

Ecological Gradients Determining the Zooplankton-Macrophyte Interaction and Diversity in Brackish Water Wetlands of Midnapore (East), West Bengal, India

Sujoy Midya^{#1*}, Sk Saruk Islam^{#2}, Raj Paul^{#3}, Susanta Kumar Chakraborty^{#4}

^{1*} Co-responding author

^{#1,2}Dept. Of Zoology Raja N.L. Khan Women's College, Midnapore, WestBengal-721102,India

^{#3}Dept. of Statistic, Banaras HinduUniversity, Varanasi, Uttar Pradesh, India.

^{#4}Dept. of Zoology, Vidyasagar University, Midnapore, WestBengal, 721102 India.

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 and 12 species of rotifer were noted, and the total density of zooplankton fauna ranged from 122 to 451 ind./dm³. 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* and *Brachionus* 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 patterns are 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]. In aquatic milieu characterized by sharp horizontal gradients, the distribution and dynamics of communities are considered to be controlled by the interaction of abiotic physicochemical factors, river flows and mixing, and biological characteristics, making spatially and temporally heterogeneous conditions [Li, M., et al. 2000, Froneman, P.W., 2001]. Such horizontal gradients of salinity, nutrients and zooplankton are evident in

estuaries and coastal areas of brackish seas [Telesh, I., 2004, Muylaert, K., et al. 2009]. This high environmental variability generally makes to low overall biodiversity, but high abundances of adapted organisms able to tolerate the variable conditions [McLusky, D.S., et al. 2007]. Therefore, zooplankton diversity is vital when examining coastal food web processes. 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 functions and 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 their mortality [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 wetlands i.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 the wetlands was sampled from 2014 to 2016 at three seasons – pre-monsoon (April-June), monsoon (July-September) and post-monsoon (October- December).

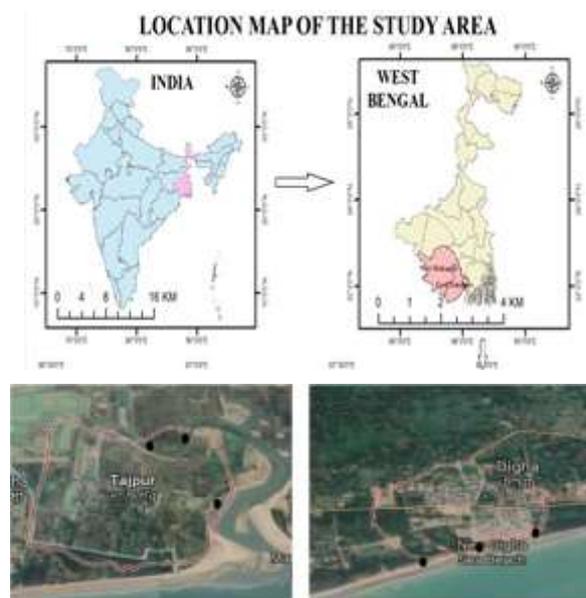


Fig:-1 Location map of the study area.

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), Nogrady and Pourriot (1995), and De Smet (1998) for Rotifera and Kiefer (1978), Reddy Ranga (1994), and Dussart and Defaye (2001) for Copepoda under 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: $\text{Individuals/ml} = \{A * (n/v)\} / L$.

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 ($^{\circ}\text{C}$), 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°C in summer to 20.4°C 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°C in winter to 32.4°C 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. Temperature 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 3.157 in site-I and 3.196 in site-II. Similarity Index (C_s) value show that both the sites were strongly similar (Fig:-2).

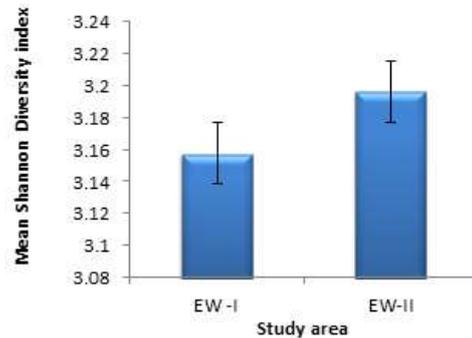


Fig. -2: Seasonal variation in zooplankton composition in study sites of PurbaMedinipur wetlands.

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.

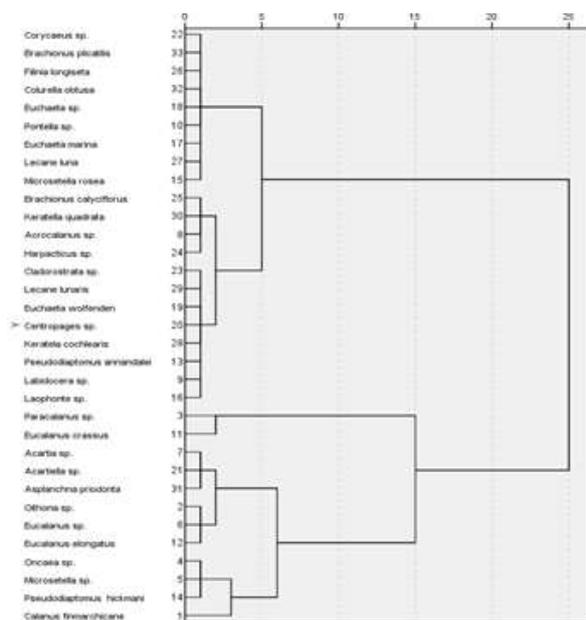


Fig-4: Cluster analysis of station-II (S-II) for entire study periods.

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 majors* 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 finmarchicus*, which has a cosmopolitan distribution throughout 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. Brucet et al., [Brucet, S., et al. 2009] suggested that indirect effects of global warming, changes in salinity and hydrology will have larger impacts on coastal ecosystems. Present study is revealed that wetlands are cosmopolite and salinity-tolerant species of the genus *Brachionus*, *Keratella* (e.g., *B. calyciflorus* and *K. quadrata*) were high in prevalence. Rotifers appeared to be dominant in brackish water wetlands [Saygi, Y., et al. 2011].

On the other hand, no efficient filter-feeding cladoceran 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 salinities below 3.5% [Viayeh, R.M., et al. 2012]. Moreover, increasing salinity creates a decrease in their species diversity [Jensen, E., et al. 2010], which concurs with the present study, where high salinity during summer lowered the species richness in the brackish wetlands. 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 sheltering many important organisms [Kennish, M.J., et al. 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 such as *Keratella cochlearis* and *Keratella quadrata*, 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 group to anoxic conditions. 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
<i>Hygrophila spinossa</i>	Acantheceae	Sub-recedent	Rooted emergent
<i>Alternanthera philoxerodes</i>	Amaranthaceae	Sub-recedent	Semi aquatic
<i>Alocasia indica</i>	Araceae	Sub-recedent	Rooted emergent
<i>Colocasia sp</i>	Araceae	Eudominants	Rooted emergent
<i>lemna major</i>	Lemnaceae	Eudominants	Free floating
<i>Enhydra fluctuans</i>	Compositae	Sub-recedent	Rooted emergent
<i>Eclipta prostrate</i>	Compositae	Sub-recedent	Semi aquatic
<i>Eichhornia carssipes</i>	Hydrocharidaceae	Sub-recedent	Free floating
<i>Ipomoea aquatic</i>	Convolvulaceae	Sub-recedent	Rooted free floating
<i>Ipomoea carnia</i>	Convolvulaceae	Sub-recedent	Free floating
<i>Marsilea quardrifolia</i>	Marsileaceae	Sub-recedent	Semi aquatic
<i>Oryza sativa</i>	Poaceae	Sub-recedent	Rooted emergent
<i>Pistia stratiotes</i>	Araceae	Sub-recedent	Free floating
<i>Polygonum barbatum</i>	Poygonaceae	Sub-recedent	Semi aquatic
<i>Typha sp</i>	Typhaceae	Sub-recedent	Rooted submerged
<i>Bacopa monnieri</i>	Scrophulariaceae	Sub-recedent	Semi aquatic
<i>Jussiaea repens</i>	Onagraceae	Sub-recedent	Rooted submerged
<i>Echinochloa colonum</i>	Poaceae	Sub-recedent	Rooted submerged
<i>Wolffia microscopica</i>	Araceae	Sub-recedent	Free floating

Acknowledgments

The authors sincerely appreciate the laboratory facilities provided by the Vidyasagar University authority.

Conflict of interest

Authors declare no conflict of interest.

Reference

[1] Anthony, A., Atwood, J., August, P., Byron C., Cobb, S., Fostr, C., Fry, C., Gold, A.,

Hagos, K., Heffner, L. Coastal lagoons and climate changes: ecological and social ramifications in U.S. Atlantic and Gulf Coast ecosystems. Ecology and society. 14: 8, (2009).

[2] Barnett, A.J., finlay, k., beisner, B.E. Functional diversity of crustacean Zooplankton communities: towards a trait-based classification. Freshwater biology 52(5): 796-813, (2007).

[3] Battish, S. K. Freshwater zooplankton of India. New Delhi: Oxford & IBH publishing Co. Pvt. Ltd, (1992).

[4] Bostrom, C., Obrien, K., Roos, C., Ekebom, J. Environmental variables explaining the structure and functional diversity of seagrass macrofauna in an archipelago landscape.

- Journal of experimental marine biology and ecology. 335:52-73, (2006).
- [5] Brucet, S., Boix, D., Gascon, S., Sala, J., Quintana, X.D., Badosa, A., Sondergaard, M., Lauridsen, T.L., Jeppesen, E. Species richness of crustacean zooplankton and trophic structure of brackish lagoons in contrasting climate zones: north temperate Denmark and Mediterranean Catalonia (Spain). *Ecography*. 32: 692-702, (2009).
- [6] Chaalali, A., Beaugrand, G., Rayboud, V., Goberville, E., David, V., Boet, P., Sautour, B. Climatic facilitation of the colonization of an estuary by *Acartia tonsa*. *PloS One* 2013: 74531, (2013).
- [7] Colombo, G., Lagoons. In: Barnes RSK, editor. *The Coastline*. London, UK: John Wiley & Sons. 63-81, (1977).
- [8] Cook C.D.K. *Aquatic and Wetland Plants in India*. Oxford University Press, Oxford. 385, (1996).
- [9] De Smet, W.H. *Cephalodellasegersin.sp.* (Notommatidae, Monogononta), a new rotifer from Belgium, with notes on *C. Catellina* (O.F. Muller, 1786), *C. Fulvialilis* (Zavadovsky, 1926) and *C. Marior* (Zavadovsky, 1926) stat. Nov. *Hydrobiologia*. 367: 1-13, (1998).
- [10] Dussart, B.H., Defaye, D. Introduction to the Copepoda. In: Dumont HJ, editor. *Guides to the identification of the Microinvertebrates of the Continental Waters of the World*. Leiden, the Netherlands: Backhuys publishers. 1-336, (2001).
- [11] Emir, N. Zooplankton community structure of Cavuscu and Eber Lajes in Central Anatolia. *Acta hydrochemica et hydrobiologica*. 22: 280-288, (1994).
- [12] Froneman, P.W., Seasonal changes in zooplankton biomass and grazing in a temperate estuary, South Africa. *Estuarine, Coastal and shelf science*. 60 (1): 125-132, (2001).
- [13] Guher, H., Erdogan, S., Kirgiz, T., Camur-Elipek, B. The dynamics of zooplankton in national park of lake Gala (Edirne-Turkey). *Acta Zoologica Bulgarica*. 63: 157-168, (2011).
- [14] Hall, C.J., Burns, C.W. Effects of Salinity and Temperature on Survival and Reproduction of *Boeckella hamata* (Copepoda: Calanoida) from a Periodically Brackish Lake. *Journal of Plankton Research*. 23 (1): 97-104, (2001).
- [15] Hooper, D.U. Vitousek, Effects of plant composition and diversity on ecosystem processes. *Science*. 227 (5330): 1302-1305, (1997).
- [16] Jensen, E., Brucet, S., Meerhoff, M., Nathansen, L., Jeppesen, E., Community structure and diel migration of zooplankton in shallow brackish lakes: role of salinity and predators. *Hydrobiologia*. 646: 215-229, (2010).
- [17] Kennish, M.J., Paerl, H.W., *Coastal Lagoons: Critical Habitats of Environmental Change*. Boca Raton, FL, USA: CRC Press Taylor & Francis Group., (2010).
- [18] Kiefer, F. *Das zooplankton der Binnengewässer*, 2. Teil. Stuttgart, Germany: E. Schweizerbart 'sche Verlage' Stuttgart. 380 (in German), (1978).
- [19] Li, M., Gargett, A., Denman, K. What determines seasonal and interannual variability of phytoplankton and zooplankton in strongly estuarine system? Application to the semi-enclosed estuary of Strait of Georgia and Juan de Fuca Strait. *Estuarine, Coastal and shelf science*. 50 (4): 467-488, (2000).
- [20] Litchman, E., Ohman, M.D., Kiorboe, T. Trait based approaches to zooplankton communities. *Journal of plankton research*. 35(3): 473-484, (2013).
- [21] McLusky, D.S., Elliott, M. Transitional waters: a new approach, semantics or just muddying the waters? *Estuarine, Coastal and Shelf Science*. 71: 359-363, (2007).
- [22] Muylaert, K., Sabbe, K., Vyverman, W. Changes in phytoplankton diversity and community composition along the salinity gradient of the Schelde estuary (Belgium/ the Netherlands). *Estuarine, Coastal and shelf science*. 82 (2): 335-340, (2009).
- [23] Nogrady, T., Pourrito, R., *The Notommatidae*. In: Dumont H, editor. *Rotifera Vol. 3*, (1995).
- [24] Reddy, Ranga. Y. *Copepoda: Calanoida: Diaptomidae*. In: Dumont HJF, editor. *Guides to the Identification of the Macroinvertebrates of the continental waters of the world*. Amsterdam, the Netherlands: SPB Academic publishing, p. 248, (1994).
- [25] Reich P.B., Tilman, D., Isbell, F., Mueller, K., Hobbie, S.E., Flynn, D.F., Eisenhauer, N., Impacts of biodiversity loss escalate through time as redundancy fades. *Science*. 336 (6081): 589-592, (2012).
- [26] Rømmert, H. Studies and thoughts about the zonation along the rocky shores of the Baltic. *Zoologica*. 22: 121-125 (1983).
- [27] Ruttner-Kolisko, A. *Plankton rotifers. Biology and taxonomy*. English translation of *Die Binnengewässer*. 26(1): 146, (1974).
- [28] Saygi, Y., Gunduz, E., Demirkalp, F.Y., Caglar, S.S. Seasonal patterns of the

- zooplankton Community in the shallow, brackish Liman Lake in Kizilirmak Delta, Turkish journal of zoology. 35: 783-792, (2011).
- [29] Segers, H., The Lecanidae. In: Dumant HS, editor. Rotifer Vol. Guides to the Identification of the Macroinvertebrates of the Continental waters of the World. Amsterdam, the Netherlands: SPB Academic publishing, p.226, (1995).
- [30] Sharma, B.K. First report of freshwater rotifers (Rotifera: Eurotatoria) from south Andaman, India: Composition and interesting elements. Journal of Asia-Pacific Biodiversity. 10: 261-266, (2017).
- [31] Siokou-frangou, I., Shiganova, T., Christou, E.D., kamburska, L., Gubanova, A., Konsulov, A., Musaeva, E., Skryabi, V., khoroshilov V. Mesozooplankton communities in the Aegean and Black Seas: a comparative study. Marine biology 144: 1111-1126, (2004).
- [32] Telesh, I., Plankton of the Baltic estuarine ecosystem with emphasis on Neva Estuary: areview of present knowledge and research perspectives. Marine pollution. Bulletin. 49 (3): 206-219, (2004).
- [33] Turner, B.L., Roger, E., Kasperson, P.A., Matson, J.J., McCarthy, R.W., Corell, L.C., Noelle, E., Jeanne X., Kasperson, A.L., Marybeth L., Martello, C. P., Alexander, P. and Andrew, S. A framework for vulnerability analysis in sustainability science. PNAS. 100 (14): 8074-8079, (2003).
- [34] Ustaoglu, M.R., Altındag, A., Kaya, M., Akbulut, N., Bozkurt, A., Ozdemir, M.D., Atasagun, S., Erdogan, S., Bekleyen, A., Saler, S., Okgerman, H.C. A Checklist of Turkish Rotifers. Turkish Journal of Zoology. 36(5): 607-622, (2012).
- [35] Viayeh, R.M., Spoljar, M. Structure of rotifer assemblages in shallow waterbodies of semi-arid northwest Iran differing in salinity and vegetation cover. Hydrobiologia. 686: 73-89, (2012).