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Assessment of physico-chemical characteristics and phytoplankton community in selected aquaculture ponds in Karnataka

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Abstract
The site characteristics include present land use, vegetation and land topography of the fish ponds were investigated based on visual field observation. Physico-chemical and biological characteristics of water from selected aquaculture ponds were assessed. The results showed variation in different water quality parameters. The water temperature ranged from 24.30 to 32.10 ºC, pH from 5.60 to 9.35, Transparency from 7.1 to 30.40 cm, Dissolved oxygen from 3.1 to 11.34 mg/l, Alkalinity from 24 to 166 mg/l, Carbon dioxide from 1.11 to 13.74mg/l, Ammonia-nitrogen from 0.29 to 18.65 µg at./l and Phosphate-phosphorus from 0.21 to 5.34 µg at. /l. All the parameters were found within the optimum range recommended for fish culture.
A total of 3 genera of phytoplankton (Cyanophyta, Chlorophyta, and Bacillarophyta) were found dominant groups. The quantitative and qualitative analyses of phytoplankton showed that plankton content was moderate. Chlorophyta and Cyanophyta dominated the phytoplankton biomass. *Microcystis spp*. was the dominant among the blue green algae whereas, green algae was mainly consisted of *Pediastrum*, *Ulothrix* and *Cyclotella*. The maximum *Ulothrix* number was recorded in all the selected ponds while *Pediastrum* contributed to the bulk of green algae in all ponds during the study period.

Keywords: Aquaculture ponds, physico-chemical characteristics, phytoplankton, species diversity

Introduction
Aquaculture is considered as one of the most important sources of animal protein production to catch the need for increased population worldwide. The conservation of a healthy aquatic ecosystem depends on physico-chemical and biological diversity of the ecosystem [1]. Physico-chemical parameters affect plankton distribution, occurrence and species diversity [2]. The water quality in ponds, rivers and streams may vary depending on the geological and morphological due to human activities such as agriculture, industrialization and urbanization.
Water quality assessment generally involves analysis of various parameters and reflects on abiotic and biotic status of an ecosystem [3]. Nutrients like, phosphorous and nitrogen from domestic wastes and fertilizers accelerate the process of eutrophication. The water in soil, animal waste and decaying plant matter in the pond are broken down and used to fuel the pond ecosystem [4].
'Plankton' normally comprises those living organisms that are only accidentally and temporarily present, imported from adjacent habitats but which neither grew in this habitat nor are suitably adapted to survive in the truly open water, apparently independent of shore and bottom [5]. Phytoplankton is an integral component of freshwater wetlands which significantly contribute towards succession and dynamics of zooplankton and fish. Community structure, dominance and seasonality of phytoplankton in tropical wetlands are highly variable and are functions of nutrient status, water level, morphometry of the underlying substrate and other regional factors [6]. Phytoplankton and zooplankton are important natural food for many fish species as well as other aquatic animals. Studies on physicochemical factors and phytoplankton standing crop of its habitat are essential for proper management of water resources and for prediction of potential changes in aquatic ecosystem.
Little or no work was done on water quality phytoplankton and primary productivity of aquaculture ponds.

Therefore, the present work has been undertaken to assess water quality and phytoplankton production in aquaculture ponds and also unconcealed the truth how lentic water bodies play an important role in carbon sequestration processes and also to understand the nutritive quality of pond water in judging its productivity status in aquaculture ponds.

The present study aims at making an assessment of the water quality with reference to physico-chemical characteristics and productivity status of the fish ponds that situated in coastal, Malnad and western Ghat section of Karnataka.

Material and Methods

The present study was undertaken in four aquaculture ponds of different agro-climatic regions. Pond-1 (P1) was an instructional fish pond with a battery of cement and earthen bottom condition located in College of Fisheries, Mangaluru in Dakshina Kannada dist. Pond-2 (P2) was a farmer pond located in Agri-horticulture farm at Kairangala, Bantwal taluk, Dakshina Kannada dist. Pond-3 (P3) was an Government pond located at Western Ghats range obstructed by the dam near Lakkolli near Bhadra reservoir in Shivamogga dist. Pond-4 (P4) was a private owner's pond situated in agriculture field at Bilaki cross in Bhadravathi taluk, Shivamogga dist.

A survey was carried out to identify the location of aquaculture ponds in the regions of Dakshina Kannada district and Shivamogga districts, Karnataka. The site characteristics such as present land use, vegetation and land topography of the aquaculture ponds was investigated based on visual field observation. Water samples from fish ponds were collected from four sampling ponds. These ponds were used to rear fish seeds as well as grow-out farming of fishes.

Physico-chemical and biological characteristics of water in selected aquaculture ponds were assessed. Physical characteristics such as temperature, transparency, depth and chemical characteristics *viz.* dissolved oxygen, carbon dioxide, alkalinity, pH, ammonia, nitrite, nitrate, phosphate and silicate were determined following the standard methods [7].

Collection of water samples for measuring the dissolved oxygen (DO) was under taken between 6 and 8 am from the surface of the pond water. Phytoplankton samples were collected using plankton net (60µm mesh size) by filtering 100 litres of water, preserved in 4% formaldehyde until further analysis. Qualitative analysis of plankton was carried out in the laboratory using standard procedure. This was carried out by drawing 1 ml of sample from each aliquots re-suspended sample. The phytoplankton identified, counted and recorded employing Sedgwick rafter plankton counting cell using compound microscope (Magnus MLX Microscope). Plankton cells were identified up to generic level and counted plankton was expressed in terms of number of cells/m^3.

Pond P1: Instructional pond College of Fisheries

Pond P2: Farmer Pond at Kairangala, Mangaluru taluk

Pond P3: Pond in BR Project, Shivamogga Department of Fisheries

Pond P4: Private owner's Pond at Bilaki cross, Bhadravathi taluk

Results and Discussion
Physico-Chemical Characteristics
During present study, as per Fig.1 air temperature recorded was varied from 26.30 and 33.30 ºC. Due to the shallowness of the ponds and influx of the channel water, the temperature varies diurnally and seasonally. Water temperature varied between 24.30 and 32.10 ºC the minimum and maximum temperatures were recorded during December and March in pond P3 pond P4 respectively Fig.2. Many workers observed similar trends while working on different water bodies [8]. Transparency is a physical variable significant to primary production. As per Fig. 3, transparency of different farm ponds during the study period varied from 7.1 cm in pond P1 to 30.40 cm in pond P4. Transparency increases with increase in temperature [9].
From Fig. 4, pH varied between 5.60 and 9.35. The low values recorded during monsoon season could be due to the dilution of rain water as pH is one of the ecological factors and thus interaction of various substances in solutions. The dissolved oxygen values varied from a minimum of 3.1 to a maximum of 11.34 mg/l according to Figure. 5. The highest value was observed in monsoon and low values in summer this could be due to high rate of decomposition of organic matter and limited flow of water, leading to consumption of oxygen from water [10]. Among four aquaculture ponds, pond P2 recorded comparatively low oxygen values since this water body is situated amidst coconut and arecanut trees and is shaded most of the day. Similar result was opined in inland water body in South-Eastern Nigeria [11].
Pond P3 showed the highest value of carbon-dioxide (13.74 mg/l) in summer could be due to decomposition of organic matter and the respiration of aquatic fauna and flora, while pond P4 and P1 showed the lowest value (1.11 mg/l) was probably due to decrease in photosynthetic activity of aquatic flora as per Fig. 6. Similar result was compared with Tripati reservoir near Satara, Maharashtra [12]. Only bicarbonate alkalinity was recorded and there was total absence of hydroxides and carbonates. During the present study as per Fig. 7, it was ranged from 24 to 166 mg of $CaCo_3$/l. The pond water remained alkaline throughout the experimental duration in all the ponds. Presence of carbonates and bicarbonates make the pond water slightly alkaline which proves to be suitable for aquatic organism [13].
During the present investigation as per Fig. 8, maximum NH_3-N (4.98 µg at. /l) was observed during April in pond P2 while minimum (0.29 µg at. /l) was noticed in October at pond P1.In ponds P3 and P4 concentration of Ammonia-N ranged from 0.54 to 18.65. µg at./l. Maximum NH_3-N (18.65 µg at. /l.) was observed in February in pond P4 while minimum (0.54 µg at./l) was recorded during September in pond P4. Similar trend was observed in shallow tropical lake in north eastern, Thailand [14]. During the study period nitrite content was varied from 0.07 to 4.45 µg at./l as per Fig. 9. During early part of investigations (June to early October), pond P2 and pond P1 recorded very low nitrite values. Only at one instance, a high value of 4.45 µg-at./1 was recorded (early October and November). Nitrate-nitrogen concentration was ranged from 0.21 to 24.04 µg at. /l which falls within favourable range for fish survival and growth. In May, lesser nitrates reported are due to algal assimilation and other biochemical mechanisms. The higher nitrate values are due to surface runoff and domestic sewage in the month of September. Higher concentration was noted during the pre-monsoon period in pond P2 and thought to be owing to the release of nitrate due to decomposition of organic matter. Similar results were reported in Danteswar pond, Vadodara, Gujarath [15]. The results of present study with respect to phosphate concentration, August month recorded highest of 5.34 µg at./l in pond P4 while lowest was in December (0.06 µg at./l) in pond P1. It is evident from the data that, seasonally phosphate concentration in the pond was more in summer followed by rainy season and further decline in winter season. A range of 0.05-0.07 ppm phosphate is optimum and productive, 1.0 ppm is ideal for plankton production whereas>3 ppm causes eutrophication [16]. From the present study, it was revealed that the pond P4 found highly fertile in terms of presence phosphate level indicating abundant plankton population during grow-out culture period.
The concentration of Silicate-silicon varied from 6.32 in pond P1 to 138.56 µg at./l in pond P3. During present study, as per Fig. 12 summer and monsoon exhibited higher values when compared to rest of the period. The obvious increase in reactive Silicate-silicon during hot period, especially summer, might be due to the increase in the dissolution of diatoms frustules at high temperatures [17].

Plankton Diversity
The species of phytoplankton belonging to three classes such as Chlorophyta, Cyanophyta and Bacillarophyta were enumerated numerically. Throughout the study period, 28 species belong to 3 genera were observed. Altogether, 30 genera of phytoplankton from Kamala Nehru Tank, Muzaffarnagar, India [18] were recorded whereas, 7 species of phytoplankton and algae in different water bodies were reported in Mymensingh. About 38 genera of phytoplankton were recorded during a three month study period in earthen fish ponds within the Mymensingh region, Bangladesh [19]. Chlorophyceae was the most significant group of phytoplankton represented by *Botryococcus, Chlorella, Cosmarium, Closterium, Cyclotella, Dictyosphaerium, Microspore, Pediastrum, Mougeotia, Spirogyra, Ulothrix, and Zygnema*. Dominance of Chlorophyceae in the ponds during dry season had been attributed to the presence of sunshine and extensive catchment area draining phosphate rich agriculture land [20]. Cyanophyceae group was mostly represented by *Aphanocapsa, Anebaena, Coelospharium, Microcystis, Oscillatoria, Phormidium sp.* and *Spirulina sp*. It was also reported in ponds in Asia, where phytoplankton scarcity could be observed during the wet months and most of the ponds in India where three plankton pulses occurred within the dry

season [21]. During the wet months, flushing disturbed the standing crop of plankton. However, when the destabilising effect reduces, the accumulated nutrient input favours an increased plankton production during the dry period. Bacillariophyceae comprised *Biddulphiasp, Cymbellasp, Coscinodiscus, Fragillaria, Gyrosigmasp, Nitzschiasp, Pinnulariasp, Turitellasp* and *Tabellaria sp*. Highest was recorded in Pond P4 while lowest was in pond P1 during the study period. Maximum abundance and diversity of Bacillariophycean genera was recorded in the months of December and February when silicate value was highest. This has been supported earlier results Kandy Lake in Sri Lanka [22].

In the current study, Chlorophyceae dominated the phytoplankton groups followed by Cyanophyceae and Bacillariophyceae in the all four ponds. This is been attributed to favourable water quality particularly high levels of total alkalinity recorded during the study. Chlorophyceae species in these fishponds in general was more dominant group in terms of species number which is attributed to optimum temperature and nutrients contents. Similar findings of high phytoplankton density recorded in river Padma Bangladesh [23]. The effects of fertilizer application and frequent water exchange to avoid development of anoxic pockets within the pond are also to account for these high levels of plankton productivity observed in the pond. The total abundance of phytoplankton is presented in Table 1. The percentage contribution of different phytoplankton group during study period at different ponds is depicted in Fig. 13, 14, 15 and 16.

Table 1: Total abundance of phytoplankton during the study period.

Cyanophyta	Chlorophyta	Bacillarophyta
Anebaena	*Botryococcus*	*Biddulphia spp.*
Aphanocapsa	*Chlorella sp.*	*Cymbellasp.*
Coelosphatium	*Cosmarium*	*Coscinodiscus*
Microcystis	*Closterium spp.*	*Fragillaria*
Oscillatoria	*Cyclotella spp.*	*Gyrosigma spp.*
Spirulina spp.	*Dictyosphaerium*	*Nitzschia spp.*
Phormidiumsp.	*Microspore*	*Pinnularia spp.*
	Pediastrum	*Turitella spp.*
	Mougeotia	*Tabellaria spp.*
	Spirogyra spp.	
	Ulothrix spp.	
	Zygnemasp.	

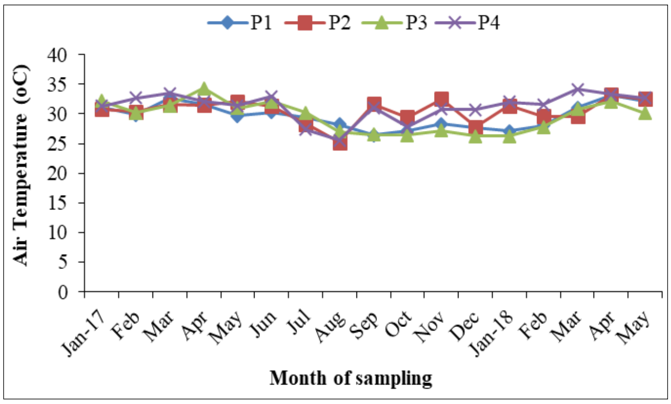


Fig 1: Variation of Air-Temperature (°C) at different farm ponds

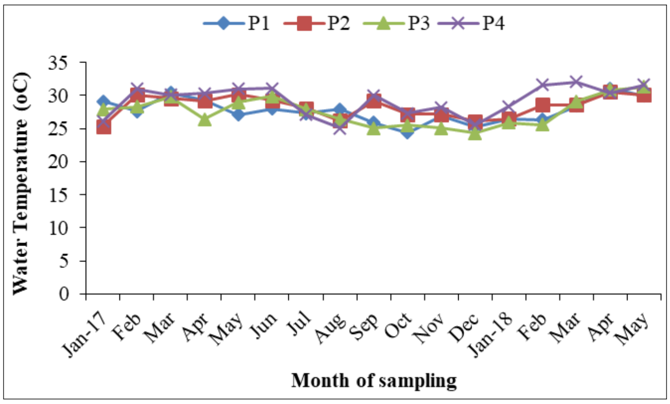


Fig 2: Variation of Water-Temperature (°C) at different farm ponds

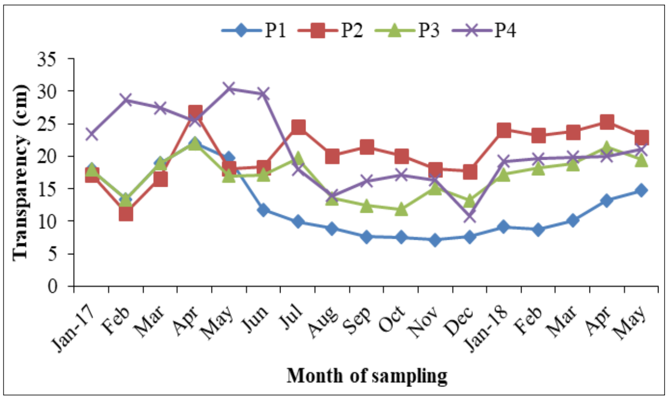


Fig 3: Variation of Transparency (cm) at different farm ponds

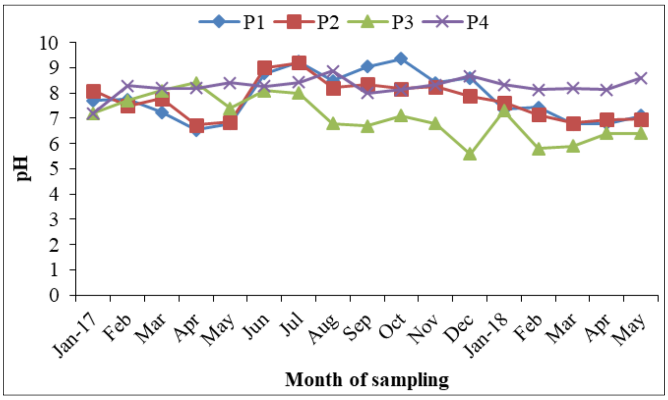
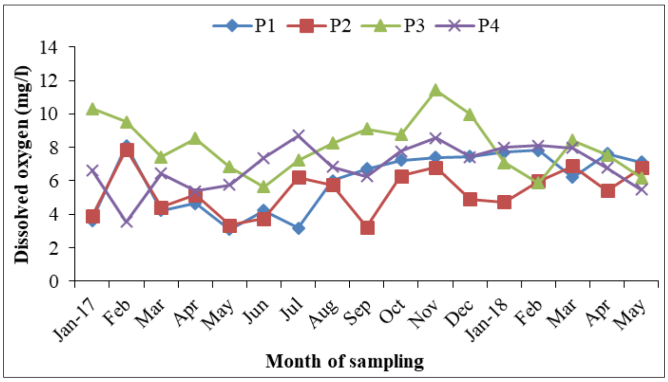


Fig 4: Variation of water pH at different farm ponds



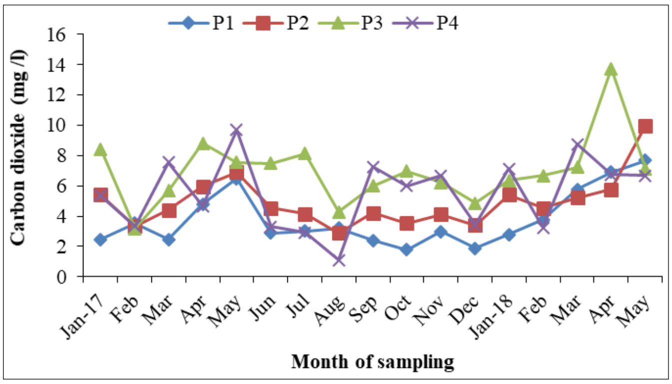
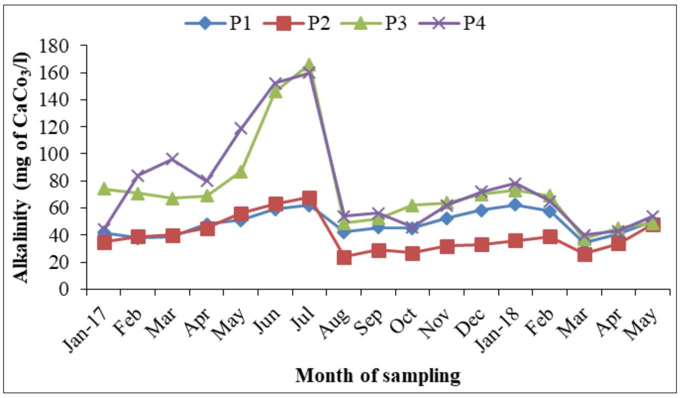


Fig 5: Variation of Dissolved oxygen (mg/l) at different farm ponds

Fig 6: Variation of Carbon dioxide (mg/l) at different farm ponds



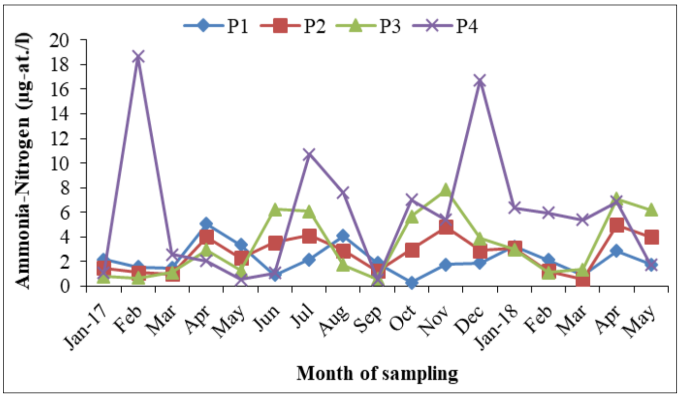
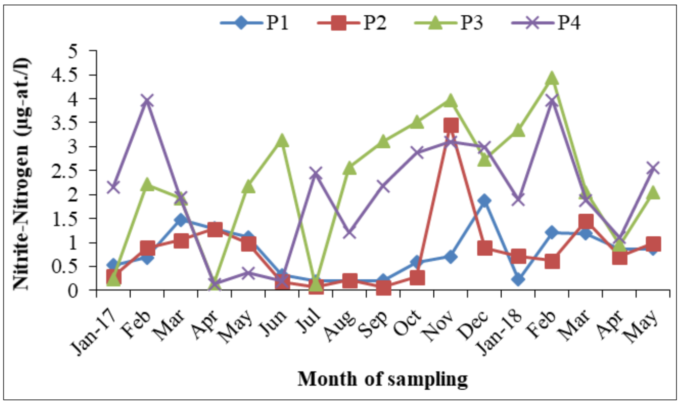


Fig 7: Variation of Alkalinity (mg/l) at different farm ponds

Fig 8: Variation of Ammonium-Nitrogen ((µg-at./l) at different farm ponds



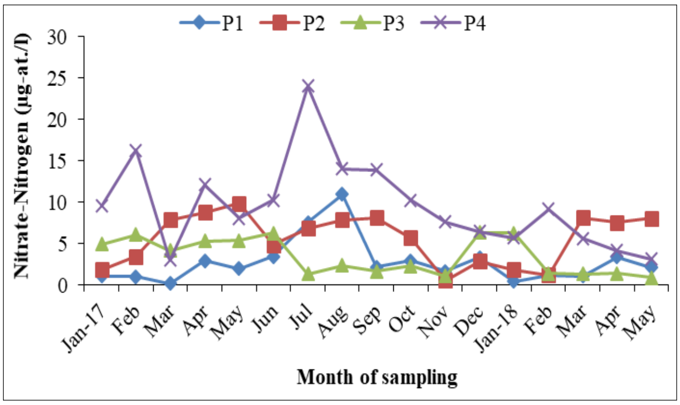
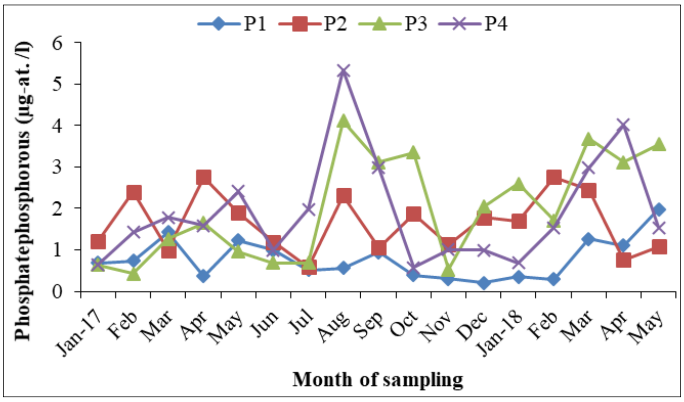


Fig 9: Variation of Nitrite-Nitrogen (µg-at./l) at different farm ponds

Fig 10: Variation of Nitrate-Nitrogen (µg-at./l) at different farm pond



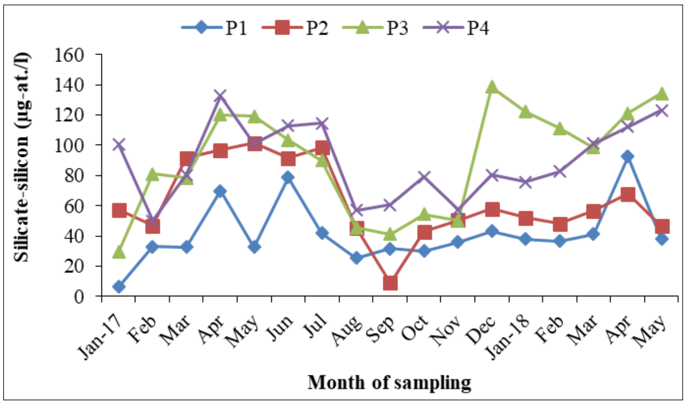


Fig 11: Variation of Phosphate-Phosphorous (µg-at./l) at different farm ponds

Fig 12: Variation of Silicate-Silicon (µg-at./l) at different farm ponds

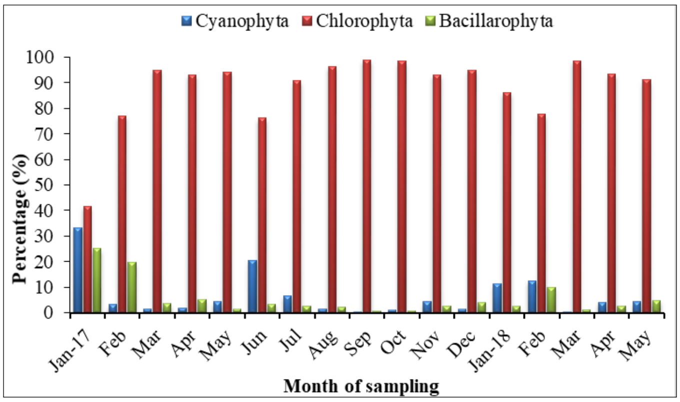


Fig 13: Percentage contribution of Phytoplankton group at pond P1

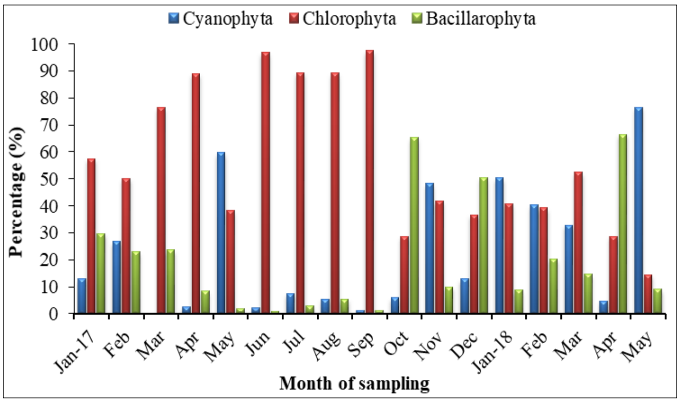


Fig 14: Percentage contribution of Phytoplankton group at pond P2

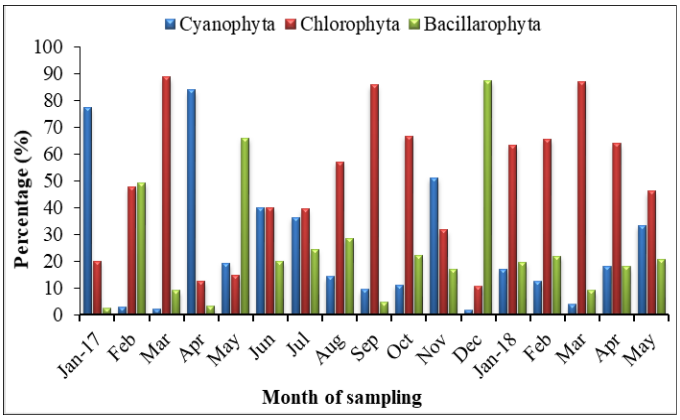


Fig 15: Percentage contribution of Phytoplankton group at pond P3

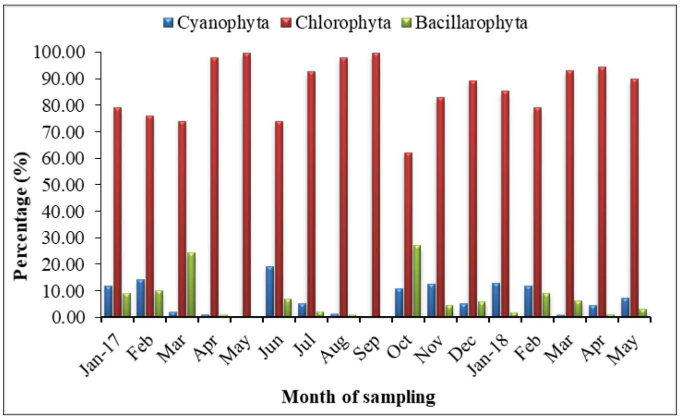


Fig 16: Percentage contribution of Phytoplankton group at pond P4

Phytoplankton indices

In the present investigation, species richness varied from 5 to 18. The maximum species richness was found in the month of May in pond P2. Similar observed results of species richness while studying in lakes of Mysore district, Karnataka recorded [24].

Species evenness varied from 0.108 to 0.980. The minimum species evenness observed in the month of June in pond P2 while the maximum species evenness was observed in the month of August in pond P3. The greater evenness was found in monsoon months which could be due to composition and structure of plankton communities revealed changes in water quality, which could be due to favourable condition prevailed by the freshwater inflow during rainy season thereby increased nutrient load. Similar observations were also made who worked on species evenness in manmade ponds in Zaria, Northern Nigeria [25].

The species diversity varied from 0.249 to 2.410. Species high is in the month of January while lowest was in the month of December 2017. Grazing of zooplankton on phytoplankton and fluctuations of environmental parameters is the reason for decrease in species diversity in all ponds. Comparatively higher values of Shannon's index (H^I) in pondsP1, P2, P4 were 2.254, 2.274 and 2.410 respectively which indicated greater species diversity compared to pond P3 (0.567). This difference might be due to the fact that the earthen ponds (P1, P2 and P4) had no outlet and therefore could not loose fertility in the water flowing out of the ponds as compared to cement pond (P3) physicochemical parameters. Similar observations were reported while working on effect of pond type on physicochemical parameters, phytoplankton diversity in Kisii, Kenya [26].

The total individual numbers of phytoplankton varied from 1600 in pond P3 to 268343 in pond P4. The greater total individual numbers was found in monsoon months could be due to favourable conditions prevailed by freshwater inflow during rainy season which carried nutrient load. Similar observations were made while working on total individuals numbers of eutrophic lake, Ranchi [27].

Conclusion

In the present investigation values of different physico-chemical parameters at all four fish ponds during seventeen months study periods are in the acceptable and desirable range for pond water fishery as prescribed in water quality guidelines for the management of pond fish culture [28]. Greater diversity of phytoplankton in pond P4 due to manuring of both cow dung and groundnut oil cake and also the high diversity observed in monsoon months when compared to pre-monsoon months, which could be due to inflow of nutrients into the ponds during rainy season from adjacent agriculture fields. The induction of nutrients, rise in temperature and sufficient light boosted plankton production and continued throughout winter season where productivity showed depression. Further, only organic or inorganic fertilizers cannot meet the requirements but both in combination or supplemented with artificial feed are the best hyper for plankton productivity.

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