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DIURNAL VARIATION IN SOME WATER QUALITY PARAMETERS OF DIFFERENT INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEM

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Abstract

The present study was conducted to evaluate water quality parameter at different times of a day in an integrated multi-trophic aquaculture system. Four treatments: T_1 (prawn+rohu), T_2 (prawn+rohu+mola), T_3 (prawn+rohu+mola+snail) and T_4 (prawn+rohu+mola+snail+aquatic vegetable), and one control (only prawn) were included in the experimental design. Four water quality parameters (Temperature, DO, pH, CO_2) were measured at 2 hours interval of a day, and recorded for one month March 2022. The maximum mean water temperature was found 24.67±1.89 ℃ at early afternoon (2 pm) in the control, while the minimum value noticed as 16.93±0.45 ℃ at morning (6 am) in the T1. The highest mean DO was measured at evening in the T2 (5.38±0.48 mg/L), while the minimum mean value observed in T1 (4.10±0.36 mg/L) at morning. pH value was found higher in evening (7.69±0.35) than in the morning (7.29±0.17).pH value was found higher in T4 (7.69±0.35) where vegetable and snail were present compared to the control where no vegetable and snail was present. The highest CO_{2value} was recorded in the control (16.32±1.1 mg/L) at the morning, while the lowest mean value noticed in the treatment 4 (12.89±1.62 mg/L) in the evening (6 pm). This study has pointed out that the water quality parameters in the prawn production ponds were influenced by the inclusion of different aquatic animal and vegetables in the IMTA system.

Keywords: Water quality, IMTA, Time variation

Introduction

Aquaculture has been one of the prominent industry because of its significant demand for fish and seafood allover the world (Cao *et al*., 2007) and it is accounted for 46% of total fish supply (Nyanti *et al*., 2012). Bangladesh, a developing country with an agricultural economy, is the only one with abundant natural fisheries resources. In terms of worldwide fish production, Bangladesh comes in at number four (FAO, 2018). Similar to the global trend, Bangladesh's capture fisheries are expanding very slowly, which has led to an increased reliance on aquaculture. 55.93% of the total fish production was contributed through aquaculture which is characterized by traditional, improved traditional and semi-intensive farming systems; feed supply and labor-intensive management have been being increasingly evident (Ali *et al*., 2013).

The farming of freshwater giant prawn is currently one of the key ventures of Bangladesh's national economy, which provides food production, employment opportunities, and significant foreign exchange profits. Unplanned integrated farming of tilapia (*Oreochromis* sp.), rui (*Labeo rohita*), silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and persa (*Liza parsia*) with prawn in their fish farms. But they don't have idea about proper way of integrated fish farming. Polyculture or mixed culture of *M. rosenbergii*with mola (*Amblypharyngodon mola)* and rui (*L. rohita*) would be a good combination for farming. On the other hand, to boost up the production in shrimp ponds with an environment friendly situation shrimp and finfishes would be a profitable approach (Shofiquzzoha and Alam, 2008). Integrated Multitrophic Aquaculture (IMTA) is one environmentally friendly method that can increase pond output. IMTA has to be shine out in both domestic and exports sector such as shrimp, Tilapia sp., oyster, and seaweed (Pantjara, 2011). IMTA is the system of farming aquaculture species of different trophic levels with complementary ecosystem functions, in a way that one's uneaten feed, waste, and by-

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products are utilized as fertilizers, feed, and energy for the other crops, and to benefit from synergistic interactions between species (Chopin *et al.,* 2001, 2008; Troell *et al*., 2003; Neori *et al*., 2004).

Water quality is the bone of culture system. Fishes are cold blooded so its growth, reproduction, maturity, survival and production mostly rely on water temperature. Certain factors of water quality had an effect on fish development and reproduction. Inadequate maintenance of water quality might be caused severe problems in their production. Poor maintenance of water quality may cause fatal death of fishes. Water quality is the prime factor to increase fish production as well as the primary production in water body. In IMTA system, the nutrients leached out from the feed as well as unused feed are likely utilized by other animal and plant species being integrated; thus water quality parameters vary with integration of different potential species. The objective of this experiment is to observe the variation of water quality parameter in the prawn IMTA system with different crop species integration.

Materials and Method

Study area and period

The experiment was carried out in the experimental ponds of 240 m^2 where water depth was maintained as 1.5m. The prevailing sunshine was fully exposed to every pond, and ponds were filled with fresh water. The experiment was carried out from 21 February to 21 March of 2022.

Experimental Design

In this research, identical-sized rectangular experimental ponds were used. The ponds were allocated to four different treatments (T1, T2, T3 and T4) and one control. Ponds were stocked with Prawn ($2/m^2$), Carps ($0.1/m^2$), Mola ($2/m^2$). Feed (30% protein) were applied in control and all treatments. During juvenile stage feed were applied at 8% of biomass and gradually decreased to 3%.

Sample Collection

Between 6 am and 8 pm, water samples were taken at 2 hours intervals from the pond's surface in order to determine the water quality variables (Temperature, pH, DO, CO_2) in every day from 21 February to 21 March, 2022.

Determination of water quality parameter

Water temperature, dissolved oxygen (DO), pH were instantly determined in the in the pond using digital instruments. Water carbon dioxide (CO_2) was analyzed in the water quality laboratory.

Results

Water Temperature

The temperature raised in the morning and continued to early afternoon, then gradually decreased as the day went on (Figure 1). The maximum mean water temperature was found 24.67±1.89 ℃in early afternoon (2 pm), while the minimum value noticed at morning (6 am) was 16.93±0.45 ℃. In the evening, Temperature is higher than morning but lower than afternoon. There was significant difference of water temperature between different times of a day for a certain treatment but there was no significant difference between the various treatment groups for a specific time of a day.

Dissolved Oxygen (DO)

DO changed depending on the time of day. The DO increased in the morning and continued to afternoon, then gradually decreased as time increasing (Figure 2). The highest mean DO was measured at evening in the treatment 2 experimental pond was 5.38±0.48 mg/L, while the minimum mean value observed in treatment 1 (4.10±0.36 mg/L) at morning. There was a statistically significant change in DO at different times of a day. DO showed positive correlation with pH (Figure 2 & 3) and negative correlation with carbon dioxide (Figure 2 & 4). It was observed that DO increased as carbon dioxide decreasing at different times of a day.

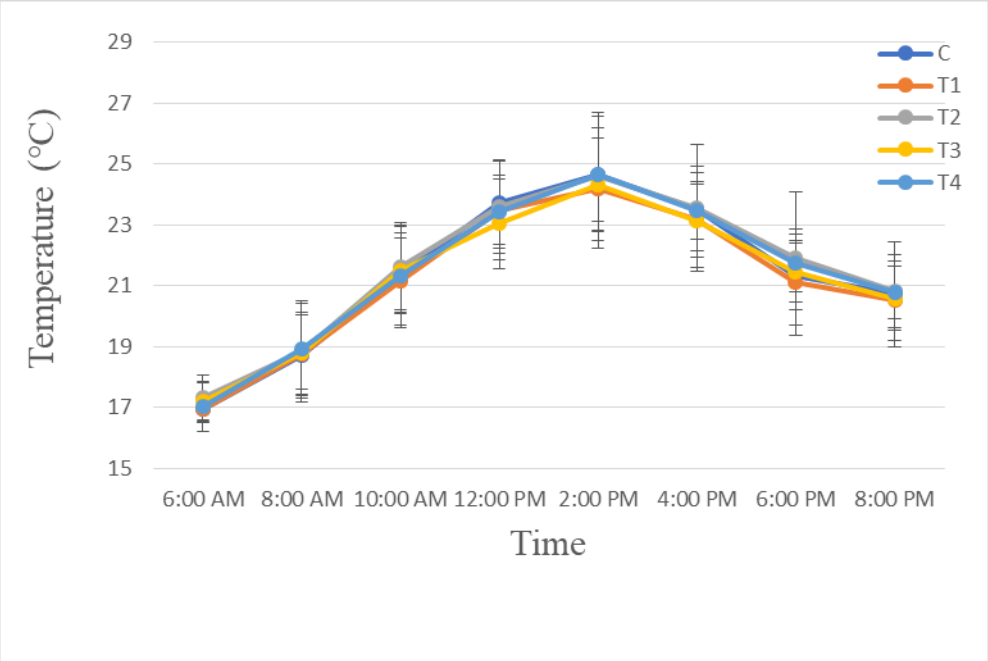

Figure 1. Water temperature at different times of a day

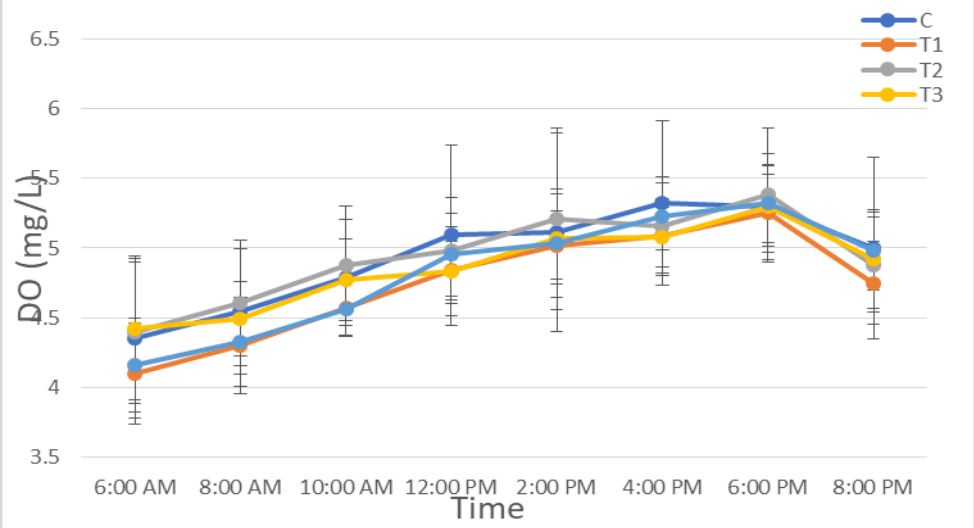

Figure 2. Dissolve oxygen at different times of a day

Water pH

Variation of pH was found different times of a day for a certain treatment group and also vary among different treatments for a specific time of a day. water pH fluctuated depending on the time where highest pH mean value found in treatment 4 (7.69±0.35) in the evening, while lowest pH mean value noticed in treatment 3 (7.29±0.17) at the morning (Figure 3). pH increased as time increased and continued to evening. Between treatment ponds, there was a statistically significant change in pH at different times of a day. pH showed weak positive correlation with DO, Temperature and negative correlation with carbon dioxide at 5% level of significance. Treatment 4 showed high pH value from other groups (Figure 3).

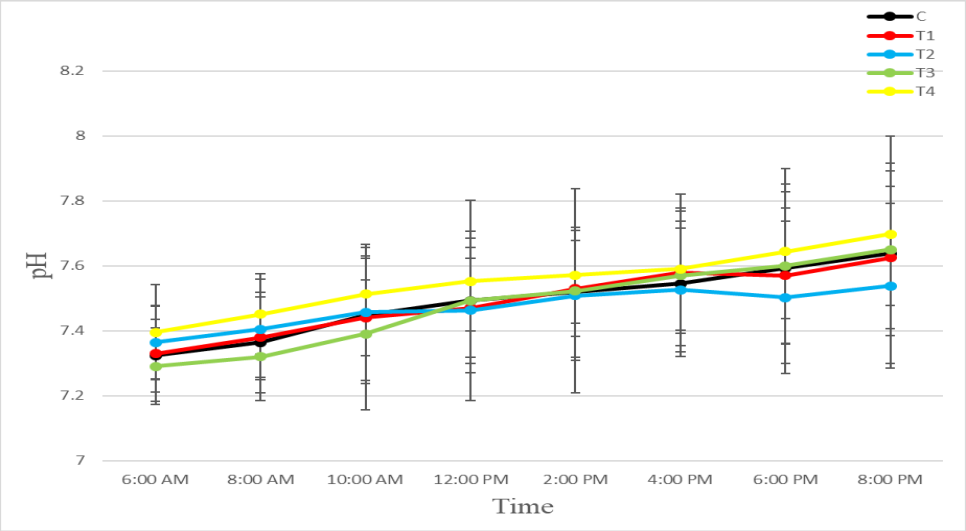

Figure 3. pH at different times of a day

Carbon Dioxide (CO_2)

Fluctuation of CO_2 was observed in various times of a day for a certain treatment group as well as between various treatments for a particular time of the day. The CO_2 of the water changed over time where highest mean value in control (16.32±1.1 mg/L) at the morning, While, lowest mean value noticed in treatment in treatment 4 (12.89±1.62 mg/L) in the evening (Figure 4).There was statistically significant difference of CO_2 between different times of a day. Free carbon dioxide is negatively correlated with pH at 5% level of significance. As result Carbon dioxide decreases as pH increases (Figure 3 & 4).

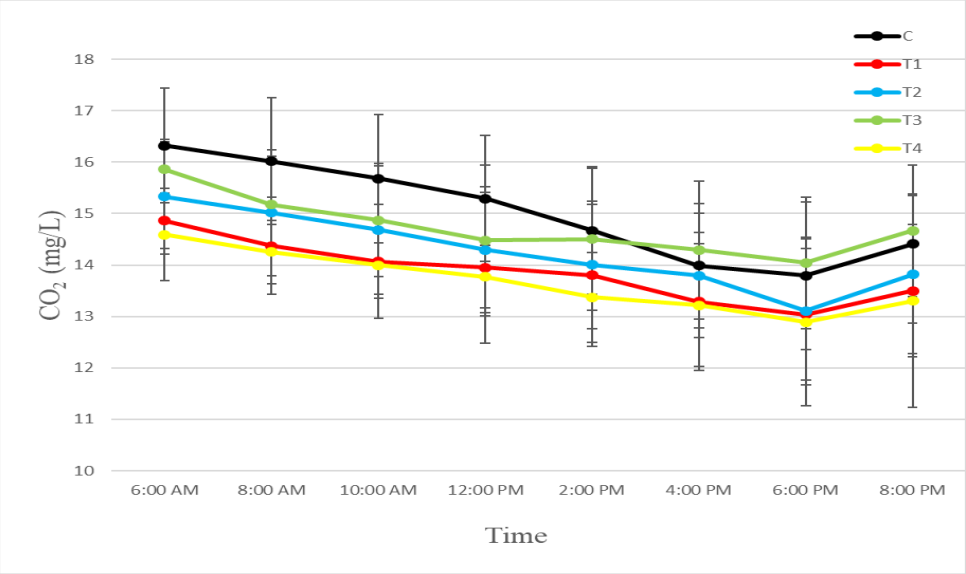

Figure 4. Carbon Dioxide with time at different times of a day.

Discussion

Management of water quality is crucial for preventing environmental stress on fish which can promote the development of many diseases. Water quality management in multi-trophic aquaculture is basically the management

of parameters daily to keep optimal condition for growth of fish. The water parameters must be in optimal range for culture system as well multi trophic culture system. Being a cold-blooded species, aquatic creatures' metabolic rates are highly correlated with water temperature. Fluctuations of water temperature with optimum level in a day may enhance the pond productivity; respiration of organism is temperature related; respiration rates can increase by 10% as 1℃ temperature rise which may impact on metabolic rate. (Livingstone, D.A., 1998). In this study, water temperature varied from 16℃ to 26℃ due to sunlight exposure from morning (6 am) to evening (8 pm). Temperature was higher at noon because of intensity of sunlight and lower at morning due to absence of sunlight The mean water temperature ranged from 16.93±0.45℃ to 24.67±1.89 ℃ (Figure 1). This is caused for shifts in the amount of daylight available, the number of trees near the pond, and the length of the day throughout the study period. The sun's location, length of the day, and presence of free CO_2 may be contributing factors to the fluctuation in water temperature across all of the ponds at different times. (Tailing, 1957). Though ideal temperature range for prawn production was 25-30℃ (Mazid,2009) which was slightly higher than that of the present study, the temperatures were within the desired range between 14℃ and 35℃ for *M. rosenbergii* (New (1990). The study was conducted in winter season; accordinglywater temperature relatively lower than other seasons due to short length of day. As water temperature depends on the intensity of sunlight, there was no significant difference among different treatments which were conducted in the study.

Prawn and aquatic species growth, survival, distribution, behavior, and physiology are influenced by dissolve oxygen (Solis, 1998). Ensuring sufficient oxygen is challenge for aquatic organisms compare to terrestrial ones due to low solubility, low atmospheric pressure, high humidity, high concentration of submerged plants, algal bloom. Poor feeding, starvation, stunted growth, and increased fish mortality are all consequences of oxygen deprivation in the water either directly or indirectly (Grag and Bhatnagae, 2000).

Variation of DO from 3.8 mg/L to 6.7 mg/L due to photosynthesis and respiration from morning (6 am) to evening (8 pm). The mean DO range was from 4.10±0.36 mg/L to 5.38±0.48 mg/L (Figure 2). Increasing of DO depends on the photosynthesis and photosynthesis occurs with the present of sunlight. Ghosh *et al.* (2016) found DO for probiotic treated prawn ponds were 5.10 ± 0.68, 5.29 ± 0.63, 5.21 ± 0.57 and 5.32 ± 0.53 mg/L which almost matches the findings of this experiment. Meyback (1989) reported that the DO content of water ranging from 5 to 6 mg/L is within good productive range. DO value of the experimental ponds at different times of a day was in good range except morning. Photosynthesis can't take place due to lack of sunlight and respiration take place continuously. As a result, DO was low in the morning and increased as time increasing. It was observed that DO declined in the evening due to lack of sunlight. From this study, it was observed that photosynthesis occurs very highly at moderate temperature. So, dissolve oxygen gradually increased just after sun rise and it was highest at 6:00 pm and lowest just before sunlight (6:00 am).

It is necessary to maintain pH level as when pH goes down to less than 6.5 fish become stressed and reproduction ceases and fry or PL die when pH less than 5.0. Death is almost certain at a pH of less than 4.0 or greater than 11.0 (Wurts *et al,* 1992); for fish culture an optimum range of pH would be 6.5 to 9.0. The mean water pH ranged from 7.29±0.17 to 7.69±0.35 (Figure 3). This is the optimum level of pH for aquaculture. (Rahman *et al.* 2001), For the productivity of the pond and normal physiology of aquatic life it is necessary to maintain pH values between 6.5 to 8.5. As time increasing from morning to afternoon, photosynthesis process was increased compare to respiration process. In this study, pH varied from 7.1 to 8.50 due to fluctuation of carbon dioxide and rate of respiration from morning (6 am) to evening (8 pm).

Concentration of Carbon dioxide (CO_2) can be increased due to respiration. When free CO2 from respiration combines with water, it creates carbonic acid (H2CO3) and lowers pH. It is rare that Carbon dioxide causes direct toxicity to fish. However, high concentrations of CO_2 cause for lower pH and limit the capacity of fish blood to carry oxygen by lowering blood pH at the gills. In this study, free CO_2 varied from 19.32 mg/L to 10.2 mg/L due to higher respiration rate compare to photosynthesis from morning (6 am) to evening (8 pm). The mean free CO_2 ranged from 16.32±1.1 mg/L to 12.89±1.62 mg/L (Figure 4). Hynes (1970) reported 25 mg/L of free CO_2 as upper limit for fish culture. Free CO_2 decreased with increasing day time because photosynthesis increase in day time. Treatment showed minimum free CO_2 value at different times from other treatments because plant continued their photosynthesis by using free water CO_2. pH increase as CO_2 decreases because carbon dioxide negatively correlated with pH (Figure 3&4).

Conclusion

Fish and crustaceans like prawns can grow successfully when water quality parameters are in optimum range. In this IMTA system, water quality parameters were evaluated in the acceptable range for prawn and fish culture. . This study demonstrated that DO, pH, CO_2, were well maintained in treatment 4 where mollusks and aquatic plants are combined in comparison to the control. Snail was used as organic extractor and vegetables acted as inorganic extractor, and integration snail and vegetables in the prawn-fish production system can ensure healthy environment of the ponds; altogether, there was effects of IMTA on diurnal water quality values of the production ponds.

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Conflict of Interest

The authors declare no conflict of interest.

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