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TEMPORAL VARIATION OF WATER QUALITY PARAMETERS IN INTENSIVELY IMC CULTURED LINED POND

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Abstract

Water is a crux in the life of all biological species. Aquaculture, which depends predominantly on water, regular monitoring water quality is given the most importance. An attempt was made at Indian Institute of Technology, Kharagpur, West Bengal, India during 2006-07 to study the response of the growth of Indian Major Carps (IMC) semi intensively cultured in polythene lined ponds. Nine ponds were stocked with IMC at stocking densities of 2.0, 3.5 and 5.0 numbers per square meter. The pond water quality was measured at regular interval to determine the levels of NO_3, NO_2, NH_3 and PO_4 pollution. Physio-chemical parameters such as temperature, pH, dissolved oxygen, organic carbon were also monitored along with the above critical nutrients. The average water temperature, dissolved oxygen, and pH during culture period were 15–32.5 °C, 6.7–8.6 ppm, 3.1–7.8 ppm and 6.5–8.0 respectively. Nutrients like Total Ammonium Nitrogen (TAN), Nitrate-N, Nitrite-N and orthophosphate-P ranged between 0.2 to 1.2 ppm, 0.1-0.7 ppm, 0.02-0.1 ppm and 0.05-0.4 ppm respectively. Water exchange interval varied between 30 to 42 days for different stocking densities. Nutrient concentration initially increased with time until the water was exchanged. The exchange of water from the pond was carried out before nutrient concentrations reached the critical values. The fluctuation of nutrients in the pond water with higher stocking density (STD-3.5 and 5.0) was higher as compared to the lower stocking density (STD-2.0). The biomass increases with the increase stocking density but water exchange is needed. In this paper an attempt has been made to highlight the variation of important water quality parameters during a perennial culture period and its management by water exchange

Key words: Water quality, IMC, stocking densities, water exchange

INTRODUCTION

Water quality includes all physical, chemical, and biological factors that influence the beneficial use of water. Where aquaculture is concerned, any characteristic of water that affects the survival, reproduction, growth, or management of fish or other aquatic creatures in any way is a water quality variable. There are many water quality variables in pond aquaculture, but only a few of these normally play an important role. Increases in overall productivity in relation to water use are desirable in the context of rising pressure to utilize water more efficiently. Integrated agri–aquaculture systems (IAAS) involving various crop, livestock and aquaculture subsystems help to provide income whilst rehabilitating the soil through better on-farm nutrient recycling (O'Donnell et al., 1994). When feeding cultured fish or shrimps in monoculture systems, a significant part of the ingested food is discharged to the environment as excretory products containing nitrogen and phosphorus, which are in general limiting nutrients in the marine environment. These nutrients are part of the proteins and hard tissues that make up the body and from the point of view of conservation their excretion into the environment is wasteful. Approximately 70% of the dietary nitrogen and 65% of the phosphorus from fish food is excreted into the water. Feed is the single most expensive item in the production of fish, with the protein component sometimes accounting for

50% of the feed cost. Water exchange in a highly stocked fish pond helps to minimise pollution, eutrophication, as well as to optimise the use of valuable natural resources. (Edwards, 1993; Luo and Han, 1990; Marten, 1986).

Freshwater aquaculture in India mostly involves polyculture of three Indian major carps, viz. catla (*Catla catla* Hamilton), rohu (*Labeo rohita* Hamilton) and mrigal (*Cirrhinus mrigala* Hamilton). They are the most important groups of fishes cultured in the Indian subcontinent and accounts for more than 95% of the world's carp production (Kalla et al.2004).Composite fish culture or polyculture of indigenous carp together has been found to result in high fish production in freshwater ponds in India. (Lakshmanan et al. 1971; Singh et al. 1972; Chakrabarty et al. 1972 a and b ; Sinha et al. 1973). Based on experimental studies, Chaudhuri et al. (1974) reported the different forms of composite fish culture in India, the highest production recorded in these studies being 7.5 t/ha/year. However, the production varies significantly in intensive culture basing on the water quality management.

Layout of Experimental Site

Nine dugout ponds were constructed at the experimental farm. The ponds are rectangular in shape with gradually sloping sides, having an average water depth of 1.45 m. For perennial aquaculture at the site with sandy type soil texture retention of water is a problem after the monsoon season. To overcome this problem all the ponds were lined with 250 micron polyethylene sheets to check seepage. Below the lining material, 30-45 cm thickness of sand cushioning was provided to avoid rupture. Over the lining, loamy soils were provided to a depth of 30-45 cm to provide suitable environment for the growth of phytoplankton and zooplankton to be used by the fish as natural feed. The average water spread areas of the three lined ponds were about 145 square meters. Ponds were individually supplied with ground water from an adjacent mini deep tube-well through a under ground pipe line system and fully exposed to prevailing sunlight. Pond embankments were covered with grass. Perforated pressure pipe lines were laid throughout the pond for aeration.

Pond fertilization with organic and inorganic fertilizers is an effective method for increasing primary productivity. However, their excessive use deteriorates the water quality (Boyd, 1992; Azim, et al. 2002.b). Prior to the trial, ponds were treated with lime (200 kg ha^{-1}), inorganic fertilizers viz. urea, and single super phosphate both at the rate of 40 kg ha^{-1} and farmyard manure at the rate of 5000 kg ha^{-1}. No further fertilization was done during the culture period in order to avoid any external addition of nutrients.

Experimental setup

Within the framework of experiment, three Indian major carp species, viz, surface feeder catla (*Catla catla* L.), column-feeder rohu (*Labeo rohita* L.), and the bottom-feeder mrigal (*Cirrhinus mrigala* L.) were considered to be suitable for this polyculture system. The growth of the species was evaluated using higher stocking densities (S.D). The usual stocking density followed by the farmers is 1 to 1.5 m^{-2} under stagnant water condition. In this case, three treatments, viz. 2.0 (T-1), 3.5 (T-2) and 5.0 (T-3) numbers per square meter of water spread area with three replications were experimented. Fishes were stocked in nine experimental ponds with a stocking ratio of 4:3:3 for catla, rohu and mrigal respectively. Ponds (P-1 to P-3) constituted one treatment i.e. (T-1); similarly ponds (P-4 to P-6) and (P-7 to P-9) constituted treatments T-2 and T-3 respectively. A schematic diagram of the experimental layout is shown in Fig-1.

The initial sizes of fingerlings stocked were (16.50 ± 1.35 g), (17.55 ± 1.46 g) and (21.5 ± 2.22 g) for catla, rohu and mrigal, respectively. Fishes were fed daily at 5.0 % of their body weight for the first month of their cultivation and subsequently reduced to 2.0 %. Sampling of fishes was carried out at 15 days intervals to assess the growth and biomass of fish. Reduction in water level in tanks was periodically compensated and water exchange as per requirement was carried out to overcome eutrophication. At the end of experiment, the species-wise number and total weight of fish were recorded for each pond for calculation of various yield parameters.

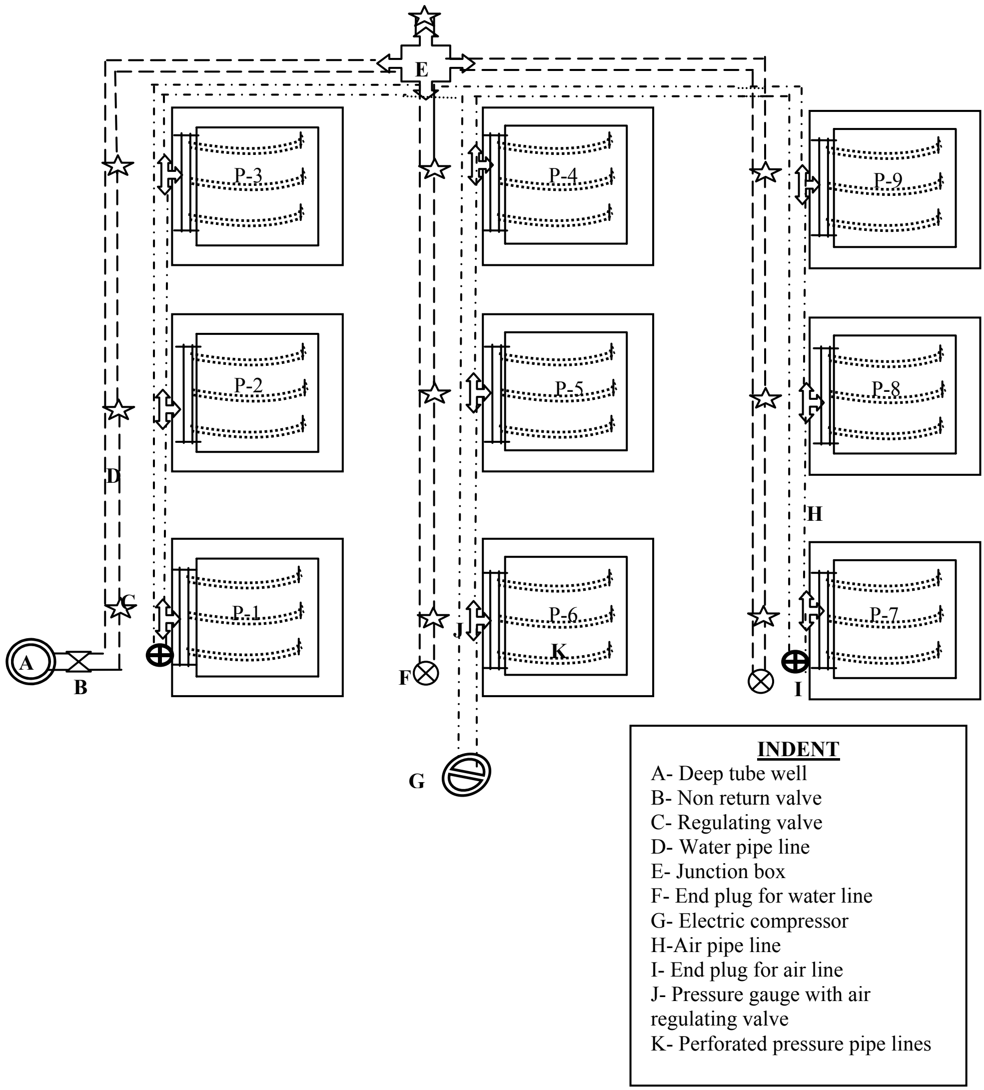

Fig-1. Schematic diagram of the experimental site

MATERIALS AND METHOD

Tubewell water along with aeration was used to ascertain desirable dissolved oxygen in the rearing experimental ponds. The pond water quality viz. total ammonia nitrogen (TAN), nitrate, nitrite, orthophosphate, total suspended solid were monitored at every alternate day using spectrophotometric method (HACH-DR/2500). Dissolved oxygen was measured by using YSI-make DO meter, pH by Systronics-make pH meter and total nitrogen by Kjeldhal apparatus. Water samples were collected at a depth of 0.30- 0.45 m from the surface at 8.30 AM for the nutrient analysis (APHA, 1998). Water exchange was done before total ammonia nitrogen (TAN) nutrient reached the critical level (i.e. 1.0 mg L^{-1}) (Aquaculture Authority of India-2001). The water quality parameters were monitored after two days interval and were maintained within the acceptable limits throughout the culture period. However, in this case the concentrations of the nutrients were maintained at a much lower level to avoid fish stress and encourage growth. The polluted water from the fish pond was not discharged in any natural stream but used beneficially for irrigation as the effluent is enriched water for the crop. This also helped to avoid environmental pollution.

Random sampling was done at every fifteen days interval to assess the growth and health of the stocked fishes in ponds. Fish weights were recorded on a top-loading balance. Around thirty sampled fishes of three different species viz. Catla, Rohu and Mirgal were netted from each pond. Fishes were sampled using cast net. Weight and length of the sample fishes were recorded. During the sampling the fishes were quarantined using 1.0 ppm potassium permanganate solution ($KMnO_4$) for disease prevention. On the sampling day, no feed was provided to the fish. However, during the sampling, efforts were made to minimise the stress due to handling. At the end of the culture period all the fishes were harvested by draining the ponds.

RESULTS AND DISCUSSION

Temporal variation of various water quality parameters like ammonia nitrogen, nitrate and nitrite nitrogen, orthophosphate, dissolved oxygen, organic carbon, pH and water temperature are shown in Fig- 2 to 9 respectively. There is a sinusoidal gradual variation of nutrients in the pond water. However, the variation is maximum in higher stocking density pond as compared to a lower one. A decreasing trend of orthophosphate (PO_4^{3-}) was found in most of the rearing ponds. It may be due to the increase in biomass of phytoplankton. Decrease in dissolved oxygen with the progress of culture in different treatments could be attributed to the increase in fish biomass. Similar results were obtained by Jena et al. (2001, 2002a, b) at CIFA, Bhubaneswar. The increasing trend of organic carbon is due to increase in phyto and zooplankton mass and it provided a better environment for fish culture. Initial reduction of water pH was observed which may be corroborated to mineralization of added organic manures. However, pH value remained around 7.5 to 8.0 for most of the times during the culture period. Intermittent liming helped in stabilization of pH during later part of culture as mentioned earlier. Water temperature fluctuated from 18^{0}C to 32^{0}C during the culture period. Minimum water temperature was recorded during 70-80 days of experimental trial.

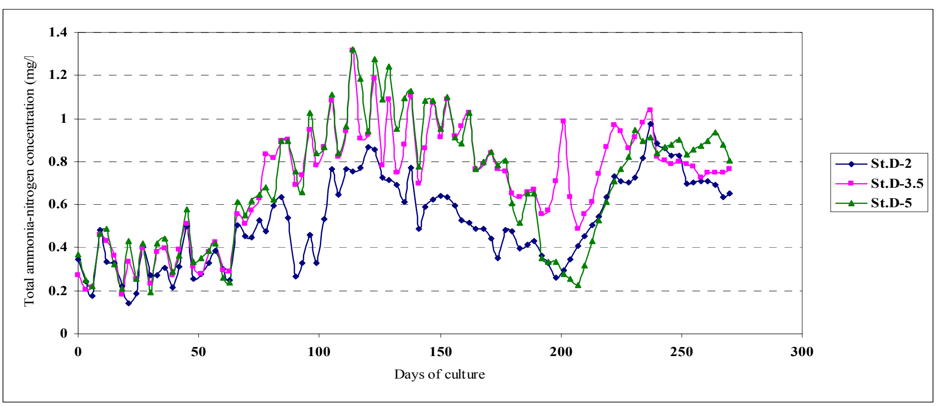

Fig-2. Temporal variation in ammonia-nitrogen concentration in ponds with different stocking densities

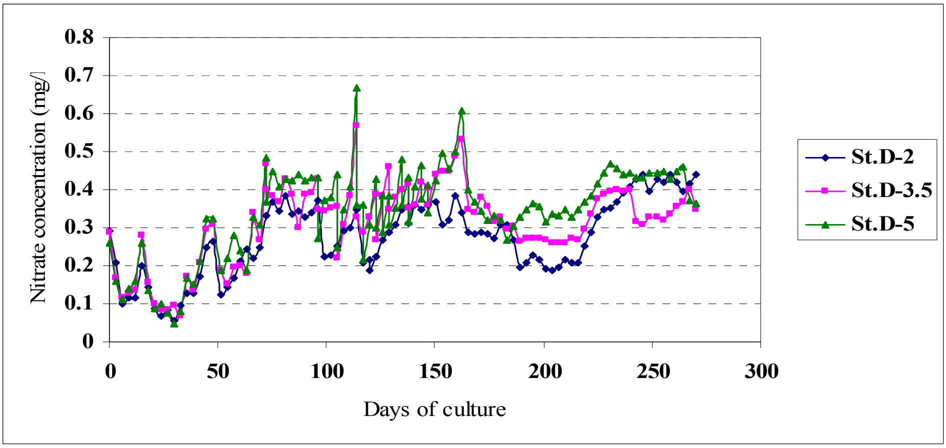

Fig-3. Temporal variation of nitrate-nitrogen concentration in ponds with different stocking densities

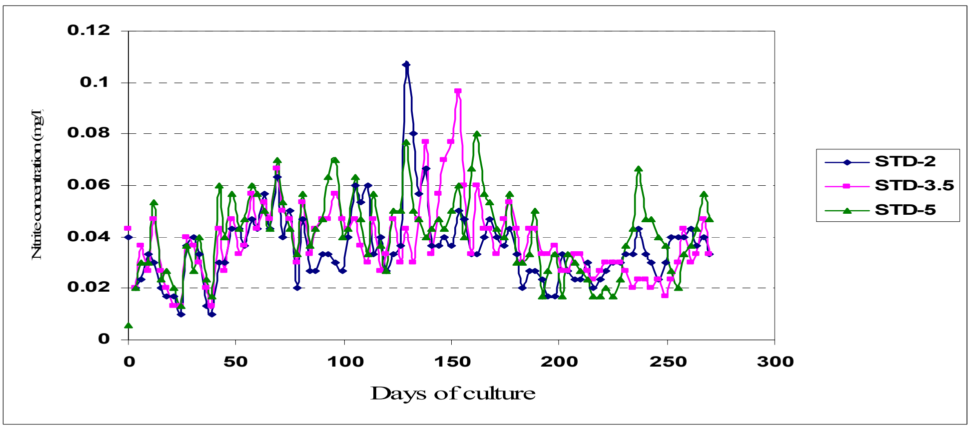

Fig-4. Temporal variation of nitrite-nitrogen concentration in ponds with different stocking densities

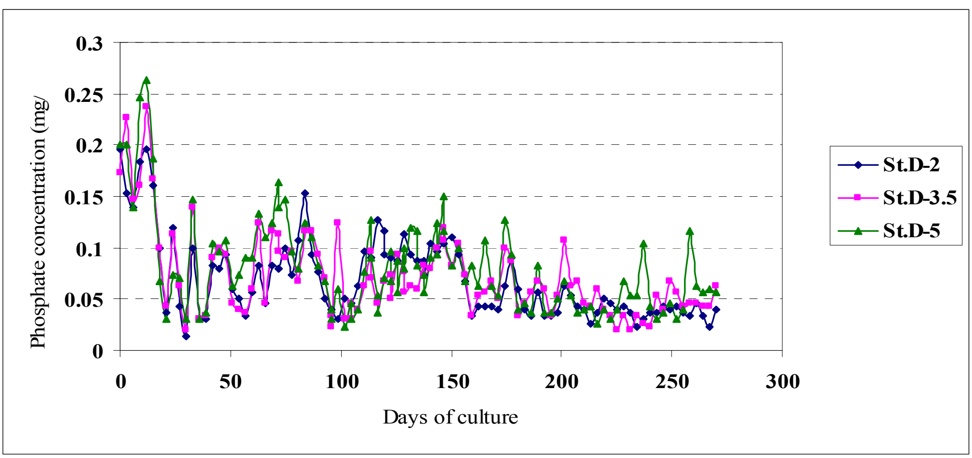

Fig-5. Temporal variation of orthophosphate concentration in ponds with different stocking densities

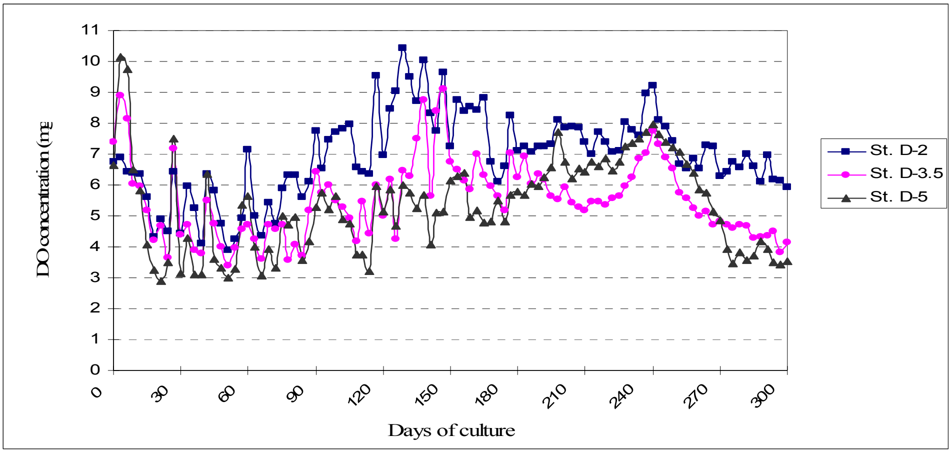

Fig-6. Temporal variation of dissolved oxygen concentration in ponds with different stocking densities

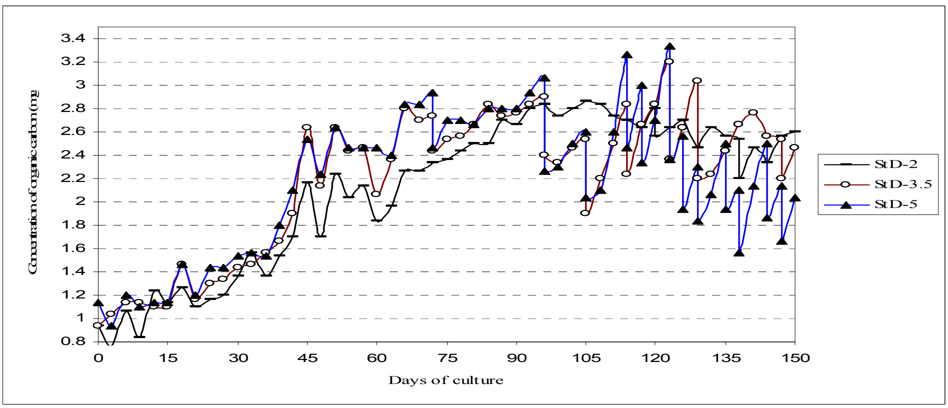

Fig-7. Temporal variation of total organic carbon concentration in ponds with different stocking densities

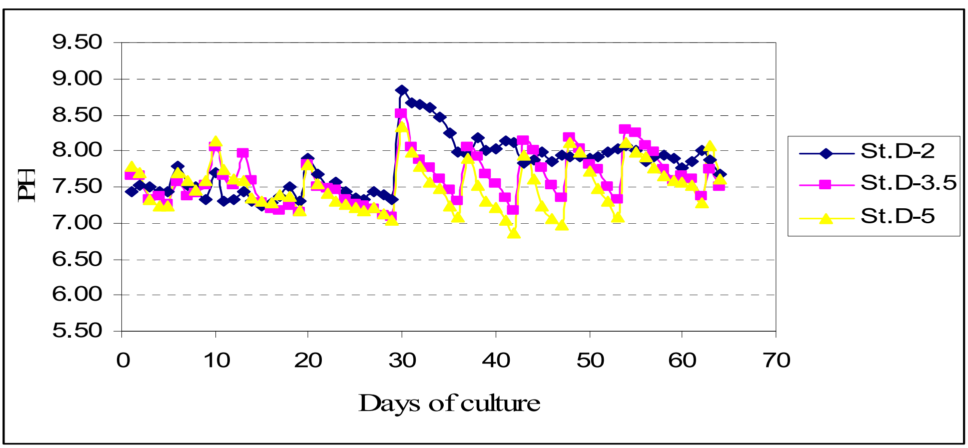

Fig-8. Temporal variation of pH in ponds with different stocking densities

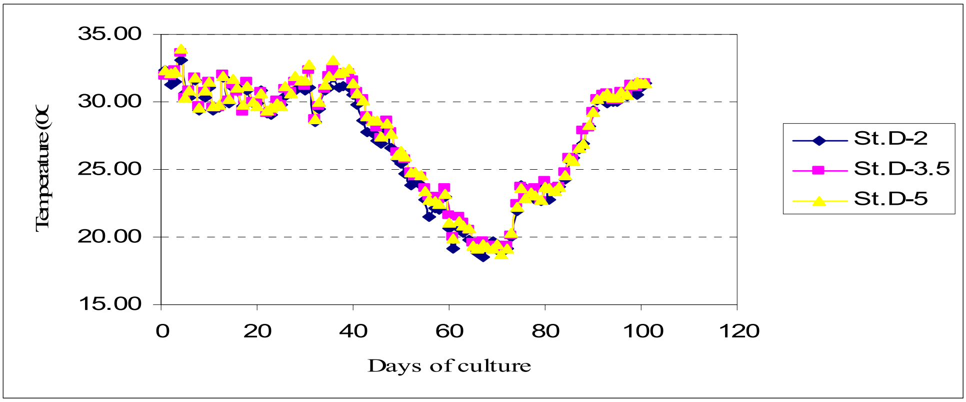

Fig-9. Temporal variation of water temperature (^{0}C) in ponds with different stocking densities

A water exchange schedule is prepared for exchanging water in different months of culture for various stocking densities viz. STD- 2.0, 3.5 and 5.0 (Table-1). It is found from the table-3 that 540 % of water is exchanged for STD-5.0 350 % for STD-3.5, 160 % for STD-2.5. Maximum frequency (17 times) is found in STD-5.0 as compared to the other stocking densities (Fig-10).

Table-1
Water exchange schedule for different stocking densities

	Water exchange schedule in different stocking densities (%)		
Month of culture	STD-2.0	STD-3.5	STD-5
Jun	0	0	0
Jul	0	0	0
Aug	0	0	0
Sep	0	10	20
Oct	0	20	20
Nov	10	20	60
Dec	10	40	80
Jan	20	60	100
Feb	20	80	120
March	20	120	140
Total	80	350	540
No. of water exchange (frequency)	4	17.5	27

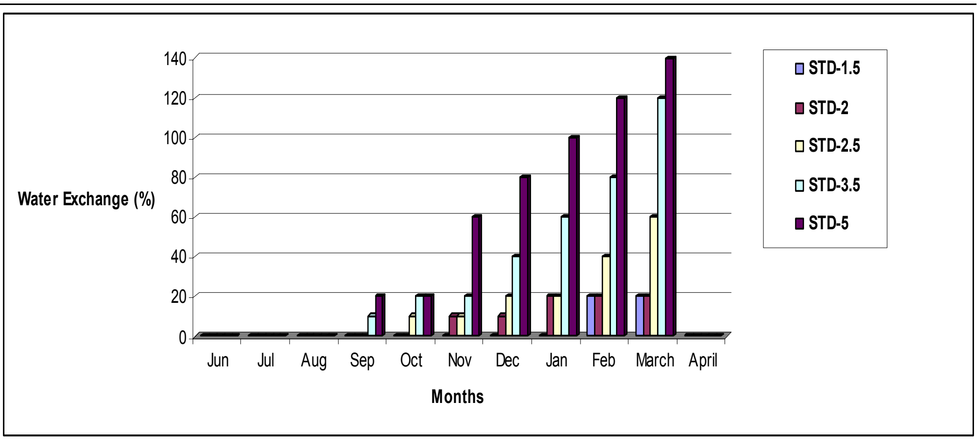

Fig-10. Water exchange for different stocking densities

It is observed from the figure that during June, July and August no water is exchanged. It is due to the fact that water quality parameters were well within the permissible range and they did not reach the pollution level. The non adherence of pollution level is due to low initial biomass, less biological activities and dilution of pond water due to rainfall.

The average harvested fish weight is presented in Table-2. It can be seen from the table and the figure that the average individual fish growth is the highest in ST.D-2.0 followed by ST.D-3.5 and ST.D-5.0. Although the higher stocking gives lower individual fish growth, but the total biomass production is much higher. The average individual growth was found to be the maximum for lower stocking density of STD-2.0 as compared to the higher stocking density of STD-5.0. The average maximum weight in STD-2.0 was 191.5 g, 202.9g, and 198.3g for catla, rohu and mirgal respectively; for STD-3.5 the corresponding respective values were 171.6 g, 176.3 g, and 175.3 g. Similarly for STD-5.0 the values were 137.5 g, 126.0 g, and 146.5g. The specific growth rate (SGR) was found to decrease with stocking density .i.e. maximum in STD-1.5 and minimum in STD-5 (Table-3).

The survivability percentage for different species of cultured fishes at different stocking densities during different year of culture is presented in the Table-4. Survivability is calculated using Equation-3 as presented earlier in this section. The maximum death of the cultured fishes is due to stress during fish sampling days. From the table it is seen that survivability percentage varied from 72 to 96. However, on an average around 90% of all the species survived during the whole culture period.

Higher yields in higher STD ponds are due to larger number of animals with better use of aeration and water exchange which helped in the survivility and growth of fishes. The fishes were grown in the ploythene lined small ponds of about 145 m^2 water spread area each. Therefore, the yields and growth can not be considered as absolute; rather they are relative values. Therefore, it can be inferred that with the increase in stocking density, the growth of individual fish is reduced but the total biomass production increases and leads to more profit.

Table-2.
Fish growth for various stocking densities in different years

Species	Fish weight (g)		
	STD		
	2.0	3.5	5.0
Catla	187.1	170.9	137.5
Rohu	202.9	176.3	153.7
Mirgal	198.3	175.3	146.5

Table-3.
Specific growth rate for different stocking densities

Species	STD-2.0	STD-3.5	STD-5.0
Catla	0.72	0.66	0.65
Rohu	0.73	0.71	0.71
Mrigal	0.70	0.71	0.66

Table-4.
Survivility of fish for different stocking densities

Species	STD		
	2.0	3.5	5.0
Catla	90.41	85.74	85.58
Rohu	93.39	87.93	87.88
Mirgal	96.17	89.09	89.95

CONCLUSION

The results of the trial conducted in polythene lined earthen pond of around 145 m^2 water spread area each may not be replicated in bigger size natural earthen ponds without lining. It is clear from the study that with higher stocking densities with a provision of water exchange and aeration, it is possible to produce more biomass of fish and the farmer can certainly earn more income. It can also be inferred from this experimental result that in upland areas with sandy loam type of soil where water retention is a problem, semi intensive fish culture can be possible with polythene lining. However, feeding on a regular basis is essential for proper growth and profitable income.

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