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# Seasonal Fluctuation of Zooplankton Community of Posna Beel (Swamp), Kalihati, Tangail, Bangladesh in Relation to Physico-Chemical Conditions

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**Abstract**

Zooplankton communities of a perennial wetland were investigated from August 2003 to April 2004. A total of 63 species under 35 genera were identified, of which 22 species belonged to Rotifera, 21 to Copepoda, 18 to Cladocera and 2 to Ostracoda. Of the total bulk of zooplankton, copepods comprised 49.14% followed by cladocerans (20.94%), rotifers (15.62%) and ostracods (7.61%). Some pollution tolerant zooplankton i.e. *Brachionus, Keratella,* and *Mesocyclops* were also noticed during the investigation. The rotifers were found to occur with highest number of genera, while *Brachionus* appeared to have maximum number of species. *Heliodiaptomus* belonging to the Copepoda appeared to have highest population abundance amongst the zooplankton. Important physico-chemical conditions of the wetland water were analyzed. Correlations between the physico-chemical parameters as well as between the plankton abundance were statistically established. Zooplankton diversity index value of the rotifers and cladocerans was highest during post monsoon period and of copepods in summer.

**Keywords:** Seasonal fluctuation, zooplankton, physical-chemical condition, Posna *beel*, Bangladesh.

## INTRODUCTION

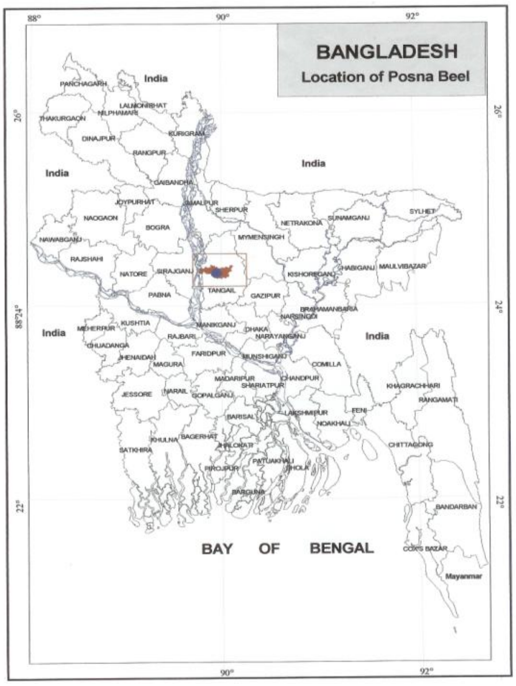
The composition, structure and abundance of zooplankton assemblages are affected by both biological factors (quality and quantity of food, predation, composition; Copper and Vigg 1985) and physico-chemical factors (salinity, transparency, turbidity, temperature, etc; Uku and Mavuti 1994, Naselli and Barone 1994).

Zooplankton plays an important role as the source of food for fishes. The variation of food of fishes throughout the year is primarily due to the changes in composition of food organisms occurring at different seasons (Dewan *et al*. 1979). Zooplankton also plays a major role in the energy transfer at secondary level in aquatic biotopes. Pollution of water bodies by different sources can cause drastic changes in zooplankton populations, and thereby affect the production potential of the ecosystem. Zooplanktons are known to accumulate chemicals by direct absorption of water and through food intake. Several zooplankton species have been classified as indicator of pollution (Arora 1966, Bianchi *et al*. 2003, Vandysh 2004).

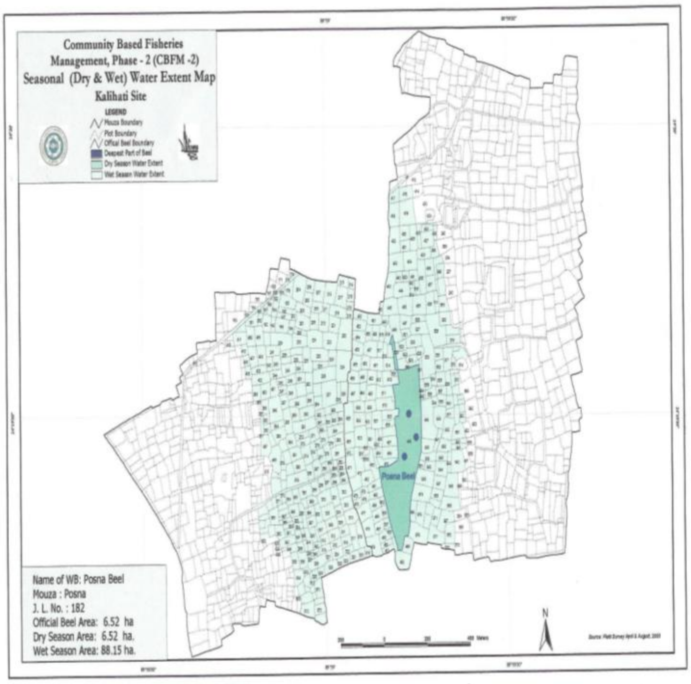
Hence, in the present paper an attempt has been made to study the community structure and population density of the zooplankton fauna and their correlation with some important physico-chemical variables of water of Posna *beel*.

## METHODS

Posna *beel* is located $24^{0}19^{/}10^{//}$N to $24^{0}19^{/}55^{//}$N latitude and $89^{0}56^{/}45^{//}$E to $89^{0}59^{/}22^{//}$E longitude in the north-central region of Bangladesh, about 120 km from the capital. It is an important perennial water body in Kalihati Cluster of Tangail District (Map-1) under the Community Based Fisheries Resources Management (CBFM) Project, Phase-2 funded by the DFID -UK and implemented by World Fish Center. The *beel* covers an area of 9.0 ha in dry period and in the in the monsoon it extends up to 121.5 ha. This *beel* is under the Jamuna floodplain area and flooded every year during monsoon period (July-August). Four villages surrounding the *beel* area are Posna in the east, Kaluha in the south, Sheroil in the west and Monotia in the north (Maps- 2 & 3). This *beel* is the main source of fish to the villagers and also to nearby Balla, Elenga and Rampur bazars.




Map-1




Map-2

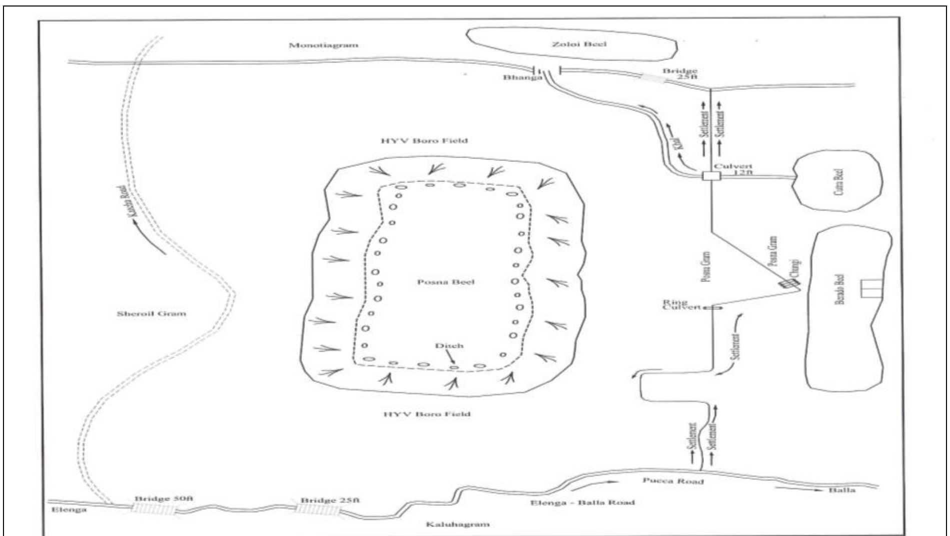



Figure: Posna Beel and Its Surrounding Environmental Set-up

Map-3

**a) Water Sample Collection**

Three water-sampling sites had been selected, which could represent the water quality of the *beel* area of Posna *beel*. Due to the length of the *beel* in north-south direction, one water sampling site had been selected in the south, another one in the north and the third one in the middle of the *beel* (Map-1). Water sampling was done namely for season like August 20, 2003 for the rainy season (monsoon) and October 22, 2003 for the post-monsoon, 30 December for the winter and 17 April for the summer period from three locations of Posna *beel*. Water samples were collected between 11:30 AM –12:40 PM from 20- 30 cm below the surface level of water. A boat was hired to collect the undisturbed water sample from the middle of the *beel*.

**b) Water Analysis**

pH, alkalinity, total hardness, DO, free $CO_2$, chloride, BOD and COD were analyzed by following APHA (1997), Winkler (1981) and Kudesia (1983) whereas Nitrate is measured at 410 nm using brucine reagents with concentrated sulphuric acid (Chopra and Kanwar, 1976), Phosphate is measured at 380 nm using molybdate reagents and nitric acid (Boltz 1958) and Ammonia was measured at 400 nm using Nessler's reagent (Boltz 1958).

**c) Zooplankton Collection and Analysis**

Zooplankton samples were collected in the evening at three months intervals from below the surface water at the horizontal three spots. Plankton collection was made by net of Bolting No.20 (mesh size 0.076 mm) by filtering 100 litres of water. The plankton samples were preserved in Transeau's solution (Transeau 1951). Quantitative enumeration of zooplankton was carried out by Sedwick rafter counting and drop method. Counted organisms were expressed as cells per liter (unit/liter). Abundance of plankton group was calculated according to the formula of Welch (Welch 1948). Besides these, the diversity indices of zooplankton were calculated using Shannon-Weaver formula (Shannon and Weaver 1949). The zooplankton prevailing at the sampling area was identified following Ward and Whipple (1959), Needham and Needham (1966), Battish (1992) and Bhouyain and Asmat (1994). Finally, data were analyzed through Microsoft-Excel.

## RESULTS AND DISCUSSION

### Physical-chemical factors

During the study period, water temperature varied from 16.5 $^0$C to 31.5$^0$ C. Highest temperature was recorded in rainy season and lowest in winter (Table1).

Transparency of water of Posna *beel* varied from 25.62 cm to 189.5 cm (Table1). The water was very clean and transparent; in some places the bed level of Posna *beel* was visible both in winter and summer.

pH is one of the most important factor, which controls the aquatic environment. Chemical and biological reactions are directly dependent upon the hydrogen ion concentration of the reaction system. pH level of water of Posna *beel* was almost same in all the seasons. The *beel* water found to be neutral to alkaline in nature; higher values of pH were obtained (Table1) in the monsoon and post-monsoon seasons.

The alkalinity and total hardness values were found to be low. Alkalinity varied from 31.35 mg/l (rainy season) to 51.3 0 mg/l (winter) while total hardness varied from 51.3 mg/l (summer) to 68.4 mg/l (post-monsoon and winter).

Chloride content of water was found to vary from 26.80 to 31.26 mg/l during the study period. The maximum value was recorded in summer and minimum in monsoon (Table1).

Table-1. Seasonal Fluctuation of Physico- Chemical Parameters of Water of Posna *beel*

| Parameters | Seasons | | | | Mean | Std Error |
|---|---|---|---|---|---|---|
| | Monsoon | Post-monsoon | Winter | Summer | | |
| Temperature($^0$C) | 31.5 | 30.33 | 16.5 | 30.0 | 27.08 | 3.54 |
| Transparency(cm) | 83.03 | 47.52 | 189.5 | 25.62 | 86.42 | 36.33 |
| pH | 7.83 | 7.7 | 7.5 | 7.2 | 7.55 | 1.37 |
| Alkalinity | 31.35 | 34.2 | 51.3 | 34.2 | 37.76 | 4.56 |
| Total Hardness | 66.4 | 68.4 | 68.4 | 51.3 | 63.62 | 4.13 |
| Chloride | 26.80 | 29.15 | 30. 15 | 31.26 | 29.34 | 0.95 |
| Ammonia | 0.04 | 0.04 | 0.09 | 0.012 | 0.045 | 0.001 |
| Nitrate | 0.28 | 0.18 | 0.07 | 0.11 | 0.16 | 0.004 |
| Phosphate | 3.79 | 4.48 | 3.58 | 6.39 | 4.55 | 0.64 |
| Free $CO_2$ | 7.5 | 10.0 | 5.0 | 5.0 | 6.87 | 1.19 |
| DO | 7.33 | 8.43 | 9.66 | 8.33 | 8.43 | 0.47 |
| BOD | 4.22 | 2.90 | 2.70 | 4.36 | 3.56 | 0.43 |
| COD | 6.70 | 5.40 | 5.20 | 6.80 | 6.02 | 0.42 |

Except pH, temperature and transparency all other values are expressed as mg/l.

In Bangladesh, monsoon (June-August), post-monsoon (September-November), winter (December-February) and summer (March-May).

Among the nitrogenous pollutants in water, ammonia is most important. Ammonia is highly toxic for fish and1-2 ppm found to be lethal (Saffiullah and Mofizuddin 1988). However the ammonia level was very low in Posna *beel*. It varied from 0.012 mg/l to 0.69 mg/l. Its concentration was high in winter than rainy, post-monsoon and summer. On the other hand, same value was found in the rainy and post-monsoon (0.04 mg/l) seasons (Table1).

Concentration of nitrate was found at very low level. It varied from 0.07 mg/l to 0.28 mg/l. The highest (0.28 mg/l) concentration of nitrogen was found in the rainy season and lowest (0.07 mg/l) was found in winter indicating productive nature of the *beel*.

Phosphate concentration was high in all seasons varying from 3.58 mg/l to 6.39 mg/l. The highest (6.39 mg/l) value of phosphate was found in summer and the lowest (3.58 mg/l) was in the winter season. This was within the limit of Bangladesh Standard for Drinking Water. The main source of phosphate is HYV Boro fields where farmers use TSP as fertilizer. The un-accumulated phosphate washed away in the Posna *beel* with surface run-off.

Generally, less than 10 mg/l carbon dioxide was present in all surface waters, although a higher concentration in ground water is not uncommon (HACH, 1999). Fish may tolerate high concentrations of carbon dioxide if dissolved oxygen concentrations are also high. In Posna *beel*, free carbon dioxide varied from 5.0 mg/l to 10.0 mg/l. Highest content was recorded in the post-monsoon and lowest (5.0 mg/l) in winter and summer seasons (Table1).

The single most important water quality parameter in aquaculture is the DO content. DO values varied from 7.33 mg/l to 9.66 mg/l (Table2). The highest (9.66 mg/l) DO was found in the winter whereas lowest value was obtained in the rainy season (Table1).

BOD is another most important water parameter for the assessment of pollution of aquatic system. The BOD shows the concentration of biodegradable organic matter in an aquatic ecosystem. The BOD values varied from 2.70 mg/l to 4.30 mg/l. Highest value of BOD was recorded in summer and lowest in winter season (Table1). The chemical oxygen demand (COD) is an indication of the total non-biodegradable present in aquatic ecosystem. Higher COD values indicate higher degree of pollution. COD values of Posna *beel* varied from 5.20 mg/l to 6.8 mg/l. Highest COD value was found in summer whereas lowest in winter (Table1).

Zooplankton: The zooplankton community of the *beel* comprised rotifers, cladocerans, copepods and crustaceans including 35 genera and 63 species. In comparison to other wetland (Hasan *et al*. 1998, Ehsan *et al*. 2000, Saha *et al*. 2002, Hasan 2002) the number of genera of zooplankton of Posna *beel* appeared to be rich. Rotifers were perennial among the zooplankton, which was 15.61%. The highest abundance (913 cells/l)was

Table-2. Abundance of Zooplankton (units/l), Average number and Percentage composition in the Posna *beel* during study Period.

| **Organisms** | | **Rainy** | **Post-monsoon** | **Winter** | **Summer** | **Total** |
|---|---|---|---|---|---|---|
| **Rotifera** | *Brachionus* | 174 | 240 | - | 140 | 554 |
| | *Keratella* | 110 | 146 | - | 576 | 832 |
| | *Notholca* | 14 | 73 | 50 | 56 | 193 |
| | *Lecane* | - | 115 | 12 | 28 | 155 |
| | *Ecdyuridae* | - | 29 | - | - | 29 |
| | *Pomphodyx* | 6 | - | - | - | 6 |
| | *Squantinella* | 4 | - | - | - | 4 |
| | *Platiyas* | - | 43 | - | 28 | 71 |
| | *Rotaria* | - | - | - | 14 | 14 |
| | *Filinia* | - | - | - | 43 | 43 |
| | *Trichocera* | - | - | 20 | 28 | 48 |
| | *Monostyla* | 4 | - | - | - | 4 |
| | Total | 312 | 646 | 82 | 913 | 1953 |
| | % of the yearly production | 2.50 | 5.16 | 0.65 | 7.30 | 15.61 |
| **Cladocera** | *Alona* | 9 | 129 | - | - | 138 |
| | *Bosmina* | 112 | 93 | - | - | 205 |
| | *Ceriodaphnia* | 164 | 63 | 146 | 128 | 501 |
| | *Chydorus* | - | 36 | - | - | 36 |
| | *Daphnia* | 20 | 9 | - | - | 29 |
| | *Diaphanosoma* | 190 | 677 | 104 | 72 | 1043 |
| | Kurzia | - | 98 | 19 | - | 117 |
| | *Lydigia* | 48 | 38 | - | - | 86 |
| | *Moina* | 31 | 145 | - | 147 | 323 |
| | *Machrothix* | - | 33 | 36 | - | 69 |
| | *Oxyurella* | - | 19 | - | - | 19 |
| | *Simocephalus* | - | - | - | 32 | 32 |
| | *Schaphaloberis* | - | 19 | - | - | 19 |
| | Total | 574 | 1359 | 305 | 379 | 2617 |
| | % of the yearly production | 4.59 | 10.87 | 2.44 | 3.03 | 20.94 |
| **Copepoda** | *Diaptomus* | 573 | 165 | 177 | 73 | 988 |
| | *Heliodiaptomus* | 439 | 435 | 156 | 62 | 1092 |
| | *Neodiaptomus* | 416 | 116 | 113 | 43 | 688 |
| | *Specodiaptomus* | 87 | - | 24 | - | 111 |
| | *Cyclops* | 657 | 194 | 239 | 241 | 1331 |
| | *Mesocyclops* | 244 | 401 | 147 | 382 | 1174 |
| | *Macrocyclops* | 84 | 341 | 85 | 114 | 624 |
| | *Microcyclops* | - | 30 | - | 104 | 134 |
| | Total | 2500 | 1682 | 941 | 1019 | 6142 |
| | % of the yearly production | 20.02 | 13.45 | 7.52 | 8.15 | 49.14 |
| **Ostracoda** | *Cypris* | 88 | 63 | 454 | 208 | 813 |
| | *Eucypris* | - | - | 97 | 41 | 138 |
| | Total | 88 | 63 | 551 | 249 | 951 |
| | % of the yearly production | 0.70 | 0.50 | 4.41 | 2.0 | 7.61 |
| ***Crustacean Larvae*** | | 126 | 448 | 221 | 40 | 835 |
| | % of the yearly production | 1.01 | 3.58 | 1.77 | 0.32 | 6.68 |
| **Total** | | **3600** | **4300** | **2100** | **2600** | **12600** |

found in summer and lowest (82 units/l) in winter. A total of 12 genera of rotifers were identified in which *Brachionus* was dominant in the number of species while *Keratella* was in highest density. Arora (1966) reported the occurrence of some species *Brachionus, Keratella* and *Filinia* from polluted and eutrophic water. In the case of Posna *beel*, the abundance of rotifers is comparatively less. The highest number of copepods (2500 units/l) was reported in rainy season and lowest (941 units/l) in winter. Hasan (2002) also observed the minimum abundance of copepods in winter season. Copepods were perennial which constituted 49.14% of the total zooplankton. Highest density of zooplankton especially copepod was found in the monsoon and post-monsoon (Rana 1996, Pandey *et al*. 1998) respectively. Among copepods eight genera were recorded of which *Heliodiaptomus* exhibited highest density whereas *Cyclops* was highest in number of species. Cladocerans were completely seasonal and dominant in post-monsoon. The highest number (1359 units/l) was recorded in post-monsoon and lowest (379 units/l) in winter, which was 20.94% of the total zooplankton. Thirteen genera were identified of which *Diaphanosoma* was in the highest density. Ostracods constituted 7.61% of the total zooplankton. During the study period, the highest abundance (551 units/l) was found in winter and lowest (63 units/l) in post monsoon. Two genera of ostracods *Cypris* and *Eucypris* were identified.

Nauplius and Metanauplius stage of crustacean larvae constituted 6.68% of the total zooplankton population and varied from 40-448 units/l during the study period. The peak was recorded in the post-monsoon period.

The zooplankton diversity index varied between 0.09270 to 2.4982 at different groups of zooplankton in Posna *beel* (Table 5). Zooplankton diversity of rotifers and cladocerans was found to be highest during post monsoon period (Table-5). In case of minimum value of diversity index of rotifers and cladocerans were obtained in summer but copepods exhibited their minimum value of diversity index during monsoon (Table-5).

Table-5. Zooplankton Diversity Indices in Posna *beel* at Different Seasons (Shannon and Weaver Index)

| Zooplankton | **Seasons** | | | |
|---|---|---|---|---|
| | Monsoon | Post-monsoon | Winter | Summer |
| Rotifera | 2.3827 | 2.4982 | 1.9491 | .0927 |
| Cladocera | 1.9989 | 2.2511 | 1.6843 | 1.6158 |
| Copepoda | 2.2129 | 2.3039 | 2.2615 | 2.3107 |

Table-3. Correlation Coefficients between the Physico-chemical Variables and Zooplankton

| | Temp | Trans | pH | Alka | T. Hard | $Cl^-$ | $NH_3$ | $NO_3$ | $PO_4$ | Free $CO_2$ | DO | BOD | COD | ZP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WaterTemp | 1.00 | | | | | | | | | | | | | |
| Transparency | -.913 | 1.00 | | | | | | | | | | | | |
| pH | .238 | .156 | 1.00 | | | | | | | | | | | |
| Alkalinity | .998** | .891 | -.234 | 1.00 | | | | | | | | | | |
| T. Hardness | -.445 | .580 | .818 | .326 | 1.00 | | | | | | | | | |
| Chloride | -.367 | -.041 | -.892 | .406 | -.448 | 100 | | | | | | | | |
| Ammonia | -.993 | .955 | -.101 | .985* | .486 | .251 | 1.00 | | | | | | | |
| Nitrate | .717 | -.370 | .774 | -.747 | .124 | -.910 | -.627 | 1.00 | | | | | | |
| Phosphate | .455 | -.749 | -.770 | -.428 | -.890 | .634 | -.555 | -.263 | 1.00 | | | | | |
| Free $CO_2$ | .536 | -.389 | .708 | .501 | .501 | -.535 | -.492 | .605 | -.243 | 1.00 | | | | |
| DO | -.896 | .657 | -.426 | .921 | .310 | .661 | .844 | -.902 | -.160 | -.409 | 1.00 | | | |
| BOD | .437 | -.479 | .342 | -.394 | .354 | -.101 | -.446 | -.231 | .049 | .895 | -.132 | 1.00 | | |
| COD | .755 | -.752 | .331 | -.721 | .069 | -.223 | -.759 | .473 | .244 | .881 | -.482 | .920 | 1.00 | |
| Zooplankton | .725 | -.562 | .668 | -.711 | .302 | -580 | -.682 | .729 | -.098 | .969* | -.612 | .834 | .920 | 1.00 |

**. Correlation is significant at the 0.01% level
*. Correlation is significant at the 0.05% level
ZP = Zooplankton

**Relationship between Zooplankton density and Physico- Chemical Variables:**

The correlation coefficients between the densities of zooplankton and physico-chemicals variables were calculated. From this calculation it was observed that the zooplankton showed positive but statistically non-significant correlation with water temperature, pH, total hardness, nitrate, BOD and COD. Free $CO_2$ showed statistically significant positive correlation (0.05% level) with zooplankton (Table-3). On the other hand, zooplankton showed negatively non- significant correlation with transparency, alkalinity, ammonia ($NH_3$), phosphate ($PO_4$) and dissolved oxygen (DO) respectively (Table 3).

Table-4. Correlation Coefficient (Pearson's *r*) between the Physico-chemical Variables and different groups of Zooplankton

| Water parameters | Rotifera | Cladocera | Copepoda | Ostracoda | Crustacean larvae |
|---|---|---|---|---|---|
| Water temperature | .678 | .468 | .619 | -.945 | -.058 |
| Transparency | -.918 | -.437 | -.246 | .795 | .065 |
| pH | -.512 | .499 | .844 | -.472 | .492 |
| Alkalinity | -.644 | -.432 | -.652 | .944 | .700 |
| Total hardness | -.761 | .410 | .384 | .019 | -.149 |
| Chloride | .434 | -.272 | -.958* | .538 | .414 |
| Ammonia | -.927 | -.373 | -.055 | .559 | .045 |
| Nitrate | -.036 | -.081 | .991** | -.810 | -.407 |
| Phosphate | .929 | .958 | -.390 | -.195 | .784 |
| Free $CO_2$ | .133 | -.226 | .602 | -.779 | .244 |
| Dissolved oxygen | -.333 | .985* | -.840 | .854 | .844 |
| BOD | .389 | -.922 | .206 | -.627 | -.595 |
| COD | .587 | -.279 | .392 | -.57 | -.126 |

**. Correlation is significant at the 0.01% level
*. Correlation is significant at the 0.05% level

**Relationship between different groups of Zooplankton and water quality:**

Rotifers showed a negative but statistically non significant correlation with transparency, pH, alkalinity, total hardness, ammonia, nitrate and DO; cladocerans had a negative non- significant correlation with transparency, alkalinity, ammonia, chloride, DO, free $CO_2$ , BOD and COD. The copepods showed a negatively significant correlation with chloride but statistically non-significant correlation with transparency, alkalinity, ammonia, phosphate, DO; and the ostracods showed negative but statistically non-significant correlation with temperature, pH, nitrate, free $CO_2$, BOD and COD; and the crustacean larvae had a negative non-significant correlation with temperature, total hardness, nitrate and COD (Table 4).

From the one-year study, Posna *beel* was found to be rich in zooplankton diversity. Even their abundance was closely correlated with some water parameters like temperature, pH, total hardness, nitrate ($NO_3$), free $CO_2$, BOD and COD. Beside these, the assessment of water quality of Posna *beel* during four seasons revealed that the water quality of this *beel* is very suitable for open water fisheries. Most important water quality parameters for fish culture such as ammonia, pH, DO and BOD were found within the limit of Bangladesh Standard for Fish Culture during the study period.

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