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Density and Biomass of Phytoplankton in the Oubeira Lake (North-East Algeria)

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Abstract: The Oubeira Lake constitutes a vast extent of fresh water (5436 acre) of a maximal depth of 5m. Exploited for the irrigation, the drinking water and the extensive raising of 9 fish of which the silvery eel and the microphage species of Carps. This lake is considered as one of the biggest RAMSAR sites of Algeria (36°50'N, 8°23'E). The composition and the biomass of the phytoplankton have been analyzed monthly in three stations of the Oubeira Lake during a yearly cycle (October 2000-September 2001) in addition to the environmental parameters. The water temperature varied all along the months between 9 and 30 °C, the pH between 6.1 and 7.9, whereas the conductivity remained in the order of 1 mS. Unusually, the year 2001 was very little rainy with only 575 mm. The phytoplankton is formed mainly by the Cyanobacteria, Chlorophycea, Diatoms and in a least measures Euglenophycea. This basic population develops active densities up to 4×10^5 ind.L^{-1}. The monthly middle biomass is 203 μg CL^{-1}. This stock is made largely of the Cyanobacteria (32.5%) Chlorophyceae (27.1%) Diatoms (24.6%) and the Euglenophyceae (15.6%). The biomass reflects an important fertility and represents a wealth of the Oubeira

Key words: Oubeira lake, density, biomass, Phytoplankton, Algeria

INTRODUCTION

The Lake Oubeira belongs to the natural protected reserve of El Kala, it occupies a surface area of 5436 acres with a catchment's area covering approximately 24 710 acres and a height of 25 m (Belair, 1990; Tomas, 1977). It is fed primarily by the brook of Messida formed from the surrounding marsh, whereas in summer the hydrological system functions in opposite direction (Marre, 1987). Oubeira is a fresh water Lake, without flow towards the sea; it has a particular importance because of its great capacity of receiving wintering water birds and plays a multiple legal protection from its geographical and ecological importance. The Lake Oubeira is registered in the list of RAMSAR Convention in 1983 as a wetland with considerable biological richness (Van Dijk and Ledant, 1983). The contributions in nutritive substances, in particular by surface waters, support the enrichment of the water level. In addition, the introduction without preliminary study, of two planktivorous fish species, the Chinese carp and the large mouth in the Lake could have a great effect on biological balance and the operation of the ecosystem. In addition to the ecological problem, specific proliferation of Cyanobacteria whose toxic species appear in spring and in summer (Bensouilah *et al.*, 2003). Thus, the low depth of Oubeira, its exploitation for fishing, for irrigation and for the production of drinking water, requires a rigorous monitoring of water, in particular the toxic species of phytoplankton. It should be stressed that Oubeira phytoplankton and up to now was given only rare specific studies.

The objective of this research therefore, consists of studying the density and the biomass of the little known Oubeira phytoplankton, as well as the seasonal dynamics of the species observed.

MATERIALS AND METHODS

Study site presentation: The Lake Oubeira is situated in the National park of El-Kala and ranked the second in water level after the Lake Tonga. It is located at 36°50 ' N and 38°23' E and at approximately 25m of altitude (De Belair, 1990 and Messerer, 1999). It acts as a fresh sheet of water, surrounded by sandy clay slopes of a surface of approximately 22 km^2 with a maximum depth of 5 m according to pluviometry. Oubeira Lake presents a typical space organisation, surrounded by vegetation with an important surface area colonised by floating herbs of hydrophytes (Miri, 1996). The quality of water represents a double use, for human consumption and the irrigation as well. Phenomena of filling by the sedimentation of alluvia and plant organic matter reduce the water blade and involve an acute silting of the Lake. Oubeira is fed

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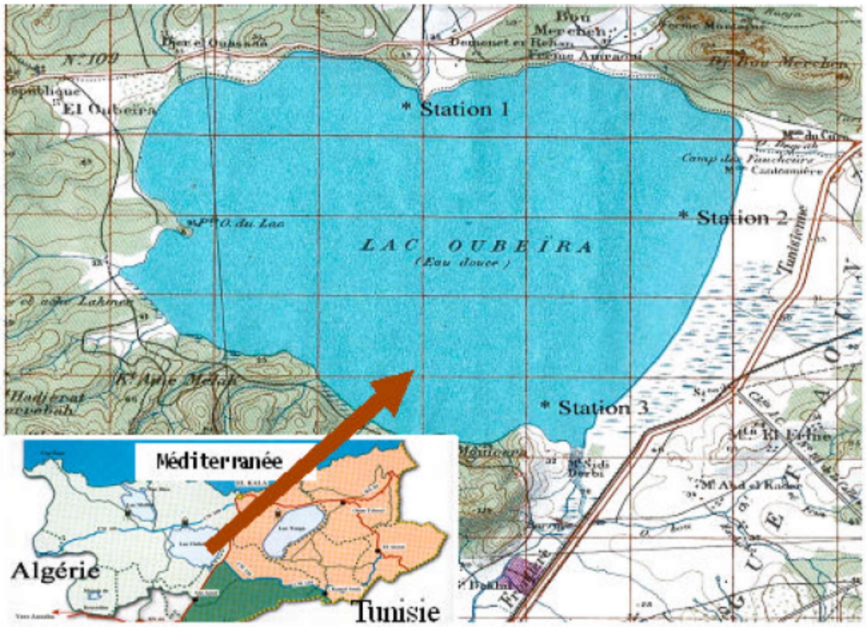

Fig. 1: Geographical situation of the Oubeira Lake and location of the 3 sampling stations

primarily by the brooks Boumarchen and Messida in the south-eastern zones, with a small depth, thus creating a large marsh in certain periods. However, during large rains of winter, water of the El-Kebir River invades this marsh and it joins the Lake through the Messida River (Fig. 1). The latter has the characteristic to run out alternatively in the two directions according to the level of Oubeira filling (Marre, 1987).

Sampling: Monthly samplings were carried out during the period of October 2000 to September 2001. Three stations were selected according to their situation with respect to the continental contributions and according to an axis of north-south wind influence (Fig. 1) and thus of water circulation. The station 1 in the north is not subjected to any anthropic influences. The station 2 located at the centre of the lake, is subjected directly to the contributions of a small brook, finally the station 3 located at the south-east is under the direct influences of the surplus contributions of the surrounding marshes.

Each sample corresponds to three collections carried out with a depth of approximately 1 meter. Measurements of pH and temperature are taken using a field pH-meter (PHYWE 0713900) whereas the conductivity is measured with a conductimeter (JENWAY 4071).

For the phytoplankton, three samples are taken in each station and a fraction of 100 mL of each sample is fixed at Lugol's solution, concentrated and then stored in the cold and darkness. The sub-samples are left to precipitate during 12 h in counting tanks. The phytoplankton was counted using an inverted microscope according to the method of Utermöhl (Utermöhl, 1958).

The bio-volume of the various invidious belonging to the found principal phytoplanktonic classes (*Cyanobacteria*, *Chlorophycea*, *Diatoms* and *Euglenophycea*) was estimated according to the method of Bratbak (1985). The individual bio-volume is calculated starting from the average of the dimensions measured on a hundred cells. The biomass (expressed in $\mu g.C.L^{-1}$) was estimated by using the conversion factor of carbon bio-volume-equivalent, by considering that $10^6 \mu m^3$ is equal to 1 µg fresh matter, in which 12% of fresh water represents the organic carbon biomass, proposed by Amblard *et al.* (1995).

RESULTS

Physical and chemical characteristics: Figure 2 shows that during the period of October-February, strong values of rainfall have been recorded, with in particular 108 mm in December. The winter cumulates 295 mm with 52% of the sum of annual rainfall. During low water level the values were as low as 0.36 mm. In winter, however, water temperatures decreased to 9°C and the maximum of temperature observed in summer (August) was of 30°C (Fig. 2). The recorded values of pH oscillate between 6.1 and 7.9 throughout the seasons and become somewhat acid between March and August, as for conductivity, which varied very little during the year with an average of about 1 ms in the three sites of samplings (Fig. 2).

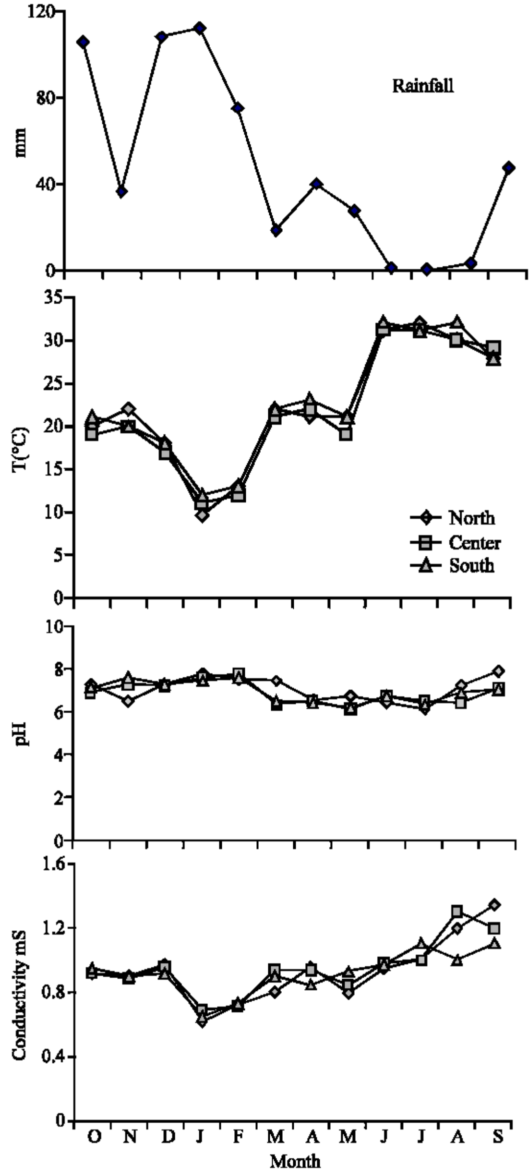

Fig. 2: Monthly variation of rainfall, temperature, pH and conductivity in the 3 sampling stations of Oubeira Lake (October 2000-September 2001)

Phytoplankton abundance: The quantitative evolution of the phytoplankton was independent of the seasons in the northern station with a monthly average of approximately 0.35×10^5 ind.L^{-1} (the maximum in May was 0.52×10^5 ind.L^{-1}) whereas in the central and southern stations, in spring, the phytoplankton peaks were up to 4×10^5 ind.L^{-1} (Fig. 3). During the summer, the phytoplankton densities relatively decreased reaching 2.4×10^5 and 3.2×10^5 ind.L^{-1} in the center and the south, respectively. The monthly averages in these stations are 2.5×10^5 ind.L^{-1} in the center and 3.0×10^5 ind.L^{-1} in the south (Fig. 3).

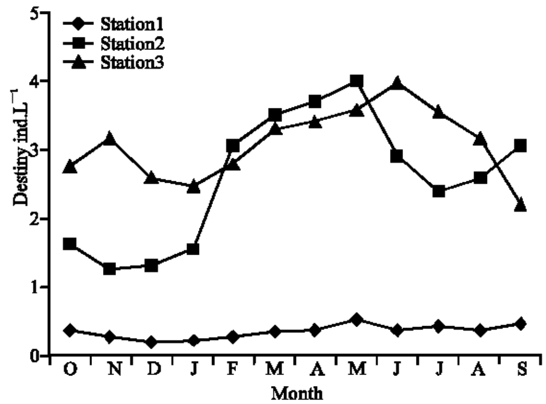

Fig. 3: Monthly variations in the total phytoplankton density (10^5 ind.L^{-1}) in the 3 sampling stations of Oubeira Lake (October 2000-September 2001)

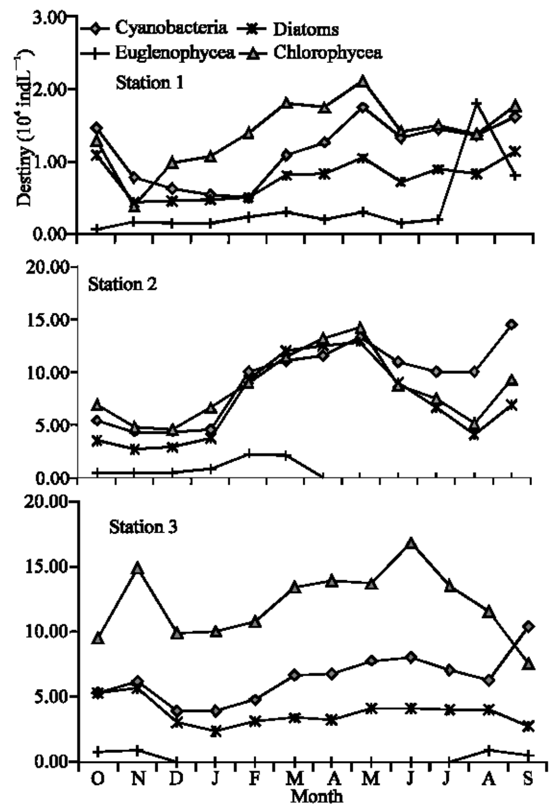

Fig. 4: Density evolution (10^4ind.L^{-1}) of the different classes of Phytoplankton in the 3 sampling stations of Oubeira Lake (October 2000-September 2001)

According to various classes of algae (Fig. 4), Chlorophycea dominate in all stations with values reaching 14×10^4 ind.$L^{-}$and 16×10^4 ind.L^{-1}, respectively, in the center and in the south. Contrary, the Euglenophycea

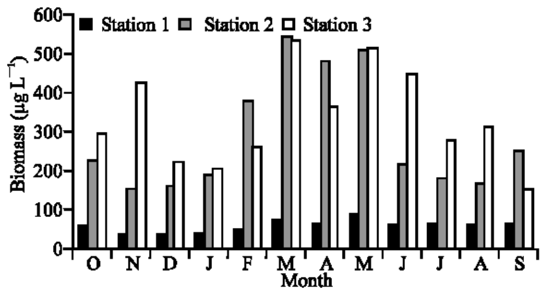

Fig. 5: Monthly variations of total biomass (µg CL^{-1}) in the 3 sampling stations of Oubeira Lake (October 2000-September 2001)

were minority, particularly in the center and the south with very low values to see null in the center and the south of the Lake. As for Cyanobacteria and Diatoms, their presence in Oubeira is regular during the year. In addition, the seasons of spring and summer were the most favourable to the phytoplankton development.

Phytoplankton biomass: The total Phytoplankton biomass fluctuated differently according to stations, with low values varying only between 36 and 88 µg CL^{-1} in north and of the values more raised definitely, in the center and the south, respectively, reaching 544 and 533 µg CL^{-1} (Fig. 5). The maximum biomass is recorded in spring and to a lesser extent in summer period. The monthly general averages in the three stations according to the southern northern axis i.e., that of the dominant winds, were, respectively, 58, 287 and 333 µg CL^{-1}.

The northern station is characterized by weak annual productions of biomasses with 694.5 µg CL^{-1} after comparing with the 2 other stations, where the biomass was definitely higher than 3000 µg CL^{-1}. In addition, Chlorophycea dominate with 350.2 µg CL^{-1} followed by Euglenophycea with 161.7 µg CL^{-1}, the Cyanobacteria (127.2 µg CL^{-1}) and the Diatoms were the least productive (55.5 µg CL^{-1}) in this station. The biomass varied very little on the level of the northern station with a minimum of 36 µg CL^{-1} in November and a maximum production which was always recorded in spring period with 87.6 µg CL^{-1}.

In general, the biomass in Oubeira was dominated by the classes Chlorophycea and Cyanobacteria, which seem to proliferate, especially in spring and summer by developing biomasses going from 107 µg CL^{-1} to 417 µg CL^{-1} during the period of March-July (Fig. 6).

In the center of the lake (station 2) the Chlorophycea class dominates the other phytoplanktonic classes with a monthly biomass average of 172 µg CL^{-1}, that is to say more than 59% of total phytoplanktonic stock. It was in spring that the biomasses were strongest varying between 320 µg CL^{-1} and 433 µg CL^{-1}. As one can note it in Fig. 6, Euglenophycea, the Diatoms and Cyanobacteria come in the third rank with a comparable contribution in average biomasses, that is to say approximately 38.5 µg CL^{-1} per month (Fig. 6).

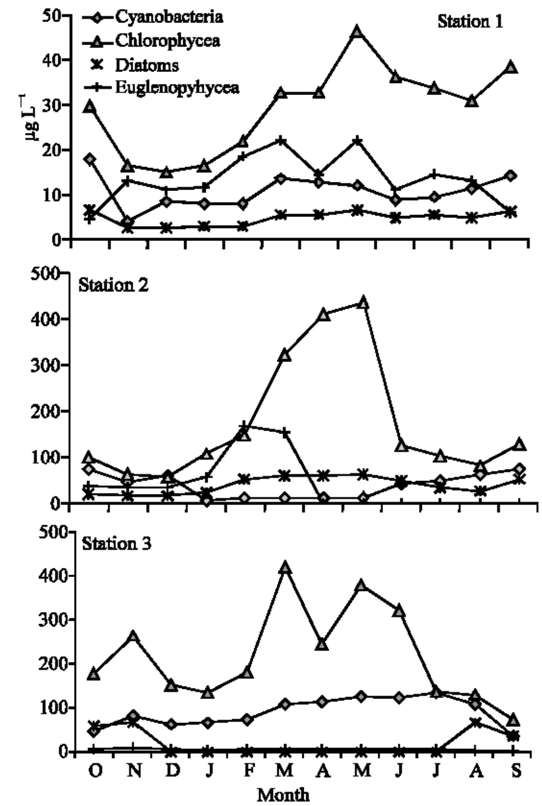

Fig. 6: Monthly variations in the biomass of the different phytoplanktonic classes (µg CL^{-1}) in the 3 sampling stations of Oubeira Lake (October 2000-September 2001)

Figure 6 shows that the monthly average of biomass at the southern station was 333 µg CL^{-1}, i.e. the most productive which was primarily due to the classes of Chlorophycea and Cyanobacteria with a monthly average, respectively of 216.9 and 90.6 µg CL^{-1}, representing more than 90% of the biomass. Euglenophycea and the Diatoms, definitely minority, have produced only 19 and 6.5 µg CL^{-1} at any season.

DISCUSSION

Several work, in particular those of Garnier *et al.* (1995) and of Sept and Reynolds (1995) showed that the phytoplanktonic production of a water level was related to the temperature, the light, the nutrients and chattering.

The variation of the physical parameters in Oubeira reflects sub-humid conditions characterized by two great periods, a soft autumn and winter with low temperatures and a spring and a summer characterized by an increase in the photoperiod and temperature.

Early in spring, these physical factors (contributions in nutritive elements, increase in the photoperiod and the temperature) support the fast increase in phytoplankton, which resulted in the phytoplanktonic density augmentation from 6×10^5 ind.L^{-1} in February to 8×10^5 ind.L^{-1} in May. In general, it has been observed weak variations of the physical parameters in the level of the tropical Lakes, which according to Melack and Fisher (1990) generally have a lower seasonal variability of their physical and chemical characteristics than those of Lakes located in the moderate zones. The pH of Oubeira water has fluctuated between 6.1 and 7.7, which corresponds to the optimal zone for the phytoplankton productivity (Arrignon, 1991).

The obtained results showed obviously that the northern station was less populated, whereas the central and southern stations were richer of phytoplanktonic density and consequently in biomass. Indeed, the central and southern stations were subjected to various contributions of fresh water effluents from the two small rivers; Messida and Boumarchen, bringing the by-products of agricultural activity. In addition to the vast catchment's area consisted of the mounts of El-Kala to the east and those of El-Frine in the south, bringing organic matter and micro-organisms, which contribute to the enrichment of the Lake. Nevertheless, the fluctuations of the densities differ according to physical and chemical conditions of the medium, in particular the temperature which is a determining factor in the phytoplankton development (Caplancq, 1995). Thus, temperature variations can have direct effects on the development of certain species which according to Arrignon (1991) are grown more easily with preferential thermal intervals, knowing that Oubeira is not a very deep Lake.

The distribution of the phytoplankton in the three stations showed that it was the northern station which was lowest in micro-algae with an average value of 0.35×10^4 ind.L^{-1}; the maximum density was observed in spring in the southern station. Contrary to the northern station, the central and southern stations expressed comparable densities; however, the values were higher than in the north of the Lake. In winter, however, the Chlorophycea and Cyanobacteria have dominated in densities. The strongest densities were recorded in the southern station with a monthly average of 3.1×10^5 ind.L^{-1}, comparable with those of the Lake center (2.6×10^5 ind.L^{-1}). Indeed, the increase in the temperature in spring allowed a renewal of the phytoplankton activity, in particular in the Lake center and consequently a stronger production of biomass. In the south, from March to September, the values of biomasses were more important, which have been supported primarily by Cyanobacteria. Nevertheless, the phytoplankton densities were from low to constants in the period of high temperature, which suggests that a part of the phytoplankton can be consumed by the higher trophic chain (Caplancq, 1995). In general, the low phytoplanktonic densities, in all the stations, were due to the low depths of the Lake, on the one hand and to the strong light intensity, on the other hand, which according to Huovenen *et al.* (1999) would inhibit the phytoplankton development on the surface water. This horizontal stratification can be justified by the very important contributions of organic matter and minerals, in particular of nitrogen and phosphorus, by the catchment's area due to fertilizers used in the agricultural activities of the neighbouring farms. In addition, the influence of the wind in this distribution is not excluded because Oubeira is very open and it is with a height of approximately 25m (Belair, 1990) which exposes it to the winds prevailing of the neighbouring Mediterranean Sea. Also the low Lake depths in the southern area, sometimes marshy, would probably contribute to a better proliferation of many species in this zone as the case of Chlorophycea and the Cyanobacteria. In addition to the marshy character of these zones, the central and southern stations were often subjected to intense winds with variations in temperature, which make it possible to note a certain distribution and diversity of the phytoplankton. Indeed, Reynolds (1984) pointed out that because of the variations in temperatures, the wind intensity and rain, on one hand and of the morphometric changes and the various trophic levels of the lakes, on the other hand, there exists a relatively large diversity of the phytoplanktonic populations.

Moreover, our results prove that the Lake Oubeira is an ecosystem very favourable to the phytoplankton proliferation, in particular the classes Chlorophycea and Cyanobacteria, with a regular presence at any season. The study of Schultze *et al.* (1995) has highlighted that each phytoplanktonic class has its own optimum conditions for growth.

The comparison between the production of monthly and annual biomass in the three stations revealed that the northern station produced a minimum of biomass whose values did not exceed 8.5% independent of the seasons. On the other hand, the central and southern stations have produced, respectively 42.3 and 49.2% with 91.5% of the total lake biomass, with varying percentages according to seasons. Also it can be noticed that during the winter period, the biomasses were in generally weak. The sub-tropical character of the region climate has induced weak seasonal variations of the abundance, the biomass and the phytoplankton productivity with a little marked succession of the species (Lewis, 1979; Smayda, 1980; Richerson and Carney, 1988). These last authors noted however, that the biological processes can fluctuate in an endogenous way in the absence of external environmental fluctuations.

The recent introduction of Chinese carp into Oubeira Lake is probably at the origin of the Cyanobacteria domination, because there is a reduction in N:P ratio. According to Sanders *et al.* (1980) it is possible to atmospheric nitrogen fixing Cyanobacteria to proliferate and dominate in the watery systems where the N/P ratio is equal to 5:1 (Findlay *et al.*, 1994) and/or the pH is higher than 8 (Prescott *et al.*, 1995). This presence in considerable quantity of Cyanobacteria was generally accompanied by an increase in the biomass (Chorus and Bartram, 1999) and consequently by a high production of toxins, which could generate intoxications to animal and man.

The diversity and irregularity in the species frequency appearance of Oubeira are explained according to Bourrelly (1991) by a specific characteristic particular to each watery ecosystem. Thus, it proves that each genus shows different capacities of adaptation in connection with its environmental conditions. Bensouilah *et al.* (2003) counted a maximum of 3×10^4 ind.L^{-1} of Cyanobacteria in April with a prevalence of the *Microcystis* genus, followed by the genus *Anabaena* and *Oscillatoria*, which was confirmed by the actual study. According to Murphy *et al.* (1976) certain species belonging to the genus *Anabaena* and *Microcystis* can be dominant owing to the fact that they secret a chelating substance, which increases their growth, or it directly prevents that of algae in competition, or the two effects at the same time. Moreover, the high water temperature (25°C) of Oubeira would support, according to Robarts and Zohary (1987) the growth of Cyanobacteria even if these authors report that the direct effects of the temperature are secondary compared to both the temperature indirect effects and the nutrients. The Cyanobacteria blooms, which play important role in the atmospheric nitrogen fixing in fresh waters was already known (Zehr *et al.,* 2001). This domination and regular presence of Cyanobacteria could mean real presence of toxins with real threat to the public health, because according to Kotak *et al.* (1996) there was a strong correlation between the concentration of phytoplanktonic toxins and the abundance of water Cyanobacteria.

CONCLUSION

It can be said that the Oubeira Lake is dominated by Chlorophycea and contains one of the very favourable conditions to the Cyanobacteria development. The continuous presence of Cyanobacteria and in great quantity requires the installation of a permanent checking routine of Lake water. In addition, regular follow-up of the physicals and chemicals parameters and the spatio-temporal dynamics of these micro-algae, particularly in the bloom period are more than necessary, because of the potential risk that they can constitute for the public health. The actual knowledge of the dynamic and phytoplankton biomass of Oubeira Lake would be beneficial for future work, not because it gives the Lake species composition only, but also it will tells about any future variations, due to the rapid changes of the ecosystems.

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