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The phosphorus biogeochemical cycle in Braşov district lakes

Luminița ISAC[a], *Lucia DUMITRESCU[a], Dorina DRĂGAN[b], Ileana MANCIULEA[a] and Rodica ȚICĂ[a]

[a]*Department of Chemistry, The "Transilvania" University of Braşov*
[b]*Water Management Braşov*

Abstract: Phosphorus is a limiting nutrient for many organisms, particularly for algae and aquatic plants growth and is found in surface water as phosphates ($H_2PO_4^-$, HPO_4^{2-} and PO_4^{3-}), which are the main form assimilated by plants. Too much phosphorus in surface waters, for example in lakes, determines the process called eutrophication. The paper presents, as theoretical part, the phosphorus biogeochemical cycle. Therefore, as experimental part, the phosphorus concentration determined in Târlung Lake, in Braşov District, during 2002 year, are monitored. The dissolved phosphorus concentration in Târlung Lake was found to be low enough to limit algal growth.

Keywords: Phosphorus biogeochemical cycle, nutrients, eutrophication, lakes.

1. Introduction

Phosphorus is found as phosphates in nucleic acids (DNA, RNA and ATP), cellular membranes, in phospholipids and phosphoproteins, in bones and teeth. Phosphorus is second only to nitrogen as a limiting nutrient in ecosystem.

Nutrients are elements and environmental compounds by which the biota synthesized live matter as cells, tissues, genetic material, energomolecules and reproduction cells, with carbon substrate correlation [1]. If a required nutrient is present in concentrations so low that the metabolic needs of organisms, population or species cannot be met, the nutrient can be considered a limiting one [2]

Phosphorus, as limiting nutrient, is present in its oxidized form (phosphate), which is taken up directly by plants, algae and some bacteria. Other sources of phosphates are the waste and remains of animals and plants, bird and bat guano accumulations and apatite. Phosphate is also found in high concentrations in sedimentary rocks containing the fossilized waste or sediments of marine plants or animal. Humans mine phosphate ores for use in fertilizer, as an animal feed supplement and for detergents. Detergents, untreated human and animal wastes and fertilizers add an excess of phosphorus in surface waters, which often determine an algal blooms.

In lakes, the excessive amounts of nutrients such as but not limited to phosphorus cause an explosion of the number of blue-green algae, process called **eutrophication**. This algae form a mat at the surface of lake, which affect:

– the organoleptic properties of water, if this water is used as potable water;

– the quantity of dissolved oxygen which decreases because it is used by bacteria to destroy the mat; if the dissolved oxygen necessary is higher than that provide of atmospheric oxygen and that produced by respiration, negative effects can affect the aquatic organisms (i.e. the death of fishes).

The present paper is focused on the phosphorus biogeochemical cycle in lakes and offers experimental data regarding the phosphorus concentrations determined in Târlung Lake bam, at different lake depth, in three seasons (spring, summer and autumn) during 2002 year. The eutrophication degree of Târlung Lake is also estimated.

2. Experimental

More than 30 elements are cycled through the environment by **biogeochemical cycles**.

The term biogeochemical cycles express the interaction among the organic (*bio*-) and inorganic

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(*geo*-) worlds, and focuses on the chemistry (*chemical*-) and movement (*cycles*) of chemical elements and compounds. In its simplest form, cycling describes the movement of elements through various media and their return to their original state [3]. There are six important biogeochemical cycles that transport carbon, hydrogen, oxygen, nitrogen sulfur and phosphorus.

In a manner similar to nitrogen, phosphorus in the environment is cycled between organic and inorganic forms. An importance difference is that some nitrogen can be lost to the atmosphere by ammonia volatilization and microbial denitrification, while no analogous gaseous loss mechanism for phosphorus exists. Also important are the differences in mobility of the two nutrients. Both are found as anions: NO_2^-/NO_3^- and $H_2PO_4^-/HPO_4^{2-}/PO_4^{3-}$. Nitrate anions do not form insoluble compounds with metals and, therefore, readily leach from soil into surface and ground waters. Phosphate anion forms insoluble compounds as calcium, aluminum and iron phosphates. Therefore, nitrogen compounds leach more readily than phosphorus compounds from soil into ground and surface waters which contribute to a phosphorus-limited algal growth in most surface water [4].

Organic compounds containing phosphorus are found in all living matter. The two major steps of the phosphorus biogeochemical cycle, illustrated in **figure 1**, conversion of organic phosphorus to inorganic phosphorus and back to organic form, are both bacterially mediated.

Conversion of insoluble forms of P, such as calcium phosphate, $CaHPO_4$, into soluble forms, principally PO_4^{3-}, is also mediated by microorganisms. Organic phosphorus in tissues of dead plants and animals, and in animal waste product is also converted bacterially to phosphates which thus released to the environment is taken up again into plant and animal tissue.

In surface waters, phosphorus concentrations are influenced by the sediments, which serve as reservoir for absorbed and precipitated phosphorus and have an important role in the phosphorus cycle in streams.

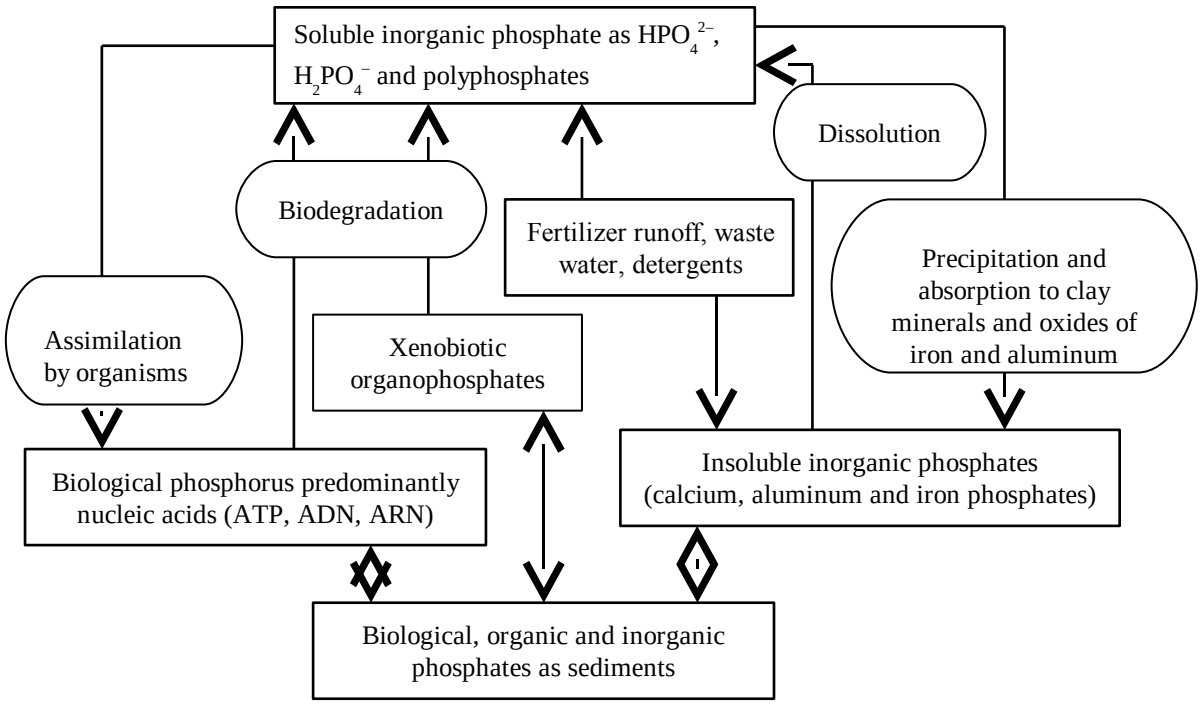

Fig. 1. The phosphorus biogeochemical cycle

It is significant to mention that the solubility of phosphates is depending on pH-values of water: the phosphate solubility increases at low pH, when dissolved phosphorus is predominantly $H_2PO_4^-$, and decreases at high pH, when dissolved phosphorus is predominantly HPO_4^{2-}, as calcium phosphate. Maximum availability of phosphorus for plant uptake occurs between pH 6–7.

In the lakes case, even when algal growth lakes is temporarily limited by carbon or nitrogen instead of phosphorus, natural long-term mechanisms act to compensate for these deficiencies. Even if a sudden increase in phosphorus occurs temporarily causing algal growth to be limited by carbon and nitrogen, eventually these deficiencies are corrected. Then, algal growth becomes proportional to the phosphorus concentration and the system becomes once more phosphorus-limited (the ratio of total nitrogen to total phosphorus is more than 21).

2. Experimental

One sampling site was chosen for this study: the Târlung Lake bam, at five different depths (0 m, photic zone, 5 m, 10 m and 20 m - the bottom of the lake). Sampling and analysis were made once a month, in four-month (April, June, August and October) during 2002 year, in the laboratories of Water Management Braşov.

For phosphorous concentration determination was used a spectrophotometric method and pure analytical reagents, according to Romanian standards [5].

3. Results and discussions

The concentrations values registered for phosphorus from Târlung Lake bam, in Braşov District, at different depth during 2002 year, are presented in **Table 1**.

From the data of Table 1, it is obvious that P concentration values varying with season and lake depth, but not significantly, the dissolved P concentration in Târlung Lake being low enough to limit algal growth.

The phosphorus concentration values are in range of 0.003-0.035 mg/L, lower than maximal admissive concentration 0.1 mg/L [6]. These values indicate the environmental behavior of phosphorus, which is largely governed by the low solubility of most of its inorganic compounds, its strong absorption to soil particles and its importance as a nutrient for biota. These values also suggest a low eutrophication process and the Târlung Lake water can be classified in the oligotroph (P concentration is lower as 0.01-0.005 mg/L) to mezotroph (P concentration is around 0.05 mg/L) water categories.

Table 1. The values of phosphorus water quality parameter register for Târlung Lake bam at different month and lake depth during 2002 year

Lake depth [m]	Phosphorus concentration [mg / L]			
	April	June	August	Octobe r
0	0.020	0.020	0.003	0.011
photic zone	0.013	0.035	0.012	0.010
5	0.004	0.012	0.004	0.024
10	0.016	0.014	0.012	0.011
20 (bottom)	0.010	0.023	0.015	0.020

The dependence of P concentration values with Lake depth, in different month of 2002 year is shown in **figure 2**.

From figure 2 it can observe that the concentration values of P increases with lake depth, in the same month the higher value (0.035 mg/L) was registered in June at 2.10 m (photic zone). This value indicates a possible forming of algal blooms, because in summer, generally Dissolved P concentration is low as 0.02 mg/L. This augmentation is verified in August, when the P concentration is lower, in the range of 0.003-0.015 mg/L, and indicates a great usage (consumption) of phosphorus by aquatic plants.

In April and October, the P concentration values are low (around 0.02 mg/L) but higher than that found in August. This mean that in cold seasons, especially in winter, aquatic plants do not assimilate phosphorus and therefore the quantity of dissolved P in water increases.

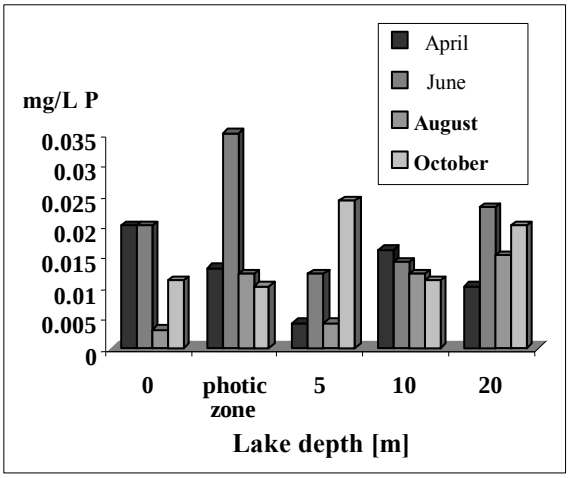

Fig. 2. The dependence of phosphorus concentration with Târlung Lake depth during four month of 2002 year

Figure 3 represents the dependence of P concentration values with season, at different lake depth. One can observe that at 0 m depth, the P concentration values are low and varying between 0.003-0.02 mg/L. At 5, 10 and 20 m depth, the lower value of P concentration was registered in August, a summer month, as was expected.

4. Conclusions

Most lakes, as Târlung Lake to, are phosphorus-limited algal growth and the N-fixing blue-green algae are favored. The dissolved P concentration in Târlung Lake is low enough to limit algal growth; therefore the eutrophication degree of lake is reduced. According with the dissolved P concentration, the Târlung Lake water has an oligotroph to mezotroph character.

A lower concentration of P in lake can be caused by:

- a generally deficiency of P in ecosystem which contribute to a phosphorus – limited algal growth and offer a oligotroph character to lake water;
- a fast biological P removal which mean that phosphorus present in water, even in small quantities, immediately it is uptake by algae; therefore, a system like this can be productive, even if the P concentration in water is low [7].

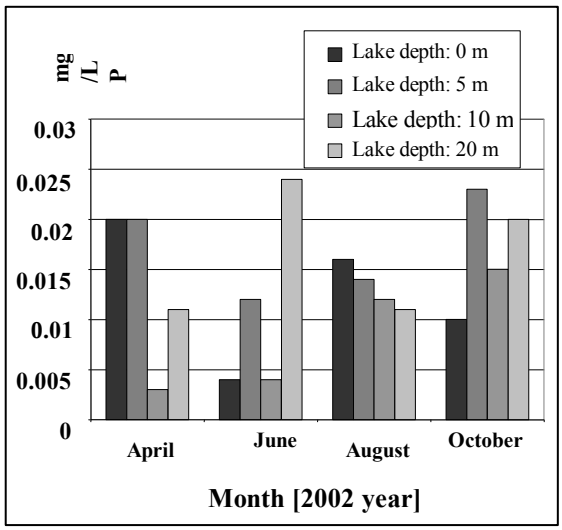

Fig. 3. The variation of phosphorus concentration (determined in Târlung Lake at 0, 5, 10 and 20 m depth) with season

Like nitrogen, phosphorus is more used by aquatic plants in summer, so the quantity of P is low. In cold seasons, the dissolved P concentration is higher because the assimilation of phosphorus by aquatic plants is more reduced.

5. References

* E-mail address: isac.luminita@unitbv.ro

[1] A. Varduca, *Protecţia calităţii apelor*, Editura HGA, Bucureşti 2000.
[2] drjoe.biology.ecu.edu./ch04/ch04.htm
[3] www.sws.uiuc.edu/nitro/biogen.asp
[4] E.R. Weiner, *Applications of Environmental Chemistry,* Lewis Publishers, 58 2000.
[5] SREN 1189-2000.
[6] STAS 4706-1988.
[7] D. Drăgan, *Lucrările Simpozionului managementul mediului urban şi industrial în contextul integrării europene*, Editura Universităţii, Braşov, 146, 2001.