ZIBELINE INTERNATIONAL PUBLISHING

Water Conservation And Management (WCM)

DOI: http://doi.org/10.26480/wcm.02.2020.61.67

ISSN: 2523-5664 (Print)
ISSN: 2523-5672 (Online)
CODEN: WCMABD

CrossMark

RESEARCH ARTICLE

AQUATIC HEALTH INDEX OF COASTAL AQUACULTURE ACTIVITIES AT SOUTH-EASTERN COAST OF BANGLADESH

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ARTICLE DETAILS

Article History:

Received 21 Februaryr 2020
Accepted 23 March 2020
Available online 09 April 2020

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. The present paper is an attempt to evaluate the economically viable shrimp culture zone through enumeration of Aquatic Health Index in and around south-east coast of Bangladesh. In the present study, 10 important sites for coastal aquaculture activity area selected for the study and the aquatic health index value of these stations varied as per the order Stn. 4 >Stn.6 > Stn. 2> Stn. 1> Stn. 5> Stn. 3 > Stn. 7> Stn. 10> Stn. 8> Stn. 9. The lower value of the index reflects deteriorated condition of the water due to excessive industrial, shipbreaking activities and domestic run-off.

KEYWORDS

Coastal Aquaculture, Aquatic Health Index (AHI), Shipbreaking activities.

1. INTRODUCTION

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 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.

In the setting of increasing world population and food demand, coastal aquaculture is considered as one of the fastest growing food industries in the earth. Even though deep-sea and inland fish capture encounters half of the share of the world fish demand, the coastal aquaculture industry donates almost 50% of world fish consumption. As per the latest estimates by the Food and Agricultural Organization (FAO), world aquaculture production reached 76.6 million tons (excluding aquatic plants and non-food products) with a value of 157.9 billion USD in the year 2015. This marks 4% annual growth from production in the year 2014, which was about 73.8 million tons (Ottinger, 2017). Depend on the world fish production, consumption, and multi-market models, the total fish supply is expected to increase from 154 million tons in 2011 to 186 million tons in 2030, with the coastal aquaculture industry solely responsible for the increase. This rapid development has significant effects on the coastal land-use systems worldwide. Although an increase in coastal aquaculture production is expected in all regions, the largest expansion (about 121%) is expected in Bangladesh during the time period of 2010–2030 (Kobayashi et al., 2015).

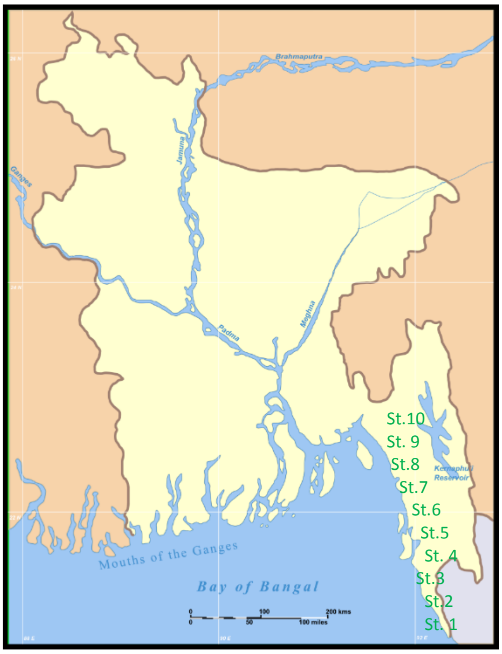

Figure 1: Geographical Location of the Study Areas

Quick Response Code	Access this article online	
	Website: www.www.watconman.org	**DOI:** 10.26480/wcm.02.2020.61.67

Cite the Article Prabal Barua and Syed Hafizur Rahman (2020). Aquatic Health Index Of Coastal Aquaculture Activities At South-Eastern Coast Of Bangladesh. *Water Conservation And Management, 4(2): 61-67.*

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 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 other potential areas along Bangladesh's coast toward coastal wetlands, deltas, and estuaries is expected in future.

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. There is 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., 2011; Barua and Sarker, 2010).

Bangladesh has taken high superiority on coastal aquaculture activities in the coastal area due to improvement of socioeconomic situation of marginalized peoples through shrimp farming This sector become a high export earning industry and livelihood development of the coastal peoples in Bangladesh (Thia-Eng et al., 1989). On the other hand, this shrimp farming sector also responsible for huge environmental cost to coastal communities and ecosystems (Salequzzaman, 2001: Yeh, 2002) because it is expanded by mangrove destruction, biodiversity loss and economic loss of fishermen, coastal pollution, loss of employment opportunity and even violation of human rights (Salequzzaman, 2001).

Coastal aquaculture in Bangladesh mostly performing in the two coastal region that are South-Western and South-Eastern area. Among the total cultivation area, about 80% of the shrimp and prawn aquaculture activities are going on in the south-western coastal area (Khulna-Satkhira-Jessor) while the others are located in the southeast (Cox's Bazar and Chittagong coastal area) coastal areas. Total area of coastal aquaculture activities in south-east region now 37,123 ha and average production of the targeted species is 587.56 kg/ha under the 2665 No of shrimp ponds reference (Table 1) (DoF, 2015).

Table 1: Shrimp production in the South-east coast of Bangladesh (1990-2015) (*)

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

* Source: (DoF, 2015)

Due to difference in water salinity in the two coastal region of the country, the culture practices and production period of shrimp and prawn in the two areas are completely different (DOF, 2015). The Chakaria Sundarban areas located in the south-east coast of Bangladesh on the location of Chakaria Upazilla in Cox's Bazar District. This coastal zone has a great importance since historical abundance of natural resources. The local inhabitants of the coastal zone have been randomly utilizing these resources and for that reason some of them are completely destroy as an example Chakaria Sundarban mangrove forest, where some valuable resources are found over-utilized like coastal shrimp farming, salt production and natural fish stock.

Regular monitoring of the entire process is of most significant in this context to concentrate an eagle eye on the quality of aquatic phase in and around the coastal aquaculture zone. One important step towards this is scaling the water quality of aquatic ecosystem through consideration of relevant parameters, that are functions of space and time. The primary objective of the study conducted for develop an index through which a single value can be assigned to aquatic environment for the purpose of its scoring highlighting the status, use and management of coastal aquaculture activities.

Thus, water quality index aim at providing a single value to a particular aquatic system on the basis of constituents lists (parameters/variables) and their values in the said aquatic system. The authors then compare with different samples for water quality on the basis of the index value of every collected sample from 10 study areas. But the present culture system of shrimp and prawn culture is fully dependent on tidal water of Matamuhuri, Naaf, Karnaphulia and Bakkhali estuaries and reuse water of aquaculture ponds directly back to these water sources of the river that deteriorates the water quality of the pond to a large extent. This leads pathway for towards the biological factors of coastal aquaculture products like poor growth, disease susceptibility and poor flesh quality of the shrimp and prawn cultured species. The index is basically a modified form of Brown's or the National Sanitation Foundation's water quality index (1970), with consolidation of aquatic salinity and organic carbon for the bottom in aquaculture pond, that are factors of high priority for aquaculture pond. The most significant parameters selected by Brown (1970) for the analysis of aquatic health index found dissolved oxygen (DO), biochemical oxygen demand (BOD), turbidity, total solids, nitrate, phosphate, pH, temperature, pesticides and toxic elements. Fundamental evaluation and weights were reuired for assess every parameter (Table 2), but deficiency of aquatic salinity is one of the main barriers from using this index in the coastal environment.

Table 2: Significance ratings and weights of the relevant parameters in connection to shrimp culture

Parameter	Ranking	Temporary weight	Final weight W	Optimum value (*)
Dissolved oxygen (DO) (mg/l)	1.2	1.000	0.1876	5.0
pH	1.9	0.6315	0.1185	8.00
Temperature (^{0}C)	2.6	0.4615	0.0866	32.0
Transparency (cm)	2.8	0.4286	0.0804	30.0
BOD (5-day)	2.9	0.4138	0.0776	3.0
Sediment organic carbon (%)	2.9	0.4138	0.0776	2.0
Salinity (%0)	3.0	0.4000	0.0750	10.0
NO_3 (µg at/l)	4.5	0.2667	0.0500	15.0
PO_4 (µg at/l)	4.8	0.2500	0.0469	1.5
SiO_3 (µg at/ l)	5.5	0.2182	0.0409	80.0
		4.481	0.8411	

Soruce : * Boyd and Tucker (1992) ; DoF (2005)

The present investigation is a techniques for compare the water quality of 10 coastal aquaculture practiced ponds located in 10 different coastal zones in and around South-Eastern coast of Bangladesh, with the aim to prepare a score card for rating these water bodies in connection to the culture of tiger prawn (Penaeus monodon) and fresh water prawn (*Macrobrachium rosenbergii*). The present study was therefore conducted with incorporation of water salinity in the calculation as this variable not only controls the physiological state of coastal biodiversity, but also determines the nature of chemical species in the process. The rating of water quality parameters was conducted on a scale of 1 to 10 and were converted into final weight for assessing the water quality of coastal aquaculture ponds of the study area.

2. Materials and Methods

The coastal belt of Bangladesh is unique in its monotonous topography, shoreline geometry, coastal dynamics and biodiversity. However, some researhcers describes that the coastal area of Bangladesh is categorized into three regions; (1) The Eastern Region (2) The Central Region (3) The Western Region (Pramanik, 1983). The South-Eastern coast is known as regular unbroken and not very susceptible to erosion and is protected along the sea by mud flat and submerged sand. This coastal zone is suitable for coastal aquaculture activities because of geographical location, suitable aquatic environment and smooth communication system. For these reason, water quality samplings have been carried out at ten different stations in and around the South East coast of Bangladesh namely Teknaf (Stn.1), Ukhia (Stn. 2), Cox's Bazar Sadar area (Stn. 3), Chakaria (Stn. 4), Pekua (Stn. 5), Banskhali (Stn. 6), Anwara (Stn. 7), Patenga-Fauzderhat (Stn. 8), Sitakunda (Stn.9) and Mirarsarai (Stn. 10).

The entire network of the present study comprise of the evaluation of the health of coastal ponds with respect to selective physico-chemical parameters, that is surface water salinity, pH, temperature, transparency, dissolved oxygen (DO), BOD (3-day at 27oC), nitrate, phosphate, silicate and sediment organic carbon during the culture period (February to September, 2017). The relevant hydrological parameters of coastal aquaculture are surface water salinity, pH, transparency, temperature, dissolved oxygen (DO), BOD (3-day at 27oC), nitrate, phosphate, silicate and sediment organic carbon (for the present site). 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., nitrate, phosphate, silicate and sediment organic carbon were analyzed as per the procedure stated (Strickland and Parson, 1972; APHA, 2012).

This is an approach to understand the aquatic environmental condition of the study areas through consideration of all the parameters relevant for coastal aquaculture. Depending on the significant of the parameter they are selected a ranking value of 1 (highest) to 10 (lowest). To convert ratings into the weights, a temporary weight of 1.0 was given to the parameter, which received the highest significance ratings (here dissolved oxygen received the topmost score). All other temporary weights were found by dividing the highest rating by each individual mean rating. Each temporary weight was then categorized by the sum of all the temporary weights to reach at the final weight of each parameters (Table 2).

The sum of the product of the individual final weight (W) and individual quality rating (q_i) was used for evaluating the water quality of coastal, estuarine and brackish water system through AHI as per the following expression:

$$\sum_{i=1}^{s} W_i \quad X \quad q_i$$

where, W = weight of ith parameter, q_i = quality of the ith parameter (a number between 0 and 100).

3. Results

Successful coastal aquaculture enterprise is an uninterrupted purpose of the ideal values of hydrological that assess by statutory administration like pollution control authority or aquaculture authority. Individual quality rating (of parameters) conducted on the base of deviation from the respective optimum figure, that referred to as the measured concentration in the present study (Table 3). This rating reflects the hospitable environment in almost all the coastal aquaculture ponds of the study area with respect to dissolved oxygen, aquatic pH, temperature, nitrate and sediment organic carbon. However, definite parameters like BOD, phosphate and silicate level have deviated from the optimum values to such an extent, that their individual quality rating has decreased (Table 3), that is ultimately reflected in the AHI values (Table 4).

Table 3: Individual quality rating(qi) on the basis of measured and optimum values for the selected ponds

Parameter	Stn. 1		Stn. 2		Stn. 3		Stn. 4		Stn. 5		Stn. 6		Stn. 7		Stn. 8		Stn. 9		Stn. 10	
	Measured value	Individual quality rating	Measured value	Individual quality rating	Measured value	Individual quality rating	Measured value	Individual quality rating	Measured value	Individual quality rating	Measured value	Individual quality rating	Measured value	Individual quality rating	Measured value	Individual quality rating	Measured value	Individual quality rating	Measured value	Individual quality rating

Dissolved oxygen (DO) (mg/l)	5.56	100	5.73	100	5.28	100	6.05	100	5.36	100	5.97	100	4.94	99	4.01	80	3.96	79	4.80	96
pH	8.00	100	8.0	100	7.8	85	8.00	100	7.99	95	8.02	100	7.8	85	7.0	72	6.8	70	7.5	80
Temperature (^{0}C)	34.5	90	34.6	90	34.6	90	34.7	90	34.8	90	34.6	90	34.8	90	34.8	90	34.8	90	34.7	90
Transparency (cm)	26.5	80	27.0	85	24.7	72	29	95	25	75	28.5	92	24.0	70	22.2	60	15.2	55	22.8	64
BOD (3-day at 27^{o}C)	3.8	85	3.6	90	4.0	80	2.9	99	4.0	80	3.4	95	4.2	78	4.5	70	4.8	65	4.5	7.0
Sediment organic carbon (%)	1.5	95	1.5	95	1.2	90	1.9	100	1.2	90	1.7	100	1.0	85	0.5	75	0.2	70	0.8	80
Salinity (%0)	7.91	79	8.70	87	10.98	90	12.02	80	7.33	73	12.85	80	21.56	60	7.48	75	24.39	70	22.14	60
NO_3 (µg at/l)	19.48	90	16.84	90	17.29	90	16.11	90	18.02	90	14.76	98	15.23	95	18.56	90	11.85	79	9.62	64
PO_4 (µg at/l)	0.98	65	2.05	85	2.83	60	1.90	90			1.30	87			2.84	60				
SiO_3 (µg at/ l)	65.50	85	70.00	88	55.60	75	75.50	95	60.00	80	72.60	90	50.00	70	45.50	65	48.70	68	50.00	70

Here, Chakaria (Stn. 4)> Banskhali (Stn.6) > Ukhia (Stn. 2)> Teknaf (Stn. 1)> Pekua (Stn. 5)> Cox's Bazar sadar (Stn. 3) > Anwara (Stn. 7)> Mirarsarai (Stn. 10)> Patenga-Fauzderhat (Stn. 8)> Sitakunda(Stn. 9).

Table 4: Aquatic Health Index (AHI) of the selected ponds

Parameter	**Stn. 1 W_i X q_i**	**Stn. 2 W_i X q_i**	**Stn. 3 W_i X q_i**	**Stn. 4 W_i X q_i**	**Stn. 5 W_i X q_i**	**Stn. 6 W_i X q_i**	**Stn. 7 W_i X q_i**	**Stn. 8 W_i X q_i**	**Stn. 9 W_i X q_i**	**Stn. 10 W_i X q_i**
Dissolved oxygen (DO) (mg/l)	15.008	18.760	18.009	18.760	18.572	18.760	18.760	14.820	18.760	18.760
pH	11.850	9.480	9.480	9.480	11.850	9.480	9.480	11.850	10.073	10.309
Temperature (^{0}C)	7.794	7.794	7.794	7.794	7.794	7.794	7.794	7.794	7.794	7.794
Transparency (cm)	4.1004	6.030	5.869	5.940	5.387	6.432	6.593	5.146	7.236	7.316
BOD (3-day at 27^{o}C)	3.104	3.104	3.104	3.104	6.208	6.208	3.104	3.104	7.372	6.984
Sediment organic carbon (%)	4.656	6.208	6.984	6.596	6.751	6.984	4.656	4.656	7.760	7.760
Salinity (%0)	5.925	6.525	6.750	6.000	5.475	6.000	4.500	5.625	5.250	4.500
NO_3 (µg at/l)	4.500	4.500	4.500	4.500	4.500	4.900	4.750	4.500	3.950	3.200
PO_4 (µg at/l)	2.814	2.814	2.814	2.814	2.814	4.221	3.986	2.814	4.080	3.049
SiO_3 (µg at/ l)	2.086	2.454	2.699	3.436	2.658	3.272	3.027	2.495	1.963	2.168
∑ Wi.qi	61.837	67.639	68.003	68.423	72.009	74.051	66.651	62.804	74.238	71.84

Dissolved oxygen is the most critical water quality variable in aquaculture (Boyd, 1989). The authors found the range of dissolved oxygen varied from 4.01 mg/ l to 6.05 mg / l in all the ponds of study areas. So, the present study for D.O range in shrimp ponds clearly ensured for suitable range of coastal aquaculture. The pH of normal brackish water usually is between 7 and 9 (Boyd, 1989). In the present study, p^H ranged varied from 7.0 to 8.02 which is close similar to the recommended p^H condition of shrimp culture in south-east cost for Bangladesh.

Temperature has a pronounced effect on the biochemical and metabolic process of shrimp (Barua and Zamal, 2010). Water temperatures of the experimental ponds were varied from 34.5^{o}C to 34.8^{o}C, which considered being ideal for the culture of *Penaeus monodon.*

The range of NO_3 and SiO_3 concentration in the study area ranges from 9.62- 19.48 ppm and 45.50- 75.50 ppm respectively and these ranges are indicated suitable range of coastal aquaculture. Pond soil plays an important role in the balance of aquaculture system and consequently on the growth and survival at aquatic organism. Organic carbon in present study was 0.5 % to 1.9% which is the best range for shrimp farming. The health score card of shrimp pond prepared on the basis of Aquatic Health Index (AHI) (Table 5) indicates the order of health in the sequence Chakaria (Stn. 4)> Banskhali (Stn.6) > Ukhia (Stn. 2)> Teknaf (Stn. 1)> Pekua (Stn. 5)> Cox's Bazar sadar (Stn. 3) > Anwara (Stn. 7)> Mirarsarai (Stn. 10)> Patenga-Fauzderhat (Stn. 8)> Sitakunda(Stn. 9).

Table 5: Score card of the selected stations according to Aquatic Health Index

Station	**∑ Wi.qi**	**Score**
Stn. 9	86.418	1
Stn. 6	80.171	2
Stn. 10	79.368	3
Stn. 5	77.006	4
Stn. 4	74.553	5
Stn. 3	74.124	6
Stn. 2	72.405	7
Stn. 7	68.336	8
Stn. 8	64.349	9
Stn. 1	61.837	10

4. Discussion

Dissolved oxygen which is vital water quality parameter it can be a limiting factor in shrimp culture (Wyban et. al., 1987). BAFRU reported that D.O range should be 5-7 mg/l and DoF (2003) stated that D.O level 4.0-6.0 mg/l is the ideal value for *P monodon* culture in Bangladesh (Bafru, 1996). The Range of dissolved oxygen from the present study was suitable for coastal aquaculture clearly ensured for suitable range of coastal aquaculture. In study stated the optimum pH for *Penaeus monodon* growth is between 8-8.5 (Chen, 1985). Again described the effect of pH on aquaculture species was generalized as when p^H is below 4 and above 11, the manifestations acid and alkaline death points respectively (Boyd, 1982). And for 4-6 and 9-11 there is slow growth, where as 6-9 is most suitable for growth. Low water p^H can stress on the shrimp body and cause soft shell and poor survival (Law, 1988).

pH ranged from 7.0-8.2 is suitable for shrimp culture which were more similar during the present study (Chanratchakol et al., 1995; Wyk and Scarpa, 2004). Low pH can also reduce natural pond productivity presumably by reducing the availability of nutrients (Alabaster and Lord, 1980). The pH of brackish water is usually not a direct threat to the health of the shrimp. Since brackish water is well buffered against pH change, pH will mostly remain with in the range of 6.5 to 9.0 (Chien, 1992) and pH of pond water coincides the limit of the afforested author in the present study. According to BAFRU p^H ranged 7 to 9 is standard range of shrimp culture in Bangladesh (BAFRU, 1996). The p^H ranged from the present study finding close similar to the recommended p^H condition of shrimp culture in south-east cost for Bangladesh.

Water temperatures of the experimental ponds considered being ideal for the culture of *Penaeus monodon* as considered 20^{o}C -35^{o}C as optimum for shrimp growths (Pakrasi, 1978). Temperature range in the present investigation agrees close similar with view, who stated that 25^{o}C -35^{o}C was optimum for shrimp growth and survival (Ling, 1974). Larkins found 24^{0}C-35^{0}C for the suitability of shrimp farming which was absolutely similar to the present study. The finding of the temperature range in the coastal shrimp culture ponds of Bangladesh resembles with the finding of many authors (Mahmood, 1985; Alam, 1989; Hassan, 1990).

During the investigation, the concentration of PO_4 recommended that for the sustainable coastal aquaculture, PO_4 ranged from 0.01- 3.0 ppm is the acceptable range for coastal aquaculture (Precilla and Myrana, 1991). A study reported that phosphate-phosphorus ranged 0.5 mg/l or less is the initial standard and target standard 3 mg/l or less is ideal water quality standard for shrimp farming (Boyd and Gautier, 2000). So, the present study indicated that phosphate-phosphorus range is close similar but within initial standard according to the report (Boyd and Gautier, 2000; Precilla and Myrana, 1991). The range of NO3 and SiO3 concentration in the study area ranges from 9.62- 18.56 ppm and 42.06- 67.51 ppm respectively and these ranges are indicated suitable range of coastal aquaculture in Chakaria sundarban region by compared the optimum range of shrimp farming in Bangladesh (BAFRU, 1996).

Pond soil plays an important role in the balance of aquaculture system and consequently on the growth and survival at aquatic organism. The soil can function as a buffer. It provides the water with nutrients serve as a biological filitered through the absorption of the organic residues of food, fish excretions and algal metabolites (Boyd, 1992). For the successful aquaculture it is recommended that organic carbon 1.0- 4.0 % is the best range for coastal aquaculture (Boyd and Clay, 2002). Boyd also reported that organic carbon value 0.60-1.50% is highly suitable for aquaculture (Boyd, 1992). Ahmed reported that organic carbon range 0.95 to 1.50% is the suitable range for coastal aquaculture of Bangladesh (Ahmed, 2005). Organic carbon in present study was 1.6 % to 3.9% which is the best range for shrimp farming (Boyd and Clay, 2002). But the range of organic carbon in the experimental ponds was higher than report (Ahmed, 2005). This variation was found due to using supplementary feeds in the ponds which remain unused and deposited on the soil bottom.

The main reason for this variation may be attributed to the proximity of the station to the urbanized and industrialized area of Sitakunda (Stn. 9) and Patenga- Fauzderhat (Stn. 8) area and releases wastages, oils and chemicals from large ship breaking zone, fishing, travelour and engine boat of cargo ship and launch of Chittagong sea port adjacent area. This sewage contaminated water from the Karnaphuli river and Banskhali-Anwara eatuarine zone and for that reason coastal shrimp ponds of Anwara, Cox's Bazar Sadar and Pekua may be one probable reason for lower AHI values in these ponds. The ponds here use this water as the source water, which deteriorated the environmental health of the ponds. The comparatively higher AHI values at Chakaria (Stn. 4) and Banskhali (Stn. 6) may be attributed to two important causes: (a) location of these ponds far away from the urban area and almost mangrove dominated region of Chakaria Sundarbans and Banskhali (b) use of specially formulated rich feed to grow the shrimps.

The specially formulated feed prepared from highly nutritional feeds accelerated the growth of cultured shrimp indicating efficient conversion of food materials in to shrimp biomass and negligible residual materials for settlement at the pond bottom (as per the expression dF/db, where df = change in feed and db = change in biomass of the cultured shrimps). The residual feed matter, which are basically responsible for spoiling the bottom through generation of H_2S, NH_3 and increased organic load is the key player behind lowering the AHI values in the shrimp ponds (Mitra, 1995). The left-over feed not only increases the organic carbon of the pond bottom soil, but also stimulates the microbial load resulting in the acceleration of BOD and subsequent lowering of DO values. All these negative alterations are reflected in the lowering of individual quality rating of organic load, pH, DO, transparency, BOD concentrations in the shrimp ponds of Teknaf (Stn. 1), Pekua (Stn. 5), Cox's Bazar Sadar (Stn. 3) and Ukhia (Stn. 2). In these ponds, the culture is carried on in traditional way with no scientific backup. The feed applied is prepared from beef extract, flour and trash fishes with no binders or chelating substances. The feed management in the shrimp ponds of these localities is also not done scientifically as per the biomass of the stocked shrimp seeds. Hence a large amount of the feed is wasted that deposits at the pond bottom and reduces the individual rating of organic load, pH, DO, transparency and BOD concentrations in the shrimp ponds.

During the conversion to commercial monoculture aquaculture farming can affect agricultural productivity, in some cases conversion to integrated shrimp or polyculture cultivation systems can retain benefits for small-scale farmers and may represent more ecologically sustainable approaches to shrimp farming. Besides, Polyculture incorporates different fish species occupying different ecological niches into a single farming methods. This can improve resource-use efficiency as well as on farm level, possible to support for ensure disease free or changes in market situations Such process can be closed and relatively self sufficient and integrated cultivation technologies where resources and wastes are found re-circulated within the pond area could be one technique of reducing the ecological footprint of coastal aquaculture farming. Generally, most of the coastal aquaculture practice in South-Eastern Bangladesh are Improved traditional shrimp culture where lot of fin, shell fish and crabs are found. Farmers no worried about the shrimp disease or less production, due to obtain better production from other species they earning lot of money and economically benefit able which is called "Environmental Risk Assessment".

The aquatic health index of East Calcutta Wetland of West Bengal, India while he analysis the 10 study points of East Calcutta Wetland and found the range of health index from 65.50 to 90.45 and proved that condition of aquatic health index suitable for aquaculture in the study area (Mitra, 2017). The authors also recorded the same value of health index in the 10 study areas. Some researchers found the range of aquatic health index in Chittagong coastal area of Bangladesh from 60.56 to 89.56 (Barua and Sarker, 2011). They explored that that water and soil quality of the aquaculture pond not degraded the aquaculture activities in the study area. But in the Sitakund and Mirsarai coastal area, water quality deteriorate because of ship breaking activities induced coastal pollution. The authors estimated the suitable range of aquatic health index as week as less health index found in the Station-9 and 10. In other hand, a group researchers found the range of aquatic health index of 10 aquaculture ponds of Malaysia from 65.90 to 95.45 during 2008 (Natasja et al., 2008). They stated that aquaculture and fisheries relate activities playing contrasting roles in the livelihood of coastal fishers and considers as complementary rather than alternative occupations. Present study finding indicated the almost same range of aquatic index in South-Eastern coast of Bangladesh and Malaysia southern coast.

Some researchers has point outthe condition of the water quality index around the Southern part of Iran (Ahmad and Lorica, 2002). They collected the water quality of 15 fishponds and stated that the range of aquatic health index from 60.85 to 85.89 that found standard ranges for coastal aquaculture activities at Iran. Sugama found the range of aquatic health index from 60.56 to 90.25 whuch explored the suitable condition for aquaculture activities in the Indonesia (Sugama, 2015). He stated that shimp culture in Indonesia now popularizing in the country for its good income generating opportunities in the country. The authors found the similar range of index range in the study areas and aquaculture activities at Indonesia. Ship breaking yards along the coast of Sitakund upazila of Chittagong district confined in an area of 10 km has become a paramount importance for the economics and employment sectors of Bangladesh. Wastes of the scrapped ships are drained and dumped into the Bay of Bengal. These wastes especially oil and oil substances, PCB's, TBT's, PAH's, etc. and different types of heavy metals (Fe, Cr, Hg, Zn, Mn, Ni. Pb, Cd) are being accumulated into the aquatic body and also ponds of coastal aquaculture that practicing along the Sitakund coastal area (Siddiquee et al., 2009). As a result, aquatic health index found lowest in Sitakund coastal which stated that coastal and marine fisheries diversity of Chittagong coastal region are at stake at this moment.

Research finding of the present study suggest 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 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 shrimp production.

5. Conclusion

Problems and opportunities of *Penaeus monodon* farms that are comparatively larger in terms of size and ownership have been widely documented, whereas the adoption of *Macrobrachium rosenbergii* farming by small and marginal farmers has accepted as relatively little attention by the farmers since 2008-2009. But now Freshwater shrimp, *Macrobrachium rosenbergii*, farming has been expanding at a much faster rate than P*enaeus monodon*, in Bangladesh with the joint venture of GOs NGOs partnership for livelihood development. At present the number of small size farms especially for M*acrobrachium rosenbergii* is more than twice that of larger size *Penaeus monodon* farm. Although the prompt growth of M*acrobrachium rosenbergii* cultivation is a relatively current phenomenon, the practice appeared relatively early in the founding of *Penaeus monodon* culture. So, coastal shrimp aquaculture is an important industry in Bangladesh because it is an important source of earning foreign currency.

However, the current practice of coastal aquaculture is not sustainable due to damage the socioeconomic, environmental, ecological and cultural environment of the coastal area of Bangladesh for a longer period of time .The principal cause behind this unsustainable aquaculture is the unplanned and unscientific approach of shrimp and prawn farming and absence of integration among various components of local ecosystem. The integration heightens the use of land and water resources like wastes produced by aquaculture activities reduce by other components of the ecosystem. In addition, the integration will increase the protection and restoration of coastal ecosystems, ensure for ecologically sustainable development, mitigate coastal resources use conflicts , increase employment opportunities and develop community involvement in coastal zone management processes in Bangladesh. So, Sustainable aquaculture development possible to earn real and lasting benefits for marginalized coastal inhabitants. But the environmental concerns of inappropriate or excessive development will harmfully impact on the large communities and the farmers themselves through poor farm management or failure. 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 the assimilative capacity of the environment.

Recommendation

Shrimp cultivation is now widely spread almost all over the coastal regions of Bangladesh. Different species of shrimps are cultivated generally in low lying, barely one meter above mean sea level and below high tide level areas where nutritious and organic foods are available for all types of aquatic lives. The people who live in and around the farm lands are not able to control its rapid expansion, stop or reduce farms, and protect the aftermaths of unplanned cultivation as the rich people own most of it. Long time farming has already emerged as a great threat to the agriculture, livestock, biodiversity, public health, ecology, local environment and sustainability in the coastal regions of Bangladesh.

The present article suggests the necessity of a combined approach rather than giving thrust towards the individual parameters for managing the health of the shrimp ponds. Fundamentally, the quality of the aquatic environment can never be a purpose of the different parameters, as several parameters may have synergistic or antagonistic impact amongst themselves that ultimately assess the rating of the water body. So, The aquatic health index (AHI) is a consideration of such rating in which the significance of all the relevant parameters have been considered with proper weighted.

Unplanned Shrimp cultivation has multifarious impact in terms of salinity increase on soil, adverse effects on population health, destroying bio-diversity and ecosystems, environmental changes, and imbalance in sustainability. In spite of the negative impacts, the economic importance of shrimp cannot be overlooked for a developing country like Bangladesh. Proper management and planning by framing an 'Ecological Model' can give a sustainable growth and benefit of shrimp cultivation, stop the trends of water pollution and destruction of sensitive coastal habitats, lessen the ongoing threats to aquatic biodiversity, and balance the significant socio-economic costs against the direct economic benefits or earning from the shrimp cultivation. Apart from the implications of the proposed ecological model, the steps should be adopted for accrediting the need of future achievements by shrimp farming in Bangladesh:

- Granting a certification of sustainability (concerning ecological, economic and social factors) for the shrimp cultivation farms where a correct planning had been realized;
- Sensitizing the leading importers in order to encourage shrimp importation exclusively from certified farms; advising leading food brands to publicize the exclusively usage of shrimps from certified farms in their merchandise;
- Educating customers in order to influence consumer's behavior towards assumption of shrimps from certified farms;
- Alerting international organizations in order to launch protection programs in the critical geographic areas.

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