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Present Status of Low Depth Shrimp Farming System with Special Reference to Soil-water Characteristics in South-West Region of Bangladesh

Md. Motiur Rahman[1*], Md. Ariful Islam[1], H. M. Rakibul Islam[1] and Khan Kamal Uddin Ahmed[1]

[1]Bangladesh Fisheries Research Institute, Shrimp Research Station, Bagerhat-9300, Bangladesh.

Authors' contributions

This work was carried out in collaboration between all authors. Author KKUA designed the study, wrote the protocol. Authors MMR, MAI and HMRI participated in field investigations and data collections. Author MMR performed the statistical analysis, wrote the first draft of the manuscript, managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Management of soil and water quality parameters is important catalysts for gaining sustainable fish production in Bangladesh. In this context, a comprehensive survey was done to categories existing shrimp farms locally called ghers of Sadar Upazilla covering each union based on water depth. Among the ghers, 69% found between 1.5 < to < 3 ft depth, 17% below ≤ 1.5 ft and 14% ≥ 3 ft. and an investigation was carried out to assess soil-water quality parameters and production performance of 9 selected low depth shrimp ghers in Bemarta Union under Sadar Upazilla at Bagerhat districts of Bangladesh over a growing cycle. Physico-chemical parameters of soil-water needed to be measured and analyzed by standard methods. Total yield (3414 kg/ha/cycle in T_1, 2470 kg/ha/cycle in T_2, 1482 kg/ha/cycle in T_3) of fishes was also calculated from the stocking and harvesting data. Most of the parameters of soil and water correlated significantly with each other

**Corresponding author: E-mail: matiur.bfri@gmail.com;*

suggesting a high degree of interactions between different parameters in the system. A pattern of qualitative and quantitative difference of zooplankton over phytoplankton was also recorded in these farms Therefore, a high degree of salinity fluctuation and iron deposition in waters was also documented. However, considerably lower concentrations of phosphorus in the soil indicated a net retention and trapping of phosphatic nutrients in the environment. Moreover cropping pattern was two cycles (fishes single, paddy single) per year, feeding frequencies was once in daily and shrimp suitability and production ranged from (15-27)% and 247 kg/ha/cycle to 741 kg/ha/cycle. The present findings indicate that low depth gher comparatively gives a better result in fin fishes than shrimp/prawn and creates a hazardous environment for shrimp post larvae survives, viral death, health risk and economically not viable for sustainable shrimp production in Bangladesh.

Keywords: Water and soil quality; low depth; shrimp; ghers; Bangladesh.

1. INTRODUCTION

Shrimp aquaculture is part of the fastest growing economic activities in coastal areas of Bangladesh and the 5th largest shrimp producer in the world [1]. In Bangladesh annual shrimp production is 2,23,582 metric tons and 2nd largest of total inland aquaculture [2]. The two main region of shrimp production are located in the south-western part composed of Khulna, Satkhira and Bagerhat districts; and the other one is located in the south-eastern part of the country composed of Chittagong and Cox's bazaar districts and 0.276 million Hectares of land are currently under brackish water shrimp cultivation [3]. About 75% of the total shrimp farms are located in Khulna, Bagerhat and Satkhira districts. *Penaeus monodon* or *Machrobranchium rosenbergii* is the major targeted species cultured in Bangladesh [4]. Shrimp farming in Bangladesh has been expanding since the early seventies and reached an industrial scale followed by increasing demand for shrimp in the export market. It alone contributes more than 70% of the total export earnings from all the agro-based products [5]. More than two millions of people directly and indirectly are involved in shrimp aquaculture activities (Harvesting, Culture, Processing, and Exporting) [6]. The rapid expansion of shrimp farming in Bangladesh for the last two decades is likely to lead both short and long-term negative environmental impacts leading ecological imbalance, environmental pollution, acceleration of land degradation, low salinity deforestation of mangrove, sedimentation and disease outbreak [7]. Mangrove is a suitable habitat for brackish water fishes and unique ecosystem of our environment [8]. However, mangrove wetlands are still being converted to shrimp farms (locally called gher in bengally) for aquaculture [9]. Fish farming in Bangladesh relies on the supply of artificially formulated feed application of agrochemicals, antibiotics and disinfectants [10]. Farm owners apply different types of chemicals and drugs for remediation of PL mortality, viral death of shrimp, and disease in their farms (locally called gher in Bengali). The farmers are not aware of the impacts of the use of those chemicals on farms' environment. 21% farmers used potassium permanganate, 18% used aqua-nourish, 17% used capsule and 14% agro-fish and almost all chemicals were used mainly for improving water quality and preventing diseases [11]. Indiscriminate and overuse of the chemicals and drugs might be the cause of death of many living organisms [10]. Shrimp gher water and sediments are important sinks for various pollutants like pesticides and heavy metals [12]. The long-term use of different chemicals and drugs in the shrimp and prawn farming has negative impacts on the environment as well as the human being. Therefore, this sector has been highly criticized by the seafood importing countries in terms of negative social and environmental issues [13]. In 2009, EU, which is the largest importer, got nitro furan in prawn/shrimp and Bangladesh had to adopt self-imposed ban on seafood export. As a result, this shrimp and prawn farming and trade became vulnerable in the export market [14]. Therefore, it is now a critical issue to identify the major sources of contaminants in the shrimp and prawn farms. The present study was conducted to assess the impacts of shrimp and prawn farming on water and soil quality parameters of gher in the southwestern region of Bangladesh particularly in Khulna, Bagerhat district which is expected to contribute to knowledge generation for sustainable seafood farming and trade in Bangladesh. The specific objective of the present study was to survey and categories the existing shrimp ghers based on water depth and assess the production performance of shrimp with finfish's in relation to limnological properties of soil and water in low depth shrimp farms.

Physical and chemical properties of water in shrimp farms are useful indicators of the farm environment [15]. For sustaining eco-friendly farm environment requires a basic understanding of the physical, chemical and biological processes occurring in shrimp farming systems and information is needed about the relative proportions or properties of the soil-water and its components [16]. Physico-chemical, biological parameter of water and soil qualities of extensively managed commercial shrimp farms in Bangladesh have not yet been sufficiently documented. The present study reports the status of problems and prospects of farm management, physic- chemical properties of soil and water, qualitative and quantitative variation of plankton and gross yield of low depth shrimp farming systems of Bangladesh.

2. MATERIALS AND METHODS

2.1 The Study Area

The study was under taken in Bagerhat Sadar Upazilla throughout a production cycle from July 2015 to June 2016. For achieving objectives under this project, 100 ghers of Bagerhat sadar Upazila covering total 12 Union were randomly surveyed, which were categorized in three (T_1≥ 3 ft depth, $T_2$1.5 < to < 3 ft depth, T_3≤ 1.5 ft depth) treatments. including each category (treatment) of ghers 09 ghers were considered for experiment in Bemarta Union Under Sadar Upazilla and each category has three replicates ranged in size (68.6±26.87 ha, 39.4±32.02 ha, 34.2±10.60 ha) and All the ghers were similar in configuration, basin and contour type, well-exposed to sunlight and natural air flow.

2.2 Shrimp Farming Techniques and Farm Management

Farm owners were interviewed for detailed information on husbandry and management practices using FGD tools. Farm records were utilized to quantify the manure and fertilizers, supplemental feeds, shrimp harvests and to have information on the management practices applied and inputs used. Per Hectare shrimp yield was calculated from the final biomass obtained in each individual gher. Gher preparation began from mid February to mid March with ploughing the enclosed land and encircling it with fence, Then lime CaO, $Ca(CO_3)_2$, $Ca(OH)_2$was applied at the rate of 250-300 kg/ ha which was left for about a week for drying under the sunshine. After one week of drying, water was introduced by allowing the high tide of the new moon or full moon to enter into the ghers. After entering water the ghers were fertilized with Urea 50 kg/ha, TSP 25/ha and semi compost cow dung 500 kg-700 kg/ha. After 5-7 days of fertilization, ghers were filled with water up to a depth about 15-20 cm and then after one week, the depth of each gher was finally maintained at about 90 cm on an average stocking in the rearing ghers was done after plankton production. Shrimp (15–20 days old post larvae) were collected from hatchery or wild and transferred into the rearing ghers. Continuous stocking and partial harvesting of shrimp were done in definite intervals.Then feeding starts and feeding frequencies was once in a day. Farmers used both commercially manufactured pelleted feed, which is locally available and homemade feed (Snail, Rice husk, Rice, Wheat husk, Wheat, Mustard Oil cake, Coconut oil cake, Cow dung etc). Bio-security and hygiene practices were not maintained properly. The mixed culture practices (*Penaeus monodon* with fin fishes or *Macrobranchium rossenbergii* with fin fishes or shrimp with prawn including fin fishes) are the main target practices for low depth shrimp farming. The amount of feed supplied was calculated based on the basis of shrimp biomass. The other forms of post-stocking management included only periodic liming of the ponds as a measure of disease prevention.

2.3 Water Quality Parameters

Water samples were collected from the selected farms using 500 ml plastic bottles between 09:00 AM to 10:00 AM twice in every month. After collection of the samples, Dissolve Oxygen (mg /l) was measured immediately in the sampling site. Other parameters of the water samples such as pH, Alkalinity (mg/l), Nitrate (mg/l), Ammonia (mg/l), Iron (mg/l) and PO_4^- (mg/l) were measured using HACH water test Kit (Model FF-1A Cat. 2430-02, Made in USA).A water temperature (°C) and salinity (ppt),were recorded directly on the spot by a Celsius thermometer and a refractometer (Atago, Made in Japan).

2.4 Soil Quality Parameters

After collection, samples were tagged and sent to Soil Resource Development Institute (SRDI) Khulna for analysis of its parameters. Samples were air-dried and results were expressed as the total dry matter, T-DM (g/kg). Soil pH was determined from a soil suspension in distilled, de-ionized water (soil: water ratio of 1:5, using a digital pH-meter. Phosphate concentrations were determined by shaking the soil samples with 0.5 M NaHCO3 solution (pH 8.5). Phosphorus in the extract was determined by developing blue color using stannous chloride reduction of phospho-molybdate complex and measuring the color spectrophotometrically at 660 nm wavelength [17]. All colorimetric examinations needed to be done using standard calibration curves. Total-P (mg/100g) was measured by ascorbic acid method [17]. To determine the total nitrogen, and sulfur, samples were oven dried at 45°C for 2 h and crushed with a mortar. The total nitrogen was determined by using the Kjeldahl method [18,19]. To determine, sulfur, the samples were treated first with water and then with 6M HCl and the parameters were determined by using an elemental analyzer [20].The organic content of the soil (also called loss of ignition) was determined by combustion of samples in porcelain crucibles at 550°C for 12h in a muffle furnace and the final product of the combustion was expressed as the ash content of the sediment [21].

2.5 Plankton Study

Plankton samples were collected from the ghers by passing deep integrated water samples through fine-meshed plankton net (0.025 mm) for qualitative and quantitative estimation at fortnightly intervals. After collection, samples were preserved immediately with 5% buffered formalin in the plastic bottles. Then Plankton density was estimated by using a sub-sampling technique, A Sedgwick–Rafter (S–R) cell was used under a calibrated binocular compound microscope for plankton counting. Planktons were identified to general level and they were counted using the formula proposed by [22] and was expressed as the number of cells per liter of water.

2.6 Statistical Analysis

For all sampling techniques, three replicates were analyzed and means and standard deviations were computed and expressed as mean (±SD). Significance of variations in water quality parameters within ghers were tested using one way analysis of variance, ANOVA, which was followed by Duncan's multiple range test (Duncan, 1995) for significant values. Significance of correlation coefficients was computed according to (Zar, 1999). Values were considered at 5% level of significance.

3. RESULTS

A comprehensive study was conducted to survey and categorize the existing shrimp ghers based on water depth using altitude reading of GPS meter in October/2015. For achieving objectives under this project, 100 ghers of Bagerhat sadar Upazila covering each Union were randomly surveyed in the year 2015-16. Among the ghers, 69% found between 1.5 < to ≤ 3 ft depth, 17% below ≤ 1.5 ft and 14% > 3 ft.

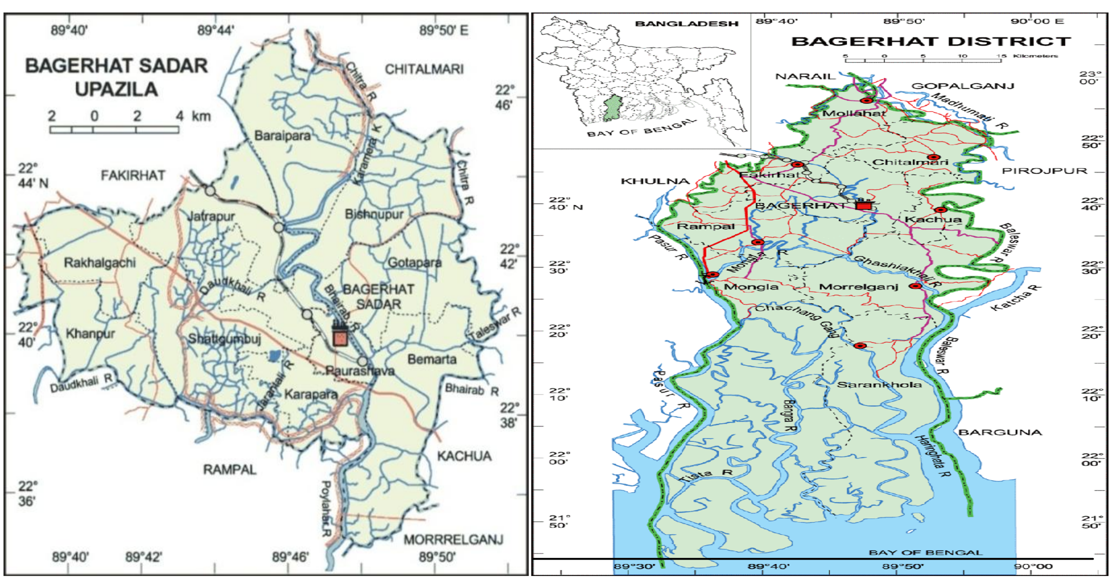

Fig. 1. Map of Bangladesh showing the study sites, Sadar Upazilla under Bagerhat district of Bangladesh

Table 1. Information about the status of water depth of surveyed ghers

Upazila	Covering area	Category based on water depth	Ghers	Total surveyed gher
Bagerhat Sadar	Randomly 10 Union	≤ 1.5 ft	17	100
		1.5 < to < 3 ft	69	
		≥ 3 ft	14	

3.1 Shrimp Farming Techniques and Farm Management

Existed shrimp culture techniques were evaluated from the degree of management applied (Table 2,3) throughout the production cycle from the initial stage of gher preparation to harvesting of shrimp. Per Hectare shrimp yields were calculated from the final biomass obtained in each individual gher. Gross yield was expressed as production in kg/ha/cycle.

3.2 Growth, Survival and Yield Parameters of Low Depth Shrimp Farming

The mean stocking density of *Penaeus monodon*, was 54,587 post larvae (PL) /ha/cycle and yield varied between 247 to 741 kg/ha/cycle with the range of survival rate being 15–27% (mean 21%) and the individual weight at harvest ranging 38–39g (mean 38.5 g). (Table 4)

3.3 Water Quality Parameters

The recorded mean water quality parameters of low depth shrimp ghers throughout the experimental period are shown in (Table 5). Temperature was discovered more or less similar and ranged from 22.94±3.73°C, 25.41±1.71°C and 26.16±1.43°C in T_1, T_2 and T_3 treatments respectively. However water temperature had an inverse relationship with DO (r= -0.013) indicating DO increasing with decreasing temperature .Dissolved oxygen was recorded higher in T_1 and lowest in T_2 treatments respectively and significantly different (p<0.05) in three treatments. The value of pH was found higher in T_3 than that of T_1 and T_2 treatments respectively and had a significant correlation with(r=0.467, p<0.05) DO. The level of ammonia and alkalinity content was recorded trace and more or less similar amount in three treatments respectively. Ammonia had a significant inverse correlation with pH (r=- 0.275) suggesting that NH_3 reduced the pH level and Alkalinity had a significant (p<0.05) inverse correlation with nitrite (r= -0.079) indicating that higher alkalinity content reduced the nitrite level of the farms and positive correlation with pH (r=408, p<0.05). The maximum salinity was recorded in T_3, whereas the minimum salinity was observed at T_1 treatment respectively and significant (r= -0.408, p<0.05) in Dissolved Oxygen. Presence of Iron was found trace amount in T_2, T_1 and T_3 treatments and had a significantly inverse correlation (r= -0.452, p<0.05) with dissolved Oxygen (Table 6).

3.4 Soil Quality Parameters

The recorded mean soil quality parameters are presented in (Table 7). Among the parameters such as pH, total nitrogen and potassium, there was not any significant (p>0.01) difference found in three treatments. However organic content highly correlated(r= 0.993, p>0.01) with nitrogen. The soil pH was inversely correlated with total nitrogen (r= -0.419), sulfur (r= -0.460) Zinc (-0.688) and which reveals that pH increased with decreasing level of total nitrogen, sulfur and Zinc in three farms (Table 8). The highest value of organic content found in T_1 followed by T_2 and T_3 treatments (Table 7) and significantly (p<0.05) correlated with available phosphorus (Table 8). The mean soil salinity was found maximum in T_3 compared to T_2 and T_1 treatments significantly (p<0.05) correlated with production (r= 1.000), sulfur (r= 0.672), which indicated that production and Sulfur, proportionately increased with the increase of soil salinity. The production is significantly correlated with salinity, potassium, nitrogen, sulfur(r=1.000, p<0.01) (Table 8).

3.5 Qualitative and Quantitative Plankton Counting of Low Depth Shrimp Farming

A number of zooplankton groups were found dominated over phytoplankton groups in low depth shrimp farming systems. Among the zooplankton groups, euglenophyceae, rotifers, copepods, crustaceans and phytoplankton groups bacillariophyceae, cyanophyceae, chlorophyceaewere available in three treatments and higher quantities of zooplankton compared to phytoplankton were recorded might be due to availability of nutrients and favorable water quality parameters in the low depth shrimp farms.

Table 2. Primary information through a questionnaire survey using FGD in November 2015 at Sadar Upazilla of Bagerhat District

Upazila	Source of water		Preparation	Culture system	Feeding type & frequency	Species composition	Constraints during culture period			Disease	Opportunity need
Bagerhat Sadar	Canal	Other Gher	Ordinary	Integrated (Fish/paddy/ Vegetables) + Mixed Culture	Non formulated & Irregular	Mixed (Shrimp/Prawn/Fin Fishes)	Water crisis	Salinity flactuation	PL Death	Virus	Timely water, optimum salinity, virus free PL
	40%	60%	90%	70%	90%	85%	60%	66%	30%	95%	75%

Table 3. Generalized scenario of management regimens in low depth extensive shrimp ghers of Bemarta Union, Sadar Upazilla Bangladesh

Issues	T1 3≥ Feet depth Gher	T2 1.5< to<3 Feet depth Gher	T3 1.5≥ Feet depth Gher
Gher size (ha)	68.6±26.87	39.4±32.02	34.2±10.60
Gher dikes	Irregular and ordinary	Irregular and ordinary	Irregular and ordinary
Design and layout	Non Planned	Non Planned	Non Planned
Water control	Clay made inlet and outlet	Clay made inlet and outlet	Clay made inlet and outlet
Water exchange	Tidal exchange (10–20%) during full moon or new moon	Tidal exchange (10–20%) during full moon or new moon	Tidal exchange (10–20%) during full moon or new moon)
Depth (m)	0.5-0.7 (mean1m)	0.5-0.9 (mean.7m)	0.2-0.5 (mean0.4m)
Source of fry	hatchery	hatchery	hatchery
Stocking density (No./ha)	49,400-61,750	61,750-74,100	61,750-74,100
Rearing period	6-8	7-8	7-8
Crops/yr	Double (fishes single + paddy single)	Double (fishes Single +paddy Single)	Double (fishes Single +paddy Single)
Feed used	Locally available domestic handmade feed	Locally available handmade feed	Locally available handmade feed
Aeration	-	-	-
Cumulative mortality shrimp/prawn/finfishes	73/31/9	75/37/7	85/51/13
Survival rates	27/69/91	25/63/93	15/49/87

Issues	T1 3≥ Feet depth Gher	T2 1.5< to<3 Feet depth Gher	T3 1.5≥ Feet depth Gher
shrimp/prawn/finfishes			
Bleaching Powder used (kg ha/ cycle)	–	–	–
Cow dung (kg ha/cycle)	500-700	500-700	500-700
Lime (kg/ ha/cycle)	250-300	250-300	250-300
Plankton Producers used (kg/ ha/cycle)	–	–	–
Production (kg/ ha /cycle)	3414	2470	1482

Table 4. Stocking, survival rate, growth and yield of *Penaeus monodon/Macrobrancium rossenbergii* with fin fishes in selected low depth shrimp ghers of Bemarta Union, Sadar Upazilla of Bagerhat Districts

Treatments	Ghers No. /Replication	Size (ha) (mean+stdv)	Stocking density(ha^{-1})		Survival Rate (%)		Average Weight (g)		Gross yield (kg/ ha/ cycle)		Total (kg/ ha/ cycle)
			Shrimp /Prawn	fin fishes	Shrimp /prawn	fin fishes	Shrimp /prawn	fin fishes	Shrimp/ prawn	fin fishes	
T1 3≥ ft	3	68.6±26.87	68666/10868	3211	27/69	91	39/126	592	741/944	1729	3414
T2 (1.5 < to < 3) ft	3	39.4±32.02	51376/10621	1482	25/63	93	38/110	896	494/741	1235	2470
T3 ≤ 1.5 ft	3	34.2±10.60	43719/9880	1729	15/49	87	38/102	492	247/494	741	1482

Table 5. Water quality parameters of low depth shrimp farm of Bemarta Union, Bagerht, Bangladesh

Parameters	T1 3≥ Feet Depth Gher	T2 1.5< to<3 Feet Depth Gher	T3 1.5≥ Feet Depth Gher
Temperature(^{o}C)	22.94±3.73	25.41±1.71	26.16±1.43
pH	8.18±0.25	8.14±0.27	8.28±0.23
DO (mg/l)	5.45±0.55	5.04±0.78	5.41±0.84
Salinity (ppt)	1.10±0.03	1.43±0.18	1.39±0.10
Alkalinity(mg/l)	150.37±15.70	153.16±17.02	152.58±22.41
Ammonia (mg/l)	0.27±0.22	0.27±0.16	0.22±0.15
Iron (mg/l)	0.50±0.15	0.52±0.15	0.47±0.13
Nitrate	0.21±0.16	0.24±0.12	0.18±0.12
PO_4^-	0.33+0.07	0.34+0.06	0.32+0.05

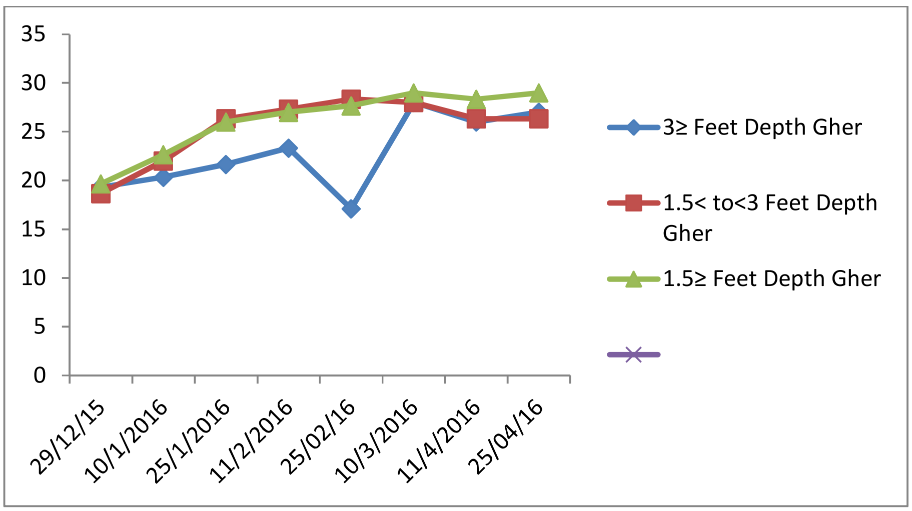

Fig. 2. Fortnightly variation of Temperature in shrimp farms of Bemarta Union in Bagerhat district of Bangladesh

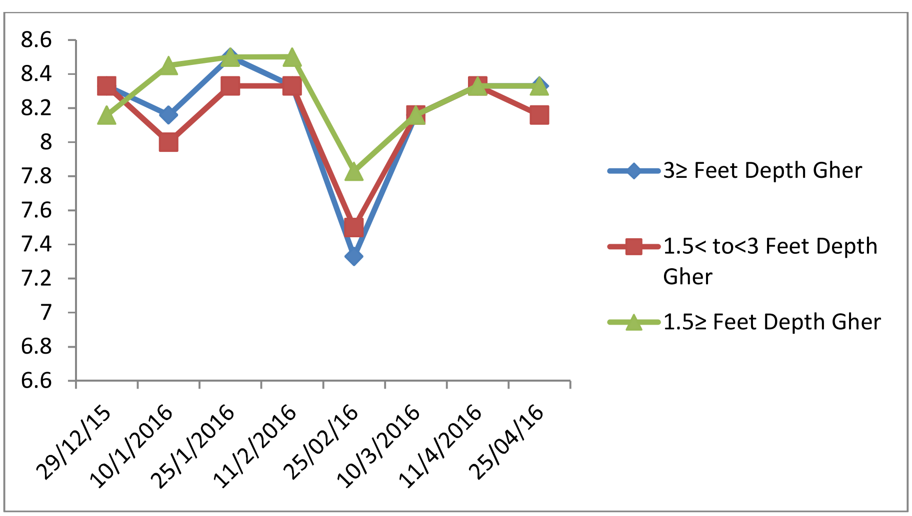

Fig. 3. Fortnightly variation of pH in shrimp farms of Bemarta Union in Bagerhat district of Bangladesh

Table 6. Pearson correlation of water quality parameters of low depth shrimp farms of Bemarta Union, Bagerhat, Bangladesh

Parameters	Depth	Shrimp_ production	Gross _production	PO4-	Temp	DO	pH	Salinity	Alkalinity	Ammonia	Nitrite	Iron
Depth	1											
Shrimp production	-1.000**	1										
Gross production	-1.000**	1.000**	1									
PO_{4-}	-.183	.000	.000	1								
Temp	.376	-.720	-.720	-.200	1							
DO	-.013	.188	.188	-.078	-.013	1						
pH	.142	.000	.000	-.130	.148	.467*	1					
Salinity	.057	-.960	-.960	.037	.304	.408*	.194	1				
Alkalinity	.141	.866	.866	.114	.073	.277	.408*	.351	1			
Ammonia	-.113	-.220	-.220	-.120	-.026	-.375	-.275	-.137	.053	1		
Nitrite	-.153	-.500	-.500	.187	.004	.034	-.048	.326	-.079	-.191	1	
Iron	-.081	.866	.866	.092	-.224	-.452*	.016	-.279	.035	.018	.175	1

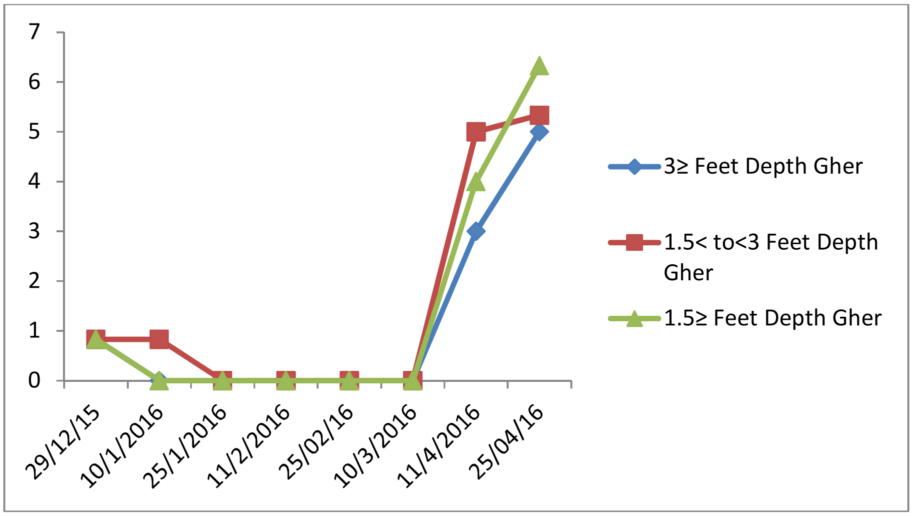

Fig. 4. Fortnightly variation of salinity in shrimp farms of Bemarta Union in Bagerhat district of Bangladesh

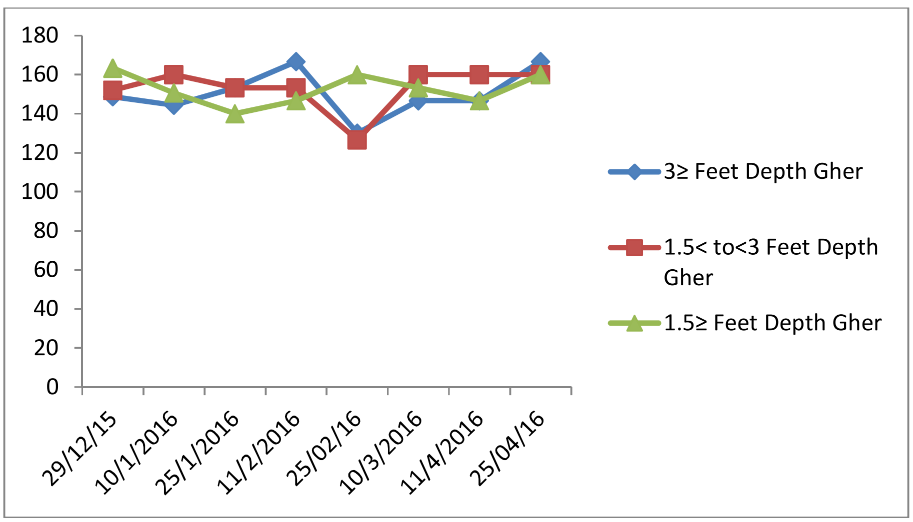

Fig. 5. Fortnightly variation of Alkalinity in shrimp farms of Bemarta Union in Bagerhat district of Bangladesh

Table 7. Soil characteristics of low depth shrimp farming system of Bamarta Union, Bagerhat, Bangladesh

Parameters	T1 3≥ Feet depth gher	T2 1.5< to<3 Feet depth gher	T3 1.5< to<3 Feet depth gher
Organic matter. (%)	2.09±0.46	1.81±0.61	1.50±0.60
pH	7.83±0.11	7.85±0.07	7.87±0.07
Salinity (EC) (ds/m*)	3.77±1.06	4.09±1.64	4.25±.50
Phosphorus (µg/g)	11.76±3.28	13.81±2.59	12.42±2.35
Total N_2 (%)	0.12±0.02	0.09±0.03	0.08±0.03
Potassium (m.eq./100g)	0.64±0.16	0.55±0.15	0.57±0.15
Sulfur (µg/g)	100.48±41.31	121.17±69.43	111.81±50.66
Zinc (µg/g)	0.86±0.07	0.76±0.15	0.80±0.14

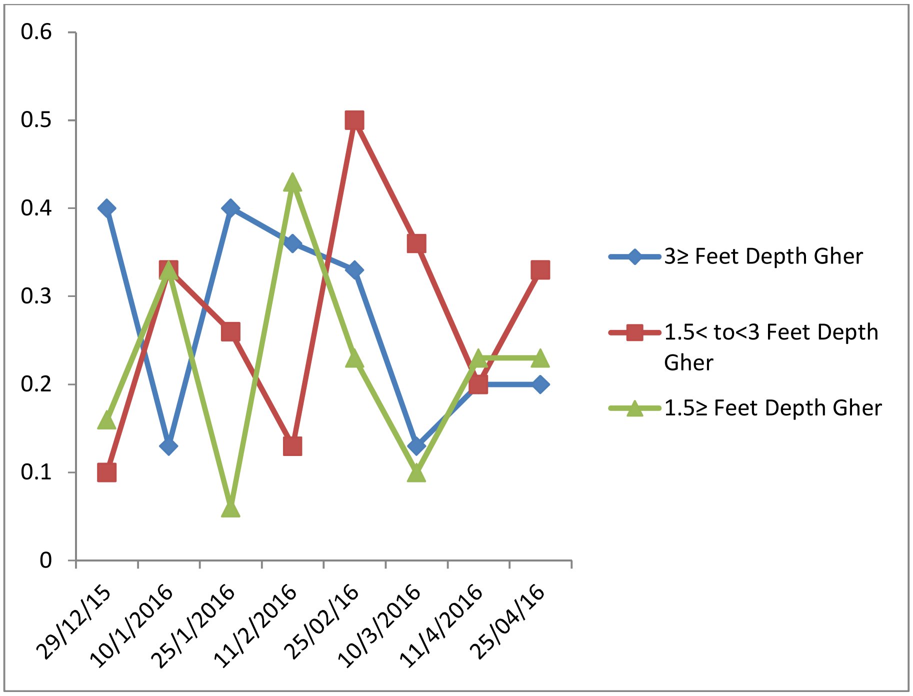

Fig. 6. Fortnightly variation of Ammonia in shrimp farms of Bemarta Union in Bagerhat district of Bangladesh

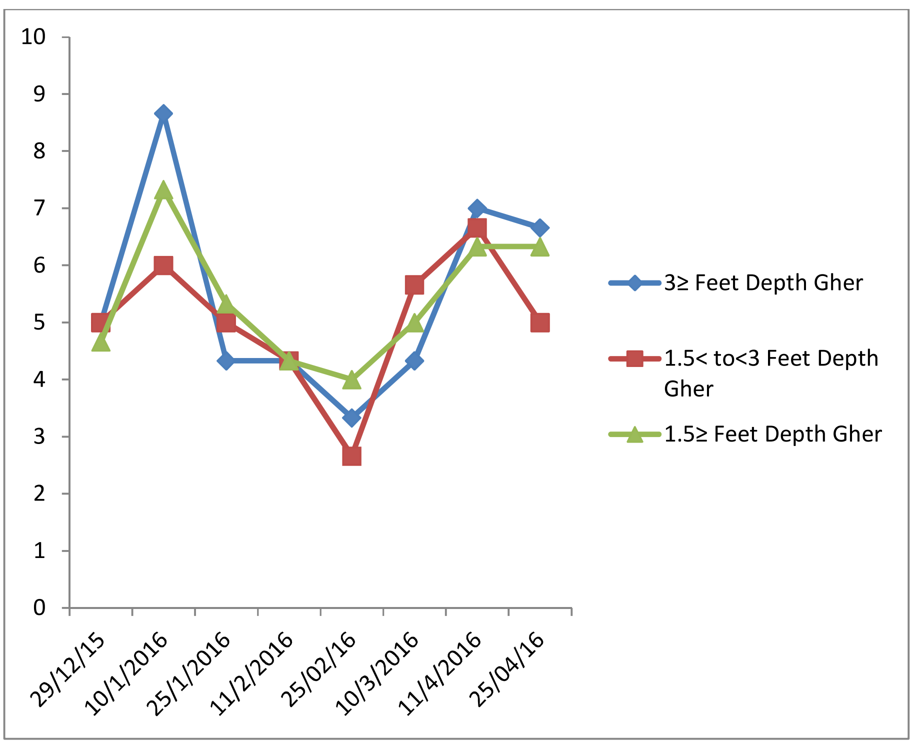

Fig. 7. Fortnightly variation of dissolved Oxygen in shrimp farms of Bemarta Union in Bagerhat district of Bangladesh

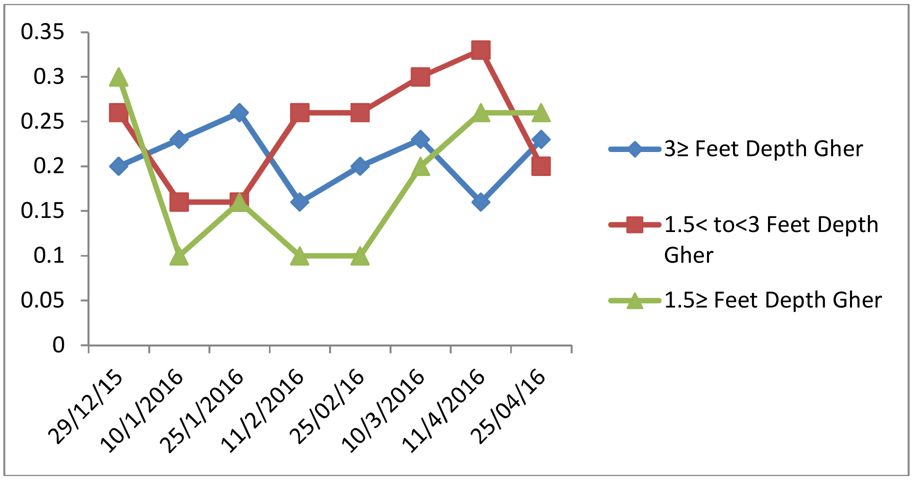

Fig. 8. Fortnightly variation of nitrate in shrimp farms of Bemarta Union in Bagerhat district of Bangladesh

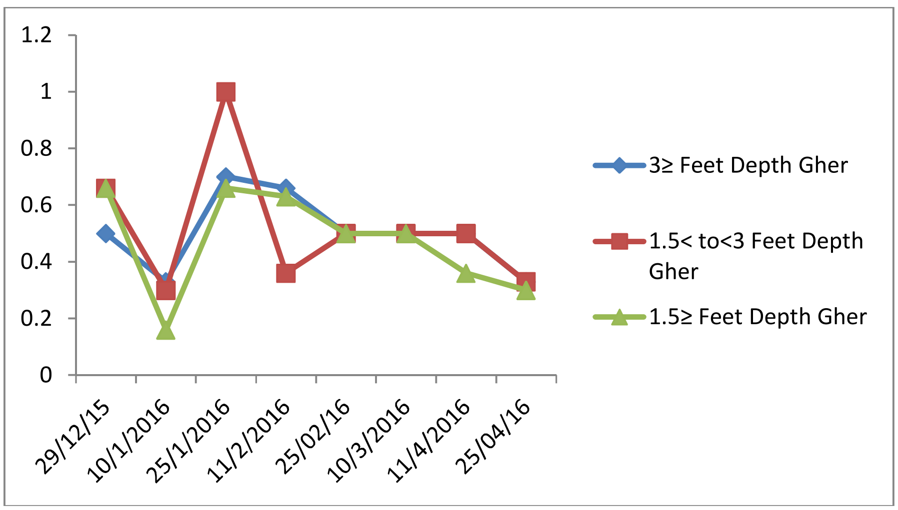

Fig 9. Fortnightly variation of Iron in shrimp farms of Bemarta Union in Bagerhat district of Bangladesh

Table 8. Pearson correlation of soil quality parameter of low depth shrimp farm of Bemarta Union, Bagerhat,Bangladesh

	Gher	Production	pH	Salinity	Organic	K	N	P	S	Zn
Gher	1									
Production	-1.000**	1								
pH	.189	.866	1							
Salinity	.287	1.000*	-.471	1						
Organic	-.611	.996	-.460	.271	1					
K	-.225	1.000**	.617	-.425	.277	1				
N	-.635	1.000**	-.419	.186	.993**	.327	1			
P	.048	-.763	-.149	.267	.551	.296	.564	1		
S	.081	1.000**	-.460	.672*	.612	.066	.582	.875**	1	
Zn	-.180	-.655	-.688*	.221	.501	-.346	.500	.498	.596	1

***. Correlation is significant at the 0.01 level (2-tailed)*
**. Correlation is significant at the 0.05 level (2-tailed)*

Table 9. (Phytoplankton/Zooplankton) availablity in low depth (Based on water depth) shrimp farms of Bemarta Union from December/15 to May/16

Group	Spp.	T1≥ 3 ft	T2 (1.5-3 ft)	T3≤ 1.5 ft
Chlorophyceae,	*Gonatozygon*	-	(5 x 10^2 nos./L)	(10^2 nos./L)
	Volvox	(5 x 10^2nos./L)	(10^3 nos./L)	(8 x 10^2 nos./L)
	Chlorella	-	(2 x 10^3 nos./L)	-
	Closterium	(8 x10^2 nos./L)	-	-
Cyanophyceae	*microcystis*	(10 x 10^3 nos./L)	(9 x 10^3 nos./L)	(10 x 10^3 nos./L)
Bacillariophyceae	*Melosera*	(2 x 10^3 nos./L)	(1 x 10^3 nos./L)	(10^2 nos./L)
	Cyclotella	(10^2 nos./L)	(10^2 nos./L)	(2 x 10^3 nos./L)
	Nitzschia	(4 x 10^2 nos./L)	-	-
	Fragilleria	-	(10^3 nos./L)	-
	Navicula	(4 x 10^3 nos./L)	-	(4 x 10^3 nos./L)
	Diatom	(1.5 x 10^3 nos./L)	(2 x 10^3 nos./L)	(2 x 10^3 nos./L)
Euglenophyceae	*Euglena*	(9 x 10^3 nos./L)	(3 x 10^3 nos./L)	(2 x 10^3 nos./L)
Rotifers,	*Brachionus*	(4x 10^3 nos./L)	(3.1x 10^3 nos./L)	(2 x 10^3 nos./L)
Copepods,	*Cyclops*	(3 x 10^3 nos./L)	(2 x 10^3 nos./L)	(1.6 x 10^3 nos./L)
	Mesocyclops	-	-	-
	Diaptomus	(1.25 x 10^3 nos./L)	(7x 10^2 nos./L)	(10^3 nos./L)
	Moina	(0.9 x 10^3 nos./L)	(10^2 nos./L)	(10^2 nos./L)
Crustaceans	*Nauplius larvae*	(1 x 10^3 nos./L)	(2 x 10^3 nos./L)	(10^3 nos./L)

4. DISCUSSION

Water quality management is a vital catalyst for enhancing yield of shrimp farm directly. A healthy environmental condition and the importance of entire management practices at different level from site selection to better production performance are crucial [23]. Water quality for aquaculture refers to the quality of water that enables successful growth and production of the desired organisms. The maintenance of good water quality is critical for survival, growth and production of commercial aquaculture species [24]. The metabolic rate of cold-blooded aquatic animal is closely linked to the water temperature. Water temperature varies depending on the season, length of the day, water depth and meteorological condition [22]. The optimum temperature range of both shrimp and prawn found at 28-30°C [25,26]. In the present study, water temperature was remaining under optimum ranged. According to [27], Low atmospheric temperature, water temperature fluctuation and low temperature are identified as risk factors for WSSV infection, while an increase in temperature can be a risk factor for an outbreak in pond-cultured *Penaeus monodon*. As the temperature rises high to 33-35^o C in the month of April, May, and June, the number of infected farms increased also. Sudden rain in those months that reduce the temperature rapidly, as most of the farm was shown to have too low water depth to resist abrupt change in water temperature. The prevalence of WSSV is highest in the months of May to September in Bangladesh. According to [28] the dissolved oxygen ranged over 6 ppm during dry season and over 4 ppm during the wet season was found in shrimp ghers, which was similar to ours the present findings. [29] had been reported that the tolerance DO for shrimp/prawn culture <3 mg /L (3-10 mg /L) and optimum range 4-7 mg/L. [30,31] reported that DO values higher than 5 mg/L have often been recommended for extensive culture system. This is very similar to the finding of the present study. pH is the concentration of hydrogen ions (H^+) present in the water is a measure of acidity or alkalinity and indicated as a pulse of shrimp aquaculture . The pH scale extends from 0 to 14 with 0 being the most acidic, 7 is a requirement of neutrality and 14 the most alkaline. In the present study, pH ranged 8.18±0.25, 8.14±0.27 & 8.28±0.23 in three categories shrimp farms, which was near to the aquaculture standard value [23,32,26,33] Ammonia in water exists in two forms, as ammonium ions (NH_4^+), which are nontoxic, and

Table 10. Production performance of low depth shrimp ghers of Bemarta Union of Bagerhat District in Bangladesh

Gher Categorization based on water depth	Area/decimal (Mean+STDV)	Culture System	Species	Stocking density (nos/dec)Shrmp/Prawn/Fin fishes	Stocking and harvesting type	Culture Period (month)	Production (Kg/ha)	Crop /Year	BCR
1.5≤ Feet	34.2±10.60	Integrated (Paddy+ Fishes+ Vegetables)	Shrimp/ Prawn+Fin fishes	224(177/40/07)	Continuous And Partial	(6-8)	247/494/741	Rice double Fishes single	1.23
(1.5-3) Feet	39.4±32.02			258(208/43/06)	Continuous And Partial	(6-8)	(494/741/1235)	Rice double Fishes single	1.30
3≤ Feet	68.6±26.87			365(278/44/13)	Continuous And Partial	(4-6)	(741/944/1729)	Rice double Fishes single	1.60

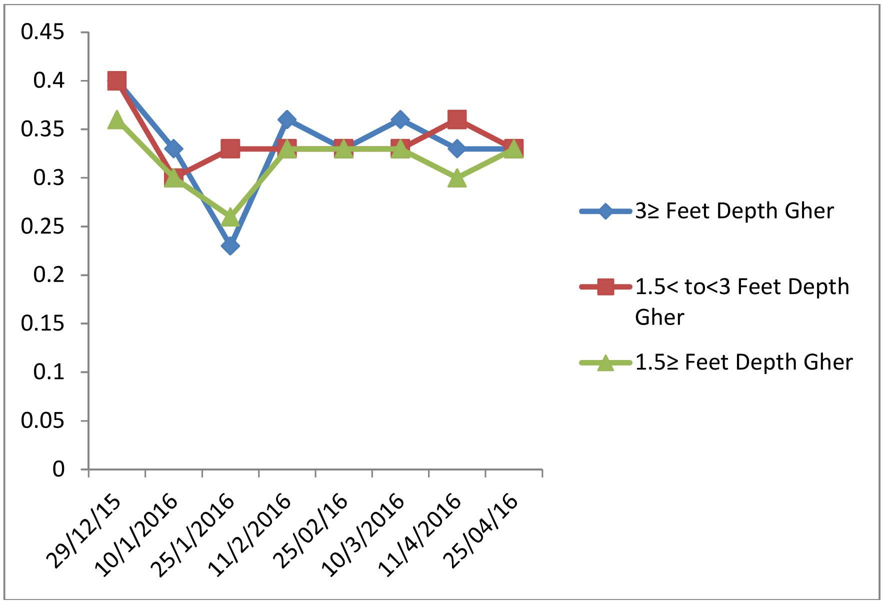

Fig. 10. Fortnightly variation of Phosphate in shrimp farms of Bemarta Union in Bagerhat district of Bangladesh

as the un-ionized toxic ammonia (NH_3). The desirable range of ammonia for shrimp farming is < 0.1 ppm and for prawn farming is 0 ppm. It was reported that half of shrimp production was reduced in Bangladeshi farms due to the presence of ammonia > 0.45 ppm [33,26]. In this experiment, Average ammonia content was 0.27±0.22, 0.27±0.16, 0.27±0.16, 0.10.22±0.15 ppm in T_1, T_2 and T_3 categories shrimp farms respectively. This level of ammonia in shrimp farm was higher at the optimum level and anaerobic decomposition of aquatic weeds, rice plants, fish's excretory always creates ammonia in shrimp ghers. Solutions that must be considered are performing intense and controlled aeration. If sufficient DO continuously updated per unit of time, it will make the environment not in anaerobic conditions and reduces ammonia level. With good aeration: alkalinity will not increase too among the various form of nitrogenous nutrients, NO_3 is the most important factor for shrimp and prawn culture. It is the suitable form of nitrogen as nutrient for phytoplankton and other plants. Nitrate is the final product of the aerobic decomposition of organic nitrogen compounds, which are generated from nitrite by oxidation and reduce to ammonia by bacterial action. The recommended level of nitrate for shrimp farming is 0.0 to 0.3 ppm and for prawn farming <0.1 ppm [34,26]. The observed value of NO_3 was 0.21±0.16, 0.24±0.12, 0.18±0.12 ppt of T_1, T_2, T_3 categories shrimp farms, respectively. The findings of the present study were higher to the optimum level of nitrate requirement for shrimp and prawn farming might be the higher amount of dead plankton/weed and the aquatic vegetation in the shrimp farm. Alkalinity is the buffering capacity of water and represents its amount of carbonates and bicarbonates. The suitable range of alkalinity for shrimp farming is 60 -180 and for prawn farming is 20 to 300 ppm [33,26]. In this study, average alkalinity content was 150.37±15.70, 153.16±17.02 and 152.58±22.41 mg/L in three categories shrimp farms respectively. The research finding was similar to the recommended level of alkalinity of shrimp farming which might be due to the appropriate management system. Salinity represents the total concentration of dissolved inorganic ions, or salts in water. The optimum range of salinity for prawn farming is 12-16 ppt and for shrimp farming 5-30 ppt [33,26]. In this experiment, mean salinity was 1.10±0.03, 1.43±0.18 and1.39±0.10 ppt in three categories shrimp farms, respectively. The finding of the present study was under the recommended salinity level in shrimp/prawn farming. In low depth shrimp farming in course of reducing the salinity level toward almost fresh (0-3 ppt) due to dilution of rain water at the mid cycle (April to August) of culture period, shrimp shell become soften because of low alkaline nature of water where the presence of carbonates/bicarbonates are poor which accelerate PL death. Salinity had been another factor having a significant association with WSSV outbreak. Several studies in captivity reported that fluctuation in salinity and temperature could weaken the shrimp's immune system and affect viral proliferation. However, the current study revealed that most of the farms could not withstand against salinity fluctuation due to the lower water depth at sudden rain. Therefore, after successive raining in the aforementioned months, number of WSSV infected farms increased as the harboring salinity falls suddenly [27]. The observed value of soil pH 7.83±0.11, 7.85±0.07, 7.87±0.07 in three treatments, which are adjacent to the findings of [35] who reported that optimum range of soil pH for shrimp production at 7.7±36. The average value of organic content in the present study was 2.09±0.46%, 1.81±0.61% and 1.50±0.60% in three categories shrimp farms. According to [36] soil with less than 0.5% organic matter is low productive, 0.5 to 1.2% average productive, 1.5 to 2.5% high productive and greater than 2.5% as less productive for integrated aquaculture which is very identical to the present study. The findings of the present study revealed that the amount of dead plankton/weed and the aquatic vegetation higher in the shrimp farm. The average value of total nitrogen in the present study of shrimp farms was 0.12±0.02%, 0.09±0.03% and 0.08±0.03%, which was under to the findings of [37] who reported that the total nitrogen content ranged from 0.11 to 0.18% in shrimp farming. The average phosphorous content was11.76±3.28, 13.81±2.59 and 12.42±2.35 ppm in three categories shrimp farms, respectively which was similar to the finding of [38]. Low depth shrimp farming system relied on stocking of wild or hatchery seeds, application of lime, fertilizers, locally available handmade feeding and effective pathogen exclusion practices require attention to all points in the shrimp *(Peneaus monodon)* production cycle, from spawning to harvest, at which viruses may be encountered or recycled into the environment [27] variation in production rate and total yield (3414 kg/ha/cycle in 3≤ feet depth gher, 2470 kg/ha/cycle in 1.5< to < 3 feet depth gher 1482 kg/ha/cycle in 1.5 ≥ feet depth gher) due to variation in water quality and management techniques. Gross yield of shrimp/prawn (741/944 kg/ha/cycle in T_1, 494/741 kg/ha/cycle in T_2, 247/ 494 kg/ha/cycle in T_3) (Table 4) indicates a level that is not economically profitable and only obtainable from low depth shrimp culture system as reported by [37-41]. Our result of shrimp yield (production ranged from 247 to 741 kg/ha/cycle) was similar to the [38] who reported an average yield of *Penaeus monodon* ranged from 233 kg/ha/cycle to 444 kg/ha/cycle for extensive shrimp culture systems in Bangladesh. According to [16,35] production fall occures in three (extensive, improved extensive, semi-intensive) culture system due to the crisis of suitable stocking and management system.

5. CONCLUSION

Most of the shrimp ghers are under depth and farm owners faces excessive water crisis, poor salinity level and rapid fluctuation, PL death, Virus in shrimp, Production fall. Existed management system shows that the low stocked extensive culture systems in low depth shrimp farm with continuous long culture period has low survival and yield compare to well managed semi-intensive culture systems in standard depth. This as usual farming system has negative impacts on salinity deposition on soil, adverse effects on population health, destroying biodiversity and ecosystems, environmental changes, and imbalance in sustainability. Sufficient water in crisis season, optimum salinity in water, virus free PL, re- excavation and continuous aeration in shrimp gher etc, these opportunities are essentially needed for shrimp farmers that will help to maintain optimum farm environment and getting sustainable shrimp production in Bangladesh

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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