INVESTIGATIONS ON THE FERTILIZING CAPACITY OF BOTTOM SEDIMENTS FROM EUTROPHICATED LAKE

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ABSTRACT

The Srebarna Biosphere Reserve is among the well known protected territories not only in Bulgaria. Its broad popularity is due to the exclusive biodiversity which this relatively small Danubian lake contains. The biggest problem of the reserve is increasing eutrophication and low water level. The main sources for nutrients are out of the lakes (rivers, soil erosion, etc.), but rich of organic matter sediments are an important source for the lake's waters eutrophication, too. A way for decreasing lake eutrophication is the partially scraping up of the lake sediments. Sediments could be used as fertilisers in nearest fields. Incubation experiment with sediments rich of organic mater showed increasing rate of the nitrogen mineralization in studied soil. Application of isotopic exchange kinetic method for assessment of phosphorus availability in sediments is a rarely used in such type of study. But this method is very useful of the assessment of P availability in sediments. Sediment organic matter is a good organic. Removal of organic sediment will act in double way – decreasing of available P in lake water and amelioration of eroded soils around the lake.
Keywords: *sediments, reutilisation, phosphorus, isotopic exchange kinetic method.*

INTRODUCTION

The Srebarna Biosphere Reserve is among the well known protected territories not only in Bulgaria. Its broad popularity is due to the exclusive biodiversity, which this relatively small Danubian lake contains.

Srebarna Lake was designated as a Monument of World Cultural and Natural heritage (1983), UNESCO biosphere reserve (1977), Ramsar site (1975) and Important Bird Area (1990) because of its extremely rich ornithofauna. During the last years the lake ecosystem underwent significant changes towards strong eutrophication and anthropogenically speeded-up succession.

The biggest problem of the reserve is increasing eutrophication and low water level. Lake eutrophication includes increased input of nutrients and the increased CO_2 fixation in the lake ecosystem (Henderson and Marklamd, 1987). In case of unbalance of organic matter decay and low output of products, accumulation of rich of organic matter sediments is observed. This is the case in some hypereutrophicated lakes as Apopka lake in Florida, USA (Gale et al., 1992) and Balaton lake in Hungary (Somlyody and van Straten, 1986).

The main sources for nutrients are out of the lakes (rivers, soil erosion, etc.), but rich of organic matter sediments are an important source for the lake's waters eutrophication, too (Gardner et al., 1987). N and P exist in lakes sediments in organic and inorganic form. Rate of transformation between these forms (mineralisation and immobilisation) is very important for the nutrition of phyto - plankton. P flux from sediments to overlaying water can be sufficient to enhance eutrophication process (Lenox, 1984). Soluble phosphorus is a function of mineralization, dissolution, sorption and sedimentation in fresh water systems (Elderfield et al., 1981).

We studied the removal of lake sediments as possible way of decreasing nitrogen and phosphorus input for water pollution and the possible use of lake's sediments as organic fertilizer.

MATERIAL AND METHODS

Sediment's samples were collected from three places in the lake – Ribarnika (West lake shore), Kamaka (East lake shore) and from the central part of the lake. Higher sediment's layer (0-30 cm) was a semi-liquid, rich of organic matter sediment. The second layer (30-60 cm) was well-metamorphosed semi-liquid grey inorganic sediment.

Total N was determined by Kjeldahl method, inorganic N by Bremner-Keeney method. Total P was determined by digestion in perchloric acid, available P by acetate-lactate extraction and C was determined by Tyurin and Anstet methods. Isotopically available phosphorus in sediments was determined by isotopic exchange kinetic method described by Fardeau et al., 1979.

Nitrogen mineralisation in soil of organic sediments was studied in laboratory incubation experiment. Four grams of wet sediment were added to 20 g of soil and incubated at 25^{o}C for 28 days. Sediment application increased with 2 mg N.kg^{-1} inorganic nitrogen content and with 185 mg N.kg^{-1} organic nitrogen in soil.

RESULTS AND DISCUSSION

Concentration of studied organogenic elements C, N and P are higher in sampling points near lake's shores - Kamaka and Ribarnika. Higher concentration is due of soil erosion from fields with high application of inorganic (N and P) and organic fertilisers (Table 1). Higher sediment layer is rich in organic matter and higher concentration of C, N, and P were observed. That is why sediments can be a source of inorganic P after mineralisation.

Table 1. *Total C, N and P content in sediments from Srebarna.*

Place of sampling	C %	N %	C:N	P %	C:P
Ribarnika	18.22	1.466	12.4	0.116	157
Ribarnika *	6.04	0.981	6.2	0.073	83
Kamaka	21.12	1.325	15.9	0.128	165
Kamaka *	7.83	1.101	7.1	0.077	102
Center	14.38	0.773	18.6	0.081	178
Center *	6.35	0.6	10.6	0.053	120

** Second layer of sediments below the first organic sediment.*

Net N mineralisation is possible in presence of organic matter with C:N ratio below 25, and net P mineralisation in presence of organic matter with C:P ratio below 200. All sediments have C:N ratio below 25 and C:P ratio below 200 (Table 1). That means that sediments will supply the lake water with ammonium and phosphate ions. Clay sediments have lower C:N and C:P ratios but overlaying sediments (organic matter enriched) isolate them and the ammonium and phosphate rate input in lake water will depend mainly from the organic matter rates of mineralisation. Ratios C:N and C:P are favourable for mineralisation in soil and it means that sediments are good as fertiliser, too.

Sediments from Ribarnika are with highest P total content (Table 1). Soils from the nearest shore are very rich of available phosphorus and this is an indicator of transfer of soil particles by the soil erosion. High soil erosion is due to the apricot orchard abolition several years ago near this lake point. High content of P in sediments from Kamaka indicates pollution from Kalneja river, disgorging near this place.

Study of isotopically exchangeable phosphorus content in different lake sediments shows that most important pools of readily available phosphorus (isotopically exchangeable phosphorus for 1 day) were observed in the higher layer of sediment from Ribarnika (Table 2). As for total P content this is due to the soil erosion of the West lake shore, where soils with high content of available P were found. Application of isotopic exchange kinetic method for assessment of phosphorus availability in organic fertilisers or sediments is a rarely used in such type of study (Fardeau J.C. and J. Martinez, 1998). But this method is very useful of the assessment of P availability in sediments and gives rapid results.

Table 2. *Isotopically exchangeable phosphorus pools in lake sediments from Srebarna lake mg P.kg^{-1}.*

Place of sampling	P exchangeable for 1 day	P exchangeable between 1 day and 3 months	P exchangeable for more than 3 months
Ribarnika	38.6	135.9	986
Kamaka	20.7	10.6	1250
Ribarnika *	10.0	38.0	682
Kamaka *	7.2	33.8	729
Center *	12.7	42.7	475
Kamaka **	20.9	59.5	530

Comparison of sediment content of N and P to the content in cattle farmyard manure makes possible evaluation of sediment fertilising capacities. In well-composted farmyard manure the average total N content is 0.5%, average P total content is 0.25%. Results for N and P analyses of sediments are shown in Table 1. Values for total N are higher in sediments than in average content in farmyard manure and lower for the P total content. Use of sediments as organic fertiliser would be optimal in the soils with high available P content or when additional phosphorus fertiliser is applied.

Incubation experiment with sediments rich of organic mater showed increasing rate of the nitrogen mineralisation in studied soil (Table 3). For 28 days of incubation 8% of organic nitrogen from sediments is mineralised. This amount is equal to 4.5 kg inorganic fertilizer nitrogen application. Nitrogen mineralisation during the growing period of different crops would be sufficient for nutrient supply of plants. Fertilising with lake sediments will improve a nitrogen and carbon regimes of soils, too. The application of high rates of organic matter will improve soil texture and will be a limiting factor for soil erosion.

Table 3. *Nitrogen mineralisation from soil and sediment incubation, mg N.kg^{-1}.*

Treatments	0 day	7 days	14 days	28 days
Soil	14.6	23.9	27.4	29.6
Soil + sediment	15.8	25.1	33.8	44.7

Organic sediments removed from lake bottom are very suitable to use in the nearest fields. Eastern lake shore is protected form erosion by the forest. South and West shores are under the impact of erosion. That is why the use of organic fertilisers will be a good amelioration practice for these places

Our studies of Srebarna Lake permit to assess the accumulation of nitrogen and phosphorus with sediments in lake bottom and to calculate the annual rate of accumulation. A large amount of N and P are available in lake – 3300 tons of nitrogen and 270 tons of phosphorus. Readily available phosphorus is about 24 tons and it is a real hazard for lake's water quality and the eutrophication. In the same time reutilisation of these nutrients in agriculture will be very useful for amelioration of trophic status of the lake.

***Table 4**. Assessment of N and P amounts in bottom sediments from lake "Srebarna" (tons).*

Nutrients	N tot	P tot	Isotopically exchangeable P		
			for 1 day	between 1 and 90 days	for more than 90 days
Total content	3300	270	6	18	246
Annual rate of accumulation	65	5	0.12	0.36	4.92

CONCLUSIONS

Our investigation in Srebarna Lake area shows that N and P content in some of soils and sediments is hazardous for lake water eutrophication. Application of isotopic exchange kinetic method for assessment of phosphorus availability in sediments is rarely used in such type of study and is enlarging the possibility of such kind of investigations. Sediment organic matter is a good organic fertilizer for the nearest eroded soils. Removal of organic sediment will act in double way – decreasing of available P in lake water and amelioration of eroded soils around the lake.

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