



Total Alkaline Phosphatase Activity of Water in the Lakes of Barlinek-Gorzów Landscape Park (North-West Poland)

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Water in the lakes of Barlinek-Gorzów Landscape Park were the subjects of a five-year study (2008-2012). Total alkaline phosphatase activity was determined seven times a year in these environments. The study on the water demonstrated that the top sublittoral layer (1 m) featured the highest alkaline phosphatase activity among all the analyzed zones. A study of seasonal fluctuations showed that a maximum total alkaline phosphatase activity, both in the water occurred in spring (May) and summer (July, August). Basing on this parameter no increase in eutrophication process in the lakes of Barlinek-Gorzów Landscape Park was determined in the course of a 5-year study.

Keywords: Total alkaline phosphatase activity, Barlinek-Gorzów Landscape Park, European Union Water Framework Directive.

INTRODUCTION

It is an important issue to properly protect water reservoirs and also take action to counter the adverse effects of human activities on the natural environment, including water bodies¹⁻⁸. To address the increasing degradation of surface waters in the European Union, the approach to the evaluation and protection of water resources was changed. This approach was formulated in the European Union Water Framework Directive (2000/60/EC), which calls for the protection of water, as well as an environment-friendly and comprehensive approach to water assessment^{2-6,9-15}.

The ecological status of surface waters and groundwater is assessed on the basis of the ecological potential of the biological and physico-chemical and hydromorphological indicators^{4,10,15-20}.

Phosphorous plays a key role in biological production and thereby in the eutrophication of the water environment^{11,21}. One of the important processes impacting on the level of available mineral phosphorous is enzymatic hydrolysis of organic bonds of this element^{16,21}. A majority of previous studies shows that alkaline phosphatase is mainly responsible for the rate of organic phosphorous mineralization, both in the pelagic zone and in the bottom sediment of water bodies with pH > 7^{1-3,16-18}. However, some authors report, e.g. Yiyong⁸, that abiotic factors can also play a part in the process. Jones²² suggests that the level of phosphatase activity in the water is linked to the degree of lake trophicity.

The objective of this paper was to observe in the course of a 5-year period the level and dynamics of annual oscillations and seasonal activity of total alkaline phosphatase in the water lakes of Barlinek-Gorzów Landscape Park, Poland.

The assumption for this cycle of study was also to demonstrate the usefulness of the applied enzymatic test as a biological indicator of the degree of lake trophicity and possibly of progressing eutrophication of the analyzed water bodies.

EXPERIMENTAL

Barlinek-Gorzów Landscape Park was established in October 1991 and includes more than 55 000 ha of forests, lakes, fields, meadows and is characterized by a great diversity of habitats and abundant life forms²³.

To protect the most valuable plant communities and animal habitats, five nature reserves were created within the boundaries of the Park: (1) "Skalisty Jar Libberta" includes Libbert's Gorge and the surrounding moraine hills and glacial erratics. It is the only site featuring lime stones and boulders in Western Pomerania and is surrounded by oak and beech forests²³. (2) "Debina" forest conservation complex known as the Central European wet-ground forest, featuring stately oaks and beeches with some lime, hornbeam and old pine trees. In its clean environment, as many as 50 species of arboreal lichen have been preserved²³. (3) "Markowe Blota" -marshland, with its typical vegetation such as the *Sphagnopsida*, wild rosemary, ordinary cranberry, cottongrass. The site is visited quite often by white-tailed eagles²³. (4) The water reserve of the "River

Przylezek". It includes a section of the river, the slopes of the river bank and the surrounding beech stand with some tree specimens that are more than 100 years old. Seen as the water-course resembles mountain streams, with its pure and cold water, it provides appropriate conditions for Salmonidae to live and spawn²³. (5) The forest reserve "Wilanów" aims to protect the natural mixed forest with vintage beech, oak and pine trees. Thanks to the varied topography, diverse rare types of forests have been preserved here²³.

Nature conservation in the park also includes natural monuments, animate and inanimate: 41 trees, 1 boulder, 3 rocks and the natural spring "Bozy Dar"²³.

The study covered seven lakes within the boundaries of the Barlinek-Gorzów Landscape park: Barlineckie lake, Glebokie lake, Lubiszewko lake, Przyleg lake.

Barlineckie lake: The area of the Lake covers 260 hectares, the depth reaches 18.0 m, max length is 3.8 km Lake is located in the north. Barlineckie parts of the park, at a height of 57 m above sea level and is part of the Mysliborskie²³.

Glebokie lake: The surface of the lake Glebokie in Barlinek is: 4.65 ha, maximum depth - 8 m²³.

Lubiszewko lake: The surface of this lake covers 52 ha, depth, width is 11.8 m dating back to 520 m, length up to 2100 m. Lake is located at a height of 63.3 m above sea level²³.

Przyleg lake: The surface of the lake is 43.2 ha, depth to 5.9 m, 650.0 m width, the length of 1,100 m²³.

Samples of littoral and sublittoral water were taken with a Ruttner sampler with a capacity of 2 dm³. Water were stored for 24 h at 4 °C. After that time total alkaline phosphatase activity in water was determined with the use of Jones's method²², which involves detecting coloured *p*-nitrophenol formed from *p*-nitrophenol phosphate dissolved in a buffered solution (0.1 M *tris*-HCl of pH 8.5).

The study was conducted during 2008-2012. The analyses were carried out 7 times a year (April, May, June, July, August, September and October), in three repetitions.

The results presented in the paper constitute mean value calculated from the repetitions.

RESULTS AND DISCUSSION

The experimental data on activity of total alkaline phosphatase in water samples collected along the in lakes of the Barlinek-Gorzów Landscape Park from the month of 2008-2012 (April to October) is presented in Table-1 to 4.

The results presented in Tables 1 to 4 demonstrate that total alkaline phosphatase activity in the waters of lakes the Barlinek-Gorzów landscape park over the five-year period of study oscillated between 214.7-651,3 nmol PO₄ dm⁻³ h⁻¹. The oscillation range in both zones of the analyzed water body was similar. In the littoral it ranged from 248.5 to 651.3 nmol PO₄ dm⁻³ h⁻¹ and in sublittoral from 214.9 to 582.6 nmol PO₄ dm⁻³ h⁻¹.

During the study oscillations of total alkaline phosphatase activity were observed in the water.

Higher stability of the activity in Barlinek lake is additionally confirmed by annual mean values for the water (355.7-468.9 nmol PO₄ dm⁻³ h⁻¹).

Higher stability of the activity in Glebokie lake is additionally confirmed by annual mean values for the water (375.3-475.2 nmol PO₄ dm⁻³ h⁻¹).

Higher stability of the activity in Lubiszewko lake is additionally confirmed by annual mean values for the water (342.7-475.5 nmol PO₄ dm⁻³ h⁻¹).

Higher stability of the activity in Przyleg lake is additionally confirmed by annual mean values for the water (348.1-485.5 nmol PO₄ dm⁻³ h⁻¹).

TABLE-1
TOTAL ALKALINE PHOSPHATASE ACTIVITY IN WATER BARLINECKIE LAKE (nmol PO₄ dm⁻³ h⁻¹)

No.	Analysis terming	2008		2009		2010		2011		2012	
		Littoral	Sublittoral	Littoral	Sublittoral	Littoral	Sublittoral	Littoral	Sublittoral	Littoral	Sublittoral
		1 m	4 m	1 m	4 m	1 m	4 m	1 m	4 m	1 m	4 m
1	April	318.7	226.3	354.6	214.9	331.6	253.9	341.7	263.8	328.3	254.1
2	May	372.6	349.8	372.3	327.6	440.2	351.6	454.3	382.5	406.8	380.5
3	June	468.4	394.8	442.0	403.9	436.4	408.7	484.6	461.3	467.5	479.8
4	July	568.9	457.1	582.3	513.1	621.3	550.2	635.8	517.0	587.9	536.4
5	August	537.4	439.6	529.7	452.7	538.5	458.9	563.2	462.5	548.4	452.6
6	September	442.8	387.4	473.9	417.4	503.9	413.5	479.7	402.8	441.7	379.0
7	October	294.1	235.2	383.8	342.2	410.7	338.3	320.4	275.3	358.4	283.9
	Annual mean	428.9	355.7	448.4	381.6	468.9	396.4	468.5	395.0	448.4	395.2

TABLE-2
TOTAL ALKALINE PHOSPHATASE ACTIVITY IN WATER GLEBOKIE LAKE (nmol PO₄ dm⁻³ h⁻¹)

No.	Analysis terming	2008		2009		2010		2011		2012	
		Littoral	Sublittoral	Littoral	Sublittoral	Littoral	Sublittoral	Littoral	Sublittoral	Littoral	Sublittoral
		1 m	4 m	1 m	4 m	1 m	4 m	1 m	4 m	1 m	4 m
1	April	278.3	256.9	324.7	234.2	317.5	283.5	329.0	263.8	351.7	290.4
2	May	382.7	379.6	395.3	347.2	403.7	361.8	419.3	382.5	438.5	374.8
3	June	476.9	394.5	462.1	416.4	486.2	438.2	484.6	461.3	468.2	417.5
4	July	598.4	472.8	612.7	575.8	641.5	582.6	635.8	517.0	609.3	537.8
5	August	542.6	456.7	558.3	498.3	583.1	478.5	563.2	462.5	583.3	473.6
6	September	438.6	380.6	459.4	437.5	513.8	463.8	479.7	402.8	451.0	379.3
7	October	347.1	285.9	369.6	312.7	380.5	347.2	320.4	275.3	362.5	294.0
	Annual mean	437.8	375.3	454.6	402.7	475.2	422.2	461.7	395.0	466.4	395.3

TABLE-3
TOTAL ALKALINE PHOSPHATASE ACTIVITY IN WATER LUBISZEWKO LAKE (nmol PO₄ dm⁻³ h⁻¹)

No.	Analysis terming	2008		2009		2010		2011		2012	
		Littoral	Sublittoral	Littoral	Sublittoral	Littoral	Sublittoral	Littoral	Sublittoral	Littoral	Sublittoral
		1 m	4 m	1 m	4 m	1 m	4 m	1 m	4 m	1 m	4 m
1	April	258.5	231.4	348.1	214.7	337.5	283.5	329.6	258.3	391.3	274.6
2	May	338.1	319.7	362.9	383.2	403.7	361.8	419.3	338.9	475.8	353.4
3	June	463.8	357.5	465.6	446.8	441.2	438.2	494.9	431.4	429.5	410.9
4	July	588.4	442.9	611.5	529.4	607.5	582.6	615.2	534.2	627.1	516.5
5	August	525.7	426.4	538.1	462.6	563.1	478.5	569.6	451.7	547.2	453.7
6	September	468.6	357.2	425.8	415.2	535.8	463.8	452.4	385.4	475.4	326.3
7	October	375.4	263.8	349.6	319.7	386.5	347.2	317.2	248.7	382.6	230.5
	Annual mean	431.2	342.7	443.1	395.9	467.9	422.2	456.8	378.4	475.5	362.7

TABLE-4
TOTAL ALKALINE PHOSPHATASE ACTIVITY IN WATER PRZYLEG LAKE (nmol PO₄ dm⁻³ h⁻¹)

No.	Analysis terming	2008		2009		2010		2011		2012	
		Littoral	Sublittoral	Littoral	Sublittoral	Littoral	Sublittoral	Littoral	Sublittoral	Littoral	Sublittoral
		1 m	4 m	1 m	4 m	1 m	4 m	1 m	4 m	1 m	4 m
1	April	248.5	236.5	314.3	254.5	357.4	253.6	319.4	253.3	331.1	290.8
2	May	367.7	349.2	375.1	327.2	427.2	374.8	406.8	372.9	406.4	374.3
3	June	474.6	394.9	442.7	446.8	459.6	428.4	464.2	451.4	453.4	417.5
4	July	551.9	451.6	582.4	512.5	651.3	563.7	615.8	537.5	649.8	537.1
5	August	521.6	412.7	548.5	448.4	576.7	445.3	538.5	452.8	563.5	473.5
6	September	456.4	342.0	425.0	413.1	533.1	476.5	474.8	426.5	484.6	379.7
7	October	350.1	249.6	336.1	348.0	393.4	325.1	329.1	241.3	353.5	294.3
	Annual mean	424.4	348.1	432.0	392.9	485.5	409.6	449.8	390.8	463.2	395.3

Comparing 5-year average values of the analyzed activity in the waters of selected lakes of Barlinek-Gorzów landscape park zones, it was established that it was lower in the sublittoral than in the littoral. Among the analyzed littoral and sublittoral layers, the surface layer (1 m) featured a higher total alkaline phosphatase activity than the deeper layer (4 m), where an average value of the parameter was only slightly lower than the one recorded in the littoral.

Results of more extensive research conducted in the reservoir of lakes of Barlinek-Gorzów landscape park demonstrate that algae phosphatase was mainly responsible for the high level of total alkaline phosphatase activity in the top sublittoral zone, while bacterial and free phosphatase were much less so. It appears that the participation of another group of heterotrophic microorganisms in the activity, namely that of fungi, was also insignificant^{10,12,18,19}.

Both in the water a higher level of the activity was determined in spring (May) and in full summer period (July and August). It is noteworthy the fact that higher values of the studied activity were not always accompanied by larger number of bacteria and saprophytic fungi^{10,12,18,19}, which would confirm the importance of algae affecting its level.

Conclusions

(1) Comparing 5-year average values of the analyzed activity in the waters of selected lakes of Barlinek-Gorzów landscape park zones, it was established that it was lower in the sublittoral than in the littoral. Among the analyzed littoral and sublittoral layers, the surface layer (1 m) featured a higher total alkaline phosphatase activity than the deeper layer (4 m), where an average value of the parameter was only slightly lower than the one recorded in the littoral.

(2) Results of more extensive research conducted in the reservoir of lakes of the Barlinek-Gorzów landscape park

demonstrate that algae phosphatase was mainly responsible for the high level of total alkaline phosphatase activity in the top sublittoral zone, while bacterial and free phosphatase were much less so. It appears that the participation of another group of heterotrophic microorganisms in the activity, namely that of fungi, was also insignificant.

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