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Nutrient (N&P) Enrichment Coupled with Phytoplankton Dynamics of *Mullaperiyar reservoir* in the Western Ghats of Kerala

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***Periyar* Lake, situated inside the *Periyar Tiger Reserve* (PTR) and Wildlife Sanctuary, a major international tourist centre in Kerala, was studied for a year (January to December 2005), in order to explore the nutrient status and associated phytoplankton growth. This oldest manmade freshwater reservoir/Lake in the Western Ghats of Kerala, is getting more attention now a days due to the dispute between Kerala State and Tamil Nadu (TN) State for the ownership of the *Mullaperiyar* Dam. More over it is situated inside India's prime Tiger reserve in its quantity, area and quality. Total Nitrogen and inorganic Phosphorus of the waters were studied every month and the data were grouped into three different seasons and analyzed the seasonal fluctuation if any, moreover, water samples from different parts of the entire Lake were also analyzed to account any spatial variation due the increasing anthropogenic influence in and around the Lake related with tourism. From the study it was revealed that Nitrogen and Phosphorus concentration of the Lake was at an alarming rate during premonsoon and northeast monsoon in stations-1 and 5 (2400 to 3000 μg/L), with maximum human influence and sewage entry. While the inlets zones (station-4) showed minimum N and P contents (1500 μg/L) . The density of Phytoplankton showed a positive correlation with the nutrients in almost all seasons. The highest plankton density(490 no./L) was recorded during premonsoon at station-5 and the lowest was at station-4 (253 no./L) during northeast monsoon.From this study it was clear that the nutrient and phytoplankton of the Lake is dependent on the seasonal fluctuations in the environment as well influenced by the increased anthropogenic activities in and around the Lake. Strict measures should be taken to monitor the water quality of this pristine water body within the sanctuary because this is the source of drinking water for 4 Districts of TN.**

Key words: Nutrients, Nitrogen, Phosphorus, tropical, high altitude, freshwater, Western Ghats.

The PTR is one of the most fascinating wildlife sanctuaries of the world, a major site of tourist attraction for the last fifty years. It is designated by the Department of Environment as a major wetland site of the Country. *Mullaperiyar* Lake located in the Idukki District of Kerala is the largest (26km^{2}area) and oldest (built in 1986) reservoir/Lake constructed in the state to irrigate the plains of TN. *Mullaperiyar* Dam was constructed near the confluence of *Mullayar* and *Periyar* (the largest river in Kerala with a length of 244km).It lies between 09'16 and 09'40N latitude, and 76'55 and 77'26E longitude, and an altitude of 1525m above mean sea level (Govt. report, 1986).

This study was designed to understand the nutrient status of the freshwater system, which was not explored and will give information about

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the general trend in nutrient load of the water bodies in the Western Ghats (one of the 25 biodiversity hotspots of the world) region of India, majority of them are under explored. This will help to understand the present nutrient condition of the water body on behalf of the fast developing tourism based on the Lake/ Sanctuary system.

MATERIAL AND METHODS

Collection of water samples

Five stations were fixed in the Lake (Fig-1), based on the maximum and minimum anthropogenic influence to different locations. They were PLS (*Periyar* Lake Station)-1(boat landing for tourists), PLS-2 (*Mullaperiyar* Dam

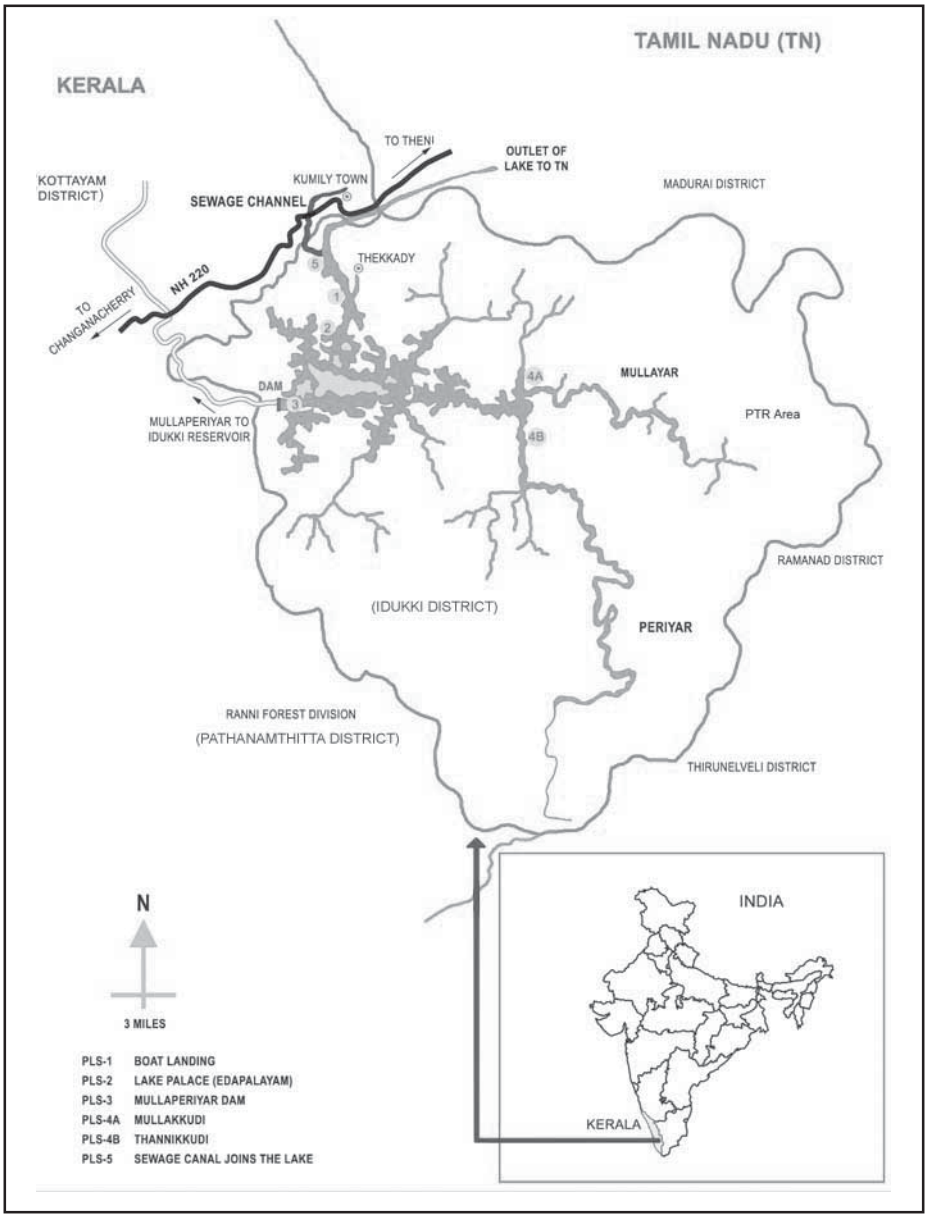


Fig. 1. Different study stations of the Lake

site), PLS-3 (confluence zone of *Mullayar* to the Lake), PLS-4 (confluence zone of *Periyar* the Lake), PLS-5 (open water tunnel to TN from the Lake, where the sewage of Kumily township enters the Lake). Sampling was done between 15th and 20th of every month from January to December 2005.Samples for nutrient analysis were collected from surface water (1to2cm) of the Lake with 2 Litre (L) acid cleaned polythene bottle and were kept in dark ice boxes at 4^0C till it reached the laboratory for analysis.

Estimation of N and P in water

Total nitrogen was determined by kjeldal method, and inorganic phosphorus was measured using UV visible spectrophotometer. All the analysis was carried out following the standard methods of APHA (1995) and Trivedy and Goel (1986).

Grouping of data

In order to account all the major seasonal environmental fluctuations of the study area the monthly measurements done were grouped into averages of three seasons such as pre-monsoon (PM) (January to April), southwest monsoon (SWM) (May to August) and the north east monsoon (NEM) (September to December).

Statistical analysis

A correlation co-efficient were calculated to find out the significant correlations between parameters. All the quantitative data were analyzed by student's t-test and significance was assumed for P-values lower than 0.05.

RESULTS

Total Kjeldal Nitrogen (N)

Comparatively high concentrations of total nitrogen was observed during PM and NEM, and the low values were obtained during SWM in almost all stations (Fig-2). Total Nitrogen of the Lake varied between 1500µ/L to 3000µg/L. The highest value was obtained at PLS-5 (3000 µg/L) during PM and the lowest (1500µ/L) was obtained at PLS-4 during SWM and NEM.

Total Inorganic Phosphorus (P)

Comparatively high concentrations of total phosphorus were observed during PM and SWM and the low values were obtained during NEM in almost all stations. Total Phosphorus of the Lake varied between 10 to 80 µg/L (Fig-3). The highest value was obtained at PLS-1 and 5 (80 µg/L) during PM and the lowest was obtained at PLS-4 (10µg/L) during NEM. PLS-5 showed high values during all the season.

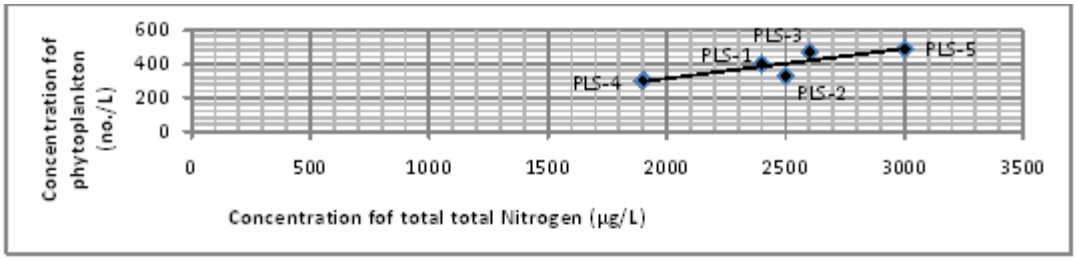
Phytoplankton Density

Phytoplankton density also showed the same trend as that of the nutrients, during PM, PLS-5 showed the highest density (490 no./L), and the lowest values were observed at PLS-4 during all the seasons. The lowest density of all the seasons and stations was 253 no./L during NEM at PLS-4 (Fig-2&3). During NEM, PLS-1 and 3 dominated (430 and 400 no/L respectively), PLS-5 in phytoplankton density. The lowest density obtained during PM was 303 no./L.

DISCUSSION

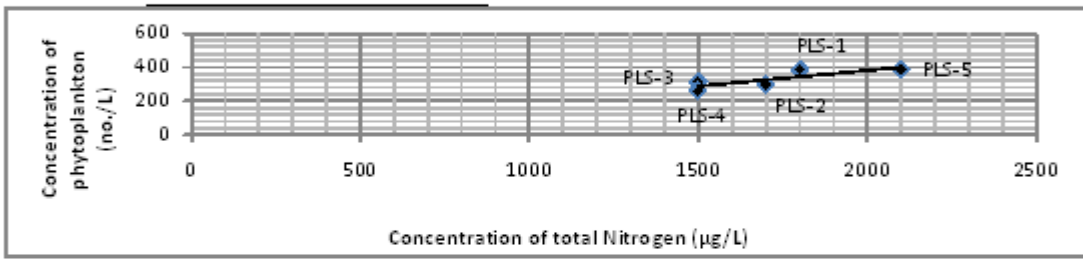
An increase in trophic status of a Lake is associated with an increase in nutrient status. N and P are the major nutrients for all phytoplankton growth and the limited availability of these nutrients in water usually limits phytoplankton growth in natural aquatic system. On the contrary excess availability of both of them triggers eutrophication. Accumulation of N and P in natural waters is more closely related to external factors such as anthropogenic influences, fertilizers, and the rate of inflow (Hutchinson, 1938). The accumulation of N in reservoirs and natural water bodies has become a common phenomenon which alters ecological process in many parts of the world due to intensive human activity. Increased nutrients along with altered nutrient ratios cause multiple and complex changes in aquatic systems (Rabalais, 2002).

In the present investigation the highest N content was noticed at PLS-5 during all the seasons coupled with an increased density of phytoplankton in that station. The highest value for N recorded in the Lake was 3000µgL^{-1} during PM, and that of phytoplankton density was 490 no./L. In natural waters N, 150 µg/L is a critical value and when the contents crosses the limit algal blooms occur (Sawyer *et al.,* 1945). The increased amount of N, in almost all stations during PM showed a significant positive correlation with phytoplankton density and significant P-values in t-test. The increased concentration during this season at all stations except PLS-4 (1900 µg/L) is



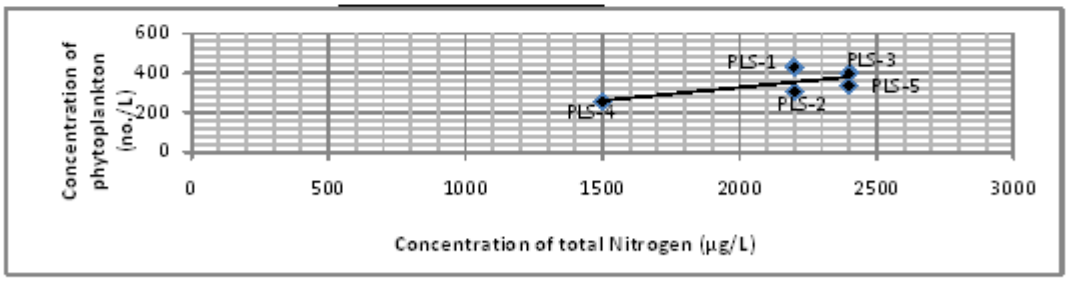
P-value critical= 1.4826E-06

	2600	*470*
2600	1	
Correlation co-efficient 470	0.886991	1



P-value critical= 9.60272E-07

	1800	*387*
1800	1	
Correlation co-efficient = 387	0.895215	1



P-value critical= 2.7238E-06

	2200	*430*
2200	1	
Correlation co-efficient 430	0.860083	1

Fig. 2. Total Nitrogen and concentration of Phytoplankton in different locations of the Lake during (1) PM (2) SWM and (3) NEM of 2005 - pp10

undoubtedly related to the concentrated state of the Lake waters due to very less precipitation and dry climate. The high rate of N indicates that the lake at certain zones (PLS-1&5) exceeds the maximum level due to the high sewage disposal and human interaction. Other zones also showed a transitional stage between oligotrophy to eutrophy. Nitrogen fixation increases during summer in Lake Waco (summer N load is more), performed by certain *Cyanobacteria* which have become common. Some *Cyanobacteria*, can use dissolved gaseous N, periodic blooms are expected when mixing or flushing is low after pulsed inputs, especially with high temperatures (Joe Plotrowski *et al.,* 2011).

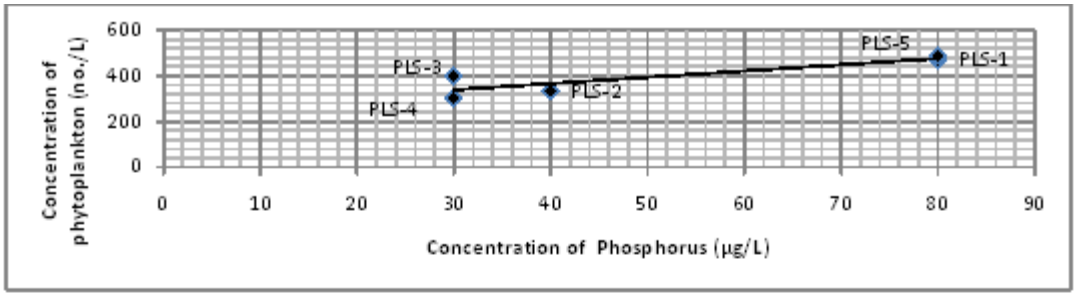
Maximum lowest N value was recorded at PLS-4 (1500 µg/L) during SWM and NEM and plankton density 263 and 253 no./L, respectively during these seasons. A low level of N was reported by Abbasi (1997) in Kuttiyadi reservoir in southern Western Ghats. Comparatively low concentrations (1500-2100 µg/L) of N and plankton noticed during SWM may be due to the dilution of waters during heavy monsoon coupled with the overflow of dam and outflow towards TN water tunnel. Horizontal mixing of water due to high wind during this season also influenced the lowering of N concentration.

Then again the concentration showed an increasing trend during NEM (1500-2400 µg/L) may be due to the inflow to the Lake. Due to the intensive agricultural activities around the reservoir during this season, might have increased the nutrient load of the Lake, through the inflow at PLS-5. Land runoff to the lake, comparatively lesser amount of rain than that of SWM also might have influenced the increased level of N during this season. Heavy thunder and lightning coupled with NEM also might have caused the large amount of *Cyanophyceae* in the bottom zone of the lake to fix the atmospheric nitrogen during the season. In deep lakes settling of suspended matter can lead to low nutrients in the epilimnion during summer. Hence internal loading depends upon the intensity of turbulence across seasonal pycnocline that transports nutrient rich hypolimnetic water to the photic zone in summer (Jellison *et al.,* 1993 and Romero *et al.,* 1998).

P occurs almost solely as soluble phosphates in natural waters. All forms of phosphates such as orthophosphates, condensed phosphates, and organically bound phosphates are found in waters. P is considered to be the critical limiting nutrient, causing eutrophications of fresh water systems and required by algae in small quantities. P limits the growth of the algal forms most often, but N limits the algal growth of certain species alone. This is because of the fact that certain species of algae which fix nitrogen themselves are not affected by scarcity of N in the water they grow. Hence, the P nutrient assessment of waters is crucial to the monitoring investigations of natural freshwater bodies. P additions to landscape enter water via wastewater effluents and soil erosions, and also from detergents. Therefore, P in large quantities in water is an indication of pollution through sewage and industrial waste. P is the primary limiting nutrient in most lakes and reservoirs. Just like N, higher P in bottom water may result from decomposition of organic matter and its release from sediments under the anoxic conditions. More P leads to more algae (*Cyanobacteria*), more algae leads to lower water clarity. Key transition range is between of P is between 10 and 100 µg/L. N: P ratio determines which algae are dominant. P concentration 5 to 50 µg/L is typical for an unpolluted water body (Joe Plotrowski *et al.,* 2011).

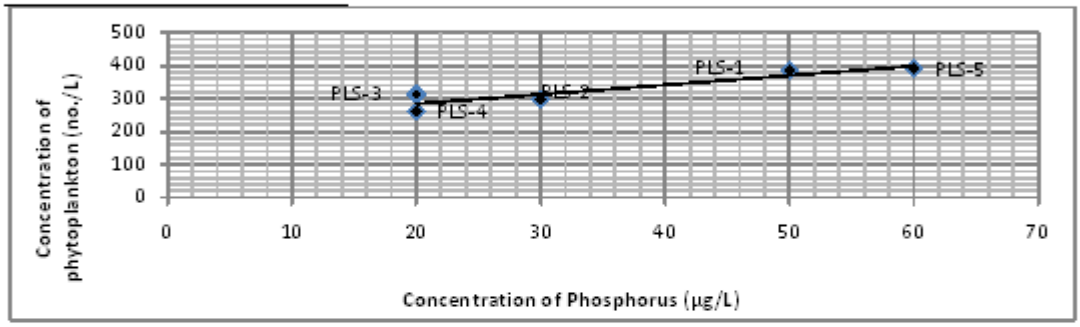
In the present study the P value ranged between10-80 µg/L. The highest P of all stations was PLS-1&5 (80 µg/L) and season was PM, and the lowest was at PLS-4 (10 µg/L) during NEM. Comparatively higher values were observed during PM coupled with positive correlation of phytoplankton and significant P-values in t-test. Second highest P values were obtained during SWM and low amounts during NEM. The concentration of P is at an alarming rate during all seasons in the Lake. According to Welch (1980), a water body may be considered to be eutrophic if the total P value exceeds 30 µg/L. Romero et al., considered Lake Pamvotis with a P content of 110 µg/L as one of the intermediate nutrient status.

The N and P content of *Periyar* lake is increasing at an alarming rate at PLS-1 and 5 with maximum anthropogenic influence and at other stations a gradual increasing trend was observed during PM when water become concentrated. The sewage channel at PLS-5 had a significant role in the increased level at that station and its influence was noticed in other stations because of the



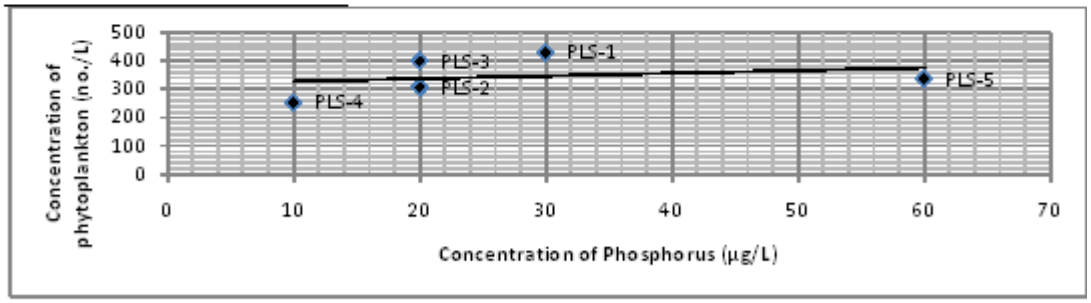
P-value critical= 9.04986E-06, correlation co-efficient

	80	*470*
80	1	
470	0.834187	1



P-value critical= 1.94008E-06, correlation co-efficient

	50	*387*
50	1	
387	0.912229	1



P-value critical= 5.59543E-06, correlation co-efficient

	30	*430*
30	1	
430	0.299778	1

Fig. 3. Total Inorganic Phosphorus and concentration of Phytoplankton in different locations of the Lake during (1) PM (2) SWM and (3) NEM of 200 - pp11

horizontal mixing during monsoon season. PLS-4 at the core zone of the lake with minimum anthropogenic influence showed comparatively lesser nutrient levels, and plankton density, because this station is almost 35Kilometers away from PLS-1&5, and altitude of that station is also higher than that of PLS-1&5, so chance for horizontal mixing is also negligible. Nutrient enrichment at locations 1 and 5 enriched the growth of unwanted plankton of eutrophic nature. These trends indicate a transition of this pristine natural high altitude tropical freshwater system from oligotrophy to eutrophy. The management of this precious water resource is very urgent and important in the increasing tourism impacts.

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REFERENCES

1. Kerala State Gazetteer, Edited by Adoor K.K. Ramachandran Nair, 1986, pp188.
2. APHA, Standard methods for the examination of water and waste water, American Public Health association, American waters works association, and Water Pollution control Federation, 19th edn. Washington Dc, 1995.
3. Trivedy, R.K., and Goel P.K., Chemical and biological methods of water pollution studies, Environmental Publications, Karad, India, 1986, pp244.
4. Huchinson, G.E., On the relation between the oxygen deficit and the productivity and typology of Lakes. *Int. Rev. Hydrobiol*., 1938; **36**: 336-355.
5. Rabalais, N., Nitrogen in aquatic system, *Ambio.*, 2002; **31**(2): 102-112.
6. Sawyer C.N., Lackey J.B., Lenz A.T., Investigation of the odour nuisances in the Madison Lakes,particularly Lakes Monoua, Wanbesa and Kegnosa from July 1943 to July 1944,Madison University Press, 1945.
7. Joe Plotrowski., Ken Wagner., Russ Gibson, N and P pollution and harmful algal blooms in Lakes: Grand Lakes, St. Marys (OH) and Lake Waco (TX), 2011.
8. Abbasi, S.A., Wetlands of India (3): Wetlands of India: Ecology and threats (3), The Kuttiyadi river basin, Discovery Publ. House, New Delhi, 1997:pp 65-143.
9. Jellison R., Miller L.G., Melack J.M., Dana g. L., Meromixis in hyper saline Mono Lake, California-2, Nitrogen fluxes. *Limno. Oceanogr.,* 1993; **38**: 1020-1039.
10. Romero J.R., Jellison, r., Melack, J. M., stratification, vertical mixing, and upward ammonium flux in hyper saline Mono Lake, California, *Arch, Hydrobiol.,* 1998; **142**: 283-315.
11. Welch, E. B., Ecological effects of waste water, Cambridge University Press, London, 1980.