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The effects of different water quality parameters on zooplankton distribution in major river systems of Sundarbans Mangrove

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Abstract: *The present study was conducted, a period from October 2010 to May 2011 covering three distinct seasons, in Sundarbans mangrove area especially in three major river systems namely Rupsha-Pashur (R-P), Baleswar-Bhola (B-B) and Malancha- Kholpetua (M-K) river systems to evaluate the relationship between different water quality parameters and zooplankton abundance.Total thirteenth sampling points were selected along the three river systems for the convenient of the study.Five different groups of zooplankton were identified in this study where Copepoda group represented as the most dominant group securing seven genus.Almost all groups of zooplankton were found at a higher number in the dry winter whereas pre-monsoon represented the lowest number of them. Zooplankton of all groups was positively correlated with dissolve oxygen, hardness and transparency whereas negatively or inversely correlated with pH, temperature, current and salinity except of Copepod. Thus the findings of the present study will be capable to provide information about the zooplankton distribution which will be ultimately helpful to identify fishing grounds in the study site as well as to maintain a sound and healthy ecosystem in Sundarbans Mangrove and to enhance captured fisheries production.*
Keywords: *Ecosystem, River system, Sundarban, Water quality parameters, Zooplankton*

I. Introduction

The Sundarban is one of the largest mangrove forests in the world and it covers 10,000 square kilometres (3,900 square miles) of which about 6,000 square kilometres (2,300 square miles) is in Bangladesh with the remainder in India. It is a part of the world's largest delta and formed from sediments deposited by three great rivers, the Ganges, Brahmaputra and Meghna. It is located between the longitudes 89°00'E and 89°55'E and latitudes 21°30'N and 22°30'N in the district of Bagerhat, Khulna and Satkhira [1].The water area of Sundarbansconsists of a couple of tidal rivers, canals and other sources. An intricate network of interconnecting waterways, by the river Rupsha, Passur, Shibsha, Arpangashia, Malancha, Baleshor, Bhola and other rivers which opens into the Bay of Bengal through Sundarbans Reserved Forest (SRF).It has a huge range of fish, crabs, shrimp, lobster, pelecypods, gastropods species. It contributes a considerable portion of the total captured fisheries in Bangladesh.

Zooplankton are microscopic aquatic life forms having little or no resistance to currents and are therefore free floating or suspended in open or pelagic waters [2]. While some forms of zooplankton move by vertical migration, their horizontal position is mostly determined by current movements of the body of water they inhabit [3].They are being considered as water quality indicator in aquatic environment from many years ago. Some species flourish in highly eutrophic water while others are very sensitive to organic or chemical wastes. Because of their short life cycles, planktons respond quickly to environmental changes and species composition are more likely to indicate the quality of water mass in which they are found.They have a profound influence on certain non-biological aspects of water quality, such as color, odor, taste, etc. [4]. In addition, eutrophication of coastal areas can be severe since these areas act as natural filters for suspended sediments and nutrients coming from the land to the open sea. The most apparent effects are the proliferation of harmful algal blooms and the hypoxia due to insufficient number of zooplankton. Thus zooplankton can speak to the condition of the water and can be used to assess overall water body health.Moreover, theyplay a vital role in the aquatic ecosystem by forming an important link in the food chain from primary to tertiary level leading to the production of fishery. It is well known that potentials of pelagic fishes viz. finfishes, demarsal fishes, crustaceans, mollusks and marine mammals either directly or indirectly depend on zooplankton [5]. Zooplankton is one of the most popular feed items of fish as for example they comprises about 32% of food item of Notoptrusnotoptrus[6]47% of the Catlacatla and 6.37% of the Labeorohita[7].Therefore, they are considered as the chief index of utilization of aquatic biotope at the secondary trophic level due to maintaining an intermediary role between phytoplankton and fish. Plankton abundance largely enhance the fisheries production through improving the decomposition and mineralization process of organic matters accumulated in the river systems, preventing the growth of different microalgae and pests, stabilizing optimum water temperature, regulating pH as well as maintaining others water quality parameters [8].

As zooplankton plays an important role in aquatic ecosystem as well as in open water fisheries production, so it is very necessary to find out the factors responsible for their distribution. To the best of our knowledge, only a very few studies have been conducted based on zooplankton and their relationship with different physico-chemical parameters throughout the world. Unfortunately such types of studies along Sunderbans mangrove are hardly exist. So the prime objective of the present study was to identify the factors particularly related to zooplankton distribution in Sundarbans Mangrove. Thus this research will contribute to maintain a sound and healthy ecosystem in Sundarbans Mangrove and to enhance captured fisheries production.

II. Materials and Methods

2.1.Study site and Sampling points

The study was conducted with three seasons including Post Monsoon (October to November), Dry Winter (December to February) and Pre-Monsoon (March to May) of the consecutive years from October 2010 to May 2011 in Sundarbans mangrove including three major river systems namely Rupsha-Pashur (R-P), Baleswar-Bhola (B-B)and Malancha- Kholpetua (M-K)river systems (Fig. 1). There were three sampling points that had been taken under the observation in B-B river system at Sarankhola range those were Bogi ,Sarankhola and Supati whereas R-P river system at Chadpai range and M-Kriver systems at Burhigoalini range were five sampling points of each including Karamjol, Karamjol cannel, Joymony, Harbaria, Harbaria cannel and Posurtala, pasurtala canal, Kalagasi, Kalagasi canal, Nildumur respectively. Thus total thirtieth sampling points were selected for the convenient of sampling during the study time.

2.2. Sample collection

Zooplankton samples were collected by passing water through plankton net (silk bolting cloth or nylon monofilament screen cloth, mesh size 50 µm). 20 liters of water is passed through the plankton net and the final concentration of plankton sample is 20mL Samples were kept in a dark container to avoid the exposure of light without any chemical preservative, and placed in ice box at 4°C temperature for species identification. For abundance measurement after collecting sample in the same procedure was preserved by Lugol Solution (20g potassium iodide (KI) and 10g iodine crystals dissolved in 200mL distilled water containing 20mL glacial acetic acid). Lugol solution was added in an amount of 0.7mL per 100mL of sample.

2.3. Identification and calculation

Sample water had been mixed with 2m1formalin (10% formaldehyde aqueous solution) and kept in a 100ml biker. Then l ml sample was poured on S-R (Sedgwick Rafter) cell. Then it had been setup with microscope (LabomediVu 1500 LX 400, made in USA) to identify different species of zooplankton. Thus, a series of photographs of the species was taken to identify the organisms. Identification was done following method applied by [9, 10].

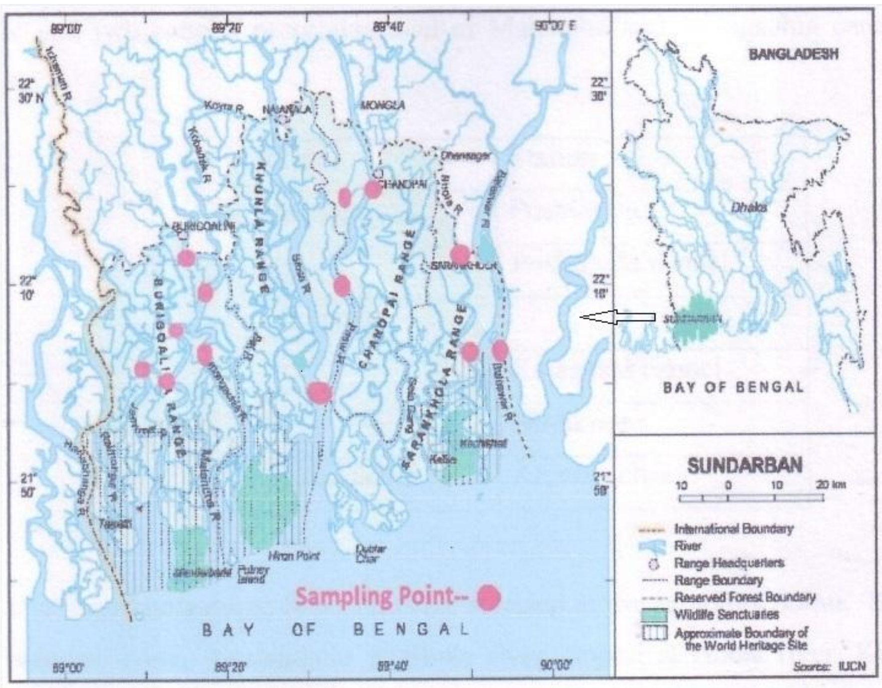

Figure 1:map of the study area

2.4. Counting

For plankton counting, the S-R (Sedgwick Rafter) cell was used which is 50 mm long, 20 wide and 1 mm deep. Before filling the S-R cell with sample, the cover glass was diagonally placed across the cell and then samples were transferred with a large bore so that no air bubbles in the cell covers were formed. The S-R cell was let standard forat least 15 minute to settle plankton. Then planktons on the bottom of the S-R cell were counted enumerated by LabomediVu 1500 (LX 400) microscope. By moving the mechanical stage, the entire bottom of the slide area was examined carefully. Organisms lying between two parallel cross hairs were counted as they passed a vertical line.

Number of plankton in the S-R cell was derived from the following formula APHA (1976):

$$\text{Number of species/Liter} = \frac{C \times 1000\ mm^3}{L \times D \times W \times S}$$

Where,
C = Number of organisms counted
L= Length of each stripe (S-R cell length) in mm
D = Depth of each stripe in mm
W = Width of each stripe in mm
S = Number of stripe

2.5. Measurement of water quality parameters

During each sampling period different water quality parameters including temperature, dissolve oxygen, transparency, pH, hardness, salinity and current were also measured along with zooplankton. Some of the parameters were measured directly at the sampling points during sampling period whereas samples from each point were collected in plastic bottles and immediately preserved in an icebox and carried to the laboratory to measure rest of the parameters.Salinity was recorded by an Atago S/Mill-E refractometer (Atago Co. Ltd., Tokyo, Japan), temperature by digital thermometer with stainless steel sensorprobe, pH by top bench electrometric pH meter (HI 98107, HANNA), dissolved oxygen (DO) by Winkler's method [11],transparency of water by using secchi disc, hardness by (Titrimetric, EDTA)and current by current meter (Model 106 Lightweight Current Meter)

III. Result

3.1. Diversity of zooplankton in the study area

The identified zooplankton populations in the present study were under five groups including Copepoda, Crustacea, Monogononta, Ostracoda, Micracantha and Taurocephala. A total of 15 zooplankton genera under the 5 groups were recorded from the study area. Among the identified zooplankton, the group Copepoda was dominant with 7 genus followed by micracantha (3 genus), Crustacea (2 genus), Ostracoda (1 genus),Monogononta(1 genus) and Taurocephala (1 genus) also found. The composition of the observed zooplankton is given in Table 1.

Table 1: Different zooplankton groups found in the study area

Zooplankton group		Genera	
1	Copepoda	**1**	Pseudocalanus
		2	Calanus
		3	Oithona
		4	Acartia
		5	Paracalanus
		6	Centropages
		7	Paracartia
2	Micracantha	**8**	Euclanis
		9	Brachionus
		10	Synchaeta
3	Crustacea	**11**	Crab larvae (Scylla)
		12	Shrimp larvae (Loligovalgaris)
4	Ostracoda	**13**	Pseudocandona
5	Monogononta	**14**	Brachionus

6	Taurocephala	**15**	Keratella

3.2. Zooplankton abundance

The number of each zooplankton group varied from season to season over the study period. Almost all types of zooplankton were found at a higher number in the dry winter whereas pre-monsoon represented the lowest number of them. The concentration of all types of zooplankton in the dry winter wasseveral times greater than both of the pre- monsoon as well as post monsoon (Fig. 2).

Different rivers system showed a varying concentration of different types of zooplankton that means they also represented a spatial variation besides the seasonal variation. Monogononta, ostracoda and taurocephala were found as a maximum level in R-P river system followed by B-B and M-K river system. Although the highest amount of crustacea were also found in R-P river system but lowest were in B-B whereas M-K represented an intermediate value of crustacean. B-B river system revealed the maximum amount of micracantha followed by M-K and B-B river system but in case of copepoda the sequence was as M-K>R-P>B-B (Fig. 3).

3.3. Changes of water quality parameters with seasons

The values of different water quality parameters including pH, temperature, dissolve oxygen,transparency, hardness,salinity and current are usually changed from season to season. The present study showed that pH as well as dissolve oxygen were remain almost constant over the study period. Although the highest value of temperature (30.88±0.90^{0}C) was observed in pre-monsoon and lowest in dry winter (21.23±1.24^{0}C). The maximum values of transparency (24.08±2.37 cm), hardness (188.73±23.30 ppm) and salinity (16.55±5.1 ppm) were found in dry winter whereas they were remained almost constant in both the post monsoon and pre-monsoon except of salinity. During post monsoon (51.05±31 m/s) the lowest value of water current was observed that increased a little bit in dry winterwhereas drastically increased during pre-monsoon (336.69±287.32) (Fig. 4).

3.4. Changes of water quality parameters with rivers system

Among all of the water quality parameters only current was largely fluctuated over every river system which turned into an extreme condition in the B-B river system. Hardness as well as salinity was observed as almost constant over R-P and B-B rivers system whereas slightly fluctuated in M-K river system. Dissolve oxygen, pH and temperature were remained almost similar over each rivers system. Each of the three rivers system maintained a constant pattern of transparency except of a little bit fluctuation in R-P river system (Fig. 5).

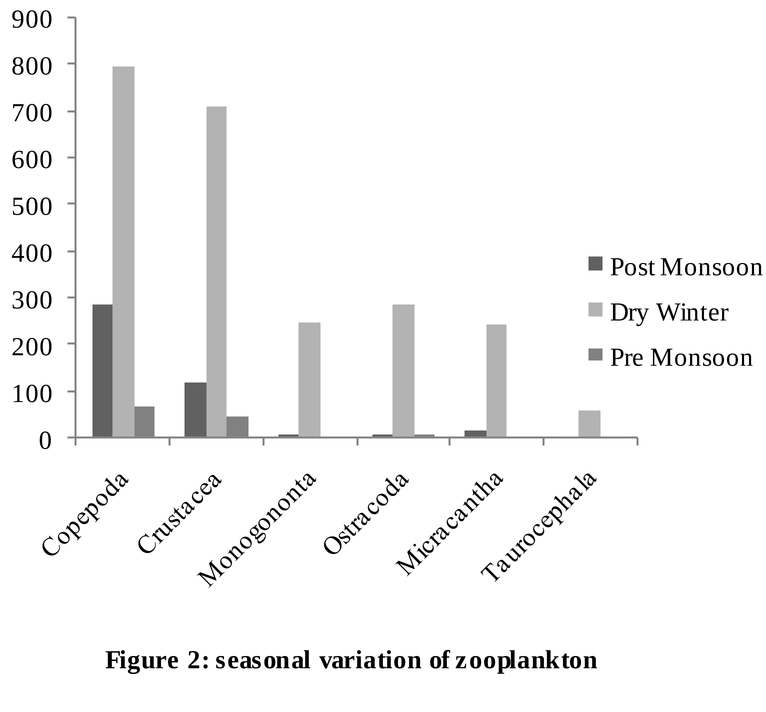

Figure 2: seasonal variation of zooplankton

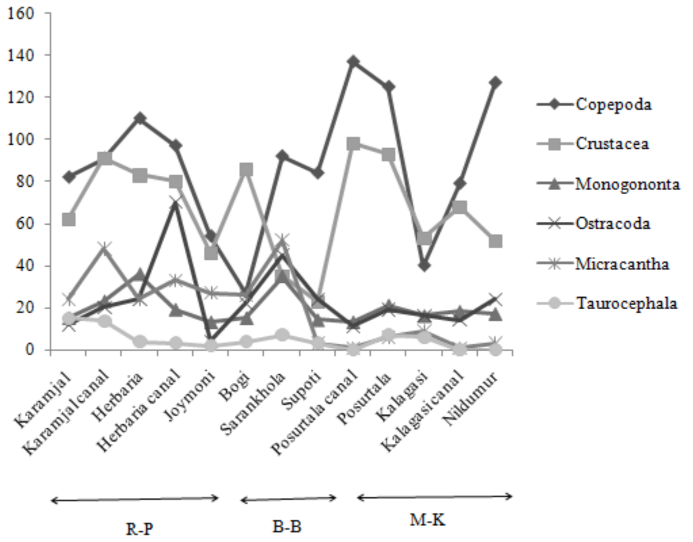

Figure 3: spatial variation of zooplankton

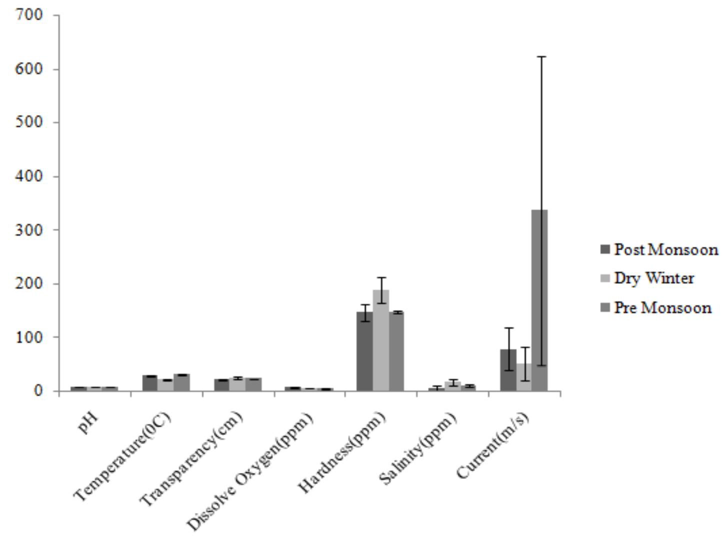

Figure 4: Seasonal changes of water quality parameters

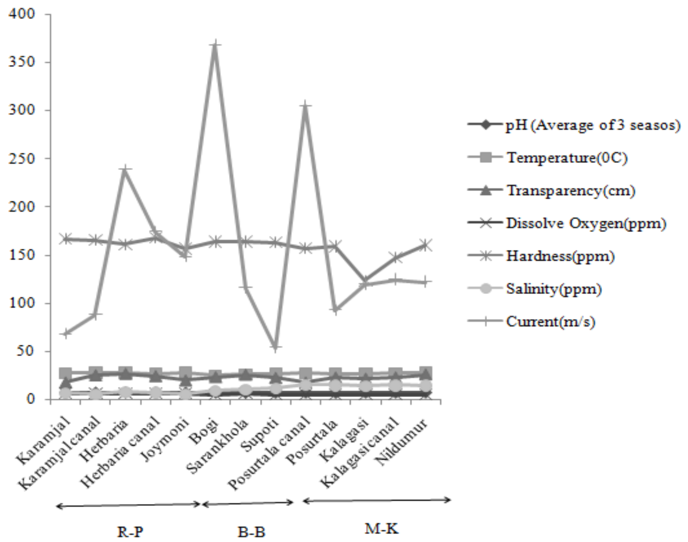

Figure 5: spatial variation of different water quality parameters

3.5. The relationship between zooplankton and water quality parameters

Different water quality parameters influence the abundance of zooplankton in the aquatic environment. Some of the parameters exhibit a positive effect on the growth, reproduction as well as their abundance in the aquatic system whereas some negatively affect their abundance in that system. In this present study, zooplanktons under all identified groups are inversely that means negatively correlated with pH. Except copepod group all of the zooplankton groups are also negatively or inversely correlated with water temperature. There was a positive correlation between all groups of zooplankton and three parameters under studied including dissolve oxygen, hardness and transparency. Although all zooplankton groups revealed a negative correlation with water salinity as well as water current (Table 2).

Table 2: The coefficient of correlation of different zooplankton with different water quality parameters

Serial No.	Particulars	Coefficient of correlation	Comments
1	Copepoda vs. pH	-0.087	Negatively related
2	Crustacea vs. pH	-0.407	Negatively related
3	Monogononta vs. pH	-0.410	Negatively related
4	Ostracoda vs. pH	-0.144	Negatively related
5	Micracantha vs. pH	-0.349	Negatively related
6	Taurocephala vs. pH	-0.143	Negatively related
7	Copepoda vs. Temperature	0.394	Positively related
8	Crustacea vs. Temperature	-0.040	Negatively related
9	Monogononta vs. Temperature	-0.183	Negatively related
10	Ostracoda vs. Temperature	-0.315	Negatively related
11	Micracantha vs. Temperature	-0.302	Negatively related
12	Taurocephala vs. Temperature	-0.047	Negatively related
13	Copepoda vs. Transparency	0.138	Positively related
14	Crustacea vs. Transparency	0.35	Positively related
15	Monogononta vs. Transparency	0.696	Positively related
16	Ostracoda vs. Transparency	0.523	Positively related
17	Micracantha vs. Transparency	0.343	Positively related
18	Taurocephala vs. Transparency	0.081	Positively related
19	Copepoda vs. Dissolve O_2	0.249	Positively related
20	Crustacea vs. Dissolve O_2	0.76	Positively related
21	Monogononta vs. Dissolve O_2	0.262	Positively related
22	Ostracoda vs. Dissolve O_2	0.317	Positively related
23	Micracantha vs. Dissolve O_2	0.700	Positively related
24	Taurocephala vs. Dissolve O_2	0.399	Positively related
25	Copepoda vs. Hardness	0.356	Positively related
26	Crustacea vs. Hardness	0.146	Positively related
27	Monogononta vs. Hardness	0.199	Positively related
28	Ostracoda vs. Hardness	0.353	Positively related
29	Micracantha vs. Hardness	0.425	Positively related
30	Taurocephala vs. Hardness	0.216	Positively related
31	Copepoda vs. Salinity	-0.307	Negatively related
32	Crustacea vs. Salinity	-0.007	Negatively related
33	Monogononta vs. Salinity	-0.182	Negatively related
34	Ostracoda vs. Salinity	-0.168	Negatively related
35	Micracantha vs. Salinity	-0.749	Negatively related
36	Taurocephala vs. Salinity	-0.529	Negatively related
37	Copepoda vs. Current	-0.118	Negatively related
38	Crustacea vs. Current	-0.531	Negatively related
39	Monogononta vs. Current	-0.30	Negatively related
40	Ostracoda vs. Current	-0.002	Negatively related
41	Micracantha vs. Current	-0.020	Negatively related
42	Taurocephala vs. Current	-0.411	Negatively related

IV. Discussion

The present study found copepoda as a dominant group among all the groups of zooplankton. A study conducted by Islam et al.(2007) [12] also found the similar findings. Similar result was observed by Ganapati (1943) and he found that copepod was a dominant order among zooplankton [13]. Although a couple of research conducted by Alam et al. (1987), Ali et al. (1989), Mathias (1991)and Shil et al. 2013represented another group of zooplankton as a dominant group [14,15,16,17] and this is due to the different study area.

In this study the maximum abundance of zooplankton was recorded during dry winter that lasts from December to February where minimum was in pre-monsoon that lasts from March to May. George (1964) observed maximum population of zooplankton in November, January [18]. Patra and Azadi (1987)also found the highest concentration of zooplankton in early winter from the Halda River in Bangladesh [19].But Miah et al. (1993)found the maximum zooplankton abundance from a fish pond at Mymenshing [20]. The findings of Miah et al. (1993) [20] differs from the findings of present study as well as the findings of George (1964) [18] and Patra and Azadi (1987) [19] because Miah et al. (1993) [20] got the finding from pond not from open water.

Most of the zooplankton groups were observed as maximum in R-P river system rather than B-B and M-K river system. This is due to the variation of the value of different water quality parameters of R-P river system from B-B and M-K river system specially the salinity and water current. The highest temperature was found in pre-monsoon and lowest in dry winter that is almost similar with the findings of Rahaman et al. (2014)[21].The lowest salinity was found during post monsoon because in that time the Rupsha-Passur and Baleswar-Bhola river system received vast amount of freshwater from the Ganges and the Meghna which activated a dilution factor to reduce the concentration of Na^+ and Cl^- in the water. Dry winter indicated the maximum value of transparency and hardness because it comes just after the ending of monsoon and the monsoon wash away wastage from the river system to the nearby sea ultimately the rivers become fresh. The same can be referenced from the findings of Malhotra et al. (2014), Mandal and Das (2011)and Sobha et al. (2009)where they revealed the fact of decreasing the concentration of Na^+, Cl^- as well as the conductance due to the dilution of river water after rains and of increasing the concentration as because of escalated evaporation during dry-winter [22, 23, 24].

Correlation among various groups of zooplankton abundance and water quality parameter including water temperature, pH, salinity, DO, alkalinity, water current and free $C0_2$ were also well marked. Water body of the R-P, B-B and M-K river systems are ecosystems with a network of various physicochemical parameters and its biota. The physico-chemical parameters and plankton communities together form a comprehensive ecosystem and as in any ecosystem, there are interactions between the plankton and also between the physico-chemical parameters. These interactions are directly or indirectly subjected to the complex influences, some of which results in quantitative changes, i.e increase or decrease of size of the population [25]. During this study a distinct fluctuation of zooplankton population in the three river systems as well as in three seasons was observed. This fluctuation is due to the impact of different physico chemical parameters. Temperature is one of the most outstanding and biologically significant phenomena of aquatic environment; it has the relationship on zooplankton variation. Zooplankton abundance showed inverse relationship with water temperature in Rupsha-Posur, Baleswere-Bhola and bdancha-kholpetua river systems. Similar findings were obtained by Chowdhury et al. (1987), Islam et al. (2000) and Patra and Azadi (1987) [26, 27].Turbidity is a general term that describes the `cloudiness' or `muddiness' of water and it is also the opposite term of transparency. It is capable of extinguishing incident solar radiation in a lake, thereby affecting the phytoplankton primary production and by extension, the zooplankton secondary production. In the study time all zooplankton showed positive correlation with transparency. Although an inverse relationship between the transparency and zooplankton abundance were found by Islam et al. (2008)[28].The zooplankton abundance also showed inverse relationship with pH. Similar results were reported by Alam et al.,(1987)and Patra&Azadi (1987).At higher pH, the species ability to maintain its salt balance is affected and reproduction cases. Most species die at approximately pH 4 or below and pH 1 l or above. The term hardness is one of the oldest terms used to describe characteristics of water. Hardness is chiefly a measure of calcium and magnesium. The present study found that zooplankton abundance in water is positively related with the total hardness. The research findings by Poongodi et al. 2009supports the present study result [29]. The result is also supported by a couple of researchers including Shil et al. 2013 [17], Miah et al.(1981)and Alam et al.(1987)[30]. Dissolved oxygen is the most important chemical parameter for zooplankton abundance. Low dissolves oxygen level responsible for more organisms' kills, either directly or indirectly, than all other problems combined. Like terrestrial animals, zooplankton need oxygen for respiration. Zooplankton showed positive relationship with DO. Similar results were reported by Miah et al. (1981)and Alam et al. (1987). Water current has inverse relationship with zooplankton. If current is high zooplankton population would be reduced because they have no locomotory organelles. Zooplankton abundance showed a negative relationship with water salinity of the present study area. These results have similarity with the findings of Islam et al. (2008); they worked at two culturable ponds at southern part of Khulna.

V. Conclusion

Zooplankton is considered as the chief index of the utilization of aquatic biotope at the secondary trophic level. The intensity of zooplankton aggregation largely depends on different factors including different water quality parameters as well as their ability to counter dispersion, phytoplankton growth, grazing rates, predator/prey relationship and reproductive strategies. The present study revealed that almost all of the water quality parameters exhibit either positive or negative correlation with zooplankton distribution in the study site.

In addition, the zooplankton is normally utilized by higher trophic levels, particularly by pelagic fish species and larvae. In the upwelling areas, the zooplankton standing stock (biomass) is higher and zooplankton community is dominated by herbivores. Zooplankton constitutes the main food item of several fish species. The pelagic fishes migrate in shoals to the feeding ground rich in food and therefore zooplankton can be used as indicators of rich potential fishing grounds.

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