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REVIEW ARTICLE

EUTROPHICATION BEHAVIOUR OF CHILIKA LAKE

[1]Peetabas, N. and *,[2]Panda, R. P.

[1]Department of Botany, Science College, Kukudakhandi
[2]Department of Zoology, Anchalik Science College, Kshetriyabarapur

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ABSTRACT

Ecosystem level changes in water quality and biotic communities in aquatic bodies of coastal lagoon have been associated with intensification of anthropogenic pressure. In light of incipient changes in Chilika lake, examination of different dissolved nutrients distribution and phytoplankton biomass was conducted. The effects of water soluble wastes containing NO_2^-, NO_3^- , $P0_4^{3-}$, NH_4^+ and Na^+ on eutrophication behavior of Chilika lake have been investigated by following standard procedures. From the evaluation parameters it was found that Nitrogen is introduced into the aquatic environment through the discharge of domestic sewage and organic industrial waste. The discharge of excessive quantities of nitrogenous compounds into rivers and lakes resulted excessive growth of algae and macrophytic plants. This phenomenon which is known as eutrophication, resulted algae death and were degraded by decay organisms, which used dissolved oxygen in the process. Thereby, the destabilization of aquaculture environment is established.

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INTRODUCTION

During the last few decades, several research works have been carried out on the nutrient dynamics of estuaries, ocean and fresh waters. These nutrients are present in natural waters in both organic and inorganic forms. Inorganic nitrogen occurs in the form of nitrate, nitrite and ammonia which can be readily consumed by the phytoplankton with different degree of preference. Elevated concentration of dissolved inorganic nitrogen (DIN) results in increased phytoplankton production and biomass, which may in turn be followed by increased population of consumer animals. At the same time excessive nutrient enrichment can be detrimental to the aquatic water bodies. Changes in nutrient concentration can shift the competitive advantage between different phytoplankton species. Also, it can change the chlorophyll specific carbon uptake rate by the individual species (Ganguly *et al*., 2013). These modifications at the primary producer level can have significant impact on the net ecosystem metabolism as well as its biodiversity. Apart from DIN, dissolved organic nitrogen (DON) is also recognized to be a dynamic component of the nitrogen pool in aquatic systems (Seitzinger *et al.,* 2002; Berman and Bronk, 2003) and has also been suggested to accumulate seasonally in coastal waters (Violaki *et al.,* 2010; Miyazaki *et al.,* 2010). Among DON, urea alone is accounting for 11–65% of Water-Soluble Organic Nitrogen (Mace *et al.,* 2003). Indeed, urea has a range of natural and anthropogenic sources; it is the most widely applied nitrogen fertilizer in many parts of the world (Glibert *et al.,* 2005).

**Corresponding author: Panda, R. P.*
Department of Zoology, Anchalik Science College, Kshetriyabarapur

The tropical and subtropical regions of the world boost as large number of wetland the case in India is not very different. The Odisha a subtropical state of India, takes pride of having the largest wetland in Asia-Chilika. Besides Chilika large number of smaller wetland are dotted across the state. It is also a source of water for both floral and faunal components. The lake is also significant to the conservation message as it plays home to many local migratory bird species that arise here seasonally, making it's avifaunal diversity even stronger faunal diversity is directly related to the complexity and stability of an eco system.

Chilika (19°28′–19°54′ N: 85º06′–85°35′ E), the largest brackish water lagoon in Asia, has been designated as a Ramsar site on the Ramsar Convention of Wetlands in 1981. The shallow water body (average depth 2 m) is about 65 km in length, spreading from northeast to southwest parallel to the coastline with a variable breadth reaching 20.1 km. The lagoon is spread over an area of 950 km^2 during summer, which swells up to 1165 km^2 during monsoon (Siddiqui and Rao, 1995). The lagoon is connected to the Bay of Bengal near Satapara (Sipakuda) by means of an artificial opening made in September 2000. High evaporation from the shallow water body during the summer and large inflow of fresh water through various rivers and rivulets at the northern end of the lagoon during the monsoon and post-monsoon seasons contribute significantly to the water spread area. The catchment area of the lagoon is 4406 km^2, in which 68% is constituted by western catchment and 32% by the Mahanadi delta, with an average rainfall of 1,238 mm (southwest or summer monsoon); nearly 75% of it occurs during the southwest monsoon. 19 rivers/rivulets (R1 to R19; Figure 19) drain enormous freshwater into the lagoon together with significant loads of nutrients and suspended matter resulting in appreciable changes in hydrological conditions both seasonally as well as annually.

A large number of studies have shown that urea is an important source of N for a great variety of marine phytoplankton, ranking often in importance as much as, or greater than, nitrate (Kudela and Cochlan, 2000). Coastal waters can be supplied with urea through terrestrial and atmospheric inputs (Middelburg and Nieuwenhuize, 2000; Glibert *et al.,* 2001) and transfer from sediments (Rysgaard *et al*., 1998). Urea uptake by phytoplankton communities as a percentage of total nitrogen uptake can contribute up 50% of the total nitrogen taken up in coastal and estuarine regions (e.g. Chesapeake Bay, Glibert *et al.,* 1991; Gulf of Bothnia, Sweden, Cochlan and Wikner, 1993 etc.).

On the basis of its physicochemical properties, the trophic state of the lagoon like Chilika can be classified as one of the four general classes, i.e., 1.oligotrophic, meaning low nutrient levels and high clarity, 2. mesotrohic, a moderate elevation in nutrient concentrations resulting in lower clarity and a reduced desirable biological habitat, 3. eutrophic, the enriched state or 4. hyper-eutrophic, the most enriched environment which can result in substantial loss of environmental qualities.

The lagoon is a unique assembles of marine brackish and fresh water ecosystems with estuarine characters. This fragile ecosystem is a hot spot of biodiversity that shelters a number of endangered species. It is also an avian grandeur and the wintering grand for more than one million migratory birds. The highly productive lagoon eco-system with its rich fishery resources sustains the livelihood of more than 0.2 million fisher folk who live in and around the lagoon.

Due to severe degraded condition around Chilika lake, the change in the ecological character surfaced. This resulted in the loss of productivity and loss of biodiversity. Increased turbidity, shrinkage of area due to choking of inlet rivers for shore sedimentation, decrease of salinity due to inflow of NO_3^- containing liquid, the depletion of fishery resources are been observed (Cloren, 2001, Jorgensen; *et al*., 1996 and Bhasin *et al.,* 2006) Present study was undertaken to ascertain the influence of NO_2^-, NO_3^-, PO_4^{3-}, NH_4^+ and Na^+ ions on the behavior of eutrophication, especially gain or loss of NO_3^- and PO_4^{3-} in Chilika lake water and reasoned out the gradual reduction of fish production (Goel and Trivedy, 2006 and Trivedy, 1997).

MATERIALS AND METHODS

The excess nutrients like NO_2^-, NO_3^- , PO_4^{3-}, NH_4^+ and Na^+ ions which are regarded as a measure of eutrophication (Nutrient Index) are studied qualitatively as well as quantitatively as per the scheme given below.

Considering the sensitive ecosystem of the lagoon, a closed monitoring was carried out to assess the impact of various management interventions of the lagoon. This was carried out from three fixed stations (S_1- Southern Zone, S_2- Northern Zone and S_3-Central Zone) covering all the ecological zones and the data collected at 3Odays intervals from the month of January' 09-Nov'09. In the present study the nutrients like Nitrogen in the form of nitrites (NO_2^-), Nitrates (NO_3^-) and Ammonia (NH_4^+) and Phosphorus in the form of Orthophosphate (PO_4^{3-}) have been qualitatively estimated during the study period. These values have been obtained by dividing the lagoon into three zones as indicated earlier. Dissolved Oxygen (DO) of the lake water was analysed by Winklers Method. To determine the BOD, samples were incubated at 20°C for 5 days and COD was carried out according to standard methods. The value of sodium (Na) was also analysed by following the standard procedure. All such data have been tabulated in Table 1 and Table 2.

RESULTS AND DISCUSSION

From the above data it can be construed where the value is < 3, especially on inorganic nutrients the region was found to be oligotrophic in nature. The high nutritional values in some regions indicate the nutrient rich fresh water from agriculture run off through major river systems.

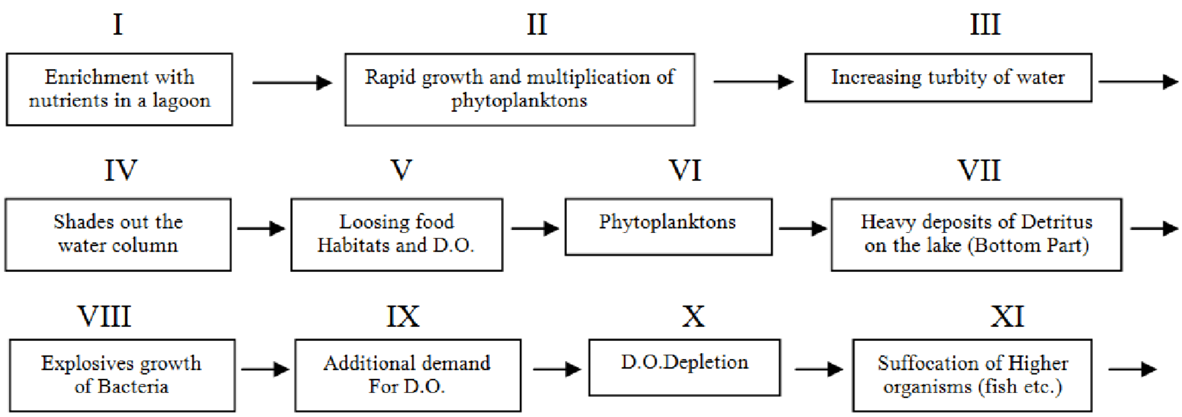

Fig.1. Flow sheet diagram of eutrophication studies

Table 1. Nutrient index Values

SI. No	Parameters	Stations (Zones)	Jan	Feb	Mar	Apl	May	June	July	Aug	Sept	Oct	Nov
1	Nitrite	S_1	3.9	3.98	3.9	3.97	3.98	3.9	3.98	3.97	3.95	3.9	3.9
		S_2	3.7	3.75	3.77	3.7	3.76	3.75	3.77	3.78	3.7	3.78	3.7
		S_3	3.1	3.18	3.18	3.17	3.1	3.17	3.18	3.18	3.1	3.17	3.17
2	Nitrite	S_1	2.5	2.58	2.57	2.5	2.57	2.58	2.5	2.5	2.57	2.7	2.5
		S_2	2.3	2.38	2.35	2.3	2.3	2.38	2.36	2.36	2.38	2.3	2.3
		S_3	2.40	2.42	2.42	2.44	2.44	2.43	2.42	2.43	2.43	2.44	2.43
3	Phosphate	S_1	2.7	2.7	2.78	2.78	2.77	2.77	2.78	2.7	2.7	2.77	2.7
		S_2	2.6	2.68	2.6	2.65	2.67	2.6	2.6	2.68	2.67	2.68	2.6
		S_3	2.4	2.47	2.4	2.48	2.47	2.4	2.4	2.47	2.47	2.48	2.47
4	Ammonium	S_1	4.5	4.5	4.4	4.58	4.55	4.5	4.4	4.58	4.57	4.57	4.58
		S_2	4.1	4.1	4.97	4.96	4.1	4.95	4.97	4.97	4.1	4.95	4.1
		S_3	3.1	3.18	3.18	3.1	3.18	3.1	3.17	3.0	3.17	3.17	3.1
5	Sodium	S_1	19.9	19.04	20.9	20.9	20.98	20.97	18.05	17.04	19.09	17.9	20.00
		S_2	19.9	18.00	20.09	20.09	20.98	20.09	18.95	16.09	19.08	18.07	20.00
		S_3	20.0	19.1	20.09	21.18	20.09	20.97	18.95	17.44	19.29	18.09	19.09

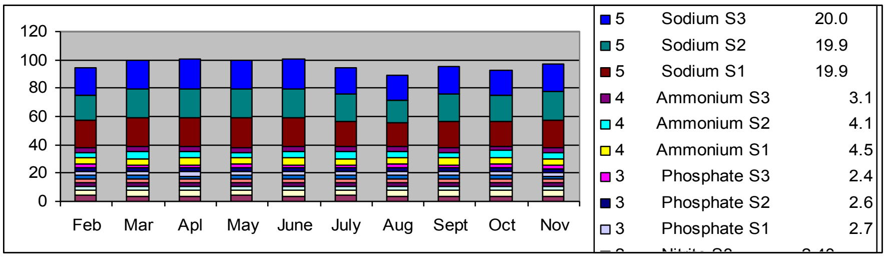

Fig. 2. Nutrient index Values

Table 2. Oxygen Level parameters

SI. No	Parameters	Stations (Zones)	Jan	Feb	Mar	Apl	May	Juno	July	Aug	Sept	Oct	Nov
1	DO	S_1	4.8	4.6	4.5	4.0	4.5	4.5	4.2	4.1	4.5	4.8	4.4
		S_2	4.7	4.5	4.6	4.3	4.4	4.5	4.2	4.1	4.7	4.7	4.5
		S_3	4.7	4.5	4.1	4.4	4.2	4.0	4.0	4.3	4.2	4.8	4.7
2	BOD	S_1	6.1	6.18	6.16	6.1	6.1	6.18	6.16	6.0	6.0	6.17	6.16
		S_2	6.14	6.16	6.18	6.1	6,1	6.1	6.15	6.0	6.18	6.17	6.17
		S_3	6.1	6.18	6.1	6.18	6.1	6.1	6.16	6.17	6.10	6.0	6.0
3	COD	S_1	81.1	81.18	81.18	81.24	81.26	81.1	81.18	81.16	81.0	80.9	80.9
		S_2	80 .9	81.08	81.0	81.1	81.1	81.18	81.0	81.0	81.07	81.07	81.08
		S_3	81 .1	81.17	81.18	81.1	81.1	81.17	81.0	81.0	81.07	81.07	80.09

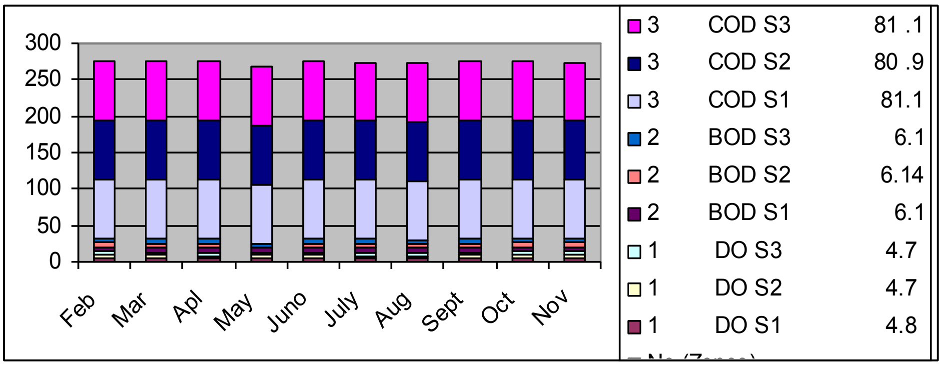

Fig. 3. Oxygen Level parameters

High Ammonia index value relates to organic decomposition of weeds or prawn farming activities. Moreover use of inorganic fertilizers enriched values to make the region oligotrophic, mesotrophic etc. A potentially significant factor affecting nutrient loads in this lagoon is the materials used in the watershed especially the spreading of inorganic fertilizers, animal/birds manure. The use of fertilizers with high phosphorus and nitrogen content can increase the nutrient loads in land run off, compared to that of unfertilized soils. Moreover it is also found that after the reopening of the entry points of Sipakuda (a canel) as well as Gabakunda (also another canel) to Chilika lake, the water flow to Chilika lake through Gabakunda canal is again flowing back through Sipakuda and therefore the salinity of chilika lake is decreasing.

Moreover as the concentration of Dissolved Oxygen (DO) highly depends on the amount of pollutants, the oxygen level becomes low and makes it difficult for species to survive and many aquatic organisms especially fishes die due to the fall of Oxygen level below 5 ppm. Further, it is observed that under eutropic conditions dissolved oxygen greatly increases during the day but is greatly reduced after dark by the respiring algae and by micro-organisms that feed on the increasing mass of dead algae. The BOD values are found to be in high level which indicate the deterioration of water quality. The COD is linked with heavy effluents and domestic sewage. The high values depict deteriorating water quality.

The concentration of Sodium is found to be in a state of variation. Hence, it can be construed that salinity is gradually decreasing.

Conclusion

The present study revealed that primary productivity of Chilika lake was largely influenced by dissolved inorganic nitrogen and dissolved nitrogen concentration and lake remained eutrophic in nature. The influence in situ bio-geochemical process like denitrification, mineralization etc and extent of sediments-water coupling could be of equal importance compared to other transport process in regulating the nutrient status of the shallow lake and corresponding productivity. Further research to quantity the relative importance of these various process will be useful to protect coastal water like Chilika lake from rapid eutrophication incidences.

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