ALGAL PHOTOSYNTHETIC DYNAMICS IN URBAN LAKES UNDER STRESS CONDITIONS

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ABSTRACT

Urban lakes form vital ecosystems supporting livelihood with social, economic and aesthetic benefits that are essential for quality life. This depends on the biotic and abiotic components in an ecosystem. The structure of an ecosystem forms a decisive factor in sustaining its functional abilities which include nutrient cycling, oxygen production, etc. A community assemblage of primary producers (algae) plays a crucial role in maintaining the balance as they form the base of energy pyramid in the ecosystem. Algae assimilate carbon in the environment via photosynthetic activities and releases oxygen for the next level of biotic elements in an ecosystem. Besides these, algal cells rich in protein serve as food and feed, used as manure and for production of biofuels. Understanding algal photosynthetic dynamics helps in assessing the level of dissolved oxygen (DO), food (fish, etc.), waste assimilation, etc. Algal chlorophyll content, algal biomass, primary productivity and algal photosynthetic quotient are some of the parameters that helps in assessing the status of urban lakes. Chlorophyll content gives a measure of the growth, spread and quantity of algae. Unplanned rapid urbanization in Bangalore in recent times has resulted in either disappearance of lake ecosystems or deteriorated the lake water quality impairing the ecological processes. This paper computes algal growth, community structure, primary productivity and composition for three major lakes (T G Halli, Belandur and Varthur lakes) under contrast levels of anthropogenic influences.

Keywords: Algae, photosynthesis, lakes, community assemblage, relative abundance, physico-chemical

1. Introduction

Urban lakes play a pivotal role in maintenance of the homeostasis in the system. These water bodies modulate temperature, regulate local hydrological cycle, detoxify water, increases the primary productivity of the system through algal photosynthesis and help in improving environmental conditions for life. Water is an essential component for life on earth, which contains minerals extremely important in human nutrition. Small water bodies are abundant (Downing et al., 2006) and have disproportionately high hydrologic and nutrient processing rates (Smith et al., 2002). However, in recent times, dramatic increase in the population and unplanned urbanization had led to deterioration of water bodies through varying degrees of environmental stress due to encroachments, eutrophication (especially from domestic effluents), and siltation. Urbanization inculcates alteration in natural ecosystem's integrity, litho-morphological characteristics, surrounding air and water quality in that particular microclimate. In Bangalore, the impact of urbanization in the last three decades has resulted in either disappearance of lake ecosystem or deteriorated the lake water quality impairing the ecological processes. The main causes for the impaired conditions of the lakes are pollutants from fixed point sources (like nutrients from wastewater, municipal and domestic effluents, organic, inorganic, and storm water runoff, etc) and pollutants from non-point sources (such as nutrients through fertilizers from agricultural areas as run off, organic pollution from human settlements located along the periphery of the lakes and reservoirs (Reddy and Char, 2006)). Contamination of water bodies also happens through atmospheric pollution, effluent discharges, use of agricultural chemicals, eroded soils, and land use (Sillanpaa et al., 2004).Freshwaters receive most inorganic nutrients and other toxic substances generated by both the domestic and industry as waste and released into the environment.

Although aquatic ecosystems are operational with a variety of physicochemical and biological mechanisms to eliminate or reduce adverse effects of such compounds, toxicants may evoke changes in development, growth, reproduction, and behavior and may even cause death of freshwater organisms (Rand et al., 2003). The water bodies as lakes, tank and reservoirs proves to be an excellent candidates for evaluating the health of the ecosystem and proved to be a good material for the study of functional aspects of the ecosystem in terms of photosynthetic productivity under varying levels of anthropogenic stress. There has been a lot of work ascribing the diversity of plankton with relation to water quality, but the photosynthetic dynamic's of the urban lake systems is seldom mentioned. Objectives of this work are:

(i) to study the nutrient status with reference to physicochemical parameters
(ii) to analyse the community structure together with determination of the day net photosynthesis

in two urban lakes - Varthur and Bellandur in the Bangalore city and a reservoir at the outskirts of the city - T. G. Halli. The study addresses the difference in photosynthetic productivity in terms of measurable variables between the lakes at varied anthropogenic stress and compares organic and nutrient stress conditions in lakes during Jan-Aug 2010.

2. Materials and Methods

2.1 Study Area:

The study areas comprises three main water bodies - Bellandur Lake , Varthur Lake and TG Halli of Greater Bangalore as depicted in Figure 1.

Bellandur Lake is the largest lake in the Bangalore city situated in the southern part of Bangalore. The lake is 130 years old and spreads across an area of 365 ha [Figure 1 b)]. Sewage from residential areas near the old Bangalore international airport is directly allowed into the lake through the main drain. Dense weeds have occupied a major portion of the lake, thus affecting the photosynthesis process by obstructing penetration of sunlight. Objectionable froth has been developed at the overflow region (at the outflows).

Varthur Lake is the second largest fresh water body in Bangalore built by the Ganga Kings over a thousand years ago [Figure 1 c)] for domestic and agricultural uses. It is part of a series of connected and cascading water bodies. The Varthur lake catchment has seen large scale land use changes after 2000, consequent to the rapid urbanization process in the region. Now the lake receives inadequately treated sewage of about 595 million liters per day (MLD).

The lake had a varying extent of floating macrophytes during different seasons. The sampling locations are shown by yellow tags in the lakes. Table 1 shows the characteristics of the studied lakes.

TG Halli is situated at the peripheral region, approximately 25 km from Bangalore city on the way to Magadi [Figure1 a)]. Water from this reservoir is pumped to a water treatment plant located nearby, which is one of the main sources that provide drinking water to the residents of Bangalore city (35 MLD). The main source of water to the reservoir is the river Arkavati and domestic discharge from North part of Bangalore including Peenya, Dasarahalli and Jalahalli connections.

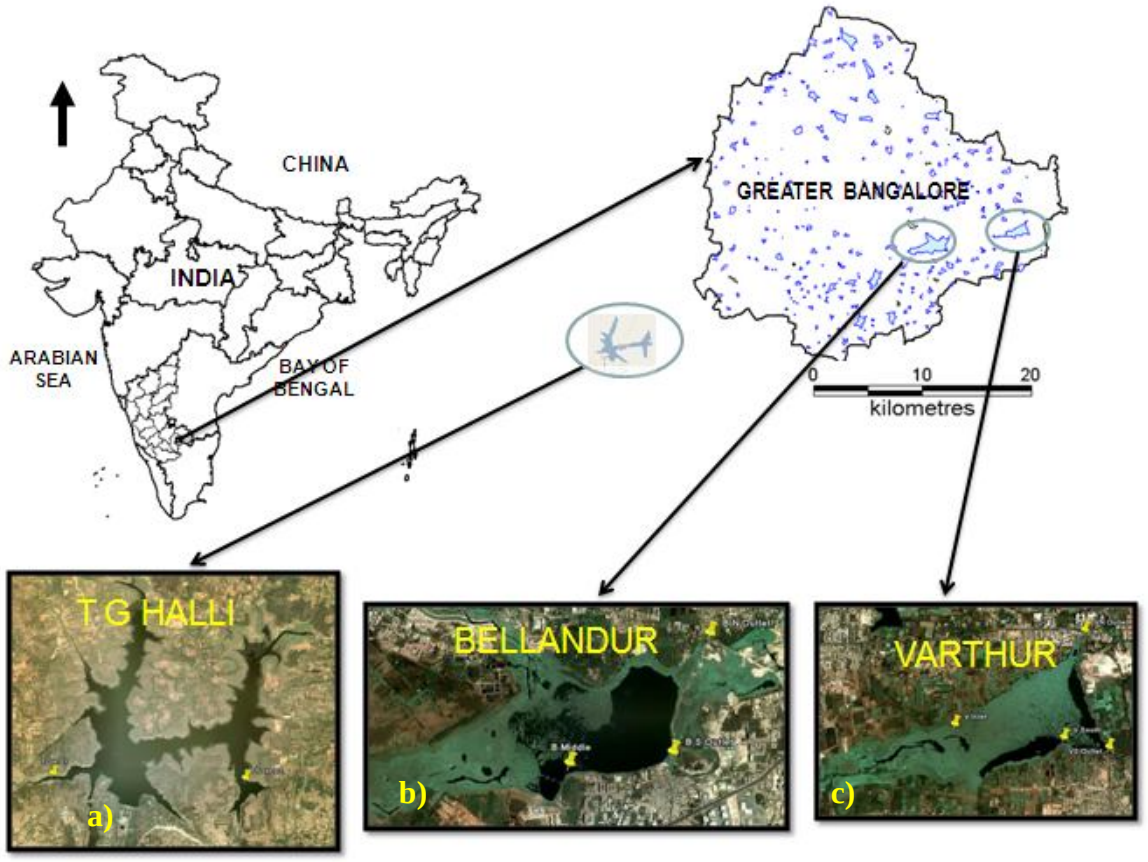

Figure 1: Study Area: Bangalore city, Greater Bangalore; 3 lakes of Bangalore.

Table 1: Characteristics of the Study area

Lakes	Varthur	Bellandur	T.G.Halli
Location	SE of Bangalore	SE of Bangalore	35 km West of Bangalore
Coordinates	12.956683° – 12.941499° N 77.745378° - 77.72805° E	12.943917° - 12.927959° N 77.638344° - 77.680167° E	12.995103° -12.963357° N 77.362962° -77.327291° E
Primary inflows	Bellandur	Sewage from Bangalore	Arkavathy river
Primary outflows	To river Pennar	Varthur lake	Dammed
Catchment area (sqkm)	1.8	148	1453
Max. length (km)	2	3.6	3.3
Max. width (km)	1.1	1.4	2.8
Surface area (sqkm)	2.2	3.6	4.2

Mean depth (m)	1.1	2.1	7.5
Surface elevation (m)	919	921	914.4
Water colour	Greenish (intense)	Greenish	Transparent
Odur	Yes	Yes	No
Macrophyte cover	*Eicchornia, Alternanathera Typha, Lemna*	*Eiccheornia, Alternanthera, Cyperus*	*Hydrilla*

2.2 Experimental Design

Samples were collected from the inlet and outlets considering the inflow and outflows of the lake. Parameters like pH, temperature, salinity, electric conductivity and total dissolved solids were analysed in-situ with the help of probes. Dissolved Oxygen, Free Carbon dioxides were recorded in situ following the Winklers iodometric method and titrimetry respectively. Further other physico-chemical analyses were carried out in lab following standard methods (APHA, 1998). Algal samples were collected with the help of Planktonic net in 100 ml polythene bottles and preserved in 70% alcohol. Algae attached to aquatic plants and stones were also collected in separate containers and preserved in 70 % alcohol. With the help of a pipette samples were mounted on the slide and observed under microscope. Images were captured using caliper pro software and DIP microscope. Algae were identified till genus level following Taylor et al., 2006 and 2007 and their community structure were observed. The relative abundance of algal communities was examined. Chlorophyll analysis was carried out by the spectrophotometric method. (APHA, 98). The day net photosynthetic productivity was calculated by measurement of dissolved oxygen in the stystem at frequent intervals (Os wald et al., 1957 and Odum and Hoskin et al., 1958).

3. Results and discussions

3.1 Physico-chemical analysis

3.1.1 Dissolved oxygen: Dissolved oxygen (DO) in the lakes ranged from 0-1.62 mg/l in Bellandur lake, 0.81-4.22 mg/l in Varthur lake and 8.13-10.97 mg/l in T.G.Halli (Table-1). The values indicate that Bellandur had anoxic conditions at the outlets due to the passage of water course underneath the floating bed of debris and macrophytes which had covered about 40 % of the surface of the lake towards the outlet areas. This anaerobic condition is due to deprivation of the air-water interface and also the decline of the algal growth under the plant cover. Varthur lake is undergoing hypoxic conditions with very low DO concentrations at the inflow region however the outlets have comparably higher DO values (4.22 mg/l). However in the case of T.G.Halli D.O.at saturated levels were observed at both the sites indicative of a lower organic load and thence lower oxygen demand in the system. There exists a positive relationship of DO with temperature. These results are in conformity with earlier studies (Srivastava et al., 2003; Masood and Krishnamurthy, 1990) which showed a positive relation between temperatures, duration of sunlight, and soluble gases like DO. The decrease in oxygen may be the result of the high load of organic substances in the inflow from the storm water drains. The deprivation of oxygen is an indicator of the present trophic status of the lakes, which is congested with inorganic and organic matter making the conditions incearsingly eutrophied. The primary production and input of degradable organic substances create's a tremendous demand for oxygen in case of Bellandur and Varthur lakes.

3.1.2 Biochemical oxygen demand: In the present investigation, the biological oxygen demand in varied from Bellandur 35.85-68.88 mg/l, Varthur lake, 99.95 - 40.78 mg/l and T.G.Halli, 12.69-15.02 mg/l. In Varthur higher BOD values were found near the inflow region, which substantially decreased towards the outlets, showing around 60% of BOD removal. However in case of Bellandur BOD levels were still lower compard to Varthur and showing better treatability of wastewater. The higher levels of BOD in the urban lakes can be attributed to sewage influx through stormwater drains, reduced circulation in water bodies. The biochemical oxygen demand levels indicate higher levels of biodegradable organic matter, high oxygen consumption by heterotrophic organisms, and a high rate of organic matter remineralization. The studies were similar to that of the shallow tropical waterbodies in Mexico (North) (Zavala et al., 2000), the lakes in urban areas increasingly serve as sinks for domestic sewage and other

municipal wastes. However in case of T.G.Halli the BOD values were very low compared to the urban lakes, which showed a lower organic load and therefore a lesser demand for oxygen.

3.1.3 Alkalinity: Total alkalinity values ranged from 260-1010 mg/l in Bellandur, 300-520 mg/l in Varthur Lake and from 340-360 mg/l in T.G.Halli. High alkalinity values are indicative of the eutrophic nature of the urban lakes like Bellandur and Varthur. High alkalinities in eutrophic waters were also recorded in earlier studies (Munawar, 1970; Singh, 2000). With an increase in DO there is an increase in the Alkalinity values. Essentially the bicarbonates buffering was the prime source of alkalinity in surface waters of Bangalore. Higher values of total alkalinity is due to the presence of excess of CO_2 produced as a result of decomposition processes coupled with mixing of sewage and other domestic effluents. Only T.G.Halli showed carbonate's (40 mg/l) compared to the urban lakes.

3.1.4 Phosphates (PO_4): Phosphate values ranged from 0.5-1.2 mg/l in Bellandur, 1.3-2.1 mg/l in Varthur Lake and 0.08-0.4 mg/l in T.G.Halli. Three urban lakes Bellandur and Varthur have higher concentrations of phosphates primarily due the inflow of sewage, sediment resuspension during high turbulence period and anaerobic conditions in the bottom of the lake and agricultural runoff from the immediate cultivated lands. These results are in conformity with earlier studies (Ravi Kumar et al., 2006). Phosphates are critical nutrients in the productivity of water in reservoir. The phosphate content in Bellandur and Varthur were well beyond the eutrophic levels. Phosphates enter the lakes through domestic wastewater, accounting for the condition of eutrophication. Phosphorus concentrations were increased by sewage input. In the present investigation, phosphate concentration is more when oxygen content is less (Table 1). However comparatively lower phosphate values were found in T.G.halli showing its healthy trophic status.

3.1.5 Nitrates: Nitrogen entering aquatic systems arises from a variety of sources that include point and non-point sources of pollution, biological fixation of gaseous nitrogen, and the deposition of nitrogen oxides and ammonium (Stoddard, 1994). Nitrate nitrogen in water in Indian reservoirs is mostly in traces and seldom exceeds 0.5 mg/L. Water with 0.2–0.5 mg/L of nitrates is of high productive reservoirs, up to 0.2 mg/L nitrates of medium productive reservoirs, and in low productive reservoirs, the nitrates are negligible (Jhingran and Sugunan 1990).The Nitrate concentration ranged from 0.02-0.03 mg/l in Bellandur, 0.03 – 0.05 mg/l in Varthur and 0.02 – 0.3 mg/l in T.G.Halli. Maximum values were recorded in T.G. Halli due to more oxidizing condition and lower organic load. The main Nitrogen sources in urban lakes are the domestic sewage, agricultural runoff and decomposition of autochthonous vegetative matter. However reactive Nitrogen forms were mostly found in the form of ammonia in the lakes pertaining to anaerobic conditions and scant oxidation. The lakes covered by the aquatic weeds are deficient of nitrates, due to persistence of anaerobic conditions (Durga Madhab et al, 2010). Moderately low nitrate values were reported in earlier studies (Chanakya et al, 2006). A positive relation was found between Nitrates and phosphates indicative of trophic status.

3.1.6 Chlorophyll-a

The chlorophyll content was more or less similar to the pattern of phytoplankton distribution and abundance. (Table 1). Maximum value of Chlorophyll-a was found in T.G.Halli (18.35 µg/l) owing to greater light penetration and higher growth of benthic microalgae and the lowest were found near the inflow region of Varthur lake (which in connected to the storm water drains that brings in 595 MLD of wastewater. However the surficial water samples had a very less micro-algal content. Table 2 gives the results for various physico-chemical parameters at selected sites in the sampled lakes.

3.2 Phytoplankton Standing Crop

3.2.1 Community composition: The total number of identified and recorded benthic phytoplankton species at all the investigated sites in the lakes during the period of study were found to be 24, belonging to 7 genera and 3 classes namely; Bacillariophyceae, Cyanophyceae and Chlorophyceae. Bellandur lake was dominated by *Chlorella* sp. populations (80%), filamentous algae (3%) comprising of *Oscillatoria* sp. and *Lyngbya* sp. were present at the outlet reaches showing N deprivation and rest comprised of the diatoms. In Varthur lake the algal community was dominated by *Chlorella* sp. member of Chlorophyceae which comprised of *C. vulgaris*, *C. pyrenoidosa* and *C. minutissima*., followed by members of Bacillariophyceae (18%) as *Nitszchia palea* and *Gomphonema parvulum. Microcystis auregonosa* a member of Cyanophyceae were found in minor proportions (1%). In earlier studies 25 algal genera were observed at Varthur lake. In T.G.halli the community composition was rather very contrasting

comprising of dominant diatom species (80 %) as *Gomphonema* sp. > *Nitszchia* sp. > *Navicula* sp. > *Acnanthes* sp.> *Cymbella* sp. 21 algal genera were observed at T.G.Halli in earlier studies the dominant being the diatoms. The chlorophycean members comprised of *Chlorella* sp. (13%) followed by *Scenedesmus* sp. Member of Cyanophyceae (7%). The dominance of diatom sp. in T.G.Halli is indicative of a good water quality, under low stress conditions. However the spur of Chlorophyceae and Cyanophyceae members is an indicator of Organic pollution and nutrient accumulation in the urban lakes as in Bellandur and Varthur. The productivity of the lakes are directly linked with the type and the abundance of the algal community. The turbidity values suggest very high algal abundance in Varthur and Bellandur lakes which is attributed to algal bloom which coincides with the high inorganic nutrient values and high BOD values in these lakes. The maximum concentration of micro-benthic algae was > 1.5 X 10^4 cells/ml. The lowest being few hundred cells /ml in case of T.G.Halli. Table 2 illustrates the relative abundance of the microlagal population at the various sampling locations. It was observed that the maximum number of counted species belonged to class Chlorophyceae in urban lakes. For example, presence of Chlorella is an indication nutrient rich eutrophic waters that can also act potential organism for nutrient bioremediation. Bacillariophyceae in case of T.G.Halli represent the most productive group at all sites during the period of study. In addition, the distribution and frequency of algal species along all sites showed that Bacillariophyceae together with some species of Chlorophyceae were always dominant especially at depending upon the nutrient load and trophic status of the lake. The algal compositions in sampled lakes are depicted in Figure 3.

Table 2: Physico-chemical parameters of the sampled locations of the Lake

Parameters	Varthur Lake				Bellandur Lake			T.G. Halli	
	Inflow	South Outlet	North Outlet	South	North Outlet	South Outlet	Middle	Near Outflow	Near Inflow
	1	2	3	4	5	6	7	8	9
pH	8.54	8.06	9.03	8.13	9.02	9.42	7.91	7.81	8.12
Temperature (^{0}C)	24.40	26.30	25.60	282.00	25.40	23.00	24.80	23.70	24.00
Electrical Conductivity (μScm^{-1})	1098	1057	1068	1038	980	1009	981	309	255
Total Dissolved Solids (mg/l)	868.00	840.00	849.00	826.00	770.00	808.00	781.00	214.00	190
Salinity (mg/L^{-1})	538.00	522.00	527.00	514.00	483.00	507.00	487.00	215.00	152
Turbidity (NTU)	216.00	96.50	90.60	76.00	127.00	108.00	102.00	9.05	25
Dissolved Oxygen (mg/l)	0.81	0.81	4.22	4.06	0.00	0.00	1.62	8.13	10.97
Free CO_2 (mg/l)	176.00	17.60	17.60	17.60	120.56	14.08	9.68	352.00	0.00
Chemical Oxygen Demand (mg/l)	293.33	229.33	325.33	282.66	192.00	224.00	282.66	48.00	44
Biochemical Oxygen Demand (mg/l)	49.95	40.78	41.68	57.72	46.28	35.85	68.88	15.02	12.69
Nitrates (mg/l)	0.05	0.04	0.04	0.03	0.03	0.02	0.03	0.02	0.03
Phosphates (mg/l)	2.10	1.80	1.70	1.30	0.50	0.90	1.20	0.80	0.40
Carbonates (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00	40.00
Bicarbonates (mg/l)	520.00	300.00	420.00	360.00	260.00	300.00	1010.00	320.00	300.00
Alaklinity (mg/l)	520.00	300.00	420.00	360.00	260.00	300.00	1010.00	40.00	40.00
Ca Hardness (mg/l)	204.16	344.27	176.14	392.31	232.18	168.13	196.15	79.97	55.97
Mg Hardness (mg/l)	30.25	102.40	106.38	61.48	71.24	67.34	68.32	19.51	13.66

Total Hardness (mg/l)	124.00	420.00	436.00	252.00	292.00	276.00	280.00	116.00	96.00
Chlorides (mg/l)	136.32	88.04	144.84	130.64	119.28	127.80	150.52	42.60	45.44
Sodium (mg/l)	19	23.2	19.4	18.3	20.9	13.9	16.5	64.8	53.4
Potassium (mg/l)	3.6	4.3	3.5	3.2	4.1	2.8	3.5	5.9	5.7
Chlorophyll-a (µg/l)	3.73	8.32	6.25	13.55	10.29	16.03	15.70	18.35	16.20

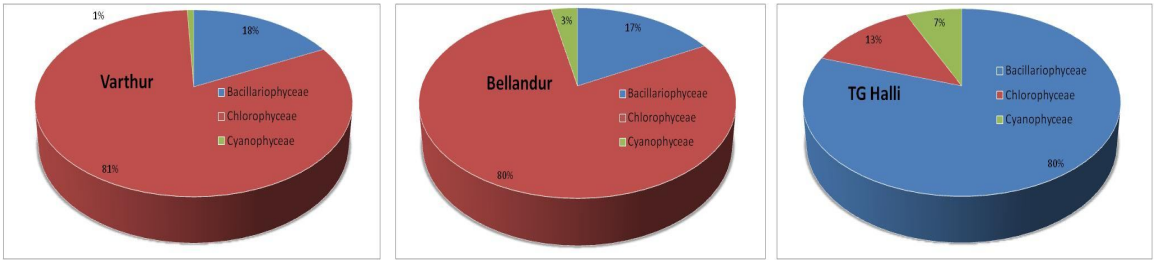

Figure 3: Algal composition in sampled lakes.

3.2.2 Distribution and relation with water quality: Study of phytoplankton population at the selected sites in all three lakes revealed that the communities were affected by the physico-chemical conditions of water, seasonal fluctuations, in addition to the different sources of pollution. In varthur, the total phytoplanktons were dominated by bacillariophyceae and were recorded in high counts due to the flourish of pollution tolerant diatom taxa namely *Nitszchia palea* and *Gomphonema parvulum*, representing the most dominant among diatoms population at this site due to the heavy load of organic pollution and nutrient salts discharged from drain to the strom water drains. This observation coincided with Abdalla et al.(1991) who reported that this species developed in Lake Mariut with the increase of the organic load. The dominance of diatoms in T.G. Halli especially indicates proper silica mineralization and pollution free conditions which is evident from the water quality paramates. Hence the presence of a high percentage and number of Bacillariophyceae represented the first productive group as mentioned before. Furthermore, the shallow lake water leads to a rapid change in the productivity with the change in physico-chemical conditions of water. These effluents enhance the biological activities of bacteria, especially in summer months due to the decomposition of organic matter, in agreement with earlier studies (El-Sherif and Aboul Ezz 1988) where the lowest standing crop area were reported due to the high density of zooplankton in addition to the low counts of phytoplankton in some sites resulting from the grazing effect of zooplankton on phytoplankton. The relative abundance of the studied algae is as listed in Table 3.

Table 3: Percentage Relative abundance of microalgae present in all sampling sites.

Algal genera	Varthur Inflow	Varthur South Outlet	Varthur North Outlet	Varthur South	Bellandur North Outlet	Bellandur South Outlet	Belandur Middle	T.G. Halli Outflow	T.G. Halli Inflow
Chlorella sp.	90.55	68.81	94.83	72.12	82.57	71.43	88.98	9.02	19.74
Nitzschia sp.	4.72	3.67	5.17	8.65	0.92	0.00	3.39	31.58	38.16
Microcystis sp.	3.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gomphonema sp.	1.57	27.52	0.00	19.23	3.67	14.29	7.63	32.33	39.47
Filamentous algae	0.00	0.00	0.00	0.00	12.84	14.29	0.00	0.00	0.00
Navicula sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.80	0.00

Achnanthes sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.51	0.00
Cymbella sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.26	2.63
Scenedesmus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00

3.3 Measurement of Day-Net Photosynthetic Productivity: The amount of oxygen released during the daylight hours minus simultaneous community respiration may be called day-net photosynthesis. Os wald et al., (1957) used the day-net photo synthesis to estimate the photosynthetic production of sewage oxidation ponds. To determine day-net photo synthesis in g-O_2/day/cu.m the minimum DO concentration were subtracted from the maximum DO concentration. The day net photosynthesis was multiplied by the depth of the euphotic zone in. meters to obtain day-net productivity in g O_2/day/sq.m (Table 4).

Table 4: Day Net Photosynthetic Productivity in the studied lakes.

Sampling sites	Turbidity (NTU)	Transparency (Euphotic Zone)	O_2 Conc. mg/l		Day Net Photosynthesis O_2/d m^3	Day Net Productivity O_2/d m^2
			Max	Min		
Varthur						
Inflow	216	0.12	0.81	0	0.81	0.09
N Oulet	96.5	0.25	0.81	0	0.81	0.20
S Outlet	90.6	0.28	4.22	0	4.22	1.18
South	76	0.18	4.06	0	4.06	0.73
Bellandur						
N Outlet	127	0.23	0	0	0	0
S Outlet	108	0.28	0	0	0	0
Middle	102	0.22	1.62	0	1.62	0.36
T.G.Halli						
Inflow	9.05	5	8.13	5	3.13	15.65
Outflow	25	3.4	10.97	5	5.97	20.29

The Day net productivity values indicates higher productivity in T.G. Halli and lower productivities in urban lakes as Bellandur and Varthur which can be attributed to decreased transparency and hence lesser sunlight penetration due to microalgal bloom.

4. Summary and Conclusion

Urban lakes of Bangalore has been subjected during the last century to a drastic rate of sewage pollution due to the high loads of discharges leading to a prominent changes in physico-chemical conditions and phytoplankton community. The study of physico-chemical parameters and their impacts on the standing crop of phytoplankton and primary production indicated that the maximum number of phytoplankton species counted, belonged to class Chlorophyceae (Chlorella blooms) in case of Urban lakes, which is an indicator of eutrophication. The stations nearby the inflow regions at Varthur receiving sewage from drains recorded the lowest content of chlorophyll-a. On the other hand, in T.G.Halli, the Bacillariopyceae taxa dominated owing to a healthy trophic status. Chlorophyll-a content is more or less similar to the pattern of phytoplankton counts. However the T.G.Halli reservoir had the highest Chlorophyll-a levels attributed by benthic chloroplast levels showing higher light penetration and photosynthetic productivity. The Day net photosynthesis was found to be higher in case of T.G.Halli compared to the urban nutrient stressed lakes varrying from site to site depending on the characteristics of water and its microclimate.

Transparency exhibited significant positive relation with the total count of phytoplankton. Chlorophyll-a, phosphates, nitrates and dissolved oxygen showed a negative relationship with the day net photosynthetic productivity. The relation of total alkalinity with the total count of phytoplankton and chlorophyll-a, was positive. From this study, we conclude that Bellandur and Varthur are undergoing a high nutrient stress resulting in anaerobic conditions with the lakes becoming increasingly eutrophied while T.G.Halli is considered as a pristine water body with a healthy trophies status which is least stressed.

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