RESTORATION OF SHALLOW HYPEREUTROPHIC LAKES. SUCCESSES AND FAILURES

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Many years ago, in early 60tieth most of the polish shallow lakes were clear-water, macrophyte dominated aquatic ecosystems. Between 60tieth and 80tieth, due to intense development of agriculture and industry, growing recreation activity, and lack of the Wastewater Treatment Plants (WTP), huge amount of sewages were entering the lakes, accumulating in their sediments.

First restoration efforts started in half of 80tieth. The most popular methods were aeration of water volume, and sediment dredging. Both methods were highly costly, and the results were truly doubtful. During next years, many different efforts were undertaken, aiming to restore structures (organisms) and functions (processes) in degraded lakes. In between, biomanipulation, artificial water mixing, precipitation of phosphorus from water volume. Recently, most frequently practiced methods are inactivation of phosphate in lake sediments, and preventing or blocking Cyanobacteria blooms development.

From over twenty years, formerly Laboratory of Applied Hydrobiology of Nicolas Copernicus University in Torun was, and recently Department of Hydrobiology of Kazimierz Wielki University in Bydgoszcz is involved in testing or improving of existing methods, and, if possible, developing new. Since fifteen years, the author is cooperating with the PROTE Company in Poznań, what allows to undertake restoration projects in a full lake ecosystem scale, supported with funds by European Union (EU).

Investigations were conducted on over 30 lakes differing in watersheds, among them urban, agricultural and forest. There were also two artificial reservoirs, one created for water storage and recreation, and another, made on closed river arm, for alimentation of refinery with pure technological water.

Lake Zdworskie (340 ha, 4,0 m maximal and 2,0 m average depth), biggest in Mazowian Voivodship, served as testing ground where almost all existing methods were checked. Also, due to very high organic matter contents in sediments of that lake (up to 67 %) trials were made to elaborate dedicated to situation method. The sequence of operations started with partial sediment removal, placing it in geotubes with simultaneous coagulant ($FeCl_3$) addition, to keep phosphates inside sediment. Water returning to the lake had no phosphorus. Dry sediment was burnt, and all phosphate was extracted from ash. After adding NH_4Cl and $MgCl_2$, and initiating the crystallization process, it was possible to obtain artificial fertilizer (struvite) with almost 70 % of phosphate built in.

Only in two, from over thirty investigated aquatic ecosystems, changes were spectacular. The first case is linked with elaboration of a new method of sediment phosphorus inactivation, allowing to applicate coagulant ($FeCl_3$) direct-

ly into sediments. In almost all described in literature cases, coagulants were applied on or below the water surface. The idea behind dosing coagulant from the surface is for the coagulant to create a layer to insulate the bottom sediment and block the migration of this nutrient from sediments to water. Such a layer could be formed only if the dosing was to be simultaneously carried out on the entire lake's surface, and the reservoir's water was not at that time subject to any movements, such as currents and waves. Even if an isolating sediment surface coagulant layer is tight, it's very small negative buoyancy can cause movement, and replacement by ebullition of gas bubbles or small water currents.

In order to be able to applicate coagulant ($FeCl_3$) directly into sediments the PROTE company designed and built a custom-made PROTEUS patented vessel. It consists of two modules. Surface module is able to precisely navigate across the reservoir and monitor its bottom, reporting accuracy of vessel position (maximum error: 1,0 to 2,0 cm). The navigation and control booth has three computers inside, one that controls the underwater module; the other, that is responsible for the preparation of chemical solution – determining its concentration, volume and dose; and the main computer that is concerned with navigation, monitoring of the underwater module's position at the sediment surface, and receives pictures from its front and rear cameras. Underwater module is responsible for triggering the intentional, controlled resuspension of sediment. The module is shaped in the form of a flattened bell, the purpose of it is to increase the contact with the surface of sediment particles, to which chemicals are applied during resuspension of precisely determined sediment layer.

It was the main method while restoring two urban lakes Jelonek and Winiary in Gniezno, during realization of restoration project in the years 2009 – 2011 co-financed from the EU Life+ programme. In lake Winiary clear regime shift to clear-water, macrophyte-dominated stable state was obtained. Positive changes in lake Jelonek were minor. That lake is situated more close to town center, and is exposed to inflows of rainwater and sewage mixture from old combined sewer system and stormwater drainage during heavy rainfalls. The method received a high recognition from the European Committee which recognized it in 2012 as one of five best environmental technologies in Europe.

Second clear positive regime shift was obtained in Lotos refinery reservoir of technological water. The only method applied was provision of barley straw baleys, mounted across reservoir in sections of proper hydrology. It is known that the decomposition of this straw in oxic water causes the emission of substances called algaestatics, which are blocking the cells division and growth of algae and especially Cyanobacteria. Mounted in March 2012 baleys caused distinct changes in August. Water transparency increased from 0,3 m to 4,5m. Next year colonies of freshwater sponge *Spongilla lacustris* developed on concrete bottom.