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Abstract

Present paper analyzes whether physicochemical parameters significantly influence the occurrence of zooplankton in a brackish wetlands. The studies were carried out on the brackish wetlands from 2014 to 2016 at three season – pre-monsoon (April-June), monsoon (July- September) and post-monsoon (October- December). The environmental conditions in the wetlands varied greatly. At the time of the investigation, 29 species of Copepod and12 species of rotifer were noted, and the total density of zooplankton fauna ranged from 122 to 451 ind./dm^3. Statistical analysis demonstrated a significant correlation between the occurrence of some zooplankton species and certain environmental parameters. In addition, dissolve organic substance from macrophytes triggers eutrophication and causing low water transparency. Calanoid copepods were the dominant species in both the wetlands and showed seasonal variation. The high abundance of rotifer species genera *Keratella andBrachionus* reflects the harsh environment in the study sites, caused by the cultural eutrophication, salinity increase and also the temperature enhanced decrease in zooplankton evenness and richness.

Keywords- *Zooplankton, Wetlands, Eutrophication, Macrophytes.*

1. Introduction

Species tolerance to environmental conditions determines distribution limits, and species abundances peak under optimal conditions. Large-scale biotic distribution patternsare thought to result primarily from the responses of organisms to their physical environment, which acts as a physiological filter and plays a crucial role in the structuring of a community [Remmert, H., 1983]. Abiotic factors, salinity and temperature form the assemblages of the organisms in brackish coastal areas [Bostrom, C., et al. 2006].Inaquaticmilieucharacterizedbysharphorizontalgradients,thedistributionanddynamics ofcommunitiesareconsidered to be controlled by the interaction of abiotic physicochemical factors, river flows and mixing, and biological characteristics,makingspatiallyandtemporally heterogeneousconditions [Li, M., et al. 2000, Froneman, P.W., 2001].Suchhorizontalgradientsof salinity, nutrients and zooplankton are evident in estuariesandcoastalareasofbrackishseas[Telesh, I., 2004, Muylaert, K., et al. 2009]. This high environmental variability generallymakestolowoverallbiodiversity,buthighabundancesof adapted organisms ableto tolerate the variable conditions [McLusky, D.S., et al. 2007].Therefore, zooplankton diversity is vital when examining coastal food webprocesses.Biodiversity may play significant role in controlling ecological processes related to the sustainability and productivity of ecosystems [Reich P.B., et al. 2012]. Zooplankton species diversity in estuarine environments varies spatially along gradients of abiotic and biotic parameters, and can be rather high below a 'critical' salinity level, even with substantial variability in the surrounding environment [Froneman, P.W., 2001]. Which one ultimately determines spatial distributions of zooplankton along with gradients are the way different species traits or combinations of traits are favoured in different environmental conditions [Barnett, A.J., et al, 2007, Litchman, E., et al, 2013].Therefore, it may be the species functionsand the diversity of functional character, rather than taxonomic identity or species richness, that are applicable when investigative ecosystem processes [Hooper, D.U., 1997]. Environmental factors are also significant elements; for instance, water temperature impacts the growth and development of organisms and can influence theirmortality [Hall, C.J., et al, 2001].The aim of this study was to survey brackish water lentic habitats and provides a description of the spatial heterogeneity of the zooplankton community structure over a subtle salinity gradient, including hydrophytes, which are often overlooked. Our goal was to determine which locally variable environmental factors are the most important predictors of the spatial patterns and diversity of the zooplankton community.

2. Materials and Methods

2.1 Study site:

The present investigation was carried out from lentic estuarine ecosystems in and around certain wetlandsi.e. Tajpur [S-I] (21˚65'81.8'' N; 87˚62'60.4''E)and New Digha [S-II] (21˚64'03.5'' N; 87˚57'19.7''E)of Medinipur(East) (Fig:-1). All study of thewetlandswas sampled from 2014 to 2016 at three seasons – prep-monsoon (April-June), monsoon (July-September) and post-monsoon (October- December).

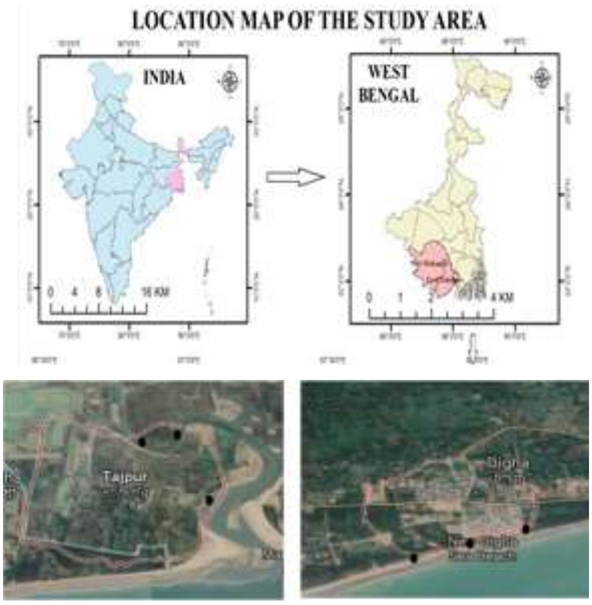

Fig:-1 Location map of the study area.

2.2 Zooplankton diversity study:

For qualitative and quantitative study of zooplankton, the samples were collected from various water bodies by filtering surface water through Nylobolt plankton net (#52µm) and were preserved in 5% formalin [Sharma, B.K., 2017]. All collections were screened with a wild stereoscopic binocular microscopic; the zooplankton taxa were isolated and mounted in polyvinyl alcohol- lacto phenol, and were observed with stereoscopic phase contrast microscope(Nikon E200). The different zooplankton species were identified according to Emir (1994), Ruttner-Kolisko (1974), Segers(1995),NogradyandPourriot(1995),andDeSmet(1998) for Rotifera and Kiefer (1978), Reddy Ranga (1994), and Dussart and Defaye (2001) for Copepodaunder research microscope[Emir, N., 1994, Ruttner-Kolisko, A., 1974, Segers, H., 1995, Nogrady, T., et al. 1995, De Smet, W.H., 1998, Kiefer, F., 1978, Reddy, ranga. Y., 1994, Dussart, B.H., et al. 2001, Battish, S. K. 1992]. A Sedgewick rafter counting cell (size: 50 mm X 20 mm X 1 mm, cell volume: 1.0 ml) was used for numerical analysis. Sedgewick rafter counting cell was filled with sample using glass pipettes. Number of plankton present in the

Sedgewick rafter cell was calculated from the following formula: Individuals/ml = {A* (n/v)}/ L.

The number of cells per mm was multiplied by a correction factor to adjust the number of organisms per litter [Dussart, B.H., et al. 2001]; Zooplankton abundance has been expressed as number of individual per litter of the sample.

Moreover, wetlands water temperature (°C), conductivity (mS cm^{-1}), salinity (‰), dissolved oxygen (mg L^{-1}), and pH were measured in situ using the Water Analyzer (TOWA, Japan, Model No- WQC-22A). Water transparency was measured with a 20-cm diameter Secchi disk.

2.3 Hydrophytes:

Diverse species of hydrophytes were recorded on a seasonal basis from April 2014 to December 2016, from three randomly selected sampling stations by walking along the margin of each wetland of the study site. Each sampling station was a stretch of about 40m. An aquascope and a rake were used for observation and collection of submerged plants. Formation of dense vegetation bed along with flowering of each species was also observed. All collected plants were kept in plastic bags and transported to the laboratory where they were washed thoroughly to remove silt, snails, epiphytes and other unwanted materials. The excess water was then drained off and healthy specimens were sorted and pressed for the preparation of herbarium. Voucher specimens of different species were kept in the laboratory. Identification was followed according to Cook, 1996.

2.4 Statistical analysis:

Pearson's correlation coefficient among biotic and abiotic factors was determined through SPSS version 25. Clustering of zooplankton and macrophytic samples were done through establishment of proximity matrix using ward linkage through SPSS version 25. P value less than 0.05 is considered statistically significant. Species abundance relation was calculated in terms of diversity index. The common indices calculated was Shannon- Weiner diversity index (*H*) and similarity index using the software XLSTAT.

3. Results:

3.1 Abiotic data:

Environmental variables showed a markedly seasonal variation in brackish wetlands of the study sites. In the Tajpur wetland, surface water temperature varied from 33.8℃ in summer to 20.4℃ in winter. Dissolved oxygen concentrations were between 3.15mg/l to 6.55mg/l at the site. Salinity in summer was high at 29.93 mg/l while in monsoon it dropped to 5.12 mg/l. Secchi depth, which was used as an indication of water transparency, was varied from 39 to 58 cm throughout the whole period. The mean pH varied in a range of 6.9 to 8.2, representing alkaline condition.

Table-1: Effect of seasonal variation of physicochemical parameter of water on zooplankton.

Groups (S-I)	Factors with	Correlation coefficient
Copepod	Temperature	-0.711**
	pH	0.054*
	DO	-0.011*
	Salinity	0.150*
	Secchi death	0.035*
Rotifera	Temperature	-0.435*
	pH	0.297*
	DO	-0.265*
	Salinity	0.238**
	Secchi depth	-0.207*
Groups (S-II)	Factors with	Correlation coefficient
Copepod	Temperature	-0.775**
	pH	0.188*
	DO	-0.379*
	Salinity	0.120*
	Secchi death	0.018*
Rotifera	Temperature	-0.345*
	pH	0.222*
	DO	-0.141*
	Salinity	0.154*
	Secchi depth	0.033*

Results of Pearson's correlation analysis among different natural physic chemical parameters of water samples, zooplankton density through twenty four months (Six seasons). The numerical values denote correlation coefficient (r).
*Significant at 5% level.
** Significant at 1% level.

In the New Digha wetlands, water temperature varied from 19.9℃ in winter to 32.4℃ in summer. Dissolved oxygen concentration was between 3.94 mg/l to 6.75 mg/l at the site. Salinity in summer was high at 25 mg/l while at monsoon it dropped to 7.87 mg/l. Water transparency range was varied from 40 cm to 60 cm during study period. The mean pH value varied in a range of 6.9 to 8.3 representing alkaline condition.
Salinity,pH, Secchi depth was found to be positively correlated with copepods in both the side. Temparature and DO are noticed to be negatively correlated with copepod in both the sites. Temperature, DO and Secchi depth have been shown negatively correlated with rotifera at site-1, where as secchi depth was positively correlated with rotifer at site-2.Rotifera has been shown to be positive correlation with the pH, salinity at site -1 and site-2. Temperature and DO have been shown negatively correlated with rotifera at site-2 (Table:-1).

3.2 Zooplankton Assemblages:

In course of studies 41 species of zooplankton have been recorded from the studies, among them 36 species were found to be present site-I and 34 species at site-II. These 41 species of zooplankton belong to two phyla, arthropod and Rotifer. All together 29 arthropods and 12 rotifer species were found within the samples collected from site-I and site-II. No caducean species were observed during the sampling periods.

Among 41 species of zooplankton in site-I and site-II, dominant species were*Calanus finmarchicans, Oncaea sp. Microsetella sp., Pseudodiaptomus hickmani*and*Acartiella sp*. Eudominant species were *Paracalanus sp*. and *Eucalanus crassus*,

Distribution patterns of zooplankton species composition revealed discontinuous distribution in the sites. Shannon Diversity index values for zooplankton community are 3.157insite-I and 3.196 in site-II. Similarity Index(C_s) value show that both the sites were strongly similar (Fig:-2).

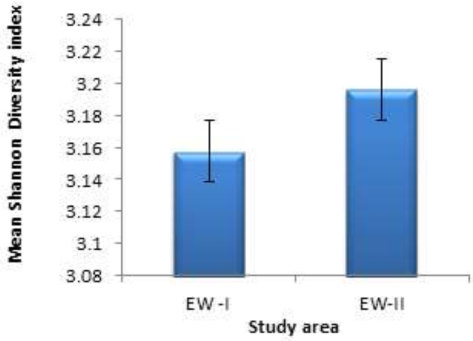

Fig. -2: Seasonal variation in zooplankton composition in study sites of PurbaMedinipur wetlands.

Sampling of zooplankton in two different contrasting environment reveals that in brackish water population arise mainly in four major cluster (Fig.- 3 & 4) based on the availability during study period.

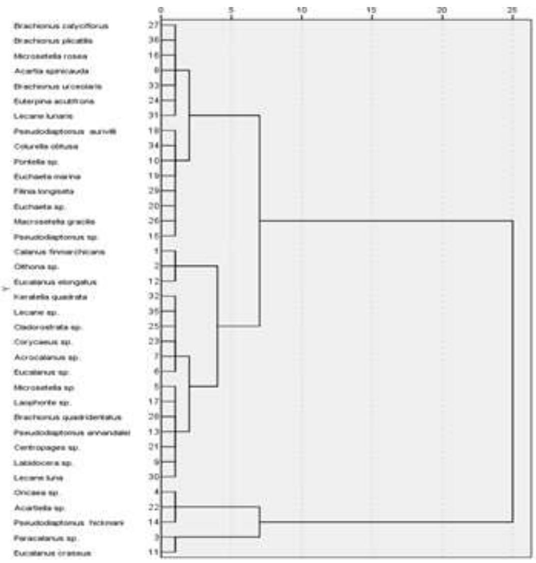

Fig-3: Cluster analysis of station-I (S-I) for entire study periods.

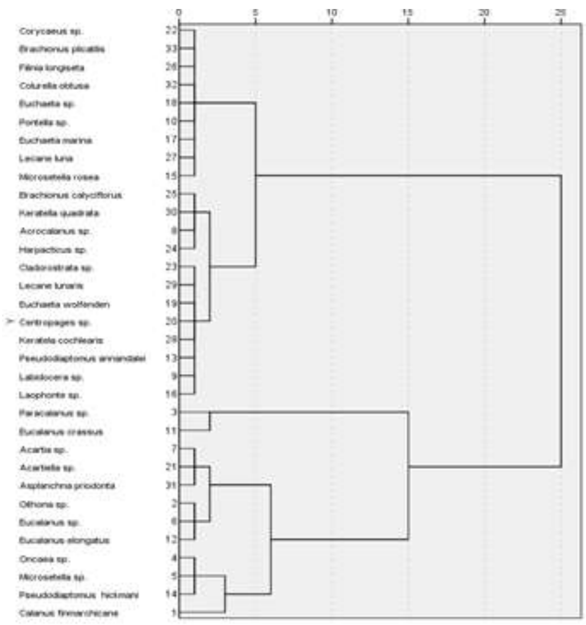

Fig-4: Cluster analysis of station-II (S-II) for entire study periods.

3.3 Macrophytes diversity study:

The species list of macrophyte along with their growth forms is given in table no:-2. All types of growth forms were found in this study. The two eudominant species (> 10%) were *lemna major*s and *Colocasia sp.* and the rest of the macrophytic were considered sub-recedents.

4. Discussion:

Two year of monitoring data from two estuarine wetlands showed strong seasonality in zooplankton composition and taxonomic diversity, indicating water temperature to be the most prominent environmental factor shaping the zooplankton communities in the study region.

In general, few species are permanently inhabitant in coastal wetlands, hence dominating the biotic community [Colombo, G., 1977]. Our findings for both of the wetlands point to the dominance of the calanoid copepod species *Calanus finmarchicans*,whichhasacosmopolitedistributionthroughout the estuarine wetlands [Siokou-frangou, I., et al. 2004], compatible with the characteristics of Mediterranean coastal lagoons, having a high abundance of calanoid copepods.

During monitored seasons, the zooplankton community had show low species evenness with only a small number of species having high relative abundance. Brucetetal., [Brucet, S., et al. 2009]suggestedthatindirect effectsofglobal warming,changesinsalinityand hydrologywill have larger impacts on coastal ecosystems.Present study is revealedthat wetlands are cosmopolite and salinity-tolerant species of the genus *Brachionus*,*Keratella*(e.g.,*B.calyciflorus*and*K. quadrata*)werehighinprevalence.Rotifersappearedtobe dominantinbrackish water wetlands[Saygi, Y., et al. 2011].

On the other hand,noefficientfilter-feedingcladoceran species were observed in the study sites, possibly forming grazing pressure on phytoplankton and creating more eutrophic conditions. Other works in the different literature confirmed that cladocerans are restricted to salinitiesbelow3.5%[Viayeh, R.M., et al. 2012]. Moreover, increasing salinity creates a decrease intheirspeciesdiversity[Jensen, E., et al. 2010],which concurs with the present study, where high salinity during summer lowered the species richness in the brackishwetlands. A cross-comparison of coastal brackish wetlands between temperate and Mediterranean regions also revealed that salinity was the main factor for low zooplankton richness [Saygi, Y., et al. 2011]. Estuarine regions are directly and indirectly influenced by anthropogenic pressure such as non-biodegradable chemical pollution, invasive species and physical deterioration [Chaalali. A., et al. 2013]. Thus, eutrophication, land utilization, and wastewater discharge are among the most imperative pressures that influence these vital habitats that shelteringmanyimportantorganisms[Kennish, M.J., etai.2010].Both study regions are situated at the site of agriculture fields. Moreover, these agricultural activities can trigger natural eutrophication and dystrophic circumstances.
During the study period a higher dominance of rotifers in wetlands suchas*Keratellacochlearis*and*Keratellaquadrata*, reflecting eutrophic conditions, was also observed in previous studies [Saygi, Y., et al. 2011, Ustaoglu, M.R., et al. 2012].

Increasing temperature influences the dissolved oxygen concentration of the water, thereby negatively affecting the zooplanktons[Turner, B.L., et al.2003, Anthony, A., et al. 2009]. Thus, the high occurrence of rotifers during summer, when the dissolved oxygen concentration is low, pointed to the resilience of this grouptoanoxicconditions.Therefore, *B.calyciflorus*, which occurred in both study regions, was reported previously to tolerate low dissolved oxygen and pH levels of 7–9 by Guher et al., [Guher, H., et al. 2011].

5. Conclusion:

Thus the present study demonstrated that physicochemical properties played a major role in creating zooplankton species structure and could also significantly impact entire zooplankton clusters.

Table-2: Occurrence of macrophytes species was noted as individuals per ml of water

Species name	Family	Dominant	Growth forms
Hygrophila spinossa	Acantheceae	Sub-recedent	Rooted emergent
Alternanthera philoxerodes	Amaranthaceae	Sub-recedent	Semi aquatic
Alocasia indica	Araceae	Sub-recedent	Rooted emergent
Colocasia sp	Araceae	Eudominants	Rooted emergent
lemna major	Lemnaceae	Eudominants	Free floating
Enhydra fluctuans	Compositae	Sub-recedent	Rooted emergent
Eclipta prostrate	Compositae	Sub-recedent	Semi aquatic
Eichhornia carssipes	Hydrocharidaceae	Sub-recedent	Free floating
Ipomoea aquatic	Convolvulaceae	Sub-recedent	Rooted free floating
Ipomoea carnia	Convolvulaceae	Sub-recedent	Free floating
Marsilea quardrifolia	Marsileaceae	Sub-recedent	Semi aquatic
Oryza sativa	Poaceae	Sub-recedent	Rooted emergent
Pistia stratiotes	Araceae	Sub-recedent	Free floating
Polygonum barbatum	Poygonaceae	Sub-recedent	Semi aquatic
Typha sp	Typhaceae	Sub-recedent	Rooted submerged
Bacopa monnieri	Scrophulariaceae	Sub-recedent	Semi aquatic
Jussiaea repens	Onagraceae	Sub-recedent	Rooted submerged
Echinochloa colonum	Poaceae	Sub-recedent	Rooted submerged
Wolffia microscopica	Araceae	Sub-recedent	Free floating

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Conflict of interest

Authors declare no conflict of interest.

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