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Impact of Poultry Birds Integration on Water Quality Characteristics of Fish Ponds in Coldwater Conditions

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Abstract : *An attempt has been made to assess the impact of poultry bird's integration on water quality of the fish ponds of different farmers of the Champawat district of Uttarakhand state. Experiment was conducted for two integration level of poultry birds (10 and 20 chicks/100m2) having fish stocking densities 3.0 fish/m3 in triple replication. Chemical properties of pond soil directly influenced the water quality of the pond. A decreasing trend in soil pH and increasing trend in organic carbon, nitrogen and phosphorus was found in integrated ponds. All parameters of physico-chemical properties of water in integrated ponds were found in permissible limits indicates the feasibility of higher stocking of fish and higher level of poultry bird's integration in cold water conditions without any adverse effect on water quality. This might be due to the cool, clean and well oxygenated water of the hilly region.*

Keywords: Poultry integration, Water quality, Stocking densities, Coldwater conditions, Hilly region.

Introduction

The aquaculture production potential of the coldwater sector has not been exploited to its fullest extent. As far as coldwater fisheries development is concerned except a few hill states like Kashmir valley and Himachal Pradesh, other mountain regions of India are still poorly developed or under exploited. Introduction of composite fish farming using Chinese carps for mid-altitudes is a major success in increasing the fish production from the hilly regions. Integrated fish farming for the hills could also be an important inexpensive aquaculture practice for the rural population residing in the mountain areas of the country. Many authors have emphasized the importance of fish livestock integration in recycling of waste products, income generation and diversification of products (Sharma and Das, 1988; Radhey, 1995; Kaunhog, 1996; Sharma *et al*., 1998; Kumar *et al*, 2012).

In the upland waters the Indian major carps do not grow well, due to the low thermal regime. Therefore, Chinese carps found suitable for the Mid-Himalayan region as the candidate species for polyculture. The land holding in the hill area is smaller (700-900 m^2) as compared to the national average (1370 m^2). The farmers in the hill region have integrated type of farming pattern. Fish can serve as an additional source of income if integrated with agriculture and animal husbandry. The integration of aquaculture with livestock and crop farming offers greater efficiency in resource utilization thus reducing risk by diversifying crops and providing additional food, income and employment. Thus, the three major side effects of population growth hunger, poverty and unemployment are solved through integrated fish farming. Integrated fish farming is generally considered particularly relevant to benefit the rural poor. Poultry- fish farming is the integration of poultry animals like chicken, duck and geese with fish farming (Tokrisna, 1995). The most common practice in India is fish cum chicken, which is widely practiced because of its profitability. Animal manure contains considerable quantities of nutrients for fish production among which are non-digested feed,

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metabolic excretory products and residues resulting from microbial synthesis (Fashakin *et al*., 2000). Organic manures, being less expensive compared to chemical fertilizers, contain almost all the essential nutrient elements and are traditionally applied to fish ponds to release inorganic nutrients which stimulate the growth of plankton (Wurts, 2000; Ansa and Jiya, 2002; Kadri and Emmanuel, 2003).

Nutrient requirement of fish ponds which depends mainly on the nutrient status of pond soil and fish density can be fulfilled by supplying needed quantity of excreta by regulating the number of poultry birds stocked with fish pond. Application of organic manure in the pond directly affects the water quality and regulates the pond productivity. According to Banerjea (1967), the nutrient status of water and soil play the most important role in governing the production of planktonic organisms. Thus, seasonal fluctuations of various physico-chemical factors of water and soil have an important role in distribution, periodicity as well as qualitative and quantitative composition of biota.

The present study is an attempt to assess the impact of poultry bird's integration on water quality of fish ponds in mid hills conditions.

Materials and Methods

Study area and experiment design : The experiment was carried out for a period of 12 months at different locations of district Champawat in Uttarakhand state (80° 10' E longitude, 29° 60' N latitude and an altitude of 1750 msal) at farmer's ponds. The experiment was designed for two level of poultry integration (10 and 20 nos. /100 m^2). The experiment was performed in triplicates. The ponds having an area of 100 m^2 and 1.0 m water depth with perennial source of water from spring were selected for the present study. Fish seed (2-3 cm size) was stocked in recommended ratio 40:30:30 (silver carp: grass carp: common carp) and fish density of 3.0 fish/m^3 in all ponds. The control ponds C1-C3 were without integration, while T1-T3 were integrated with 10 chicks/100m2 and R1-R3 were integrated with 20 chicks/100m^2. The poultry cages were fabricated with locally available bamboo or wooden splits and constructed on the dyke of the fish ponds with the proper facility of the waste drainage directly into the pond water.

Sampling and analysis : The soil samples were collected randomly from 5-6 different places, air dried, grinded and mixed for further analysis. A mixture of soil and distilled water was prepared in the ratio of 1:2 and its pH was determined with pH meter (Black, 1965). Organic carbon was determined by the method of Jackson (1958). The nitrogen and phosphorus content of soil samples was determined by the method followed by Olsen *et al*. (1954).

The water samples were collected fortnightly in sampling bottles from each pond between 10-11 am for the estimation of pH, dissolved oxygen, free carbon dioxide, alkalinity, ammonia, nitrite, nitrate, phosphate and silicate. Water temperature and dissolved oxygen were measured at pond itself while rests of the parameters were analyzed in the laboratory following the standard procedures of APHA (2005). Statistical analysis was done using two-way ANOVA at 1% and 5% level of significance.

Results and Discussions

Chemical properties of soil directly influenced the water quality of the pond. The pH remained slightly alkaline in all ponds throughout the experimental period. The pH value of pond sediments was existed as 8.0-8.4 in different ponds. In all ponds, pH was recorded in the beginning and at the end of the experiment. Mean values of initial pH in different ponds are non-significantly different ($P<0.05$). At the end of the experiment these values were in the acidic side due to the continuously increasing organic load. A significant difference was found in the initial (8.15 0.27) and end (7.7 0.34)

values of the integrated ponds. Banerjea (1967) and Jhingran (1988, 1991) have reported that moderate alkaline nature of the bottom soil is indicative of optimal conditions for fish production.

Organic carbon content in soil ranged from 0.54-1.385% in different ponds initially. The concentration of organic matter at the end of the experiment was found in the range of 0.930-1.570% with average mean value of 1.33 0.05% in integrated and 0.93 0.04% in non-integrated ponds. In general the organic matter was increased in both types of ponds due to the incorporation of poultry waste and faecal matter of the growing fish. No significant difference was observed in average values among the different ponds initially, but they were found significantly different in the integrated and non- integrated ponds at the end of the experiment. As the process of decomposition is temperature dependent, it slows down during the winter months leading to the accumulation of organic carbon in pond soil. Similar results were reported by Saha (1985) and Chatterjee and Saha (2000). Poultry excreta were the main source of organic carbon in the ponds, besides the autochthonous organic matter.

Nitrogen concentration in soil ranged from 40.6-59.25 mg/100g soil in all ponds initially. As the experiment proceeded, an increasing trend was observed in this parameter with maximum difference in the integrated ponds. Significant difference ($P<0.05$) was observed in the initial and final mean values of integrated ponds. The increase in soil nitrogen content towards the end of the experiment may be attributed to the constant deposition of excess nitrogenous substances to the pond bottom. The similar pattern of the soil nitrogen content was also reported by Saha (1985).

Soil acts as a reservoir of phosphorus which is released slowly to the overlying water and made available to the primary production (Boyd and Pillai, 1984). In the present study, there is a gradual increase in phosphorus content from beginning to the end of integrated ponds. It was in the range of 3.10-4.80 mg/100g soil initially and 2.38-4.92 mg/100g soil at the end of the experiment. The average, 4.20 0.38 mg/100g soil and 2.69 0.15 mg/100g soil was observed in the integrated and non- integrated ponds at the end of the experiment, which was significantly different ($P<0.05$). As the phosphorus content in the poultry waste remain in higher side, it was reflected in the pond sediment of the integrated ponds, but, decreasing trend of this element in the non-integrated ponds reflected the use on phosphorus in the primary productivity. According to Banerjea (1967), Sreenivasan (1967) and Jhingran (1988, 1989), the available phosphorus content of <3mg/100 g, 3-6 mg/100 g and >6mg/100 g soil are indicative of poor, moderate and high productivity, respectively. However, the existing values of phosphorus content reflect the good productive status of soil. The values of phosphorus concentration recorded in the present study are comparable to those obtained by Nath *et al*. (1994) in semi-intensive fish culture ponds. All chemical parameters of pond soil except pH showed significant positive correlation with GPP, while pH showed negative correlation.

Water temperature significantly affects the biological productivity of ponds by controlling chemical and metabolic reactions (Huchinson, 1957). Low temperature reduces the metabolic activity of the organism (Khanna, 1993). Changes in temperature of the water body can influence the speed and course of decomposition of organic matter (Karause, 1962). In the present study, water temperature was found in the range of 7.8-24.8°C. Seasonal variation in the surface water temperature of all ponds was found in correlation of air temperature. In general, minimum values were observed during the months of December and January and maximum during May- August. In present study, a positive correlation was found between water temperature and GPP.

According to Boyd and Pillai (1984) better fish production could be possible in pond water with pH value ranging as 6.5-9.0. In present study, the average pH values were found as 7.65, 7.48 and 7.25 in non- integrated, integrated ponds with 10 chicks and integrated ponds with 20 chicks respectively, which indicates the favorable condition of productivity. Gradual decrease in pH value just after the fertilization supports the report of Alabaster and Lloyd (1980), Sharma and Saini (1992) Jha *et al*, (2004, 2006, 2007). In ANOVA analysis the f value was found significant for integrated and non- integrated ponds at 0.05 level.

A minimum acceptable level of DO is considered to be 5ppm (Jhingran, 1988). In pond water DO mainly evolves through the process of photosynthesis by phytoplankton. In spite of rich planktonic organisms in pond water, dissolved oxygen remained in sub optimal level (6.87 0.77 mg/l, 6.04 0.42 mg/l and 5.71 0.36 mg/l in non-integrated, integrated ponds with 10 chicks and integrated ponds with 20 chicks, respectively). The low level of dissolved oxygen in these ponds, especially in winter months, reflects the richness of organic matter, which consumes large amount of dissolved oxygen in the process of decomposition. Das (1987) also observed decrease in DO when nutrient level increases due to application of manure. In ANOVA analysis the f value was found significant for integrated and non-integrated ponds at 0.01 and 0.05 level. A negative correlation was found between DO and GPP for integrated and non-integrated types of ponds. Similar correlation was observed by Singh and Sharma (1999).

Free CO_2 appeared in moderate concentration in the experimental ponds during almost entire period of study (0.98, 1.22 and 1.24 mg/l in non-integrated, integrated ponds with 10 chicks and integrated ponds with 20 chicks respectively). The values were relatively lower (0.9 mg/l) during summer and higher (9.2 mg/l) in winter. Baruha *et al*. (1998) also registered the same pattern. In ANOVA analysis the f value was found non-significant for integrated and non-integrated ponds at 0.01 and 0.05 level.

Total average alkalinity fluctuated in experimental ponds (103.1, 96.83 and 96.76 mg/l in non-integrated, integrated ponds with 10 chicks and integrated ponds with 20 chicks respectively) were in the conformity of suggested range given by Tripathi (1982) for optimal fish production. The average lower value in integrated ponds could be attributed to higher release of free CO_2 in decomposition of organic matter (poultry waste). The accumulation of free CO_2 reduces the pH of water as it was higher in integrated ponds. In integrated and non-integrated ponds a significant positive correlation was found between alkalinity and GPP. In ANOVA analysis the f value was found non-significant for integrated and non-integrated ponds at 0.01 and 0.05 level.

Ammonia is an important nitrogenous end product of heterotrophic break down of organic matter. The concentration of NH_3-N was found in the range of 0.010- 2.42 mg/l, 0.012- 2.56 mg/l and 0.012-2.90 mg/l in non-integrated, integrated with 10 chicks and in integrated with 20 chicks ponds, respectively. The average values were found higher (0.144 mg/l and 0.166 mg/l) in integrated ponds than the non-integrated ponds (0.136 mg/l). Akpan and Okafor (1997) obtained higher values of ammonia (2.9-2.4 ppm) during December and January in ponds manured with poultry excreta. In ANOVA analysis the f value was found non-significant for integrated and non-integrated ponds at 0.01 and 0.05 level.

Nitrite and nitrate are oxidized forms of ammonia nitrogen and are important plant nutrients. Padmavathi *et al*. (1997) reported that generally nitrate occurred in very high concentrations in pond water, while ammonia ranked next to it. They also found higher positive correlation between nitrate concentration and duration of culture period. The concentration of NO_2-N was found in the range of 0.016- 0.062

Table 1 Mean values (? SD) of chemical characteristics of sediments of experimental fish ponds.

Pond	Integrated		Non-integrated(Control)	
	I	E	I	E
pH	8.15?0.27	*7.7?0.34	8.2?0.22	8.06?0.37
Organic carbon (%)	*0.83?0.03	*1.33?0.05	0.82?0.02	*0.93?0.04
Available nitrogen (mg/100g soil)	*52.35?4.5	*61.9?4.9	43.68?3.8	45.87?3.2
Available phosphorus (mg/100g soil)	*3.81?0.32	*4.20?0.38	3.79?0.24	2.69?0.15

Figures having same superscript in each row are significantly different ($P < 0.05$)
I-initially, E-at the end of the experiment.

Table 2 Mean values (? SD) of Physico-chemical characteristics of fish ponds.

Pond	Non- integrated (Control)		Integrated(10 Chicks)		Integrated(20 Chicks)	
	Min	Max	Min	Max	Min	Max
Water temp. (^{O}C)	8.7	24.8	7.6	22.9	8.6	24.6
Water pH	7.0	8.6	7.0	8.1	7.0	7.9
DO (mg/l)	6.0	7.6	5.2	7.4	5.1	7.2
Free Co_2(mg/l)	0.6	1.6	0.5	1.9	0.4	1.9
Alkalinity(mg/l)	87	115	80	115	80	120
Ammonia (mg/l)	0.010	0.242	0.012	0.256	0.012	0.290
Nitrite (mg/l)	0.016	0.062	0.015	0.078	0.016	0.092
Nitrate(mg/l)	0.42	0.98	0.62	1.28	0.67	2.15
Phosphate (mg/l)	0.04	0.26	0.10	0.78	0.10	1.43
Silicate(mg/l)	4.10	22.62	4.02	20.45	4.00	19.63

Min-mean of minimum values, Max-mean of maximum values

mg/l, 0.015- 0.074 mg/l and 0.016-.092 mg/l in non-integrated, integrated with 10 chicks and in integrated with 20 chicks' ponds, respectively. The average values were found higher (0.05 mg/l and 0.07 mg/l) than the non-integrated ponds (0.04 mg/l). Nitrite concentration increased with the progress of the experiment and with the increase in the integration and reaching peak values in the winter months. In ANOVA analysis the f value was found significant for integrated and non-integrated ponds at 0.01 and 0.05 level.

The concentration of NO_3-N was found in the range of 0.42- 0.98 mg/l, 0.62- 1.28 mg/l and 0.67-1.52 mg/l in non-integrated, integrated with 10 chicks and in integrated with 20 chicks' ponds, respectively. The average values were found higher (0.85 mg/l and 1.11 mg/l) than the non-integrated ponds (0.73 mg/l). Nitrate concentration increased with the progress of the experiment and with the increase in the integration density and reaching peak values in the winter months. The stagnant level of the nitrate during winter months might be due to the negligible activity of the nitrifying bacteria (nitrobacter) at very low temperature. In ANOVA analysis the f value was found significant for integrated and non-integrated ponds at 0.01 and 0.05 level.

The concentration of PO_4 was found in the range of 0.11- 0.26 mg/l, 0.11- 0.78mg/l and 0.11-1.43 mg/l in non-integrated, integrated with 10 chicks and in integrated with 20 chicks' ponds, respectively. The average values were found higher (0.47 mg/l and 0.85 mg/l) than the non- integrated ponds (0.14 mg/l). It might be due to the richness of the poultry excreta in phosphorus content. According to Nath *et al*. (1994) phosphorus content ranging between 0.2 and 0.6 ppm was found optimal for fish production. In ANOVA analysis the f value was found significant for integrated and non-integrated ponds at 0.01 and 0.05 level.

The concentration of silicate was found in the range of 4.1- 22.62 mg/l, 4.02- 20.45mg/l and 4.00-19.63 mg/l in non-integrated, integrated with 10 chicks and in integrated with 20 chicks' ponds, respectively. The average values were found lower (9.3 mg/l and 8.5 mg/l) in the integrated ponds than in non-integrated ponds (10.5 mg/l). It might be due to utilization of silicate for the production of phytoplankton. In ANOVA analysis the f value was found significant for integrated and non-integrated ponds at 0.01 and 0.05 level.

Though, the present study was carried out with comparatively higher fish stocking density (3.0 fry/m^3) and higher integration level of poultry birds (10-20 chicks/100 m^2) than the existing practice in plain area (500 chicks/ha), but there was not found any adverse situation in pond water quality in this integration model under coldwater conditions, might be due low thermal regime and cool, clean and well oxygenated water in hills. These findings reflected the feasibility of the aquaculture of exotic carps with higher fish stocking density and high level of poultry integration.

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