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Effect of chlorination on the production of shrimp (*Penaeus monodon*) in brackishwater ponds

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Abstract
An experiment was conducted to standardize dose of chlorine for improving sanitation of shrimp (*Penaeus monodon*) culture in brackishwater ponds in modified extensive system over a period of 120 days from 27 March 2013 to 25 July 2013. The experiment designed with four treatments whereas one treatment is a control of without any chlorine dose and other three treatments designed with three chlorine doses such as T1 (No chlorination), T2 (3 ppm), T3 (6 ppm) and T4 (9 ppm) each with three replicates. Total bacterial load reduced after application of chlorine. After chlorination at 3-9 ppm, about 82-85% total bacterial load was reduced. Increase in concentration of chlorine concentration showed no significant reduction of bacterial load. But after two days, bacterial load again started to increase. Load of total coliform also reduced drastically after application of chlorine at the same rate. The mean final weight of shrimp was 18.89±1.20, 17.90±0.50, 19.25±0.53 and 19.00±0.66 g in T1, T2, T3 and T4, respectively. The highest mean survival was recorded in T1 (77.16±4.41%) followed by T2 (77.09±4.26%), T3 (63.61±3.35%) and T4 (64.24±3.25%). The highest production was recorded in T1 (730.73±87.55 $kgha^{-1}$) which was significantly differed from ($p < 0.05$) T2, T3 and T4. Higher concentration of chlorine also showed no negative impact on the growth of shrimp but mortality of some moulted shrimp was observed. The present study, it was revealed that increasing the chlorine doses, decreasing the production and without chlorination highest production was recorded.

Keywords: chlorination, production, *Penaeus monodon*, brackishwater ponds

Introduction
Shrimp culture practice expanded rapidly and created a remarkable development in the fisheries sector of Bangladesh. The area of brackishwater shrimp culture spread from 0.064 million ha in 1985-86 to 0.173 ha in 2006-07. Over the same period, production of shrimp increased from 13,600 to 52,893 MT. This increase in production is not due to intensification of culture practice but for horizontal expansion of shrimp culture. There was a trend of intensification of culture in early nineties but after the spread of viral disease in shrimp in 1994~1995 [1], it has been totally stopped. Even farmers have become very cautious about stocking of shrimp to their *ghers.* In this way, the sequence of shrimp culture practice in the *ghers* of the whole coastal areas has been changed. Deb [2] also reported that in spite of vast potential, there had been an unregulated, uncontrolled and uncoordinated horizontal expansion of the shrimp farming rather than an attained efficiency of the production system.

Most of the farmers (>90%) still follow the extensive traditional method, which is characterized by a larger sized *gher*, low stocking density, no feeding and fertilization and poor management of water quality. As a result, production is lower and the farmers often incur losses rather than profit. Wahab [3] recommended the use of smaller units of shrimp culture area and better management practices to improve this situation and obtain a sustained production and profits.

Shrimps are cultivated in many different systems worldwide – from extensive to super-intensive ones. Recently Bangladesh Fisheries Research Institute developed high tech semi-intensive shrimp culture in closed system with a production target of more than 2.0 $Tonha^{-1}$ [4]. To enhance primary productivity, *ghers* are fertilized with different fertilizers. Excess fertilization may also create uncongenial environment increasing the level of ammonia, intolerable to the stocked shrimp. BFRI conducted primary study on this aspect and reported that addition of urea up to 1.5 ppm will not be harmful for shrimp but will be beneficial for increasing primary productivity to a considerable extent in modified extensive culture [5]. After nineties decades, most of the brackishwater shrimp ponds have been affected by various pathogenic diseases. There are many ways to prevent these pathogenic diseases and chlorination is one of them. Chlorine is mainly used in brackish water aquaculture for sanitation. Sanitation refers to the selective destruction of disease causing organisms. Chlorination will also successfully eliminate toxic plankton (dinoflagellates) and aquatic animal pests and competitors that come in with the water supply. Poduska and Hershey [6] invented a mathematical model to explain virus activation by chlorination, based on the principles of first order, irreversible chemical reaction kinetics. Chlorination is also used to include attempts to destroy disease organisms, control phytoplankton abundance, and improve water quality in ponds stocked with fish or shrimp [7]. Sukumar *et al.* [8] studied the impact of chlorination on water quality of shrimp farms and revealed that even though chlorination helped in preventing horizontal propagation of diseases, it had an adverse effect on the development of algae in shrimp ponds and on the survival of the other biota of the receiving water bodies. Browdy *et al* [9] developed a bio-secure shrimp culture system and reported destruction of at least 99% of the bacteria

and yeast present in the filtered seawater by chlorination. Husnah and Chang [10] reported that chlorine at a dose of 1200 and 2400 mgl^{-1} inactivated 100% bacteria within 2 days of contact time. With high chlorine dose, chlorination was effective to inactivate bacteria only to a depth of 2.1 cm. The present study undertaken different dose of chlorination on micro flora, water quality, survival and growth of shrimp, *Penaeus monodon.*

Methodology

Experimental design

The experiment was conducted in 12 ponds of 1000 m^2 each of Bangladesh Fisheries Research Institute, Brackishwater Station, Paikgacha following the design as given in Table 1.

Table 1: Design of the Experiment.

Treatments (T)		Replications	Stocking density
T_1	No chlorination	3	$5/m^2$
T_2	3 ppm		
T_3	6 ppm		
T_4	9 ppm		

Pond preparation

The ponds were prepared by treating soil with lime (Quick lime: dolomite 3:1) @ 250 $kgha^{-1}$ and then filled with tidal water up to a depth of 1.0 m. After that, all animalcules were killed by using 55ppm bleaching powder. The buffering capacity of the pond water was strengthened by applying dolomite @ 10-15 ppm. The pond water was fertilized with urea and TSP @ 2.5 ppm, 3.0 ppm respectively. Fermented molasses were applied to the pond water @ 15ppm to develop colour of water to check penetration of sunlight. If any pond was not grown sufficient primary production then again use of 5 ppm fermented molasses.

Stocking and Management

After production of sufficient plankton, required quantity of PCR (polymerized chain reaction) tested PL20 was stocked to the respective pond. The stocked shrimps were fed with commercial feed. The used different grades (crumble to pellet) of feed contains 39-45% protein, 3% lipid, 6% fiber, 18% ash and 11% moisture. Protein concentration was higher in feeds used for smaller shrimps. Feed was applied by spreading and adjusted fortnightly after sampling with cast net. The load of total heterotrophic bacteria and total coliform of water was checked as indicator of sanitation. The estimation of bacterial load was done before and after two hours and two following successive days after application of chlorine. Total heterotrophic bacteria were counted by pour plate technique method and total coliform by most probable count (MPN) method as mentioned in APHA [11]. Primary productivity of the ponds was monitored before and after two hours and two following successive days after application of chlorine following classical dark and light bottle method as mentioned by Adoni [12]. Basic water quality variables (*viz.*, depth, temperature, salinity, pH, transparency, free carbon dioxide, dissolved oxygen and alkalinity) were determined at fortnight intervals following standard methods [11]. To maintain undisturbed ecology of the ponds, no water was exchanged. Only the evaporated water was replenished with the water of the adjacent canal. Health of the stocked shrimps was checked almost daily through check tray.

Harvesting of shrimp

After 120 days of rearing, all shrimp were harvested by de-watering the ponds and growth, survival and production were estimated.

Data Analysis

Data were analyzed using MS Excel. One way analysis of variance (ANOVA) was used to determine the final weight, survival and production. The Duncan's test was used to determine the differences among the treatments. Differences were considered statistically significant at 5% level.

Results and Discussion

Data on water quality parameters are shown in Table 2 indicates that the recorded water quality parameters were congenial for culture of shrimp. The highest water depth was in T1 whereas lowest in T3 and the ranges of water depth was 95 to 110 cm. The ranges of transparency were 20 to 45cm which indicates the productivity of ponds. Higher temperature of surface water was recorded in the month of April and May of 35 ^{0}C. As depth of water was maintained around 1 meter, no stress in shrimp was observed in spite of high surface water temperature. Lower salinity was recorded during stocking the shrimp and salinity increased with the progress of culture period. This is due to replenishment of evaporated water with the.

Table 2: Water quality variables of ponds under different treatments

Water quality Variables	Treatments			
	T1	T2	T3	T4
Depth (cm)	100 - 109	98 - 110	95 - 108	96 -107
Transparency (cm)	35 - 45	20 - 40	25 - 45	30 - 45
Temperature (ºC)	31 - 35	31 - 35	31 - 35	31 - 35
Salinity (ppt)	6 - 15	6 - 15	6 - 15	6 - 15
pH	7.8- 9.4	7.8 - 9.6	7.9 - 9.6	8.0 - 9.4
Morning dissolved oxygen (mgl^{-1})	3.6-8.8	3.8-6.6	4.6-7.2	4.8-7.8
Evening dissolved oxygen (mgl^{-1})	6.3-10.2	6.8-11.6	7.7-10.1	6.6-10.4
Total alkalinity	90 – 124	80-140	75 - 140	66 - 120

Higher saline water of the adjacent Shibsa River. The pH ranges was 7.8 to 9.6 which was suitable ranges for shrimp culture. The lowest dissolved oxygen was recorded in T1 of 3.6 mgl^{-1} in the morning and highest was in T2 of 11.6 mgl^{-1} in the evening. The range of total alkalinity was recorded 66 to 140 in shrimp culture pond during the culture period. The

dissolved oxygen and total alkalinity were sufficient enough for the normal growth of shrimp. Similar water quality parameters were recorded by Saha and Ali [13] and Khatun *et al.* [14] in brackishwater shrimp culture pond.

Primary productivity and bacterial count were determined to evaluate the impact of chlorination on pond environment. As shown in Table 3, there is no significant change in productivity where chlorination was not done. But chlorination reduced both gross primary productivity and net primary productivity. Reduction in productivity increased with the increase in chlorine dose.

Table 3: Change in primary productivity after chlorination at different dose over a period of 120 days.

Dose of chlorination	Gross primary productivity			Net primary productivity			Respiration		
	Before chlorination (g C/m^3/d)	Change (%)		Before chlorination (g C/m^3/d)	Change (%)		Before chlorination (g C/m^3/d)	Change (%)	
		After 2 hr.	After 2 days		After 2 hr.	After 2 days		After 2 hr.	After 2 days
No chlorination	1.800	+1.33	+2.22	1.350	-7.40	+0.29	0.450	+27.53	+8.00
3 ppm	1.675	-25.37	-31.34	1.225	-26.53	-59.35	0.450	-22.22	+44.89
6 ppm	1.900	-28.68	-53.57	1.250	-24.00	-68.00	0.650	-39.23	-15.38
9 ppm	1.800	-34.88	-67.53	1.250	-28.00	-91.84	0.550	-47.81	-12.36

Total bacterial load reduced after application of chlorine (Table 4). After chlorination at 3 to 9 ppm, about 82-85% total bacterial load was reduced. Increase in concentration of chlorine concentration showed no significant reduction of bacterial load. But after two days, bacterial

Table 4: Change in bacterial load of water after chlorination at different doses.

Dose of chlorination	Total heterotrophic count			Total coliform		
	Before chlorination (CFU/ml)	Change (%)		Before chlorination (CFU/ml)	Change (%)	
		After 2 hr.	After 2 days		After 2 hr.	After 2 days
No chlorination	45×10^3	+2.22	+8.89	294	+2.04	+1.36
3 ppm	52×10^3	-81.94	-61.11	300	-89.00	-88.33
6 ppm	44×10^3	-83.53	-66.00	300	-92.00	-93.53
9 ppm	46×10^3	-84.78	-67.39	300	-97.00	-97.00

Load again started to increase. Load of total coliform also reduced drastically after application of chlorine at the same rate.

Production performance of shrimp under different treatments has been furnished in Table 5. After 120 days of culture, the mean final growth of shrimp was 18.89±1.20, 17.90±0.50, 19.25±0.53 and 19.00±0.66 g in T1, T2, T3 and T4, respectively. The mean values of final growth were no significantly different ($p > 0.05$) among the treatments. The mean survival was 77.16±4.41%, 77.09±4.26%, 63.61±3.35% and 64.24±3.25% in T1, T2, T3 and T4, respectively. The mean highest survival of shrimp was found in T1 (77.16±4.41%) where shrimp was cultured without chlorination. This survival is almost same with that of 77.09±4.26% in T2 treated with 3.00 ppm chlorine. There was no significant difference ($p > 0.05$) was found between T1 and T2. But survival of shrimp is significantly reduced to 63.61% in T3 with 6.00 ppm chlorine and 64.25% in T4 treated with 9.00 ppm chlorine. This might be due to the fact that after application of chlorine at 6 to 9ppm dose, some moulted shrimps were found dead at the periphery of the pond. This is similar to the findings of Khatun *et al.* [14] who found that chlorination effect on bacterial load in brackishwater shrimp culture pond.

Table 5: Production performance of shrimp ((*Penaeus monodon*) in different treatments over a period of 120 days

Treatments	Replications	Final Wt (g)	Survival (%)	Production (Kg/ha)
T1 (No chlorination)	R1	20.24	81.50	824.78
	R2	17.93	72.68	651.57
	R3	18.52	77.32	715.9
	Average	18.89±1.20^a	77.16±4.41^a	730.73±87.55^a
T2 (3 ppm chlorination)	R1	18.18	72.40	658.12
	R2	18.18	80.72	733.74
	R3	17.35	78.14	677.86
	Average	17.90±0.50^a	77.09±4.26^a	689.91±39.22^{ab}
T3 (6 ppm chlorination)	R1	19.50	62.61	610.50
	R2	18.64	60.88	567.41
	R3	19.60	67.35	660.00
	Average	19.25±0.53^a	63.61±3.35^b	612.64±46.33^c
T4 (9 ppm chlorination)	R1	18.28	61.25	559.83
	R2	19.60	67.35	660.00
	R3	19.12	64.12	612.99
	Average	19.00±0.66^a	64.24±3.25^b	610.94±50.12^c

Figures with different superscript differs significantly

The mean production of shrimp was 730.73±87.55, 689.91±39.22, 612.64±46.33 and 612.64±46.33 kgha^{-1} over a culture period of 120 days in T1, T2, T3 and T4, respectively. The highest production was found in T1 where shrimp culture was done without chlorine and significantly different ($p < 0.05$) from T3 and T4 but not differ from T2 where the ponds were treated with 3 ppm chlorination. But at @ 6ppm and 9ppm chlorination, the production of shrimp was significantly reduced 612.64 kgha^{-1} and 610.94 kgha^{-1} in T3, and T4, respectively. Saha and Ali [13] obtained the production of shrimp was 667.57-811.76 kg /ha with the average body weight of 20.81-23.95g after 120 days culture at the stocking density of 5 Nos m^{-2}. In another experiment, Saha *et al.* [15] reported 699.72-940.19 kgha^{-1} production of shrimp with the average body wt of 17.23-23.95g at the same culture period, stocking density and feeding rate. These findings more or less similar with the present study. However, the production in T3 and T4 was lower than T1 and T2, due to the fact that mortality of some moulted shrimp was observed after application of higher dose of chlorine.

Conclusion

From the present study it is stated that the higher dose of chlorine in brackishwater shrimp culture pond decrease the production of shrimp due to higher mortality of moulted shrimp. But the lower dose of chlorination is reduced the pathogenic load without any hamper of survival and production of shrimp in brackishwater culture. So, further studies for a longer period with more treatments and replications should be done for more helpful results.

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