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Applicability of water reuse for coastal shrimp ponds in southern Bangladesh

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Abstract
Coastal aquaculture is the most productive export earning sectors of Bangladesh. South-Eastern coast of Bangladesh is the most productive region of coastal aquauculture and millions of people depend on this sectors for livelihood. Three categories of tidal water exchange system based ponds of canal connected, river connected and pond connected pond were selected to study the nutrient loading and existing health management in the shrimp ponds. The aims of the study were quantified the hydrology of ponds, health evaluation test with the gut content investigation of shrimp body and nutrient loading from the shrimp ponds. It was found that higher nutrient load in the river connected pond also carried the higher growth and survival rate, feed conversion ratio and the highest production of shrimp. Although unplanned expansion and slightly improved traditional system of shrimp culture exists there is still no risk of environmental degradation in the aquatic environment of shrimp farming in Cox's bazaar region. It was concluded that reuse water or connected pond system for coastal shrimp ponds should not be practiced anywhere in Bangladesh, due to the uncertainity associated with water productivity in such regions.

Keywords: Coastal Quaculture; Growth Rate; Nutrient Load; Soil Quality; Water Productivity; Water Quality

INTRODUCTION

The coastal zone can be defined in various ways depending on the focus of interest and the availability of relevant data. According to the Millennium Ecosystem Assessment, 100 km from the coast as the distance door sill and 50 m as the elevator door sill, choosing whichever was closer to the sea. So, the interaction between the land and water considered as coastal zone where the majority of the world's population is living in the zone. About 40% of the global population inhabiting within 100 km of the coastline. Most of the developing countries of the world not have the capacity to manage the existing coastal population expansion in an evenhanded manner. This zone is rapidly changing due to the active interface between the oceans and the land. Winds and waves around the coastal area are eroding rock and sediment depositing on a regular basis, and erosion rates and deposition noticeably from day to day in the coastal zone. The energy attainment in the coastal area can become elevated during the time of storms and for that reason high energies create a coastal region of high susceptibility to natural hazards. Thus, a consideration of the interactions of the land and ocean is indispensable in understanding the hazards connected with the coastal zones (Gari *et al*., 2015).

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Coastal aquaculture is one of the supreme valuable seafood sectors, clarification for about 20% of the measure of internationally traded fisheries merchandises. The speedy ontogeny of coastal aquaculture and trawling has had intense counter environmental affects, with the direct people consequences. In the present world, shrimp farming has been connected with environmental degradation, enhanced social and economic differences, and, in some countries this business involved on violation of human rights. Besides, shrimp culture has been accountable for devastation of ecologically and economically valuable mangrove and wetland habitats and the debasement of adjacent coastal and marine ecosystems, with consequences for biodiversity conservation as well as coastal ecosystem healthiness. These same aspects also neutralize the very ground of coastal aquaculture production (Barua *et al*., 2020).

Coastal areas supply the crucial ecological processes like nutrient cycling, flood control, stability of shoreline, beach replacement and genetic resources. Ocean and coastal systems added 63% of the total value of world's ecosystem services. Increasing population is a major issue for the coastal areas with more than 50% of the world inhabitants concentrated within 60 km of the coast. The continued growth of world population and of per capita consumption has the consequences for unsustainable exploitation of world's biological diversity, worsen with the climate change, acidification of the ocean and other anthropogenic environmental effects (Gaaloul *et al*., 2020). The effective conservation of biodiversity is necessary for survival of human and the maintenance of ecosystem processes (Barua *et al*., 2017. 2020).

Coastal aquaculture specially shrimp and prawn culture predicted to continue to play an crucial part in secure food security and poverty diminution, peculiarly for the rural people. The urban inhabitants will be benefited from the improvement in processing, value adding, and marketing of the coastal aquaculture sectors as a whole. Incidence like "EU ban on Bangladeshi shrimp" should not occurred again and most significantly, this business sectors is operating under capacity and can addition the productiveness up to five times than the current capacity. A majority of shrimp and prawn industry based workers in the processing industries are women. The shrimp industry benefits three to four million "mostly poor" Bangladeshis while providing living conditions directly numbering some 15,20,000 people. In 2014-2015, a total of 1,67,65 MT shrimp produced in Bangladesh that contributes 20,785.90 Crore BDT in the GNP (Table 1).

There is a huge demand in the international markets for frogen foods of Bangladesh because the country is blessed with an environment friendly for shrimp production. Technological conception has been creating a greater effect on internal economy. A primary study was confiscated to observe the problems pestilence the different levels of the value chain of coastal aquaculture product in the country. The swelling demand and steadily rising prices of coastal aquaculture products encouraged its cultivation in the coastal belt of the country (DoF, 2015; Barua *et al*., 2017).

The rapid increase of coastal aquaculture production in Bangladesh led to uncontrolled and unsustainable conversion of such coastal wetlands, particularly mangrove wetlands to shrimp cultivation ponds in the recent times, raising concerns among climate scientists, environmental managers, and policy-makers regarding the impact of coastal aquaculture systems on prevailing coastal ecosystems. Furthermore, eutrophication and ecological degradation of coastal and estuarine systems was caused due to nutrient-rich effluents, chemicals, antibiotics, and feeds from fish and prawn culture ponds. Furthermore, the introduction of exotic species and the dispersal of diseases disturb the ecological sustainability of the coastal ecosystem. In Bangladesh, the south-east coast experienced a significant loss of mangroves due to large-scale conversion to aquaculture ponds, such as that experienced in the Chattogram coastal plains. Further expansion of aquaculture ponds in the other potential areas along Bangladesh's coast toward coastal wetlands, deltas, and estuaries is expected in future.

Coastal regions are environmentally, economically and politically important areas supporting a diverse range of industries and large population centers. As society increasingly populated along the coasts, the deterioration of the coastal environment has become a critical issue. One of the most significant problems is the over enrichment of coastal waters with nutrients. Introduction of excess nitrogen and phosphorus to the area may lead to the eutrophication effects by unbalancing organic supply to the marine ecosystem. One of the most negative effects of the eutrophication encompasses oxygen deficiency in bottom waters followed by mass mortality of fish and benthic organisms (Leangruxa *et al*., 2010).

Nutrient load is the mass of nutrients carried by water into surrounding waterways, over a period of time. Because of the use of fertilizers and manure, water that passes through agricultural soils often carries a high 'nutrient load' into local creeks. An overabundance of nutrients in water causes algae to grow, use up oxygen, and reduce the availability of oxygen to the other organisms such as fish (Hepher, 2015).

Coastal aquaculture specially shrimp and prawn culture predicted to continue to play an crucial part in secure food security and poverty diminution, peculiarly for the rural people. The urban inhabitants will be benefited from the improvement in processing, value adding, and marketing of the coastal aquaculture sectors as a whole.

Table 1. Shrimp production in the South-east coast of Bangladesh (1990-2019) (Barua *et al*., 2020)

Season	No. of farm	Area of farm (Ha)	Total production (MT)	Average production (Kg/ha)
1990	1855	26673.45	4698.61	175.15
1991	1879	27388.91	4185.10	196.32
1992	1889	27410.53	5381.40	196.32
1993	1901	27359.62	5454.16	199.35
1994	2040	28466.57	5451.16	191.52
1995	2055	28521.22	4174.36	160.95
1996	2055	28521.24	4490.38	157.44
1997	2055	28521.24	3683.355	129.144
1998	2150	29025.09	6301.42	217.10
1999	2174	29025.09	6700	230.83
2000	2184	29131.28	5086.47	174.60
2001	2184	29131.28	4809.55	165.09
2002	2184	29131.28	4972.94	170.71
2003	2403	32018.21	7107.69	221.51
2004	2560	33335.41	8586.88	257.59
2005	2580	33350.50	9086.89	272.46
2006	2580	33367	9090.90	272.5
2007	2590	33390	9150.00	274
2008	2600	33400	10500.50	314.37
2009	2610	33450	12540.00	374.9
2010	2620	33500	13450	401.5
2011	2645	35456	14565	425.56
2012	2655	35489	15422	435.45
2013	2658	36235	16325	525.45
2014	2662	36756	16765	535.45
2015	2665	37123	17545	587.56
2016	2720	38980	18500	590.65
2017	2790	40435	19800	595.00
2018	2820	42145	20500	610.54
2019	2890	43245	21500	625.00

Incidence like "EU ban on Bangladeshi shrimp" should not occurred again and most significantly, this business sectors is operating under capacity and can addition the productiveness up to five times than the current capacity. A majority of shrimp and prawn industry based workers in the processing industries are women. The shrimp industry benefits three to four million "mostly poor" Bangladeshis while providing living conditions directly numbering some 15,20,000 people. In 2014-2015, a total of 1, 67,65 MT shrimp produced in Bangladesh that contributes 20,785.90 Crore BDT in the GNP. There is a huge demand in the international markets for frogen foods of Bangladesh because the country is blessed with an environment friendly for shrimp production. Technological conception has been creating a greater effect on internal economy. A primary study was confiscated to observe the problems pestilence the different levels of the value chain of coastal aquaculture product in the country. The swelling demand and steadily rising prices of coastal aquaculture products encouraged its cultivation in the coastal belt of the country (DoF, 2015; Barua *et al*., 2017). Health management should be an ongoing process, not a series of reactions to disease. The degree of management required controlling the introduction and development of diseases varies with the magnitude of production, with the intensity of production, with the design of the facility and with risks due to known (and also unknown) hazards and to the nature of life support.

One of the most important criteria for a successful operation is to ensure that the health of the shrimp is maintained. Shrimp health management is a term used in aquaculture to describe management practices which are designed to prevent shrimp disease. Successful shrimp health management begins with prevention of disease rather than treatment. Prevention of shrimp disease is accomplished through good water quality management, nutrition, and sanitation (Quyen *et al*., 2020). So, properly managed ponds can provide the excellent fishing opportunities to a large number of anglers at a reasonable cost. However, it takes careful planning and wise management to maintain the high-quality fishing in a pond year after year. To produce a good crop of shrimp every year, it is necessary to select the proposed site carefully, construct the pond properly, maintain good water quality, availability of exchanging tidal water and stock and harvest the pond correctly. Often the difference between a productive pond and an unproductive one is the ability of the owner to obtain sound pond management advice and carry out the recommended practice.

The present study has been undertaken to estimate the water and soil quality of shrimp ponds, estimation of growth rate, growth and production nutrient loading of 3 different tidal water exchanged based shrimp ponds, analysis of water and soil quality for the suitability of the culture ponds, observation of growth performance and health evaluation of shrimp in the experimental ponds.

MATERIALS AND METHODS

Site selection

Chakaria Upazila, the highest shrimp culture and production area for Cox's Bazar. was selected for the research work. Its geographical coordinates are 21°30'27.67''N and 92° 1'46.15''E. The selected experimental culture ponds are located in the inter-tidal water of the Matamuhuri river estuary, which drains into Bay of Bengal. These farms are situated on the southern side of the Matamuhuri (Bara Muhuri) river (Figure 1).

Selection of experimental ponds

There are 3 types of coastal shrimp ponds selected for the research work on the basis of the water exchanged system. First category of pond was river connected pond (RCP), where water was exchanged of this pond occurred directly from the river; the second category of pond was canal connected pond (CCP) where water was exchanged from canal and third category of pond was pond connected pond (PCP) where water was exchanged or sourced from another culture pond. Grow out pond of each 3 categories of ponds were selected for experiment. Total production area of canal connected, river connected and pond connected pond are 81ha, 107ha and 28ha, 265 acrewhich occupy 66.6%, 69.7% and 70% respectively of total farm area.

Sampling design

The entire network sampling of the present study twice a month, full moon and new moon over one year during the year of 2018. Time to go to the different sampling stations had been selected by using the tide table referenced by BIWTA (Bangladesh Inland Water Transport Authority) to know the starting and ending time of ebb and flood.

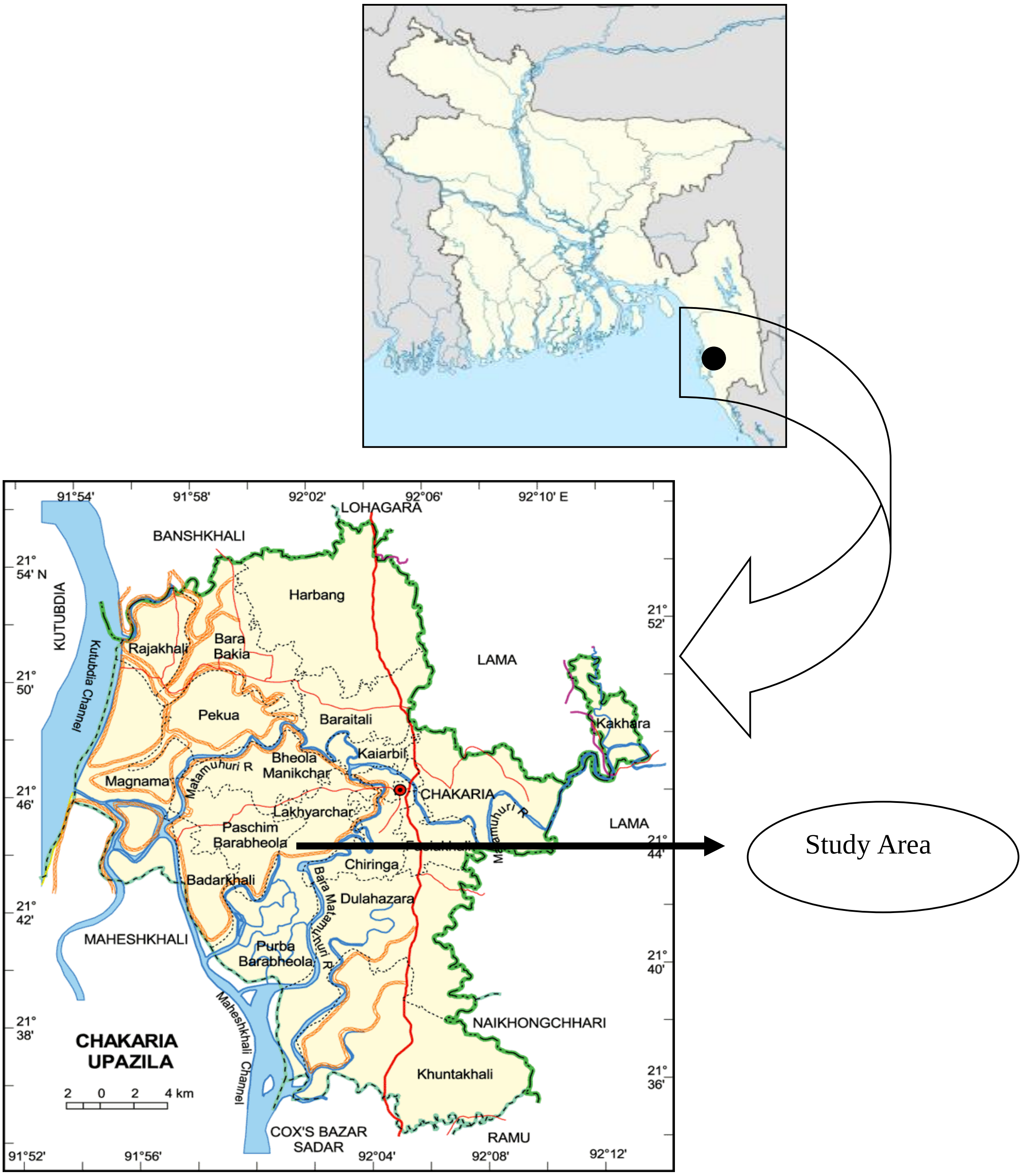

Fig. 1. Geographical location of the study areas

Health Management Issue

One of the most important criteria for a successful operation is to ensure that the health of the shrimp is maintained.

Water quality analysis

The entire network of the present study comprise of the evaluation of the health of coastal ponds with respect to the selective physico-chemical parameters, that is surface water salinity, pH, temperature, dissolved oxygen (DO), BOD (3-day at 27oC) and Total suspended and dissolved solids during the culture period (February to September, 2017). Surface water salinity was assess in the field by refractometer and cross-checked by argentometric method. pH of the pond water was recorded by a portable pH meter (sensitivity = ± 0.02). Surface water temperature was estimated by a Celsius thermometerand transparency was measured in the field by using a Secchi disc of 30cm in diameter. D.O, B.O.D, TDS and TSS were analyzed as per the procedure stated in APHA (2012).

Analysis of Soil quality

Collected soil samples from each 3 ponds were air dried, powdered and passed through a 2mm mesh sieve. Before analysising the soil samples were finally dried in an oven at 60^{0}C for 24 hours. Soil pH of water was determined by digital soil pH meter, Soil texture was analyzed by the formula described by Boyd and Tucker (1992), Soil salinity was measured by formula described by Richard (1954), Soil alkalinity was measured by method described by Boyd (2012). Organic matter of the soil was determined by method described by Jackson (2013).

Variables to consider in determining the health of shrimp

Farmers commonly consider a number of variables when they evaluate the health of the shrimp in the culture system. These variables include survival rate, mortality rate, growth rate, size variation, food conversion ratio and appearance of the shrimp (Brock *et al.,* 2014).

Survival rate was calculated by using the formula described by Solbe (2010). Absolute growth rate and specific growth rate in terms of length and weight was determined from a simple arithmetic calculation, which was also advocated by Sedgwick (2017). The feed conversion ratio (FCR) is calculated by following formula as advocated by Castell and Tiews (2015), FCE or Feed efficiency is the reciprocal of the FCR converted to a percentage value: it was determine by following formula as advocated by Castell and Tiews (1980).

Health Evaluation Test

Gut content exams were only done when a growth or survival problem is encountered. This evaluation can be done by an assessment of the relative degree of fullness of abdominal appendages. According to the guideline of gut content formula by Clifford and Cook (2002). Again, In addition to quantifying gut fullness and using it to detect under-feeding or predict the onset of disease, the color of the shrimp's gut contents can also be very informative. Again, application for formula of gut content colour by Clifford and Cook (2002).

Data collection

This part of the study was based on primary and secondary data. Different techniques and tools were used to gather the data. To gather data about health management of shrimp farms, include: Questionnaire survey and interview. Interviews of the farmers were carried out . In developing the questionnaire, a pretest was done with the interviews to check the effectiveness of formulated questions and made necessary corrections prior to the survey. Secondary data included topographic maps and land use data of study area, annual report from Bangladesh Meteorological Department, Cox's Bazar and policy document of District Fisheries office, Cox's Bazar and Upazila Fisheries office, Chakaria, Bangladesh Frozen Foods Exporters Association which all involved in coastal shrimp aquaculture were collected.

Nutrient loading for experimental ponds

The nutrient load from an aquaculture farm is the difference between what is supplied with the feed and what is utilized by the fish or their growth. According to the formula by Ackefors and Enell (2016):

The equation for the phosphorus load is
$$\text{Kg P} = (A \times C_{dp}) - (B \times C_{fp}) \quad (1)$$

The equation for the nitrogen load is
$$\text{Kg N} = (A \times C_{dn}) - (B \times C_{fn}) \quad (2)$$

Where,

A = wet weight of feeds used per year (normal water content in dry feed is 8.10%)

B = wet weight of fish produced per year

C_d = phosphorus (c_{dp}) and nitrogen (C_{dn}) contents in feed, expressed as % of wet weight

C_f = phosphorus (Cfp) and nitrogen (Cfn) content of the fish, expressed as % of wet weight

Statistical Analysis

After obtaining all of the parameters mentioned above, these were analyzed by standard statistical methods described by Pauly (1983). SPSS (Statistical package for social Sciences) software was used for the analysis of correlation coefficient (r).

RESULTS AND DISCUSSION

Water quality

Temperature has a pronounced effect on the biochemical and metabolic process of shrimp (Barua *et al.*, 2011). After one year investigation, average water temperature was 27.8^{0}C, 26.6^{0}C and 28.8^{0}C in canal connected, river connected and pond connected pond, respectively. Nagarajaiah (2015) observed that, highest temperature prevailing during May-June in two brackish water ponds of Mangalore that corroborates with the present finding. Mahmud (2015), Singh (2016) and Hassan (2018) reported that the temperature cycle of the water followed rather closely the meteorological cycle of air temperature.

Salinity is the main distinguishing factor among the experimental ponds. Average salinity was 17500 ppm, 18600 ppm and 15750 ppm in canal connected, river connected and pond connected pond, respectively (Figure 2).

Apud *et al.*, (2016) reported that the salinity range of 10-25 ppt 10000-25000 ppm was congenial for shrimp growth.

Water p^H was more or less constant throughout the study period through a gradual decrease was observed in culture ponds. During the study, pH ranged from 7.2 to 8.6 in 3 experimental ponds. No significant variation of water pH *among* the 3 experimental ponds have been observed (Figure 2).

Dissolved oxygen is the most critical water quality variable in aquaculture (Boyd, 2012) and it can be a limiting factor in shrimp culture (Wyban *et al.*, 2018). BAFRU (1996) reported that D.O range should be 5-7 mg/l and DoF (2015) stated that D.O level 4.0-6.0 mg/l is the ideal value for *P monodon* culture in Bangladesh. Average value of dissolved oxygen was 5.72 mg/l, 5.77 mg/l and 5.27 mg/l at canal connected, river connected and pond connected pond respectively. So, the present study for D.O range in shrimp ponds clearly ensured for suitable range of shrimp culture (Figure 2).

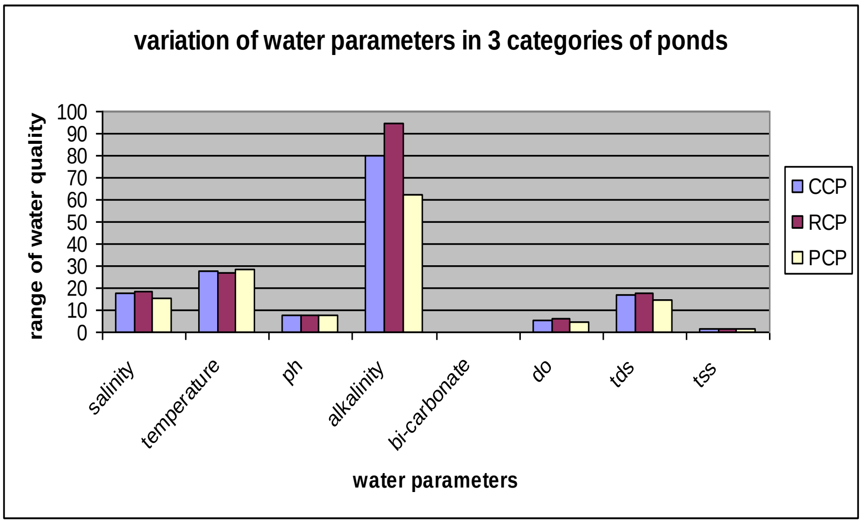

Fig. 2. Variation of water parameters on 3 ponds

Alkalinity of water is a measure of its ability to neutralize acid that acts as a buffer to change the water pH and thus a low alkalinity may allow the average value of the water pH to fall. Average alkalinity at canal connected pond was 80 ppm, 95 ppm and 62.5 ppm at canal connected, river connected and pond connected pond (Figure 2). During the investigation, very low level of alkalinity 40 mg/l was found in pond connected pond although it was the standard range for shrimp culture in Bangladesh (BAFRU, 1996).

During the present study, total dissolved solids ranged from 0.145 gm/l to 33.749gm/l in the experimental ponds which is suitable range for aquaculture as Meade (2014) reported that TDS ranged below 400 mg/l is the optimum values for aquaculture. During the investigation it was found that salinity and TDS has close relationship. During rainy season, salinity decreased and TDS also decreased, salinity become increased, TDS also increased (Figure 2).

Total suspended solids ranged during the present study from 0.198 gm/l to 3.356 gm/l. According to Meade (2014), total suspended solids range below 80 mg/l is the optimum range for aquaculture. Boyd and Gautier (2000) stated that initial standard 100 mg/l or less and target standard 50 mg/l or less are the standards for shrimp farms effluents. TSS also has a strong relationship with salinity, When salinity decreases, TSS also decreases, and salinity becomes increased, TSS again increased (Figure 2).

The present study indicated the suitable range of bicarbonate (0.122 mg/l to 0.654 mg/l) for shrimp culture in the experimental ponds. BAFRU (1996) stated that 0.2 to 2 mg/l of bicarbonate is the target standard for shrimp culture in Bangladesh (Figure 2).

Soil Quality

Range of salinity in the experimental ponds was moderately suitable. Salinity values were 17.50$‰_0$, 20.40$‰_0$ and 15.56$‰_0$ in canal connected, river connected and pond connected pond respectively. Soil pH in the experimental ponds was neutral. The pH values were 6.6, 7.0 and 6.4 respectively in canal connected, river connected and canal connected ponds respectively (Figure 3).

Soil alkalinity values in the experimental ponds was moderately suitable for shrimp culture. Range of alkalinity levels were 31.5 ppm, 34.01 ppm and 28.75 ppm in canal connected, river connected and pond connected pond respectively. Boyd (2012) recommended that alkalinity range 15-20 ppm is normal, 25 ppm is moderately suitable and 30 ppm is highly suitable range for coastal aquaculture. So, Alkalinity range in the present study was 28.75 to 34.01 ppm which indicate the slightly higher level than suitable range of soil alkalinity (Figure 3).

Recorded value of organic carbon of experimental ponds is Mineral soil, moderate organic matter content, and best range for aquaculture. Range of alkalinity range was 1.647 %, 2.356 % and 1.165 % in canal connected, river connected and pond connected pond respectively. Boyd (2012) also reported that organic carbon value 0.60-1.50% is highly suitable for aquaculture. Ahmed (2015) reported that organic carbon range 0.95 to 1.50% is the suitable range for coastal aquaculture of Bangladesh. Organic carbon in the present study was 1.165% to 2.356% which is the best range for shrimp farming according to Boyd (2012). But the range of organic carbon in the experimental ponds was higher than report of Ahmed (2015). This variation was found due to using supplementary feeds in the ponds which remain unusedd and deposited on the soil bottom. Organic matter of experimental ponds is 2.832 %, 4.052% and 2.00 % in canal connected, river connected and pond connected pond (Figure 3).

Soil texture analysis of experimental ponds is a sandy loam or loam. According to sandy clay loam type is the preferable soil type for brackish water finfish and shrimp culture. Ahmed (2015) reported that sandy clay loam to sandy loam is the suitable for coastal aquaculture in Bangladesh. So, it can be lucidly remarked that the bottom soil of all of the studied ponds were suitable for shrimp culture (Figure 4).

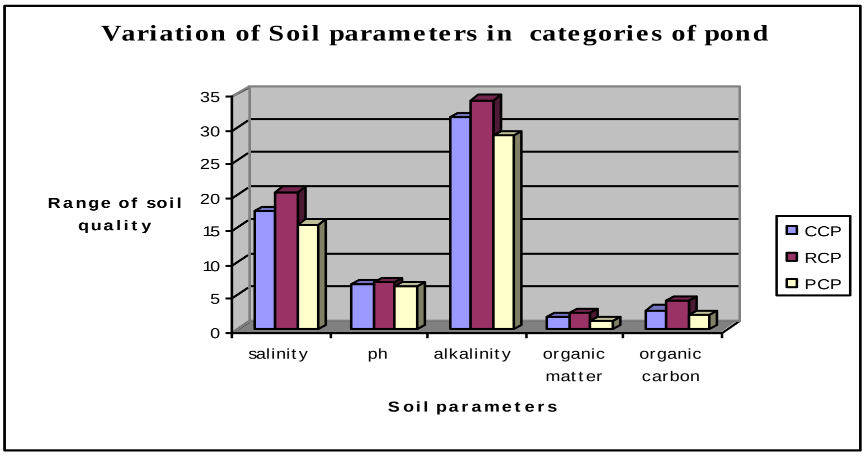

Fig. 3. Variation of Soil quality on 3 coastal ponds

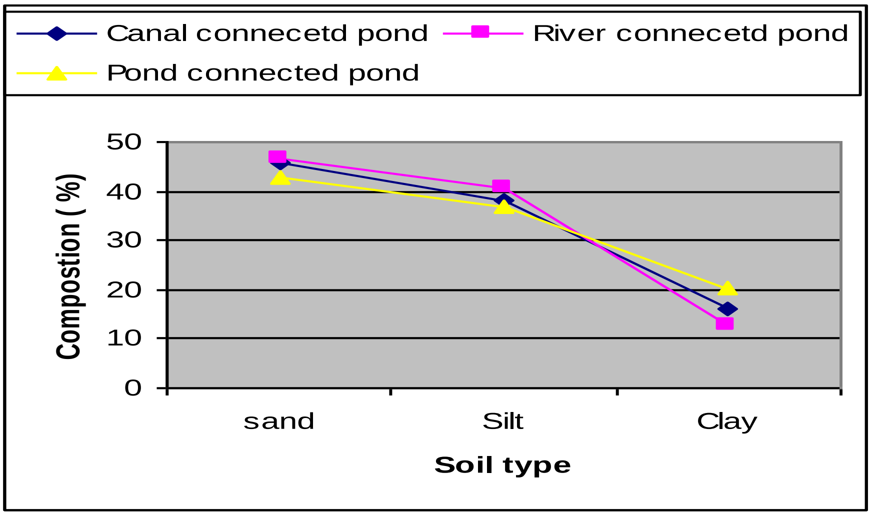

Fig. 4. Soil Texture (%) of three types of 3 ponds

Growth rate

Growth rates are a good indicator of the health of the shrimp in aquaculture. The absolute growth rate of canal connected pond, river connected pond and pond connected pond was 0.201 gm /day, 0.205 gm/day and 0.175 gm/day respectively (Table 2).

On the other hand, Specific growth rate (SGR) of canal connected , river connected and pond connected pond was found 1.02 % /day, 1.03 % /day and 0.94 % /day, respectively (Figure 5-6).

Food value determination

Feed conversion ratio of canal connected, river connected and pond connected pond is 3.24, 3.67 and 1.12, respectively (Table 3).

On the contrary, food conversion efficiency (FCE) of canal connected, river connected and pond connected pond was 30.80%, 27.23 % and 89.20 % , respectively (Figure 7-8).

Survival rate

Survival rate of canal connected, river connected and pond connected pond was 45%, 50% and 38 %, respectively (Table 4).

Gut content analysis

For the length-weight and survival rate, then all of the samples should display the intestinal tract (mid-gut) run the length of the tail to be full of food. The overall average of grade for canal connected, river connected and pond connected pond varied from 1.9, 2 and 1.4 respectively. Clifford and Cook (2002) reported that if the overall average for the sample is 1.6 or less, it may indicate under-feeding or disease. So, it was concluded that shrimp (*P. monodon*) of pond connected pond not healthy and they are attacked by disease or under-feeding stage (Table 5).

Table 2. Growth record of P monodon in the 3 ponds after rearing 150 days

Types of pond	Pond size (m^2)	S.D/m^2	Length (mm)	Weight (gm)	Growth (g/day)	stock	Survival (%)	No of juvenile	Biomass (kg)	Production (kg/acre)
CCP	809400	5	165	38.45	0.256	4047000	45	1821150	70023.21	55.12
RCP	1072455	4.5	170	39.08	0.260	4826047	50	2413023	94300.93	60.78
PCP	283290	5	158	32.45	0.230	1416450	40	566580	18385.52	42

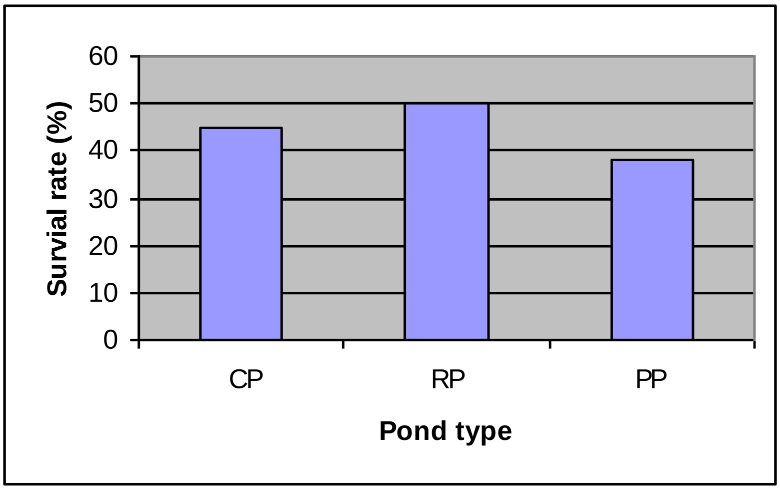

Fig. 5. Survival rate (%) of shrimp of 3 coastal ponds

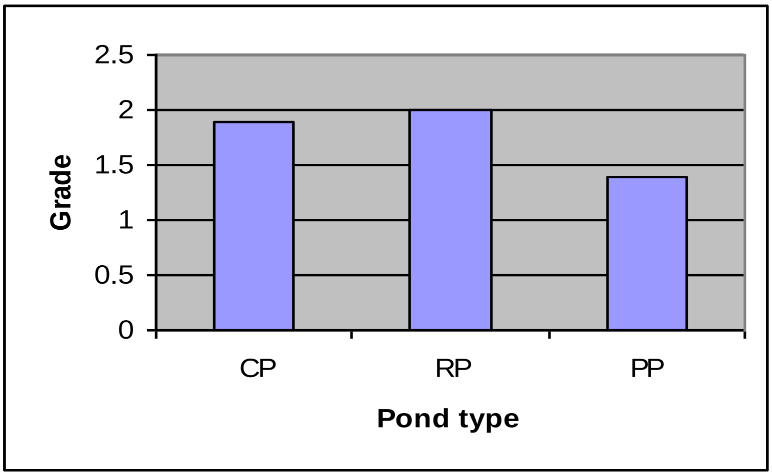

Fig. 6. Grade of shrimp gut in 3 coastal ponds

Table 3. Estimation of supplied feed and FCR in three ponds

Types of pond	Pond size (m^2)	Growth (g/day)	No of juvenile	Biomass (kg)	Feed (%)	Cumulative feed (kg)	FCR	Production (kg/acre)
CCP	809400	0.256	1821150	70023.21	3.5	2450.8	4.5	55.12
RCP	1072455	0.260	2413023	94300.93	4.0	3772.0	4.2	60.78
PCP	283290	0.216	566580	18385.52	4.0	735.42	4.0	42

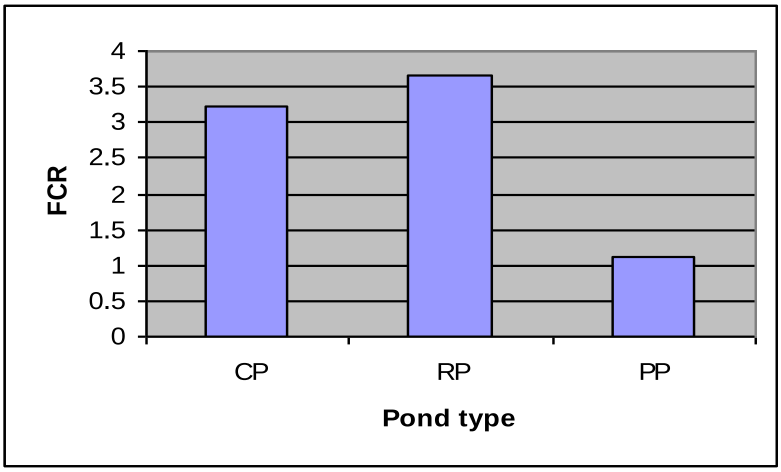

Fig. 7. Variation of Food Conversion Ratio of 3 ponds

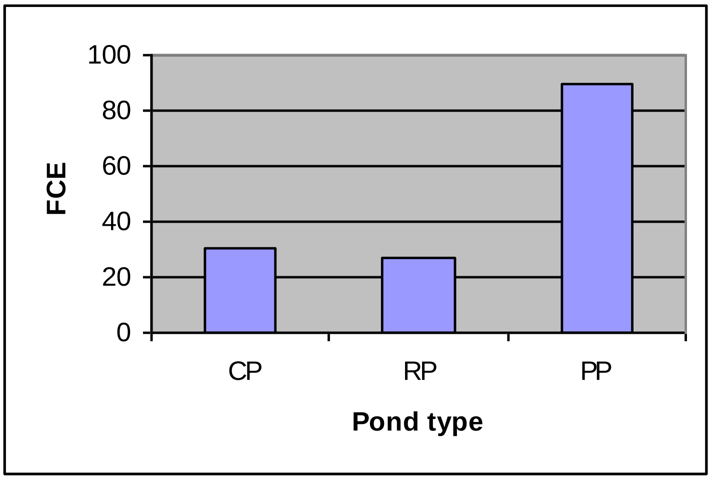

Fig. 8. Variation of Food Conversion Efficiency of 3 ponds

Table 4. Estimation of supplied feed and FCR in three ponds

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PCP	283290	0.216	566580	18385.52	4.0	735.42	4.0	42

Table 5. Gut content colour of 3 categories of ponds

Types of Ponds	Gut Content Color	Probable Food Item	Probable Cause (S)
Canal Connected Pond	Black, dark brown	Benthic detritus, sediment	Under-feeding; inadequate feeding frequency
	Green	Benthic algae	Under-feeding
River Connected Pond	Black, dark brown	Benthic detritus, sediment	Under-feeding; inadequate feeding frequency
	Green	Benthic algae	Under-feeding
Pond Connected Pond	Red, pinkish	Cannibalized body parts from dead shrimp	Disease event in pond
	Green	Benthic algae	Under-feeding
	Pale, whitish	None (disease condition)	Gregarines, or some other disease condition (*)

Gut colour also indicated disease outbreak in ponds which result the unhealthy shrimp which ultimately expressed poor environmental condition of water body in pond connected pond. Again, In addition to quantify the gut fullness and using it to detect under-feeding or predict the onset of disease, the color of the shrimp's gut contents can also be very informative.

Length-weight Relationship

In canal connected pond, during stocking time the average length was (9.2 ±0.23) cm and final length was estimated (16.5± 0.21) cm. The average weight of the brood was (8.26 ±0.12) gm during stocking and at the final stage it was found to be (38.45 ±0.19) . The values of intercept "log C" and slop "n" of brood were -0.240 and 1.21 respectively, where the correlation coefficient (r) was 0.931 and the value of "t " was 4.41. Correlation is significant at the 0.005 level (1-tailed) (Figure 9).

In river connected pond, during stocking time the average length was (9.2 ±0.23) cm and final length was estimated (17.0± 0.20) cm. The average weight of the brood was (8.26 ±0.14) gm during stocking and at the final stage it was found to be (39.08 ±0.20). The values of intercept "log C" and slop "n" of brood were -0.01 and 1.16 respectively, where the correlation co-efficient (r) was 0.928 and the value of "t" was 5.99 Correlation is significant at the 0.05 level (1-tailed) (Figure 10).

In pond connected pond, during stocking time the average length was (9.2 ±0.21) cm and final length was estimated to be (15.8± 0.22) cm. The average weight of the brood was (8.26 ±0.10) gm during stocking and at the final stage it was found to be (34.5 ±0.20). The values of intercept "log C" and slop "n" of brood were -0.01 and 1.16 respectively, where the correlation co-efficient (r) was 0.910 and the value of "t" was 3.80. Correlation is significant at the 0.05 level (1-tailed) (Figure 11).

The value of 'n' in fish and shrimp usually lies between 2.5 and 4.0 (Hile, 2015). The value of 'n' will be ex1ctly 3.0 when the growth is isometric in length-weight relationship of fish (Ricker, 2013). Clifford and Cook (2002) found the value of `n' fairly close to 3.0 for Penaeid shrimp. Mahmood (2015) and Alam (2016) reported that the value of 'n' for *P. monodon* were below 3.0 But In present study, the values of 'n' in canal connected, river connected and pond connected ponds were 1.21, 1.16. 1.16 respectively. So, it may be said that the present findings support the study of Mahmood (2015) and Alam (2016).

Nutrient Loading

It was found that phosphorus load of canal connected, river connected and pond connected pond was 59.54 kg, 109.96 kg and 4 kg respectively. On the other hand, Nitrogen load of canal connected, river connected and pond connected pond was 235.87 kg, 370.9 kg and 56.36 kg respectively.

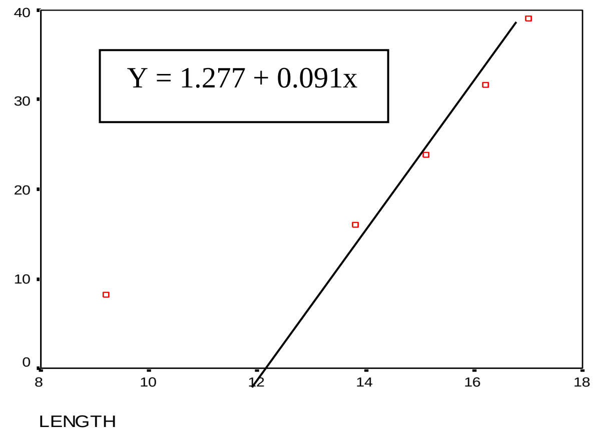

Fig. 9. Length-weight relationships of shrimp in CCP

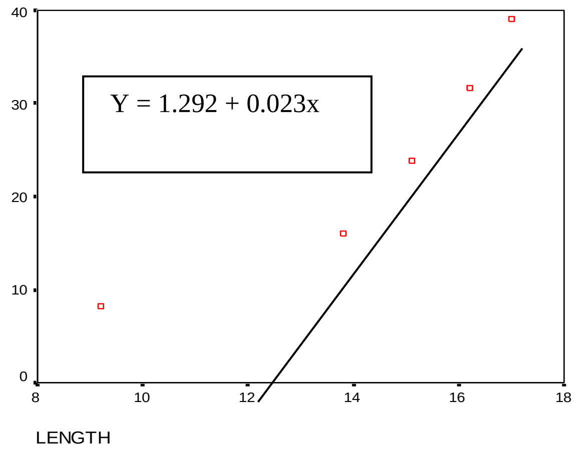

Fig. 10. Length-weight relationships of shrimp in RCP

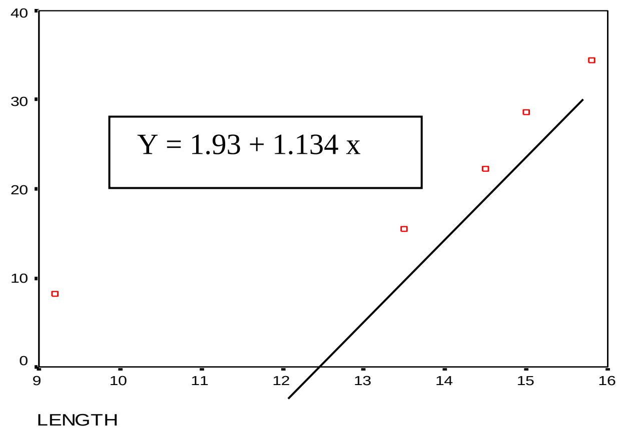

Fig. 11. Length-weight relationship of shrimp pond in PCP

Coastal shrimp aquaculture in Bangladesh is still traditional to improved traditional. Farmers use low amount of lime and fertilizer and the application of feed were rare to absent. Present study indicated that traditional extensive system of shrimp culture not provides any significant loading of nutrients to the surrounding coastal environment. Excessive use of fertilizer and feeds in semi-intensive and in intensive (Alam, 2016) culture system causes a considerable amount of nutrient discharge in the natural water through the discharge canal. Where as, extensive shrimp culture ponds are supplied with small amount of nutrients. The average input of nitrogen and phosphorus to intensive shrimp culture in Thailand was 858 kg TN $ha^{-1}cycle^{-1}$ and 291 kg $ha^{-1}cycle^{-1}$ (Briggs and Funge-Smith, 2018), which is 11 time for TN and 7 times for the estimated average input of the present study. Rouf *et al.* (2015) reported that average input of nitrogen and phosphorus to improve the traditional shrimp culture in Khulna was 48.706 kg TN ha^{-1} $cycle^{-1}$ and 28.954 kg $ha^{-1}cycle^{-1}$.

In the present study, pond are supplied very low amount of feeds (rice bran, nmustared oil cake, wheat bran and rice starch) with more reliance on fertilization. So, the overall nutrient mass balance of the present study indicates that fertilizer was the highest nutrient contributor (67.3% TN and 92.18%TP), which can be best compared with Rouf *et al.* (2015) who reported 60.2% TN and 82.4% TP and Abdul-Wahab (2014) who reported 67%TN and 71% TP contribution from fertilizer in extensive shrimp farm. However, Abdul-Wahab (2014) reported intake water as the second largest source of TN (33%) and TP (29%). During the present study, intake water as found second largest source of nutrients (20.53% N and 1.59% P) in canal connected pond. Rouf *et al.* (2015) reported that feed (21.1% N and 9.3% P) was the second highest nutrient contributor in the improved traditional shrimp ponds while during the present study feed also the second nutrient contributor of experimental ponds (16.5% N and 6% P).

Only 34.3% of nitrogen and 8.25% of phosphorus were removed as harvested shrimp, fish and crab that is supported strongly by Rouf *et al.* (2015). who estimated 33.4% N and 6.1% P and Pratoomyot *et al.* (2018) also estimated 24.8% N and 9.1% P removed as shrimp harvested.

The effluent loading is strongly affected by the water exchange rate throughout the growth cycle. Abdul-Wahab (2014) reported that 13% of Tn and 21% of TP was discharged effluent as net loss to he surrounding water, which supports the overall mass budget of present study in terms of nitrogen (14.3 %), but different scenario has found in terms of phosphorus which is very low (1.65%), which also similar to the study of Rouf *et al.* (2015) who estimated effluent water has 14.5% N and 2% of P. the lower rate of TP discharge may be due to less water exchange in the average mass balance. Because the individual budget of the river connected pond having higher flushing rate (96%) in compare to other types showed the higher P discharge of 1.9 % which also supported by the study of Rouf *et al.* (2015) who found higher flushing rate (66%) of river connected pond showed higher discharge rate of 8.17%.

Rouf *et al.* (2015) estimated that the intake of nutrients through supply rater (TN 5.72 kg cl^{-1} and TP 0.38 kg cl^{-1}) were slightly higher than nutrient discharged (TN 5.6 $kgcl^{-1}$ and TP 0.36 $kgcl^{-1}$) through water discharged, which indicates that small amount of nutrients enrichment within the farms was occurred rather load to he river. In the present study, it was found that average intake of nutrients through supply water and discharged water was same ranged (TN 12.5 kgcl-1 and TP 0.708 $kgcl^{-1}$). So, it is clear that improved traditional shrimp culture is not loading nutrients to the wider aquatic environment, rather acting as a nutrient removal from that system.

According to Edwards (2014), in extensive and semi-intensive systems, typically a major part of nitrogen and phosphorus is accumulated in the sediments. This also strongly supports the findings of the present study. 28.7 kg N and 37.75 kg P ha-1 cycle-1 accounts for 37.73 % of TN and 89.4% of TP output ended up in sediments and unaccounted for. Rouf *et al*. (2015) estimated 20.6 kg N and 26.66 kg P ha-1cycle-1 accounts for 39.1% of TN and 92% of TP output form sediments which was closely similar to the present study. According to Islam *et al*. (2014) 10% of nitrogen was estimated as unaccounted. Unaccounted nitrogen may have been trapped in the systems or lost through denitrficataion, ammonia volatilization and diffusion at high pH and seepage (Boyd, 2010). When calculating nitrogen budget for shrimp farms, denitrification and ammonia volatilization are two potential loses of nitrogen that are often not measured directly (Jackson *et al*., 2013). Denitrification and ammonia volatilization in the semi-intensive shrimp farm are reported 10% by Rouf *et al*. (2015). Although other researchers in other studies reported it 30%, a lower value of 3# was also reported by Jackson *et al*. (2013). Rouf *et al*., (2015) estimated nitrogen removed through denitrification and ammonia volatilization is assumed 13% according to Doson, 2014. During the present study, denitrification ranged was 8.18%.

Present study has indicated that average range of nutrient enrichment (0.0032 g/m^3/year TN and 0.0016 g/m^3/year) has been occurred within the ponds for shrimp farming. Rouf *et al*. (2015) found also minor nutrient enrichments (0.002g/m^3/year TP and 0.004 g/m^3/year TN). Minor difference of TN and TP among the supply and discharge water in the present study support the minor level nutrient enrichment within the system. There is no TN and TP standard set up for Bangladesh coastal water.

Hambrey (2017) referred the effluent standards for coastal water in Asia –Pacific countries where the ministry of Agriculture, India, 1995 mentioned the TN as 2 mg/l and TP (0.2-0.4 mg/l). but it is observed that nutrient level particularly NH_3-N (0.50-2.60 mg/l) at the experimental ponds is comparatively higher than the standard level declared by the Department of Environment of Bangladesh (1.2 mg/l), NEB, 2011 (<0.4 mg/l) from march to August. i.e., during the peak shrimp culture period. Dissolve oxygen also indication of nutrient pollution. But through the shrimp culture period DO was more than 5 mg/l . It implies that nutrient level within the system is in such a stage that there is no question of eutrophication during the shrimp culture period. Additionally 60-96% flushing rate in the experimental ponds may also pave the control of eutrophication within the system. In that respect, it may be said that the environmental capacity may not exceeding in the shrimp culture of the study area. Additionally, environmental capacity is not exceeding according to the Vietnam standard (4mg/l N and 2 mg/l P).

Correlation (r) between Nutrient load and health management

The correlation coefficient “r” indicates a relationship between nitrogen and phosphorus load with health management issue for shrimp pond. Correlation coefficient ‘r” shows significantly correlated between nutrient loading with survival rate, water temperature, salinity, alkalinity and total suspended solids. Nutrient load has positively correlated with Feed Conversion Ratio (FCR). Specific Growth Rate (SGR), Absolute Growth rate (AGR), Dissolved Oxygen and Total Dissolved Solids (TDS) But negatively correlated with Feed Conversion efficiency.

CONCLUSION

Shrimp is one of the most valuable seafood commodities, accounting for approximately 20% of the value of internationally traded fishery products. The rapid growth of shrimp farming and trawling has had the serious negative environmental impacts, with direct human consequences. Worldwide, shrimp farming has been associated with environmental degradation, increased social and economic disparities, and, in some countries, serious human rights abuses. Shrimp aquaculture has been responsible for the destruction of large areas of ecologically and economically important mangrove and wetland habitats and the degradation of adjacent coastal and marine ecosystems, with implications for biodiversity conservation and ecosystem integrity. These same factors also undermine the very basis of shrimp production.

Coastal shrimp aquaculture is an important industry in Bangladesh because it is an important source of earning foreign currency. However, the present practice of shrimp aquaculture is not sustainable, because it has damaged the local socio-economic, environmental, ecological and cultural environment of coastal Bangladesh on a long term basis. The main reason behind this unsustainable aquaculture is the unplanned and unscientific methods of shrimp cultivation, and lack of integration among various components of the local ecosystem. The integration optimizes the ue of land and water resources such as wastes produced by aquaculture systems minimize by other components of the ecosystem. In addition, the integration will enhance the protection and restoration of coastal ecosystems, ensure ecologically sustainable development, mitigate coastal resources use conflicts, increase employment opportunities and develop public participation in coastal management processes.

While conversion to commercial monoculture shrimp farming can impact agricultural productivity, in some cases conversion to the integrated shrimp or polyculture farming systems can bring the benefits for small-scale farmers and may represent more ecologically sustainable approaches to shrimp farming. Polyculture incorporates several species occupying different ecological niches into a single farming system. This can improve resource-use efficiency, and, on a farm level, can help to insure against risks of disease or changes in market conditions. Such systems can be closed and relatively self sufficient and integrated farming technologies where resources and wastes are re-circulated within the farm may be one way of reducing the ecological footprint of shrimp farming. Improved traditional shrimp culture practice in Bangladesh where lot of fin, shell fish and crabs are found. Farmers no worried about the shrimp disease or less production, because by production from other species they earning lot of money and economically benefit able which is called "Environmental Risk Assessment".

Sustainable aquaculture development can bring real and lasting benefits to real and coastal communities. But the environmental consequences of inappropriate or excessive development will adversely impact on the wider communities and the farers themselves through poor farm performance or failure. There is therefore an increasing need for good planning an management of aquaculture in our countries. Environmental capacity is being used in some progressive developed countries to inform the management of aquaculture as it provides a more objective basis on which to plan and regulate aquaculture conditions, recognizing the cumulative impacts of resource users and th assimilative capacity of the environment.

Research finding of the present study suggests that the present level of coastal shrimp culture practice no longer risk of exceeding environmental capacity. The water quality in shrimp ponds and aquatic system during culture cycle in this experiment was also in acceptable range.

Present status of nutrient (TN and TP) concentration for shrimp farming is less and the aquatic environment is able to accommodate the preset level of aquaculture practice. However, it was found that there is close relationship between nutrient load and growth, survival and production of shrimp pond. Generally very few amount of feed (some ingredients) applied into the pond which provides nutrient is significantly lower, that results in the low aquaculture production. Because of less production and having less to no chance of environmental capacity degradation shrimp farms should be provided with adequate fertilizer and feed to increase the shrimp production.

During the investigation, it was found that nutrient enrichment, growth performance, water and soil quality and production of shrimp were very poor in pond connected pond which practiced reused water from another shrimp pond. So, farmers must need to stop use reused water as a water sources for shrimp culture. Effective strategies to control the occurrence and spread of disease are primarily related to proper management of the production system. When shrimp are cultured in a poorly managed environment, both growth and survival rates will decrease. To ensure that the shrimps are under a limited amount of stress, it is necessary to establish and implement good management practices. At the same time, it is also important that current shrimp lands are properly managed and their yield is increased at an acceptable level.

Therefore, it may be expected that the present study will give an valuable information to develop and demonstrate an improved shrimp culture technology for the country and serve as a source of information for the researcher who will be interested to work on nutrient loading and dynamics for coastal aquaculture in Bangladesh. Reusing water should be stopped for the water sources of shrimp culture. It could not help to water productivity.

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