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DYNAMICS OF NUTRIENTS IN AQUATIC ECOSYSTEMS: THE CASE STUDY OF CIRIC BASIN RIVER AT NORD OF IAŞI CITY

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ABSTRACT

A 1 year dynamics of two biologically limiting nutrients (N and P) has been carried out in the Ciric basin river at nord of Iasi City. The total nitrogen concentrations varied from 7.55-17.55 mg N/L and total phosphorus concentrations fluctuated between 0.84 and 1.428 mgP/L. According to our experimental data concerning the total nitrogen concentrations, the highest level of pollution is recorded in the spring region of the Ciric brook. The results obtained on the phosphorus content confirm the increase of the pollution degree with carrying phosphorus substances. It is obvious that the waters of Ciric lake rapidly shifted to a hypertrophic status.

KEYWORDS: dynamics, nutrients, total nitrogen, phosphorus, Ciric river

1. Introduction

Increasing nutrient enrichment of aquatic ecosystems is a widespread and significant threat around the world. The increased nutrient supply results in higher biological productivity and often leads to undesirable effects including algal blooms and depletion of oxygen in bottom waters.

The process of eutrophication is greatly increased by various human activities. Phosphorus (P) and nitrogen (N) resulting from agricultural and urban activities are now recognized to be major causes of human-driven eutrophication [1].

This is the most common impairment of surface waters, affecting lakes, rivers and estuaries. Among the most threatened lakes and rivers are those located in or near urban settlements, because of various effluent sources [2].

These sources can be separated into point sources such as municipal waste water treatment plants and industrial discharges and nonpoint sources which include agricultural runoff of fertilizers and animal waste, urban runoff such as pet waste, atmospheric deposition and construction runoff.

The relative importance of different nutrient sources varies spatially and temporally. Generally, the nonpoint sources are responsible for most delivery of N and P. According to literature data, over half of the rivers studies received >90% of their N and one-third of the rivers studied received >90% from nonpoint sources [3]. However, point sources of N and P can contribute over half of the N and P load to urban river reaches [3]. Thus, although lake ecosystems constitute an essential resource for many ecosystem service and human activities, urban lakes often exhibit serious degradation and interfere with these services and benefits [4]. However, with a proper management lakes can be important tourist and fish-culture centres capable of stimulating regional revenue. Over the past decades, the Ciric basin river, at nord of Iaşi city, previously an excellent leisure centre has been suffering increasing degradation.

The pond has been threatened for years by phytoplankton, blooms and dense floating growths of maesophytes, both indicating poor ecosystem health.

In this context, in order to asses the Ciric’s trophic status and to propose measures for controlling its degradation process, a study of nutrient dynamics in Ciric basin river, at nord of Iaşi city has been carried out.

2. Experimental results

Ciric River is part of plain water with a slow flow regime and reduced flow. Dorobant Aroneanu, Ciric I and II lakes, represents the surface water, whose load natural places them in a category lower, especially in summer, when biological growth conditions. Ciric water quality is influenced by the vicinity of the four municipalities located entirely Ciric river basin. The river bathymetry map is presented in figure 1.

Water samples were collected between March and November 2007:

- march-april ;
- may-june ;
- october-november .

The sampling station was: 1-from origin of Ciric river; 2, 3-from Dorobant lake; 4, 5-from Aroneanu lake; 6, 7-from Ciric I and 8-from Ciric II.

Analyses performed in the laboratory included:

- Total phosfhorus, ammonium-nitrogen, nitrate and nitrite concentrations was determined by spectrophotometric methods using a spectrophotometer JK-UVS-752N.
- Total nitrogen was determined by Kjeldhal method.

Fig. 1. *The map of Ciric river with the four lakes and the sampling stations (1, 2, 3, 4, 5, 6, 7, 8)*

Prior to spectrophotometer measurement, samples were subjected to a mineralization process, using the persulphate digestion technique for total phosfhorus, and a catalytic mixture (1/3 sulfuric acid + 2/3 hydrogen peroxide) for total nitrogen.

3. Results and Discussion

3.1. Dynamics of N in Ciric basin river

Nitrogen exists in lakes and rivers as *mineral nitrogen* (nitrates, nitrites and ammonium) and *organic nitrogen*, associated to the structures of proteins, peptides, nucleic acids and urea type. In normal conditions of oxygenation, nitrogen is present especially as nitrates. The nitrite and ammonium forms are present in the case of organic disfunctionality, being toxic to the living organisms. Usually these forms are rare and transitive in any case.

The analyses carried out in different sectors of the Ciric basin river have been lead to average values of the total nitrogen concentrations ranged from 10.00-17.55 mg N/L in the period of March-April 2007 and 7.55-13.2 mg N/L in May-June period of 2007, respectively (figure 2). As it was expected, the concentration of total nitrogen exhibits a decrease in the warm period of year, when some structures containing nitrogen are consumed by the phytoplankton.

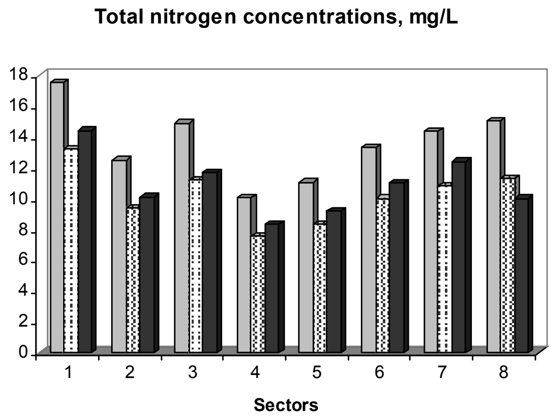

Fig. 2. *The gradient of total nitrogen concentrations*

As in all statistical studies is shown, the temperature decrease in the months of fall results in the increases of total nitrogen concentration. The recorded degree of increase is lower than the estimated values. This fact may be explained by correlation with relative high temperatures on the sampling periods. The lowest value of 8.32 mg N /L has been obtained for the sample 4, tail Dorobanţ lake. According to our experimental data, the highest level of pollution is recorded in the spring region of the Ciric brook. The single explanation is the pollution of the phreatic layer with animal wastes from the former Popricani farm of pigs. The content of nitrate decreases downstream by dilution.

The main component of the total nitrogen is the *organic nitrogen* (figure 3), representing an average of about 61% and 66.7% in the spring and summer period, respectively. In the colder months of fall, the organic nitrogen concentration ranged from 72 to 88% of the total content. The content of organic nitrogen has a complex enough dynamics, depending on the hydrological and hydrobiological regime of waters. Its weight is increasing with lapse to the warm periods of the year. The increasing trend is maintained in the warm periods of the fall, also.

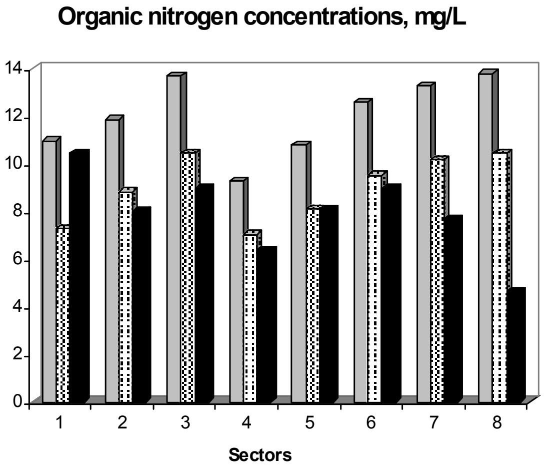

Fig. 3. *The variation of organic nitrogen concentration*

The *mineral nitrogen* reunites the contribution of ammonium ion, nitrates and nitrites (figure 4). The whole of mineral nitrogen records a decrease of its absolute value on the spring-summer lapse. On an average the decrease is of about 43%. The value record an increase to the fall period, correlated to the nitrate content increase, properly to the periods of phytoplankton amount diminishing.

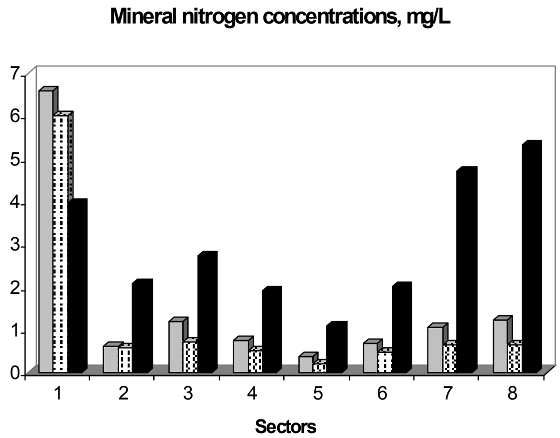

Fig. 4. *The variation of mineral nitrogen concentration*

The concentration of nitrogen from *nitrates* is prevailed in the whole concentration of the mineral nitrogen (table 1). Excepting of the first sample, the content of nitrate (on absolute value) is relatively low, ranging from 0.4-1.3 mgN/L on March – April 2007 period and 0.2 – 0.9 mg N /L in the summer period for all the other samples. These low values are specific to the waters in which this compound is consumed by phytoplankton in the warm periods.

Table 1. *The concentration of nitrogen from nitrates in the water samples under investigation*

Sectors	**Spring** March-April 2007	**Summer** May-June 2007	**Fall** October-November 2007
	[mg/L]		
1	6.33	5.46	3.64
2	0.49	0.224	1.84
3	0.894	0.483	2.28
4	0.555	0.352	1.58
5	0.253	0.104	0.91
6	0.497	0.267	1.61
7	0.930	0.526	4.45
8	1.066	0.673	5.05

The values record significant increases running to about an order of magnitude in the cold period of the fall. This trend is in good agreement with the phytoplankton evolution. Again, excepting of values corresponding to the first point of sampling, the content of nitrate ion was recorded in 2007 year an increasing trend during the accumulation of waters discharged by the river localities.

The *nitrites* have significant minor contributions and exhibit a concentration decrease on spring-summer lapse (table 2). The explanation is based on the unstable and transient character of this structure. It may be noticed that the nitrite consumption in the processes of oxidation or reduction is intensified by the increase of temperature and partners concentration.

Table 2. *The concentration of nitrogen from nitrites in the water samples under investigation*

Sectors	**Spring** March-April 2007	**Summer** May-June 2007	**Fall** October-November 2007
	[mg/L]		
1	0.094	0.054	0.0055
2	0.0034	0.0020	0.0022
3	0.049	0.028	0.026
4	0.0245	0.14	0.027
5	0.0082	0.0052	0.024
6	0.0085	0.0052	0.028
7	0.0116	0.0037	0.038
8	0.0048	0.0028	0.018

For the most samples, the values recorded an increase with temperature decrease in the colder months of fall.

The nitrogen content due to the presence of *ammonium* ion records an increase in the summer period (table 3).

This evolution may be explained on the basis of more intense activity of the bacteriophytoplankton specific to the ammonification process.

The obtained values decrease in the fall months remaining superior to those recorded in March-April months.

Table 3. *The concentration of nitrogen from ammonium in the water samples under investigation*

Sectors	**Spring** March-April 2007	**Sommer** May-June 2007	**Fall** October-November 2007
	[mg/L]		
1	0.164	0.476	0.328
2	0.148	0.338	0.254
3	0.264	0.776	0.421
4	0.171	0.551	0.319
5	0.119	0.464	0.174
6	0.205	0.721	0.379
7	0.120	0.446	0.239
8	0.171	0.726	0.262

Table 4. *Integration of Ciric waters into quality degrees/N regime*

Quality degree												
	Spring				**Summer**				**Fall**			
Quality indicator	N-NH_4^+	N-NO_2^-	N-NO_3^-	N_{total}	N-NH_4^+	N-NO_2^-	N-NO_3^-	N_{total}	N-NH_4^+	N-NO_2^-	N-NO_3^-	N_{total}
Dorobanţ Lake	I	II–III	I	III	I-II	I-II	I	II-III	I	I-II	I-II	II-III
Aroneanu Lake	I	I–II	I	III–IV	I-II	I	I	II-III	I	I-II	I-II	II-III
Ciric I Lake	I	I	I	III–IV	I-II	I	I	II-III	I	I-II	II	II-III
Ciric II Lake	I	I	I	III–IV	I-II	I	I	II-III	I	I-II	II-III	II-III

The obtained values decrease in the fall months remaining superior to those recorded in March-April months.

On the basis of nitrogen dynamics the Ciric waters may be integrated on the quality grades presented in Table 4.

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4. Dynamics of P in Ciric basin river

It is unanimously recognized that the phytoplankton development is controlled by the concentration of total phosphorus in water.

However, the researches emphasized that the N: P ratios are more important relative to the level of phosphorus concentration. Thus, numerous studies at scales from algal cultures to whole lakes manipulations have been demonstrated that interactions between N and P can impact algal productivities [5]. It has been noticedd that chlorophyll yield in Japanese lakes was in balance with both total nitrogen and phosphorus concentrations when the ratios of the two nutrients was between 10 and 17 and only on total phosphorus when ratios were >17 [1]. Another study reported that total nitrogen: total phosphorus ratios varied significantly with lake trophic status [6]. The authors of this study found that the total nitrogen: total phosphorus ratios declined in a curvilinear fashion as the amount of total phosphorus increased.

In this context, it is obvious that the phosphorus total content is an important indicator in the establishment of water degree and lake trophic status.

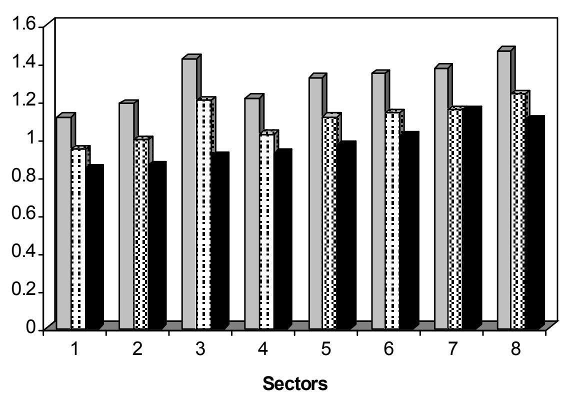

Fig. 5. *The gradient of the total phosphorus concentrations*

The results obtained at the analysis of phosphorus content on the water samples from the eight points of sampling, previously established, point out a practical constant increase over the whole flow length (figure 5). This evolution confirms the increase of the pollution degree with carrying phosphorus substances. The advance to the warm seasons of the year results in a decrease of phosphorus content, on an average of about 20%. The recorded dynamics is natural and in good agreement with functioning of microorganisms and phytoplankton.

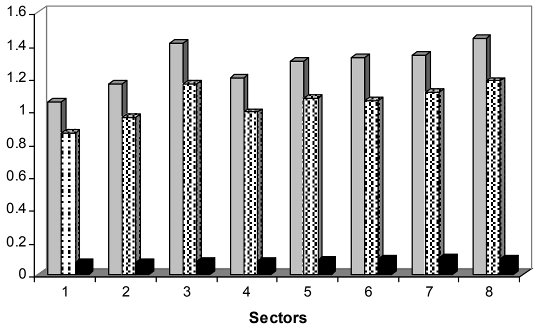

Fig. 6. *The variation of the organic phosphorus concentrations*

The cycle of phosphorus in water take place between inorganic and organic species. In spring-summer period the main component of total phosphorus is the *organic phosphorus,* with a contribution on an average of 88-90% (figure 6).

Also, the content of organic phosphorus records during the flow a constant increase, accompanied by a diminishing with an average percent of 9.5% on spring-summer lapse. In the cold periods of the fall the content of organic phosphorus exhibits significant decreases, its contribution being below 8-9 % of total value. In both periods under investigation, the values obtained for the *inorganic phosphorus* were significantly low (table 5). The inorganic phosphorus become the main component of the total phosphorus in fall season.

Table 5. *The content of inorganic phosphorus in the Ciric water samples*

Sectors	**Spring** March-April 2007	**Sommer** May-June 2007	**Fall** October-November 2007
	[mg/L]		
1	0.062	0.0548	0.769
2	0.0108	0.0095	0.788
3	0.0153	0.0134	0.832
4	0.0104	0.0091	0.842
5	0.0124	0.0111	0.895
6	0.0248	0.0218	0.912
7	0.025	0.0222	1.050
8	0.022	0.0218	1.005

The content of the inorganic phosphorus at the sampling points is lower with about 1-2 orders of magnitude and stays almost constant during the whole investigated period (spring-summer). In the third period of sampling the content of inorganic phosphorus increases constantly reaching at the last sampling point a value that is higher with about 30% than the recorded value at the first point. Based on the dynamics of these two biologically limiting nutrients the trophic status of the Ciric lake ecosystem has been evaluated (table 6).

The analyses point out that urgent actions need to be undertaken in order to rehabilitate this lake which rapidly can shifted to a hypertrophic status.

Table 6. *Evaluation of the trophic status of the Ciric lake*

Indicator	Spring		Summer		Fall	
	Total P	Total N	Total P	Total N	Total P	Total N
	[mg/L]					
Dorobant lake	1.27 Hipertrof	0.86 Mezotrof - Eutrof	1.07 Hipertrof	0.62 Oligotrof – Mezotrof	0.89 Hipertrof	2.25 Hipertrof
Aroneanu Lake	1.29 Hipertrof	0.61 Oligotrof - Mezotrof	1.08 Hipertrof	0.41 Oligotrof	0.97 Hipertrof	1.6 Eutrof
Ciric I lake	1.36 Hipertrof	0.885 Mezotrof – Eutrof	1.14 Hipertrof	0.57 Oligotrof - Mezotrof	1.08 Hipertrof	3.37 Hipertrof
Ciric II Lake	1.42 Hipertrof	1.15 Mezotrof - Eutrof	1.19 Hipertrof	0.75 Mezotrof - Eutrof	1.12 Hipertrof	5.02 Hipertrof

5. Conclusions

The results obtained in this study can be viewed as an alarm. Lake management and restoration has an important contribution to positive management of environmental and human health.

Short-term solutions to lake water quality problems based more on political jurisdictions of municipality than sound ecological principles can result in failure.

For the waters of Ciric lake continue to meet both human and ecosystem needs comprehensive integrated management programs must be implemented without delay.

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