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STRUCTURE AND DIVERSITY OF PHYTOPLANKTON COMMUNITY IN THE WATER OF A SAHARAN WETLAND'S: CASE OF OUED RIGH, ALGERIA (LELLA FATMA AND ZERZAIM PONDS).

Meiada KHELLOU[1,2], *Zahra RAZKALLAH[3], Aziz LAIFA[2], Mohammed LOUDIKI[4], Mountasser DOUMA[4,5] and Moussa HOUHAMDI[3]

[1]*Centre for Scientific and Technical Research on Arid Regions; B.P.1682,07000 Biskra, Algeria*

[2]*Faculty of Sciences, Badji Mokhtar University of Annaba;B.P.12, 23000Annaba,Algeria,*

[3] *Laboratoire Biologie, Eau et Environnement (LBEE).Faculté SNV-STU, Université 8 Mai 1945 Guelma,BP. 401 24000 Guelma, Algeria,* zahra.razkallah@yahoo.fr

[4]*Faculty of Sciences Semlalia, Cadi Ayyad University; B.P.511, 2390 Marrakech, Morocco*

[5]*Polydisciplinary Faculty of Khouribga (FPK),Hassan Premier University;B.P.145, 25000Khouribga, Morocco.*

*Corresponding author:
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Abstract: *Phytoplankton is a very important part of the ecosystem and is extremely susceptible to environmental variations. Understanding and evaluating the effects of environmental changes on planktonic populations is central to freshwater ecology. In order to explore the phytoplankton diversity and abundance of two ponds in the arid region of Megarine (Lella Fatma and Zerzaim) District, Oued Righ, Algeria, we collected phytoplanktonic samples during the period January-December 2016. The results showed that the ponds harbored a total of 58 species of phytoplankton. Lella Fatma had 55 species and Zerzaim had 56 species. These species belonged to three phyla (Bacillariophyta, Euglenophyta, Cyanobacteria) and 5 classes, and included 23 species of Cyanophyceae and 21 species of Bacillariophyceae. The latter was the most abundant class of phytoplankton community. The study reveals that the distribution equipoise in the Megarine region is balanced with equity of 0.89 in Lella Fatma and 0.92 in Zerzaim. The autumn season is the best period for phytoplankton in Megarine 2016.*

Keywords: *Richness, Plankton, Megarine, Bacillariophyceae, Cyanophyceae*

1.Introduction

Phytoplankton is a polyphyletic group with utmost variation in size, shape, color, type of metabolism, and life history traits [1].They represents the microscopic algal communities of water bodies and the pioneer of aquatic food chain. The productivity of an aquatic system is directly related to diversity of phytoplankton. They are source of food for zooplankton, fishes and other aquatic organisms. Phytoplankton communities are sensitive to changes in their environment and therefore phytoplankton total biomass and many phytoplankton species are used as indicators of water quality [2, 3, 4]. According to Harikrishnan et al., (1999) [5], the maintenance of a healthy aquatic ecosystem depends on the physical-chemical and the biological diversity of the ecosystem. Physical-chemical parameters affect plankton distribution, occurrence and species diversity [6]. Phytoplankton communities give more information on changes in water quality than mere nutrient concentrations or chlorophyll-a concentration. They are highly susceptible

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to environmental disturbances such as changes in temperature, salinity, and turbidity [7].

Here, we explore the diversity and composition of phytoplankton in an arid region where phytoplankton communities are rarely studied. Thus, the current study represents a crucial baseline for future studies assessing biodiversity trends under climate change and anthropogenic stress [8, 9]. In addition, the fact that water is scarce in this arid region and used in agriculture, the local phytoplankton community needs to be documented because it is threatened by drought, agricultural pollution, and eutrophication [10, 11]. In Algeria, diversity of phytoplankton in different freshwater systems along with their physico-chemical characteristics were studied by various scholars [12]. However, this study targets the phytoplankton populations of two ponds in the Saharan region of Algeria (Lella Fatma and Zerzaim) of Megarine, Ouargla.

2.Materials and methods

2.1.Study area

The study was carried out during 2016 in Megarine region. Megarine is a district in Ouargla, Algeria. It is one of the oasis in Oued Righ Valley, north of the city of Touggourt (Fig.1).

Fig.1. **Picture of the ponds in Megarine region.**

The region is characterized by a large area of palm plantations surrounding an oasis network that extends from Sidi Slimane to Blidet Ameur. It is limited to the North by Sidi Slimane, to the South by Meggar and on the West by El Alia. Beyond the oasis is the arid and barren landscape of the Sahara, featuring areas of sand dunes (ergs) and flat rocky plains (regs). The surface of Megarine is about 285 km² [13]. The climatic conditions were characterized by a mean annual precipitation of 35.05 mm, a temperature of 23.3 °C, and a relative humidity of 42.8% [14]. The climate is hyper-arid with a long dry season.

In Megarine there are two small ponds namely Lella Fatma and Zerzaim. Lella Fatma is located at latitude 33°12′21″ North and longitude 06°05′54″ East and Zerzaim lake is located at latitude 33°12′12″ North and longitude 06°05′50″ East. The two ponds are connected to each other by a natural trench but still distinct during the wet period (Fig.2) (Fig.3).

Fig.2. Geographic location of the two study ponds (2016).

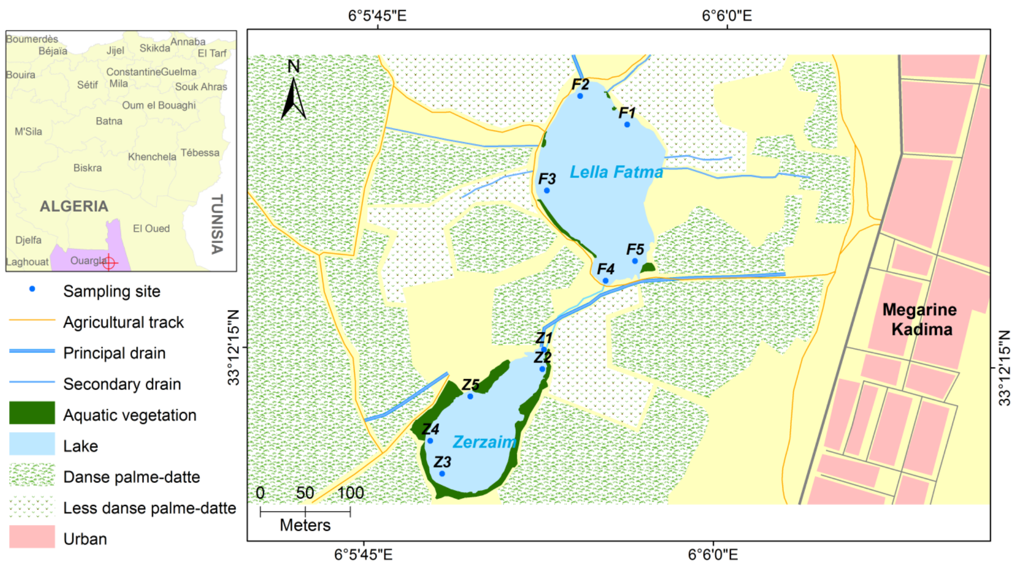

Fig.3. Geographic location of the localities where sampling was conducted in both ponds (2016).

2.2.Sampling

Five sampling points were selected across the entire pond for an exhaustive representation of the phytoplanktonic communities (Table 1),(Fig.4). Considering the shallow average depth of the water body, vertical variations of phytoplankton were very less likely.

Phytoplanktons were sampled from the surface water stratum lying between 0 and 40 cm; a suitable depth for the vital processes of phytoplankton (such as temperature, illumination, and oxygen). Sampling was carried out monthly in the morning from 07:00 to 09:00 during 2016. This time of day is typically suitable for sampling because phytoplanktons are usually found on the surface [15].

Table 1.

Average morpho-dynamic characteristics of the studied ponds

			Latitude	Longitude	Description
Sampling points	LellaFatma pond	F1	33°12′23,95″N	6°5′55,56″E	Near a run of the secondary drainage channel. Presence of a few date palms. Sandy soil.
		F2	33°12′24,20″N	6°5′53,40″E	Outlet point of a primary drain. The part of the soil near this point is bare and not very clayey.
		F3	33°12′20,31″N	6°5′52,66″E	Very close to a palm grove and the presence of Phragmites.
		F4	33°12′18,4″N	6°5′55,07″E	Connection point with the second Zerzaim pond, which is only visible during the rainy season.
		F5	33°12′18,64″N	6°5′56,92″E	just near the point of discharge of domestic wastewater.
	Zerzaim pond	Z1	33°12′15,25″N	6°5′52,62″E	Connection point with the Lella Fatma pond. The connecting channel is covered with emerging plants.
		Z2	33°12′13,44″N	6°5′51,81″E	Near a palm grove.
		Z3	33°12′10,54″N	6°5′48,29″E	Near a palm grove.
		Z4	33°12′11 ,58″N	6°5′47,86″E	Presence of aquatic plants (Tamarix and Phragmites).
		Z5	33°11′13,49″N	6°5′49,78″E	Near a bare land with the presence of salt crusts.

In order to obtain more accurate information, we repeated the collection of samples three times, both for qualitative and quantitative parameters. Plankton samples were collected by filtering pond water through plankton net with 45μ mesh size. The quantitative collection of phytoplankton was carried out using a labelled dark sample 1L-bottle. The filtrate was immediately preserved in 4% formaldehyde for the identification of phytoplankton. In qualitative sampling, the contents of the collector are recovered from a dark glass sample bottle. Qualitative sampling is not appropriate for accurate counts or biomass estimates [16]. Diatom identification is based on microscopic examination of siliceous frustule [17]. We have made the specific identification of phytoplankton with the appropriate books and manuals.

To get an overall idea of the spatio-temporal organization of the phytoplankton population in the study area we determined the parameters of mean abundance, which is the total number of cells (density).

Community structure analysis: three indices were used to obtain the estimate of the species diversity (H'), species richness (S), and species equitability (J). Shannon and Weaver (1963) [18] diversity index values were obtained using the following equation:

$$\boldsymbol{H' = -\sum_{I=1} pi\ \log 2\, pi} \qquad (1)$$

Where

Pi: = the proportion of species i relative to the total number of species in the site = richness

H'= Shannon and Weaver diversity index

Species richness (d) was obtained using the equation

$$\boldsymbol{d = S - 1 \div \log 2\, N} \quad (2)$$

Where:

d= Margalef's diversity index (1970)[19]

S=No of species

N= No of individuals.

Species equitability was determined by using the expression of Pierlou (1966)[20]:

$$\boldsymbol{J = \frac{H'}{In} S} \qquad (3)$$

Where :

H'= Shannon and Weaver index

J= Equitability

S= Total No of species

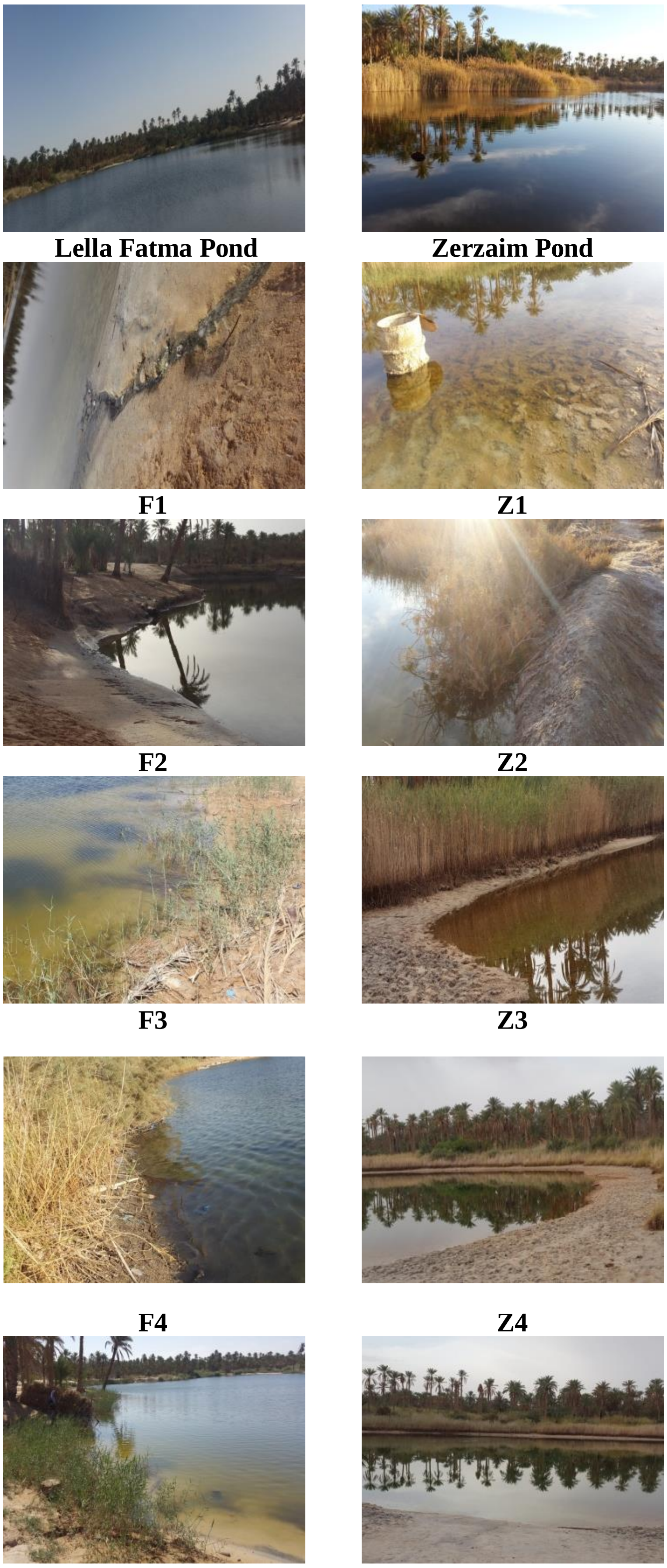

Fig.4. Pictures of the sampling points in ponds (2016).

3. Results and discussions

During the study period a total of 58 species of phytoplankton was recorded. They belong to three major phyla Diatoms (Bacillariophyta), Cyanobacteria and Euglenophyta. The phytoplankton community was dominated by diatoms. Out of the total taxa identified, 34 species (58 %) were Diatoms from 17 genera. The blue-green algae included 23 species (39%) among 17 genera. *Phacus* is the only representative genera of the Euglenophyta (Table 2 and 3) (Fig.5).

Table 2.

Phytoplankton Class and species diversity in Lella Fatma and Zerzaim ponds (2016).

		Lella Fatma Pond			Zerzaim pond		
Phylum	**Class**	**Species diversity**	**Total Number (cells/ml)**	**Percentage abundance (%)**	**Species diversity**	**Total Number (cells/ml)**	**Percentage abundance (%)**
Diatoms (Bacillariophyta)	**Mediophyceae**	11	585	25.46	12	900	23.75
	Coscinodiscophyceae	0	0	0	1	90	0.76
	Bacillariophyceae	21	2720	37.43	21	4645	39.33
Euglenophyta.	**Euglenophyceae**	1	15	0.20	1	45	0.38
Cyanobacteria	**Cyanophyceae**	22	2680	36.88	21	4225	35.77

Table 3.

Number and percentage of phytoplankton families (2016).

	Megarine Region		Lella Fatma		Zerzaim	
	No of spices	**%**	**No of spices**	**%**	**No of spices**	**%**
Catenulaceae	3	5.17	3	5.45	3	5.36
Amphipleuraceae	2	3.45	1	1.82	2	3.57
Brachysiraceae	1	1.72	1	1.82	1	1.79
Naviculaceae	2	3.45	2	3.64	2	3.57
Pleurosigmataceae	1	1.72	1	1.82	1	1.79
Cocconeidaceae	1	1.72	1	1.82	1	1.79
Stephanodiscaceae	2	3.45	2	3.64	2	3.57
Melosiraceae	1	1.72	0	0.00	1	1.79
Cymbellaceae	1	1.72	1	1.82	1	1.79
Gomphonemataceae	1	1.72	1	1.82	1	1.79
Fragilariaceae	2	3.45	2	3.64	2	3.57
Achnanthaceae	1	1.72	1	1.82	1	1.79
Mastogloiaceae	2	3.45	2	3.64	2	3.57
Bacillariaceae	11	18.97	11	20.00	11	19.64
Surirellaceae	3	5.17	3	5.45	3	5.36
Phacaceae	1	1.72	1	1.82	1	1.79
Chroococcaceae	3	5.17	3	5.45	3	5.36
Cyanobacteriaceae	1	1.72	1	1.82	0	0.00
Microcystaceae	2	3.45	2	3.64	1	1.79
Gomphosphaeriaceae	1	1.72	1	1.82	1	1.79
Oscillatoriaceae	1	1.72	1	1.82	1	1.79
Phormidiaceae	1	1.72	1	1.82	1	1.79
Coelosphaeriaceae	4	6.90	3	5.45	4	7.14
Merismopediaceae	1	1.72	1	1.82	1	1.79
Leptolyngbyaceae	2	3.45	2	3.64	2	3.57
Romeriaceae	1	1.72	1	1.82	1	1.79
Pseudanabaenaceae	5	8.62	5	9.09	5	8.93
Spirulinaceae	1	1.72	1	1.82	1	1.79

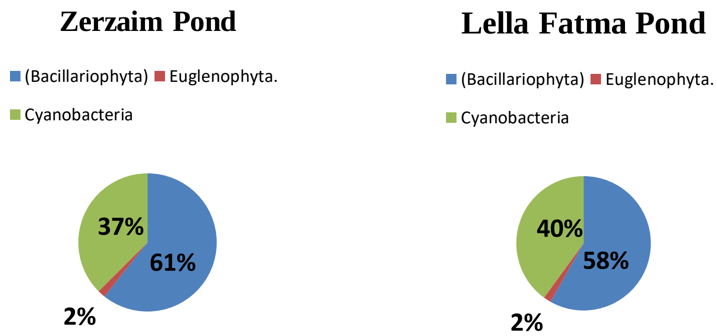

Fig.5. Phytoplankton species in Megarine region (2016).

Species richness was variable in the study sites and between seasons (Fig .6).

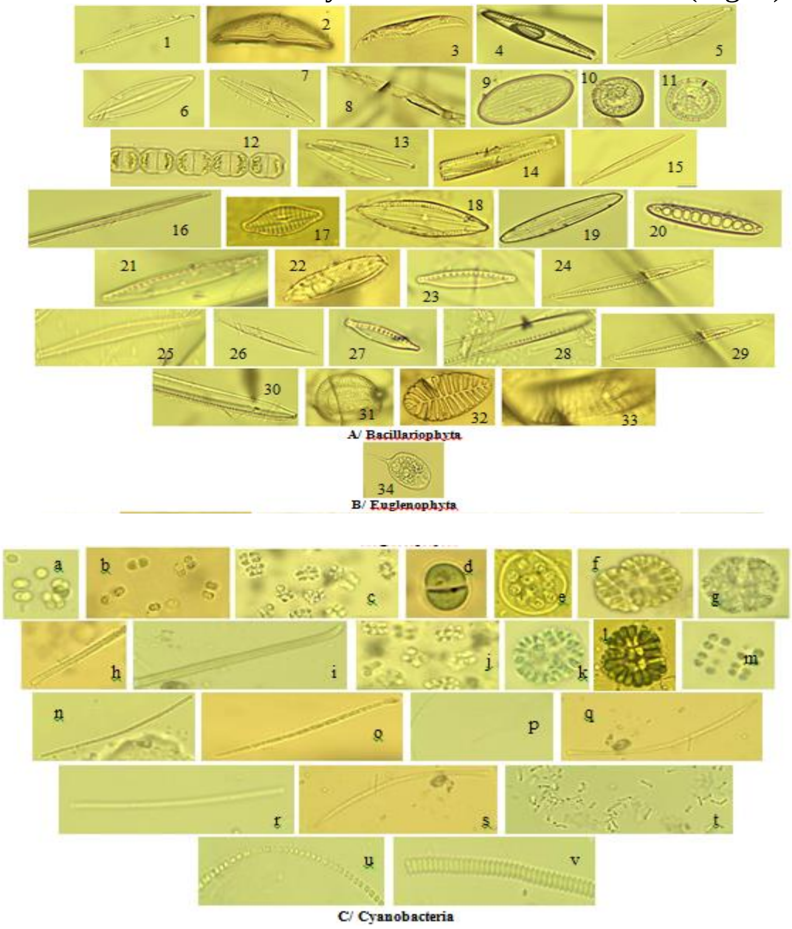

Fig.6. Phytoplankton species in Megarine region (2016).
A : 1) Amphora coffeaformis 2)Amphora ovalis 3)Amphora lineolata 4)Amphiprora (-sp 5)Frustuliarhomboides 6)Brachysiraaponina 7)Naviculahalophila 8)Naviculamargalithie 9)Pleurosigmaangulatum 10)Cocconeisplacentula 11)Cyclotellamenighiniana 12)Cyclotellastriata 13)Melosiradickiei 14)Cymbellapusilla 15)Gomphonemaangustatum 16)Fragilariatenera 17)Fragilariafasciculata 18)Achnanthesminutissima 19)Mastogloiabraunii20)Mastogloiaelliptica 21)Denticulakuetzingii 22)Hantzschiaelogantula 23)Nitzschiaconstricta 24)Nitzschiafonticola roman 25)Nitzschiavitrea 26)Nitzschiageitleri 27)Nitzschiatubicola 28)Nitzschiapalea 29)Nitzschia obtuse 30)Nitzschia recta 31)Nitzschiasigmoidea 32)Campylodiscusclypeus 33)Surirellastriatula 34)Surirellaovata var. pinnata B) 1)Phacusorbicularis. C: a)Chroococcus minutes b)Chroococcusturgidus c)Chroococcuslimneticus d)Cyanothece major e)Gloeocapsasp f)Microcystissp g)Gomphosphaeriasalina h)Oscillatoriachalybea i)Phormidiumchalybeum j)Coelomoronpusillum k)Coelosphareiumsp l)Woronichiniakarelica m)Woronichinianaegeliana n)Merismopediawarmingiana o)Leptolyngbyagranulifera p)Planktolyngbyasp q)Romeriasp r)Jaaginemasubtilissimum s)Pseudanabaena recta t)Pseudanabaena galeata u)Pseudanabaena mucicola v)Pseudanabaena papillaterminata w)Spirulina tenuior

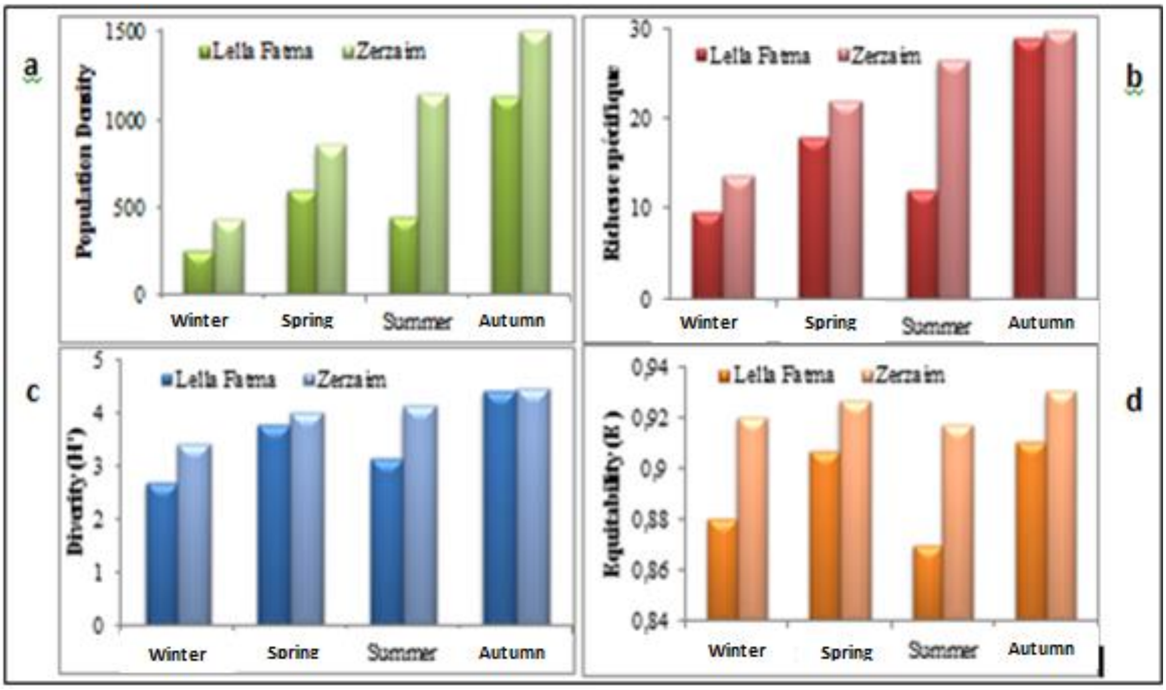

Fig.7. Phytoplankton population in Megarine region ponds' (2016); Density (a), Species Richness b), Species Diversity (c) and Species Equitability (d).

Species richness ranged between 4 and 33 in Megarine ponds'. The highest richness of 33 species which represented 56% of all species were found in November at Zerzaim pond, whereas the minimum species richness of four species was detected at Lella Fatma pond in December. The same results were found during the dry season when the species richness in Zerzaim pond reached double Lella Fatma pond (Fig.7b).

According to their **abundance** in the pond, classes are listed as follows (Table 2): Bacillariophyceae were the most abundant class at the two ponds with 34 species, 39% and 37% respectively. *Mastogloia braunii*, *Amphora coffeaformis*, *Achnanthes minutissima* and *Fragilaria tenera* were the most abundant diatoms encountered during study period, whereas *Chroococcus minutus* and *Chroococcus lemnticus* were the highest abundant two species of blue-green algae. Although the number of Euglenophyceae species was relatively low, this group's total cell abundance represented the 0.2% and 0.38% of the total cells collected during the sampling period. They were represented by *Phacus orbicularis* as the only representative of the class, which only appeared during the dry season. The last one was recorded as an indicator of moderately to strongly polluted water [21]. Reynolds (1998) [22] suggested that the presence of euglenophytes is characteristic of eutrophic to hypereutrophic water bodies in tropical and temperate regions.

The phytoplankton **density** (Fig.7a) ranged between $65*10^3$ and $1610*10^3$cell/l at Megarine region. The maximum density of $1610*10^3$cell/l was observed in the November sample at Zerzaim pond whereas the minimum density of $65*10^3$ cell/l was reported in the December sample at Lella Fatma pond and in February sample with $380*10^3$ cell/l at Zerzaim. In general, higher phytoplankton biomass was recorded in the dry months than wet months (January and Febreury). Throughout the sampling period the **Shannon –Waever** (H') diversity were higher (>1.67) (Fig.7c). The highest diversity values were recorded in October at Lella Fatma and in November at Zerzaim (H'=4.59 and H'=4.54 respectively). The comparison of species evenness (J') between months and sampling areas showed that the highest equitability was recorded during wet months (Fig.7d). The greater values were observed in February and November at Lella Fatma (J'=0.93), whereas in February and September at Zerzaim pond (J'=0.95). The period of high species richness corresponded with the period of lower evenness (Fig .7). Equitability (j) was relatively higher during all seasons (very close to 1) indicating reductions in the degree of dominance across the year.

To understand the dynamics of the phytoplanktonic communities in the water of a Saharan wetland's, case of Oued Righ (Lella Fatma and Zerzaim ponds), we surveyed two ponds of similar size, exposed to the the same climatic influence (temperature and rainfall) and human impact. We performed the sampling during 2016. The results of this early study showed that the phytoplankton community was dominated by diatoms in Lella Fatma and Zerzaim ponds during all study period. The highest densities of phytoplanktons were usually found during dry period ($1610*10^3$cell/l in Zerzaim). Species density increased in the dry season and decreased in the rainy season, due to dilution.

Peak phytoplankton biomass, species richness and diversity were observed during the dry season in both ponds, which was attributed to favorable climatic and hydrologic conditions resulting from elevated temperature, solar irradiation and increased water retention time. Such conditions tend to encourage algal development in lakes [23, 24]. The reasons for such elevation in biomass are more directly attributed to efficient utilization of light and nutrients [25].

Qualitative and quantitative research reveals that the phytoplankton population's evolution and distribution are unpredictable and display major variations depending on the characteristics of the ecosystems in which they live. Indeed the various groups of phytoplankton are sensitive to variations in ecological factors such as temperature, salinity, turbulence, and nutrients which are the precursors of the phenomena that govern the dynamics of phytoplankton groups. The environmental conditions at the origin of these variations are complex and specific to the considered geographic area, as well as to the species, responsible for these variations [26]. The temperatures also influence the entire ecosystem [27].

The **dominant** species was *Amphora coffeaformis, Chroococcus lemnticus (*diatoms), *Mastogloia braunii, Chroococcus minutus*(Cyanophyceae); which composed on average 34% of the density in Lella Fatma and 27% in Zerzaim pond. The genera Pseudanabaena represented by four species (*Pseudanabaena recta; Pseudanabaena papillaterminata ;Pseudanabaena galeata ;Pseudanabaena mucicola*)recorded in the study site are considered potentially toxic [28]**.** The genera Melosira represented by one species *Melosira dickiei* and only in Zerzaim pond during summer and autumn season.

Two phyla (Diatoms and Cyanobacteria) were detected during winter and spring seasons in two ponds (Fig.8), whose diatoms represent more than 70% of species. According to Patrick (1976) [29] diatom community affected by toxic pollution typically has a low diversity and low number of species, which is not our case. In summer, a third phylum was identified (Euglunophycea) but with a very low frequency that does not exceed 2%. However, autumn season Cyanobacteria were the most dominant with more than 56% of species. Cyanobacteria tend to become dominant in turbid water because

they are superior competitors at low light intensity, and once their high biomass has created a turbid environment, other phytoplankton species compete less effectively. A previous study found high cyanobacteria density in water body due to its morphometric parameters and high nutrient availability, and its great capacity to reproduce and absorb nutrients [30, 31].
The **Shannon–Wiener index** values fluctuated between 1.67 and 4.59 in Lella Fatma and between 3.31 and 4.54 in Zerzaim pond. A value of this index above 3 indicates clean water, whereas values lower than this would indicate pollution, noted that the latter was found to decrease with the increase in eutrophication [32, 33]. In the light of these results, we can conclude that Lella Fatma is more polluted than Zerzaim pond.

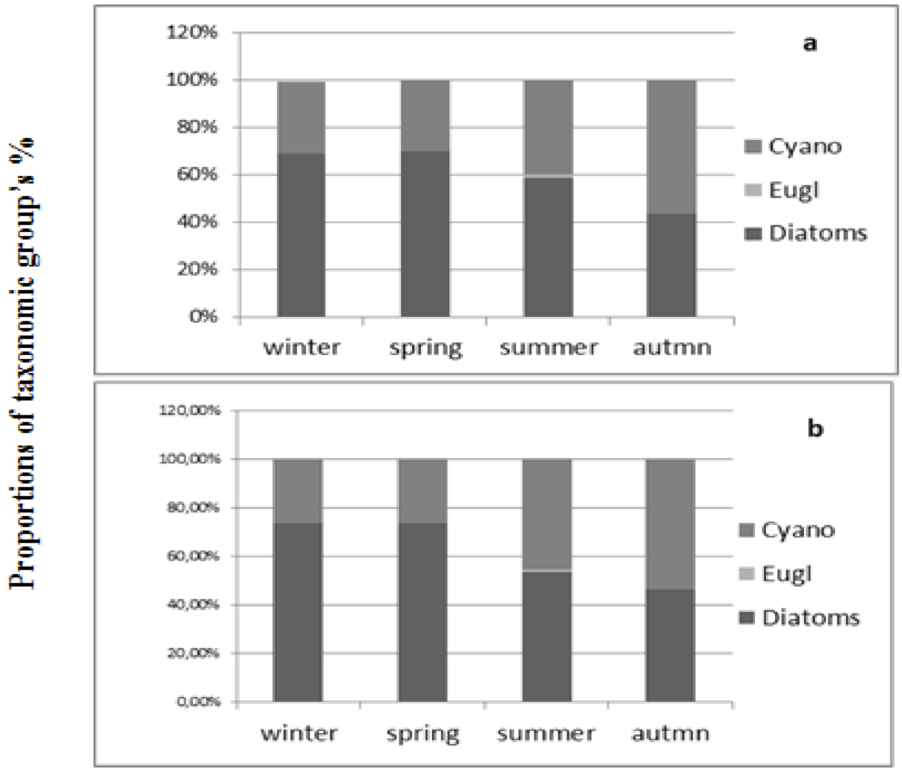

Fig.8. Evolution of the proportions of different taxonomic groups in Lella Fatma (a) , Zerzaim ponds (b) (2016)

4. Conclusion

The ponds of Megarine have interesting environmental characteristics enough to be the subject of much research. Results from this study provide baseline information concerning the population density, species diversity and species richness of phytoplankton in ponds. The maximum diversity of phytoplankton observed during the season where temperature was high in the region. The phytoplankton species composition was found lower in Lella Fatma pond than Zerzaim pond. The same for the population density was higher in Zerzaim pond. These results are probably related to the location of the two ponds, of which Zezaime is located in an area where palm cultivation is predominant compared to Lella Fatma, which makes it more vulnerable to organic pollution which generally affects the diversity of planktonic species.
Therefore, our results suggested that management efforts should be focused accordingly to check the deteriorating water

quality of these ponds. Based on these observations, other researchers can develop concepts to monitor the water quality and biodiversity of different water bodies.

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