E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2017; 5(2): 27-32

www.fisheriesjournal.com
Received: 07-01-2017
Accepted: 08-02-2017

Md Ali Haider
Faculty of Fisheries, Hajee Mohammad Danesh Science & Technology University, Dinajpur

Sheik Istiak Md Shahriar
Faculty of Fisheries, Hajee Mohammad Danesh Science & Technology University, Dinajpur

Md Hafiz All Hosen
Faculty of Fisheries, Hajee Mohammad Danesh Science & Technology University, Dinajpur

Mousumi Sarker Chhanda
Faculty of Fisheries, Hajee Mohammad Danesh Science & Technology University, Dinajpur

Mst Masuma Khatun
Faculty of Fisheries, Hajee Mohammad Danesh Science & Technology University, Dinajpur

Correspondence
Sheik Istiak Md Shahriar
Faculty of Fisheries, Hajee Mohammad Danesh Science & Technology University, Dinajpur

A study on water quality parameters and benthos abundance in freshwater homestead ponds of Dinajpur, Bangladesh

Md Ali Haider, Sheik Istiak Md Shahriar, Md Hafiz All Hosen, Mousumi Sarker Chhanda and Mst Masuma Khatun

Abstract
An experiment on water quality parameters and the abundance of benthos in freshwater homestead ponds was carried out for a period of 90 days from Dinajpur district of Bangladesh. The study was conducted considering three treatment ponds such as T1 (small sized), T2 (medium sized) and T3 (large sized) and each has three replications. Different water quality parameters were measured at 15 days interval. The ranges of water temperature were 24 to 34 °C, transparency 27 to 36 cm, dissolved oxygen 3.75 to 4.97 mgl^{-1}, pH 6.16 to 7.10, total alkalinity 28 to 122 mgl^{-1}, chlorophyll-a 4.76 to 460.77 μgl^{-1}, ammonia-nitrogen 0.01 to 0.70 mgl^{-1}, phosphate-phosphorus 0.12 to 0.99 mgl^{-1}, nitrite-nitrogen 0.00 to 0.26 mgl^{-1} and nitrate-nitrogen 0.01 to 0.45 mgl^{-1} were found among three treatments. Significantly varied values of transparency, total alkalinity and nitrate-nitrogen were observed while other parameters showed non-significant among three treatments. Four groups of benthos i.e. Oligochaeta, Chironomidae, Mollusca and Unidentified were distinguished during the study period. Oligochaeta was dominant among different groups of benthos. The mean (±SD) values of total benthos were 526.75±76.30, 498.77±68.72 and 553.09±61.53 in T1, T2 and T3 respectively. The highest total benthos abundance was recorded in T3 due to its comparatively better water quality. The research findings will be beneficial for the pond owners for the improvement of homestead fish production.

Keywords: Water quality parameters, benthos abundance, Dinajpur district, Bangladesh

1. Introduction
The physico-chemical and biological characteristics of water play a significant role in overall productivity of a water body as well as the biology of the cultured organisms. The culture of different species under different environments always depends on optimum water quality [8]. Survival, health and adequate growth of cultured species also depend on good water quality [4]. Thus, the knowledge of water quality parameters of the water bodies provides an important tool for successful production of aquatic organisms in aquaculture.

The abiotic environment of the water body directly influences the distribution, population density and diversity of the macro benthic community. Benthic organisms are rich in amino acids, fatty acids, vitamins and minerals, etc; can alone provide a complete diet for many bottom feeding fishes [25]. It not only serves as an important food item for fishes, but also considered as an indicator of productivity of a water body [7]. In scientific culture and management of fisheries resources, there is a great need of understanding regarding benthic fauna as they play a vital role in regulating the aquatic environment.

The ponds located in north-west region of Bangladesh, especially in Dinajpur district is mainly used for traditional fish culture of carps, pangus and tilapia etc [11]. It also serves domestic purposes like personal hygiene, washing of clothes, dishes and household materials, bathing of cattle etc. Moreover, these ponds contain heavy silt particles and domestic wastes and decomposed organic toxic plastic materials from the neighboring houses. Poor performance of the fish growth and high rate of mortality occurs during culture period sometimes. Since benthos is suitable indicator for better water quality as well as increases the survival and growth of aquatic organism thus estimation of benthos abundance along with various water quality parameters of those homestead ponds are essential.

In Bangladesh, several researches regarding water quality parameters of ponds and benthos abundance have been carried out such as monthly variation of plankton in relation to physico-chemical properties of water [18], effects of water quality on pond ecology and growth performances of fishes [13, 25, 19], depth wise abundance of benthic fauna [10], study of different benthic organisms including its biology, structure and life cycle [23, 6, 1]. Most of these researches were performed around greater Mymensingh district in this country. However, this experiment was conducted to address the actual scenario of homestead ponds of Dinajpur district of Bangladesh.

1.1 Objectives of the study

The major objectives of the present study were as follows-

- To determine the monthly changes of various water quality parameters in different water bodies.
- To identify and quantify different groups of benthos.
- To study the response of fishes to the physico-chemical and biological parameters of water.

2. Materials and Methods

2.1 Study area and site selection

The study was conducted in nine ponds for a period of three months from January 2016 to March 2016. The experimental ponds were selected from sadar upazila of Dinajpur, Bangladesh (Fig 1). In order to observe the physico-chemical conditions and benthic fauna of the ponds, samples were collected at 15 days interval. Ponds were selected by size, shape, water color and surrounding conditions. Present study includes three treatment where treatment 1 (T1) represents small sized pond (5 decimal), treatment 2 (T2) represents medium sized pond (10 decimal) and treatment 3 (T3) represents large sized ponds (15 decimal) and each of them had three replications.

Fig 1: Geographical location of Dinajpur district, Bangladesh.

2.2 Study of water quality parameters

A number of water quality parameters such as temperature (°C), transparency (cm), dissolved oxygen (mgl^{-1}), pH, total alkalinity (mgl^{-1}), chlorophyll-a (μgl^{-1}), ammonia-nitrogen (mgl^{-1}), phosphate-phosphorus (mgl^{-1}), nitrite-nitrogen (mgl^{-1}) and nitrate-nitrogen (mgl^{-1}) were measured. Water samples were collected within 8.30 to 10.30 am on each sampling day using a tube sampler (3-4ft) in a manner that it is representative of all layers of the water column. Temperature and transparency was measured on the spot and rest of the above parameters was measured in the Water Quality and Pond Dynamics Laboratory, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh. A volume of 250 ml of water sample was filtered through glassfibre filter paper (Whatman GF/C) with the help of electronic vaccum pressure air pump for chlorophyll-a measurement.

Water temperature was recorded with a celsius thermometer. Transparency was measured with a secchi disc. Dissolved oxygen and pH of the water samples were determined by using a direct reading digital meter (HACH 40d, multi-parameter sensor) in the laboratory. Total alkalinity was determined titrimetrically. The concentration of Nitrate-nitrogen and phosphate-phosphorus of water samples were determined by HACH kit (DR-4000, a direct reading spectrophotometer) using Nitra Ver-6 and Nitri Ver-3 powder pillows. Ammonia-nitrogen was also determined by HACH kit with mineral stabilizer and Nesslar reagent. Chlorophyll-a was measured in a spectrophotometer (DR 6000) at 664 and 750 wavelength.

2.3 Collection of benthos samples

The benthic macro-invertebrate samples were collected from 3 different locations of each pond by using an Ekman dredge (covering an area of lower mouth 225 cm). After collecting, the bottom materials were passed through a 0.2 mm mesh sieve in order to separate benthic organisms. Collected organisms were washed and preserved in 10% formalin. Finally, samples were taken to laboratory for further analysis.

2.4 Separation, identification and calculation of benthic fauna

Benthic samples were kept in a petri dish and washed with tap water to remove the remaining washable detritus and mud. The samples were then cleared using distilled water. The organisms were separated from each other with the help of sorting needles and fine forceps. Subsequently, the benthic organisms were identified and counted according to different taxonomic groups. The abundance of benthic organism was expressed as density ($ind.m^{-2}$) by following the formula of Welch (1984) [27].

$$N = \frac{O * 10000}{A * S}$$

Where, N= Number of macroscopic organisms of pro-fundal bottom (m^{-2}); O= Number of organisms actually counted; A= Transverse area of Ekman dredge in (cm^2) and S= Number samples taken at one sampling station.

2.5 Statistical analysis

For the statistical analysis, a one-way ANOVA and DMRT (Duncan's Multiple Range Test) was performed by using the SPSS (Statistical Package for Social Science) version-16. Significance of mean values was tested at 0.05% level.

3. Results and Discussion

3.1 Water quality parameters

The mean (±SD) values of water quality parameters of the studied ponds have been shown in Table 1.

Table 1: Mean (±SD) values of water quality parameters recorded from different treatments.

Parameters	Treatments			Level of significance
	T1 (Mean ±SD)	T2 (Mean ±SD)	T3 (Mean ±SD)	
Temperature (°C)	28.22±3.03	28.58±2.47	29.33±3.67	NS
Transparency (cm)	32.56±1.74^{b}	31.58±2.19^{ab}	30.33±2.00^{a}	*
DO (mg/l)	4.77±0.12	4.57±0.32	4.48±0.47	NS
pH	6.79±0.27	6.85±0.20	6.79±0.28	NS
Total Alkalinity (mg/l)	45.56±8.76^{a}	67.50±28.9^{b}	50.22±8.39^{ab}	*
Chlorophyll-a (µg/l)	18.67±8.96	59.78±36.98	64.62±38.30	NS
Ammonia (mg/l)	0.03±0.02	0.10±0.04	0.12±0.06	NS
Phosphate (mg/l)	0.55±0.29	0.34±0.13	0.49±0.28	NS
Nitrite (mg/l)	0.05±0.03	0.02±0.01	0.01±0.01	NS
Nitrate (mg/l)	0.17±0.15^{b}	0.07±0.05^{a}	0.05±0.04^{ab}	*

Note: NS= Mean values are not significantly different (P>0.05). *Mean values with different superscript letters in the same row indicate significant different at 5% significance level.

3.1.1 Water temperature (°C)

Temperature has always been the most important water quality parameter which has direct influence on the growth, food intake, metabolism, reproduction and other physiological activities of fishes. The maximum value of water temperature (34 °C) was found in March in T3, while the minimum (24 °C) was found in March in same treatment. The statistical analysis showed that there was no significant difference (P>0.05) among three treatments (Table 1). During the study period, highest water temperature was recorded in March in T3, which might be due to higher solar radiation, low water level, and higher atmospheric temperature. Aminul (1996) [3] stated that the water temperature ranged from 28 to 35 °C is suitable for fish culture in Bangladesh. In the present study, water temperature was found to a favorable limit for fish culture which is also similar to Kunda *et al.* (2008) [15], Wahab (1995) [25], Dewan *et al.* (1991) [7].

3.1.2 Transparency (cm)

Water transparency is a gross measure of pond productivity. The maximum value of water transparency (36 cm) was found in T1 and T2, while the minimum (27 cm) was observed in T3. The statistical analysis showed that the values were significantly different (P<0.05) among three treatments (Table 1). According to Wahab *et al.* (1994) [24], the transparency of productive water bodies should be 40 cm or less. In this study, water transparency was ranged to 27 to 36 cm among the treatments, which was similar with the findings of Kohinoor *et al.* (1998) [13]. The lower values of secchi disc reading were observed (27 cm) in the present study might be due to various human activities, domestic sewage and sludge wash from the adjoining areas.

3.1.3 Dissolved Oxygen (mgl^{-1})

The maximum value of dissolved oxygen (4.97 mgl^{-1}) was found in T1, while the minimum (3.75 mgl^{-1}) was found in T3. The statistical analysis showed that there was no significant difference (P>0.05) among three treatments (Table 1). Dissolved oxygen in fresh water pond should be 5 mgl^{-1} or more which is favorable for fishes [9]. DO of these experimental ponds were found 3.75 to 4.97 mgl^{-1}among the treatments, which was relatively low and might be due to alteration of photosynthesis, respiration by fishes and other aquatic organisms and decomposition of organic materials.

3.1.4 pH

The maximum value of pH (7.10) was found in T1 and T3, while the minimum (6.16) was found in T1. The statistical analysis showed that there was no significant difference (P>0.05) among three treatments (Table 1). According to Swingle 1967 [21], pH ranges from 6.5 to 9.0 is suitable for pond fish culture whereas pH more than 9.5 is unsuitable. In the present study, pH values ranged from 6.16 to 7.10 among the treatments. These values were similar with the findings of Dewan *et al.* 1991 [7]. Accelerated rate of decomposition during the period of high temperature months might responsible for low pH value.

3.1.5 Total Alkalinity (mgl^{-1})

The maximum value of total alkalinity (122 mgl^{-1}) was found in T2, while the minimum (28 mgl^{-1}) was found in the same treatment. The statistical analysis showed that the values were significantly different (P<0.05) among three treatments (Table 1). Mairs (1966) [17] reported that water bodies having alkalinity 40 mgl^{-1} or more considered more productive. According to Alikhunhi (1957) [2], total alkalinity more than 100 mgl^{-1} should be present in highly productive water bodies. Total alkalinity values in this study ranged between 28 to 122 mgl^{-1} which also complies with the findings of Wahab (1995) [25], Dewan *et al.* (1991) [7].

3.1.6 Chlorophyll-a (µgl^{-1})

The maximum value of Chlorophyll-a (460.77 µgl^{-1}) was found in T2, while the minimum (4.76 µgl^{-1}) was found in T1. The statistical analysis showed that there was no significant difference (P>0.05) among three treatments (Table 1). The values of Chlorophyll-a in the present study ranges from 4.76 to 460.77 µgl^{-1}, which complies with the observation of Kunda *et al.* (2008) [15]. The maximum value of Chlorophyll-a (460.77 µgl^{-1}) was found in T2 which might be because of higher production of phytoplankton might be due to higher temperature, nutrient and organic matter concentration.

3.1.7 Ammonia-nitrogen (mgl^{-1})

The maximum value of ammonia-nitrogen (0.70 mgl^{-1}) was found in T3, while the minimum (0.01 mg/l) was found in T1 and T2. The statistical analysis showed that there was no significant difference (P>0.05) among three treatments (Table 1). The range of ammonia-nitrogen concentration in this study was 0.01 to 0.70 mgl^{-1}. The range of ammonia-nitrogen concentration reported by Kohinoor *et al.* (1998) [13] and Wahab *et al.* (1995) [25] were from 0 to 1.36 mgl^{-1}. In this study, the value of ammonia-nitrogen was suitable range for freshwater fish culture.

3.1.8 Phosphate-phosphorus (mgl^{-1})

Phosphate-phosphorus concentration in water has been considered as an important limiting factor in aquatic productivity. The maximum value of phosphate-phosphorous (0.99 mgl^{-1}) was found in T3, while the minimum (0.12 mgl^{-1}) was found in T1. The statistical analysis showed that there was no significant difference (P>0.05) among three treatments (Table 1). The phosphate-phosphorous concentration in the present study ranged from 0.12 to 0.99 mgl^{-1} which was similar to the findings of Wahab *et al.* (1995) [25] and Uddin (2002) [22].

3.1.9 Nitrite-nitrogen (mgl^{-1})
The maximum value of nitrite-nitrogen (0.26 mgl^{-1}) was found in T1, while the minimum (0.00 mgl^{-1}) was found in other treatments. The statistical analysis showed that there was no significant difference (P>0.05) among three treatments (Table 1). In this experiment, nitrite-nitrogen concentrations ranged from 0.00-0.26 mgl^{-1} which also complies with the findings of Uddin (2002) [22].

3.1.10 Nitrate- nitrogen (mgl^{-1})
The maximum value of nitrate-nitrogen (0.45 mgl^{-1}) was found in T1. The statistical analysis showed that the values were significantly different (P<0.05) among three treatments (Table 1). In present study, the range of nitrate-nitrogen lies between 0.01 to 0.45 mgl^{-1}. The present findings are similar to the observation of Uddin (2002) [22]. The lower values of nitrate-nitrogen were observed in the present study that might be due to the lower doses of urea fertilization and supplementary feed in the ponds.

3.2 Abundance of benthic fauna
Benthos population of the study ponds were composed of four major groups: Oligochaeta, Chironomidae, Mollusca and unidentified benthos. Mean abundance of benthos in the experimental ponds are shown in Table 2.

Table 2: Mean (±SD) values of different groups of benthic fauna (ind.m^{-2}) observed in three different treatments.

Group	Treatments			Level of Significance
	T1 (Mean ±SD)	T2 (Mean ±SD)	T3 (Mean ±SD)	
Oligochaeta	363.79±61.13	360.49±46.99	383.54±35.09	NS
Chironomidae	115.23±30.34	107.41±31.03	125.10±29.73	NS
Mollusca	16.46±8.90	11.11±9.21	16.46±15.62	NS
Unidentified	31.28±8.90^{b}	19.75±13.15^{a}	27.98±11.58^{ab}	*
Total Benthos	526.75±76.30	498.77±68.72	553.09±61.53	NS

Note: NS= Mean values are not significantly different (P>0.05). *Mean values with different superscript letters in the same row indicate significant different at 5% significance level.

3.2.1 Oligochaeta (ind.m^{-2})
The mean (±SD) abundances of Oligochaeta were found 363.79±61.13, 360.49±46.99 and 383.54±35.09 ind.m^{-2} respectively in T1, T2 and T3 (Table 2).The statistical analysis showed that there was no significant difference (P>0.05) among three treatments. Monthly variations of Oligochaeta in three treatments were shown in Fig 2.

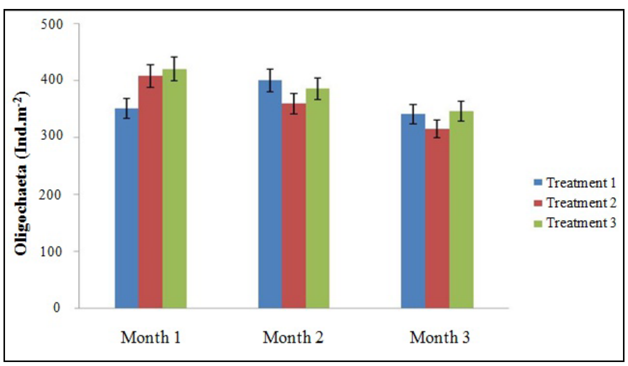

Fig 2: Monthly variations of Oligochaeta among three treatments during the study period.

3.2.2 Chironomidae (ind.m^{-2})
The mean (±SD) abundances of Chironomidae were found 115.23±30.34, 107.41±31.03 and 125.10±29.73 ind.m^{-2} respectively in T1, T2 and T3 (Table 2).The statistical analysis showed that there was no significant difference (P>0.05) among three treatments. Monthly variations of Chironomidae in three treatments were shown in Fig 3.

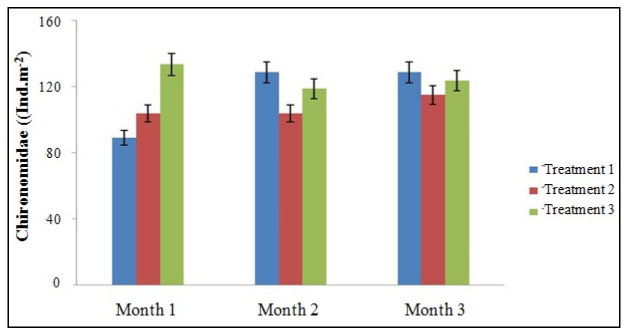

Fig 3: Monthly variations of Chironomidae among three treatments during the study period.

3.2.3 Mollusca (ind.m^{-2})
The mean (±SD) abundances of Mollusca were found 16.46±8.90, 11.11±9.21 and 16.46±15.62 ind.m^{-2} respectively in T1, T2 and T3 (Table 2).The statistical analysis showed that there was no significant difference (P>0.05) among three treatments. Monthly variations of Mollusca in three treatments were shown Fig 4.

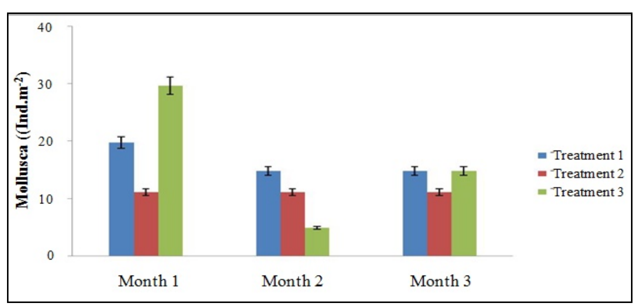

Fig 4: Monthly variations of Mollusca among three treatments during the study period.

3.2.4 Unidentified benthos (ind.m^{-2})

The mean (±SD) abundances of unidentified benthos were found 31.28±8.90, 19.75±13.15 and 27.98±11.58 ind.m^{-2} respectively in T1, T2 and T3 (Table 2).The statistical analysis showed that the values were significant different (P<0.05) among three treatments. Monthly variations of unidentified benthos in three treatments were shown Fig 5.

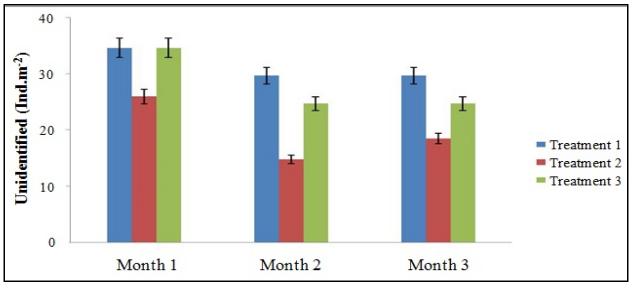

Fig 5: Monthly variations of unidentified benthos among three treatments during the study period.

3.2.5 Total benthos (ind.m^{-2})

The mean (±SD) abundances of total benthos were found 526.75±76.30, 498.77±68.72 and 553.09±61.53 ind.m^{-2} respectively in T, T and T (Table 2).The statistical analysis showed that there was no significant difference (P>0.05) among three treatments. Monthly variations of Total Benthos in three treatments were shown Fig 6.

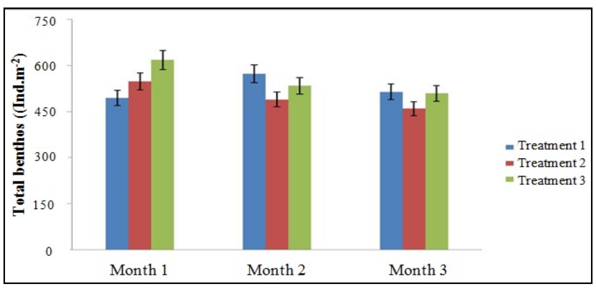

Fig 6: Monthly variations of total benthos among three treatments during the study period

In the present study, the dominant groups of benthic organisms were Oligochaeta> Chironomidae> unidentified> Mollusca respectively i.e. Oligochaeta was found the most dominant group throughout the experimental period while Chironomidae was the second dominant group followed by the unidentified and Mollusca. These are similar to the findings of Das and Islam (1983) [6] as they reported that Oligochaeta, Chironomidae and Mollusca were the dominant macro-benthos in tropical freshwater ponds and Oligochaeta was the most dominant group followed by Chironomidae and Mollusca. Similar results were also reported by Mahato *et al.* (2000) [16], Ignat *et al.* (1994) [12], Soechting (1989) [20]. According to Chowdhury (2000) [5], the comparative abundance of benthos ought to be high in the fertilized pond whereas marginal in the unfertilized ponds. Soechting (1989) [20] concluded that the abundance of species composition of the benthic organisms was distinctly increasing with the application of fertilizers. In this study, the mean abundance of benthos was comparatively low. It might be due to not using fertilizers in the experimental ponds.

4. Conclusion

Present investigation therefore, stated that the causes of low fish production and high rate of fish mortality in these experimental ponds might be due to lack of proper management of water quality. Pollutants from different sources such as domestic wastes, surface run-off, washing of clothes, residues from traditional fish farming system etc. are entering into the ponds and creating the environment unsuitable for fish culture. Proper management of water quality parameters by controlling agricultural, urban and storm water run-off, maintaining septic system and applications of fertilizers would have probably the most effective measures to improve the fish production in these ponds. From this short-term survey on benthos abundance and physico-chemical parameters, it could be concluded that there is an urgent need for additional research for betterment of water quality and sustainable production of fish in this region.

5. Acknowledgement

The authors are grateful to Professor Dr. Shahroz Mahean Haque for her cordial support and authorities of water quality and pond dynamics laboratory; Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh.

6. References

1. Ali S, Begum F. The Chironomid larvae of Dhaka City. Journal of Asiatic Society Bangladesh. 1979; 5:89-92.
2. Alikhunhi KH. Fish culture in India. Farm Bull., Indian Council of Agricultural Research, New Delhi. 1957, 144.
3. Aminul IM. Qualities of water and soil in Aquaculture, Fish Week Compilation, 96. DoF Publication, Ramna, Dhaka. 1996, 1000.
4. Burford SM. Physico-chemical qualities of some ancient tanks of Sibsagar. Indian Journal of Fisheries. 1997; 10:623-63.
5. Chowdhury MAH. A comparative study on the abundance of benthos in fertilized and unfertilized pond. MS Thesis, Dept. of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh. 2000, 95.
6. Das M, Islam MA. A study on the macrobenthos of an artificial pond in Agricultural University campus. Bangladesh Journal of Aquaculture. 1983; 2:1-11.
7. Dewan S, Wahab MA, Beveridge MCM, Rahman MH, Sarker BK. Food selection, electivity and dietary overlap among planktivorous Chinese and Indian major carps fry and fingerling grown in extensively managed rain fed ponds in Bangladesh. Aquaculture and Fish manage. 1991; 3:277-294.
8. Dhawan A, Karu S. Pig dung as pond manure: Effects on water quality, pond productivity and growth of carps in polyculture system. Naga: The ICLARM Quarterly. 2002; 25:11-14.
9. Ellis MM, Kumar PD, Bhaumik U, Roy B, Chakrabarty DP. Observation on four species culture of Indian major carps and exotic silver carp. Journal of Inland Fisheries Society India. 1946; 14:18-22.
10. Hasan R, Hossain MS, Amin MR, Ali H, Rahman MO. Depth wise abundance of benthic fauna in a selected pond of Mymensingh district. Bangladesh Journal of Agriculture. 2009; 2:44-54.
11. Hossain MA, Alam MR, Haque MR, Mehbub MF. Study on present status of carp-sis polyculture in Dinajpur district of Bangladesh. Bangladesh Research Publications Journal. 2013; 9:123-130.

12. Ignat GS, Florescu C, Vadineanu A, Nafornita G, Risnoveanu G *et al.* Structure and dynamics of benthic fauna From Danube Delta in 1993. Analalastintifice-de-Instutui-de-cercelare-si-Proiectare-Delta-Dunarii-Tulcea (Romania). Statiunea hindrobioligica. 1994; 3:87-94.
13. Kohinoor AHM, Islam ML, Wahab MA, Thilsted SH. Effects of mola (*Amblypharyngodon mola*) on growth and production of carps in polyculture. Bangladesh Journal of Fisheries. 1998; 2:119-126.
14. Kohinoor AHM. Development of culture technology of three small indigenous fish mola (*Amblypharyngodon mola*), punti (*Puntius sophore*) and chela (*Chela cachius*) with notes on some aspects of their biology. PhD Dissertation, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh. 2000, 363.
15. Kunda M, Azim ME, Wahab MA, Dewan S, Roos N *et al.* Potential of mixed culture of freshwater prawn, *Mascrobrachium rosenbergii* and self-recruiting small species mola, *Amblypharyngodon mola* in rottional rice-fish/prawn culture systems in Bangladesh. Aquaculture. 2008; 39:506-517.
16. Mahato B, Kumar M, Sinha MP, Panday PN. Studies on some aspects of community composition and relative abundance of invertebrate macro benthic fauna of a newly constructed tropical reservoir. Advances inzoolo India. 2000; 200-208.
17. Mairs DR. A total alkalinity atlas for Maine lake waters. Limnology and Oceanography. 1966; 11:68-72.
18. Mollah MFA, Haque AKMA. Studies on monthly variations of plankton in relation to the physico-chemical conditions of water and bottom soil of two ponds. Bangladesh Journal of Fisheries. 1978; 1:29-39.
19. Rahman MA, Gheyasuddin H, Rasid MH, Choudhury MFZ. Proximate composition and native quality of freshwater Zeol fishes of Bangladesh. Bangladesh Journal of Fisheries. 1982; 25:37-43.
20. Soechting W. The influence of lime fertilizations on the benthic macrofauna of oberer Grumbacher Teich near Hahnenklee Brckswiese (Haz Mountains). Braunschw-Naturkd-Schr. 1989; 3:499-506.
21. Swingle HS. Relationships of pH of pond water to their suitability for fish culture. Proceedings of 9th Pacific Science Congress. 1967; 10:72-75.
22. Uddin MM. Effects of addition of small fish on pond ecology and production in polyculture, MS thesis, Dept. of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh. 2002, 99.
23. Wahab MA. Studies on Chironomidae of fish ponds at Howietourm, Stirling, Central Scotland. Bangladesh Journal of Fisheries. 1988; 11:91-99.
24. Wahab MA, Ahmed ZF, Haq MS, Begum M. Compatibility of silver carp in the polyculture of cyprinid fishes. Progressive Agricultural. 1994; 5:221-227.
25. Wahab MA, Ahmed ZF, Islam A, Rahmatullah SM. Effect of introduction of common carp (*Cyprinus carpio*) on the pond ecology and growth of fish in polyculture. Aquaculture Research. 1995; 26:619-628.
26. Walker I, Henderson PA, Sterry P. On the pattern of biomass transfer in the benthic fauna of an Amazonian black water as evidenced by 32 P level experiments. Hydrobiology. 1991; 215:153-162.
27. Welch PS. Limnological method. Mc Graw Hill Book Company, London. 1984, 101-297.