USE OF BIO-ENZYMATIC PRODUCTS FOR THE REDUCTION AND MODIFICATION OF FISHPOND SEDIMENTS

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Abstract: Accumulation of sediments in fishponds is a big problem in the Czech Republic. Most owners of fishponds are not able to manage this problem financially, organizationally or professionally. A product that could degrade organic depositions at the bottom and in the water column using natural unmodified bacteria could be an excellent and innovative solution to the problem of silt removal in fishponds. The aim of the project was to examine the ability of bacterial-enzymatic mixture to decompose pond sediments and the effect of these products on the quality and composition of sediments. The experiment was conducted in laboratory conditions, so the results of this experiment do not match the results that could be achieved in ponds under natural conditions. The degradation of pond sediments was not confirmed during the course of the experiment. However, the influence of the product on the change in sediment composition and the increase in oxygen content in water was confirmed.

Key Words: sediment, water extraction, Mehlich extraction, bio-enzymatic preparations

INTRODUCTION

A significant change in strategy management of fishpond ecosystems occurred during the second half of the 20th century, especially in connection with the intensification of carp breeding and overall intensification of agriculture (Vrána 2002). Increase in sediment depositions at the bottom of ponds is occurring due to increased erosion in the catchment area, which is caused by an inadequate management practise of agricultural land. As a result, not only fish production, but also the function of fishponds in the process of pollution elimination is reduced (Kubík 2011, Plaster 2014).

Sediments from fishponds are often removed and deposited in piles, and recorded as pond mud (Havlíček 1969). Dredged sediments from fishponds, water reservoirs and water courses do not have to be regarded as waste, if the quality of sediment complies with the requirements listed in the Annex no. 9 of Act no. 185/2001 Coll. on waste, as amended (after adoption of amendment no. 9/2009 Coll) (Kubík 2011). Sediments from fishponds and reservoirs contain higher content of nutrients and organic material when compared to arable land. Considering the conditions of our soil and deposits of pond material, whether still in ponds or removed to fishpond dam, their use in agriculture is very small (Havlíček 1969). The amount of allochthonous material getting into the water increases risk of sediment contamination, which entails tightening of the legislative requirements for the use of sediments in agriculture. Nowadays, interest in the reuse of sediments is minimal and excavation from ponds and reservoirs is more expensive and more difficult.

A product, which should decompose organic parts of sediments in fishponds and reservoirs, can be purchased on the market. It is a bacterial-enzymatic mixture containing concentrate of spores and endospores of specially selected and purposefully cultivated strains of native soil bacteria. One of the specific properties of those bacteria is the ability to increase the production of the desired enzyme. All strains of bacteria should be non-pathogenic and naturally occurring in natural environment. These strains of soil bacteria were selected for specific efficiency and should not be genetically altered or modified. After introducing the mixture to water environment, spores

and endospores should revive in a short time, produce specific enzymes and consume the present organic sediment.

Regular use of PTP Plus should lead to the reproduction of bacteria, followed by continual cleaning of fishponds. Producers of the mixture further state that biological balance in fishponds occurs after couple of weeks of using this product. The amount of organic deposition, as well as turbidity at the bottom and in the water column, should be significantly reduced. The result should be a clear and transparent fishpond. Furthermore, a significant reduction in chlorophyll a, which is a measure of algal biomass, should be achieved, as well as an increase in the oxygen content in the water. The product should be safe for animals and cannot be overdosed (Baktoma 2017).

MICROBE-LIFT/Sludge-Away from USA company Ecological Laboratories, Inc is a similar product available on the market. This product has organic and microbial base and it is formulated specifically for the removal of organic bottom solids that are slow to degrade. It works faster at warm temperatures; however, it may be used effectively at any temperature year-round. The product may slightly discolour pond water for a short while. Company also states that product precipitates phosphorous, improves transparency of fishpond and it is safe for fish, plants and environment. It will accelerate the solubilisation and biological digestion of organic solids in pond. As a result of this increased oxygen demand, the oxygen uptake rate in the pond will increase in the process, along with the aquatic life's need for oxygen. The fishpond must be sufficiently oxygenated (> 4.0 mg/l of dissolved oxygen) during the time of use of this product (MIKROBELIFT 2017).

MATERIAL AND METHODS

Sediments from eutrophic fishponds Bohuslavický I and Bohuslavický III, situated in cadastral area of municipality Bohuslavice u Konice in Olomouc Region, were used in this study. Sediments were collected during the vegetative period on 9. 5. 2017 from the surface layer (0–15 cm).

Sediments were deposited in six graduated cylinders. Height of sediments layer was 20 cm, and 30 cm of tap water was added. All cylinders were placed in a room with a constant temperature (12 ºC) and limited light access. Bio-enzymatic mixture PTP Plus was applied in two of graduated cylinders with the mixture of sediment and water. In the first one the applied concentration was according to the instructions of the producer and in the second one 100 times greater. The third cylinder was without any product, and it was used as a control. The dosing according to the instructions recalculated on the water surface of the cylinders was following:

1st week – application of 9.5 mg

2nd and 3rd week – application of 4.8 mg

4th and 5th week – application of 3.2 mg

6th and 7th week – application of 1.6 mg

Other product (MICROBE-LIFT/Sludge-Away from USA company Ecological Laboratories, Inc) available on the market has been tested for comparison with the effect of PTP Plus. MICROBE-LIFT was applied in two graduated cylinders (fourth and fifth) with prepared water and sediment. One was with concentration recommended by producer and the other with hundred times higher concentration. The last cylinder was used as a control, so it was without application. The product was applied every week, for five weeks, according to the instructions, recalculated to the volume of the cylinder, i.e. 0.12 ml of product every week.

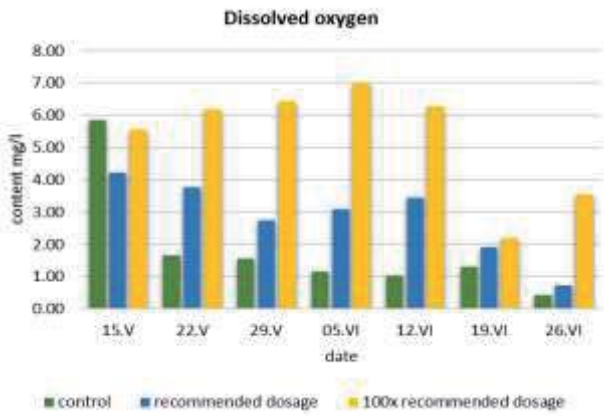
Basic hydrochemical parameters: dissolved oxygen, water temperature, pH (Hach HQ40d) and water conductivity (Hanna combo) were measured in cylinders every week during the product's application. PTP Plus and MICROBE-LIFT were applied for the first time on 15 May 2017 according to the above-mentioned instructions. Eleven weeks (31. 7. 2017) after the first application, all sediments were analysed. Dry matter of the sample was determined and water extraction according to standard ČSN EN 12457-4 and according to Mehlich III was done. The content of available nutrients (N, P) in sediments was determined in both extracts. At the same time, the loss of sediment in cylinders was monitored and the share of organic matter before and after the application of products was measured. Chemical parameters from the extract were analysed using standard methods according

to Horáková (2007) and Zbíral (2016). The results are expressed in dry weight units of the used sediments.

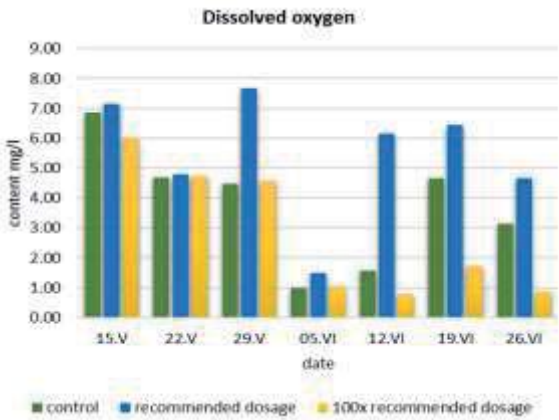
RESULTS AND DISCUSSION

Figure 1 Dissolved oxygen content

A) PTP plus application



B) Microbe-lift application

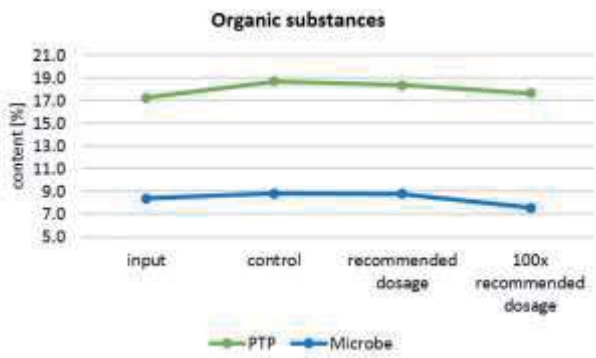


Dissolved oxygen content was higher in cylinders where PTP plus was applied than in cylinder without mixture, with the exception of the first application (15. 5. 2017). During the almost entire period of PTP plus application, the highest oxygen content was measured in cylinder where a hundredfold dose of the product was applied, and the lowest in the cylinder with control, i.e. without application (Figure 1A). On the other hand, in case of Microbe-lift, the lowest values of dissolved oxygen were in the cylinder with a hundredfold dose. The highest values were documented in the cylinder where the product was applied in recommended dose (Figure 1B).

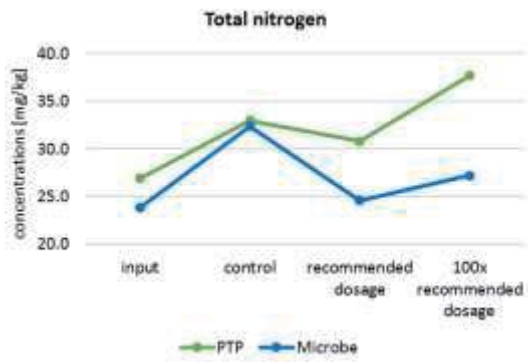
The amount of dissolved oxygen actually increases during the application of both products, when compared to the control. In the case of Microbe-lift, where an oxygen content of more than 4 mg/l is necessary for the functioning of the product, it is important to keep accurate dosing. Other measured hydrochemical parameters (temperature, pH, conductivity) were relatively balanced in the cylinders with PTP plus product. Significantly increased values of conductivity were detected in the cylinder with hundredfold dosage of Microbe-lift. The other measured hydrochemical parameters were again relatively balanced.

Figure 2 A) Content of organic matter and B) concentration of total nitrogen in water extraction

A)



B)



Content of organic matter in sediments from fishponds Bohuslavický I and Bohuslavický III is presented in Figure 2A. Values "input" are values of sediment, which was analysed immediately after the sampling, i.e. 9. 5. 2017. Other values are from analyses conducted after eleven weeks (31. 7. 2017). PTP plus was applied to the sediments from the Bohuslavický I pond from 15. 5. 2017

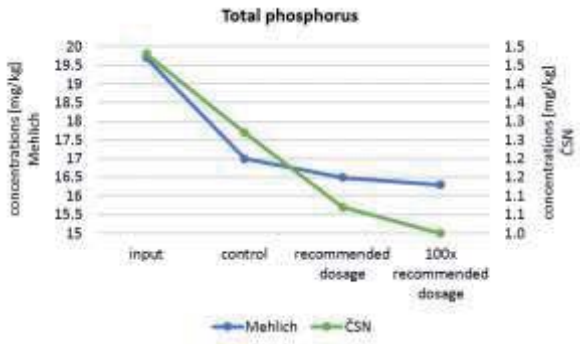
to 26. 6. 2017 and Microbe-lift/sludge-away was applied to the sediment from the Bohuslavický III pond from 15. 5. 2017 to 12. 6. 2017. The values in graduated cylinders with recommended dosage and hundredfold higher dosage than recommendation of producers were recorded. "Control" represents the values of sediments taken from cylinders without any application (only sediment and tap water), eleven weeks after the beginning of the test.

The highest amount of organic matter in sediments from Bohuslavický I fishpond was in the control (Figure 2A). A slight decrease in the amount of organic substances occurred in sediments treated with PTP plus; but the lowest values were in the sediment analysed on the day of the sampling (input). A similar trend is also shown in the second curve presenting the effect of Microbe-lift. The lowest value was documented in the sediment where a hundredfold higher dosage of the product was applied. However, the values do not differ by more than 2%, so in this case, neither one product is evidently functional.

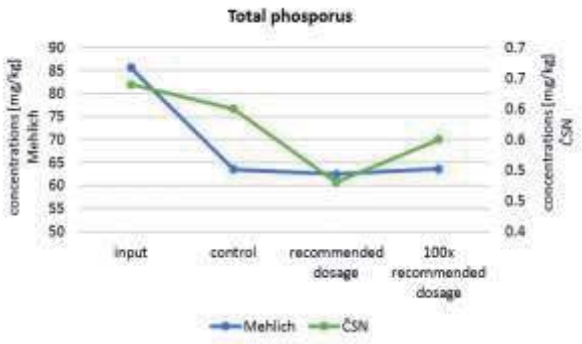
Concentration of the total nitrogen in sediments decreased in cylinders with recommended dosage of both products, when compared to the control. However, an increase in values was detected in the sediment treated with the hundredfold dosage; values of the sediment treated with PTP plus exceeded and the control values. It is clear from Figure 2B that the lowest total nitrogen concentration was measured in fresh sediments, i.e. those analyzed on the day of the collection.

Figure 3 Concentration of total phosphorous in sediments determined in extract according to standard ČSN EN 12457-4 and according to Mehlich III

A) PTP plus application



B) Microbe-lift application



The amount of total phosphorus declined with an increased concentration of the PTP plus product (Figure 3A). The value of total phosphorous also decreased in control, when compared to the input. In this case, we can evaluate that the PTP plus slightly decreases the phosphorus concentration in sediments. Concentration of the total phosphorus also decreased significantly in the control sample when compared to the input sample, in sediment from Bohuslavice III treated with Microbe-lift, as can be seen in Figure 3B. In this Figure, the differences in values obtained from different methods of extraction were recorded. According to Mehlich extraction, the product has no effect on the change in phosphorus concentration. Values obtained by standard ČSN EN 12457-4 show a decreased concentration of phosphorous in sediments treated with recommended dosage. However, increase occurs at higher dosage. In this case, the effect of the product on the sediment cannot be evaluated.

Amount of calcium in water extract increased after PTP plus application; the value in control also was slightly higher, when compared to the input analyses (Figure 4A). Therefore, in this treatment, the product had influence on the increase in the amount of available calcium in the sediments. In case of Microbe-lift (Figure 4B), more distinctive increase was documented in control when compared to the input value. Values obtained from different methods of extraction have differed. According to Mehlich analyses values increased and according to the standard ČSN values are more balanced, with a slight decline. The influence of Microbe-lift product is minimal.

Figure 4 Concentration of calcium in sediments determined in extract according to standard ČSN EN 12457-4 and according to Mehlich III

A) PTP plus application *B) Microbe-lift application*

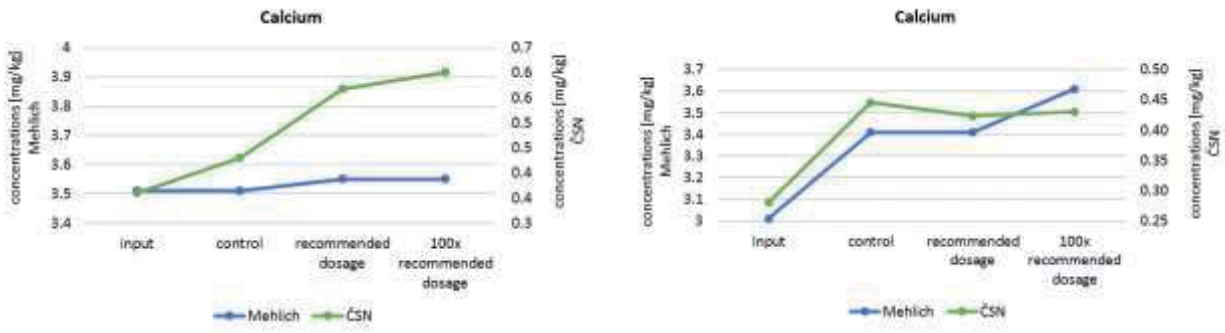
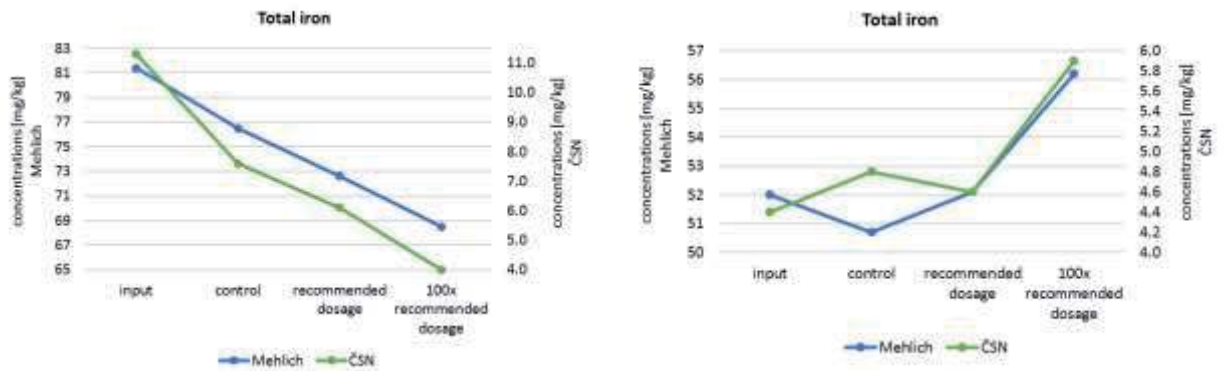


Figure 5 Concentration of iron in sediments determined in extract according to standard ČSN EN 12457-4 and according to Mehlich III

A) PTP plus application *B) Microbe-lift application*



Concentration of total iron declined in sediments from Bohuslavice I with a higher concentration of PTP plus (Figure 5A). In that case, there was a slight decline in concentration of iron in sediments. The value of total iron was lower in control, when compared to the input. In Microbe-lift treatment, values of total iron vary, depending on the type of the extraction method used. According to Mehlich, there is an increase in the values of the treated sediments, and only in control the value is lower than in the analysed fresh sample (Figure 5B). Values in the water extract prepared according to the standard ČSN EN 12457-4 are more balanced. A slight decline of iron concentration occurred in the graduated cylinder with recommended dosage, but the concentration rises again at a hundredfold higher dose. In this case, the effect of the product on the sediment again cannot be clearly assessed.

CONCLUSION

PTP plus producer states that this mixture should decrease the amount of organic sediment, and thereby also the turbidity at the bottom and in the water column. Furthermore, a decrease of phosphates and increase in oxygen content in the water should occur. The product does not decline the amount of organic sediment according to the conducted laboratory experiment. The height of sediment layer was the same in graduated cylinders during the entire period of application and four weeks after the application. Values of organic matter slightly decreased during the product's application, but only in a negligible amount. The content of dissolved oxygen in water actually increases with an increasing concentration of the product. Concentration of phosphorus in the sediments slightly decreased with the higher concentration of the product. The amount of available calcium in sediments is influenced by the PTP plus treatment; higher values in cylinders with higher dosage. Concentration of total nitrogen in water extraction was reduced when the product

was applied at the recommended dose. Total iron in extractions was also analysed and as with phosphorus, its concentration decreased with an increasing concentration of the product.

Concurrent product Microbe-lift should also decrease the amount of organic sediments and precipitate phosphorous. A condition for the functioning of this product is sufficiently oxygenated water (> 4.0 mg/l of dissolved oxygen), but this condition has not always been met. Values of dissolved oxygen increased in cylinder with the recommended dosage of the product, but decreased in sediment treated with a hundredfold concentration. The amount of organic matter slightly decreased during the application of the product, but also at a negligible quantity. The amount of total nitrogen also slightly decreased in cylinder with a recommended dosage. Other parameters cannot be clearly evaluated. Used extraction methods (according to Mehlich and standard ČSN EN 12457-4) show different values in order of magnitude in both products. In sediments treated with Microbe-lift, different tendency of increasing and decreasing was noticed in each of the methods. In PTP plus the treatment values are different, but the curves in figures are with the same or similar tendency of ascending and descending.

The results of our experiment show that none of the products fulfilled all of the producers claims. However, the experiment conducted under laboratory conditions does not fully correspond with natural conditions in fishponds. For the best possible functioning of the products, sufficient oxygenation and mixing of water in the cylinders should be provided. In fishponds, weather conditions and fish stocks contribute to water and sediment movements, and in addition, there is a number of other factors, which can have influence on the efficiency of the products.

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