

Diatoms diversity in Oubeïra Lake, northeastern Algeria

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ABSTRACT

Mediterranean wetlands are currently subjected to habitat loss and degradation derived from pollution, climate change, eutrophication and the occurrence of exotic species as the most important threats, affecting numerous taxonomic groups. Different tools are being used to assess water quality conditions in these environments, including physicochemical measurements and biological indicators (fish, invertebrates, and diatoms). We aim to study the diversity and ecology of the diatom assemblage inhabiting the RAMSAR site Oubeïra Lake in northeastern Algeria, contributing to the catalogue of diatoms recorded for Algeria. The identification of the morphological characters allowed us to make an inventory of 18 genera of diatoms belonging to 13 families of diatoms. *Navicula* and *Cymbella* resulted in the most abundant genera in the two studied stations during February, June, and August over two years (2017, 2018). The diatom community is structured, with a diversity index (H) equal to ~2.30.

KEY WORDS Algae; PNEK; polluosensitive; Bacillariophyta; Ramsar.

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INTRODUCTION

Aquatic ecosystems are subject to multiple pressures from both natural and anthropogenic sources. Factors such as drought, water transfers, eutrophication and the increase in the amount of organic matter due to agricultural and livestock pressures, generate a worsening of the ecological status that affects the communities of organisms associated with these ecosystems.

Diatoms (Bacillariophyta) are organisms distributed in a wide variety of environments around the world, both in aquatic (freshwater and marine) and terrestrial ecosystems. They constitute an enormously diversified group, with ca. 200,000 different species worldwide. Despite their ecological importance and great diversification in the world's aquatic ecosystems, the diatoms of many regions of the

world remain virtually unknown. In Algeria, Baudrimont (1974) made a first review of the diatoms historically recorded, confirming that the first systematic algal studies of the region date back to the 1930s. Excluding fossil forms, a total of 400 species of continental diatoms have now been recorded in Algeria, with notable contributions by the eminent archaeologists (Belloc, 1893; Debray, 1897). As for the studies of fossil diatoms, the work of (El Ouahabi et al., 2008) on the diatomites of the Boudinar basin is a primary source. The applicability of biological methods for monitoring water status using diatoms has been successfully tested in several hydrographic basins (Fawzi et al., 2001; Nehar et al., 2015). As a whole, the diatom flora of the region is characterized by the predominance of cosmopolitan elements, with planktonic and benthic communities strongly influenced by nutrient concentrations

and, above all, by the presence of electrolytes, with clear environmental gradients associated with the presence of different types of cations.

The objective of this work is to perform preliminary characterization of the diatom flora identity at one of the most important lakes at the national and international level, which is the RAMSAR site Oubeïra Lake in northeastern Algeria.

MATERIAL AND METHODS

Study area

Oubeïra Lake is located in northeastern Algeria (36°50'N, 8°23'E); it is part of the El-Kala National Park (NPEK). Oubeïra Lake has been classified as a RAMSAR site since 4 November 1983. It is a naturally occurring, permanent freshwater body with an area of 2257 ha and a depth of 4 m (Slimani, 2009). Rich in fish (carp); it is a reception area for

various species of piscivorous birds such as gulls, seagulls, cormorants or ospreys (Chalabi et al., 1985). The catchment area covers an area of 9900 ha. Oubeïra Lake is a freshwater lake with no flow towards the sea. The Demnet Erihane wadi to the north, the Boumerchène wadi to the northeast, the Wadi Day Graa to the east and the Wadi Messida to the south are the main wadis that feed the lake. During the rains, the waters of Oued El Kebir pass through Oued Messida to reach Oubeïra Lake and are fed by the Monts de la Chèffia (Marre, 1992). When Wadi el Kebir is at its lowest level, in summer, the waters flow in opposite directions (Joleaud, 1936). These waters are found in the sea near Wadi Mafragh. This simplified schema obviously can not reflect the complexity of existing hydrological exchanges (Messerer, 1999).

Physicochemical parameters

The physicochemical analysis of water in

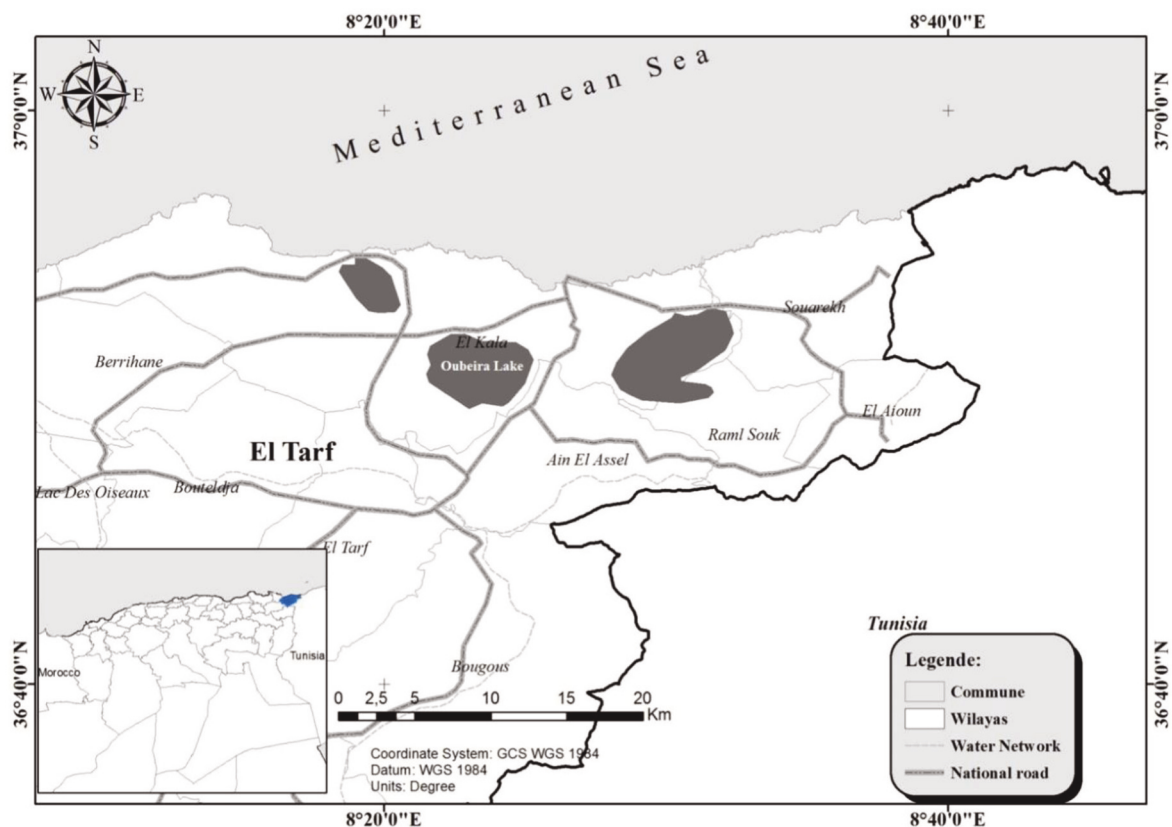


Figure 1. Location of Oubeïra Lake, El Tarf, Algeria (ArcGIS, 2018, modified by Chabaca Hasna).

Oubeira Lake is carried out in the field with a multi-parameter (pH, temperature, conductivity). We called on a private water analysis laboratory for the other physicochemical parameters

Collection and preparation of diatoms

We sampled natural substrates at the edge of the lake collecting biofilm by employing toothbrushes. The collected samples were placed in glass bottles filled with water from the sampling sites, adding neutralized formalin to 10%. In the laboratory, samples were treated with boiling hydrogen peroxide (30%) for 90 minutes to degrade the organic matter, and for five additional minutes with boiling hydrochloric acid (35%) to remove the carbonate inclusions. Then, the samples were subjected to a series of centrifugations for five minutes at 2500 rpm and a succession of rinses with distilled water (3 times). An aliquot of the cleaned sample was deposited on a coverslip, dehydrated on a hot plate and mounted with Naphrax resin on a slide (Unité de recherche REBX, 2013 adapted).

Diatom identification

We performed a microscopic examination of the permanent slides obtained using a LEICA DM

5000 optical microscope. Subsequently, we identified and counted taxa through an immersion oil lens (1000x). In total, on each slide, we identified at least 400 valves based on previous works by (Noël, 1982; Krammer & Lange-Bertalot, 1988, 1991a; Rumeau & Coste, 1988; Meddour, 1988, 1999; Hartley et al., 1996; Al-Asadi et al., 2006; Taylor et al., 2007; Lange-Bertalot et al., 2009; Bey & Ector, 2013; El Haouati, 2015; Taylor & Cocquyt, 2016).

RESULTS

Physicochemical parameters

The physicochemical parameters of Oubeira Lake (Table 1) vary according to the season. The average temperature of the water is 21.5 °C, with a maximum value of 30 °C during the summer period (June, July, and August) and a minimum value of 15 °C during the winter period (January).

The diversity of benthic diatoms of Oubeira Lake

According to our observations, the community identified at Oubeira Lake is typical of fresh and

Year	2017						2018					
Month	Feb		Jun		Aug		Feb		Jun		Aug	
Station	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
T°C	16	16	30	30	30	30	16	16	30	30	30	30
DO	12	12	7	7	5	5	12	12	7	7	5	5
pH	7	7	8	8	8	8	7	7	8	8	8	8
Orthophosphates	2	2	4	4	10	10	2	2	4	4	10	10
Nitrates	30	30	0	0	30	30	30	30	0	0	30	30
Nitrites	2	2	1.9	1.9	3	3	2	2	1.9	1.9	3	3
SM	10	10	53	53	42	42	10	10	53	53	42	42

Table 1. Physicochemical parameters of Oubeira Lake during 2017, 2018.

Year	2017						2018					
Month	Feb		Jun		Aug		Feb		Jun		Aug	
Station	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
S	17	16	13	15	16	16	14	15	14	14	17	17
Diversity	2.331	2.323	2.33	2.277	2.41	2.434	2.133	2.211	2.213	2.223	2.311	2.255

Table 2. Shannon-weaver (H) diversity index and equitability of Oubeira Lake.

Year	2017						2018					
Month	Feb		Jun		Aug		Feb		Jun		Aug	
Station	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	
Amphora	3.96	2.237136465	5.620608899	3.303964758	3.95480226	3.166226913	3.872437358	2.202643172	5.970149254	4.275534442	4.022988506	
Brachysira	3.68	2.013422819	4.683840749	2.202643172	2.824858757	3.957783641	2.733485194	3.303964758	3.731343284	2.375296912	3.735632184	
Caloneis	7.08	6.711409396	5.854800937	7.709251101	5.649717514	8.179419525	4.555808656	7.04845815	7.462686567	8.313539192	6.896551724	
Ctenophora	0.283286119	0	1.170960187	0.8810572687	0	0	0	0	1.243781095	0.9501187648	0	
Cymbella	25.49575071	26.84563758	18.735363	22.02643172	18.36158192	10.55408971	29.61275626	27.53303965	14.92537313	18.76484561	20.11494253	
Cyclotella	9.915014164	7.158836689	11.70960187	14.0969163	8.474576271	10.55408971	9.111617312	8.810572687	11.19402985	16.62707838	12.93103448	
Diatoma	0.566572238	0.4474272931	0	0	1.412429379	0.7915567282	0.4555808656	0.4405286344	0.2487562189	0.2375296912	1.149425287	
Diploneis	0.566572238	0.2237136465	0	0	0.5649717514	0.5277044855	0	0	0	0	0.8620689655	
Fragilaria	4.249291785	3.803131991	5.386416862	4.405286344	5.649717514	5.013192612	4.555808656	4.845814978	6.218905473	6.413301663	4.310344828	
Gomphonema	0.8498583569	2.237136465	0	0.2202643172	1.412429379	2.638522427	0.6833712984	1.101321586	0	0	0.5747126437	
Gyrosigma	11.33144476	7.606263982	9.601873536	8.810572687	9.88700565	10.55408971	13.66742597	9.691629956	9.950248756	9.501187648	8.620689655	
Melosira	2.83286119	3.803131991	4.918032787	3.303964758	4.237288136	5.277044855	1.59453303	0.8810572687	0	0	1.149425287	
Navicula	14.16430595	15.21252796	18.735363	16.51982379	19.7740113	19.78891821	15.9453303	16.96035242	27.36318408	17.33966746	20.11494253	
Neidium	0	0	0	0	0	0	0	0	0.7462686567	0.4750593824	0.2873563218	
Nitzschia	8.498583569	11.63310962	8.196721311	11.01321586	9.88700565	13.19261214	10.02277904	11.01321586	7.213930348	10.6888361	10.05747126	
Pinnularia	1.699716714	3.355704698	1.8735363	2.202643172	2.824858757	2.110817942	0	2.202643172	1.243781095	1.187648456	2.011494253	
Surirella	0.566572238	1.565995526	0	0.6607929515	0.8474576271	1.055408971	0.9111617312	0.4405286344	0	0	0.2873563218	
Synedra	4.249291785	5.14541387	3.512880562	2.643171806	4.237288136	2.638522427	2.277904328	3.524229075	2.487562189	2.850356295	2.873563218	

Table 3. Average frequency of diatoms identified in two stations at Oubeira Lake during 2017-2018.

brackish waters. We identified 18 genera belonging to 13 families of diatoms, two genera belonging to the centric morphology (*Cyclotella* and *Melosira*) and 16 genera are pennate. This form dominated both two stations of Oubeira Lake. During the years 2017 and 2018, the genera *Cymbella* and *Navicula* dominated the two stations of Oubeira Lake. *Caloneis*, *Cyclotella*, *Gyrosigma*, and *Nitzschia* are present with average rates, the genera least present in all the stations are: *Ctenophora*, *Diatoma*, *Diploneis*, and *Neidium*.

The Shannon index calculated according to di-

atom surveys (Tables 2, 3) shows that in the year 2017, February S1 and August S1, S2, are the most diverse in diatoms (17,16,16 genera of diatoms respectively), by contrast in 2018, the richest month in diatoms with 17 genera is August (S1 and S2).

DISCUSSION AND CONCLUSIONS

Our study was conducted at Oubeira Lake, the physicochemical characteristics change according to the sampling station and period, the water tem-

perature of the lake varies from 15 ° C in winter to 30 ° C in summer. The results are similar to the works (Bensafia, 2005; Amri, 2008; Sehili, 2008; Djabourabi, 2014) that have been carried out at the Oubeira Lake, as these seasonal variations allow a good oxygenation of the lake water (Aquaportal, 2016). The average value of the hydrogen potential is slightly alkaline (8.1). This alkalinity could be due to the increase of the diatom communities as

reported (Seyni, 2006) and by an increase of oxygen in the water and by CO₂ consume through photosynthesis (Stum & Morgan, 1991; Martin, 2004). Nutrients are important to the development of photosynthetic microorganisms including diatoms, the orthophosphate reaches a maximum concentration in summer (August) with 10 µmol/l. This value would come from the fine sediments which act as accumulator of this element under the usual oxidiz-

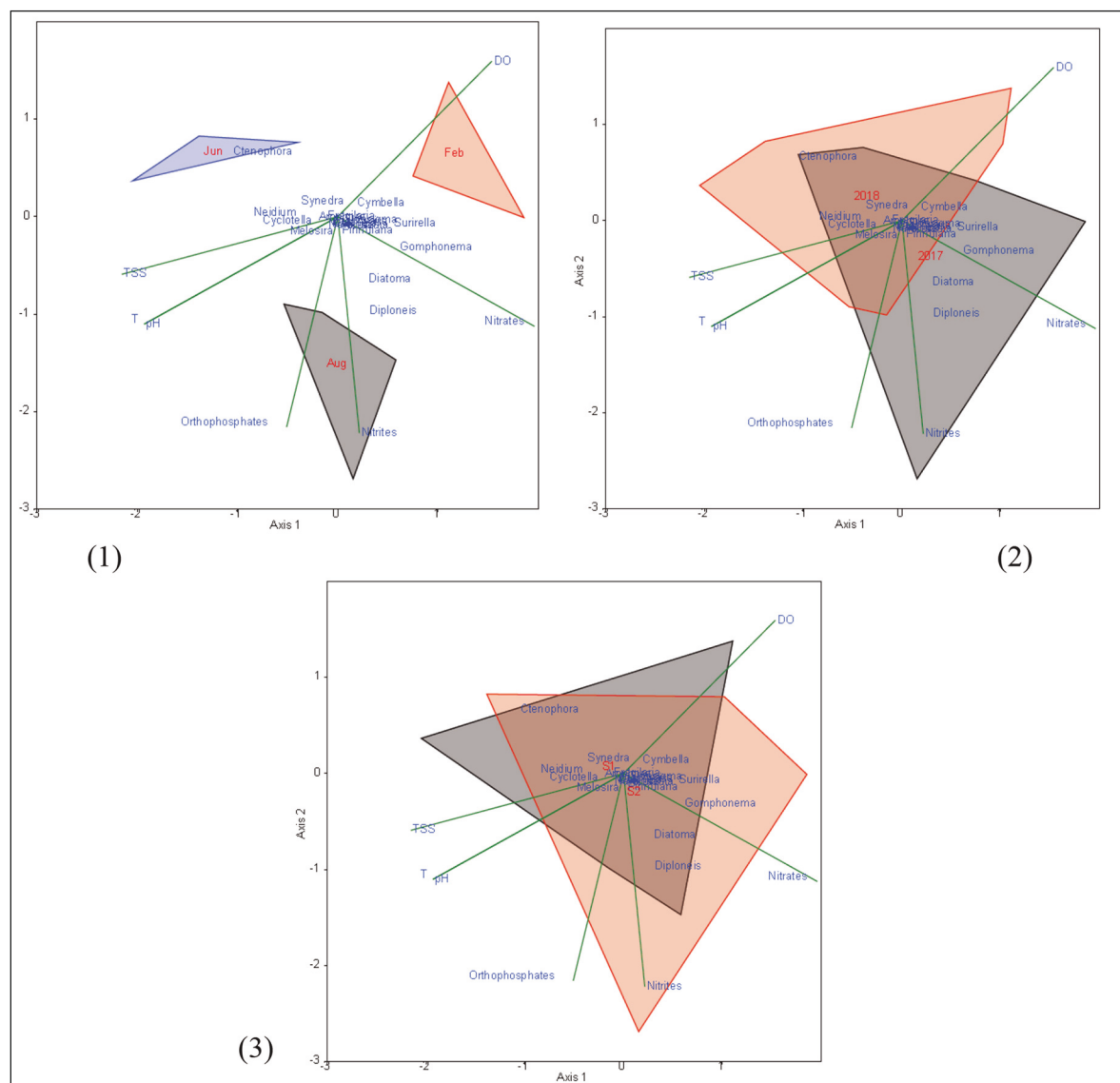


Figure 2. Canonical Correspondence Analysis (CCA) based on correlation between diatoms density and the environmental parameters from Oubeira Lake at two stations (S1 and S2), during February (Feb), June (Jun) and August (Aug), over two years (2017 and 2018). (1) Canonical Correspondence Analysis (CCA) based on the correlation between months of sampling, diatoms and physicochemical parameters of Oubeira Lake. (2) Canonical Correspondence Analysis (CCA) based on the correlation between years, diatoms and physicochemical parameters of Oubeira Lake. (3) Canonical Correspondence Analysis (CCA) based on the correlation between sampled stations (S1 and S2), diatoms and physicochemical parameters of Oubeira Lake.

ing conditions to release it in large quantities if the medium becomes reducing (Sehili, 2008). We found low levels of orthophosphate (0–4 $\mu\text{mol l}^{-1}$), these low levels are due to the high phytoplankton biomass consumption of this element (Seyni, 2006). The same author has shown that phosphorus is used to describe the degree of fertility of lakes when the concentration is lower. At 0.32 $\mu\text{mol l}^{-1}$ the lake is oligotrophic, while it is between 0.32 and 0.68 $\mu\text{mol l}^{-1}$ in mesotrophic lakes and greater than 0.97 $\mu\text{mol l}^{-1}$ in eutrophic lakes. From these results, Oubeïra Lake is considered oligotrophic in winter and eutrophic in summer. According to our experimental study at Oubeïra Lake, nitrate concentration is very high during the two months of July and January, respectively 40 and 45 $\mu\text{mol l}^{-1}$. The elevation of nitrate at the lake level is caused by agricultural discharges. Thus, the concentration of nitrite reaches 6 $\mu\text{mol l}^{-1}$ during July. Our results are very similar to those of Sehili in 2008 in the same study area. The suspended matter at the lake level is very high in spring (March) and summer (July). Our results are very similar to those of Dakki (2003) and Sehili (2008), who explained that the abundant precipitation during the winter and the shallow depth of the lake are at the origin of this rise; abundant rainfall generates floods that contribute to the “fattening” of the lakes by allochthonous inputs. The shallow lake facilitates the transfer of sedimentary particles to the water column by waves created by the wind. As for the summer increase of SS in the lake, it may be related to the high microalgal density observed during this period. We can classify Oubeïra Lake as meso-eutrophic in winter (SM in February = 10mg/l) and hyper-eutrophic (<25 mg/l) in summer. When environmental conditions are favorable, the development of diatoms is at best.

Microscopic observation of the frustules of diatoms sampled at Oubeïra Lake, allowed us to identify 18 genera, dominated by *Cymbella*, and *Navicula*. Sehili (2008) identified 24 genera dominated by *Navicula* and *Fragilaria*. The summer period (August) is the most diverse at Oubeïra Lake; this important diatom population is related to the availability of nutrients, light and especially the high concentration of nitrates. At Oubeïra Lake at the two stations, the average values of the indices is equal to H (2017) = 2.34, H (2018) = 2.22. Chaïb et al. (2011) and Chaïb & Tison-Rosebery (2012) reported the dominance of a single species (*Achnan-*

thidium minutissimum) in the wadi el Kebir in north-eastern Algeria, the mean values of the Shannon index is equal to H = 3.7. In northwestern Algeria, Nehar et al. (2015) studied the diatoms of Oued El Hammam and calculated this index as H = 1.9.

In conclusion, Oubeïra Lake is considered meso-eutrophic in winter and hyper-eutrophic in summer, due to its proximity to neighboring farmland using uncontrolled releases of fertilizers. The availability of nutrients at Oubeïra Lake and the surrounding favorable conditions have contributed positively to the richness of the diatom community. The Oubeïra Lake is a protected natural reserve which shelters a very diversified fauna and flora, the alarming state of this lake is due to the traditional agriculture with its irrational use of the fertilizer and thus the intensive irrigation participant to its degradation and lead it towards eutrophication. Permanent monitoring of the water quality of Oubeïra Lake is required, and diatoms can be used as bioindicators of water quality.

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