International Journal of Research and Review
www.ijrrjournal.com E-ISSN: 2349-9788; P-ISSN: 2454-2237

Original Research Article

Effects of Integrated Biomanipulation Approach for Eutrophication Management in Jajpur, Odisha

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ABSTRACT

Many people throughout the world depend on fresh water bodies such as ponds as the main source of drinking water. The water in these ponds can sometimes be subject to eutrophication which leads to negative health impact in human and livestock. An ecotechnological method of treating water is known as biomanipulation which was applied to experimental ponds undergoing eutrophication at Jajpur, Odisha. It has been carried out in a highly eutrophic water body at Mulapal, Jajpur from 2009-11. Ecosystem parameters like Phytoplankton blooms as Cholorophyll- a concentration, transparency and Phosphate, Nitrates etc. were taken for test.

Results of this integrated biomanipulation experiment showed that reduction of chlorophyll- a concentration, increase of transparency are improved, however this tendency of improvements of parameters are more prominent during the next two years of biomanipulation. This may continue in next years ahead. This suggests that this new biomanipulation technique and its effects are observed in a long term period. Results of this experiment also showed that size of Daphnia pulex are increased in 2nd phase biomanipulation, which is a positive sign for phytoplankton grazing intensity. This integrated biomanipulation is different from traditional biomanipulaton. In this Integrated biomanipulation approach stresses are given to involve both filterivores as well as piscivores for removal of algae along with nutrients from the hyper-eutrophic water bodies. Whereas piscivores are associated with removal of phytoplankton by zooplankton grazing. So zooplankton like Daphnia etc. are provided a predation free system with piscivorous fish population.ipulated

Key Words – Eutrophication, biomanipulation, eco-technology, bioman ipulated (BM), prebiomanipulated (PBM),

INTRODUCTION

Millions of people throughout the world do not have access to potable water from treatment plants rather dependent on natural water bodies such as lakes and ponds. Onsite filtration of water by installation of filters in water bodies is not convenient as it is clogged by algal biomass and affected the final filtered product. In order to solve this problem, a cost-effective solution as well as one that is ecologically sound is being explored.

Integrated biomanipulation is an ecotechnological approach for eutrophication management in water body. Biomanipulation of eutrophic water source is a procedure that changes the food web in order to favour grazing on algae by zooplankton or reduce algae by introducing planktivorous fish. This method is fairly new and does not require machinery or toxic chemicals. A study performed in this relation showed that the introduction of silver carp a phyto -planktivorous fish, in a water body led to reduction in blue-green

algae. It is important to note that biomanipultion is not always as simple as a fish/zooplankton-algae food chain. It may achieve success when fish removal triggers other processes like the increase in herbivorous zooplankton such as Daphnia, which are effective grazers of phytoplankton (Beklioglu et al.2003). Reduced internal loading, a state which occurs when a lower amount of phosphorus is available for phytoplankton, is another effective process for reducing phytoplankton after fish removal.

It has also been found that the introduction of silver carp may stimulate phytoplankton growth. While integrated biomanipulation has had successes in controlling algae growth and improving water quality it has also been shown to have negative impacts.

The goal of this study is to examine whether integrated biomanipulation is a useful method in treating eutrophic man-made ponds in eastern India particularly in Jajpur district of Odisha.

The effectiveness of integrated biomapnipulation will be studied by looking at the impacts of involving a combination of both filter feeder fish and piscivores to control planktivores with different predator fish species over time on algal biomass, nitrate levels, and water clarity or turbidity etc.

The introduction of fish in the ponds will result in a reduction of algal biomass through direct consumption of algae, algal biomass reduce nitrate and phosphates levels and decrease the turbidity of the water.

Study could be used to inform local villages about the types of fish that could potentially improve water quality of their ponds, reduce nitrate and phosphates levels and decrease the turbidity of the water.

METHOD

Study Site - This study took place in Mulapal area near Jajpur Town in Odisha, India. In order to conduct the experiment. A small ponds measuring approximately 40m by 40m by 2 m was selected. Another hypertrophic pond at Baidyarajpur served as the control pond, which did not have fish like *Wallaga attu, silver carp,* and Grass carp etc.The combinations of fishes in test pond were decided based on the type of algae or vegetation that was present. For instance, a pond that had vegetation on the surface was stocked with grass carp, whereas one that consisted of unicellular algae was stocked with silver carp. Because the number of ponds available for manipulation were limited and with different eutrophic state.

To study the effectiveness and increase the intensity of cleaning the algal biomass a new combination of both filter feeder like silver carp,grass carp were inventoried with piscivores like wallaga attu to regulate the planktivores to give a safe haven for zooplankton grazing.

PARAMETERS OF CONCERN

In order to determine the purification potential of introduced fishes on eutrophication and water quality indices like phosphate, nitrate, algal biomass (chlorophyll-a) transparency and turbidity were observed in the biomani pulated pond. Phosphate and nitrate which act as fertilizers promoting growth of algal bloom and vegetation were measured using an spectrophotometer method. The amount of algal biomass was measured and analysed by measuring chlorophyll-a content using spectrophotometer. samples were taken on monthly basis for two years which were analysed in the laboratory. Data from the sample analysis were made for statistical analysis.

POND PREPARATION FOR BIOMANIPULATION

Food chain manipulation or biomanipulation techniques basically target a particular component of fish community such as planktivorous fish and its removal from the water bodies. To play it safe nearly 75% of the fishes are removed from the pond water of Mulapal, Jajpur. Then this pond is

stocked with filter feeding and piscivorous fishes.

Fish that were used for this study and Stocking rates of the fishes were on a species by species basis.

Fish that were used for this study were grass carp [*Ctenopharyngdon idella*] and silver carp [*Hypothalmichthys molitrix*].

Additionally, grass carp is an effective grazer of vegetation along with filamentous algae and silver carp feeds on phytoplankton or unicellular algae. Grass carp and silver carp were chosen for the study because they are typically used to treat water with vegetation and phytoplankton, respectively, Wallaga attu is native and predator fish, available in this locality which are added to provide a planktivores free water for zooplankton.

Table 1.0 Types of fish used in treatment.

Treatment	Control	Treatment pond
Fish	No change in Fish community	Grass Carp, Silver Carp, Wallaga attu

Table 2.0 Stocking rates and feed for each fish along with references.

Fish	Grass Carp	Silver Carp	Wallaga attu
Stocking Rate	50 fish/acre	50 fish/acre	20 fish/acre
Primary Feed	Phytoplankton Filamentous Algae	Phytoplankton Unicellular Vegitation	planktivorous fish, small fish
Study	Jhingran 1975 Starling 1993	Jhingran 1968	Opuszynksi and Shireman 1995

(a) Silver carp
Hypothalmichthys molitrix

(b) Grass carp
Ctenopharyngdon idella

(c) Helicopter cat fish
Wallaga attu

Plate 1.0 Different species of fish utilized in bio-manipulation experiment.

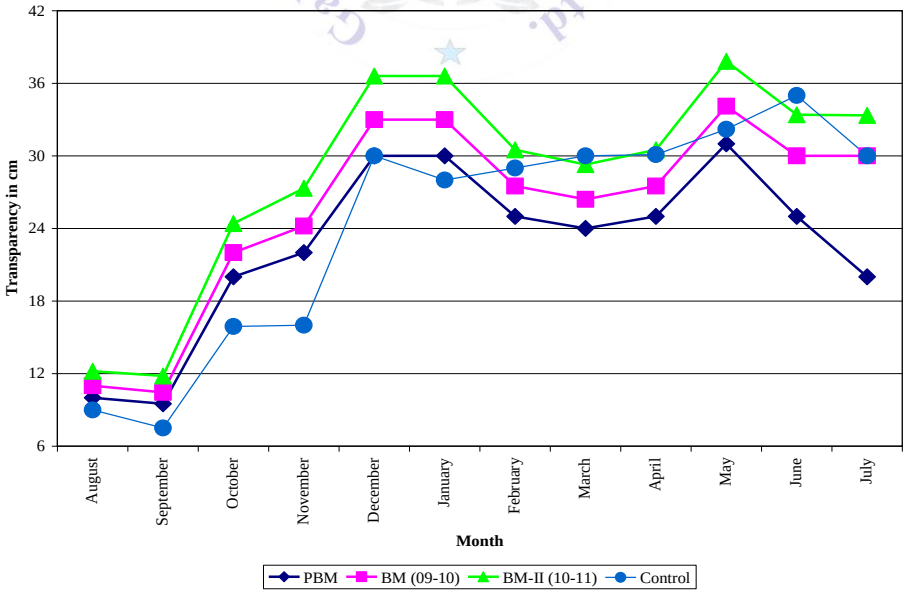

Fig. 1.0 Showing restoration effect of Bio-manipulation on Transparency at Mulapal (BM) with respect to PBM and Control Pond At Baidyarajpur, Jajpur (2009-2010, 2010-2011).

Plate 2.0 Control Pond at Baidyarajpur ,Jajpur

Plate 3.0 Photograph showing the hypereutrophic water body at Mulapal, Jajpur Before Biomanipulation.(PBM)

Plate 4.0 Photograph showing effect of Biomanipulation and improvement of water quality in Mulapal,(BM) Jajpur, 2009-10.

TRANSPARENCY

Transparency is a primary and basic requirement to judge the quality of a clean water. Integrated biomanipulation approach at Mulapal pond shows more improvement after 2nd year in comparison to 1st year of biomanipulation. Transparency is lowest in September, June and July because of rainy season and surface runoffs decreases the transparency of water. In December and January it shows maximum clarity of water due to improvement of transparency that is maintained throughout the year with a little fluctuations.

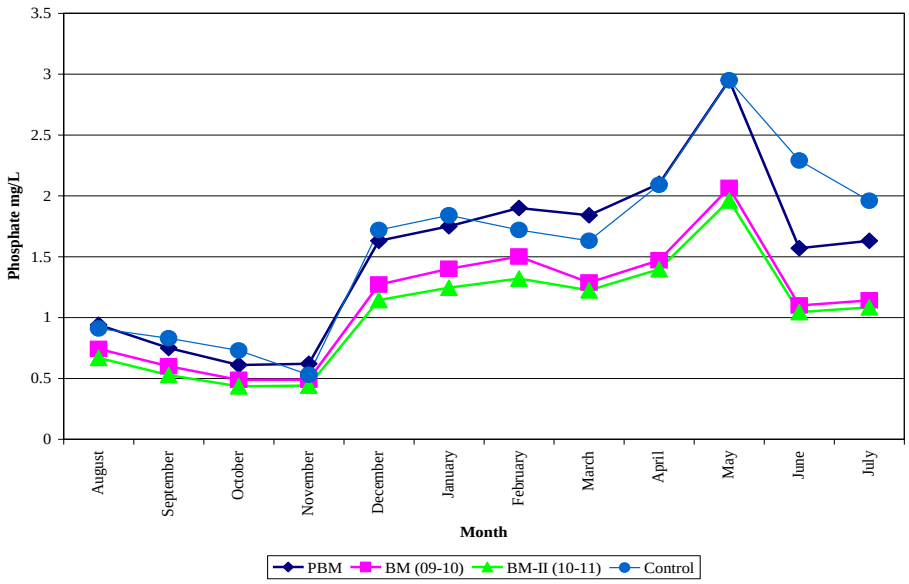

Fig. 2.0 Showing restoration effect of Bio-manipulation on Phosphate at Mulapal (BM) with respect to PBM and Control Pond At Baidyarajpur, Jajpur (2009-2010, 2010-2011).

Phosphate

Phosphate provide nutrients and enrich the water body for phytoplankton production. It shows that initialy before the application of biomanipulation in the test pond (PBM) and in control pond phosphorus was at peak 2.95mg/L and From 2009-2010 phosphate level fell and the situation improved. In 2010 and 2011 the average phosphate value remains 0.87mg/L within a range of 0.7 mg/L to 1.03mg/Lin the biomanipulated test pond (BM).

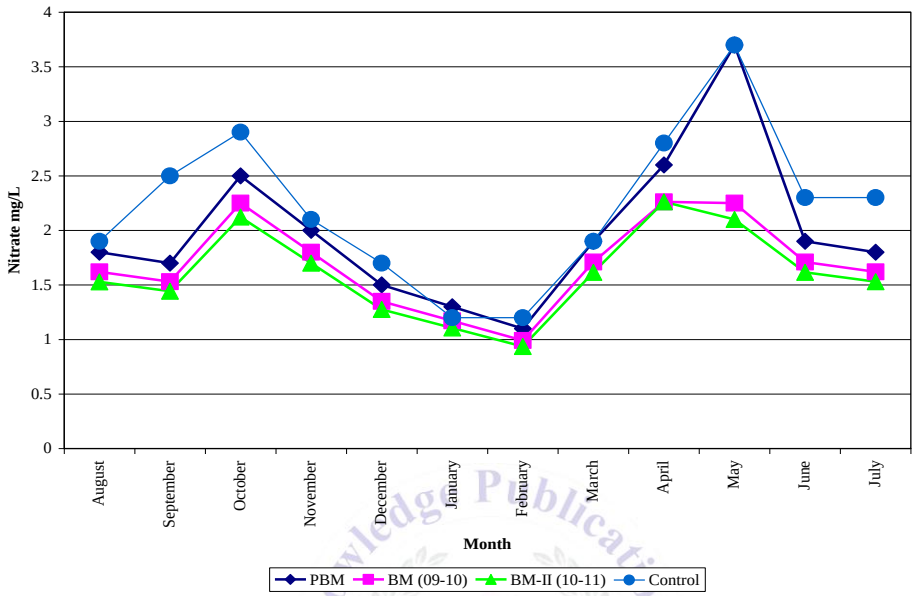

Fig. 3.0 Showing restoration effect of Bio-manipulation on Nitrate at Mulapal (BM) with respect to PBM and Control Pond At Baidyarajpur, Jajpur (2009-2010, 2010-2011).

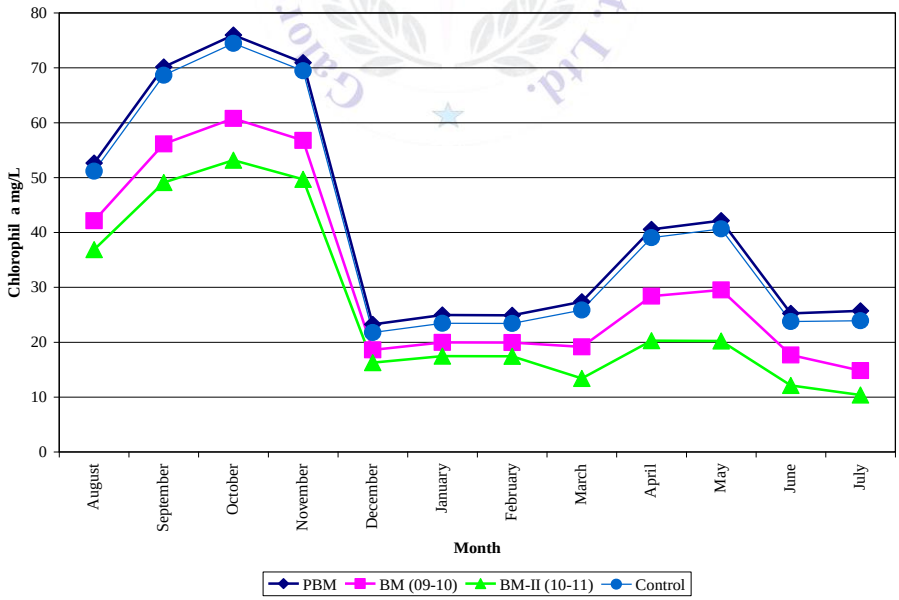

Fig. 4.0 Showing restoration effect of Bio-manipulation on Cholorophyll-a at Mulapal (BM) with respect to PBM and Control Pond At Baidyarajpur, Jajpur (2009-2010, 2010-2011).

NITRATE

Nitrate and algal biomass (chlorophyll-a) levels were measured from 2009 to 2010,2010-11.

It shows that initialy before the application of biomanipulation in the test pond (PBM) and in control pond nitrate was at peak 2.29mg/L and From 2009-2010 nitrate level fell and the situation improved . In 2010 the

average nitrate value remains 1.75mg/L within a range of 1.0 mg/L to 2.1mg/Lin the biomanipulated test pond (BM).

CHLOROPHYLL

Phytoplankton (the blue green algae) were at it's highest peak, dense summer phytoplankton with chlorophyll-a at midsummer over 135.89mg/L dominated by colonial blue-green algae. Macrophytes have been almost completely absent since the pre-restoration period. After integrated biomanipulation in test pond Phytoplankton blooms were limited with chlorophyll-a less than 21 mg/L, dominated by flagellates and macrophytes. Submerged plant like Trapa-natans, Elodea etc. covered 10% of bottom in test pond.

RESULT AND DISCUSSION

Biomanipulation is another process of ecotechonology. It has been carried out in a highly eutrophic and hypertrophic water body at Mulapal, Jajpur from 2009-11. Ecosystem parameters like Phytoplankton blooms as Cholorophyll-a concentration, transparency,phosphates and nitrates concentration in water were studied .

It shows that different combination of filter feeder fish and piscivorous fish lead to positive result shown in Table 3.0 and Prior to application of integrated biomanipulation method of ecotechnological approach in Mulapal pond, the nutrients like phosphate, nitrate, phytoplankton (the blue green algae) were at it's highest peak, phosphorus (peak-2.95mg/L) and dense summer phytoplankton with chlorophyll-a at midsummer over 135.89mg/L dominated by colonial blue-green algae. Macrophytes have been almost completely absent since the pre-restoration period since 2006. From 2009-2010 the situation improved phosphate level fell and remained roughly constant. In 2010 the average phosphate value remains 0.87mg/L within a range of 0.7 mg/L to 1.03mg/L.

Phytoplankton blooms were limited with chlorophyll-a less than 21 mg/L, dominated by flagellates and macrophytes. Submerged plant like Trapa-natans, Elodea etc. covered 10% of bottom.

Results of this biomanipulation experiment showed that reduction of chlorophyll- a concentration , increase of transparency are improved, concentration of phosphate and nitrate were reduced in test pond water, however this tendency of improvements of parameters are more prominent during the next two years of biomanipulation. This may continue in next years ahead. This suggests that this integrated biomanipulation technique and its effects are observed in a long term period. Results of this experiment also showed that size of Daphnia pulex are increased in 2nd phase biomanipulation, which is a positive sign for phytoplankton grazing intensity.

STATISTICAL ANALYSIS

The data collected for this study was used to display and compare the trends of phosphate, nitrate, and transparency from experimental pond to control pond by analysis of variance ANOVA.

Table 3.0. Comparison of water quality between raw water control pond and the output water of the biomanipulated pond from Aug'2009 to Jul'2010,2010-11.

Aug'09-Jul'10	Raw water in Control pond		Water in the biomanipulated pond	
	Mean	Range	Mean	Range
Phosphate mg/L	1.51	0.51-2.95	0.87	0.7-1.03
Chlorophyll mg/L	72.38	30.25-135.89	45.03	20.01-82.25
Nitrate mg/L	2.29	1.2-3.5	1.75	1.0-2.1
Transparency cms	11.5	6.0-16.0	62.91	50-60
pH	7.35	6.5-9.3	7.15	7.15-8.5
Colour	Deep Blue Green		Light Green	

ANOVA

Chlorophyll a PBM and BM						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
PBM	12	499.25	41.604167	432.85248		
BM (09-10)	12	383.755	31.979583	298.20408		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	555.79563	1	555.79563	1.520527	0.2305537	4.3009495
Within Groups	8041.6222	22	365.52828			
Total	8597.4178	23				

Chlorophyll a BM and BM-II						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BM (09-10)	12	383.755	31.979583	298.20408		
BM-II (10-11)	12	316.352	26.362667	259.16837		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	189.29852	1	189.29852	0.6792532	0.41869	4.3009495
Within Groups	6131.097	22	278.68623			
Total	6320.3955	23				

Phosphate PBM and BM						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
PBM	12	18.29	1.5241667	0.4795356		
BM (09-10)	12	13.5558	1.12965	0.2272185		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.9338604	1	0.9338604	2.6426742	0.1182691	4.3009495
Within Groups	7.774295	22	0.353377			
Total	8.7081554	23				

Phosphate BM and BM-II						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BM (09-10)	12	13.5558	1.12965	0.2272185		
BM-II (10-11)	12	12.49247	1.0410392	0.2064272		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.0471113	1	0.0471113	0.2172801	0.6457026	4.3009495
Within Groups	4.7701024	22	0.2168228			
Total	4.8172137	23				

CONCLUSION

This approach differs from traditional biomanipulation method followed in other parts of world that either adds piscivorous fish to control planktivores, and this in turn increase zooplankton and decrease algae, or filter feeders like silver carp etc. were used to feed directly algae. This new integrated biomanipulation approach is being inventoried, involving both filter feeder and planktivores. Which are being tested to counteract cyanobacteria blooms, especially in the water bodies where nutrient input cannot be reduced sufficiently, where zooplankton or carp alone cannot effectively control phytoplankton production.

ACKNOWLEDGEMENT

The authors are grateful to the principal of N.C. (Auto.) College, D.D (Auto.) College and V.C.of F.M.University for providing their laboratory facility for the work.

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How to cite this article: Das DS, Naik BN. Effects of Integrated biomanipulation approach for eutrophication management in Jajpur, Odisha. International Journal of Research and Review. 2017; 4(5):133-141.

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