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Characteristics of the trophic status, vulnerability to degradation, habitat conditions ichthyofauna and bioconcentration factors of lakes in the Barlinek-Gorzów Landscape Park

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ABSTRACT

Urbanization is the cause of many changes which are taking place in the environment, including those found in the catchment. With this in mind, 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 bodies. 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. Herein, the ecological status of surface waters and groundwater is assessed on the basis of the ecological potential of the biological, physico-chemical and hydromorphological indicators.

***Keywords*:** trophic status, vulnerability to degradation, habitat conditions ichthyofauna, bioconcentration factors, lakes, Barlinek-Gorzów Landscape Park

"... water is not a commercial product like any other, but rather
a heritage which must be protected, defended and treated as such..."
(Preamble to the European Union Water Framework Directive)

1. INTRODUCTION

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

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 forests.
2. "Dębina" 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 preserved.
3. "Markowe Błota" – marshland, with its typical vegetation such as the *Sphagnopsida*, wild rosemary, ordinary cranberry, cottongrass. The site is visited quite often by white-tailed eagles.
4. The water reserve of the "River Przyłężek". It includes a section of the River, the slopes of the riverbank and the surrounding beech stand with some tree specimens that are more than 100 years old. Seen as the watercourse resembles mountain streams, with its pure and cold water, it provides appropriate conditions for *Salmonidae* to live and spawn.
5. The forest reserve "Wilanów" aims to protects the natural mixed forest with vintage beech, oak and pine trees. Thanks to the varied topography, diverse rare types of forests have been preserved here.

Nature conservation in the Park also includes natural monuments, animate and inanimate: 41 trees, 1 boulder, 3 rocks and the natural spring "Boży Dar". The study covered seven lakes within the boundaries of the Barlinek-Gorzów Landscape Park: Barlineckie Lake, Suche Lake, Lubiszewko Lake, Przyłęg Lake, Chłop Lake, Lubie Lake, Wielgie Lake.

Barlineckie Lake - the area of the Lake covers 260 hectares, the depth reaches 18.0 m, and max length is 3.8 km. The lake is located in the North. Barlineckie sections of the Park, at 57 m above sea level and it constitutes a part of the Mysliborskie.

Suche Lake - the surface of the Lake is 21.5 hectares, the depth – 8.6 m, the width - 330.0 m, and the length – 1180 m.

Lubiszewko Lake - the surface of this Lake covers 52 hectares, the depth reaches 11.8 m reaching up to 520 m, while its length - up to 2100 m. The lake is located at 63.3 m above sea level.

Przyłęg Lake - the surface of the Lake is 43.2 hectares, the depth - 5.9 m, the width - 650.0 m, and the length – 1090 m.

Chłop Lake - The surface of the Lake is 58.7 hectares, its depth goes to 16.0 m, width - 470 m, and length - 1760 m. The Lake is located at 59.1 m above sea level and it belongs to the catchment area of the River Santoczna.

Lubie Lake - the surface of the Lake is 58.7 ha, depth goes up to 16.0 m, width is 470 m, and length is 1760 m. The Lake is located on the height of the peasant 59.1 m above sea level and belongs to the catchment area of the River Santoczna.

Wielgie (Dankowskie) Lake - the area of the Lake covers 90.2 ha, its depth is 7.7 m, width - 920 m, and length - 1880 m. It is situated at the height of 69.7 metres above sea level and it lies in the western part of the Dobiegniewskie.

The research was carried out in the years 2008-2012, between April and October. From each of the three measuring stations located in the lakes included the study, two separate water samples were taken for chemical analysis. Upon sampling, the water pH was measured. Water was tested in compliance with the Polish Standards. Collected water samples were stabilised pursuant to the guidelines of the Polish Standards**.** Other indicators of water quality were marked within 24 hours of sampling.

The oxidation of dissolved organic matter was measured with the COD-Mn method, in accordance with Polish Standards. Dissolved oxygen was marked in accordance with the methodology described by Winkler in Daniszewski's work.

The degree of water oxygenation was specified by arrays described by Nemerov. The levels of Total Suspended Solids, BOD_5, NH_4^+, NO_2^-, NO_3^-, PO_4^{3-} diss, and $P_{tot.}$ were marked – in accordance with the methodology described by Daniszewski.

The level of water pH in the lakes was influenced by physico-chemical and biotic interactions of environmental factors. Among others, the degree of acidity directly affects life processes occurring in ecosystems. It is responsible for the correct uptake of nutrients by organisms. High alkalinity is beneficial for assimilation, and therefore, the nitrogen and phosphorus compounds found in water are much more accessible than in an acid medium. Apart from high acidity, excessive alkalinity of natural waters (pH above 9) also has a clearly detrimental impact on organisms.

The studied lakes had pH values in the neutral range - 7.48 to 7.85. According to the classification of the European Union Water Framework Directive, all lakes were classified as first class. The aquatic ecosystems of the studied lakes experienced loss on ignition and non-corresponding values of COD-Mn according to the estimates, which were based on the measurements of "loss on drying" and "residue on ignition" in accordance with the methodology set out by Macioszczyk (1987) and on the basis of COD-Mn results, which invariably matched III class water quality. In the lake waters tested, considerable levels of organic matter, including reducing agents, were maintained throughout the year. The reasons for this state of affairs should also be sought in the lake bed sediment, which is rich in organic matter.

The most important elements involved in primary production are phosphorus and nitrogen. The presence of these substances determines the productivity of a water body, as well as its quality. One nutrient significantly affecting the quality of water is phosphorus. It is the primary factor which constrains the development of phytoplankton, and thus affects massive algal blooms. It can occur in water bodies in the form of inorganic phosphorus as well as dissolved organic forms. Phosphates, or the mineral forms of phosphorus, are best absorbed by organisms and play a huge role in the primary production of a reservoir. They are involved in the circulation of matter in any water body. Therefore, one should pay attention to phosphorus compounds in the demersal zone.

Nitrogen occurs in the form of gas dissolved in the water, ammonium ions, nitrate and nitrite. In lakes, it is the main factor limiting the growth of organisms.

The tests have demonstrated that water quality in the lakes with regard to the tested indicators varied. By analyzing the average annual values, one can note that the pH, O_{2diss} and NO_3^- concentration showed a relatively small variation in all the investigated lakes.

The Total Suspended Solids in the lakes Barlineckie, Suche, Lubiszewko, Przyłęg, and Chłop, fell into the II class, while the lakes Lubie and Wielgie met the criteria of the III class.

The P_{tot}. concentrations in the surface layer of the lakes was little differentiated, reaching the levels appropriate for the II and III quality class according to the classification of the European Union Water Framework Directive.

The total phosphorus concentration was 0.21-0.67 $mg \cdot dm^{-3}$. The highest concentration of total phosphorus was recorded in Lakes Przyłęg and Wielgie.

The concentrations of $PO_4^{3-}{}_{diss}$ in the tested lake waters varied more significantly – corresponding to water quality classes ranging from II through V. An upswing in the concentration of phosphorus compounds in a lake may indicate a decreased amount of oxygen in the benthic waters and changes in their redox status leading to releasing phosphorus compounds accumulated in the bed sediment.

In the case of nitrogen compounds, nitrates and nitrites values for these indicators fell into the I and II class in all the surveyed lakes in accordance with the classification of the European Union Water Framework Directive.

The indicator which proves high productivity of the lakes is the biochemical oxygen demand (BOD_5). The level of this indicator in the studied Lakes was at level II and III.

The highest concentration of oxygen in the lake waters was found in the Lake Barlineckie (about 9.7 mg $O_2 \cdot dm^{-3}$). In the remaining lakes oxygen levels were similar (still in I class). Phosphorous plays a key role in biological production and thereby in the eutrophication of the water environment. One of the important processes impacting on the level of available mineral phosphorous is enzymatic hydrolysis of organic bonds of this element. A majority of previous studies shows that alkaline phosphatase is chiefly responsible for the rate of organic phosphorous mineralization, both in the pelagic zone and in the bottom sediment of water bodies with $pH > 7$.

However, some authors report, e.g. Yiyong, that abiotic factors can also play a part in the process. Jones suggests that the level of phosphatase activity in the water is linked to the degree of lake trophicity. Whereas phosphatase activity in bottom sediment, according to Kobari and Taga, can indicate their enzymatic potential. 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 and bottom sediment of various eutrophic zones of a West Pomeranian water body. 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.

Total alkaline phosphatase activity in the water and bottom sediments of the analyzed water body was subject to seasonal oscillations. Irrespectively of the state of the environment aggregation, they typically demonstrated similar course in both analyzed zones. Both in the water and in the bottom sediments a higher level of the activity was determined in spring (May) and in full summer period (July and August). In the pelagic zone a maximum of total alkaline phosphatase activity occurred in July, which is consistent with the results of research the author of this paper conducted on other lakes. What is noteworthy is the fact that higher values of the studied activity were not always accompanied by larger number of bacteria and saprophytic fungi, which would confirm the importance of algae affecting its level. Whereas in the bottom sediment an increase in total alkaline phosphatase activity in July and August clearly showed a link between the number of heterotrophic bacteria, which most probably results from an influx into the sediments of phytoplankton, dying after spring blooms.

Heavy metal pollution is an ever increasing problem of our lakes. These toxic heavy metals entering in aquatic environment are adsorbed onto particulate matter, although they can form free metal ions and soluble complexes that are available for uptake by biological organisms. The increase in residue levels of heavy metal content in water, sediments and biota has resulted in decreased productivity and increase in exposure of humans to harmful substances. Many of these metals tend to remain in the ecosystem and eventually move from one compartment to the other within the food chain. Food chain contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in biosystems through contaminated water, soil, sediment and air. The water samples collected from different sampling stations were filtered using (0.45 μm pore size) filter paper to remove suspended particles. Filtrates were preserved in polythene bottles. In order to prevent the precipitation of metals 2 mL nitric acid was added to the filtrate.

The analysis for the majority of the trace metals like Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Nickel (Ni), Lead (Pb) and Zinc (Zn) was done by Atomic Absorption Spectrophotometer. On the basis of the research, it can be concluded that the quality of the waters of Lake catchment land use affects the way the Lake (direct and total) and its natural conditions. The water of the Lakes Barlineckie, Suche, Lubiszewko, Przyłeg, Chłop, Lubie, Wielgie has a high ability to deliver. A significant load of nitrogen and phosphorus compounds reaching the courses and boat ride, combined with natural surface determinants of these tanks may contribute to the deterioration of the quality of their waters.

Inference about the impact of the use of water reservoirs on the quality of their water was based primarily on identifying the risks excessive phosphorus supply from the confluence of the spell/Rune and tributary of the courses. The annual phosphorus load from the sources related to the use of the waters of the catchment area for trips into the Lakes of the worst quality (Chłop, Lubie) exceeds the value of the cargo dangerous. This is evidence of the threat caused by the use of catchment area, of the receipt of the cargo of the phosphorus which causes deterioration of the quality of these lakes and a large likelihood of progress of their eutrophication. The pace of this process may be different, but the load of phosphorus greater than dangerous does not guarantee the maintenance of the trophic constant.

Explored Lake belong to moderately susceptible to degradation (II category of vulnerability). The least resistant to degradation is Lake Lubie, Przyłeg, Wielgie (2.0 points). The resistance of the tank lowers the volume ratio to above all the length of the shoreline and the way the management of catchment areas.Only in the case of the load the load of phosphorous from Lake Siecino annual use of the catchment area is greater than the acceptable, but less than dangerous (II category danger). The annual phosphorus load from source stated the use of catchment areas reaching the Lakes Mąkowarskiego and Osiek is larger (2-fold) from the dangerous for the tank (III category)

The calculated phosphorus loads were brought to criterion Vollenweidera [1976] hydraulic model, adopted for the flow rate of the water of the Lakes, taking into account the exchange of the year, and so were compared with calculated for cargo tanks and hazardous wastes under consideration limit. So you can tell if the estimated annual phosphorus load associated with the use of catchment areas can be a potential threat to the Lakes, even when given its minimum value that comes from its tributaries. Knowing the loads of phosphorus and dangerous, and going to the lakes as a result of the use of their catchment area defined categories of their risk according to Hillbricht-Ilkowskiej and Kayak [1986]. Water has always been the foundation of human existence. Once man's survival depended on access to water, however, along with the development of civilization, human reliance on water changed. Humans started treating water as a common good, assuming its resources to be limitless. This line of thought has resulted in degradation of waters constituting a reserve of drinking water for future generations.

2. CONCLUSION

These alarming changes gave an impetus to taking suitable legal actions for the protection of water resources. The European Union issued a series of regulations, the so-called "water directives", yet it recognized the need for introducing a coherent framework regulating the acts of law aimed at conservation of water resources in all EU member states. Directive 2000/60/EC, the so-called Water Framework Directive (WFD), which entered into force in December 2000, constitutes such an integrated act of law. The main objective of the WFD is providing access to good quality water to present and future generations as well as enabling the use of water by, inter alia, industry and agriculture, while simultaneously preserving and conserving the natural environment.

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