Short communication

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Ecological health assessment of the multitrophic river-lake system – recommendations for effective lake management

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ABSTRACT. Every component of the river-lake system is characterized by a complex biological community interaction among among animals, plants, and microorganisms, as well as the abiotic determinants of a habitat in which they live. If one part of the ecosystem is disturbed, it affects other parts. Lake health assessment can advance our understanding of the health status of lakes and contribute to strengthening the protection and management of lakes. The key to evaluate the health status of several lakes linked with one watercourse and differed by trophic state requires selection of the most appropriate evaluation method.
We studied multitrophic river-lake system refers to a set of five lakes of different trophic status: oligotrophic (lobelia), eutrophic and dystrophic, isolated from the river flow lakes. The results showed that among factors constituting the assessment basis of lake health are: (1) the trophic state related to water quality characteristics; (2) landscape connectivity which relies on the integrity of elements in the river-fed lake systems; (3) lake residence time related to the hydrological and hydrodynamic characteristics of lakes. When planning protective measures in the river-fed lake habitats, a wide range of issues should be taken into account and setting conservation objectives requires many compromise decisions.

Keywords: multitrophic, river-lake system, water management, Poburzanka river, ecological health assessment

1. Introduction

River-lake systems consist of a variety of aquatic water bodies which are highly complex and interconnected, which undergo multiple stressors and threats. Every component of the system is characterized by a complex biological community interactions among animals, plants, and microorganisms, as well as the abiotic determinants of a habitat in which they live. A complex interdependence has evolved among the organisms in a lake community. If one part of the ecosystem is disturbed, it affects other parts, such changes in the watershed can alter the delicate balance not only the lake ecosystem but the interconnected waterbodies downstream the river. Protection of all of these natural resources as a whole is vital to the protection of lakes. Lake health assessment can advance our understanding of the health status of lakes and contribute to strengthening the protection and management of lakes. The key to evaluate the health status of several lakes linked with one watercourse and differed by trophic state requires selection of the most appropriate evaluation method.

2. Methods

For the present study we have chosen the Poburzanka river-lake system (NE Poland). The studied multitrophic river-lake system refers to a set of five lakes of different trophic status: uppermost on the river is oligotrophic (lobelia) Lake Długie (85 ha), lakes Gil (167.80 ha) and Baltyn (8,7 ha) are eutrophic. Two lakes: Czarne (3,26 ha) and Harcerskie (11,02ha) are dystrophic and isolated from the river flow. The area is covered by EU Natura 2000 area PLH280030 Jezioro Długie (Długie Lake, with three habitats types: 3110 Oligotrophic waters (*Littorelletalia uniflorae*); 3150 Natural eutrophic lakes with Magnopotamion or Hydrocharition - type vegetation; 3160 Natural dystrophic lakes and ponds.

We designed and performed water ecological monitoring of five lakes on the Poburzanka river to evaluate their health status and the influence of their upstream inflows. In the *in situ* stage, ten sampling sites were established in the representative areas of the river-lake system. The monitoring campaigns were designed to determine various aspects of the health of the lakes,

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such as 1) the degree of eutrophication at different lakes and their segments; 2) the correlations between the physical and chemical indices at different sampling points; and 3) the biotic patterns of plankton and aquatic plants. To monitor the water quality of the lakes on the Poburzanka river, the water quality parameters (temperature, pH, conductivity; secci disc transparency), oxygenation parameters (dissolved oxygen, chemical oxygen demand), nutrient parameters (ammonium-N, nitrate-N, total nitrogen, total phosphorus), and photosynthetic pigment contents (chlorophyll a) were investigated. Hydrological and morphometry variables (water table are, shoreline development, lake volume; exchange rate of water) were used to characterise the standing water bodies. Biological descriptors included the submerged and emergent plant communities as well as the presence or absence of a fish community. *Inter alia* these variables are key indicators of the state of eutrophication, acidification and infilling of a water body. The landscape features of the catchment area of the Poburzanka river-lake system were also examined.

3. Results

From a number of holistic indicators which have been proposed and discussed in the literature, we propose in this study the pressure–state–response (PSR) framework for evaluating lake health based on establishing an index system; determining the index weight; identifying risk factors; and a comprehensive lake health evaluation proposed by Su et al. (2020). Based on the monitoring data, we identified the health risk factors of the lakes. According to Su et al., (2020) we applied standard difference rates (SDR) and risk degree (Rd) concepts, and classified the indices of risk areas employing the Pareto analysis method. For each lake we identified the lake residence time, landscape connectivity, and identify eutrophication as the major threat for the aquatic ecosystems' health.

The results showed that among factors constituting the assessment basis of lake health are: (1) the trophic state related to water quality characteristics; (2) landscape connectivity which relies on the integrity of elements in the river-fed lake systems; (3) lake residence time related to the hydrological and hydrodynamic characteristics of lakes. The results contribute to decision-making for comprehensive urban lake management.

4. Conclusion

Designing an appropriate water management to protect and improve the condition of various lake habitats requires establishing safety priorities, designing a sequence of actions that will allow for the adoption of universal procedures. Transparency in data collection and synthesis, and the recognition of benefits and costs, including ecosystem services, associated with different endpoints are essential to the success of the decision-making process for protection and restoration of lakes. Due to the disruption of many polluted sites, the landscape context and associated geochemical and biophysical processes that affect polluted sites can serve as a more accurate barometer of the feasibility of protecting or restoring lakes. Global and regional factors (e.g. invasive species, climate change, nutrient flows, hydrological cycles, habitat fragmentation, trophic cascades) may prohibit or dictate the type of conservation or restoration options available. For example, the restoration of a dry peat patch may be impractical due to the limitation of the runoff of humic compounds to the lobelia lake, fed by waters from the fen.

When planning protective measures in the river-fed lake habitats, a wide range of issues should be taken into account, and setting conservation objectives requires many compromise decisions. Tying endpoints to ecosystem services provides a common currency for prioritizing ecological attributes to be protected within ecosystems lakes and worldwide management goals.

References

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