The Role of Biomanipulation in Fisheries of Lacustrine Ecosystems

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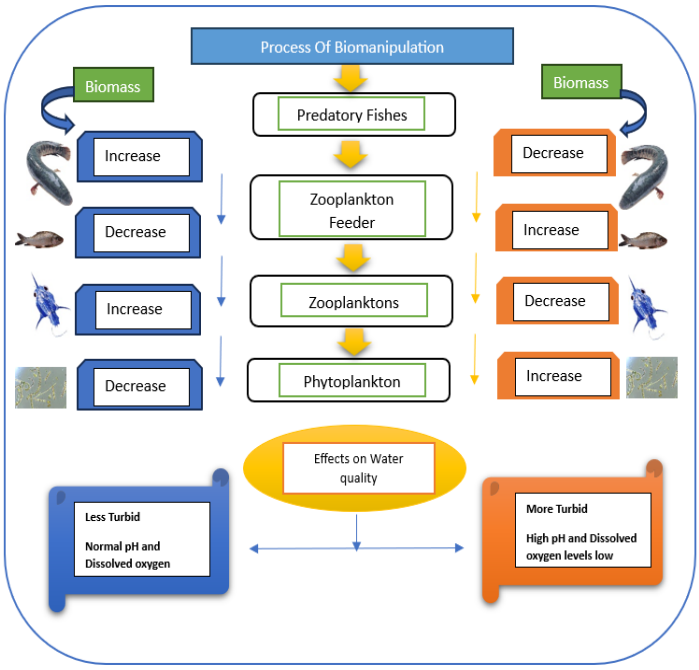
Abstract

Eutrophication resulting from high nutrient loading has been the paramount environmental problem for lakes world-wide for the past four decades. Efforts are being made in many parts of the world to reduce external nutrient loading via improved wastewater treatment or diversion of nutrient-rich inflows. In that case, biomanipulation technique which is cost-effective technique can be considered as one of the most suitable solutions to overcome the problem of eutrophication and to restore the quality of water in small and shallow eutrophied lakes. Biomanipulation was originally based on the idea that when the number of planktivorous fish are reduced, the density of large cladoceran zooplankton increases, and their grazing during the summer period can reduce certain species of planktonic algae and reduce the algal turbidity of the water. There is a need of more scientific research with respect to the potential bio-manipulation of lake ecosystems with the long-term positive effects.

Introduction

The problem of eutrophication nowadays is greatly affecting the water quality and aesthetic values of the lake ecosystems. In that case, bio-manipulation technique which is cost-effective technique can be considered as one of the most suitable solutions to overcome the problem of chances for success of bio-manipulation technique depends on the approach adopted i.e. whether the removal of fish was partial or complete, if only predatory fish were stocked, size (small lakes are easy to manipulate, Meijer 2000) and depth of the lake but the complete success through bio-manipulation is still debatable. Bio manipulation is generally described as engineering technology." Biomanipulation has become a routine technique for improving water quality of lakes and reservoirs (Hansson *et al.*, 1998; Drenner & Hambright, 1999). Bio manipulation biology is further explained as a management practice adopted by humans to improve degraded water bodies. Wysujack & Mehner (2002) suggested Best bio-manipulation strategy for the fisheries management is the combination of piscivore introduction, manual removal of fish species and its integration with the nutrient management. There is a need of more scientific research with respect to the potential bio-manipulation of lake ecosystems with the long-term positive effects.



Major components behind Bio-manipulation mechanisms

Fish

Fish is an important component of the bio manipulation process. There are two types of approaches we can follow in order to control the population of planktivorous fishes and to increase the zooplankton biomass. First approach to reduce the biomass of planktivorous fish is through kill (using some chemicals like rotenone by following the recommended dose) and removal (capturing the fish directly by netting) whereas secondly, we can go for the stocking of predatory (piscivorous) fishes. A reduction in the biomass of benthivorous fish is also suggested to have a favourable impact on the bio-manipulation process because the benthivorous fish

while feeding will stir-up the bottom causing more turbidity, impairing the colonization & growth of macrophytes and their stability.

Whereas the role of Phyto-planktivorous fish in bio-manipulation process is important as they improve the water quality by actively grazing upon the phytoplankton blooms. Radke and Kahl (2002) carried out an experiment of fish bio-manipulation and concluded that silver carp (Hypophthalmichthys molitrix), a Phyto-planktivorous fish species can more strongly impact the planktonic Cladocera's than phytoplankton, therefore, this fish cannot be considered as a candidate fish species for bio-manipulation in mesotrophic lakes. Starling *et al.* (2002) carried out a study and suggested that introduction of some small-scale commercial fish species targeted against these fishes would not only improve the water quality of the reservoir but also provide the local population with good quality protein. As an alternative to the fish , Roy *et al.* (2010) and Gulati *et al.* (2008), suggested that the introduction of mussels can also create clear water through the filtration of water as they are the filter-feeders and by reducing the nutrient load. In this case, Zebra mussel (Dreissena polymorpha) could be considered as a suitable candidate for bio-manipulation technique as it can reduce the phytoplankton biomass through filter feeding (Caraco *et al.* 1997 and Reeders *et al*. 1993)

Zooplankton

Being a key component of lake ecosystems, zooplanktons have a very important role in the process of bio-manipulation. Cooke (1986) stated that larger zooplanktons can consume a variety of algal blooms more efficiently as compared to smaller ones. Daphnia is recognized as the most significant genus to impact upon algae blooms and major contributor to the success of bio-manipulation. When large Daphnia are absent, zooplankton cannot reduce phytoplankton biomass. Mehner *et al.* (2002) suggested that intensive grazing by Daphnia on phytoplankton leads to the better water quality and also macrophytes becomes the dominant primary producers which would ultimately suppress the phytoplankton biomass. So, the main goal of the bio-manipulation technique is to lower the mortality of Daphnia to achieve the desired results.

Macrophytes

Aquatic macrophytes have been identified as a key component for the long-term success of biomanipulation management. Macrophytes stabilize the sediment preventing re-suspension of nutrients as well as utilizing nutrients for their own growth. The main role of the macrophytic communities of the lake is that they provide refuge to the zooplanktons and create the zone of low-oxygen levels where planktivorous fishes cannot survive well which would result in the prohibited entry of planktivorous fishes to zooplankton refuge (Shapiro 1990). Increased macrophytic population will reduce the algal blooms ((Hosper 1990). Fugl and Myssen (2007) attempted the restoration of lake L. Rogbolle in Denmark with the natural establishment of submerged flora whereas Moore *et al.* (2010) attempted the restoration of Freshwater tidal area in USA by following the artificial or man-made introduction of shoots, seeds and seed pods of Vallisneria americana and protection against grazing.

Purpose of bio manipulation

The key purpose of this technique is to decrease the high concentration of toxic phytoplankton in the water bodies that cause eutrophication. The growth of phytoplankton is controlled by introducing zooplanktons that eventually improve water quality and nutrient cycling.

Importance of bio manipulation

Bio manipulation has significant importance for fisheries. This method is being used by people for decades. Eutrophication has an impact on the diversity of the fish population, this could cause fishermen to lose their source of livelihood. Predator species have been purposefully introduced into the aquatic ecosystem by humans in an effort to control and enhance water quality through a biological process. It is important for the transparency of water in lakes. The habitat is restored for the fish population and aquatic biodiversity.

Advantages of Biomanipulation

1. Natural Process Introduced by Humans, It is a kind of natural/ biological process induced by humans to improve the water quality of the aquatic ecosystem.

2. Reduces Turbidity

3. No Requirement of Chemicals

4. Improves Fisheries

5. Maintain Nutrient Cycling

6. Supports Biodiversity, the decreasing biodiversity due to algal blooms starts increasing as water quality gets better.

Disadvantages of bio manipulation

- ✓ **Management of Lakes:** When using the bio manipulation technology, lakes need to be managed continuously.
- ✓ **Poisoning of Water Bodies:** The water bodies are poisoned by Rotenone application and water is not suitable for human consumption.
- ✓ **Lack of Awareness:** The fishermen are often not aware of the side effects of dominant species. Awareness about the importance of predator species is important for Fishermen.
- ✓ **Expensive Treatment:** The cost of the bio manipulation method is high and it is totally dependent on the method which is being used.

Challenges for bio-manipulation

- ✓ Bio-manipulation can only be used for small, shallow and closed system which means lake system needs to be totally closed (no connection with other water bodies)
- ✓ It is must to remove some fish fauna prior to the introductions of new piscivorous fishes to the lakes to reduce the risk of competition for food, shelter and breeding ground
- ✓ The eutrophication of lakes is being caused by increased worldwide development activities and climate change, which are doing so through increased nutrient influx.
- ✓ Modifications to the lake ecosystems' structure
- ✓ Limited long-term effectiveness

Conclusion

In summary, biomanipulation plays a crucial role in fisheries management in lacustrine ecosystems by influencing fish populations and trophic interactions to restore and maintain ecological balance. It's an approach that requires careful planning, monitoring, and adaptive management to ensure its effectiveness and minimize potential negative impacts on the ecosystem.

References

Caraco NF, Cole JJ, Raymond PA, Strayer DL, Pace ML, Findlay SE, et al. Zebra mussel invasion in a large, turbid river: phytoplankton response to increased grazing. Ecology 1997;78:588-602.

Drenner R.W. & Hambright K.D. (1999) Biomanipulation of fish assemblages as a lake restoration technique. Archiv fu¨r Hydrobiologie, 146, 129–165.

Fugl K, Myssen PM. Lake Maribo Sonderso, In: Liboriussen L, Sondergaard M, Jeppesen E (Eds.) 2007. Sorestaurering Denmark. Report from NERI no. 636.

Gulati RD, Pires IMD, Van Donk E. Lake restoration studies: failures, bottle-necks and prospects of new ecotechnological measures. Limnologica 2008;38:233- 248.

Hansson L.-A., Annadotter H., Bergman E., Hamrin S., Jeppesen E., Kairesalo T., Luokkanen E., Nilsson P.-A., Soendergaard M. & Strand J. (1998) Biomanipulation as an application of food-chain theory: constraints, synthesis, and recommendations for temperate lakes. Ecosystems, 1, 558–574.

Hosper SH, Jagtman E. Biomanipulation Additional to Nutrient Control for Restoration of Shallow Lakes in the Netherlands. Hydrobiologia 1990; 200-201:523-534.

Meijer ML. Biomanipulation in the Netherlands–15 Years of Experience. Wageningen University 2000.

Mehner T, Benndorf J, Kasprzak P, Koschel R. Biomanipulation of lake ecosystems: successful applications and expanding complexity in the

underlying science. Freshwater Biology 2002;47:2453–2465.

Moore KA, Shields EC, Jarvis JC. The role of habitat and herbivory on the restoration of tidal freshwater submerged aquatic vegetation populations. Restoration of Ecology 2010;18:596-604.

Reeders H, Bij De Vaate A, Noordhuis R. Potential of the zebra mussel (Dressena polymorpha) for water quality management. In: Nalepa, T F, Schloesser D W (Eds.) Zebra mussels: Biology, Impacts and control. Lewis Publishers, Boca Ratton 1993, Pp. 439-451.

Radke RJ, Kahl U. Effects of a filter-feeding fish [silver carp, Hypophthalmichthys molitrix (Val.) on phytoplankton and zooplankton in a mesotrophic reservoir: results from an enclosure experiment. Freshwater Biology 2002;47:2337-2344.

Roy ED, Martin JF, Irwin EG, Conroy JD, Culver DA. Transient social-ecological stability: the effects of invasive species and ecosystem restoration on nutrient management compromise in Lake Erie. Ecol Soc 2010;15(1):20.

Starling F, Lazzaro X, Cavalcanti C, Moreira R. (2002). Contribution of omnivorous tilapia to eutrophication of a shallow tropical reservoir: evidence from a fish kill. *Freshwater Biology*; 47:2443–52.

Wysujack K, Mehner T. Comparison of losses of planktivorous fish by predation and seine-fishing in a lake undergoing long-term biomanipulation. Freshwater Biology 2002;47:2425-34.

Sarbjeet Kaur. (2020). Bio-manipulation: A restoration tool for eutrophied Lakes. *International Journal of Fauna and Biological Studies*., 7(6): 01-04.

Jeppesen, E., Søndergaard, M., Lauridsen, T. L., Davidson, T. A., Liu, Z., Mazzeo, N., Meerhoff, M. (2012). Biomanipulation as a Restoration Tool to Combat Eutrophication. Global Change in Multispecies Systems Part 2, 411–488.

Wetzel, R. G. (2001). Planktonic Communities: Zooplankton and Their Interactions with Fish. *Limnology*, 395–488.

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