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Original Research Article

Study of the Physico-Chemical Parameters of Eutrophicated Ponds before and after Restoration

D.S. Das[1], P.C. Rout[2], B.N. Naik[3]

[1]Reader and Head, Department of Zoology, D.D. (Auto) College, Keonjhar, Odisha, India
[2]Asst. Professor in Zoology, S.B. Women's College, Cuttack-753001, Odisha, India.
[3]Ex-Professor and Head, Department of Env Sciences, F.M. University, Balasore-756020.

Corresponding Author: P.C. Rout

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ABSTRACT

Water quality of various eutrophicated ponds was studied before and after ecotechnique restoration measures and remarkable improvement of the various physic-chemical parameters were observed. The various parameters studied included Transparency, PH, Dissolved Oxygen, Turbidity, Total Phosphate, Total Nitrate and total Chlorophyll content of the water bodies. Restoration trials were made through Physico Ecotechnological Engineering Application (PEEN) using biofiltration and bio-remediation. The improvement of various parameters indicated the success of the technology ready for environmental improvement in large scale basis.

Key words: co-technique, Eutrophication, PEEN, PBM, Jajpur.

INTRODUCTION

Eutrophication (Greek: eutrophia-healthy, adequate nutrition, development; German: Eutrophie) or more precisely hypertrophication, is the ecosystem response to addition of artificial or natural, such as nitrates phosphates, through fertilizer or sewage, to an aquatic system. The process of enrichment of water body due to accumulation of higher amount of nutrients (phosphates, nitrogen) that normally results in the problem associated with algal blooms or that of macrophytes. Eutrophic waters are nowadays commonly thought of as those showing signs of excess nutrient loading with associated changes in flora and fauna. Eutrophication is a form of damage that must be gauged relative to the natural balance that should prevail in the area and the size of the basin. Jorgensen (1980) suggested that eutrophication occurs after the habitat's ability to suffer against excessive nutrient inputs, especially the phosphorus binding capacity of the sediments, is exhausted. The degradation can then happen quickly and represent a definite shift in the state of the ecosystem, not merely an accelerated degradation. Eutrophication has become a problem in many countries. It has been briefly reviewed the long-term changes in aquatic macrophyte of selected water bodies under the impact of eutrophication in Finland, Germany, Switzerland, the Netherlands, Poland, UK and the USA

Ecotechnology combines basic and applied science for restoration, design and construction of ecosystems. Here submerged vascular plants like potamogeton and ceratophyllum, floating and leaf floating plants, zooplankton like daphnia etc, certain invertebrates like snails, shrimp and other molluscs, bacteria and vertebrates like fish, frog and duck etc. are used as tools of ecotechnological Endeavour to improve transparency, reduction of phytoplankton reducing the nutrients like nitrogen, phosphate and others to improve the water quality.

The major aim and objective of the present research approach are:

- to work out various remedial technique to improve water quality of certain hypertophic freshwater bodies of Jajpur, Orissa.
- to find out application of alternative ecotechnology in restoration of certain hyper- eutrophic freshwater bodies of Jajpur, Orissa..
- to study the feasibility of integrated freshwater farming at Jajpur implementing eco-technological applications in highly eutrophic or hyper- eutrophic fresh water bodies.

MATERIALS AND METHODS

Study area and selected fresh water bodies.

Jajpur town is remarkable in having numerous water bodies tanks and pools.

General Information of Jajpur:

Dist	:	Jajpur
District Headquarters:		Jajpur Town
Location - Latitude:		20°/43´ -21°/10´
Longitude	:	85°.40´- 86°.44´
Co-ordinates	:	20°51´00´´N 86°19´59´´E
Area Covered	:	2887.69 squre kilometers.
Total Population	:	19, 00054
A	:	Rural - 1814649
B	:	Urban- 85405

Growth rat: 17.08 per year.

Jajpur town is situated in the northern Part of Odisha state.

Topography

Jajpur town present a climate typical of coastal eastern Odisha tropical wet and dry conditions. The temperature vary between 12°C to 38°C and the average rainfall being 1014mm per annum. This area is surrounded by network of many big river like Baitarani, Budha, Kharasrota and Brahmani and their tributaries etc. Therrby numerous small ponds often loosely termed as tanks are common sights in this area. Many of these ponds or tanks are perennial or seasonal, depending upon their morphology and normal rainfall of the region. All waterbodies are fed by monsoon rains or streams, which serves the inhabitats directly or indirectly for agricultural, irrigation, fishing, recreational purposes and other human activities.

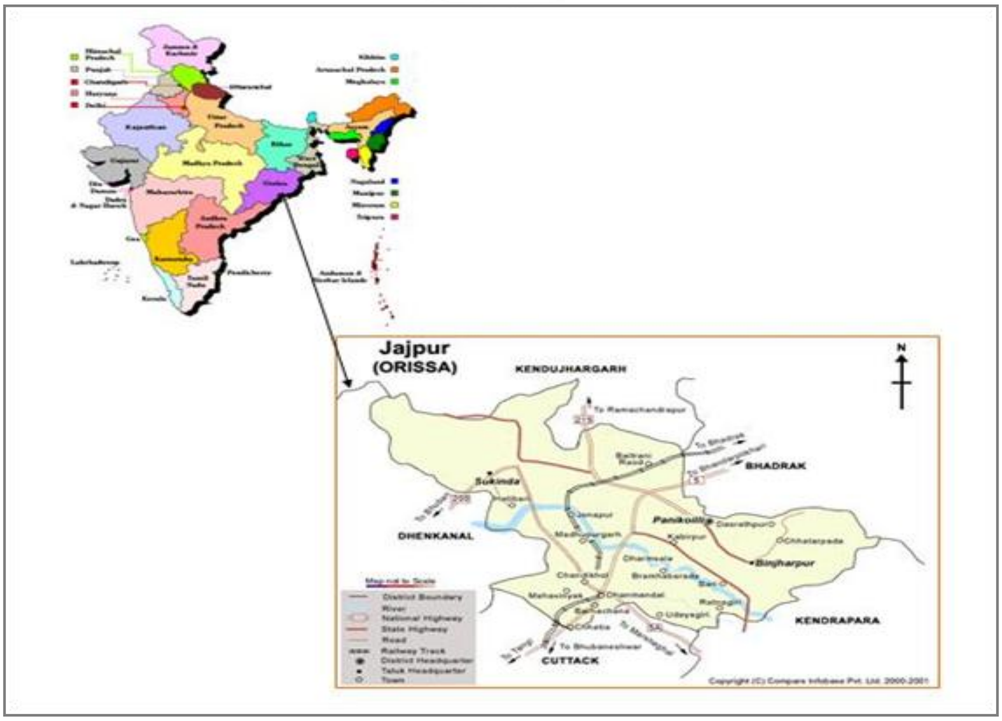

Fig. 1.India map showing Jajpur District Study sites, Jajpur Town

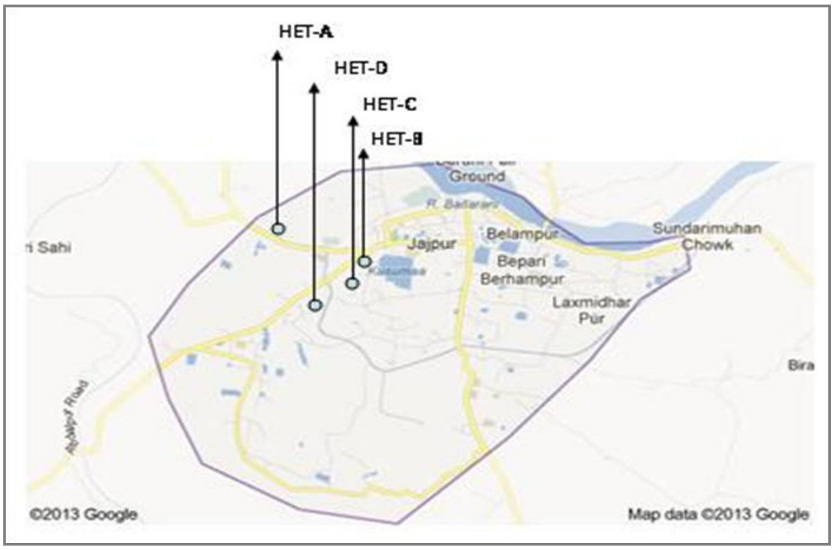

Fig. 2: Location map of hyper-eutrophic waterbodies for ecotechnological studies.

Table 1: Description of different selected fresh waterbodies of JajpurTown under study

Sl No.	Name of the Fresh water body	Samling site	Area in sq.mt	Surrounding villages	No.of people depending	Remark
HET-A	Mulapal	centre	1000	Mulapal, Rudhia, Sathipur etc	2000	Selected for Ecotech. application (Biomanipulation)
HET-B	Banpur	centre	900	Banpur, Nilakanthapur		
HET-C	Baidyarajpur	centre	1200	Baidyarajpur, Patpur		Conrol pond
HET-D	Gokhana	centre	1000	Gokhana Abdalpur		Selected for Ecotech. application (biofiltration)

Mulapal Pond (HET-A)

This pond is somewhat square in shape with an area of 1000 sq.mt with an average depth of 2 meter. This pond mainly depend on rain water apart from the inlet from village sewage. Two sides of the pond are bordered by a road connecting Jajpur to Cuttack. Western side of the pond is fringed by paddy field. Southern side joins the village portion of the land. Northern side is also touches the Jajpur Cuttack road.

During the investigation, it was found that pond surface is covered with mixed algal blooms dominated by a reddish -brown look. Macrophytes populations were rare and insignificant. There is no regular fishing activity in the pond occasional hook and line catches revealed the presence of some small zooplanktivorous fishes and benthic cat fishes etc.

Banpur pond (HET-B)

Banpur pond is rectangular in shape with an area of 900 sq. meter and an average depth of 2 meter .Northern side of the pond is bordered by village road and other three sides are surrounded by farming land.

Investigations revealed that this pond water surface was covered with a mat of greenish phytoplankton bloom.

Baidyarajpur pond (HET- C)

It is a village pond near Jajpur town. This pond is somewhat rectangular in shape and an average depth of 1.5 meter. It has raised embakement on all sides, planted with trees.

There are varieties of some floating macrophytes were observed during the survey. Some vertebrates and invertebrates were also noticed in this waterbodies.

Gokhana Pond (HET- D)

It is a village pond situated at the outskirt of village Gokhana .Pond is surrounded by paddy fields from three sides and the western side is the village part dotted with thatched houses on the embankment.

After investigation, it was found that surface of the pond water was covered with a thick mat of blue green algae. Macrophytes were absent. Vertebrates species were very rare, invertebrates were dominated by tubifex and keratella specis. A foul smell was felt near the pond water.

HET-A

HET-B

HET-C

HET-D

Plate-I-Photographs of hyper-eutrophic water bodies of Jajpur

Field sampling and Analysis

The investigation on physical, chemical and biological parameters were carried out during August 2009 to July 2010. The water samples were collected from four selected sites pond (A to D) and around the pond considering the shape and size of the pond, human activities at different sites, vegetations and position of land and soil types around the ponds.

Monthly water samples were collected from different stations during hours (7.30 am to 8.30 am) and brought to the laboratory for further analysis. Physical parameters like water temperature, water depth, turbidity and transparency were studied. Water sample from the surface is colleted in plastic bottle after rinsing these with the same water 3 to 4 times. Samples from the bottom of shallow water were collected by lowering a closed glass bottle to the bottom, opening and closing it there by hands, and taking it out.

Handling and preservation of water sample

Sample from the sampler were transferred to well rinse appropriately labeled, suitable sample containers, (bottles). Containers made up of borosilicate glass and polyethylenes were used for this purpose.

Proper labelling were made one each sample as bellow:

1. Name and location of body of water.
2. Date
3. Time of sampling.
4. Depth of sampling

After labelling, immediately the samples, were sent to the laboratory for analysis to avoid any change/deterioration in quality due to chemical and microbial activity. Parameters like temperature, pH alkalinity, dissolved oxygen (by oxygen meter) etc. is immediately estimated after collecting the sample. While the estimation of DO by Winkler's method were done by fixing by the addition of manganous sulphate and alkaline potassium iodide solutions. For most other physical and chemical analysis some holding time for sample were taken.

During the chemical investigation seven major parameters namely pH, dissolved oxygen, free carbon dioxide and important nutrients like phosphates and nitrates from different sites were studied.

Attempts were also made to study the aquatic flora and fauna of the water body qualitatively during monsoon of the year 2009-2010. In biological studies main emphasis was given to indigenous water purifier species, phytoplankton and zooplankton etc. The plankton samples were collected by using standard nylon plankton net having mesh size 55µm and number 25. The planktons were preserved in 4 percent formalin.

Field collection of Biological matter of water

Collection of Macrophytes

Macrophytes are collected using long handled hooks nets and by hand. For qualification of sample in a given area the floating or sinking type of quadrates of known size (viz., 1m x 1m) made up of PVC pipes or wood are used. These quadrates are placed in the macrophyte locality to mark the area from which sample is to be taken. Macrophytes taken out are thoroughly washed, excess water is absorbed on a cloth or filter paper, kept in polythene bags and brought to the laboratory in a ice box.

Collection and preservation of phytoplankton

Phytoplanktons are collected by plankton net made up of silk having mesh size 55µm and number 25. In this method a known amount of water sample is filtered through the net.

Measurement of Phytoplankton Population

After collecting the phytoplankton as described above and counted them by adopting the sedgewick- Rafter procedures. The results of enumeration expressed as units/L where, a unit represents to a colony of any size for colonial phytoplankton, a definite length (say 10 µm) for a filamentous phytoplankton, or a cell for a solitary single celled phytoplankton. The degree of abundance for individual phytoplankton are recorded as follows.

Rare occurrence $< 15x10^3$ unit/L
Frequent occurrence 16 to 99 x 10^3 units/L
Subdominant 100 to 999 x 10^3 units/L
Dominant > 1000 x 10^3 units/L

Estimation of Photosynthetic pigments

The photosynthetic pigments are determined in aquatic plants and phytoplanktons.

Estimation of total chlorophyll content and ratio of chlorophyll a and b in macrophytes.

Chlorophyll a and b have different absorption peaks. The spectrophotometer reading of the absorption peaks give an estimate of the concentration of these pigments in the leaves.

Materials in use:

- Spectrophotometer.
- Fresh young leaves
- Acetone

Method of analysis

Grinded 01gm green leaf material and homogenize it in 10ml acetone. Centrifuge the homogenate at 3000 rpm for 10 minutes. Transfer the supernatant to a 100ml. standard flask. Repeated the tissue extraction with acetone until the extract is free from pigments. Make up to 100ml with acetone. Record the optical density in a spectrophotometer at 645 and 663 rpm.

Calculation of chlorophyll a, b and total chlorophyll content with the following formula.

Total Chlorophyll: O.D. (645)x20.2+O.D (663)x8.02.

Chlorophyll a: OD (663)x12.7-OD(645)x2.69

Chlrophyll b: OD (645)x22.9-OD (663)x4.68

The total amount of the pigments present in the leaf material can be calculated as follows.

Total amount of pigment = $\frac{V}{W} \times 1000$ **mg/g fresh weight**

Where V= volume of the total extract and

W- Fresh weight of leaf material.

Estimation of chlorophyll in phytoplankton

500ml of water sample having phytoplankton is taken, to it a little aqueous suspension of magnesium carbonate is added (this avoid the degradation of chlorophyll) filter the sample through glass fibre filter. After filtration remove glass fibre filter and put it into a tight capped dark glass bottle containing 10ml. of 90 percent acetone. It is placed in refrigerator for 6 hours. The extract is taken out and centrifuged it at 3000 for about 15 minutes. Transferred the supernatant to a volumetric flask of 25ml. and made the volume of contents to the mark by adding 90 percentage actone. Recorded the absorbance of the extract at 630, 645, 665 and 750 mm. Acidified the extract with 3-4 drops of 1 percent HCl and again recorded absorbance at 665 and 750 nm.

Calculation

Total Chlorophyll: O.D (645) x20.2+O.D (663) x 8.02.

Chlorophyll: O.D. (663) x12.7O.D (645) x 2.69

Chlorophyll b: O.D (645) x22.9-OD (663) x4.68

The total amount of pigment (mg/L) or g/m^3 = V^1/V x1000

Where V^1= Volume of entract (ml) taken that is 25ml,

V= Volume of sample filtered that is 500ml.

Analysis technique for physico-chemical and biological Characteristics of eutrophicated pond

All the Physical and chemical parameters were analyzed following APHA (1989) and Rout & Naik(2013).

Remedial Technique for restoration of fresh water bodies

The term restoration means the reestablishment of predisturbance or pre-eutrophic aquatic functions and related physical, chemical and biological characteristics. The aim is to emulate a natural, self-regulating system that is integrated ecologically with the surrounding land in which it occurs, often restoration requiring one or more of the following process:

- Reconstruction of physical conditions
- Chemical adjustment of water and soil and
- Biological manipulation, including reintroduction of absent native flora and fauna.

Pre-application activities

Preparation of waterbody: Application of ecotechnology and physico-ecological engineering (PEEN) in an enclosed stable artificial ecosystem with a high efficiency of purifying water constructed in a eutrophic or hyper-eutrophic water body of Gokhana in Jajpur. Pond site HET-D of Gokhana is selected by observing the base line data collected by survey of four water bodies in this area of Jajpur. Water quality in PEEN is to be compared with the rest of the water outside it. The living varieties of hydroflora and fauna in this ecotechnologically engineered PEEN are indicators of good water quality on the one hand and important components of ecosystem with a high efficiency for purifying eutrophic water on the other hand.

Strategies of PEEN have been carried out in the ponds of Jajpur since 2010. A part of the pond is enclosed using bamboo stakes, water isolated materials and filters. Water was pumped from one end of the PEEN to stimulate the dynamics of different retention timings. Different ecotechnologies were tested in this enclosed part of the pond. The principles of purifying hyper-eutrophic water by ecotechnological application are presented below.

- Economic water usage multiple usage of water resources, developing the technologies related to eutrophic water bodies and harnessing the polluted water for domestic, industrial and agricultural purposes etc.

- Emphasis on enhancing self-purification in the water body as the fundamental measure, converting the eutrophic water body into the base for water purification;
- Harnessing of water from local to large areas and to the whole of water body by using physico-ecological engineering (PEEN);
- Development of water purification technologies with economic benefits-biological environmental enterprise (BEE) that converts waste into useful materials.

In the present situation it is not convenient to control eutrophication in whole surface waters of the concerned water body; it is possible and suitable to improve water quality for a limited volume in an enclosed area. Application of ecotechnology along with some physical and ecological engineering in a eutrophic water body with a aim to restore the ecosystem and purify waters in a limited area in a hyper-eutrophic water environment. The success of this ecotechnology and PEEN are expected to be expanded and extended step by step to the whole water body. The goals of controlling eutrophication, developing biological diversity and achieving economic benefits would then be realized in the near future. The principles of purifying water by ecotechnology and PEEN in the water body are presented as bellow (Fig.-3)

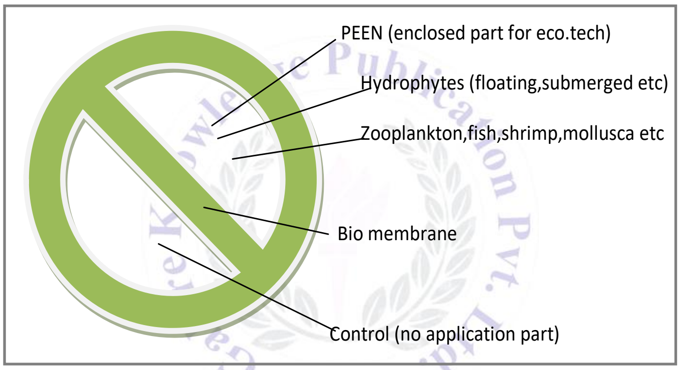

Fig.3. Concept diagram of the principle of purifying water by physico-ecotechnological engineering (PEEN)

Physical-biological membrane

This is for protection of the hydro-environment and ecosystem in the PEEN area. The reasons for physico-biological membrane construction are to provide protection to the submerged living macrophytes and macro fauna from the surrounding harsh and unsuitable environment. The PBM should be easily constructed, installed and repaired; and suitable in different hydrometeorological and sedimentary conditions.

Separator or physico biological membranes were constructed by utilizing locally available low cost biodegradable material like bamboo, straw and coir etc. Bambo piece provides a strong frame work on which straw and coir are stacked and attached on it`s surface to form a tight filter. Bambo stick in water provide place to periphyton. Straw are also acts as allelopathic to algal blooms.

Frame engineering

It needs certain processes and periods for converting polluted hydro-environment. Frame engineering for installing physical biological measures on area, the ways and position of inflow the current control, the carriers of biological population, etc. were constructed.

Filtration

Floating impurities and suspended algae and other organic and inorganic substances decreased dramatically in the enclosed part of the pond or in the PEEN by filtration. The transparency in the PEEN is increased. Improvement of water quality in the PEEN was tried by two time filtration.


Elodea nuttallii


Elodea nuttallii


Pistia


Trapa natans


Alternanthera philoxeroides


myriphyllum spicatum

Plate 2 Photograph of Macrophytes inventoried in the experiment.

Application of ecotechnology for restoration

Biological Purification

Several macrophytes, were introduced to newly constructed enclosures in a eutrophic pond. The self purification and ecotechnological restoration were investigated during the period. Several hydrophytes could be introduced to this eutrophic lake by physico - ecological engineering (PEEN) technique. Various genus of floating plants, leave floating plants, and submerged plants along with some vertebrates and invertebrate animal species were cultured in the PEEN site. Floating plants like (*Eichhornia crassipes*) water hyacinth, *Alternanthera philoxeroides* (water peanuts), *Lemna minor* (duck weed), *Trapa natans* (water chestnut), *Elodea nuttallii*, *Pistia stratiotus*(water lettuce), *Ipomoea aquatica*, *Utricularia stellaris* (khainchia dala), *Potamogeton crispus*(L), *Hydrocharis dubia* (BL), *Myriophyllum spicatum* L. *Salvinia natans* (L) *Nelumbo and Nymphaea* etc. were carefully planted in the PEEN water.

Silver carp, Grass carp and some selected cat fish i.e Wallaga attu, Clarias batrachus etc. were introduced in to the enclosed site of PEEN.Shrimp, snails and other mollusks like oyster were cultured and tested in the PEEN for purifying water (Ayappan and Gupta 1985).The dominant species were changed during the year to gain the maximum effects on purifying water. Eichornia species were used in a calculated way to manage it`s population upto only five percent of total floating plant species.Because of its evasiveness it can dominate the hydrophytes community and break the purifying capacity of the nascent PEEN.

Quality of water is improved in the PEEN mainly by attaching, coagulation, absorption, decomposition, predation etc. optimization of the ecosystem structure in the PEEN was realized by physical measures changing and controlling the biological population. Management efforts focused on improving transparency, reducing the concentration of phytoplankton, ammonia-nitrogen, and phosphate, and the colour degree. Some artificial carriers like bamboo stick and twigs of wood are used for attached algae and snails.

Micro-organisms make their habitats at the root of different macrophytes which help in the reduction of nitrogen from eutrophic water. (Chaurasia and Adony, 1985) restraining the release of pollutants from sediment and secondary pollution. The release of nutrients from sediment is enhanced by strong resuspension, especially during frequent storms for shallow lakes. The precipitation of suspended solids, some organic detritus and excretory products of animal could not be avoided in the PEEN. All these substances may lead to secondary pollution. It seems logical that to store pollutants in bottom sediments and to restrain the release of nutrients and other pollutants from sediments might be the best measure. Water quality is good in areas covered by submerged plants, where are rich in nutrients and organic substances in sediment. Plant cover on a water body bottom is similar to forest grass cover on the land, which make air clear, there for, the key measure should be to restore submerged plant cover with different dominant population and all it related complex community including some detrivorous animals for the whole year. To convert secondary pollutants in to usable aquatic products, store nutrients and restrain the release of nutrients from sediment into water are the best measure.

Submerged plants, attached algae and phytoplankton reduction

Clear Freshwater body which are dominated by macrophytes and submerged plants in coastal area are in the process of natural eutrophication but without the production of phytoplankton mass in these waters, Where the preliminary production is the growth of macrophytes not phytoplankton. There is a strong self-purification mechanism and clear water in these water bodies. In the PEEN experimental area submerged plant cover may grow up well, where the transparency is more than 1m, and the water is clear with low suspended solid and chlorophyll-a.

In the mean time, in waters out of the PEEN, the transparency is about 7.5-10 cms with high level of turbidity (about ten times higher then that in the PEEN). If the water in the small area of the experiment mixed with outside water, transparency in the area would be almost the same of that in its surrounding environment (about 7.5-10 cms).The submerged plants would die after about 1-2 weeks because of light limitation and would require culturing again. Therefore, physical-biological membrane (PBM) is of extremely important for the PEEN. If the eutrophic/hypertrophic water into the PEEN is controlled then we may have clear water output. The submerged plants release some allelopathic substances, which restrain phytoplanktonic growth. In water out of PEEN under the same sunshine, temperature and similar nutrient loadings, phytoplankton production is much higher than that in the PEEN.

There is another case with attached algae (Spirogyra sp.).It grows on physical substances hanging in the water column and stems of submerged plants, when the water open for sunshine. In order to prevent competition of periphytes with the submerged plants like Elodea nuttalii, Potemogeton crispus L these are manually taken out or may be eaten by the introduction of gastropod species.

Moreover, the newly introduced macrophytes could increase the transparency, improve water quality and remediate the eutrophic ecosystem. After six months, the transparency increased positively as much as original level inthe enclosure with macrophytes.

Biomanipulation Approach

Many communities 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.

Biomanipulation is an ecotechnological approach for eutrophication management in water.

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 phytoplanktivorous fish, in a waterbody 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 (Jeppesen and Sondergaard,2005 and Hupfer and Kleeberg, 2007).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 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 biomanipulation is a useful method in treating eutrophic man-made ponds in eastern India.

The effectiveness of biomanipulation will be studied by looking at the impacts of top-down control with different fish species over time on algal biomass, nitrate levels, and water clarity or turbidity (Sterner et.al. 1995).

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.

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 each 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.

Pond preparation for Biomanipulation

Food chain manipulation or biomanipulation technique basically targets 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 piscivorous fishes.

Fish that were used for this study 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.

Table 2: Types of fish used in treatment

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

Table 3: Stocking rates and feed for each fish along with references.

Fish	Grass Carp	Silver Carp	Wallaga attu
Stocking Rate	100 fish/acre	100 fish/acre	50 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

Pond at HET-A after Bio-manipulation.

Pond at HET-B after Bio-manipulation

Control pond at HET-C without Bio-manipulation.

Pond at HET-D after Bio-manipulation

Plate 3: Comparison of Ponds Before and after Biomanipulation

Unio (Fresh water mussel) utilized in the experiment (PEEN).

Measuring DO in the fild pond

Silver carp *Hypothalmichthys molitri* used in PEEN

Lymnae utilized in the experiment (PEEN)

Grass Carp utilized in PEEN

Wallago Attu used in PEEN

Plate 4: Biomanipulating agents used in PEEN

RESULTS AND DISCUSSION

Table 4: Water quality of different ponds (HET) under studies before eco-technological approach for restoration (2008-2009)

Parameters	Observed water quality of ponds							
	HET-A		HET-B		HET-C		HET-D	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Physico-chemical								
Transparency(cm)	9.5	31	10.0	35	9.0	35	6.0	16
SD	(2.8)	(3.1)	(2.1)	(2.88)	(2.85)	(3.3)	(2.60)	(3.14)
PH	6.5	9.3	6.5	8.9	7.2	9.2	6.5	9.3
SD	(0.08)	(0.12)	(0.10)	(0.12)	(0.07)	(0.13)	(0.04)	(0.17)
Dissolved Oxygen(mg/L)	0.55	3.62	0.57	2.93	1.25	4.72	0.71	4.95
SD	(0.3)	(0.31)	(0.14)	(0.21)	(0.45)	(0.45)	(0.46)	(0.41)
Turbidity(mg/L)	48	89	50	94	51	95	57	99
SD	(0.3)	(0.5)	(0.3)	(0.2)	(0.2)	(0.4)	(0.5)	(0.5)
Total Phosphate(mg/L)	0.61	2.95	0.49	2.95	0.53	2.95	0.51	2.95
SD	(0.1)	(0.8)	(0.1)	(0.2)	(0.1)	(0.3)	(0.1)	(0.4)
Total Nitrate(mg/L)	1.1	3.7	1.5	3.7	1.2	3.7	1.2	3.5
SD	(0.5)	(0.3)	(0.4)	(0.3)	(0.3)	(0.5)	(0.4)	(0.5)
Biological								
Chlorophylla(mg/L)	23.25	80.18	22.9	74.53	21.76	71.05	24.25	82.15
	(2.1)	(2.5)	(2.3)	(2.6)	(2.2)	(2.5)	2.3)	(2.6)

SD= ± Standard Deviation.

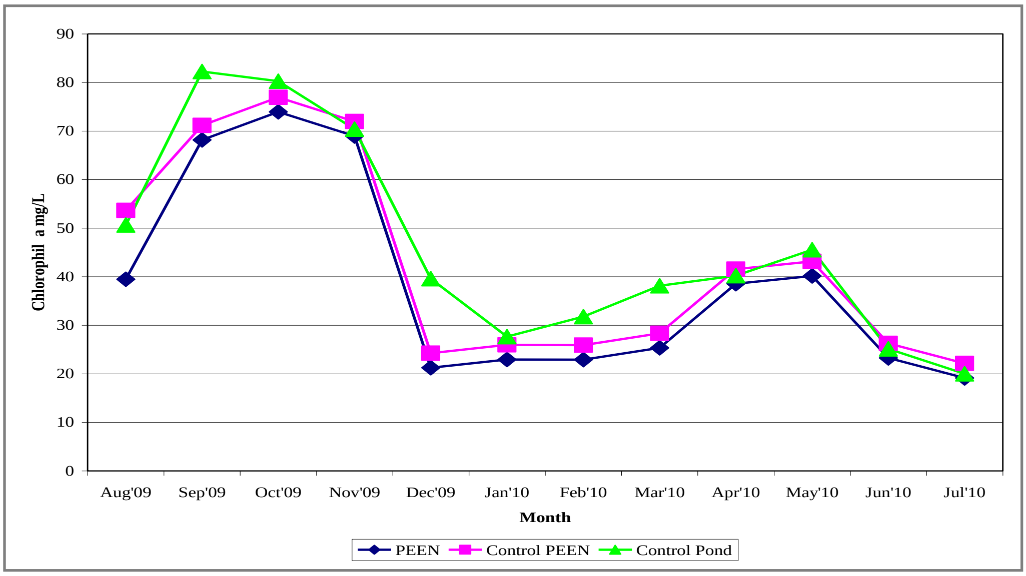

Fig. 4: Showing decreasing trend in monthly reading of Cholorophyll a in mg/L at pond sites PEEN, in comparision to Control PEEN and Control Pond after eco-technological application for the period of August -2009 to July 2010.

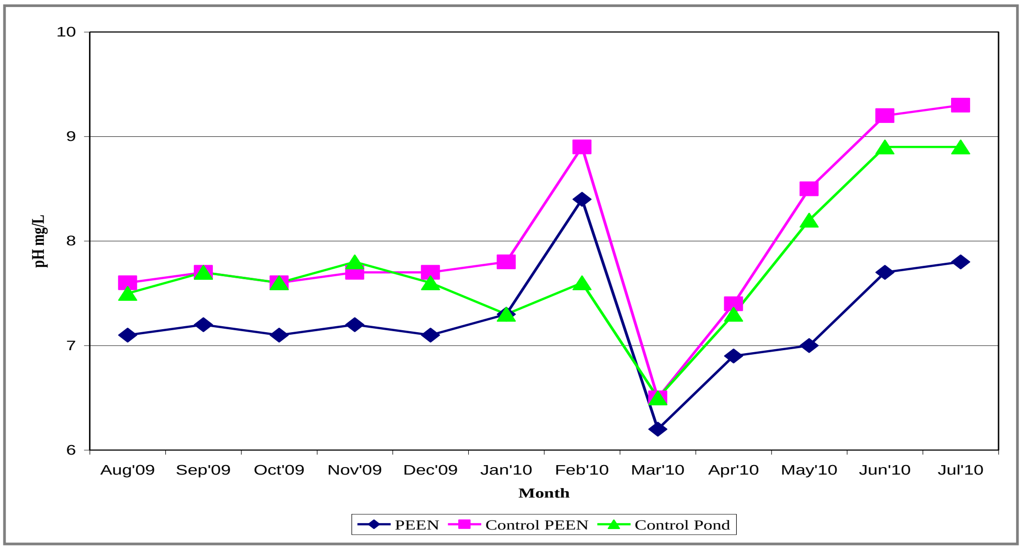

Fig. 5: Showing improving trend in monthly reading of pH in mg/L at pond sites PEEN, in comparision to Control PEEN and Control Pond after eco-technological application for the period of August -2009 to July 2010.

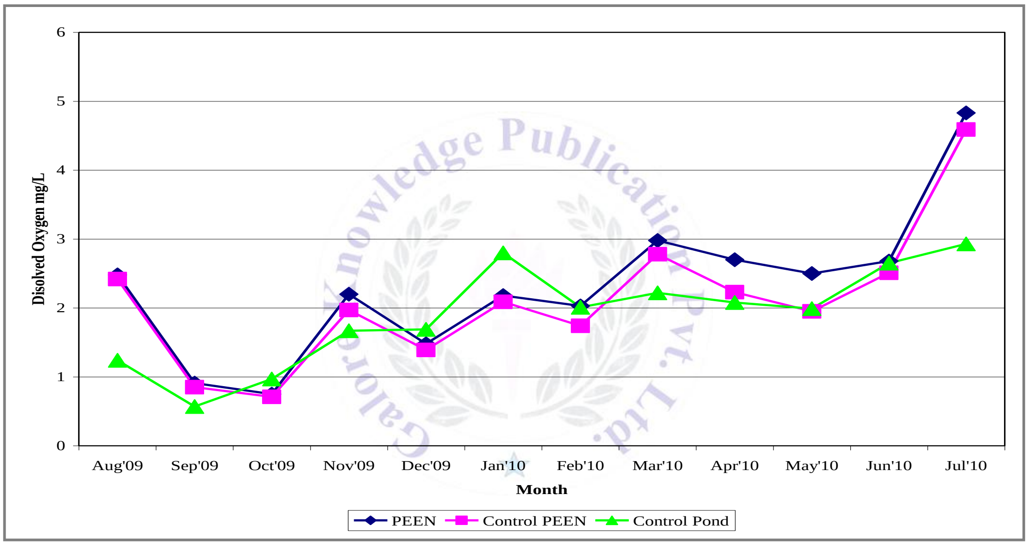

Fig. 6: Showing improvement in monthly reading of disolved oxygen in mg/L at pond sites PEEN, in comparision to Control PEEN and Control Pond after eco-technological application for the period of August -2009 to July 2010.

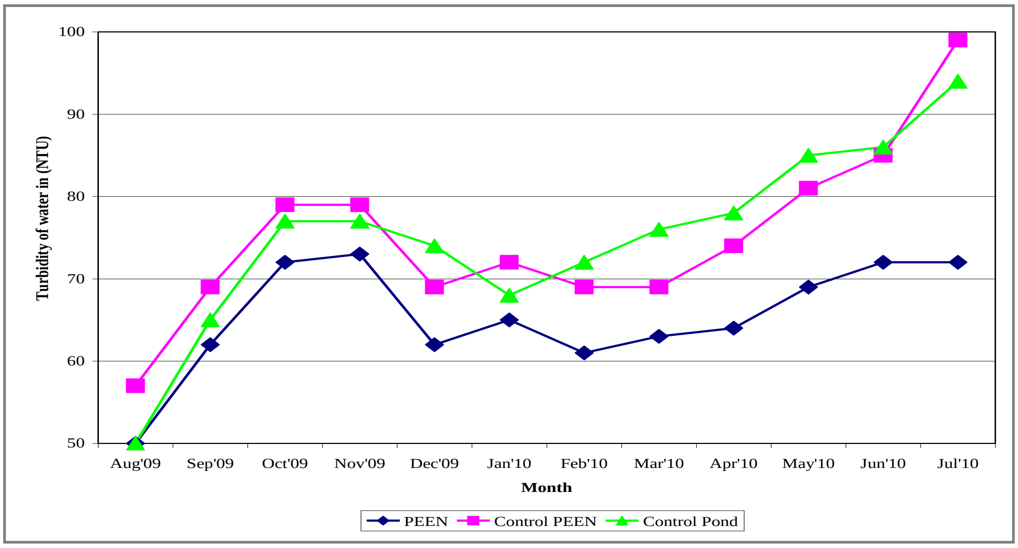

Fig. 7: Showing decreasing trend in monthly reading of Turbidity of water in (NTU) at pond sites PEEN, in comparision to Control PEEN and Control Pond after eco-technological application for the period of August -2009 to July 2010.

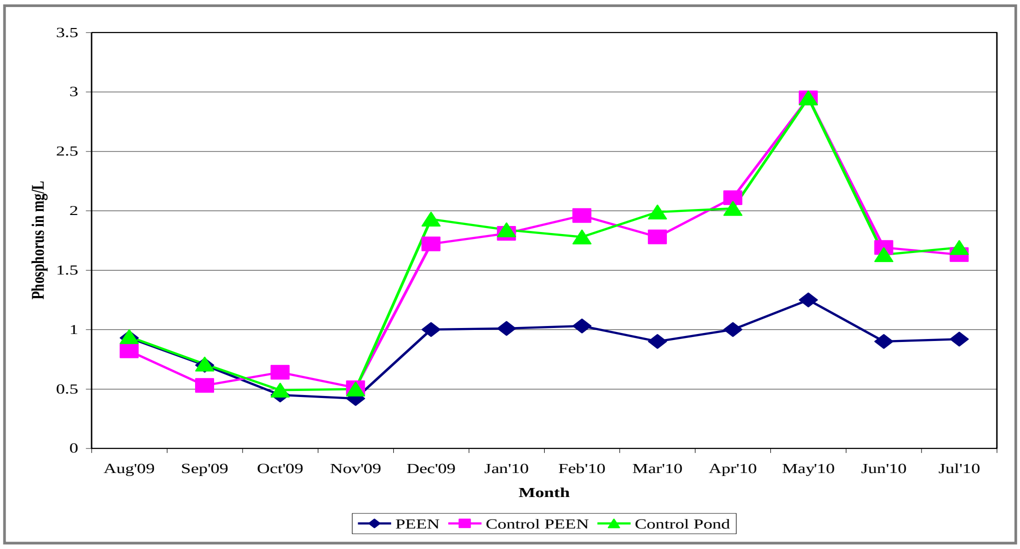

Fig. 8: Showing decreasing trend in monthly reading of Phosphate in mg/L at pond sites PEEN, in comparision to Control PEEN and Control Pond after eco-technological application for the period of August -2009 to July 2010.

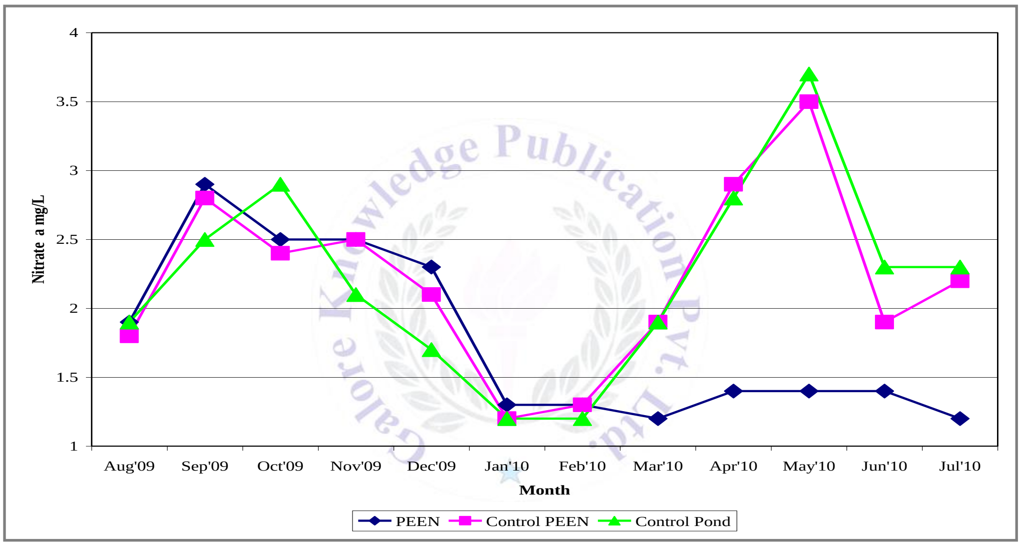

Fig. 9: Showing decreasing trend in monthly reading of Nitrate in mg/L at pond sites PEEN, in comparision to Control PEEN and Control Pond after eco-technological application for the period of August -2009 to July 2010.

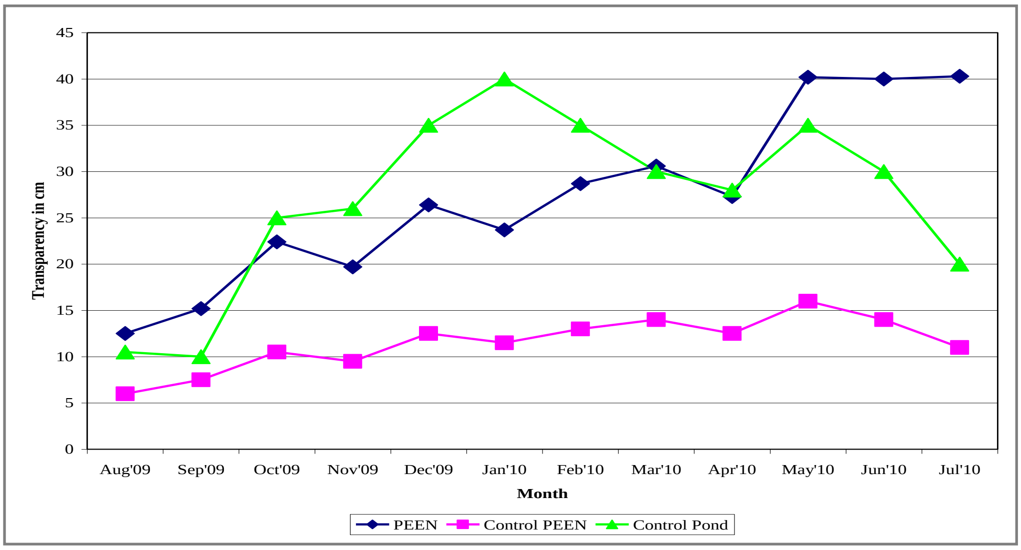

Fig. 10: Showing improvement in monthly reading of Transparency in cms at pond sites PEEN, in comparision to Control PEEN and Control Pond after eco-technological application for the period of August -2009 to July 2010.

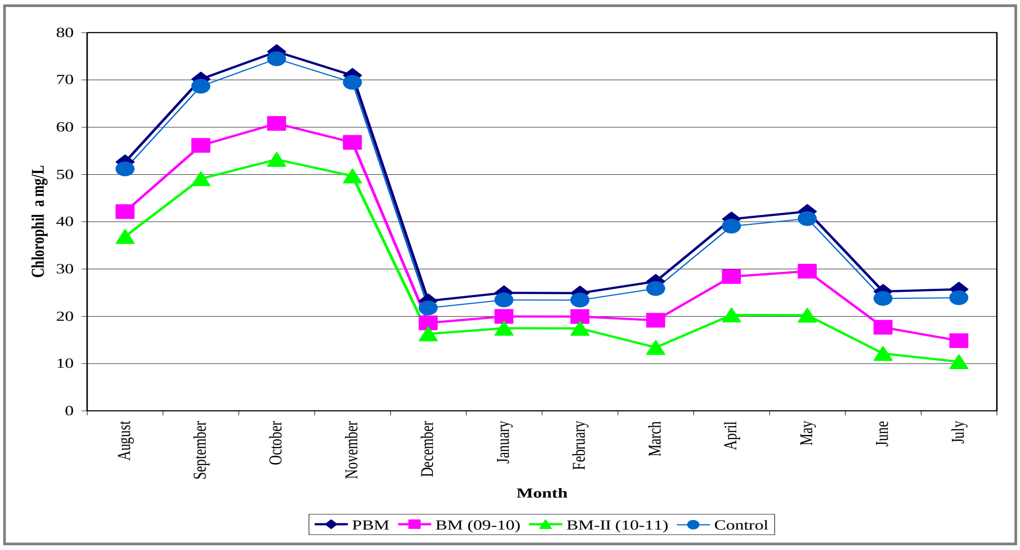

Fig. 11: Showing restoration effect of Bio-manipulation on Cholorophyll a at Mulapal (BM) with respect to PBM and Control Pond At Baidyarajpur, Jajpur (2009-2010, 2010-2011).

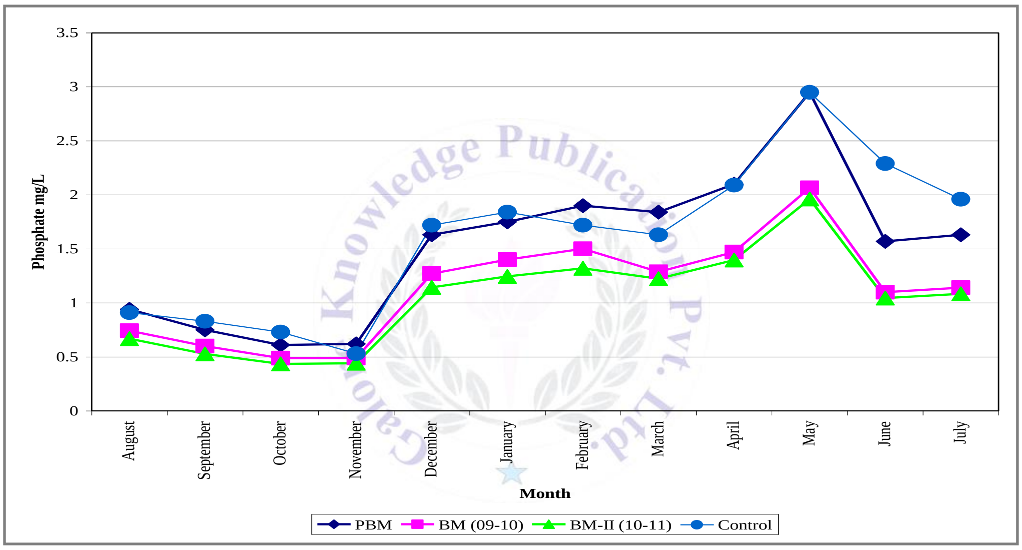

Fig. 12: Showing restoration effect of Bio-manipulation on Phosphate at Mulapal (BM) with respect to PBM and Control Pond At Baidyarajpur, Jajpur (2009-2010, 2010-2011).

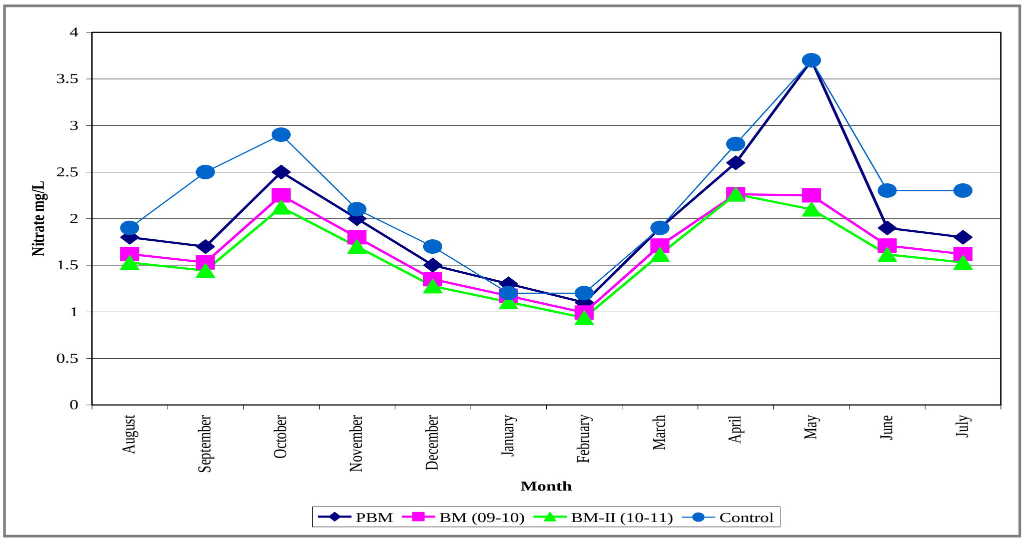

Fig. 13: Showing restoration effect of Bio-manipulation on Nitrate at Mulapal (BM) with respect to PBM and Control Pond At Baidyarajpur, Jajpur (2009-2010, 2010-2011).

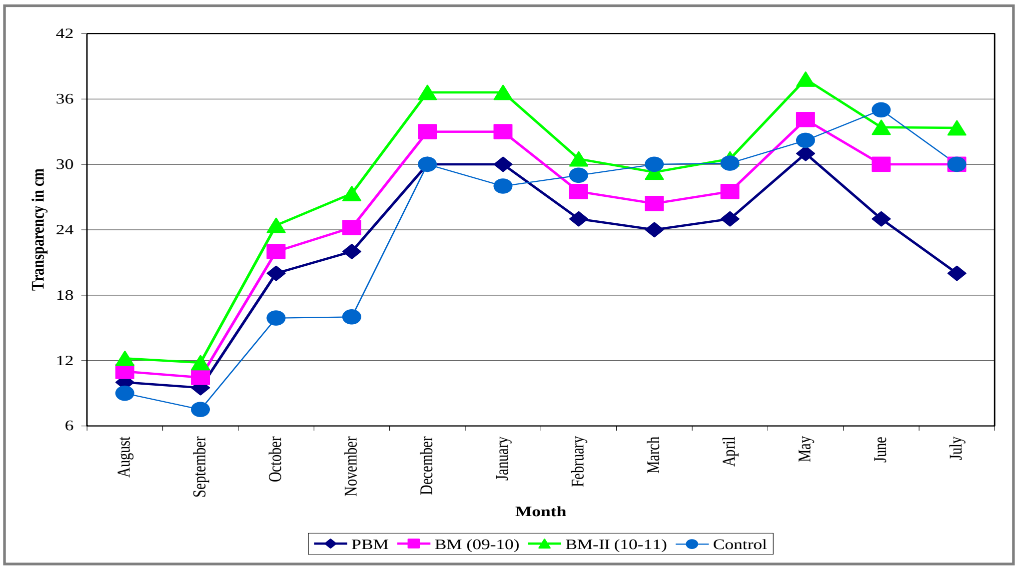

Fig. 14: Showing restoration effect of Bio-manipulation on Transparency at Mulapal (BM) with respect to PBM and Control Pond At Baidyarajpur, Jajpur (2009-2010, 2010-2011).

Anova for Chlorophyll a						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
PEEN	12	540.46	45.03833	445.58734		
Control PEEN	12	511.25	42.60417	432.85248		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	35.551004	1	35.551	0.0809412	0.778687	4.300949
Within Groups	9662.8381	22	439.2199			
Total	9698.3891	23				

Anova for Phosphate						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
PEEN	12	10.51	0.875833	0.0580629		
Control PEEN	12	18.15	1.5125	0.5530205		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.4320667	1	2.432067	7.9598527	0.009942	4.300949
Within Groups	6.7219167	22	0.305542			
Total	9.1539833	23				

Anova for Nitrate						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
PEEN	12	21.3	1.775	0.3765909		
Control PEEN	12	26.5	2.208333	0.4390152		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.1266667	1	1.126667	2.7627717	0.110665	4.300949
Within Groups	8.9716667	22	0.407803			
Total	10.098333	23				

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				

Table 5: Comparision of water quality between raw water and the output water of the PEEN from Aug'2009 to Jul'2010

Aug'09-Jul'10	**Raw water outside PEEN (Control)**		**Water output in the PEEN**	
	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	2.21	1.2-3.5	1.77	1.1-2.9
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	

The restorations of water bodies in and around the Jajpur town by ecotechnological approach have been carefully monitored since 2009 to 2010. After proper investigation two hypertrophic freshwater bodies were selected for glorification and restoration by ecotechnological approach.

A physico-ecotechnological engineering (PEEN) of ecotechnology has been applied in the hyper eutrophic pond of Gokhana, Jajpur to improve water quality. Efficiency of PEEN was observed in an enclosed part of the water body. It was observed on monthly basis for one year 2009-2010. It shows that different combination of physical and biological measures lead to positive result shown in Table 6.3 and 6.4. Prior to application of biofiltration method of ecotechnological approach in Gokhana 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 135.89 mg/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 0.87 mg/L within a range of 0.7 mg/L to 1.03 mg/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.

The water quality is improved in the PEEN mainly by precipitation, attaching, coagulation, absorption, decomposition and predation etc. Optimization of the ecosystem structure in the PEEN (micro pond) was realized by physical measures changing and controlling the biological species populations. The dominant species like Eichronia crassipes etc. should be changed during the year to gain the maximum effect on purifying water.

Transparency is not only an important indicator of water quality, but is of great importance for utilization of solar energy in water and growth of submerged plants. Some snails (Li 2002, Zhen 2002 and Yan & Wang 2002) and shells, for examples Zebra mussel (Dreissenia *polymorpha*) (Gary, 1995) also improves transparency. Combination of snails (Lymnae) and (Unio) were used for purifying water in the experiment. The result shows that the snail releases some substances facilitating coagulation in raw water. Bivalve like Unio has the ability to purify water by its filter feeding process. As a result of this combination of mollusca species the transparency of water in the PEEN is increased to a great extent in comparison to water outside it.

CONCLUSION

Result of the experiment on eco-technological approach for last years' showed and proved that different combination of physical and biological measures lead to different result. We may select the best combination of measures of eco-technology in various geophysical conditions for improving the efficiency of purifying water quality. Variation in physical, chemical and biological condition is characteristic of aquatic ecosystem, whether or not perturbed by anthropogenic activities. Hence, understanding of the proper functioning of the water bodies and management of its water quality is dependent on long term descriptive data, experimental manipulation technologies and intergrative data.

ACKNOWLEDGEMENT

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