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Water quality characteristics of some carp hatcheries of West Bengal

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Abstract
The fish seed being the major input for fish farming, there is always a growing demand for quality fish seeds. The uncertainty in the quantity and quality of riverine fish seed collection led to development of many carp hatcheries in West Bengal. But in these hatcheries, there has been large-scale mortality during the early stages and it may be due to lack of proper care in water quality management in hatcheries. A study was conducted to assess the water quality in carp hatcheries and it was observed that the most of the water parameters were within the prescribed range. But in the H-4, the dissolved oxygen, pH, free CO_2, total alkalinity, total hardness, total solid, total dissolved solid and turbidity were significantly higher than the other three hatcheries. Probably this was the reason for lower fertilization and survivality rate in this hatchery. Among the all four hatcheries the performance of Naihati hatchery (H-2) was comparatively better because of more congenial physico-chemical condition. The highest rate of fertilization and hatching was observed in H-2 (Naihati hatchery) which was significantly (P<0.05) higher than other three where as the fertilization and hatching percentage of H-4 (Faculty of Fishery Science) were significantly lower than the other three hatcheries.

Keywords: Carps, hatchery, water quality

Introduction
West Bengal is the pioneer and leader in fish seed production in India. In carp hatchery, water is the prime requirement. Water quality management is one of the most important aspects of any fish seed farm [7]. opined that manipulating of water during running condition of breeding cycles was prime requirement for maximum survival of eggs and spawn. Therefore, special attention should be give for manipulating water quality to eliminate the harmful effects of excess excretory products released from eggs and spawn for maximum survival of spawn in hatcheries.

The success of carp hatcheries depends on water. Hence water quality management can be defined as "the system comprising the analysis of various water parameters, to have knowledge of the favorable range of these parameters and control techniques involve to bringing the parameters under desirable limits" [18]. The quality of water must be such that it should support carp hatchery to get the maximum survival rate of fish seed. The present study has been carried out to assess water quality and its impact on spawning and survivality of successive stages and to advocate or suggest measures for better water quality management of the selected hatcheries.

Materials and Methods
The study was carried out to find out the prevailing water quality of four carp hatcheries situated in the three districts of West Bengal and also to assess the impact of water quality variation on breeding and hatching for a period of three months viz May, June and July 2009. The four different hatcheries selected for study is located at Gaighata in North 24 Parganas district, Naihati in 24 Parganas North, Habibpur in the Nadia and Faculty of Fishery Science campus in 24 Parganas South districts and is designated as H-1,H-2, H-3 and H-4 respectively.
Water samples were separately collected in labeled plastic bottles from four carp hatcheries. Water samples were taken from over head tank, breeding pool and hatching pool. Three operation cycles were completed for study during the month of May to July, 2009. The water parameters like temperature, pH, dissolved oxygen, free carbon dioxide, total alkalinity and total hardness were analyzed on the site itself. For the estimation of other parameters, the

water samples were brought to laboratory for analysis following standard methods [3].

Procedure used for analysis of different parameters

The surface water temperature was recorded by using mercury centigrade thermometer (0 to 50˚C) to nearest 0.1˚C graduation at station itself [1]. The pH of water samples was measured in the field by pH pen meter and also in the laboratory with digital pH meter (Systronics: Model No.MK-VI) following the electrometric method described by [1]. Dissolved oxygen (DO), Free Carbon dioxide (Free CO_2), Hardness and Total alkalinity of water sample were estimated following [3]. Turbidity, Total solid (TS), Total dissolved solid (TDS), Ammonia Nitrogen (NH_4-N) and Iron of water sample was estimated following [4]. Nitrate –nitrogen content of water was estimated following the Spectrophotometer method [23]. Phosphate–Phosphorus was estimated by methods given in [3]. In the hatchery, measurement of egg and spawn was done by volumetric method [5, 19, 24]. The data generated from the investigation were tested for significance of difference among the different stations of carp hatchery during the month from May to July, 2009 using 't' test. All the statistical procedures were followed after [8] and with the help of Statistical Package for Social Sciences (SPSS version 16.0 for windows, 2013).

Results and Discussion

The significance of differences between different hatcheries has been found out with the help of't' test taking into consideration the different parameters under study and presented in the Table 1. The average highest water temperature of Faculty of Fishery Science (H-4) hatchery in the breeding and hatching pool were 36.33 °C and 35.0 °C respectively. Based on their detail study [7] said that at higher temperature mortality is high and hatching percentage also gets reduced [5]. stated that when spawning occurs at high water temperature of 35 to 38 °C, the percentage of fertilization and hatching of eggs is low. During present investigation similar condition was observed in the H-4 hatchery where fertilization and hatching percentage found to be lower compared to the other three hatcheries.

The average water pH in the breeding pools of the hatcheries H-1, H-2, H-3 and H-4 were 7.73, 7.33, 7.53 and 7.86 respectively. During investigation the average water pH of the hatching pools of H-1, H-2, H-3 and H-4 hatcheries were found to be 7.23, 7.10, 7.20, and 7.53 respectively [2]. advocated that the pH range of less than 6.0 and more than 8.5 for longer durations adversely affect hatching. According to him the pH between 7.2 to 9.0 is considered suitable for hatching. According to [7, 5] if pH is less than 6.5 and more than 9 pH for longer duration, it adversely affects hatching. According to them pH between 7 to 9 is considered suitable for hatching. The spawning occurs at a fairly wide range of pH. [13] concluded that free CO_2 of the hatchery water tended to rise gradually as the length of embryonic development advanced because of respiratory activities of the fertilized eggs and larvae. This caused the pH of the water to decline from 8.57 to 7.0. The pH of water in the breeding and hatching pool was within the prescribed range but in all four hatcheries it was observed that the pH level was low in the hatching pool compared to breeding pool. This may be due to the rise in CO_2 level in the hatching pool because of respiratory activities of the fertilized eggs and larvae and for this reason the pH was comparatively low [13].

The maximum dissolved oxygen in breeding and hatching pool of Naihati (H-2) carp hatchery were 6.30 mg/l and 5.83 mg/l respectively. In the hatching pool, the dissolved oxygen of three hatcheries namely H-1, H-3 and H-4 were less compared to the H-2 hatchery due to fertilized eggs require dissolved oxygen for their development [27]. advocated the suitable range of Dissolved oxygen 5 to 6 mg/l [7]. suggested that the dissolved oxygen in water plays an important role on the percentage of hatching, incubation time and survival of spawn [17]. Found that the dissolved oxygen was decreased after spawning and hatching of fish even after a constant supply of compressed air probably due to increased oxygen consumption by fertilized eggs, brooders and hatchling. The other three hatcheries namely the H-1, H-3 and H-4 did not fully maintained dissolved oxygen and so, the rate of fertilization and hatching percentage were not found as expected.

The average free CO_2 recorded from the breeding pool of four carp hatcheries H-1, H-2, H-3 and H-4 were 2.40 mg/l, 2.40 mg/l, 1.53 mg/l and 6.40 mg/l respectively and the average CO_2 level in the hatching pool were 6.66 mg/l, 3.33 mg/l, 6.20 mg/l and 6.83 mg/l respectively. It showed that in H-4 hatchery free CO_2 was higher in the breeding pool compared to the H-1, H-2 and H-3 and at hatching pool of H-2 hatchery the free CO_2 was less compared to H-1, H-3 and H-4. The higher CO_2 was reported after spawning and hatching. This may be because of the decomposition of unfertilized eggs requires more oxygen. But in the H-2 hatchery due to high level of dissolved oxygen in the hatching pool, the free CO_2 was less compared to other three hatcheries. So, fertilization and hatching percentage was high [25]. suggested that high levels of dissolved carbon dioxide interfere with respiration by eggs and spawn [6]. Observed that the present of free CO_2 in hatchery operation was due to fouling caused by unfertilized eggs and the CO_2 was reported only when the fertilization percentage was low. According to [13] the ratio of carbon dioxide release to oxygen uptake by the developing embryos showed a sharp rise in hatching pool. Carbon dioxide was liberated from the embryos at a faster rate than the rate of oxygen uptake during the process of hatching [17]. reported that the free CO_2 was present in breeding and hatching pools after spawning and hatching. This is due to decomposition of unfertilized eggs and high number of eggs laid in limited quantity of water.

The average maximum and minimum total alkalinity recorded from the four carp hatcheries H-1, H-2, H-3 and H-4 were 153.46 mg/l, 123.66 mg/l, 151.90 mg/l and 364.10 mg/l in breeding pool and 173.80 mg/l, 146.80 mg/l, 191.50 mg/l and 392.66 mg/l in hatching pool respectively. From all the hatcheries it was observed the total alkalinity was higher in H-4 hatchery compared to the H-1, H-2 and H-3. The average total alkalinity of H-1, H-3 and H-4 hatchery in the breeding and hatching pool were found to be higher compared to the H-2 hatchery. Due to the higher total alkalinity the fertilization and hatching percentage was found to be lower compared to the H-2 hatchery. According to [22] mass mortality resulted from higher total alkalinity of above 150 ppm [9]. also suggested that total alkalinity of the water used for hatchery operations played an important role for the development of fertilized eggs and hatching of the embryos. It has been recorded that total alkalinity beyond 150 ppm is detrimental. [12, 22] observed that that the effect of total alkalinity of >150ppm in incubation system of carp hatchery lead mass embryonic mortality. It was observed that in the hatching pool the total alkalinity was higher compared to breeding pool [13].

stated that the value of the total alkalinity in the hatchery rise in the hatching tanks after eggs transfer due to the liberation of Ca^{2+} and Mg^{2+} from the eggs mass. During present investigation also the alkalinities of all hatcheries were within the limit except in H-4 which has led to large mortality during initial breeding operation. The eco hatchery has been critically assigned by the't' test where the test of significance of variance was observed with the help of Microsoft excel 2003 and it was found that from the data (Table -1) it is clear that the breeding pools of H-2 hatchery had the lowest total hardness which was significantly lower than the other three hatcheries. H-4 had very high (Significantly high) total hardness compared to other three hatcheries. Similar trend in case of hardness was observed in the hatching pools of four hatcheries. In the present study the average total hardness from the experimental site H-1, H-2, H-3 and H-4 were 275.46 mg/l, 175.50 mg/l, 285.36 mg/l and 724 mg/l in breeding pool and 295.46 mg/l, 190.86 mg/l, 320.46 mg/l and 785.33 mg/l in hatching pool respectively. The highest total hardness in breeding and hatching pools was seen in H-4 which were 724 mg/l and 785.33 mg/l and the lowest in H-2 as 175.50 mg/l in breeding pool and 190.86 mg/l in hatching pool. It was observed that in the hatching pool the total hardness was higher [13]. stated that the value of the total hardness in the hatchery rise in the hatching tanks after eggs transfer due to the liberation of Ca^{2+} and Mg^{2+} from the eggs mass [14]. suggested that excessive hardness of water was detrimental to the eggs of Atlantic salmon [12]. observed egg shell disintegration and when the hardness was between 156 to 184 ppm. All the hatcheries during investigation it indicate that the total hardness was not in prescribed range except H-2. So percentage of fertilization and hatching found to be lower. But in H-4 hatchery the hardness level was extremely higher compared to other three hatcheries so it had adversely effected the fertilization and hatching process.

The average nitrate nitrogen recorded from the site H-1, H-2, H-3 and H-4 were 0.03 mg/l, 0.02 mg/l, 0.02 mg/l and 0.06 mg/l in breeding pool and 0.07 mg/l, 0.04 mg/l, 0.05 mg/l and 0.53 mg/l in hatching pool respectively. At the experimental site H-4 the highest value was found to be 0.06 mg/l and 0.533 mg/l in breeding pool and hatching pool respectively. The lowest value was observed in H-2 which was 0.02 mg/l and 0.04 mg/ l in breeding pool and hatching pool respectively. In the hatching pool of H-1, H-3 and H-4 hatcheries the nitrate value was higher [17]. reported that the nitrate was found increased in breeding and hatching pool due to the decomposition of excretory products, milts and unfertilized eggs. But in the H-2 hatchery the nitrate value was lower compared to the all the three hatcheries due to high dissolved oxygen [13]. pointed that concentration of nitrate in the hatching tanks were highly dependent upon the amount of oxygen present.

The average values of ammonia- nitrogen from the H-1, H-2, H-3 and H-4 were 0.06 mg/l, 0.05 mg/l, 0.04 mg/l and 0.50 mg/l in breeding pool and 0.43 mg/l, 0.13 mg/l, 0.233 mg/l and 0.16 mg/l in hatching pool. In all the four hatcheries the ammonia level was found to be higher [24]. pointed out that the metabolic wastes from the developing embryos such as ammonia are liberated in to the water [13]. suggested that rise of ammonia level in the incubation pool or hatching pool is mainly due to ammonia excretion from developing embryos. Ammonia is dependent on the dissolved oxygen. In the H-2 hatchery the ammonia level was low in hatching pool compared to the other three hatcheries due to maintenance of higher dissolved oxygen level. But the similar case was not there in the H-4 hatchery.

The results obtained indicated that there was no significance difference between the breeding pools of four hatcheries in respect of phosphate-phosphorus. The average values of phosphate at H-1, H-2, H-3 and H-4 were 0.03 mg/l, 0.05 mg/l, 0.03 mg/l and 0.04 mg/l in breeding pool and 0.006 mg/l, 0.006 mg/l, 0.005 mg/l and 0.006 mg/l in hatching pool respectively. It showed that phosphate level in the hatching pool was found to be lower in all four hatcheries [13, 15]. reported that the phosphate level in the hatching tank was reduced during hatching period. Food reserve in the yolk was exhausted during hatching and the developing embryos utilized phosphate (necessary for bone formation) and this uptake was presumably mediated through the permeable cell membrane by cationic exchange mechanism [26]. observed maximum loss of phosphorus from the yolk during hatching in *Salmo gairdineri*.

Table-1: Average water quality of the breeding pools and hatching pools of different hatcheries of West Bengal

Parameters	Breeding pools				Hatching pools			
	H 1	H 2	H 3	H 4	H 1	H 2	H 3	H 4
Water Temperature (°C)	32.0^{a} ±2	29.0^{ab}±1	29.0^{abc}±1	36.33^{a}±3.51	30.33^{a}±1.52	30.33^{ab}±2.08	28.66^{ab}±1.52	35.0^{c}±2
pH	7.73^{a} ±0.15	7.33^{b}±0.15	7.53^{abc}±0.15	7.86^{ac}±0.30	7.23^{a}±0.15	7.10^{ab}±0.10	7.20^{abc}±0.10	7.53^{ac}±0.25
Dissolved Oxygen (mg/l)	5.53^{a} ±0.25	6.30^{b} ±0.20	6.53^{b}±0.35	5.53^{c}±0.30	3.43^{a}±0.25	5.83^{b}±0.30	3.46^{ac}±0.25	3.43^{ac}±0.25
Free CO_2 (mg/l)	2.40^{a} ±0.20	2.40^{b}±0.20	1.53^{c}±0.40	6.40^{d}±0.20	6.66^{a}±0.25	3.33^{b}±0.25	6.20^{c}±0.20	6.83^{a}±0.40
Total alkalinity (mg/l)	153.46^{a}±2.60	123.66^{b}±1.45	151.90^{a}±2.10	364.10^{c}±4.03	173.80^{a}±3.01	146.80^{b}±2.56	191.50^{c}±3.50	392.66^{d}±2.51
Total hardness (mg/l)	275.46^{a}±0.95	175.50^{b}±3.10	285.36^{c}±1.26	724.0^{d}±4.58	295.46^{a}±4.57	190.86^{b}±1.55	320.46^{c}±1.05	785.33^{d}±2.51
Nitrate-nitrogen (mg/l)	0.03^{a}±0.01	0.02^{ab}±0.005	0.02^{ab}±0.01	0.06^{c}±0.01	0.07^{a}±0.02	0.04^{ab}±0.01	0.05^{ab}±0.01	0.53^{c}±0.15
Phosphate-phosphorus (mg/l)	0.03^{a}±0.01	0.05^{ab}±0.01	0.03^{abc}±0.01	0.04^{abc}±0.02	0.006^{a}±0.002	0.006^{ab}±0.003	0.005^{abc}±0.001	0.006^{abc}±0.002
Ammonia-nitrogen (mg/l)	0.06^{a}±0.01	0.05^{ab}±0.01	0.04^{ab}±0.01	0.50^{c}±0.10	0.43^{a}±0.152	0.13^{bc}±0.02	0.23^{a}±0.02	0.16^{c}±0.02
Iron (mg/l)	0.37^{a}±0.02	0.22^{b}±0.01	0.28^{c}±0.01	0.31^{d}±0.005	0.33^{a}±0.02	0.17^{b}±0.01	0.25^{c}±0.01	0.29^{d}±0.005
Total solid (mg/l)	172.0^{a}±2	165.0^{b}±3.60	113.66^{c}±1.52	295.0^{d}±2	181.33^{a}±3.51	174.33^{b}±4.04	126.0^{c}±5.29	302.30^{d}±3.05
Total Dissolved solid (mg/l)	95.33^{a}±2.51	96.0^{a}±2	88.33^{b}±2.08	174.0^{c}±4	109.0^{a}±5.56	108.66^{a}±3.51	95.33^{b}±3.05	191.66^{c}±2.51
Turbidity (NTU)	12.43^{a}±1.23	12.53^{a}±1.10	9.93^{b}±0.66	18.83^{c}±0.80	15.73^{a}±1.60	15.36^{a}±0.66	12.66^{b}±1.00	20.93^{c}±0.8
Fertilization (%)	59.0^{a}±0.01	72.0^{b}±0.01	64.0^{c}±0.02	46.0^{d}±0.05	69.0^{a}±0.01	77.0^{b}±0.01	74.0^{c}±0.02	52.0^{d}±0.03

(**Note:** The value marked with different letters denotes the significant difference)

The average iron recorded from the experimental site H-1, H-2, H-3 and H-4 were 0.37 mg/l, 0.22 mg/l, 0.28 mg/l and 0.31mg/l in breeding pool and 0.33 mg/l, 0.17 mg/l, 0.25 mg/l and 0.29 mg/l in hatching pool respectively. In H-2 hatchery the iron in the hatching pool is lower compared to the breeding pool. In other three hatcheries the dissolved oxygen level is not maintained [25]. Suggested that iron is oxidized by vigorously aerating the water. The highest iron found to be from the site H-1, H-3 and H-4 which is detrimental for fertilization and hatching. So fertilization and hatching

percentage was low compared to H-2 hatchery. Iron rich water is not suitable for hatcheries [10]. As per [11] well water containing 0.25 ppm of total iron has adversely effect in the hatchery and heavy mortality will occur. The heavy loads of iron with underground water are undesirable of development embryos during carp hatchery operation as reported by [5].

In the present investigation, the highest average total solids were recorded in breeding and hatching pool as 295 mg/l and 302.30 mg/l at H-4 respectively and the lowest values as 113.66 mg/l and 126 mg/l at H-3 respectively. The maximum average total dissolved solid values in the breeding pool and hatching pool observed were 174 mg/l and 191.66 mg/l at H-4 respectively. The lowest values found in breeding and hatching pools were 88.33 mg/l and 95.33 mg/l at H-3 respectively. The TS and TDS were found to be higher in H-4 hatchery which might be due to excessive of silts and clay [16]. According to [7] excessive silt or deposition of silt on the eggs prevents successful development of eggs. Silt deposition on egg surface and gills of spawn prevents proper diffusion of oxygen through gill membrane or egg shell [20]. Observed that total dissolved solid of 165 mg/l during the development of egg was normal and at the TDS level of 184 mg/l the egg shell was found to be soft and ruptured. The values of TDS observed in all hatcheries in the breeding and hatching pools were within the prescribed range except in case H-4. The value of TDS found to be high in H-4 hatchery which is adverse for eggs [20].

During the study period the maximum average value of turbidity in breeding and hatching pool found to be at H-4 which was 18.83 NTU and 20.93 NTU respectively. The lowest value was observed at H-3 which was 9.93 NTU at breeding pool and 12.66 NTU at hatching pool. The high value of turbidity at H-4 might be due to high dissolved solids and suspended matter [24, 2]. Stated that surface water carried suspended solids which coat eggs and clog the gills of fry. The highest turbidity was found at H-4 hatchery which was harmful for fertilization and hatching. So fertilization and hatching percentage was found to be lower.

Conclusion

The result of present investigation indicates the significantly higher (P<0.05) rate of fertilization and survivability in case of Naihati hatchery (H-2) compared to the hatcheries of Habra (H-1), Habibpur (H-3) and Faculty of Fishery Science (H-4). The result from the't' test reveals significantly lower free CO_2, total alkalinity, total hardness, ammonia-nitrogen and iron levels both in breeding as well as hatching pools. The analysis also indicates significantly higher dissolved oxygen level in H-2 compared to H-1, H-3 and H-4. Similarly it was also observed that the average water temperature (29.0 °C and 30.3 °C) and average pH (7.33 and 7.10) of Naihati hatchery (H-2) are significantly different (lower) than the three hatcheries. It is also the most optimum range prescribed by [21, 24].

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