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Effect of Aeration on Water Quality, Fish Growth and Survival in Aquaculture Ponds

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Abstract.- Fingerlings of *Labeo rohita*, *Cirrhinus mrigala*, *Hypophthalmichthys molitrix* and *Ctenopharyngodon idella* (average weight 32.0 gram) were cultured in six brick lined (26'x12'x6') ponds for a period of six months. The stocking ratio was 7:4:4:3, respectively and the stocking density of each pond was 2508 fish/acre. Three of the six ponds served as aerated ponds and other three as non-aerated ponds. Aeration was done with the help of 1/3 Hp vertical pump. Fish in each pond were fed with 20% protein diet @ 3% body weight. The ponds were fertilized with cattle manure (@ 500 kg/acre) and chemical fertilizers @ 20:2:0 (N:P:K). Significantly high growth ($P<0.0001$) and survival of fish ($P<0.0001$) was observed in aerated ponds as compared to the non-aerated ponds. Pond aeration has resulted in 2095 Kg/acre more fish production with economic benefit of Rs. 144,130.

Key Words: Pond aeration, dissolved oxygen, fish survival, fish growth, pond fish culture.

INTRODUCTION

Fish culture is considered today as one of the promising resources of animal proteins for the future. Pond fish culture provides an efficient way of turning low value protein stuffs into high quality fish protein. The availability of suitable food and ecological conditions for the fish depend upon certain water quality parameters like dissolved oxygen, total ammonia-nitrogen, free carbon dioxide, total alkalinity, total hardness and edible planktonic life of ponds (Hepher and Pruginin, 1981; Ali *et al*., 2000). Failure to maintain an adequate water quality regime in ponds may cause parasitic infection or other diseases in fish (Boyd, 1981, 1982; Collins, 1994).

In heavily stocked and artificially fed fish ponds, many problems like organic pollution, deficiency of oxygen, increased level of free carbon dioxide and total increase in ammonia-nitrogen ratio is frequently occurring. Aeration is a better way to get rid of them (Agarwal, 1999; Boyd, 1995). Boyd (1990) reported that aeration system is one of the best methods to oxidize ammonia to nitrate or to adjust pH and to voltalize the ammonia.

Dissolved oxygen is one of the most important parameter and a primary limiting factor controlling the growth and survival of fish. Anoxia is one of the major causes of fish kills in fertilized ponds during summer conditions. Swingle (1968), Grizzel *et al.* (1969), Mayer *et al.* (1973) and Tiemeirer and Deyoe (1973) proved that emergency aeration is best technique for preventing fish kills during Dissolved Oxygen Crisis.

In Pakistan, pond aeration is not so common and developed. A few years back, locally manufactured aeration system has been introduced in the market. Some fish farmers have installed these aerators on their fish culture ponds but efficiency of these aerators and economic benefits of their use in commercial ponds has not been standardized in our local conditions.

Keeping in view the economic importance of pond aeration, present study was carried out to determine the effect of pond aeration on survival, growth of fish and water quality parameters using locally manufactured pond aerators.

MATERIALS AND METHODS

Experiment was conducted in six equal sized (26'x12'x6') brick lined ponds (with a layer of clay deposited on the bricks). The soil type was clay loam. These six ponds were divided into two sets of treatments – one set consisting of 3 artificially aerated ponds served as treatment I (T_1) and other set of 3 non-aerated ponds served as treatment II (T_2).

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Fingerlings of *Labeo rohita* (rohu), *Cirrihinus mrigala* (mori), *Hypophthalmicthys molitrix* (silver carp) and *Ctenopharyngodon idella* (grass carp) were stocked in all the six ponds. Each pond having stocking density of 2508 fish/acre. The stocking ratio was 7:4:4:3 respectively.

Aeration was done with the help of $^1/_3$ HP vertical pump diffusers (Model No. WA-3, $^1/_3$ HP. 220V-AC, manufactured by Hybrid Techniques Pvt. Ltd.) in treatment I (T_1). Two pump diffusers were used for each aerated pond. Aeration was done for 1 hour during the month of March and for 3 hours (1:00 a.m.- 4.00 a.m.) during the month of April to July. Dissolved oxygen was measured after every 4 hours at 1ft depth of surface water during the months of April to July and diel fluctuations were observed. Supplementary feeding was done in each pond with 20% protein diet (maize gluten 20%, rice polish 67%, fish meal 12%, vitamin premix 1%) @ 3% body weight twice a day (8:00 a.m. and 4:00 p.m.). Ponds were fertilized fortnightly with cattle manure @ 500 kg/acre and inorganic fertilizers (urea, super phosphate) @ 20:20:0 (N:P:K). Fish was also fed with green fodder.

Water samples were fortnightly collected from surface, column and bottom of each pond using Kemmerer and Van Dorn Bottle Sampler. Two sub stations were fixed in east and west corner of each pond. Water samples were mixed to have a composite sample. These water samples were stored in plastic bottles of one liter capacity. The samples were carried to the laboratory in an insulated box at 4°C and stored in refrigerator before analysis. The analysis was conducted within 24 hours of sample collection. Temperature and pH were determined at the spot. Temperature was determined with the help of alcoholic thermometer and pH was determined with the help of Lutron-pH meter. pH meter was daily standardized with pH-tablets (BDH, Chemicals, Pool, England). Dissolved oxygen was recorded with the help of YSI-Model-57 Dissolved Oxygen Meter. The dissolved oxygen meter was calibrated after one week using Winkler's method (American Public Health Association, 1995).

Other physico-chemical parameters determined were total ammonia, free carbon dioxide, total alkalinity, total hardness, calcium hardness, chloride, turbidity and conductivity by the methods prescribed by American Public Health Association (1995) and A.O.A.C. (1984).

For growth rate studies, fish were sampled fortnightly and weighed on top loader balance. Species growth rate in terms of body weight was determined using the formula of Wootton (1990).

Student's 't' test (Steel and Torrie, 1980) was performed to see the level of significance.

RESULTS

Diel fluctuations in dissolved oxygen

Dissolved oxygen was measured after every four hours in aerated (T_1) and un- aerated (T_2) ponds. Dissolved oxygen concentrations fluctuated in both aerated (T_1) and non-aerated (T_2) ponds during the months of April to July. Minimum dissolved oxygen values were recorded at dawn and maximum dissolved oxygen values were found in the afternoon.

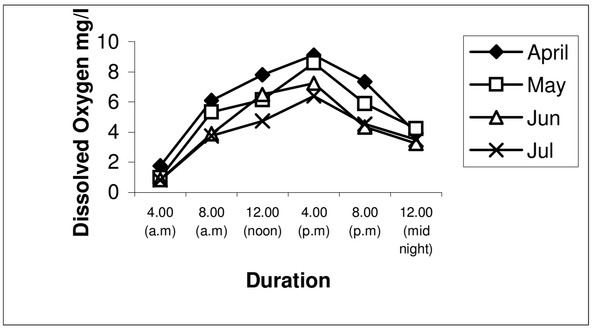
Figure 1 show diel fluctuations in dissolved oxygen for T_1 and T_2 during April to July 2001. Dissolved Oxygen was maximum at daytime and minimum during night in both aerated (T_1) and non-aerated ponds (T_2). In T_2 dissolved oxygen was < 2.0 mg/l at 4 a. m. and < 5.0 - 8.0 at 4.0 p. m. but in T_1 these concentrations were > 4.0 mg/l and > 6.0 - 9.0 mg/l respectively. Plankton abundance and sunshine has favored the photosynthetic rate during daytime, therefore, dissolved oxygen was >5.0 mg/l in both T_1 and T_2 (Fig. 1). Maximum dissolved oxygen was during the month of April and minimum during the months of June and July. Cloudy season resulted in decreased oxygen during these months. Aeration from 1.0 p. m. to 4.0 p. m. in T_1 maintained the dissolved oxygen within the desired range resulting in better survival and growth of fish in T_1 as compared to T_2.

Fish survival

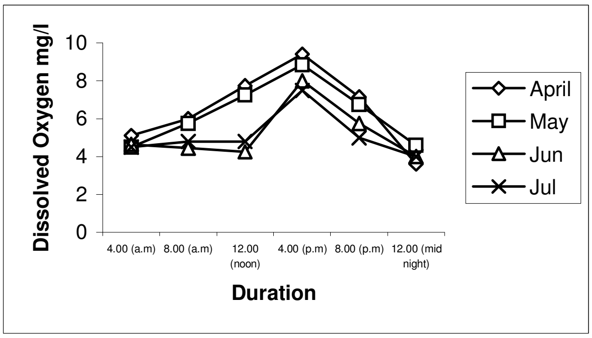
Percentage survival rate was monitored on daily basis for all the four species under study. Survival rate was 62% (rohu), 61% (mori)), 67% (silver carp and grass carp) for T_1 but 30% (rohu), 0% (mori), 17% (silver carp) and 37% (grass carp) for T_2 during 5 months period of study. Survival rate for all the four fish species was 64% in T_1 and 21% in T_2 (Fig. 3). Hollerman and Boyd (1990) reported

92% survival in aerated ponds and 40% survival in un-aerated ponds in their studies on night aeration in Channel Catfish ponds. Percentage survival rate in present study was less as compared to the survival rate reported by them.

Unaerated ponds



Aerated ponds



Aerated and unaerated ponds

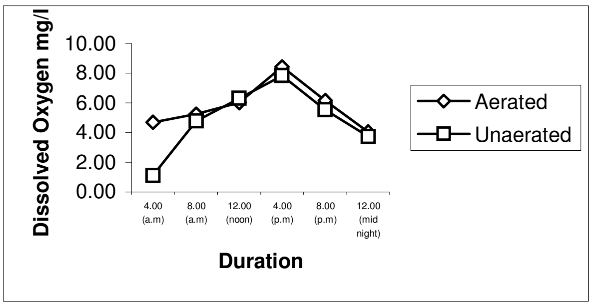


Fig. 1. Mean diel fluctuation in dissolved oxygen in aerated and un-aerated ponds during the months of March to July 2001.

Fish growth

The fish growth rate was determined fortnightly for aerated (T_1) and non-aerated (T_2) experimental sets. There was a highly significant increase (P<0.001) in weight of Rohu and Silver carp during the months of May, June & July in T_1 as compared to T_2 (Fig. 2). Grass Carp showed highly significant increase (P<0.001) in weight during the four months (April-July 2001) and Mori showed significant increase in weight during the months of March (P<0.01), and highly significant increases in weight during the month of May & June (P<0.001). Due to mortality of whole fish (Mori) in T_2 during the month of July, weight comparisons could not be made with T_1.

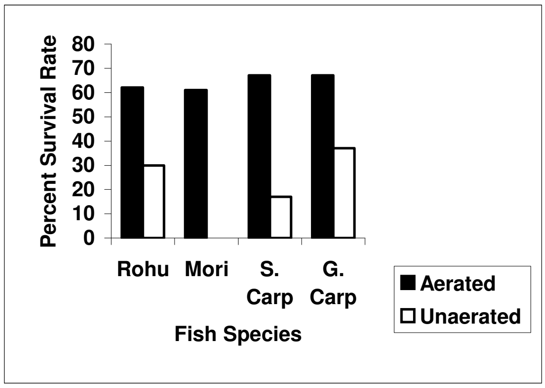


Fig. 2. Comparison of survival rate (%) in rohu, mori, silver carp and grass carp.

Fish growth/production per acre was also calculated and compared for both the treatments (T_1 & T_2). Fish production was 867 kg/acre, 612 Kg/acre, 615 kg/acre and 475 kg/acre for rohu, mori, silver carp, grass carp in T_1 and 265 kg/acre, 0 kg/acre (due to mortality of whole fish), 99 kg/acre and 146 kg/acre in T_2, respectively.

Mayer *et al.* (1973) in his studies on Channel Catfish ponds reported that the average yield in aerated ponds was 5307 kg/hectare with net economic gain of $ 1500/hectare. The un-aerated ponds yielded an average of 1400 kg/hectare and were obvious economic failure. The total cost of fish @ Rs.70 per kg was Rs. 179830 from T_1 (aerated ponds) and 35700 Rs. from T_2 (non-aerated ponds. There was Rupee 94850 more income generation from aerated ponds (T_1) by fish sale as compared to the non-aerated ponds (T_2).

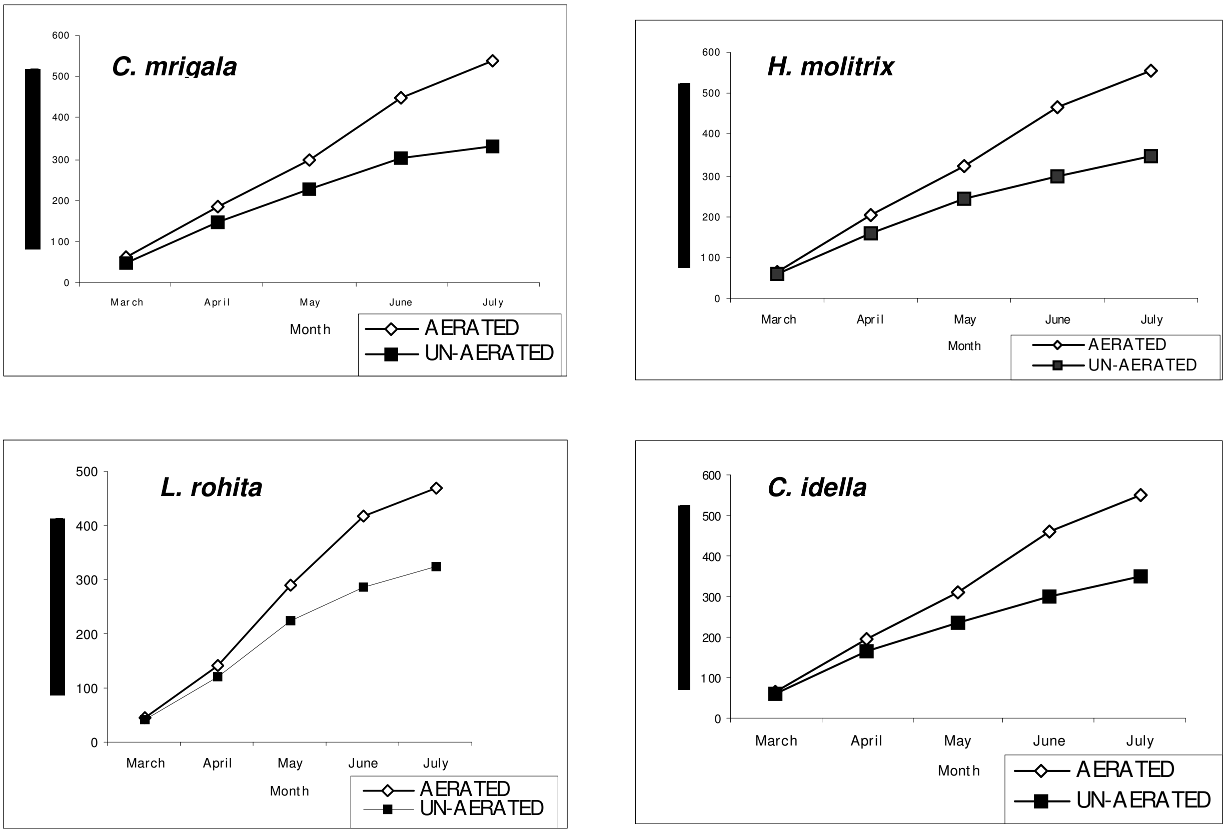


Fig. 3. Average weight of *C. mrigala, H. molitrix, C. idella* and *L. rohita* in aerated and un-aerated ponds.

Water quality parameters

Water quality parameters i.e. total alkalinity, total hardness, magnesium hardness and chloride did not show any significant difference ($P<0.05$) within the treatments and between the treatments Fig. 4).

Total ammonia nitrogen concentrations were measured during the months of May and June. Maximum concentration was at dawn, when dissolved oxygen concentrations were low. During the month of May these concentrations were 30 µg/l (T_1), 73 µg/l (T_2) but during the month of June these concentrations were 39 µg/l (T_1) and 80 µg/l (T_2).

Temperature

Temperature of water was between 15°C -30°C and 15°C -31°C at dawn but 18°C -31°C and 18°C -32°C at dusk for T_1 and T_2 respectively. pH values were 7.1-8.0 & 6.5-7.5 at dawn and 7.3-7.8 & 6.8-7.7 at dusk for aerated (T_1) and non-aerated (T_2) ponds (Fig. 5).

Weather conditions

During the month of March, the sky was clear most of the time. During the months of April and May weather was almost clear with full sunny days (cloudy during the end days of May) but during the months of June and July, weather was cloudy and there was continuous rain during the last few days of July.

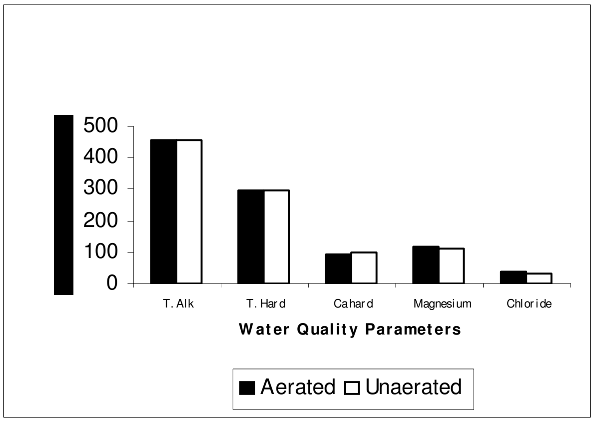


Fig. 4. Comparison of water quality parameters in aerated and un-aerated ponds.

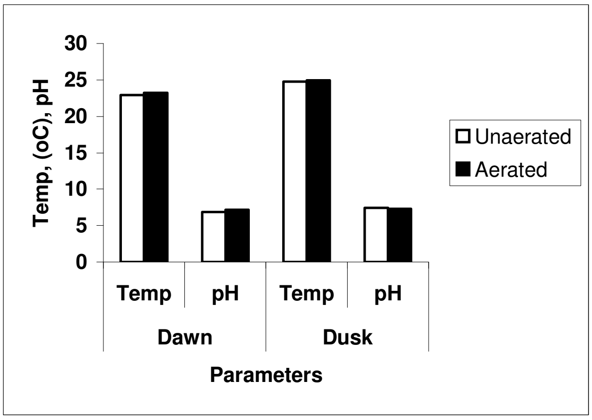


Fig. 5. Comparison of temperature and pH at Dawn and Dusk in aerated and un-aerated ponds.

DISCUSSION

Average survival rate for all the four fish species was 64% in T_1 and 21% in T_2 (Fig. 3). Hollerman and Boyd (1990) reported 92% survival in aerated ponds and 40% survival in un-aerated ponds in their studies on night aeration in Channel Catfish ponds. Percentage survival rate in present study was less as compared to the survival rate reported by them.

Fish growth/production per acre was also calculated and compared for both the treatments (T_1 & T_2). Fish production was 867 kg/acre, 612 kg/acre, 615 kg/acre and 457 kg/acre for rohu, mori, silver carp, grass carp in T_1 and 265 kg/acre, 0 kg/acre (due to mortality of whole mori due to lack of oxygen in cloudy weather conditions), 99 kg/acre and 146 kg/acre in T_2, respectively. Mori showed significant increase in weight during the months of March ($P<0.01$), May and June ($P<0.001$) but whole fish died in T_2 during the month of July due to oxygen depletion. Mori being bottom feeder (feeds on detritus) mostly remained on the bottom and anaerobic conditions at the pond bottom I n cloudy weather resulted in mortality of whole fish in un-aerated ponds. Better survival rate of mori in aerated ponds was due to sufficient oxygen in the ponds during cloudy weather. Silver carp mostly remains on the upper surface of water and its survival rate is better.

Boyd (1982) employed dissolved oxygen dynamics, aerator performance data and price information in channel catfish ponds and estimated 20% to 25% increase in profit for 1.49 kw/ha of supplemental aeration. Mayer *et al.* (1973) in his studies on Channel Catfish ponds reported that the average yield in aerated ponds was 5307 kg/hectare with net economic gain of $ 1500/hectare. The un-aerated ponds yielded an average of 1400 kg/hectare and were obvious economic failure. Fish production (2569 kg/acre) was significantly high ($P<0.001$) in aerated ponds as compared to the fish production (510 kg/acre) in un-aerated ponds. Pond aeration has resulted in 2095 kg/acre more fish production. Fish production in aerated ponds is higher in present studies as compared to the reported fish production by Mayer (1973) in channel catfish ponds but lower in un-aerated ponds, which seems to be due to mortality of whole mori resulting in overall decrease in fish production. The total cost of fish @ Rs. 70 per kg was Rs. 179830 from T_1 (aerated ponds) and 35700 Rs. from T_2 (un-aerated ponds). There was Rs. 144130 more income generation from aerated ponds (T_1) by fish sale as compared to the un-aerated ponds (T_2).

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