THE INFLUENCE OF AQUATIC MACROPHYTES (*Potamogeton crispus, Myriophyllum spicatum*) ON PHYSICAL AND CHEMICAL PARAMETERS OF THE TINERETULUI LAKE, BUCHAREST

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Abstract. *In the paper we present the influence of the aquatic macrophytes Potamogeton crispus (LINNAEUS 1753) and Myriophyllum spicatum (LINNAEUS 1753) on some physical and chemical parameters caractherizing the Tineretului Lake in Bucharest, especially on the transparency, pH, carbonate contents, the dissolved oxygen and the dissolved carbon dioxyde concentrations, the nitrites, the nitrates and ammonia concentrations. The presence or the absence of the aquatic vegetation has drastically influenced the quality of the lake's water, with complex and immediate effects on the primary and secondary productivity in terms of biomass and diversity. The replacement of the macrophytic vegetation with a large phytoplankton bloom following the harvesting of the first by mechanized means is visible in the evolution of the physical and chemical parameters. The best water quality corresponds to a maximum development of the Potamogetoneto-Myriophyletum as shown in the evolution of the measured parameters while the worst quality coincides with the absence of the macrophytes from the Tineretului Lake. Since the Tineretului Lake from Bucharest has never been studied before, although it has a rich and diverse biocenosis, this first study is particularly important for its physical and chemical characterisation.*

Keywords: *aquatic macrophytes, water quality, Tineretului Lake, Bucharest.*

Rezumat. Influenţa macrofitelor acvatice (*Potamogeton crispus, Myriophyllum spicatum*) asupra factorilor fizico-chimici din Lacul Tineretului Bucureşti. *În acest articol prezentăm influenţa macrofitelor acvatice Potamogeton crispus (LINNAEUS 1753) şi Myriophyllum spicatum (LINNAEUS 1753) asupra unor factori fizici şi chimici ce caracterizează Lacul Tineretului din Bucureşti, in special transparenţa, pH-ul, concentraţia totală de carbonaţi, concentraţia de oxigen dizolvat şi de dioxid de carbon dizolvat, cea a unor compuşi ai azotului. Prezenţa sau absenţa vegetaţiei acvatice a influenţat drastic calitatea apei lacului cu efecte imediate şi complexe asupra productivităţii primare şi secundare în termeni de biomasă şi de diversitate. Înlocuirea vegetaţiei de macrofite cu un important bloom fitoplanctonic în urma recoltării prin mijloace mecanizate a celei dintâi, se poate decela din evoluţia parametrilor fizici şi chimici ai apei lacului. Cea mai bună calitate a apei a corespuns dezvoltării maxime a Potamogetoneto-Myriophyletumului, dupa cum se observă în evoluţia indicilor măsuraţi, în timp ce calitatea cea mai slabă a apei corespunde cu absenţa macrofitelor din Lacul Tineretului. Deoarece Lacul Tineretului din Bucureşti nu a mai fost studiat până în prezent, deşi posedă o biocenoză diversă şi bogată, acest prim studiu este deosebit de interesant pentru caracterizarea sa fizico-chimică.*

Cuvinte cheie: *macrofite acvatice, calitatea apei, Lacul Tineretului, Bucureşti.*

INTRODUCTION

Although the Tineretului Lake, from the Tineretului Park in Bucharest, had a varied, complex and equilibrated biocenosis since at least 30 years ago, there are no biological or hydrological studies on this subject. Due to its separation in two differently used sectors, the north-eastern part, subject to anthropisation, and the northwestern part, seldom used in anthropic activities, this lake can provide the needed instrument for the far-reaching study of the ecological role of the aquatic macrophytes in the lake ecosystems, in our case the role of *Potamogeton crispus* and *Myriophyllum spicatum.* In the present article we present the results of the survey of physical and chemical parameters of the lake along a vegetation cycle between 2007 and 2008.

The Tineretului Lake began its existence in 1974, following the creation of the Tineretului park in one of Bucharest's poor central neighbourhoods, initially called „The Valley of Tears". Unlike the majority of the other lakes of the capital city, this one is not situated on neither of the rivers crossing the Bucharest area, the Colentina and the Dambovita and, in this circumstances, it is not surveyed by the Environmental Protection Agency of Bucharest.

Until now, this lake has not been the object of ecological or biological studies (according to a verbal communication of Prof. Dr. Angheluta Vadineanu in January 2008).

From the author's observations and the communications of the Lake's administration personnel, we conclude that the lake is fed by several subterranean sources, big enough to ensure a constant level of the lake's water, even during dry periods like the summer of 2007. Theses springs are maintaining pockets free of ice during winter, even if the lake's surface freezes to a depth of 30 cm, as it happened in December 2007-January 2008. Eleven such sources have been counted, all situated in the north-western end of the lake. The water flows very slowly to the south and then to north-east, where a letting out valve allows the excess of water to pour into the Dambovita waste water collector.

The lake is divided in two water bodies by a transversal elevated area situated undet the concrete bridge in the eastern side of the lake (Fig. 1). These waterbodies have different uses: the north-eastern sector is occupied by a restaurant built on piers and it is used for recreation. Because of that specific use, the vegetation is periodically harvested in order not to encumber the pleasance boats. The southern and the north-western sector are used only for line fishing, with no or very small incidence on the fish population most of the year. This segment is strongly populated by submerged macrophytes, especially in the southern part.

The presently repertoried macrophytes are *Potamogeton crispus* with large colonies, followed by *Miriophyllum spicatum* (next by biomass production). The other vegetation species observed are the filamentous algae from the genus *Cladophora* and *Spirogyra.*

At the end of the autumn, in November and December, the Lake's administration harvests art of the fish populations in nets in order to allow the wintering of the remaining population in good conditions, given the fact that the water level decreases during winter.

Fig. 1. The satellite map of the Tineretului Lake in Bucharest (1:10,000). The red squares from 1-6 mark the sampling points. The lines I and II mark the plankton sampling transect trajectories. The dots 1 and 2 are situated in the area called « Oala Mica »; the dots 5 and 6 are situated in the area « Terasa ». The restaurant on piers is indicated by the brown polygon T.A. (image by Google Earth 2007).

Fig 1. Harta satelit a Lacului Tineretului din Bucureşti, scara 1 :10 000. Pătratele roşii 1-6 marchează punctele de prelevare a eşantioanelor. Liniile I şi II marchează traseele transectelor de prelevare a zooplanctonului. Punctele 1 şi 2 sunt amplasate în zona « Oala Mică », punctele 5 şi 6 sunt amplasate în zona « Terasă ». Unitatea de alimentaţie publică este indicată de poligonul brun « T.A. » (imagine Google Earth 2007).

The lake is inhabited by a sedentarized population of mallards *Anas plathyrhyncos* (LINNAEUS 1758) of approximately 50 individuals, males and females in equal proportion and is visited occasionally by common golden eye ducks *Bucephala clangula* (BOIE 1822) and gadwall ducks *Anas strepera* (LINNAEUS 1758) (according to C.S.III dr. Andrei Giurginca - verbal communication from March 2008). It is also inhabited by sedentarized populations from three species of seagull: *Larus argentatus* (PONTOPPIDAN 1763)*, Larus ridibundus* (LINNAEUS 1766) and *Larus canus* (LINNAEUS 1758) and in February – March 2008 some pairs of little grebe, *Tachybaptus ruficollis* (PALLAS 1764) and mute swan, *Cygnus olor* (GMELIN 1789), the latter accompanied by juvenile specimens.

Other observed species: mollusks (*Viviparus* spp.), several species of herbivorous fish (*Scardinius erythrophtalmus* (LINNAEUS 1758) - rudd, *Cyprinus carpio* (LINNAEUS 1758) - carp, *Carassius carassius* (LINNAEUS 1758) – crucian carp, *Ctenopharingodon idella* (VALENCIENNES 1844) - grass carp, *Hypophthalmichthys nobilis* (RICHARDS 1845) – bighead carp, *Pelecus cultratus* (LINNAEUS 1758) - sabre carp) and predatory fish (*Silurus glanis* (LINNAEUS 1758) - catfish, *Perca fluviatilis* (LINNAEUS 1758) - European perch, *Esox lucius* (LINNAEUS 1758) - northern pike), amphibians (*Rana esculenta* (LINNAEUS 1758) - edible frog), as well as turtles of at least two species: the red ear slider, *Trachemys scripta elegans* (WIED-NEUWIED 1839) , and the protected species *Emys orbicularis* (LINNAEUS 1758), the European pond turtle (a young specimen observed by the author in July 2008).

METHOD

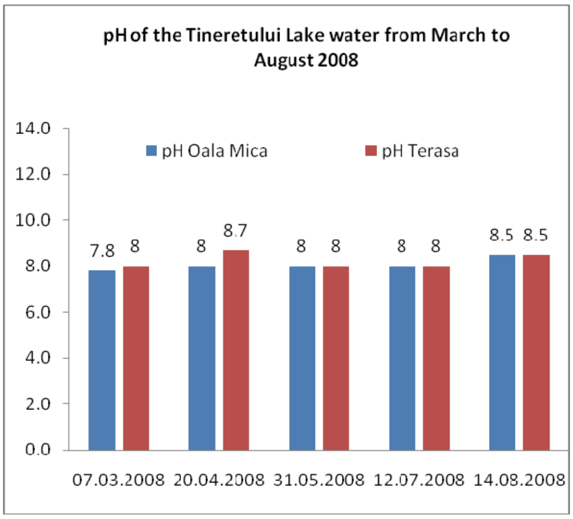
For the physical and chemical characterization of the lake's water the author used the colorimetric titration method. In the beginning, trials were performed for all the ecologically significant points: springs, islands, free water area and vegetated areas. The differences between the obtained results were not detectable by the tests accuracy. The relevant result was a graduation of certain environmental factors from the two areas: "Oala mica", in the north-western sector, where the subterranean sources are situated, and the "Terasa" point, near the outflow valve, considered as the discharge point. These two points allow the water quality survey to be performed highlighting the differences between the initial parameter value and the final parameter value, after the passage of the waterflow through the macrophytic vegetation.

The following parameters have been tested: pH, carbonate and bicarbonate concentration, dissolved oxygen content, dissolved carbon dioxide content, nitrite and nitrate content, ammonia content. The water transparency has been measured with the Secchi disk (PRICOPE et al., 2007). Other registered parameters were: wind speed, nebulosity, sampling hour, air and water temperature.

RESULTS AND DISCUSSIONS

In the following chapter we will present the results of the water quality survey in the Tineretului Lake in Bucharest during October 2007 – August 2008, during a vegetation cycle of the aquatic macrophytes (*Potamogeton crispus*, mostly, followed by *Myriophyllum spicatum*) which included a complete harvest of the macrophytic vegetation in May 2008.

During the surveyed period the vegetation started to develop since early February (in March, at the sampling date, the plants were already covering large areas on the bottom of the lake and measured almost 50 cm in height), reaching the maximum height by the end of April (extended thick meadows of *Potamogeton* with patches of *Myriophyllum*, measuring up to 3 m in length).

a)


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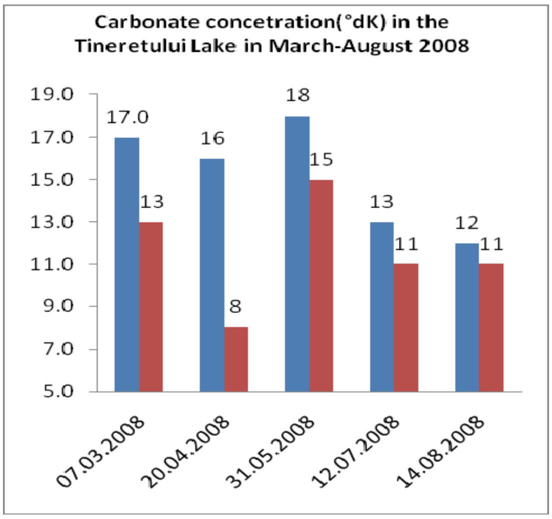


Fig. 2. The evolution of some chemical parameters in the Tineretului Lake between October 2007 and August 2008. a) The pH ; b) The total carbonate concentration. In blue the values registered at the origin point « Oala Mica ». In red the values registered at the discharge point « Terasa ».

Fig. 2. Evoluția unor factori fizico-chimici în apa Lacului Tineretului între lunile octombrie 2007 şi august 2008. a) pH ; b) conținutul total de carbonați. În albastru valorile înregistrate la punctul de obârşie « Oala Mică ». În roşu valorile înregistrate la punctul de vărsare « Terasă ».

In May 2008, the vegetation has been completeley harvested by mechanized means. This fact, combined with the high temperatures of June-August 2008, led to a rapid phytoplankton and *Spirogyra* bloom (BATTES et al., 2003). Also, the mallard populations have been affected by the lack of the soft aquatic vegetation that ducklings are eating during the first part of their life, as well as by the lack of shelter from the predatory fish, provided by the aquatic macrophytes. This was visible in the juvenile mortality of the mallard, up to the 50% for some of the families[1].

The macrophytic vegetation started to recover at the beginning of August 2008, producing small plants, under 1.8 m in height for *Potamogeton crispus*, and rare patches of *Myriophyllum spicatum* (up to 2 m in length), rapidly consumed by the lake's herbivorous fauna (herbivorous fish, *Anas plathyrhyncos* ducklings etc.)

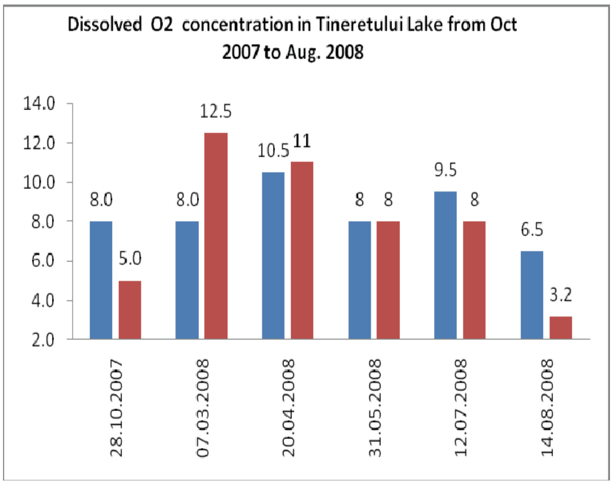
Regarding the pH values (Fig. 2a), they were within the normal limits (PRICOPE *et al*., 2007). As for the total carbonate and bicarbonate concentration, expressed in German degrees, (Fig. 2b) it has reached high values, specific to the phreatic layers from which the lake is alimented. This parameter registers a spectacular decrease during the month of April 2008, when the macrophytic vegetation was at its biomass peak, due to the apparition of a physical support extended enough to allow the precipitation of the solid Ca and Mg carbonates : the *Potamogeton crispus* meadows were completely covered with white 0.3 mm thick carbonate crusts.

[1] Author's personal observations and personal communication from Lake's administration.

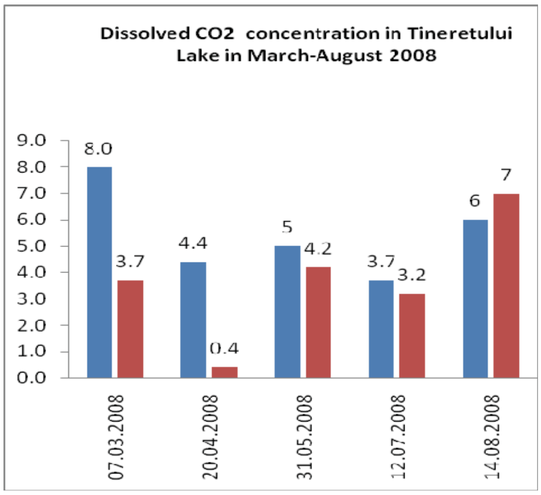
This phenomena is closely related to the concentration of the dissolved CO_2 and to the water pH of that period. These three indicators are in direct interdependency through the chemical carbonate pump's mechanism.

The concentration of dissolved gases (Fig. 3) follows closely the evolution of the vegetation and animal biomass during the maximum vegetation period. The oxigenating effect of the macrophytes is visible in the difference between the 8 mg/l and 10.5 mg/l dissolved O_2 concentration in the „Oala Mica" area (the origin point) in March and April 2008 and the 12.5 mg/l respectively the 11 mg/l dissolved O_2 concentration in the „Terasa" area (the discharge point). The difference is bigger in the begining of spring because the oxygen breathing organisms (zooplankton, alevins, fish) had not yet reached large numbers in that period (Fig. 3a). Thus, the difference in the graffic can be attributed to the oxygenating effect of the aquatic macrophytes.

The same goes for the carbon dioxyde absorbtion from the lake's water by the macrophytes and the epiphyton (filamentous algae) during the analysed period (Fig. 3b), as well as for the decarbonatating effect of the submerged vegetation, due to the biological CO_2 pump, that modifies the equilibrium of the carbonates naturally present in the water lake. This phenomena has also a second cause, meaning the fact that the aquatic macrophytes are forming a physical support for the Ca and Mg carbonates and bicarbonates precipitation.



a)



b)

Fig. 3. The dissolved gases concentrations in the Tineretului lake water. a) The dissolved oxygen concentration during October 2007-August 2008; b) The dissolved CO_2 concentration during March –August 2008. In blue: the dissolved gases concentration at the origin point ("Oala Mica"). In red: the dissolved gases concentration at the discharge point ("Terasa").

Fig. 3. Concentrațiile gazelor dizolvate în apa Lacului Tineretului. a) concentrația oxigenului dizolvat în perioada octombrie 2007-august 2008; b) concentrația CO2 dizolvat în perioada martie – august 2008. În albastru: concentrația gazelor dizolvate la punctul de obârşie ("Oala Mică"). În roşu: concentrația gazelor dizolvate la punctul de vărsare ("Terasă").

At this time, the differences between the origin point and the discharge point are reaching a 10x factor for the decrease of the dissolved CO_2 concentration, unlike the free of vegetation water period when the differences had very much diminished. Thus the carbonate solubility pump effect is accentuated by the macrophytic vegetation to the right sense in the chemical reaction (1).

$$CO_{2\ (aq)} + H_2O \longleftrightarrow H_2CO_3 \longleftrightarrow HCO_3^- + H^+ \longleftrightarrow CO_3^{2-} + 2\,H^+ \qquad (1)$$

Concerning the main nitrogen compounds concentrations, the nitrites, the nitrates and the ammonia, (Fig. 4) there is a distinct difference between the constant concentration of these products in the lake's water previous to the macrophytic vegetation harvesting as well as their significant increase in concentration after the vegetation was harvested (almost three times the previous concentration). The differences from the beginning of summer between the nitrites concentrations (Fig. 4a) of 0.8 mg/l at the origin point and 0.5 mg/l at the discharge point, respectively between the nitrate concentration (Fig. 4b) of 89 mg/l at the origin point and 50 mg/l at the discharge point are due to the lack of nitrogen fixing macrophytic vegetation as well as to the partial fixation by the unicellular algae that were at the verge of a massive bloom during this period. Compared with the macrophytic vegetation, the phytoplankton has been much less efficient at nitrites and nitrates fixing.

The ammonia, main product of the fish excretion function, is not directly influenced by the presence of the macrophytes or of the phytoplankton (WILCOCK et al., 2004), the concentrations being constant in the whole lake (Fig. 4c). In May 2008 we registered high ammonia values probably due to the increased fish activity, this period being the reproduction period of most of the fish species present in the lake (BURIAN, 2005). Correlated with a pH=8, the ammonia concentration in the lake's water reached toxic levels for the fish during May - July 2008, when the macrophytic vegetation was absent.

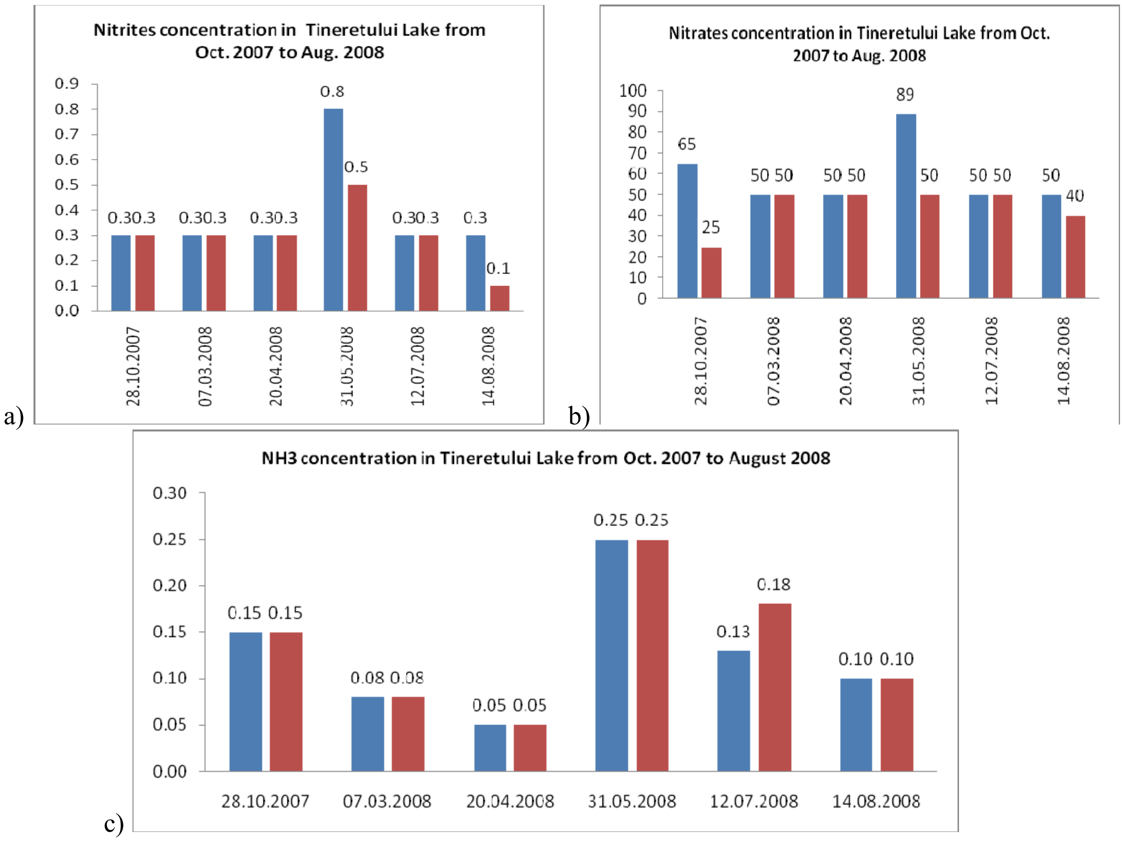


Fig. 4. Nitrogen compounds concentrations in the Tineretului Lake during Octombrie 2007 -June 2008. a) nitrites concentration; b) nitrates concentration ; c) ammonia concentration. In blue: concentration at the origin point “Oala Mica”. In red: concentration at the discharge point “Terasa”.

Fig. 4. Concentraţia de compuşi ai azotului în apa Lacului Tineretului între octombrie 2007 şi iunie 2008. a) concentraţia de nitriţi ; b) concentraţia de nitraţi ; c) concentraţia de amoniac. În albastru: concentraţia la punctul de obârşie (“Oala Mică”). În roşu: concentraţia la punctul de vărsare (“Terasă”).

The water transparency was also strongly influenced by the presence of macrophytes (Fig. 5). The clear water, with an up to 2.4 m depth transparency from April-May 2008 coincided with vegetation maxima for the macrophyte species. This water turned turbid, charged with sediment and phytoplankton with a transparency of maximum 1 m deep, near half of the sampled 2 m deep water column. During this low transparency period the macrophytes have already been harvested. The situation gets worse in August 2008, due to the high temperatures of 15th of July- 31th of August, in spite of the timid comeback of some *Myriophyllum* patches and of some small height *Potamogeton crispus*.

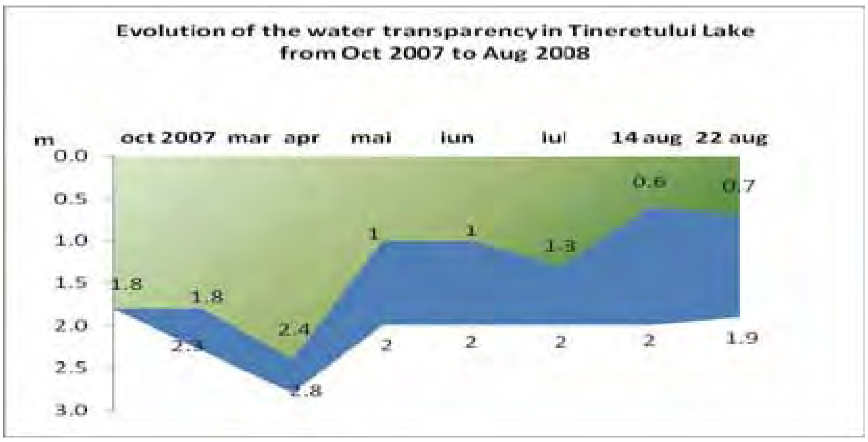


Fig. 5. The water transparency evolution in the Tineretului Lake during October 2007- August 2008. The green polygon represents the Secchi disk measured transparency. The sum of the green and blue represents the measured depth in the sampling point.

Fig. 5. Evoluţia transparenţei apei din Lacul Tineretului între lunile octombrie 2007 şi august 2008. Poligonul verde reprezintă transparenţa măsurată cu discul Secchi şi suma poligoanelor verde şi albastru reprezintă adâncimea măsurată în punctul de eşantionare.

CONCLUSIONS

The analyzed parameters have presented optimum values for the March-April period, correlated with the period of macrophytic vegetation growth which reached its maximum development in height and density at the end of April. After the harvesting period of May 2008, the water quality deteriorated significantly and the phytoplankton received the necessary light, temperature and nutrient stimulation in order to bloom massively. The evolution of the physical and chemical indicators of the water quality have closely followed the presence of the macrophytic species, especially that of the *Potamogeton crispus*.

The submerged macrophytes are an integrant part of the lacustrian ecosystems, being the cause but also the indicator of these ecosystems's quality. A lacustrian ecosystem at its climax needs a reasonably large surface covered with aquatic vegetation in order to maintain the phytophilous species of invertebrates, economically interesting fish and water fowl. This vegetated surface is especially important for the fish populated Romanian Plain lakes in order to maintain a suitable water quality, due to the fact that the aquifers of this region are highly charged with nitrates accumulated during 50 years of intensive agriculture (EPA, 2007).

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