated from positive tubes, incubated at 37°C for 24-48 hrs. Confirmation was detected by producing yellow-green to blue-green color colonies according to **(Balkhair, 2016)**.

$$E.coli/100\ ml = \frac{Number\ of\ E.coli\ colonies \times 100}{Volume\ of\ sample\ filtered\ (ml)} \quad \textbf{(1)}$$

$$S.aureus/100\ ml = \frac{Number\ of\ S.aureus\ colonies \times 100}{Volume\ of\ sample\ filtered\ (ml)} \quad \textbf{(2)}$$

Salmonella sp.and *Shigella* sp.were detected by the Membrane filtration (MF) technique, 100 ml of water samples were filtered through 0.45µm filter paper, and for *Salmonella* sp. was transferred to tetrathionate broth media and incubated at 43°C up to 5 days with repeated streaking on Salmonella-Shigella (S-S) agar medium at 35°C for 24 hrs. Black-centered colorless colonies on S-S agar media refer to a positive result, while *Shigella* sp. was transferred to nutrient broth media and incubated for 6 hrs at 35 °C, then

isolates were cultivated on S-S agar media at 35°C overnight. Colorless colonies refer to a positive result. Identification of *Salmonella* sp.and *Shigella* sp. were carried out according to **Robert and Noel (1981); APHA (2005)**. Detection of *Vibrio cholerae* occured after samples concentrated by filtration (0.2-µm). Overnight enrichment was performed using APW (alkaline peptone water) at pH 8.6. Surface aliquots are streaked onto TCBS agar media (Thiosulfate Citrate Bile Sucrose) according to **Koch (1994)** Identification of *V. cholera* was carried out according to **APHA (2005)**.

Physico-chemical characterization:

Physico-chemical parameters were analyzed at chemical laboratories (NIOF) according to the standard methods (**APHA, 2005).**

Data processing:

Statistical analysis was processed for data by Principal component analysis (PCA) to correlate physicochemical parameters in water with different biological aspects using the XL STAT program 2020.

RESULTS

Macrophytes distribution and community structure

According to the data mentioned in Table (2), seven species of aquatic macrophytes belonging to seven genera related to 7 families were recorded. They were classified ecologically into three major groups (viz; sub-merged, floating, and emergent hydrophytes). The sub-merged hydrophytes were represented by *Myriophyllum spicatum* and *Ceratophyllum demersum*. During winter the two species were recorded at three sites (RC, R5, R7), and *Ceratophyllum demersumwas* recorded at R 1 and R7, however, during summer *Myriophyllum spicatum* was the only recorded species. Floating hydrophytes were represented by two species (*Eichhornia crassipes* and *Potamogeton nodosus*). In which, *Eichhornia crassipes* were recorded at all sampling sites (Percentage= 100% of sampling sites), however, *Potamogeton nodosus* was recorded at only one site (site R5). Emergent hydrophytes represented by *Polygonum tomentosum* (L.), *Cyperus alopecuroides* Rottb.(Per) and *Echinochloa stagnina* (Retz.) P. Beauv. (Per). During winter *Echinochloa stagnina* was recorded in 5 sites (RC, R2, R3, R4, R5), however, during summer it was found in only three sites (RC, R6, R7). The other two species were less frequent (Table 3).

Table 2: Classification of the macrophytes recorded at the Rosetta branch.

Scientific name	Family
Ceratophyllum demersum L.	*Ceratophyllaceae*
Cyperus alopecuroides Rottb.(Per)	*Cyperaceae*
Myriophyllum spicatum L.	*Haloragaceae*
Potamogeton nodosus Poir	*Potamogetonaceae*
Polygonum tomentosum L.	*Polygonaceae*
Echinochloa stagnina (Retz.) P. Beauv. (Per)	*Poacea (Gramineae)*
Eichhornia crassipes (Mart.) Solms	*Pontederiaceae*

Comparing the two studied seasons, winter was the richest season in species number (7 species), and site RC was the richest site (5 species) (Table 3). During this season two submerged macrophytes species were detected, however, during summer this group of macrophytes was represented by only one species, with the highest percentage for *Myriophyllum spicatum* (percentage =37.5 and 25.0% of the total sampling sites for the two seasons respectively). However *Ceratophyllum demersum* L. was the least frequent species present (Table 3). Throughout the two studied seasons *Eichhornia crassipes* (floating macrophytes) and recorded widely distributed and were considered the most dominant species (100%). *Echinochloa stagnina* (emergent macrophytes) was registered widely distributed and the most dominant species were found in 62.5% and 37.5% of the total sampling sites for the two seasons respectively.

Table 3: Floristic composition of the different sites at the Rosetta Branch.

Season	Species	Life form	Ecological sites								NS	P%
			RC	R1	R2	R3	R4	R5	R6	R7		
Winter	**Submerged**											
	Myriophyllum spicatum L.	Hy	+	-	-	-	-	+	-	+	3	37.5
	Ceratophyllum demersum L.	Hy		+	-	-	-	+	-	+	3	37.5
	Floating											
	Eichhornia crassipes (Mart.) Solms	Hy	+	+	+	+	+	+	+	+	8	100
	Potamogeton nodosus Poir.	Hy		-	-	-	-	+	-		1	12.5
	Emergent											
	Echinochloa stagnina (Retz.) P. Beauv. (Per)	G, He	+	-	+	+	+	+	-	-	5	62.5
	Cyperus alopecuroides Rottb.(Per)	G, He	+	-	-	+	-	-	-	-	2	25.0
	Polygonum tomentosum L	G, He	+	+	+	-	-	-	-	+	4	50.0
Summer	**Submerged**											
	Myriophyllum spicatum L.	Hy	+	-	-	-	-	-	-	+	2	25.0
	Ceratophyllum demersum L.	Hy		-	-	-	-	-	-		0	0.0
	Floating											
	Eichhornia crassipes (Mart.) Solms	Hy	+	+	+	+	+	+	+	+	8	100
	Potamogeton nodosus Poir.	Hy		-	-	-	-	-	-	+	1	12.5
	Emergent											
	Echinochloa stagnina (Retz.) P. Beauv. (Per)	G, He	+	-	-	-	-	-	+	+	3	37.5
	Cyperus alopecuroides Rottb.(Per)	G, He		-	-	-	-	-	-	+	1	12.5
	Polygonum tomentosum L	G, He	+	-	-	-	-	-	-	+	2	25.0

NS = Number of sites in which the plants is recorded; P% = Presence percentage; life-form: G = Geophytes, He = Helophytes, Hy = Hydrophytes.

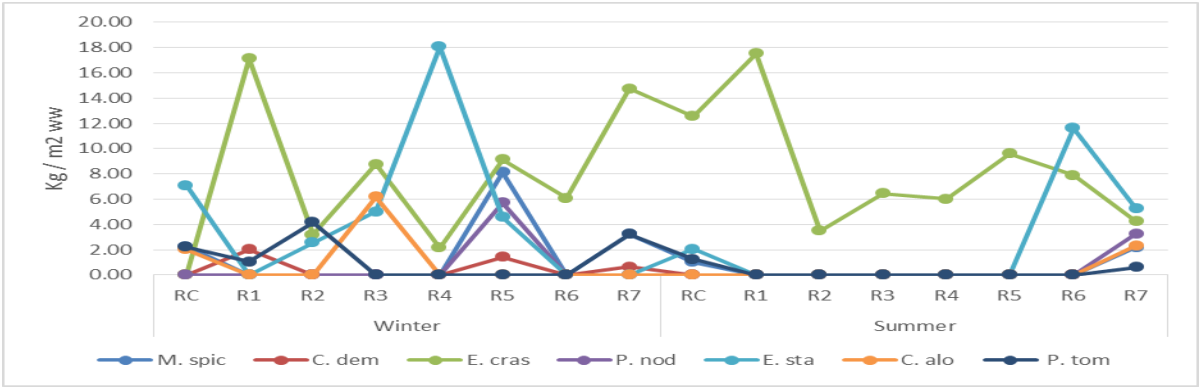

Fig.2. Biomass production values of different macrophytes species

M. spic =*Myriophyllum spicatum, C. dem = Ceratophyllum demersum, E. cras =Eichhornia crassipes, P. nod =Potamogeton nodosus, E. sta =Echinochloa stagnina, C. alo =Cyperus alopecuroides* and *P. tom= Polygonum tomentosum*

The standing crop data (Fig.2) of the collected macrophytes showed a considerable seasonal and spatial variation. During the whole study period, the emergent macrophyte species *Echinochloa stagnina* recorded the highest biomass production value (18.06 kg/m^2 ww) at site R4, followed by the free-floating species *Eichhornia crassipes* (17.14 kg/m^2 ww) from site R1. However, during summer, the highest value was recorded for *Eichhornia crassipes* being 17.54 kg/m^2 ww from the same site. The other five species showed very low production values.

Epiphytic micro-algae

A total of 294 of epiphytic algal species were charachterized and identified (Bacillariophyceae 122 spp., Chlorophyceae 109 spp., Cyanophyceae 46 spp., Dinophyceae 6 spp., Euglenophyceae 6 spp., Cryptophyceae 5 spp., and Xanthophyceae 1 sp.).

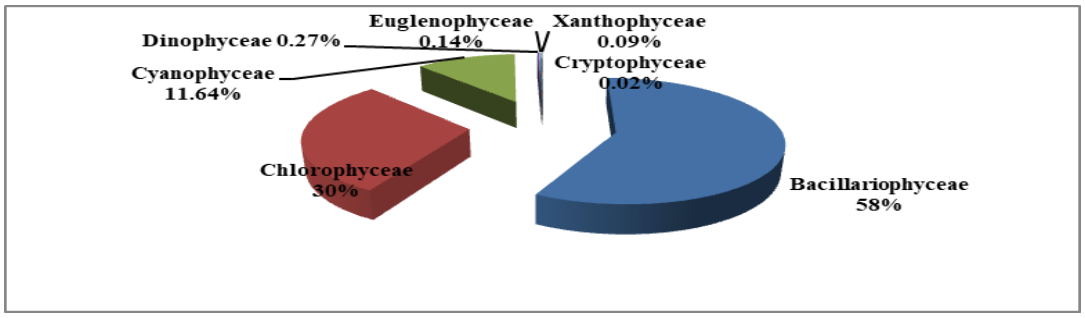

Fig.3: Percentage of epiphytic algal classes at the Rosetta branch.

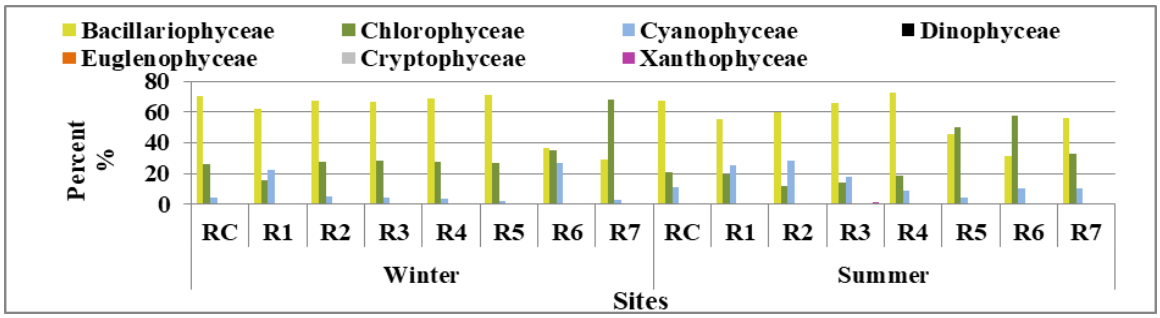

Fig. 4: Percentage of epiphytic algal classes at the Rosetta baranch.

Bacillariophyceae had the highest number of species compared with other groups of attached algae. The percentage of epiphyte algae varied according to sites and seasons. Bacillariophyceae occupied the first and the greatest predominance position (58 %) followed by greens (30 %), blue-greens (11.64 %), Dinophyceae (0.27 %), Euglenophyceae (0.14 %), Xanthophyceae (0.09 %) and Cryptophyceae (0.02 %),(Figs. 3&4). In the present study, the most dominant diatom species were *Fragilaria construns* (its highest percentage was 49.9 at site 4 during summer), *Cyclotella ocellata* (17.6 % at site 3 during summer), and *Cyclotella meneghiniana* (11 % at site 1 during winter) (Table 4). Chlorophyceae was dominated by *Ankistrodesmus fusiformis, Coelastrum sphaericum, Scenedesmus ecornis*, and *Scenedesmus* quadricauda (Table 5). *Oedogonium* sp. made the peak of green epiphytes only during summer at sites 5 & 6. Cyanophyceae was dominated by *Leptolyngbya perelegans, Lyngbya limnetica*, *Microcystis aeruginosa*, and *Phormidium* sp.

Table 4: Most dominant epiphytic diatoms and occurrence percentage at the Rosetta branch

	Winter								Summer							
dominant diatoms	**RC**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**RC**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**
Cyclotella meneghiniana	4	11	6.2	4.4	4.9	10.9	5.4	3.4	4.8	8.2	9.6	3.5	4.3	3.7	7.7	6.2
Cyclotella ocellata	2.7	5.2	9.5	9.3	8.7	9.5	4.3	2.7	6.0	7.1	7.2	17.6	0.0	7.5	0.0	0.0
Cyclotella operculata	0	1.8	0.4	0.0	3.6	4.1	2.2	4.1	2.2	3.4	5.3	2.0	0.0	3.4	3.1	4.0
Fragilaria construns	3.6	0.5	0.4	3.3	3.5	0.0	4.0	0.0	4.7	0.0	0.0	0.0	49.9	0.0	0.0	10.4
Melosira granulata	4.3	8	5.0	2.6	6.1	8.2	0.7	1.0	1.2	3.8	2.4	3.5	0.0	3.7	2.3	0.0
Nitzschia holastica	4.6	8.8	6.4	5.5	5.8	10.9	7.2	1.7	0.0	0.0	0.3	0.0	0.0	0.6	0.0	0.0
Nitzschia palea	0	6.91	2.0	5.5	3.3	6.8	0.0	0.0	0.0	4.2	0.0	0.0	4.3	1.5	1.5	6.2
Syndra ulna	0.7	0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	1.5	4.0	2.4	3.0	0.0	0.0
dominant greens																
Ankistrodesmus fusiformis	3	6.2	2.0	19.5	4.0	6.4	2.0	0.0	0.0	5.0	15.0	0.0	0.0	0.0	0.0	0.0
Coelastrum sphaericum	0.4	7	5.8	0.0	0.0	0.0	10.2	4.2	0.0	1.0	0.0	0.0	0.0	0.0	3.0	2.3
Oedogonium sp.	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.5	0.0	0.0	0.0	0.0	22.4	30.7
Planktonema lauterbornii	0	3	1.6	0.0	0.0	0.0	8.5	2.0	0.0	5.9	4.3	0.0	0.0	5.7	0.0	0.0
Scenedesmus ecornis	2.1	3	3.7	4.9	1.6	2.2	1.0	3.2	0.0	3.7	0.0	0.7	0.0	0.0	4.5	3.8
Scenedesmus dimorphus	0	7	2.8	0.0	0.0	0.0	8.5	3.1	0.0	2.0	0.0	1.0	0.7	0.0	2.2	3.1
Scenedesmus quadricauda	2	5.2	4.4	0.0	0.0	2.2	6.8	0.0	4.4	5.2	3.2	2.9	5.3	7.1	0.7	4.6
dominant blue greens																
Chroococcus turgidus	0.1	0.5	0.0	0.0	9.0	0.0	1.0	0.2	0.1	0.7	0.2	1.4	0.0	0.0	0.0	0.0
Cylindrospermopsis raciboroskii	0	0.6	2.0	0.7	0.0	0.0	0.0	0.0	0.7	3.8	1.2	0.0	0.0	0.7	3.8	0.0
Leptolyngbya perelegans	0	0.5	0.0	1.5	0.0	0.0	0.0	0.0	5.0	4.9	11.5	7.0	4.3	0.0	0.0	4.2
Lyngbya limnetica	1.7	19	2.4	1.3	1.0	1.0	18.0	1.5	1.1	7.8	8.7	6.3	0.0	1.5	2.3	0.0

Microcystis aeruginosa	0.2	0.9	0.2	0.0	0.0	0.0	0.3	0.1	0.0	2.1	1.0	1.8	0.0	0.0	0.0	0.0
Phormidium sp.	0	0.9	0.2	0.9	0.0	0.3	0.0	0.0	0.0	4.0	4.8	0.0	0.0	2.2	3.8	0.0
Planktothrix agardhii	0	3.5	0.0	0.0	0.0	0.5	.3.8	0.3	0.0	5.3	0.0	0.0	4.3	0.0	0.0	6.2

Table 5: List of epiphytic algal species recorded at the Rosetta branch

Bacillariophyceae

Achnanthes brevipes C. Agardh
Achnanthes lanceolata Breb.
Achnanthes oestrupi (H.Bachm.& A.Cleve) Hustedt
Aanthocerus zachariasii (Brun)Simonsen
Amphora ovalis kutz.
Asterionella formosa Hassall
Bacillaria paradoxa J.F.Gmelin in Linnaeus
Biddulphia laevis Ehrenberg
Caloneis permagna (Bailey) Cleve
Campylodiscus clypeus Ehrenberg ex Kützing
Cocconeis diminuta Pantocsek
Cocconies placentula Ehrenberg
Cocconeis placentula var. *lineata* (Ehrenberg) Van Heurck
Cocconeis placentula var. skvortzowii (Skv.) Ska.
Cocconeis scutellum Ehrenberg
Coscinodiscus lacustris Grunow
Cyclotella bodanica Eulenstein ex Grunow
Cyclotella glomerata Bachmann
Cyclotella ocellata Pant
Cyclotella operculata (Ag.) kutz.
Cyclotella meneghiniana kutz.
Cyclotella stelligera Cleve & Grunow Heurck
Cyclotella sp.
Diploneis smithii (Brébisson) Cleve
Eunotia veneris (Kützing) De Toni
Eunotia sp.
Epithemia argus (Ehrenberg) Kützing
Fragilaria construns (Ehr.) Grun
Fragilaria construns var. *veneter* (Ehr.) Grun
Fragilaria crotonensis Kitton
Fragilaria inflata (Heiden) Hustedt
Fragilaria sp.
Fragilaria virescens Ralfs
Gomphonema apicatum Ehrenberg
Gomphonema augur Ehrenberg
Gomphonema olivaceum (Langb.)Kutz
Gomphonema bohemicum Reichelt
Gomphonema lanceolatum Kützing
Gomphonema montanum (Schumann) Grunow
Gomphonema truncatum var. *capitatum* Ehrenberg
Gomphonema sp.
Gomphonema ventricosum W.Gregory
Gyrosigma acuminatum (Kützing) Rabenhorst
Mastogloia elliptica var. *dseri* Thwaites
Mastogloia smithii Thwaites ex W.Smith
Mastogloia smithii var.
Navicula cryptocephala Kutz
Navicula cryptocephala var. *veneter* (Kutz.) Grun
Navicula cryptocephala var. intermedia Gran.
Navicula cuspidata Kutzing
Navicula exigua (Gregory) O. Muller
Navicula festiva Krasske
Navicula helvetica (Brun)
Navicula lanceolata Ehrenberg
Navicula luzonensis Hustedt
Navicula punctulata W.Smith
Navicula pupula Kutz.
Navicula rhyncocephala Kützing
Navicula salinarum Grunow
Navicula salinarum var.intermedia (Grunow) Cleve
Navicula specula (Hickie) Cleve
Navicula tuscula Ehrenberg
Navicula viridula (Kützing) Ehrenberg
Navicula verecunda Hust.
Nitzschia acicularis W. Smith
Nitzschia acula (Kützing) Hantzsch
Nitzschia amphibia Grunow
Nitzschia apiculata (W.Gregory) Grunow
Nitzschia communis
Nitzschia holastica Hust.
Nitzschia ignorata Krasske
Nitzschia kutzingiana Hilse
Nitzschia linearis W. Smith
Nitzschia obtusa var. *scalpelliformis* Grunow
Nitzschia ovalis H.J.Arnott
Nitzschia palea (Kutz.) W. Smith
Nitzschia paleacae Grum
Nitzschia recta Hantzsch ex Rabenhorst
Nitzschia sigmoidea (Nitzsch) W.Smith
Nitzschia stagnorum Rabenhorst
Nitzschia sublinearis Hustedt
Nitzschia subtilis (Kützing) Grunow
Nitzschia thermalis (Ehrenberg) Auerswald
Opephora martyi var. *polymorpha* Jouravleva
Pleurosigma elongatum W.Smith
Stauroneis anceps Ehrenberg
Stauroneis schroederi Hustedt
Suriirella obtusa var. *splandida* Ehrenberg
Synedra actinastroides Lemmermann
Syndra acus Kützing
Synedra acus var. *angustissima* (Grunow) Van Heurck
Synedra affinis Kützing

	lacustris Grunow	Rabenhorst	
Cyclotella striata (Kützing) Grunow	*Melosira granulata* (Her.) Ralfs	*Nitzschia epithemoides* Grunow	*Synedra affinis var. fasciculata* (Lyngbye) Grunow
Cymbella affinis Kützing	*Melosira granulata* var. *angustissma* Muller	*Nitzschia fasciculata* Grunow	*Synedra delicatissima* W.Smith
Cymbella cistula (Hemprich) Grun	*Melosira varians* C. A. Agradh	*Nitzschia filiformis* (W.Smith) Van Heurck	*Synedra nana* F.Meister
Cymbella delicatula Kützing	*Meridion circulare* (Greville) C.Agardh	*Nitzschia fonticola* Grun.	*Syndra ulna* (Nitzsch) Ehr.
Cymbella laevis Nägeli	*Navicula angalica* Ralfs	*Nitzschia frustulum* (Kützing) Grunow	*Synedra ulna* var. *biceps* (Kützing) Schönfeldt
Cymbella microcephala Grunow in Van Heurck	*Navicula atomus* (Kützing) Grunow	*Nitzschia dissipata* (Kutz.) Grum	*Synedra ulna* var. *ramesi* (Herib.) Hust.
Cymbella prostrata (Berkeley) Cleve	*Navicula braunii* Grunow in van Heurck	*Nitzschia gracilis* Hantz	
Diatoma elongata (Lyngbye) C.Agardh	*Navicula confervacea* (Kützing) Grunow	*Nitzschia hantzschiana* Rabenhorst	
Chlorophyceae			
Actinastrum aciculare Playfair	*Cosmarium ochthodes* Nordstedt	*Nephrocytium limneticum* G.M.Smith	*Scenedesmus dimorphus* (Turpin) Küzing
Actinastrum hantzschii Lagerheim	*Cosmarium punctulatum* Brébisson	*Nephrocytium lunatum* W. West	*Scenedesmus ecornis* (Ehrenberg) Chodat
Actinastrum hantzschii var. *fluviatile* J.B.L.Schröder	*Cosmarium* sp.	*Oedogonium* sp.	*Scenedesmus bicudatus* Dedusenko
Actinastrum hantzschii var. *javanicum* C.Bernard	*Crucigenia tetrapedia* (Kirchner) W. & G.S. West	*Oocystis solitaria* Wittrock	*Scenedesmus intermedius* Chodat
Ankistrodesmus falcatus (Corda) Ralfs	*Crucigenia quadrata* Morren	*Oocystis marssonii* Lemmermann	*Scenedesmus quadricauda* (Turpin) Brébisson
Ankistrodesmus fusiformis Corda	*Dactylosphaerium jurisii* Hindak	*Oocystis parva* W.&G.S. West	*Scenedesmus protuberans* Fritsch
Ankistrodesmus spiralis (Turner) Lemmermann	*Dicloster acuatus* C.-C.Jao, Y.S.Wei & H.C.Hu	*Oocystis borgei* Snow	*Scenedesmus subspicatus* Chodat
Ankistrodesmus convulatus Corda	*Dictosphaerium ehrenbergianum* Nägeli	*Oocystis elliptica* W. West	*Scenedesmus sempervirens Chodat*
Ankistrodesmus nitzschioides G.S. West	*Dictyosphaerium planctonicum* Tiffany & Ahlstrom	*Oocystis crassa* Wittrocle	*Scenedesmus spinosas* Chodat
Basicladia vivipara Normandin & Taft	*Dictosphaerium pulchellum* Wood	*Pediastrum araneosum*	*Scenedesmus bijugatus* (Turp.) Kutzing
Carteria globosa Korshikov in Pascher	*Dictosphaerium subsolitarium* Van Goor	*Pediastrum clathratum* (Schröder) Lemmermann.	*Scenedesmus* sp.
Characium limneticum Lemmermann	*Docidium baculum* Brébisson ex Ralfs	*Pediastrum duplex* Meyen	*Schroederia setigera* (Schröder) Lemmermann
Chlamydomonas globosa Snow	*Eudorina unicocca* G.M.Smith	*Pediastrum simplex* Meyen	*Selenastrum bibraianum Reinsch*
Chlorella vulgaris Beyerinck	*Franceia ovalis* (Francé) Lemmermann	*Pediastrum simplex* var. *ramci* (Reinsch) wolle	*Selenastrum capricornutum* Printz
Choricystis coccoides (Rodhe & Skuja) Fott	*Gloeotila* sp.	*Pediastrum tetras* (Ehrenberg) Ralfs	*Selenastrum gracilis* Reinsch
Closterium accrosum (Schr.) Ehr.	*Golekinia radiata* Chodat	*Planktonema lauterbornii* Schmidle	*Selenastrum minutum* Naegeli
Closterium acutum Bredisson	*Keratococcus braunii* (Nägeli) Hindák	*Pleurotaenium ehrenbergii* (Ralfs) De Bary	*Sphaerocystis schroeteri* Chodat
Closterium acutum var.	*Keratococcus suecicus*	*Pleurotaenium truncatum*	*Spirogyra* sp.

variabile (Lem.) Willi Kre.

Closterium ceratium Perty

Closterium strigosum Brébisson

Coelastrum microporum Nägeli

Coelastrum reticulatum (P.A.Dangeard) Senn

Coelastrum sphaericum Nägeli

Coelastrum cambricum Archer

Cosmarium depressum (Nägeli) P.Lundell

Cosmarium formosulum var. *nathorstii* (Boldt) West & G.S.West

Cosmarium laeve var. *distentum* G.S.West

Cyanophyceae

Anabaena circinalis Rabenhorst ex Bornet & Flahault

Aphanizomenon flosaquae Ralfs ex Bornet & Flahault

Aphanocapsa elachista West & G.S.West

Chroococcus dispersus (Keissler) Lemmermann

Chroococcus minutus (Kützing) Nägeli

Chroococcus turgidus (Kützing) Nägeli

Cyanothece sp.

Cylindrospermopsis raciboroskii Woloszynska

Eucapsa densa M.T. de P. Azevedo

Gomphosphaeria aponina Kützing

Gomphosphaeria fusca Skuja

Leptolyngbya perelegans (Lem.) Anag. & Komá.

Lyngbya limnetica Lemmermann

Lyngbya major Meneghini ex Gomont

Hindák

Kirchneriella contorta (Schmidle) Bohlin

Koliella spiculiformis (Vischer) Hindák

Legerheimia ciliata. (Lag.) Chodat

Legerheimia citriformis (Snow) G.M. Smith

Legerheimia subsalsa Lemm.

Monoraphidium dybowskii (Wol.) Hindák& Komárková-Legenerová

Monoraphidium contortum Thuret

Monoraphidium griffithii (Ber.) Komárková-Legnerová

Mougeotia sp.

Merismopedia danubiana Hortobágyi

Merismopedia glauca (Ehrenberg) Nägeli

Merismopedia punctata Meyen

Microcystis aeruginosa Kützing

Microcystis flosaquae (Wittrock) Kirchner

Microcystis grevillei (Hassall) Elenkin

Oscillatoria agardhii Gomont

Oscillatoria chalybea Mertens ex Gomont

Oscillatoria curviceps

Oscillatoria exospira Skuja

Oscillatoria planctonica Woloszynska

Oscillatoria limnetica Lemmermann

Oscillatoria limosa C.Agardh ex Gomont

Oscillatoria tenuis C.Agardh ex Gomont

Oscillatoria sp.

(Brébisson ex Ralfs) Nägeli

Pseudosphaerocystis lacustris

Quadrigula closterioides (Bohlin) Printz

Rhadiococcus nimbatus

Scenedesmus acutiformis Schröder

Scenedesmus acuminatus (Lagerh.) Chodat

Scenedesmus abundans var. *longicauda* G.M. Smith

Scenedesmus denticulatus Lagerheim

Scenedesmus obliqus (Turpin) Küzing

Scenedesmus opoliensis P.G.Richter

Phormidium molle Gomont

Phormidium sp.

Phormidium tenue Gomont

Planktothrix agardhii (Gomont) Anagnostidis & Komárek

Pseudanabaena galeata Böcher

Raphidiopsis curvata Fritsch & Rich

Rhabdoderma irregulare (Naumann) Geitler

Rhabdoderma lineare Schmidle & Lauterborn

Rhabdoderma lineare var. *unicellulare* Hollerbach

Romeria victoriae komarek

Spirulina platensis

Dinophyceae

Ceratium hirundinella (O.F.Müller) Dujardin

Exuviaella apora Schiller

Gymnodinium discoidal

Staurastrum paradoxum Meyen ex Ralfs

Stichococcus bacillaris Nägeli

Tetraedron triangulare Korshikov

Tetraedron minimum (A. Braun) Hansgirg

Tetradesmus wisconsinensis G.M.Smith

Tetrallantos lagerheimii Teiling

Treubaria triappendiculata C.Bernard

Ulothrix sp.

Westella botryoides (West) De Wildeman

Euglenophyceae

Euglena acus (O.F.Müller) Ehrenberg

Euglena gracilis G.A.Klebs

Euglena pisciformis Klebs

Phacus caudatus Huoner

Phacus pleuronectes (O.F.Müller) Nitzsch ex Dujardin

Trachelomonas planctonica Svirenko

Cryptophyceae

Chromonas acuta Utermohl

Cryptomonas erosa Ehrenberg

Cryptomonas marssonii Skuja

Cryptomonas rostrata Triozkaja

Cryptomonas phaseolus Skuja

Xanthophyceae

Tribonema minus (Wille) Hazen

Lyngbya martensiana Meneghini ex Gomont *Lyngbya profundalis* Lindstedt	*Phormidium dictyothallum* Skuja *Phormidium interruptum* Kutz. *Phormidium laminosum* Gomont ex Gomont	*Peridinium cinctum* O.F.Muller *Peridinium penardiforme* Lindemann *Peridinium* sp.	

Epiphytic microinvertebrates

Maximum occurrence of epiphytic invertebrates (20008 org./g plant dw) was recorded during winter while the lowest (18684 org./g plant dw) was observed during summer. On the other hand, the highest number of epiphytic microinvertebrate species and taxa was recorded during the summer season (23 species) while the lowest one was found during the winter season (19 species). An average of Twenty-five species and taxa were recorded belonging to Rotifera (14 species), Protozoa (4 species), Cladocera (2 species). In addition, one species of Nematoda, ostracoda, and Oligochaeta. Copepoda larvae and insect larvae were observed with low abundance.

Protozoa were the dominant group during this study, it forms 51.76% of the total epiphytic microinvertebrates and was represented by four species (*Arcella discoides*, *Centropyxis aculeate*, *Euglypha* sp., and *Vorticella* sp.) (Fig.5)**.** Rotifers recorded the highest number of species (14) and it was represented by 28.12 % of the total epiphytic microinvertebrates count. Rotifera were dominated with *Philodina* sp. (16.31 % of the total epiphytic microinvertebrates. *Brachionus* spp. were observed at the most studied stations. (Table 6). Nematoda formed 17.82% of the total epiphytic microinvertebrates with the highest biomass during winter. Cladocera was represented by 2 species; genus *Alona and Diphanosoma*.

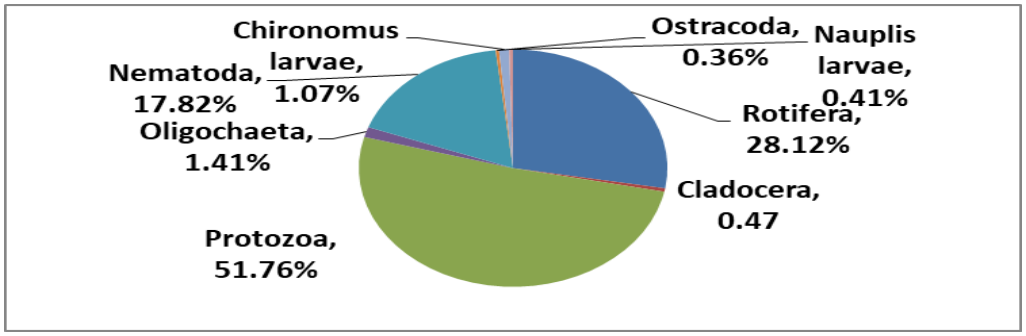

Fig.5. The percentage of each epiphytic microinvertbrates groups associated with the floating plant *Eichhornia crassipes* at Rosetta branch.

Table 6. Variations of epiphytic microinvertbrates (org./g plant dw) at the Rosetta branch.

Group/species	winter		Summer		Average	
	Number	%	Number	%	Number	%
Rotifera						
Anuraeopsis fissa	135	0.67	45	0.24	90	0.46
Asplanchna priodonta	0	0	104	0.56	52	0.28
Brachionus patulus	135	0.68	193	1.03	164	0.86
Brachionus plicatilis	418	2.09	904	4.84	661	3.46
Brachionus qudridentatus	556	2.78	389	2.08	472	2.43
Colurella adriatica	30	0.15	26	0.14	28	0.14
Euchlanis dilatata	115	0.57	292	1.56	203	1.07
Keratella cochlearis	0	0	92	0.49	46	0.25
Keratella tropica	73	0.37	0	0	37	0.18
Monostyla bulla	267	1.33	172	0.92	219	1.13
Monostyla Closterocerca	358	1.79	75	0.4	216	1.1
***Philodina* sp.**	1439	7.19	4753	25.44	3096	16.31
Filinia longiseta	0	0	126	0.67	63	0.34
***Trichocerca* sp.**	0	0	92	0.49	46	0.25
Total Rotifera	3525	17.62	7218	38.63	5371	28.12
Cladocera						
Alona intermedia	82	0.41	0	0	41	0.2
Diphanosoma excisum	54	0.27	49	0.26	52	0.27
Protozoa						
Arcella discoides	531	2.66	289	1.55	410	2.1
Centropyxis aculeata	56	0.28	77	0.41	66	0.34
***Euglypha* sp.**	157	0.79	110	0.59	133	0.69
***Vorticella* sp.**	9084	45.4	9697	51.9	9390	48.65
Total Protozoa	9821	49.08	10173	54.44	9997	51.76
Oligochaeta	342	1.71	208	1.12	275	1.41
Nematoda	6166	30.82	901	4.82	3534	17.82
Ostracoda	0	0	135	0.72	68	0.36
Chironomus larvae	0	0	400	2.14	200	1.07
Nauplis larvae	19	0.09	135	0.72	77	0.41
Total number	20008	100	18684	100	19346	100
Species/Taxa	19		23		25	

Documentation and evaluation of zooplankton

According to the results, the winter recorded thirty-eight taxa of zooplankton included in five groups, Rotifera (28 taxa), Copepoda (2 taxa), Cladocera (3 taxa), Meroplankton (2 taxa), and Protozoa (3 taxa), while the summer recorded forty-five taxa of zooplankton, included in five groups, Rotifera (29 taxa), Copepoda (3 taxa), Cladocera (6 taxa), Meroplankton (4 taxa) and Protozoa (3 taxa) were identified based on morphological characters. The highest number of Rotifera species during winter and summer were calculated in R7 (638400 org.m^{-3}) and (600000 org.m^{-3}) respectively. Numbers of Copepoda were observed at R2, R3, and R5 during winter and RC, R2, and R3 during summer. A total of 12000 org.m^{-3} and 62400 org.m^{-3} of Copepoda species were recorded in R7 during winter and summer respectively (Table 7).

Table 7:Standing crop of zooplankton species (org.m^{-3}) at the Rosetta branch

Sample	Winter						Summer					
	Rotifera	Copepoda	Cladocera	Meroplankton	Prortozoa	Total zooplankton	Rotifera	Copepoda	Cladocera	Meroplankton	Prortozoa	Total zooplankton
RC	110400	2400	0	2400	4800	120000	160800	0	2400	0	0	163200
R1	96000	2400	0	4800	2400	105600	187200	7200	2400	21600	0	218400
R2	117600	0	2400	12000	2400	134400	96000	0	2400	12000	24000	134400
R3	72000	0	2400	2400	12000	88800	110400	0	4800	9600	14400	139200
R4	36000	7200	0	0	21600	64800	451200	28800	0	0	0	480000
R5	60000	0	0	0	2400	62400	381600	2400	0	4800	0	388800
R6	103200	2400	0	2400	67200	175200	595200	31200	43200	2400	0	672000
R7	638400	12000	2400	7200	7200	667200	600000	62400	26400	4800	0	693600

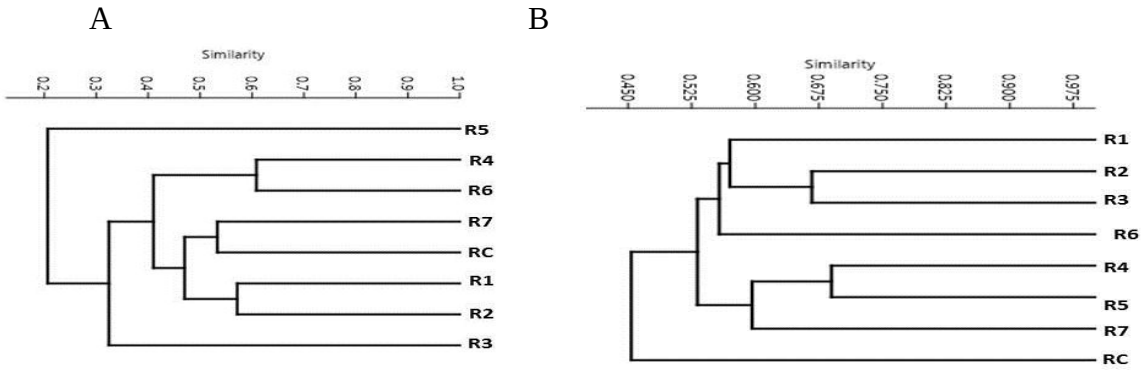

Fig.6.Clustering analysis based on zooplankton biodiversity. A) winter, B) summer.

During Winter, a total of 2400 org.m^{-3} of Cladocera were recorded at R2, R3, and R7 stations. The Meroplankton organisms were presented by Nematoda species (in R1, R2, R3, and R6) and Oligochaeta larvae (in RC and R7), while summer recorded a total of 43200 org.m^{-3} Cladocera at R6 station. No Cladocera species was observed in both R4 and R5. The Meroplankton organisms were presented by Nematoda species (in R1, R2, and R6), Chironomus larvae (in R3, R5, and R7), Chironomus pupa (in R5) and Oligochaeta larvae (R1). Three Protozoa species were detected at the two seasons. These species were represented by *Arcella* spp., Colony of *Zoothamnium duplicatum*, and *Pseudodileptus* species.

Clustering analysis

Data mentioned in Fig. (6) shows the winter was recorded high similarity values between each of the following stations: (R1 and R2), (RC and R7) and (R4 and R6). The station (R5) is distantly related to the stations (RC, R1, R2, R3, and R4). The similarity between the stations (R5 and R6) is higher than the similarity between both (R5 & R7). The highest similarity value was noted between the R1 and R2 stations, while during the summer recorded high similarity values between each of the following station pairs: (R1and R2), (R2 and R3), (R4 and R5) and (R4 and R7). The station (RC) is distantly related to all the other evaluated stations. The similarity between the stations (R6) and each of R1, R2, and R3 is similar. The lowest similarity value was noted between the R4, and RC.

The zooplankton species richness, evenness, and diversity index

The total zooplankton species (S) species richness (d), evenness (J), and diversity index (H) in each the evaluated Rosetta branch station were calculated in each estimated season (Table 8). The calculated values were varied among evaluated stations within each estimated season. Concerning the seasonal variations, the highest S, d, J, and H values were detected in the summer within the most evaluated stations (RC, R1, R3, R4, R5, and R7). On the other hand, this observation was reversed in the station (R2). Regarding station R6, (d) and (H) values in summer were higher than those calculated in winter.

Table 8: Total zooplankton species, species richness, evenness and diversity index

Stations	Winter				Summer			
	S	d	J	H	S	d	J	H
RC	12	0.94	0.71	1.78	15	1.17	0.8	2.16
R1	11	0.86	0.76	1.83	13	0.98	0.78	1.99
R2	16	1.27	0.91	2.53	12	0.93	0.88	2.18
R3	13	1.05	0.89	2.29	15	1.18	0.93	2.51
R4	6	0.45	0.87	1.57	15	1.07	0.6	1.63
R5	4	0.27	0.42	0.59	15	1.01	0.71	1.88
R6	15	1.16	0.74	2	14	1.34	0.72	2.12
R7	16	1.11	0.72	2.01	19	1.33	0.82	2.41

S=Total species, d=species richness and J=evenness, R=station, H= diversity index.

A total of five zooplankton groups (Rotifera, Copepoda, Cladocera, Meroplankton, and Protozoa) were documented and identified based on morphological characters. Rotifera (constitute 28 taxa in winter and 29 taxa in summer). The standing crop values of the Rotifera group were varied among the evaluated stations. Copepoda species was represented by *Acanthocyclops americanus* and Nauplius larva in the winter. In addition, the third species (*Mesocyclops leuckarti*) was recorded only in summer (station R7).

The Cladocera and Meroplankton organisms were documented in some stations, while the Protozoa group were detected (dominated) in all stations in winter. The highest Protozoa species was recorded in the station (R6). On the other hand, this group was documented only in two stations (R2 and R3) in the summer. Regarding the calculated diversity index (H), all (H) values did not match 3. It ranged at the winter from 0.59 (R5) to 2.53 (R2). Concerning the summer, these values ranged from 1.63 (R4) to 2.51 (R3).

Bacteriology

Total bacterial counts are shown in Table 9. Numbers at 22°C ranged between 1×10^4 and 800×10^4 CFU/ml, while at 37°C ranged from 3×10^4 to 840×10^4 CFU/ml, the highest values (at 22°C and 37°C) recorded during summer at R1 (El-Rahawy drain outfall), affected by El-Rahawy drain.

Table 9: Variation of Total viable bacterial count (CFU/ml) at the Rosetta branch

Stations	Winter		Summer	
	TVBC at 37° C	TVBC at 22° C	TVBC at 37° C	TVBC at 22° C
RC	3×10^4	1×10^4	12×10^4	9×10^4
R1	145×10^4	98×10^4	840×10^4	800×10^4
R2	93×10^4	65×10^4	460×10^4	380×10^4
R3	84×10^4	80×10^4	125×10^4	88×10^4
R4	50×10^4	12×10^4	108×10^4	85×10^4
R5	30×10^4	26×10^4	98×10^4	78×10^4
R6	69×10^4	32×10^4	220×10^4	185×10^4
R7	102×10^4	85×10^4	334×10^4	346×10^4
Mean	72×10^4	49.9×10^4	274.6×10^4	246.4×10^4
Max	145×10^4	98×10^4	840×10^4	800×10^4
Min	3×10^4	1×10^4	12×10^4	9×10^4
SD	44.5×10^4	36.6×10^4	270.1×10^4	260.2×10^4

Max= maximum, Min=minimum, SD= standard deviation.

Table10: Enumeration of TC, FC, FS, *E. coli*, *S.aureus* and *P.aeruginosa* at the Rosetta branch.

Stations	Winter						Summer					
	TC $\times 10^3$ MPN/100ml	**FC$\times 10^3$ MPN/100ml**	**FS$\times 10^3$ MPN/100ml**	***E. coli* $\times 10^2$ CFU/100ml**	***S.aureus* $\times 10^2$ CFU/100ml**	***P.aeruginosa* $\times 10^2$ MPN/100ml**	**FC$\times 10^3$ MPN/100ml**	**FS$\times 10^3$ MPN/100ml**	**FS $\times 10^3$ MPN/100ml**	***E. coli* $\times 10^2$ CFU/100ml**	***S.aureus* $\times 10^2$ CFU/100ml**	***P.aeruginosa* $\times 10^2$ MPN/100ml**
RC	**0.3**	**0.3**	**0.9**	**N.D**	**60**	**N.D**	**11**	**2.3**	**7**	**20**	**32**	**95**
R1	**46**	**15**	**110**	**130**	**155**	**1100**	**110**	**110**	**64**	**902**	**350**	**1100**
R2	**24**	**9.3**	**110**	**53**	**98**	**1100**	**110**	**110**	**110**	**260**	**88**	**1100**
R3	**2.3**	**2.3**	**110**	**18**	**24**	**23**	**64**	**64**	**110**	**35**	**48**	**1100**
R4	**7.5**	**4.3**	**110**	**36**	**165**	**290**	**23**	**23**	**110**	**14**	**178**	**290**
R5	**46**	**24**	**15**	**135**	**71**	**75**	**110**	**110**	**21**	**400**	**200**	**460**
R6	**0.9**	**0.9**	**110**	**5**	**105**	**120**	**64**	**15**	**110**	**105**	**89**	**460**
R7	**2.9**	**2**	**110**	**6**	**128**	**23**	**6.4**	**3.5**	**110**	**33**	**650**	**1100**
Mean	**16.2**	**7.3**	**84.5**	**54.7**	**100.8**	**390.1**	**62.3**	**54.7**	**80.3**	**221.1**	**204.4**	**713.1**
Max	**46**	**24**	**110**	**135**	**165**	**1100**	**110**	**110**	**110**	**902**	**650**	**1100**
Min	**0.3**	**0.3**	**0.9**	**5**	**24**	**23**	**6.4**	**2.3**	**7**	**14**	**32**	**95**
SD	**19.9**	**8.4**	**47.4**	**55.1**	**48.2**	**477.0**	**44.9**	**49.6**	**44.0**	**308.0**	**207.5**	**428.9**

Max= maximum, Min=minimum, N.D= Not Detected, SD= standard deviation.

Numbers of TC & FC and FS were mention in the Table (10), TC, FC,and FS during the winter in the range of 0.3×10^3- 46×10^3, 0.3×10^3- 15×10^3, 0.9×10^3- 110×10^3 MPN/ per 100ml respectively, the highest numbers were recorded at site R1, while during the summer in the range of 6.4×10^3-110×10^3, 2.3×10^3- 110×10^3, 7×10^3 - 110×10^3 MPN/ per 100ml respectively. Some pathogenic bacteria isolated from the Rosetta branch, and numbers of *E. coli, S. aureus,* and *P. aeruginosa* during the winter ranged from 0 - 135×10^2 , 24 $\times10^2$ - 165×10^2, 0- 1100×10^2 CFU/100ml respectively, but during the summer ranged from 14×10^2-902×10^2, 32 $\times10^2$ - 650×10^2, 95×10^2 - 1100×10^2 CFU/100ml respectively. Qualitative detection (presence-absence test) for *Salmonella* sp., *Shigella* sp. and *V. cholera* at Rosetta branch was listed at Table 11.

Table11: Detection of *Salmonella* sp., *Shigella* sp. and *Vibrio cholera* at the Rosetta branch.

Stations	Winter			Summer		
	Salmonella sp.	*Shigella* sp.	*Vibrio cholera*	*Salmonella* sp.	*Shigella* sp.	*Vibrio cholera*
RC	N.D	D	N.D	D	N.D	N.D
R1	D	D	D	D	D	D
R2	D	D	D	D	D	D
R3	D	D	D	D	D	D
R4	D	D	D	D	D	D
R5	D	D	D	D	D	D
R6	N.D	D	D	D	D	D
R7	N.D	D	N.D	D	D	D

N.D= Not Detected D= Detected

Physico-chemical Characteristics

During the present study at the Rosetta branch, water temperature was ranged between 17.7°C - 20.9°C during the winter and incresed during the summer and was ranged from 28°C to 31.2 °C, the highest value recorded at R5. Transparency values ranged from 10 cm to 130 cm during the winter while the summer ranged from 38 cm to 80 cm, the minimum value was found at site R1 during winter, electrical conductivity (EC) fluctuated between (546-1508 µS/cm) during the winter, while EC during the summer fluctuated between (594 - 1100µS/cm). the maximum values of EC were found at site R1 during two season. Hydrogen ion concentration (pH) was ranged durng winter and summer between (7.4 –8.2) and (7.3 –8.5) respectively.

DISCUSSION

A total of 35 of macrophytes species were identified in the River Nile recorded by **Zahran and Willis (1992)**. **El-Amier *et al.*, (2015)** detected 70 species in the Damietta branch. **Haroon and Hussian (2017)** recorded 11 species in El Rayah Al- Behery and **Haroon (2020b)** recorded 12 species in El-Rayah Al-Nasery and El-Noubaria Canal. During the study period only seven macrophytes species were recorded, indicating low species diversity in this area. Regarding the biomass production values, the lowest values were detected for submerged macrophytes which may be related to the effect of shading caused by tall and crowded plants like, *Echinochloa stagnina* and *Eichhornia crassipes*. Comparing with the previously recorded results, the values registered for emergent and floating species were higher than those recorded by **Shaltout *et al.*, 2009**. However, the data of submerged macrophytes species were relatively lower than that detected by **Hussian and Haroon (2019)** during the cold season for *M. spicatum* (66.00 kg/m^2 ww) and *C. demersum* 18.85 kg/m^2 ww from River Nile Egypt. The lower values were detected by **Shaltout *et al.*, 2016; El-Sheekh, *et al.*, 2018** for *Ceratophyllum demersum* (0.036 to 1.094 kg/m^2 ww) from different locations of the Nile delta which may be related to the effect of environmental factors and allelopathic interaction between different species.

Bacillariophyceae had the highest number of species compared with other groups of attached algae these results were shown by many authors (**Adam *et al.*, 2017, Hussian and Haroon, 2019; Haroon *et al.*, 2020).** The percentage of epiphyte algae were varied according to locations and seasons, due to concentrations of nutrients, macrophytes substances, and pollution (**Wetzel, 1993**). The differentiation in epiphytic microalgal species percentage may be due to plant growth period, and physicochemical characteristics (**Dere *et al.*, 2002**). **Jan** (**1996)** suggested that diatoms are favored over other groups due to their size and their resistance to fluctuation in some abiotic variables (as light and temperature). Diatoms species identified in the present study are agreed with **Abd El-Karim *et al.*, (2016)**. Epiphytic algae are considered essentially facultative. Also, it was not influenced with the host **(Wahl and Mark, 1999).** On the other hand, some of them are known as specific and obligate on certain hosts (**Pearson and Evans, 1990**). **Ondrusek** (**1991)** found that diatoms have an advantage over another group of epiphytes due to its high fucoxanthin content. **(Totti *et al.*, 2009**) stated that pennate diatoms attaching themselves to macrophytes gelatinous pads such *Synedra* or by the attachment of the cell along its entire valve face such as Navicula, while the centric forms as *Cyclotella*, held in the tangle of attached forms. **(Cattaneo *et al.*, 2004)** confirmed that diatom can be an excellent specific indicator of metal contamination. **(Albay and Akçaalan, 2003)** mention that the species of *Leptolyngbya perelegans, Lyngbya limnetica, Microcystis aeruginosa,* and *Phormidium* sp. have a wide range of tolerance to physical disturbance (including the fluctuation of water level and large amounts of suspended solids).

El-Enany (2009) Epiphytic microinvertebrates were constituted from seven main groups at Nasser Lake; (Nematoda, Rotifera, Protozoa, Cladocera, Insecta, Oligochacta, and Copepoda). Forty-five species were recorded (27 Rotifera, 9 Cladocera, 5 Protozoa, 2 Copepoda, and 2 Oligochaeta). The wide difference in diversity between the previous study and the present was attributed to the effect of the heavy load of pollution discharged to the Rosetta branch of the Nile especially at El-Rahawy region. **Mola *et al.* (2018)** reported the epiphytic microinvertebrates were represented by 34 species and 5 larval stages involved in 8 main groups and those are lower than this study, this may be attributed to the differences in sampling methods and sampling area. **Arora and Mehra (2003)** investigated the species variety of planktonic and epiphytic rotifers in the backwaters of the Delhi segment of the Yamuna River (India). They recorded a total of 110 species belonging to 39 genera of 20 eutrophic families.Similar observations of Protozoa species in the present study were mentioned by **Mola *et al.* (2018).** This highest number of epiphytic Rotifera was observed by **Sakuma *et al.* (2002); Arora and Mehra (2003)** This may be attributed to the Rotifer species preferred plants which could be predominant body features, e.g. small size and short toes (sessile), to avoid predators and to feed on epiphytic algae (**Ali *et al.*, 2007)**. *Brachionus* spp. were observed at the most studied stations. This is agreed with **Mola *et al.* (2018)**. Also, **Ali *et al.* (2007)** observed a

high number of genus *Lecane*. **Sakuma *et al.* (2002)** stated that a large number of *Lecane* remained on the plant even after shaking 50 times macrophytes. This indicates that, this Rotifer was very strongly attached to submerged macrophytes. The relative abundance and composition of microinvertebrate varied depending on the type of microhabitat (e.g. plant species, benthic sediments, or water column) as mentioned by **Difonzo and Campbell (1988).** Similar observations of the highest biomass of Nematoda during winter were recorded at Lake Naser (**El-Enany, 2009**). While **Mola *et al.* (2018)** stated that Nematoda, Cladocera, Insecta (Chironomus larvae), Copepoda, and Cercaria (infected stage of *Schistosoma* sp.) considered the lowest recorded groups of the epiphytic microinvertbrates. The presence of Cladocera attributes to this species and can adapt to live near the bottom or on the aquatic plants **Mola *et al.* (2018).** This agreed with **Iskaros *et al.* (2008)**. Cladocera is one of the most preferred species recorded in fish guts **(El-Enany, 2009)**. The different food components generally occurred in varying decreases during different periods of the year (**Azim, 1991**). Also, it constitutes the basis for the development of a successful fisheries management program in fish capture and culture (**Oso *et al.*, 2006)**.

Zooplankton are affected by several factors such as the geological history of the area, the abundance of organisms (to be easily transported), and Physico-chemical and biological conditions in their new habitat (**Shurin, 2000**). Rotifers were constituted the main dominant zooplankton groups and This abundance may be due to its evolutionary adaptation ability in different environmental conditions such as salinity as confirmed by **(Mageed, 2005).** The relatively low and/or disappearance zooplankton density as Copepoda (winter season) in some stations (R2, R3, and R5) and in the summer season in the station (RC, R2, and R3) may be due to changes in the abiotic factors (temperature, and pH) and food availability. A similar observation was described by **Benítez-Díaz *et al.* (2014)** they found that, transparency, temperature, pH, water exchanges rates, and food availability (such as Chl a, b, and c) were the main factors of zooplankton abundance (in the brackish lagoon located in Veracruz, Mexico) and diversity, elucidation the seasonal variations. During the winter, Cladocera was calculated in each R2, R3, and R7 station while this group was observed in both R4 and R5 in the second season. This rarely abundance may be due to the negative impact of light conditions on Cladocera (**Benítez-Díaz *et al.*, 2014**). Also, **Leech *et al.* (2005)** found that cladocerans (*Daphnia* spp.) were shown to be less UV-tolerant than rotifers or copepods nevertheless of the UVR transparency of their source lake. Also, the Cladocera are sensitive to visual predation as confirmed by **Ramcharan *et al.* (2009)**. The present study approved that, the (H) value in the station (R5) less than (1) indicates instability or heavy pollution while values exceeding (3) indicate stability or clean water as reported by **Shannon and Weaver (1963); Mageed (2005).** Total bacterial count at two different temperatures at 22^{o}C and 37^{o}C were considered parameters are usually used to determining water quality and bacterial density of water **(Afify *et al.*, 2019)** and results of TVBCs at the rosetta

branch are similar to those reported by **Safaa *et al.* (2012)**. The highest values of TVBCs at 22°C and 37°C were recorded during summer. This might be due to high temperatures prevailing during summer. This result was in accordance with (**Sabae and Saleh, 2007; El-Fadaly *et al.*, 2001**).

The minimum counts of bacterial indicators were detected at the warmer seasons (**Hany and Shawky, 2011)** which might be due to rapid die-off with raising solar radiation and high temperature. High results of TC densities in the present study might be attributed to the effect of the drains and human activities and pollution effect on bacterial association (**Noble *et al.*, 2004)**. **Cabelli (1978)** recommended a maximum count of TC in surface water that is going to be used as a drinking water supply was 1000 CFU/100ml. FC is used as good indicator of fecal contamination; these high values of FC might be attributed to the effect of wastewater. So that, the root of pollution at the Rosetta branch was the drains that discharge the drainage water (wastewater, agriculture waste), these findings agreed with those previously reported by (**Safaa *et al.*, 2012***)*. Restricted limits for surface water intended for use as drinking water supply (200 CFU/100ml) indicate unsafe water from a bacteriological point of view **Cabelli (1978).** Also, **Afify *et al.* (2019)** reported that the drainage water loaded with wastewater and agriculture waste causes highly ratio of pollution with fecal coliform bacteria.FS numbers effected by drainage water loaded with agricultural or industrial wastes, so that affects the cultural condition necessary for bacterial growth as pH and temperature. Briefly, numbers of TC, FC, and FS at the present study showed a marked increase in indicator bacteria during the warm season at the Rosetta branch as mention in the previous results reported by (**Safaa *et al.*, 2012).** There are numbers of drains were discharging wastewater and agricultural waste at the Rosetta branch such as El-Rahawy drain which is highly affected at the Rosetta branch, so that, the high load of organic matter and pollutants came to the Rosetta branch (Nile River) water from El-Rahawy drain and others caused the high value of the count of microbial flora and the drainage effluents induced the active multiplication of the bacteria, these results in accordance with **Safaa *et al.* (2012)**. The municipal and agricultural sewage wastes discharged into the water body cause a serious problem of its water quality (**Afify *et al.*, 2019**). *E.coli* is the best biological water indicator for public health protection because it is present in extremely high numbers in the feces of all mammals (**Edberg *et al.*, 2000**). **Saad *et al.* (2012)** found that *E. coli* was detected in all samples collected from River Nile water at Great Cairo, Egypt. **Yehia and Sabae (2011)** reported that the MPN count of *P. aeruginosa* ranged from 0 to 4600 /100 mL at El-Salam canal. Also, **El-Bahnasawy (2013),** isolated *P. aeruginosa* from water samples of the Rosetta branch. Bacterial diseases are commonly associated with fecal contamination of water. Ex. *Salmonella* (Typhoid, paratyphoid,), *Shigella* (Bacterial dysentery), *V. cholerae* (Cholera). The water-borne disease remains a major public health problem in many countries this is where a pathogen is transmitted by ingestion of contaminated

water. Numbers of TC and FC and pathogens at the Rosetta branch during the current study are not in match with the **Egyptian standards (2007)** for drinking water quality.

Relationship between macrophytes, microinvertebrates, microalgea, zooplankton, bacteria, and water characteristics

Principal component analysis (PCA) shows different relations between different biological aspects and physicochemical parameters of water (Fig.7). There are some biological parameters closely correlated with others such as TVBC at 22°C were significantly strong correlated with TVBC at 37°C, TC, FC, Meroplankton, Cyanophyceae, and Dinophyceae (r =0.99, 0.62, 0.64, 0.81, 0.59 and 0.52 respectively).

Rotifera was more associated with Copepoda, Chlorophyceae and *Polygonum tomentosum* (r =0.76, 0.69 and 0.12respectively). Also Cladocera were significantly correlated with FS, Oligochaeta, Cryptophyceae. *Cyperus alopecuroides* and *Polygonum tomentosum* (r =0.50, 0.51, 0.85, 0.37 and 0.34 respectively).The correlation statistical analysis shows a significant positive relation between Nematoda and *Ceratophyllum demersum*, *Eichhornia crassipes* (r =0.88, and 0.41 respectively).On the other hand, there is a strong positive correlation between biological Aspects and physicochemical parameters such as Total Dissolved Solid show a significant relation with *Ceratophyllum demersum*, *Eichhornia crassipes* and Nematoda (r =0.64, 0.55 and 0.67 respectively).

Temperature had a strong positive correlation with TC, FC, and Euglenophyceae with a significance level alpha more than 0.05. Orthophosphorus is a strong positive correlation with TVBC at 37°C, TVBC at 22°C, Meroplankton, Cyanophyceae, Dinophyceae and Cryptophyceae with a significance level alpha of more than 0.05 and weak correlation with P. tom *Polygonum tomentosum*, *Ceratophyllum demersum*, *Eichhornia crassipes*, Xanthophyceae, Nematoda, Total zooplankton, Vorticella sp., Total Protozoa, Cladocera,TC, FC, FS and Protozoa with a significance level alpha lower than 0.05, also there are negative correlation between Rotifera and Arcella sp. and Bacillariophyceae with a significance level alpha more than - 0.05. These results are similar to those found by (**Haroon *et al.*, 2020 ; Othman and Haroon, 2020**) they recorded variable relations among epiphytes, macrophytes and bacteria at Damietta branch of Nile River and Nile River Rayahs.

CONCLUSION

The present study concluded that the distribution of flora and fauna along the Rosetta branch are affected by environmental conditions through seasonal changes of environmental characteristics as well as the interaction between these aquatic organisms. There are different positive relations between different types of flora and fauna refer to the power correlation between biological aspects at freshwater ecosystem, In addition, the quality of fresh water at the Rosetta Branch have deleterious effects by discharge water comes from several drains along the Rosetta branch thus exposed to different sources of pollution which were approved by the presence of indicator species of pollution.

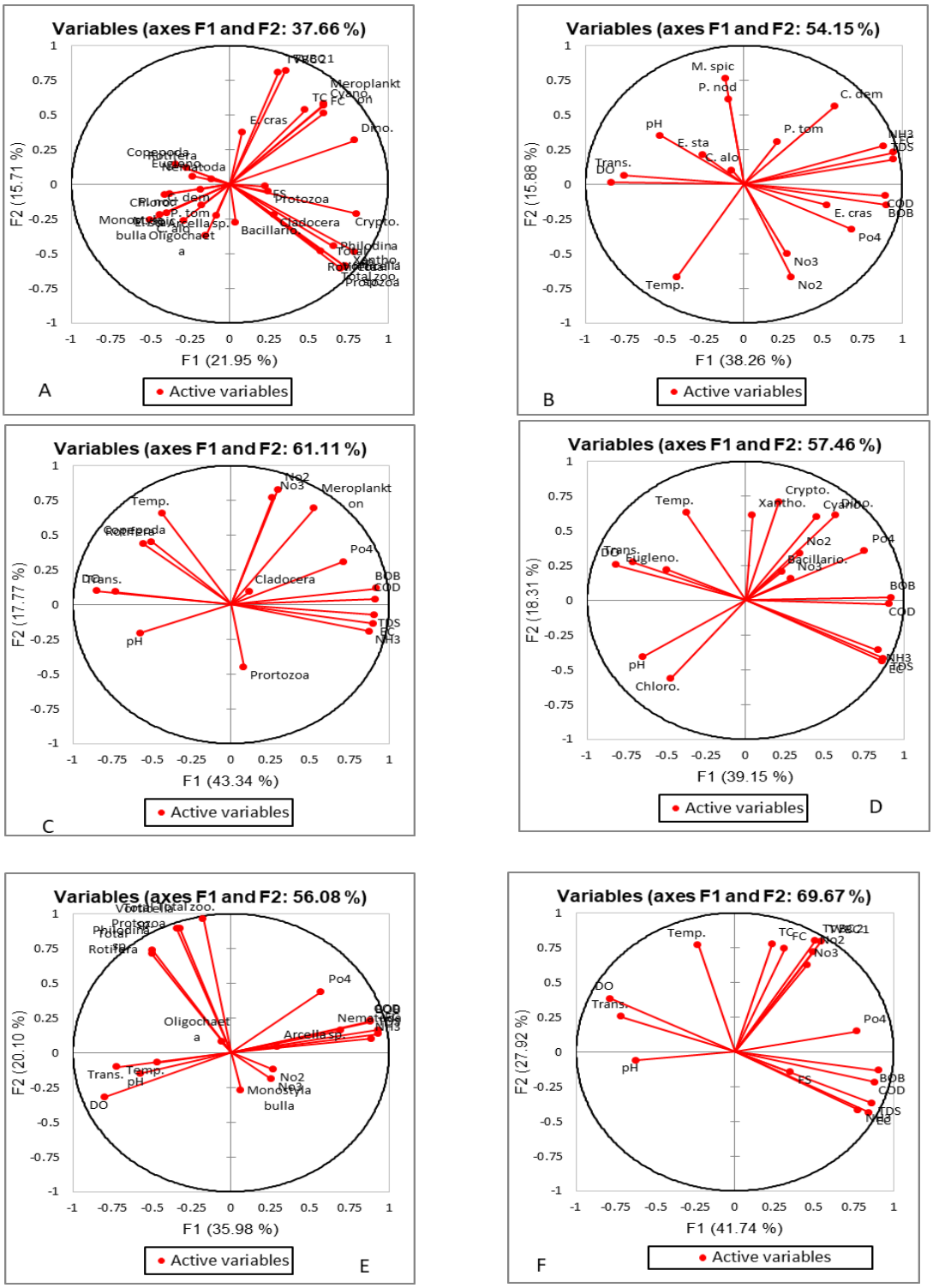

Fig.7. Principal Component Analysis performed on the relation between A) all biological Aspects (Bacteria, Macrophyte, Zooplankton, Microinvertebrates, and Microalgae), B) Macrophyte and Physico-chemical properties, C) Zooplankton and Physico-chemical properties, D) Microalgae and Physico-chemical properties, E) Microinvertebrates and Physico-chemical properties, F) Bacteria and Physico-chemical properties.

TVBC1=TVBC at 37° C, TVBC2=TVBC at 22° C, TC= Total Coliform, FC= Fecal Coliform, FS= Fecal Streptococci, Temp.= Temperature, Trans.= Transparency, EC=Electrical Conductivity, TDS =Total dissolved solid, DO=Disolved Oxygen, BOD=Biological Oxygen Demand, COD=Chemical Oxygen Demand, NH3=Ammonia, No_2=Nitrite, No_3=Nitrate, Po_4= ortho phosphorus, Total zoo.=Total Zooplankton, Bacillario.= Bacillariophyceae, Chloro.= Chlorophyceae, Cyano.= Cyanophyceae, Dino.= Dinophyceae, Eugleno.= Euglenophyceae, Crypto.= Cryptophyceae, Xantho. = Xanthophyceae, M. spic= Myriophyllum spicatum, C. dem= Ceratophyllum demersum, E. cras= Eichhornia crassipes, P. nod= Potamogeton nodosus, E. sta= Echinochloa stagnina, C. alo= Cyperus alopecuroides, P. tom= Polygonum tomentosum.

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