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The effects of Physico-chemical parameters on plankton distribution in poultry manure and artificial formulated feed treated fish ponds, Noakhali, Bangladesh

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Abstract
The present study was carried out in two differently treated fish ponds. One of the sampling ponds was treated with poultry manure (Pond A) and another with artificial formulated fish feed (Pond B). Water samples were collected weekly (five weeks) from 19 April 2019 to 17 May 2019 for water physico-chemical parameters and plankton analysis. Water physico-chemical parameters specifically temperature, P^H, transparency, total suspended solids, dissolved oxygen, ammonia, total alkalinity, free CO_2 were determined during study period in two fish ponds. The density and diversity of plankton in fish ponds were also evaluated in this conducted study. A total four classes of phytoplankton namely Chlorophyta, Bacillariophyta, Cyanophyta and Euglena were identified. Moreover, total four classes of zooplankton as Crustacea, Cladocera, Copepode and Rotifera were also recognized. Additionally, Chlorophyta and Rotifera found dominant through the all sampling periods in two sampling ponds. The lowest total phytoplankton (Pond A: $8.49\times10^4\pm7.4\times10^2$ ind/l, Pond B: $1.5\times10^5\pm2.2\times10^3$ ind/l) and highest total zooplankton (Pond A: $5.65\times10^4\pm2.2\times10^3$ ind/l, Pond B: $8.77\times10^4\pm2.6\times10^3$ ind/l) among all sampling periods were recorded when cyclone Fani stroke over Bangladesh. The effects of physico-chemical parameters on phytoplankton and zooplankton abundance in two different feed treated ponds were also reveled in this study. The total phytoplankton showed positive relation ($p< 0.05$) with dissolved oxygen and negative relation ($p< 0.01$) with transparency. Furthermore, total zooplankton showed positive relation ($p< 0.05$) with water temperature.

Keywords: Phytoplankton, zooplankton, poultry manure, Fish feed, pond, cyclone Fani

1. Introduction
Sustainable fish production in pond is controlled by phytoplankton as primary producer. The diversity and density of phytoplankton indicates the richness of an aquatic ecosystem. The availability of phytoplankton depends on nutrients level of aquatic ecosystem which estimate the fertility of water [1]. Zooplankton maintains a link between phytoplankton and fishes in pond trophic chain. Zooplanktons are very sensitive indicator to their environment by expressing their qualitative and quantitative characteristics [2]. The species composition of plankton is determined by environmental tolerance but their abundance is decided by availability of resources [3]. In fish pond the characteristics of aquatic physical and chemical parameters have straight impact on primary subsequently secondary production [2]. The species composition and distributional patterns of plankton are influenced by physico-chemical parameters and availability of nutrients [4]. Furthermore, the density and diversity of plankton in fish pond are related to season and pond maintenance. Aquatic organisms also used for determine the degree of pollution associated with Physico-chemical parameters [5]. Planktons are recognized as bio-indicator for monitoring of water quality in aquatic ecosystem [6, 7]. Different types of fish cultures are commonly practice in Noakhali, one of southern district in Bangladesh. Maximum fish farmers consider the main source of food for fish is natural primary production of ponds. Fish farmers uses fertilizers (organic and inorganic) and feeds as poultry manure or artificial feeds for fish farming [8]. The properly treated poultry manure is an excellent source of organic feed in fish culture and cultivated fishes are fit for human diet according to research [9]. Poultry manure contains plenty of NO_3-N and PO_4-P, very supportive to phytoplankton growth in pond [10, 11].

Poultry manures are often used as organic fertilizer and also promotes zooplankton production in pond [12]. Fertilizers and formulated fish feed ingredients have impact on growth and diversity of phytoplankton and zooplankton. It was already reported that the density and diversity of phytoplankton differs with location and pond to pond even with similar ecological environments [13]. In fish culture pond artificial feeding also plays an important role in increasing critical density of fish [14, 15, 16]. Artificial feeds can be destructs fishes from plankton and maintains an ecological balance, controls blooms of cyanobacteria in pond [17, 18, 19].
Therefore, this study aimed at estimating distribution of phytoplankton and zooplankton in poultry manure and artificial formulated feed treated fish ponds. This conducted study also focused to determine physico-chemical water parameters. Moreover, the present study made a relationship between distribution of plankton and physico-chemical parameters.

2. Materials & Methods
2.1 Sampling site
The study was conducted in two fish (*Pangasius pangasius* Hamilton, 1822) ponds in Bismillah Agro Production located in Sonapur, Noakhali district. Total five weeks from August 2019 to June 2019 were spent for sampling. Pond A (110 decimal) and Pond B (100 decimal) were treated with poultry feed (150 kg/day) and commercial feed (120 kg/day) respectively. There are no other water sources except ground and rain water for these ponds. These sampling ponds were maintained by lime if needed.

2.2 Plankton collection and estimation
Planktons were collected through plankton net (mesh size: 20 µm) and preserved in 7% formalin on sampling site. A light binocular microscope (Labomed, model: CXL- 110446002, 9135002) was used at 16×10 and 16×40 magnification to identify phytoplankton and zooplankton. Furthermore, a Sedge wick-Rafter counting cell (S-R cell) was used for quantitative plankton analysis. The plankton density was determined by the formula [20].

$$N= (A\times1000\times C)/ (V\times F\times L)$$

Where
N= Number of plankton/ liter in collected sample water
A= Total number of counted plankton
C= Concentrate volume of final sample water in ml
V= Volume in cubic mm of a field
F= Number of fields counted
L= Volume of collected sample water in liter

The phytoplankton and zooplankton were identified up to the genus level and determined by [21, 22, 23, 24].

2.3 Water quality analysis
In conducted study, environmental variables (temperature, P^H, dissolved oxygen, ammonia, total suspended solids, total alkalinity, free CO_2 and transparency) were recorded weekly in both sampling ponds. Water temperature (°C), P^H and transparency (cm) were measured directly on sampling spot with mercury bulb thermometer, P^H meter (HANNA-HI96107) and secchi disc respectively. Dissolved oxygen (mg/l), total alkalinity (mg/l) and free CO_2 (mg/l), ammonia (mg/l) and total suspended solids (mg/l) were determined by using guidelines from the American Public Health Association [25].

2.4 Statistical analysis
Statistical Package for the Social Sciences (SPSS, Version 20) and Microsoft EXCEL were used for analysis obtained data using ANOVA (One-way analysis of variance) and linear regression.

3. Results and Discussion
3.1 Physical and chemical environmental parameters
In conducted study, environmental variables (temperature, P^H, dissolved oxygen, ammonia, total suspended solids, total alkalinity, free CO_2 and transparency) were recorded weekly in both sampling ponds (Table 1, 2). The prime factor temperature significantly varied weekly in pond: A and B ($p< 0.01$). The ranges in p^H were observed in sampling ponds (Table 1, 2). The concentrations of dissolved oxygen were differed significantly ($p< 0.01$) in pond: A (Table 1) but showed no significant variable concentrations in pond: B (Table 2). The other supporting factors to the aquatic environment as ammonia, total suspended solids and total alkalinity were temporally varied ($p< 0.01$) in pond: A and pond: B (Table 1, 2). The variations of free CO_2 were significance in pond: A ($p< 0.01$) and pond: B ($p< 0.01$), (Table 1, 2). In two sampling ponds (A, B) the indicator of water transparency as secchi disk depths were significantly ($p< 0.01$) different (Table 1, 2).

Table 1: Environmental physical and chemical parameters for pond: A, values (mean ± standard error mean) with p value (significance level) and ranges of P^H value.

Weeks	Temperature (°C), $p< 0.01$	P^H	Dissolved Oxygen (mg/l), $p< 0.01$	Ammonia (mg/l), $p< 0.01$	Total suspended solids (mg/l), $p< 0.01$	Total Alkalinity (mg/l), $p< 0.01$	Free CO_2 (mg/l), $p< 0.01$	Transparency (cm), $p< 0.01$
W1	29.20 ± 0.20 ^{a}	8.00-8.20	8.10 ± 0.10 ^{bc}	2.60 ± 0.10 ^{b}	1.75×10^{-3} ± 0 ^{c}	39.00 ± 1.00 ^{c}	2.90 ± 1.00 ^{bc}	5.75 ±0.05 ^{a}
W2	29.25 ± 0.25 ^{a}	8.10-8.20	7.45 ± 0.05 ^{ab}	3.60 ± 0.10 ^{c}	1.55×10^{-3} ± 0 ^{c}	33.50 ± 1.50 ^{b}	3.68 ± 0.52 ^{c}	5.85 ±0.05 ^{a}
W3	29.75 ± 0.25 ^{a}	8.20-8.30	6.40 ± 0.40 ^{a}	4.10 ± 0.10 ^{c}	2.50×10^{-4} ± 0 ^{a}	10.25 ± 0.25 ^{a}	1.10 ± 0.10 ^{a}	8.95 ±0.05 ^{c}
W4	32.75 ± 0.25 ^{b}	8.40-8.50	8.60 ± 0.10 ^{c}	0.85 ± 0.15 ^{a}	3.50×10^{-4} ± 0 ^{a}	08.25 ± 0.25 ^{a}	2.10 ± 0.10 ^{ab}	7.45 ±0.05 ^{b}
W5	31.75 ± 0.25 ^{b}	7.20-7.30	6.60 ± 0.10 ^{a}	2.25 ± 0.25 ^{b}	9.40×10^{-4} ± 0 ^{b}	41.00 ± 1.00 ^{c}	1.90 ± 0.10 ^{ab}	5.85 ±0.05 ^{a}

Table 2: Environmental physical and chemical parameters for pond: B, values (mean ± standard error mean) with p value (significance level) and ranges of P^H value.

Weeks	Temperature (°C), $p< 0.01$	P^H Ranges	Dissolved Oxygen (mg/l), ns	Ammonia (mg/l), $p< 0.01$	Total suspended solids (mg/l), $p< 0.01$	Total Alkalinity (mg/l), $p< 0.01$	Free CO_2 (mg/l), $p< 0.01$	Transparency (cm), $p< 0.01$
W1	28.20 ± 0.20 ^{a}	8.50-8.60	8.20 ± 0.20	0.28 ± 0.03 ^{a}	8.95×10^{-4} ± 0 ^{c}	23.00 ± 1.00 ^{c}	1.30 ± 1.00 ^{ab}	5.95 ±0.05 ^{a}
W2	28.25 ± 0.25 ^{a}	7.90-8.00	8.05 ± 0.05	3.10 ± 0.10 ^{bc}	4.50×10^{-4} ± 0 ^{b}	25.00 ± 1.00 ^{c}	2.50 ± 0.30 ^{c}	6.10 ±0.10 ^{a}
W3	28.25 ± 0.25 ^{a}	8.40-8.50	7.25 ± 0.25	3.65 ± 0.15 ^{c}	9.25×10^{-4} ± 0 ^{a}	24.50 ± 0.50 ^{c}	2.05 ± 0.05 ^{bc}	8.75 ±0.05 ^{c}
W4	32.25 ± 0.25 ^{c}	8.20-8.30	8.55 ± 0.05	3.60 ± 0.10 ^{c}	3.45×10^{-4} ± 0 ^{b}	06.25 ± 0.25 ^{a}	2.30 ± 0.10 ^{c}	7.25 ±0.05 ^{b}
W5	30.75 ± 0.25 ^{b}	8.00-8.10	8.10 ± 0.10	2.90 ± 0.10 ^{b}	1.60×10^{-4} ± 0 ^{a}	13.00 ± 1.00 ^{b}	0.90 ± 0.10 ^{a}	6.05 ±0.05 ^{a}

ns= not significant

3.2 Phytoplankton and zooplankton

A total four classes with 40 genera of phytoplankton were identified in this study (Table 3). The most abundant class Chlorophyta (19 genera) followed by Bacillariophyta (9 genera), Cyanophyta (7 genera) and Euglena (3 genera) was observed in both sampling ponds (Figure 1, 2). Furthermore, there are also four classes of zooplankton were identified with 37 genera (Table 3). Rotifera (16 genera) was found dominant followed by Cladocera (8 genera), Copepode (5genera) and Crustacea (4 genera) in both sampling ponds (Table 3).The Cladocera: *Bosmia* only found in pond A. On the other hand *Cerlodaphnia* from the same group only identified in pond B (Table 3). Two genera from Rotifera group as *Lecane*, *Platyias* only found in pond B (Table 3).

Table 3: List of phytoplankton and zooplankton

Phytoplankton	Genus
Chlorophyta	*Actinastrum, Ankistrodesmus, Botryococcus, Chlorogonium, Ceratium, Chlorella, Characium, Cladophora, Closterium, Cosmarium, Gomphosphaeria, Oocystis, Pediastrum, Scendesmus, Sphaerocystis, Tetraedron, Ulothrix, Volvox, Zygnema*
Bacillariophyta	*Cocconeis, Cyclotella, Cymbella, Cymatopleura, Fragilaria, Navicula, Synedra, Melosira, Amphora*
Cyanophyta	*Anabaena, Aphanocapsa, Aphanothece, Merismopedia, Microcystis, Nostoc, Oscillatoria*
Euglena	*Euglena, Phacus, Trachelomonas*
Zooplankton	Genus
Crustacea	*Cyclops, Daphnia, Diaphanosoma, Diaptomus*
Cladocera	*Scapholeberis, Chydorus, Bosminopsis, Alona, Alonella, Simocephalus, Bosmia*^{A}, *Ceriodaphnia*^{B}, *Macrothrix, Sida*
Copepode	*Neodiaptomus, Mesodiaptomus, Mesocyclops, Helidiaptomus, Thermocyclops*
Rotifera	*Brachionus, Filinia, Keratella, Lecane*^{B}, *Notholca, Polyarthra, Trichocerca, Asplanchna, Cephalodella, Conochilus, Amuraeopsis, Lepadella, Asplanchna, Testudinella, Plationus, Euchlanis, Mytilina, Platyias*^{B}

^{A}Pond A, ^{B}Pond B

The highest total phytoplankton in pond A ($2.48\times10^5\pm1.4\times10^3$ ind/l) and pond B ($2.9\times10^5\pm7.81\times10^3$ ind/l) were recorded in 2nd week (Table 4). The lowest total phytoplankton in pond A ($8.49\times10^4\pm7.4\times10^2$ ind/l) and pond B ($1.5\times10^5\pm2.2\times10^3$ ind/l) were recorded in 3rd week (Table 4). Furthermore, the highest total zooplankton in pond A ($5.65\times10^4\pm2.2\times10^3$ ind/l) and pond B ($8.77\times10^4\pm2.6\times10^3$ ind/l) were also recorded in 3rd week (Table 4). The lowest total zooplankton in pond A ($2.3\times10^4\pm1.3\times10^3$ ind/l) and pond B ($3.34\times10^4\pm1.6\times10^3$ ind/l) were recorded in 5th and 1st week respectively (Table 4). The strong cyclone Fani [26] was most probable reason for lowest and highest count of phytoplankton and zooplankton respectively in both sampling ponds. The present findings phytoplankton assemblages are in close similarity to the earlier study [8] reported Chlorophyceae (7), Bacillariophyceae (5), Cyanophyceae (5) and Euglenophyceae (4) in Sonapur, Noakhali. The group of phytoplankton Chlorophyta and Bacillariophyta indicate good pond water productivity for aquaculture [27]. The Chlorophyta (19 genera) was found dominant followed by Cyanophyta (8 genera), Bacillariophyta (7 genera) and Euglenophyta (7 genera) in poultry manure treated pond reported by [28].

Table 4: Abundance of phytoplankton and zooplankton

Weeks	Total Phytoplankton (ind/l)		Total Zooplankton (ind/l)	
	Pond: A	Pond: B	Pond: A	Pond: B
W1	$2.35\times10^5\pm2.6\times10^3$	$2.83\times10^5\pm3.9\times10^3$	$2.38\times10^4\pm1.8\times10^3$	$3.34\times10^4\pm1.6\times10^3$
W2	$2.48\times10^5\pm1.4\times10^3$	$2.9\times10^5\pm7.81\times10^3$	$3.64\times10^4\pm2.04\times10^3$	$5.2\times10^4\pm3.7\times10^3$
W3	$8.49\times10^4\pm7.4\times10^2$	$1.5\times10^5\pm2.2\times10^3$	$5.65\times10^4\pm2.2\times10^3$	$8.77\times10^4\pm2.6\times10^3$
W4	$1.77\times10^5\pm1.86\times10^3$	$2.2\times10^5\pm3.3\times10^3$	$5.13\times10^4\pm5.5\times10^2$	$5.35\times10^4\pm1.8\times10^3$
W5	$1.64\times10^5\pm2.16\times10^3$	$1.88\times10^5\pm5.3\times10^3$	$2.3\times10^4\pm1.3\times10^3$	$4.53\times10^4\pm1.3\times10^3$

The order of phytoplankton density (Chlorophyta-Bacillariophyta-Cyanophyta-Euglena) was observed in pond A (Figure 1). On the other hand, Cyanophyta lead Bacillariophyta and Euglena after Chlorophtya in pond B (Figure 2).

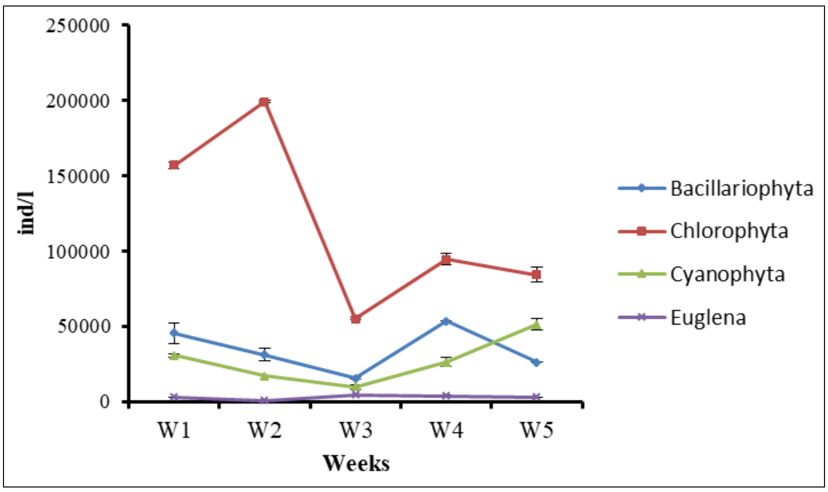

Fig 1: The phytoplankton abundance in pond A

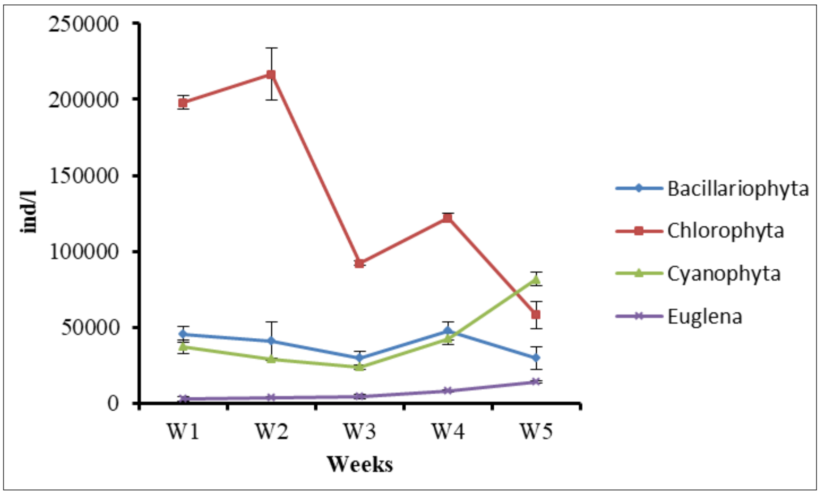

Fig 2: The phytoplankton abundance in pond B

In present study, Rotifera was dominant group of zooplankton following by Crustacea, Copepode and Cladocera in pond A (Figure 3). Furthermore, Cladocera lead Copepode after Rotifera and Crustacea respectively in pond B (Figure 4).

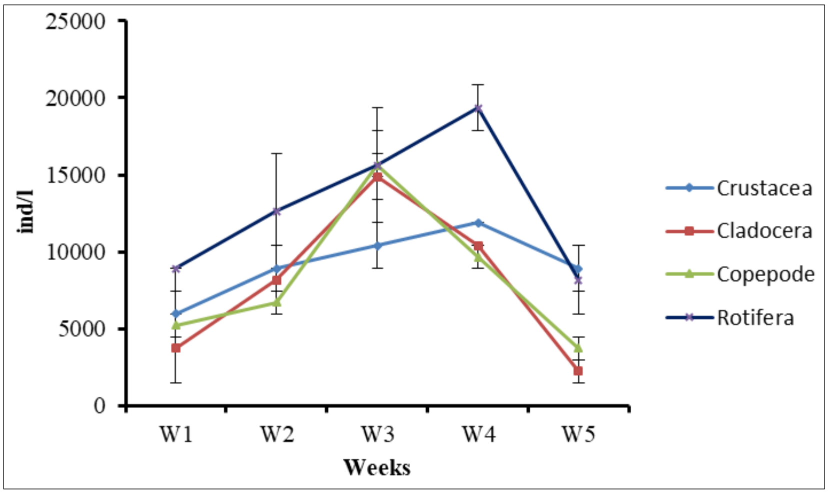

Fig 3: The zooplankton abundance in pond A

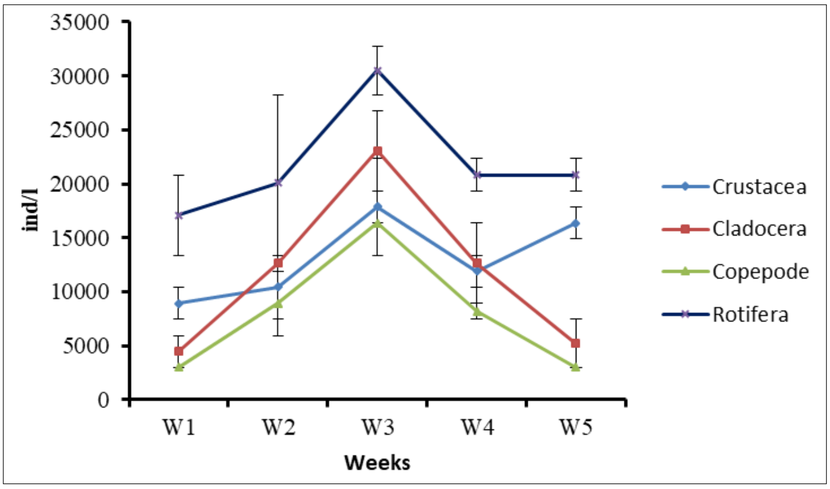

Fig 4: The zooplankton abundance in pond B

Among all groups of zooplankton Rotifera was found dominant in both sampling ponds. Rotifers were recognized as dominant zooplankton in poultry manure treated waters [29, 30]. Rotifers were dominant in ponds of Kolkata, India reported by [31]. Rotifers reported as nutrient tolerant creatures which are commonly found in highly productive aquatic zone [32].

3.3 Correlation Matrix: Physico-chemical parameters versus planktons

In present study, temperature showed negative ($p < 0.05$) relationship with dominant Chlorophyta, group of phytoplankton and positive ($p < 0.05$) relationship with total zooplankton population (Table 6). Among all physico-chemical parameters temperature controls the phytoplankton growth secondarily production of zooplankton through enhancing the photosynthesis [33]. The positive correlation between temperature and total zooplankton was also observed by [34]. In the conducted study, the recorded p^H range (7.20-8.60) of both sampling ponds was in agreement with the ideal p^H range (6.5-9.0) in fish culture pond [35]. The present range of p^H indicates the well buffered quality of pond water [36]. The variation of water p^H specifies the prominently productive nature of water body [37]. The prominent source of dissolved oxygen is considered as phytoplankton in aquatic environment. Phytoplankton release dissolved oxygen as a byproduct of photosynthesis [38, 39]. Dissolved oxygen showed positive ($p< 0.01$) relation with Bacillariophyta and total phytoplankton respectively (Table 6). The relation between dissolved oxygen and Bacillariophyta and total phytoplankton are in agreement with [40, 41, 42]. It has been stated that phytoplankton biomass become increased through photosynthesis which encouraged by pond water nutrients [43]. Ammonia as one of the most important inorganic nitrogen is preferable nutrient to phytoplankton. Ammonia had negative relation ($p< 0.05$) with Bacillariophyta might be due to assimilation for biological purpose (Table 6). Therefore, ammonia showed positive relations ($p< 0.01$) with Cladocera and Copepode respectively zooplankton groups (Table 6). Ammonia excretion by zooplankton has potential impact on phytoplankton growth [44, 45, 46]. Alkalinity as the buffering capacity of water had negative ($p< 0.05$) relation with euglena (Table 6). The dominant rotifer showed negative ($p< 0.05$) relation with alkalinity (Table 6). High alkalinity indicates the excessive photosynthetic activities in the aquatic body [47]. Carbon dioxide is released through decomposition which reduces alkalinity and causes to lower p^H in water body [48]. Free CO_2 showed positive ($p< 0.01$) relation with Chlorophyta and negative ($p< 0.01$) relation with euglena vice versa (Table 6). Free CO_2 enhance the organic production and especially supportive to the Euglena [49, 50]. Secchi disk depth determines the water transparency as well as light penetration capacity to the water body. The light penetration decreases by turbidity because of bottom soil resuspension in water body [40]. Transparency made negative relations with Chlorophyta, Cyanophyta ($p< 0.05$) and total phytoplankton ($p< 0.01$) concentration (Table 6). Sun light enhance the photosynthesis rate which influences the phytoplankton growth [51]. Water transparency also showed a significant positive correlation ($p< 0.05$) with Cladocera, Copepode and Rotifera (Table 6). Total zooplankton distribution was positively influenced by water transparency in aquatic ecosystem reported by [52, 53].

Table 6: Correlations between physico-chemical parameters and planktons.

Parameter	Bacillariophyta	Chlorophyta	Cyanophyta	Euglena	Total Phytoplankton	Crustacea	Cladocera	Copepode	Rotifera	Total Zooplankton
Temperature	0.188	-0.516*	0.330	0.317	-0.350	0.050	-0.236	-0.139	-0.156	0.543*
P^H	0.308	0.129	-0.355	0.016	0.113	0.244	0.384	0.370	0.448*	-0.176
Do	0.762**	0.349	0.259	0.257	0.581*	0.022	-0.203	-0.347	-0.193	0.359
Ammonia	-0.512*	-0.204	-0.193	0.166	-0.350	0.223	0.449*	0.484*	0.133	0.051
TSS	-0.115	0.431	-0.315	-0.421	0.234	-0.229	-0.103	-0.019	-0.248	0.142
Alkalinity	-0.119	0.399	-0.056	-0.536*	-0.285	-0.416	-0.383	-0.333	-0.493*	-0.264
Free CO_2	0.237	0.611**	-0.422	-0.526*	0.435	-0.283	-0.035	-0.011	-0.279	0.238
Transparency	-0.281	-0.548*	-0.456*	0.051	-0.674**	0.430	0.784**	0.856**	0.510**	-0.175

*significant ($p< 0.05$), **significant ($p< 0.01$)

3.4 Correlation Matrix: Phytoplankton versus Zooplankton

The group of zooplankton is Crustacea had positive relation (r= 0.553, $p< 0.005$) with relative Euglena abundance in sampling ponds (Table 7). Cyanophyta made negative (r= 0.470, $p< 0.005$, r= -0.589, $p< 0.001$) relations with Cladocera and Copepode respectively (Table 7). Copepode played negative (r= -0.485, $p< 0.001$) role to the total phytoplankton distribution (Table 7). Many studies indicate that the diversity of phytoplankton stimulus zooplankton through predator-prey relations [54, 55].

Table 7: Correlation between phytoplankton and zooplankton.

Group	Bacillariophyta	Chlorophyta	Cyanophyta	Euglena	Total Phytoplankton
Rotifera	-0.074	-0.207	-0.041	0.241	-0.155
Crustacea	-0.185	-0.400	-0.246	0.553*	-0.278
Cladocera	-0.192	-0.182	-0.470*	-0.022	-0.320
Copepode	-0.230	-0.290	-0.589**	-0.135	-0.485*
Total zooplankton	0.280	0.094	0.254	0.185	0.234

*significant ($p< 0.05$), **significant ($p< 0.01$)

The freshwater zooplankton groups (rotifer, Cladocera and Copepode) especially depend on Bacillariophyta more than Chlorophyta and Cyanophyta groups of phytoplankton for living [56].The strongest tropical cyclone Fani in the last twenty years in India was also introduced heavy to heavy rainfall and strong wind in some parts of Bangladesh [26]. The present study was observed lowest phytoplankton and highest zooplankton assemblages might be due to heavy rainfall brought by cyclone Fani.

4. Conclusion

This study provides preliminary description of the phytoplankton and zooplankton distribution of poultry manure and artificial formulated feed treated fish ponds. Chlorophyta and Rotifer are dominant group of phytoplankton and zooplankton respectively in both fish ponds. The effects of physico-chemical parameters on phytoplankton and zooplankton groups also determined in this study. This study is useful to further plankton and water quality research in poultry manure and formulated fish feed treated pond ecosystem.

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