The ability of a bacterial-enzymatic preparation to break down the organic fraction of pond sediments

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Abstract: The high amount of sediments in ponds is a common problem in Czechia. In most cases, pond owners are not able to manage this problem neither financially, nor organizationally or professionally. An innovative solution could be a product that is able to decompose organic deposits directly on the bottom and in the water column using natural, unmodified microbial assemblages. The aim of the experiment was to evaluate the ability of a bacterial-enzymatic preparation to decompose pond sediments and to investigate the influence of this preparation on the quality and overall composition of sediments and water. According to our experiment the decomposition of pond sediments during the application of the preparation is not demonstrable. Our experiment did not confirm any significant effect of the product on the quality of the water in aquatic environment during the application of the products. However, the experiment was carried out under laboratory conditions, the results of this experiment do not fully correspond to the results that can be obtained in ponds under natural conditions.

Key Words: bacterial-enzymatic preparation, organic sediment, quality of pond water

INTRODUCTION

The sediment reaches the ponds in various ways. In the case of flow-through ponds, this mainly concerns the transport of soil particles through the feeding watercourse. Furthermore, it may reach the pond due to a bank abrasion or biomass breakdown directly in the pond water space (Mikšíková et al. 2012). The largest inflow of soil particles into the pond is caused by run-off from agricultural lands as a result of increased erosion in the basin, which is caused by inappropriate agricultural land management. Increased deposition of sediments at the bottom of ponds leads to their grounding, which limits the pond in the processes of removing pollution and the pond has subsequently a reduced ability to produce fish (Kubík 2011, Plaster 2014). The accumulation of organic matter in the pond is undesirable as it can accumulate to a level where the yield of fish can be adversely affected due to the release of toxic substances such as hydrogen sulfite and nitrite. High deposition of organic substances also results in high oxygen consumption, which can lead to depletion of oxygen mesocosmicand thus further reduce fish production (Boyd 1998, Muendo et al. 2014).

Pond sediments are mined and stored in piles; in many cases they are labelled as pond mud. Extracted sediments from ponds, reservoirs and watercourses are then regarded as waste, but the disposal of sediments in natural systems poses a threat to the environment in the form of wasting valuable nutrients (Havlíček et al. 1969, Muendo et al. 2014). Pond sediments contain high amounts of nutrients and organic substances, reported to be several times higher than in fertile ground. However, their use mesocosmicin agriculture is very low (Havlíček et al. 1969).

PTP Plus is a mixture of bacterial spores and enzymes that can be purchased from Baktoma Ltd. The product should decompose the organic content of sediments in ponds and reservoirs. It is a concentrate of spores and endospores of specially selected and targeted breeding strains of native soil bacteria that exhibit specific properties, such as the ability to increase production of the desired enzyme. According to the manufacturer, all strains of bacteria present in the mixture are non-pathogenic and naturally occurring, neither are they genetically altered or modified.

Shortly after the introduction of the product into the aquatic environment, spores and endospores should revive and feed the organic sediment. Regular use of PTP Plus should reproduce bacteria, resulting in continuous cleaning of ponds and lakes. The manufacturer of this preparation states that after a few weeks of use of the preparation, biological equilibrium will occur in the aquatic environment, thus reducing the amount of organic deposits and turbidity at the bottom and in the water column. Furthermore, the phosphorus and chlorophyll *a* content in the water column should be significantly reduced and the oxygen content of the water should be increased (BAKTOMA 2017).

MATERIAL AND METHODS

Pond sediment from Pohořelický pond (Pohořelice nad Jihlavou, South Moravian region) was used in the experiment. The pond is eutrophic and the sediment was taken after the spring fish harvest on April 3, 2019, namely from the fishing ground in the surface layer of 0–30 cm.

Sediment layers were deposited in nine tanks at a height of approx. 20 cm (approx. 115 kg of sediment per tank) and supplemented with aged drinking water. The tanks were placed in a room with unrestricted daylight and with a temperature ranging from 20.2 °C to 34.1 °C, the average temperature in April was 21.8 °C, in May 23.7 °C, in June 29.3 °C and 28.1 °C in July. On April 16, 2019 the bacterial-enzymatic preparation PTP Plus was applied to three tanks (tank No. 2, 5 and 8) with the sediment-water mixture prepared in the concentration according to the instructions recommended by the manufacturer. In three additional tanks (tanks number 3, 6 and 9) the preparation was applied at a concentration ten times higher. The remaining three tanks (tank number 1, 4 and 7) mesocosmicwith no PTP Plus addition served as a control. Here we added only pure zeolite. Zeolite serves as a carrier for the active ingredient of PTP Plus. The dosage of the product as recalculated mesocosmicto the water surface of the tanks was as follows:

Week 1 – application of 100 g

Weeks 2 and 3 – application of 75 g per week

Weeks 4 and 5 – application of 50 g per week

Weeks 6 and 7 – application of 25 g per week

To maintain the amount of water, the tanks were replenished every second week with 30 litres mesocosmicof aged water. The basic physico-chemical parameters were measured five times a week mesocosmicin each tank. We measured the amount of dissolved oxygen, temperature, pH (Hach HQ40d) and conductivity (Hanna combo). A water sample was taken from each tank for chemical analysis mesocosmiceach week prior to application of the PTP Plus. Samples were taken into 0.5 l plastic bottles, about 20 cm below the tank surface. The following parameters were monitored: chemical oxygen consumption (COD_{Cr}), total nitrogen, phosphorus and iron, ammonium nitrogen, nitrites, nitrates, phosphates, chlorides, chlorophyll *a* concentration, acid neutralizing capacity and calcium content. Chemical parameters were determined by standard methods according to Horáková (2003). PTP Plus was first applied on 16/04/2019 according to the instructions above. After seven weeks (04/06/2019) from the first application, a part of the sediments was taken from the tanks and processed, the dry matter of the samples was determined and the soil extract was prepared using Aqua regia. The total phosphorus, calcium and iron content was determined from the extracts. The proportion of organic substances mesocosmicbefore and after application was also determined. Chemical parameters of extracts were determined by standard methods according to Horáková (2003) and Zbíral (2011). The results mesocosmicare expressed in dry weight units of the sediments.

RESULTS

This chapter shows the results of the most important parameters, dissolved oxygen, total phosphorus, organic substances and chlorophyll *a*.

Figure 1 shows the dissolved oxygen content of all nine tanks. The measurements were taken five times a week for the duration of application and one week after the application, i.e. 8 weeks, from which the weekly average was calculated. Oxygen was measured once a week before (11/04/2019) and once five weeks after the last dose (02/07/2019). The amount of dissolved oxygen was relatively balanced in all tanks for the first three weeks. Especially in the fifth and sixth week of application

of the preparation there was a significant decrease in the oxygen content, but again in all tanks. Significantly the lowest values of measured oxygen were recorded, with the exception of the ninth tank, on the last day of the measurement, i.e. five weeks after the last dose of the preparation. There was no significant effect of PTP Plus on the amount of oxygen in the water. Other measured physico-chemical parameters (temperature, pH, conductivity) were relatively balanced in all tanks before, during and after application.

Figure 1 Dissolved oxygen saturation in tanks with a mixture of sediment and water. Each point represents week average.

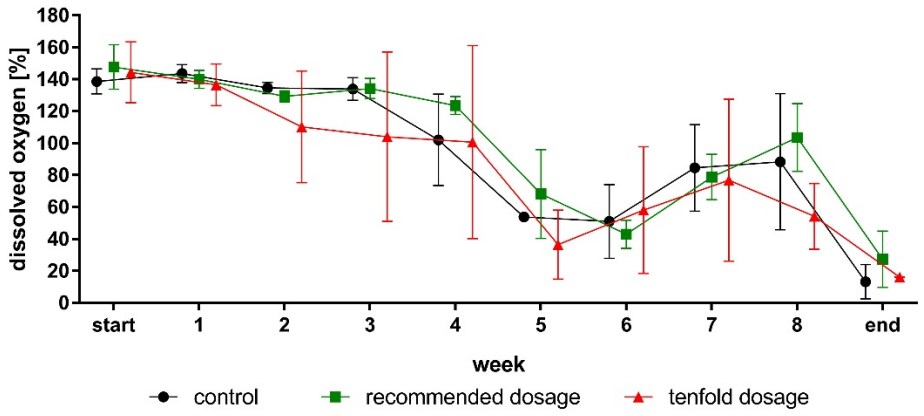
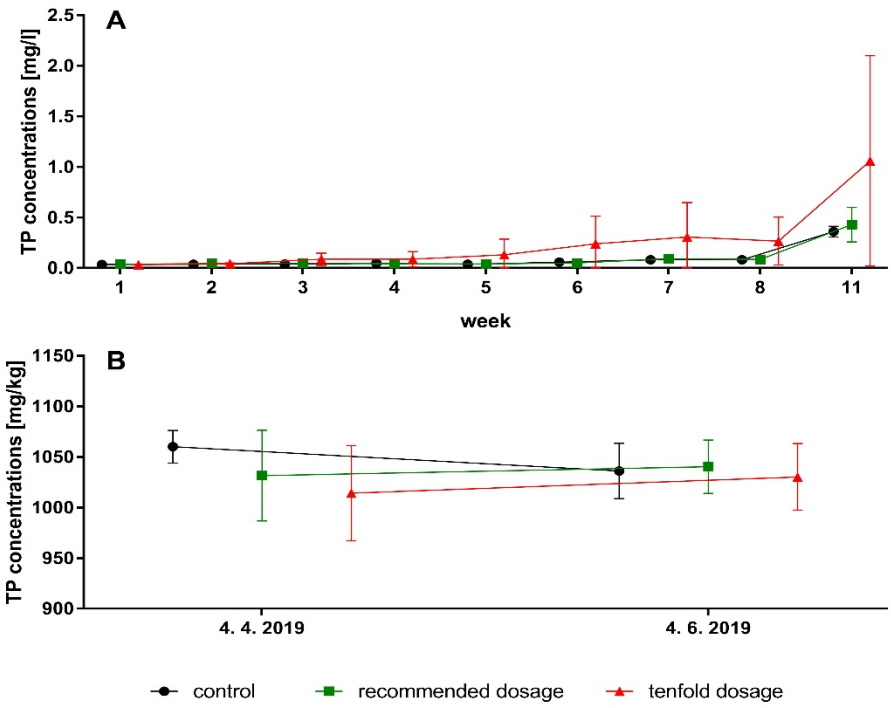


Figure 2 A) Total phosphorus concentration in water in tanks B) Total phosphorus concentration in sediments

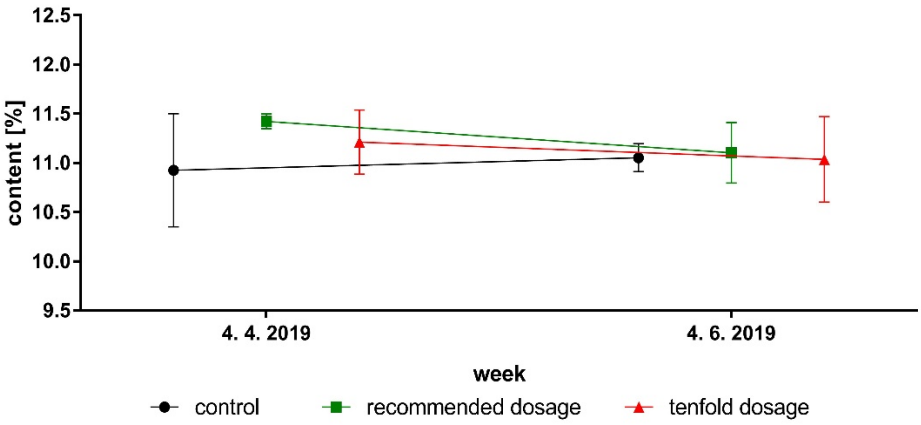


In Figure 2 A, the total phosphorus concentration in water is recorded in all nine reservoirs during application and five weeks after the last dose of product. For the first six weeks, the phosphorus concentration in the water is low and balanced in all tanks except tank number 9. The tank No. 9, for unknown reasons, differed from the beginning of the experiment, and therefore the results from this tank cannot be used as a standard to evaluate the experiment. There is a slight increase in phosphorus concentration in all tanks in the 7th and 8th weeks of application, the highest values

are reached at the last measurement, five weeks after the application of the last dose of the product. The highest values of phosphorus in water were measured in tanks where a ten-fold dose of the preparation was used. Neither of these values can be attributed to the effect of PTP Plus on the amount of phosphorus in water.

The concentration of total phosphorus in the sediments was analysed twice, from the sediment taken prior to application (04/04/2019) and from the sediment taken from the tanks a week after the last dose of the product (04/06/2019). In tanks, where only zeolite was applied, the total phosphorus in the sediment was reduced. Conversely, in tanks where at the recommended and a ten-fold dose was applied, there was a slight increase in total phosphorus in sediments (Figure 2 B). With the application of the preparation, phosphorus concentration should decrease in the water column and increase in sediment. As with a preparation Phoslock ™, which has been tested for Lake Okareka in New Zealand (Hickey and Gibbs 2009). But it didn't happen in our experiment.

Figure 3 Amount of organic substances in sediments



The content of organic substances in the sediments was also determined from the sediment taken before the start of PTP Plus (04/04/2019) and from the sediment taken from the tanks a week after the last dose of the preparation (04/06/2019). In tanks, where only zeolite was applied, the amount of organic substances in the sediment increased. The amount of organic substances in the sediments at the tanks where PTP Plus was applied in the recommended and ten-fold dose slightly decreased (Figure 3).

Figure 4 Concentration of chlorophyll a in sediment-water tanks

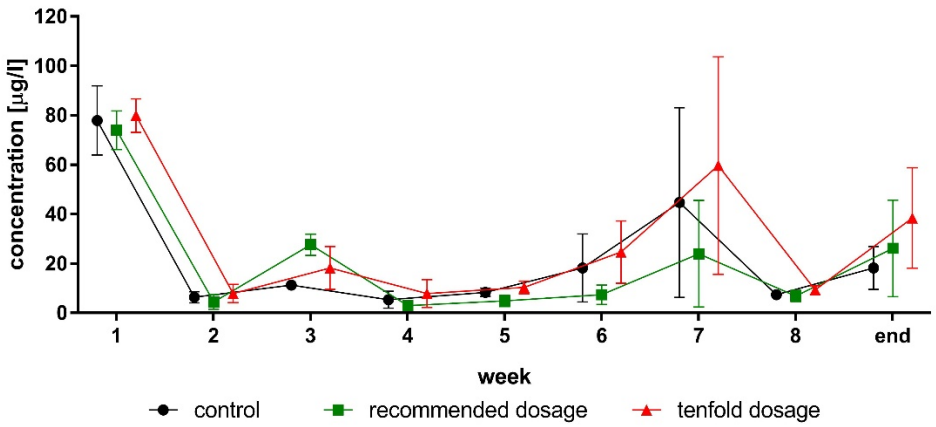


Figure 4 shows the concentration of chlorophyll *a* in water during application and five weeks after the last application of PTP Plus. The highest values of chlorophyll *a* concentration were reached at the beginning of the experiment, during the first measurement. During the second week of application a significant decrease in chlorophyll *a* concentration occurred in all tanks. In the third week

of application, a higher increase of the concentration was observed, especially in the tanks where PTP Plus was applied at the recommended dose. In the following weeks, the concentration of chlorophyll *a* in all tanks decreased only in the seventh week of application of the product, in almost all tanks the concentration of chlorophyll *a* increased again. At the eighth week of application, the chlorophyll *a* concentration in the water decreased again and was increased again at the last measurement. The fluctuation of the chlorophyll *a* content mainly depended on the successive development of the tank, i.e. the alternation of maxima of development of primary producers (cyanobacteria and algae) with the development of zooplankton.

Calcium and total iron were also determined from sediment extracts, where no significant changes were observed before and after application. Neither do other results from chemical analysis of water show any significant influence of the product on water quality.

CONCLUSION

The manufacturer of PTP Plus states that the application of the product in the aquatic environment will reduce the amount of organic deposits, significantly reduce phosphorus and chlorophyll *a* in the water column, and increase the oxygen content in the water (BAKTOMA 2017). Based on the results of our experiment, we found no significant effect of PTP Plus on the monitored parameters of the aquatic environment or sediments. Neither the addition of the product to the tank at the recommended dose according to the manufacturer nor the 10-fold increased dose had any positive or negative effect on any of the monitored parameters compared to the control.

Although we tried to mimic the natural aquatic environment as much as possible, the experiment does not fully correspond to the natural conditions in ponds. Due to weather conditions and fish stock, water and sediments move in natural waters, which is not easily simulated in mesocosm experiments.

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