



Characterisation of pond water quality in the freshwater intensive culture of Indian Major Carps (IMC)

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Abstract

Indian major carp culture in India over the years has shifted from semi-intensive and intensive farming. The increase use of additional inputs in the pond has resulted in the huge change in pond ecosystem. The present study was carried out with the objective to find out the variation in the water quality parameters influenced by the high stocking of the carps. It was observed in the study that the various parameters measured were present in high concentrations. At times the values exceeded the regulatory limits for aquaculture pond water. Among the three nitrogenous parameters monitored, the maximum values for nitrate (NO_3^-) and total ammonia nitrogen (TAN) were observed to be 0.57 mg/l and 0.89 mg/l, respectively, well below the prescribed respective limits of 1 mg/l and 3mg/l for warm water fishes. However, the values of nitrite (NO_2^-) spiked to 0.15 mg/l and dissolved oxygen levels fell to a low of 3.15 mg/l, impacting the growth of the carps.

Keywords: water quality, dissolved oxygen, nitrite, nitrate, total ammonia nitrogen, aquaculture, Indian major carps.

Introduction

Aquaculture, the science and art of cultivating aquatic organisms, is an age old institution. The growth shown by the aquaculture sector over the years is unparalleled compared to any other farming sector. Being an exceptionally lucrative business a large number of aquaculture farms have come into existence in almost all part of the world (Daniels and Boyd, 1989; GOI, 1996; FAO, 2009) [8, 10, 9]. Indian major carps are mainly freshwater species grown in a wide variety of systems, ranging from low stocking extensive to high stocking intensive methods (Jhingran, 1991; Chatterjee *et al.*, 1997) [11, 7]. Indian major carps have a ready market and are sold locally throughout the country. With limiting land and water constraints the extensive farming techniques have been taken over by semi-intensive and intensive ones (Boyd, 1990) [5]. With this changeover, new technologies have been introduced so as to increase the overall production from the same unit of land. Carp polyculture in India have been utilizing a huge amount of added nutrients (Banerjea, 1967; Boyd, 1982) [3, 4]. Aquaculture ponds are typically high in nutrients, both from the biological transformations within the ponds, as well as from nutrients added to the ponds as fertilizer or feed. The nutrient status and physico-chemical factors of the culture environment play a significant role in governing the productivity of any aquatic system (Boyd and Pillai, 1984) [6]. Among the nutrients of importance, nitrogen, phosphorus and carbon are the three major ones required for the production of natural food in ponds (Ayyappan and Jena, 2003) [2]. Though voluminous literature is available on the aspects of fertilization, supplementary feeding, stocking density, ratios of different species stocked, aeration, etc., systematic information on the relative contributions of different inputs on nutrient dynamics in tropical carp culture ponds are scanty. The present research aims at scientific understanding about

processes influencing the nutrient dynamics through the arduous measurement of various water quality parameters of an intensively cultured Indian Major Carp pond.

Material and Methods

Experiments related to the study were conducted in four experimental ponds of the Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur (22°19' N, 87°19' E), India. The experiments on evaluation of individual growth rates of different carp species and nutrient generated were conducted in a set of four ponds of 0.015 ha (10 m x 15 m) each. The study was carried out for a period of 6 months. The ponds were newly constructed for the purpose of experimentation and were lined with 300-micron polyethylene sheets in order to check the seepage loss of pond water. All the ponds were constructed with about two meter depths. Below the lining material, 30 cm depth of sand cushioning was provided to avoid rupture. Prior to filling up the newly constructed ponds with water, polyethylene lining was overlaid with 30 cm of soil. The soil used in the pond bottom was analysed for the various physico-chemical properties before the start of the experiments (Table 1). The ponds were then filled up with water from tube-well up to a depth of 120 cm from a deep tube-well and allowed to stand for a week.

Organic manure in the form of cow dung was applied at the rate of 15 tonnes/ha/yr. While 1/5th of the total quantity (3 tonnes/ha) was applied as basal dose, a week prior to stocking of fish seed, the remaining amount was applied in equal split doses at fortnightly intervals. Inorganic fertilizers in the form of urea and single super phosphates were applied at the rate of 200 kg and 300 kg/ha/yr respectively as source of nitrogen and phosphorus on a monthly basis. The fingerlings of three varieties of Indian major carps (catla, rohu and mrigal)

obtained from a local fish farm were used as stocking material for the experimental ponds. All the three ponds were stocked at the same stocking density of 35000 fingerlings/ha in the combination of catla 35%, rohu 35% and mrigal 30%. Stocking was done during early morning hours when the temperature of water was comparatively low. The mean initial weights of fish species stocked were recorded by taking measurements of 50 samples from each species. The mean initial weight of species stocked were catla 7.2 g, rohu 4.25 g and mrigal 3.75 g.

Table 1: Physico-chemical properties of soil of the pond

Parameter	Value
Bulk density	1.63 g cm ⁻³
Saturated hydraulic conductivity	9.84 (cm day ⁻¹)
Particle size distribution (% Silt :% Sand:% Clay)	14.3 : 26.2 : 59.5
pH	5.7
Electrical conductivity	0.56 mmhos cm ⁻¹ at 25 °C
Cation Exchange Capacity	6.00 meq/100g soil
Total nitrogen	0.03%
Available moisture	0.025%
Available P	0.004%
Available K	0.015%

The fishes were provided with supplementary diet comprising traditional mixture of rice bran, groundnut oil cake, cooked rice and fish meal at 7:7:3:3 ratio by weight. The ingredients were soaked in water after thorough mixing and provided in the form of dough. Feeding was provided at 5% of biomass stocked per day during first two months, reduced to 3% from 3rd month onwards till the end of culture period. The feeding quantity was adjusted at monthly intervals, after estimating the biomass increase through intermittent samplings at monthly intervals. The assessment of fish biomass was based on mean growth as obtained through samplings and an expected survival levels of 80%, decided based on the previous culture records. Feeding was done twice daily, during morning (9 AM) and evening hours (3 PM) of the day. Periodic samplings were carried out for assessment of growth and health of the fish species at monthly intervals with the help of drag nets of suitable mesh size. Mean growth increments of each species were recorded from random samples of 25-50 specimens from each species using a single pan balance or spring balance of different capacities depending on the requirements. The water levels in the experimental ponds were maintained at a depth of 1 - 1.2 m during the study period, compensating the loss of water due to evaporation by drawing in the water from the nearby tube-well.

Selected physico-chemical parameters of water, viz., water temperature, pH, dissolved oxygen, BOD, total alkalinity, total hardness and dissolved inorganic nutrients such as ammonia, nitrite, nitrate and phosphate were analysed from water samples collected between 0800 and 0900 hours daily. While parameters like water temperature and dissolved oxygen were recorded at the pond site in order to avoid error during transport, other parameters were examined immediately after the samples were brought to laboratory. In order to evaluate the variation of the physico-chemical parameters of water, the various water quality parameters were measured on a daily basis. For all the measurements made through the spectrophotometer, standard methods prescribed by APHA (1998) ^[1] were followed. Maximum and minimum air temperature, pan evaporation, wind speed, photo-synthetically active radiation at one-hour interval and maximum intensity at which light saturation occurs for the corresponding data set were collected from the weather station data of Soil and Water Conservation Engineering field laboratory, IIT Kharagpur for both the experiments.

Table 2: Physico-chemical properties of water and soil measured during experimentation

Sl. No.	Parameter	Instrument used	Time of Measurement
1	Temperature	Oxi 330i/SET	Daily 0900 hr
2	Dissolved Oxygen (DO)	Oxi 330i/SET	Daily 0900 hr
3	pH	Hana, H1-8414	Daily 0900 hr
4	Nitrite – N (NO ₂ ⁻)	HACH spectrophotometer (DR./2500)	Daily 0900 hr
5	Nitrate – N (NO ₃ ⁻)	HACH spectrophotometer (DR./2500)	Daily 0900 hr
6	TAN (TAN)	HACH spectrophotometer (DR./2500)	Daily 0900 hr

Results and Discussion

The stocking and harvesting details of each species described in culture conditions are shown in Table 3. It can be observed that the survival rate was highest in case of catla followed by rohu and mrigal. This may be attributed to the high concentration of nutrients build-up at the pond bottom as a result of the feed fed to sustain the intensive culture practice. However, it may be observed from the results obtained for growth increments of each species that though the maximum weight gain was more for catla, the specific growth rate was maximum in case of mrigal followed by rohu and catla (Table 4). This may be credited to more availability of food at the pond bottom for mrigal to feed.

Table 3: Stocking and Harvesting details of Fish during the Culture

Item	Pond 1		Pond 2		Pond 3		Pond 4	
	Stocking	Harvest	Stocking	Harvest	Stocking	Harvest	Stocking	Harvest
Catla								
Weight (g)	7.2	251	7.2	234	7.2	213	7.2	256
Length (cm)	4.6	18.5	4.6	17.9	4.6	16.8	4.6	18.9
Number of fish	185	150	188	161	179	145	189	157
Biomass (kg)	1.33	37.65	1.35	37.67	1.29	30.89	1.36	40.19
Survival (%)	81.3		85.6		80.8		83.2	
Rohu								
Weight	4.25	208	4.25	202	4.25	192	4.25	212
Length (cm)	3.6	17.8	3.6	17.7	3.6	16.7	3.6	17.7
Number of fish	185	158	187	158	179	146	189	160
Biomass (kg)	0.79	32.86	0.79	31.92	0.76	28.03	0.80	33.92
Survival (%)	85.6		84.3		81.5		84.6	
Mrigal								
Weight	3.75	196	194	3.75	3.75	188	3.75	216
Length (cm)	3.3	17.7	3.3	17.7	3.3	17.5	3.3	17.9
Number of fish	159	126	161	131	153	101	162	128
Biomass (kg)	0.60	24.70	31.23	0.49	0.57	18.99	0.61	27.65
Survival (%)	79.1		81.3		65.7		78.9	

The water temperature ranged from a minimum of 18.5 °C to a maximum of 32.5 °C during the study period. The water temperature variation during the culture period is presented in Fig. 1. While the lowest temperature was recorded on 20 November in Pond P3 and the highest was observed on 14 August in Pond P4. The water temperature did not show any distinct variations between the experimental ponds at any given sampling time. The morning air temperature on the

other hand varied from 19.5 °C to 36.6 °C. The highest temperature was observed on 14 August, 2004 and the minimum on 29 December, 2004. It was observed that there was difference of almost about 5 °C between the air and the water temperature in the initial 3 months of culture when the air temperature was more than 25 °C. However, as the air temperature fell in the last three months of the culture the water temperature remained almost at par.

Table 4: Growth Increments of Carp Species at Different Time Intervals

Pond	Species	Initial stocking size (g)	Weight (g) over number of days				Final harvested size at 164 days (g)	SGR (%/d)
			30	61	90	120		
P1	Catla	7.2	67.1	121.5	164.6	203.8	251	2.165
	Rohu	4.25	45.4	85.4	121.1	157.3	208	2.372
	Mrigal	3.75	51.3	91.2	125.2	158.1	196	2.412
P2	Catla	7.2	56.4	102.1	143.2	182.4	234	2.122
	Rohu	4.25	46.2	86.8	124.1	157.6	202	2.354
	Mrigal	3.75	43.6	79.9	112.8	147.3	192	2.399
P3	Catla	7.2	51.4	96.4	137.6	172	213	2.065
	Rohu	4.25	42.8	80.2	111.9	146.7	192	2.323
	Mrigal	3.75	42.9	77.6	110.7	145.4	188	2.387
P4	Catla	7.2	67.8	121.6	165.7	204.3	256	2.177
	Rohu	4.25	47.8	88	123.4	160.3	212	2.383
	Mrigal	3.75	47.9	88.2	123.7	161.2	216	2.471

Fish generally survive and reproduce over a wide range of water temperature but the optimum temperature required for maximum growth is narrow, as the resultant growth is due to many biochemical processes which are again temperature-

dependent. Banerjea (1967) ^[3] and Boyd (1990) ^[5] opined that the desirable temperature for maximum growth of warm water fishes is between 22–32 °C.

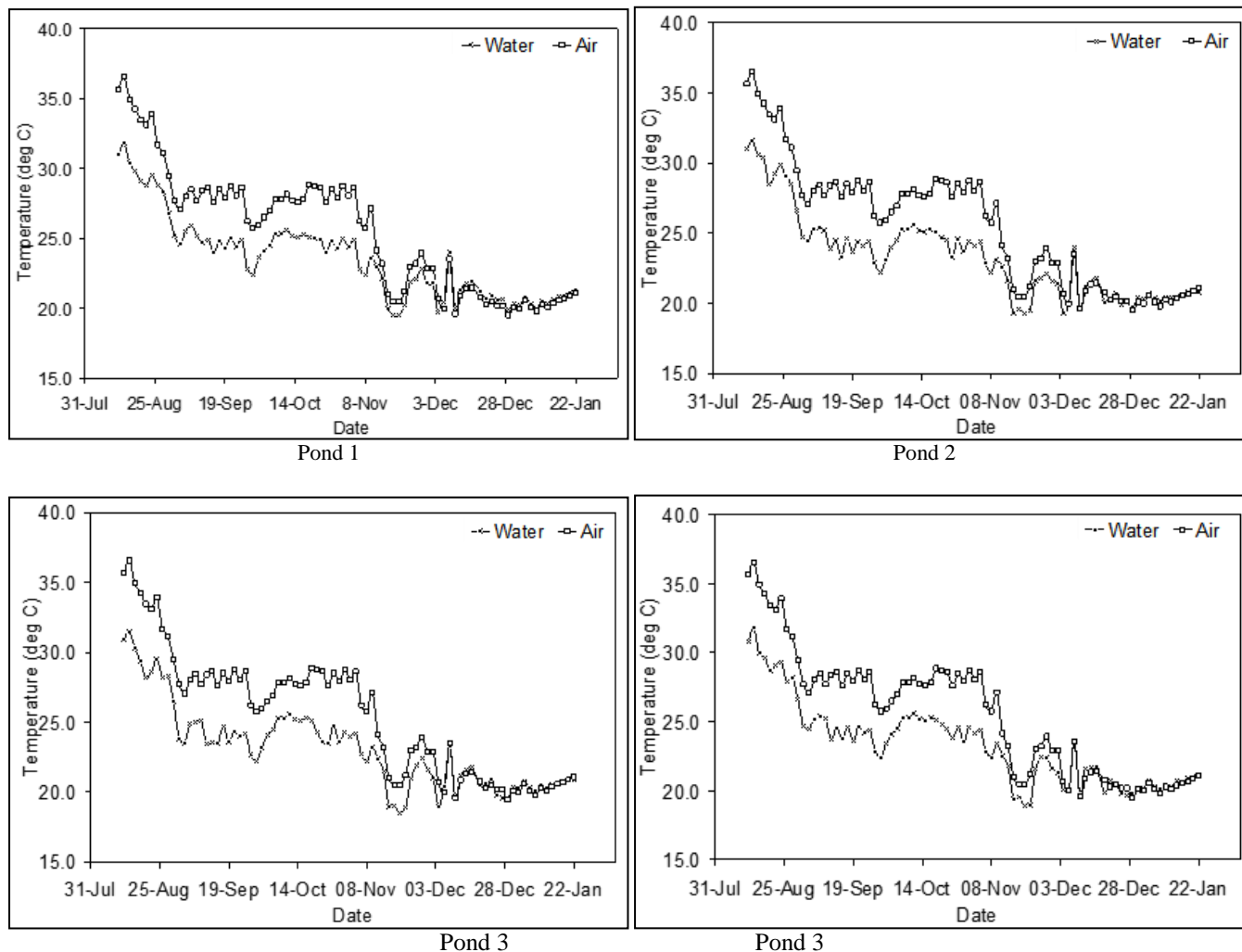


Fig 1: Water and Air Temperature Variation during the Culture Cycle

In the present study, for the first 3 months (12 August to 12 November) the morning water temperature was within the optimum range. Thereafter the temperature hovered between 22 – 19 °C. Further, the water temperature did not fall below 18 °C, even during last 3 months, indicating comparatively low influence of winter temperature on growth. The variation in pH for ponds is shown in Fig. 2. It can be observed from the figure that the pH in all the ponds kept on decreasing as the culture progressed. The sudden rise in the pH of all the ponds after 8th November is attributed to the addition of lime so as to maintain the pH within the desirable limits. The water

pH varied between 6.92 - 8.63 during the present study was well within the desirable range. The maximum value of pH observed was 8.63 in pond P2 on 12th November while the minimum value of 6.92 was noted in pond P3 on 8th November. pH is a measure of acid base status of the environment and serves as an indicator of productivity. The gills of fish are highly sensitive to acid and alkaline media (Daye and Garside, 1976). Water pH values ranging from 6.5 to 9.0 at the day break are reported to be most suitable for fish culture (Banerjea, 1967) ^[3].

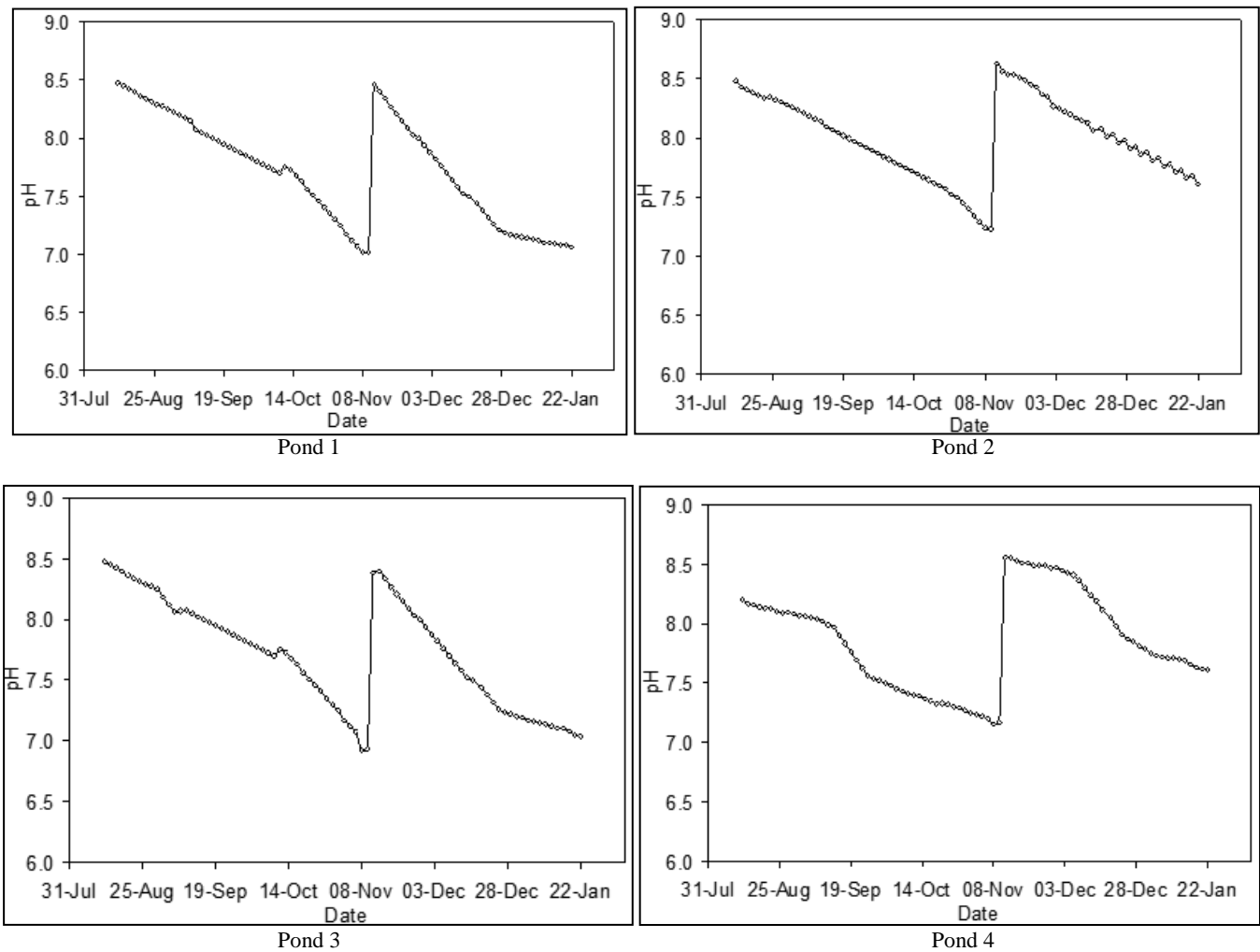
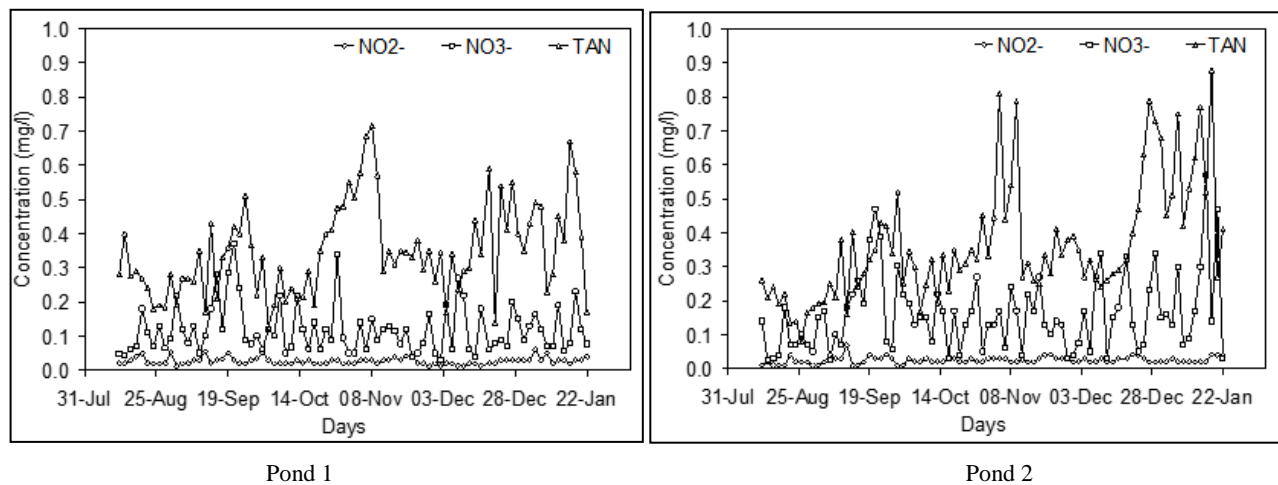


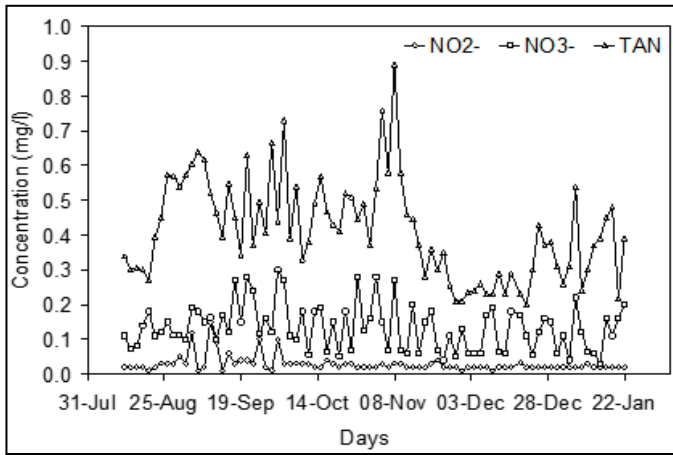
Fig 2: Daily Variation of pH during the culture cycle

Since concentration of NO_3^- , NO_2^- and TAN in water are interdependent their variation of are shown in Fig 3. The maximum concentration of NO_2^- , NO_3^- and TAN were all observed to be 0.15, 0.57 and 0.89 mg/l in pond P3 on 9th September, 8th November and 8th November, respectively. The minimum value of NO_2^- and NO_3^- were observed to be 0.01 mg/l and 0.03 mg/l in all the ponds at numerous instances. Ammonia level was measured at a minimum of 0.08

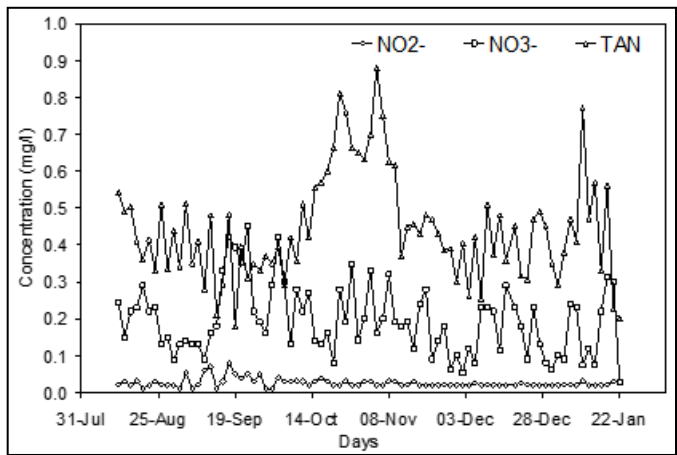
mg/l in pond P2 on 26th August.

It is well that during the cycling process, ammonia levels will go up and then suddenly plummet as the nitrite-forming bacteria take hold. Because nitrate-forming bacteria don't even begin to appear until nitrite is present in significant quantities, nitrite levels skyrocket (as the built-up ammonia is converted), continuing to rise as the continually-produced ammonia is converted to nitrite.





Pond 3

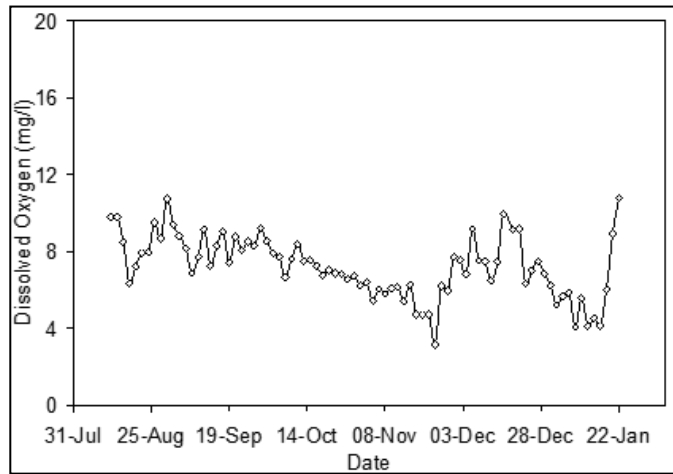


Pond 3

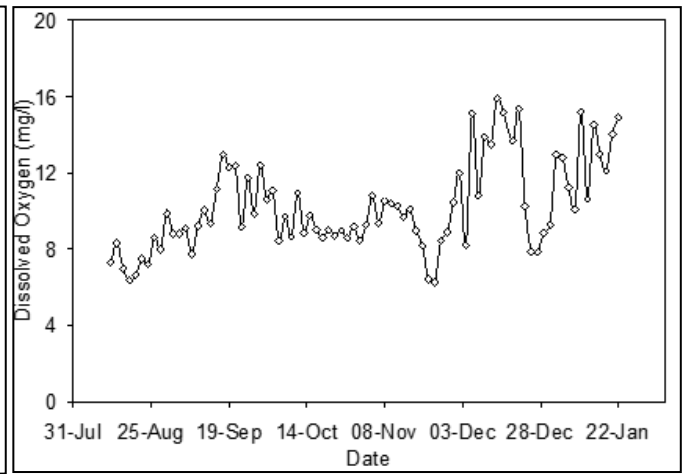
Fig 3: Daily variation of NO_2^- , NO_3^- and TAN during the culture cycle

Once the nitrate-forming bacteria take hold, nitrite levels fall, nitrate levels rise, and the pond is fully cycled. Since this is a dynamic process which depends on temperature, pH, dissolved oxygen and dissolved carbon dioxide distinguished pattern can be deduced. However, it can be observed from the

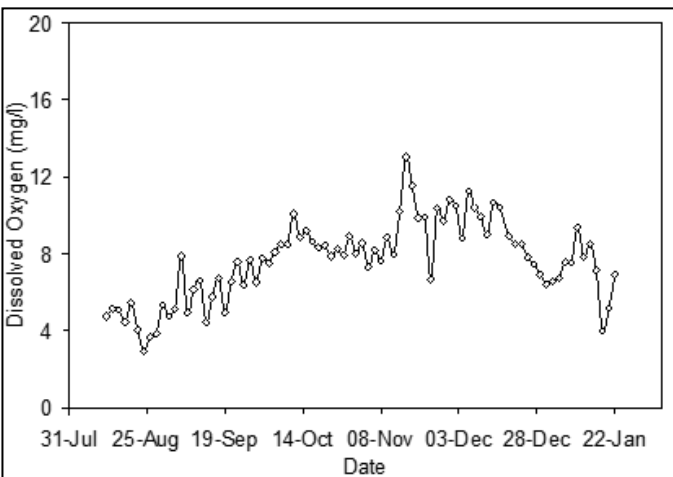
figure that there is a sudden drop in the concentration of ammonia after 8th November due to the addition of lime which is in turn responsible for the reduction of nitrate and nitrite.



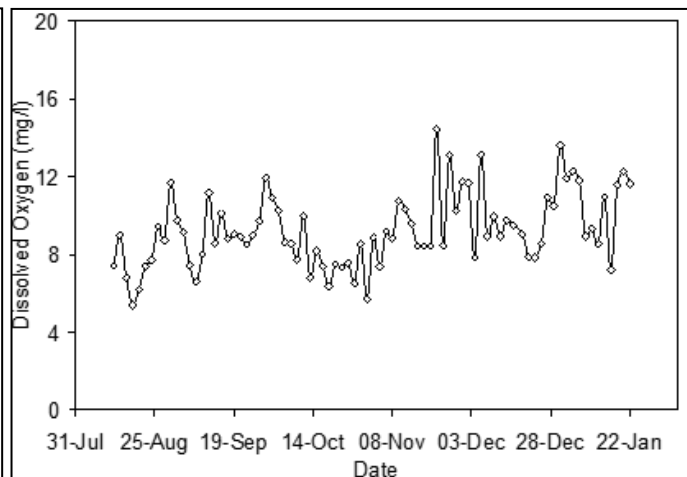
Pond 1



Pond 2



Pond 3



Pond 3

Fig 5: Daily Variation of Dissolved Oxygen during the Culture Cycle

Though the amount of phytoplankton in the ponds showed an increasing trend, the DO levels did not vary following the same pattern (Fig 5). It may be observed from the figure that the DO level varied from minimum of 3.15 mg/l, 6.24 mg/l, 2.92 mg/l and 5.40 mg/l to a maximum of 10.77 mg/l, 15.91 mg/l, 13.03 mg/l and 14.43 mg/l in ponds P1, P2, P3 and P4 respectively. This may be attributed to the various factors like variation in temperature, nutrients, growth in fish biomass, etc.

Conclusions

Water quality parameters were measured for characterisation of nutrients generated in IMC pond culture system. It was observed that although values of almost all the nutrients increased with time, the nature of variation did not reveal any specific trend. It was also observed that the nitrate and total ammonia levels remained less than the prescribed limits. However, the nitrite level was more and the dissolved oxygen was less than the prescribed limit. These two parameters greatly influenced the growth of the fish.

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