

Seasonal Dynamics in the Phytoplankton Density 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 center in Kerala, was studied for a year (January to December 200fi), 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 day due to the dispute between Kerala State and Tamil Nadu (TN) State for the ownership of the Mullaperiyar Dam. Moreover, 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 fi (2400 to 3000 µg/L), with maximum human influence and sewage entry. While the inlets zones (station-4) showed minimum N and P contents (1fi00 µg/L). 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.

Keywords: Nutrients, Phosphorus, Tropical, High Altitude and Freshwater.

Introduction

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 (26km²area) 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 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.

Materials 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 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 4⁰C 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 were 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 1500 μ /L to 3000 μ g/L. The highest value was obtained at PLS-5 (3000 μ g/L) during PM and the lowest (1500 μ /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 $\mu\text{g/L}$ (Fig-3). The highest value was obtained at PLS-1 and 5 (80 $\mu\text{g/L}$) during PM and the lowest was obtained at PLS-4 (10 $\mu\text{g/L}$) 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 3000 $\mu\text{g/L}^{-1}$ during PM, and that of phytoplankton density was 490 no./L. In natural waters N, 150 $\mu\text{g/L}$ is a critical value and when the contents cross 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 $\mu\text{g/L}$) is 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 $\mu\text{g/L}$) 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 $\mu\text{g/L}$) 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 $\mu\text{g/L}$) 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 lead to lower water clarity. Key transition range is between of P is between 10 and 100 $\mu\text{g/L}$. N: P ratio determines which algae are dominant. P concentration 5 to 50 $\mu\text{g/L}$ is typical for an unpolluted water body (Joe Plotrowski et al., 2011).

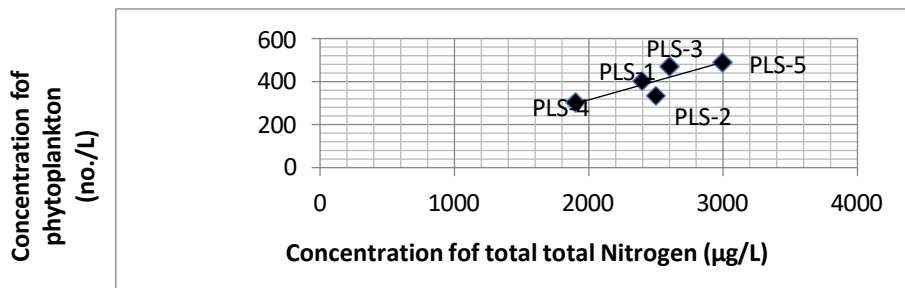
In the present study, the P value ranged between 10-80 $\mu\text{g/L}$. The highest P of all stations was PLS-1&5 (80 $\mu\text{g/L}$) and season was PM, and the lowest was at PLS-4 (10 $\mu\text{g/L}$) during NEM. Comparatively higher values were observed during PM coupled with positive correlation 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 $\mu\text{g/L}$. Romero et al., considered Lake Pamvotis with a P content of 110 $\mu\text{g/L}$ 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 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 35 Kilometers 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.

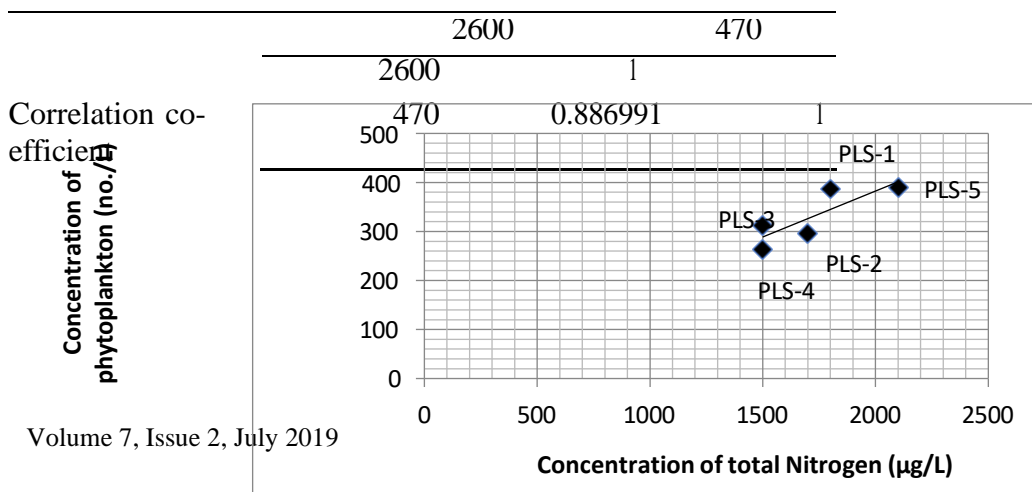
Fig-1: Different study stations of the Lake (pp-12)

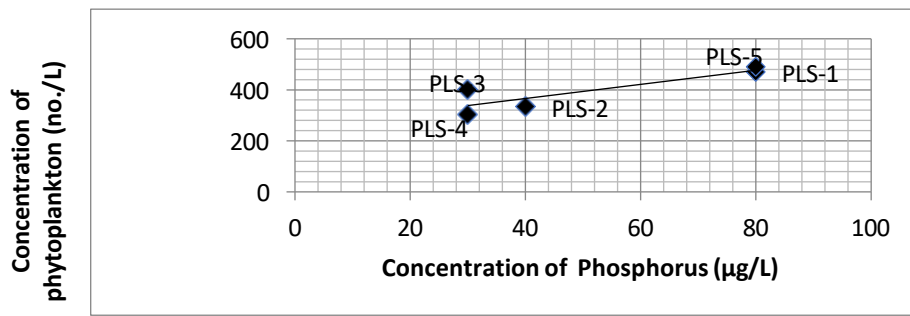
Fig-2: Total Nitrogen and concentration of Phytoplankton in different locations of the Lake during (1) PM (2) SWM and (3) NEM of 2005 (pp-10)

Fig-3: Total Inorganic Phosphorus and concentration of Phytoplankton in different locations of the Lake during (1) PM (2) SWM and (3) NEM of 2005 (pp-11)



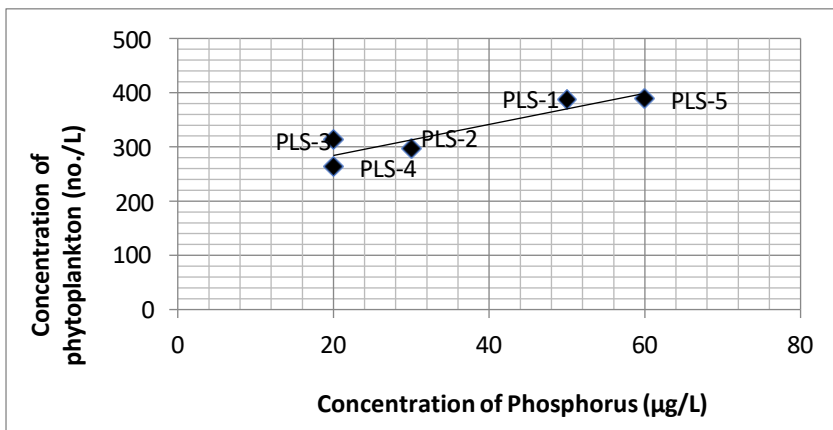
P-value critical= 1.4826E-06





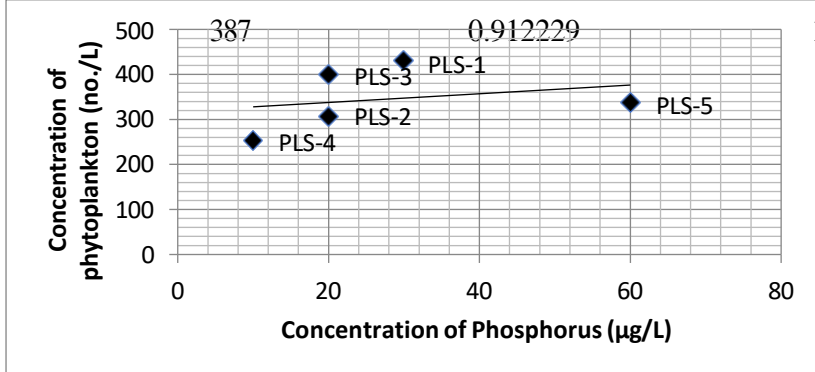
P-value critical= 9.04986E-06, correlation co-efficient

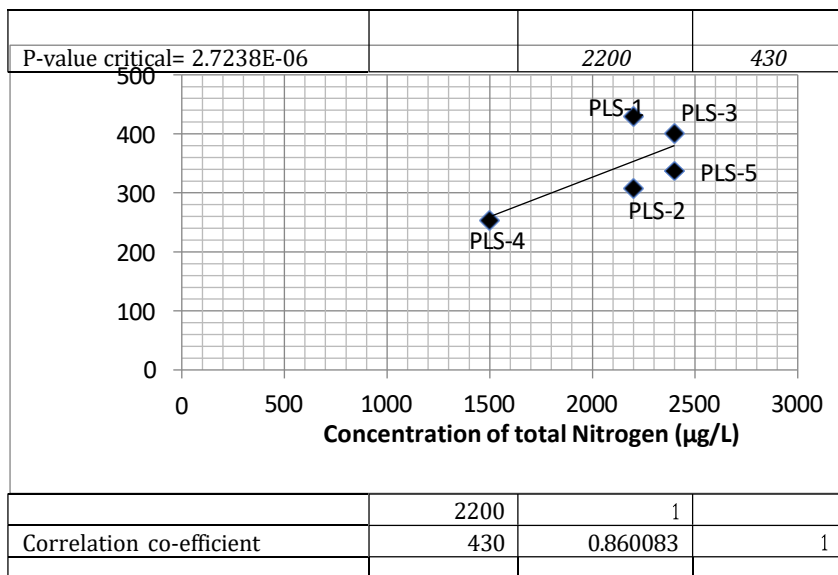
	80		470
80		1	
470		0.834187	1



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

	<i>fi0</i>		387
50		1	

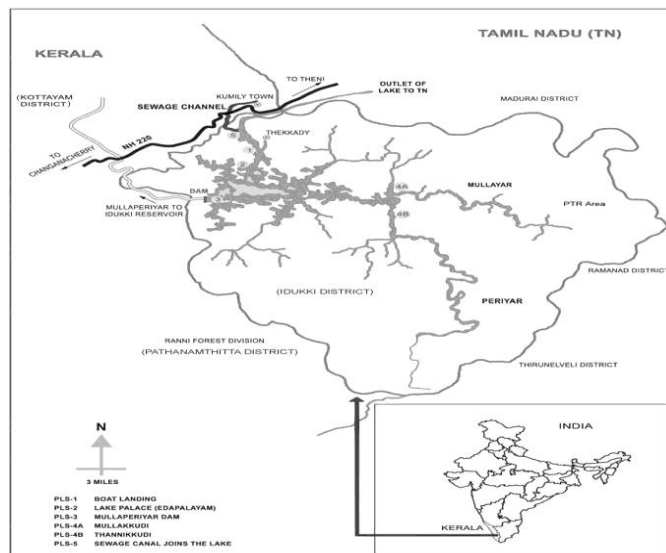




P-value critical=5.59543E-06, correlation co-efficient

	30	430
	30	1
430	0.299778	1

Figure-1: Different study stations in Periyar Lake



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