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Review Paper

A Critical Review of Zooplankton Studies of Lentic Water Bodies of India

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Abstract
Zooplanktons are the primary consumers of aquatic ecosystem. Zooplanktons are the plankton consisting of small animals and the immature stages of larger animals. Zooplanktons play an important role in food chain and also evaluate the ecological status of water bodies. Zooplanktons are the bio indicators of pollution and water quality. Present study reveals on the research on zooplanktons in India. . Zooplankton population is very useful indicators of food web stability. Zooplanktons are affected by many environmental factors such as pH, temperature, salinity; oxygen etc. zooplanktons are play important role on food chain, energy transfer between primary and tertiary trophic levels. Due to their large densities they are being used as the indicator organisms of physical, chemical and biological process of aquatic system

Key words: *Zooplankton, lentic water bodies, India, rotifera, copepoda, cladocera*

Introduction
Zooplanktons are the important portion of aquatic ecosystem. Zooplanktons play vital role in the biogeochemical cycles and in food web. They are the useful indicators of environment changes. So according to present context zooplankton is the intent area for research. In this paper we are try to collect review of literature at one place. Zooplanktons are the bio indicators of environment for pollution, physical, chemical and biological status of aquatic system.

Literature Review
Forel *(1841 – 1912)* was the founder of modern hydrobiology. He worked on different lakes found in Switzerland. The early fresh water stations yielded a mass of information, which made early groundwork of modern ecology. Elaborated investigations have been carried out during last few decades on limnology of different types of water resources. The study includes various aspects of lotic and lentic fresh water ecosystems, such as quality of water its physical, chemical and biological characteristics (phytoplankton, zooplanktons, macrophytes and animal of different taxonomic categories which has been reviewed and included in many research papers, dissertations, theses, monographs and books (Dube, *2002 and Basavarajappa et al., 2014)*.

Ecologically zooplanktons are important biotic components and play an important role in the aquatic ecosystem as they constitute the most import link in the energy transfer between phytoplankton and higher aquatic fauna (Iloba, 2002).

Dube (2005a) has studied physicochemical characteristics of a semi-permanent pond at Baran Rajasthan, India. In the same year (2005b), Dube and Sharma have studied distribution pattern of amphibian biodiversity in southeastern plateau of Rajasthan, India in relation to ecology of the habitat and niche. In southeastern plateau of Rajasthan, Jhalawar, Baran district represent the rich amphibians biodiversity.

Zooplanktons influence all the functional aspects of an aquatic ecosystem such as food chains, food webs, energy flow and cycling of nutrients (Park and Shin, 2007). Zooplankton diversity responds rapidly to changes in the aquatic environment. Several zooplankton species are served as bio indicators (Ahmad *et al.,* 2011, Mola, 2011). Shallow lakes have an exceptional ecological significance (biodiversity of invertebrates, fish, water birds), but they are often neglected in limnological studies (Céréghino *et al*., 2008).

Anthropogenic impacts frequently lead to the eutrophication and acidification of these habitats, and the introduction of invasive plants and animals results in reduced biodiversity (Kruk *et al.,* 2009). Water quality of several lakes of Bucharest city area on the comparison of standard and florescence measurement was studied (Ghir Vase *et al.* 2011). According to fluorescence measurement it appears that the lake water quality is not directly influenced by the Geological characteristic but more likely by the flora and fauna and the combination of anthropogenic degradation sources. The correlation between the fluorescence spectroscopy appears to the suitable for the evaluation and monitoring of the health of water system thus providing the opportunity for real time. Concurrently,

macrophytes increased habitat diversity, provided plenty and diverse food resources and refuge from predators (larvae and adult fish insects) forth zooplankton and benthic invertebrates (Estlander *et al*., 2009; Špoljar, 2013).

Soil bank diversity and zooplankton emergence pattern of some recently dried water bodies in north Maharashtra region, comparing to that of neighboring temporary pond and that permanent ponds studied by *Gaikwad et al.,(2008)* the diversity in permanent pod was significantly higher(i.e. 19) than the diversity in the temporary ponds (i.e. 8). We have recorded 8 species of rotifera species which are not present in the neighboring permanent for ephemeral water bodies during that period. A total 19 species were recorded including copepoda 6 species, cladocera 5 species, and rotifera 8 species.

Kedar et al., (2008) studied the seasonal abundance of zooplankton population in Rishi Lake with physico-chemical parameters. The no. of zooplankton recorded in summer and lowest in rainy season. The inter-relationship between physico-chemical factors and zooplankton is that all parameters pH, DO, alkalinity, total hardness, chlorides, sulphates, nitrates, and phosphates were at peak in summer and minimum in rainy season. Total 61 species were identified during study period such as Protozoa (14 sp.) Rotifera (29 sp.), Copepoda (6 sp.), ostracoda(5sp.) and Cladocera(7sp.).

Periodical ecological study of an urban pond near Vadodara Gujarat was studied by Soni and Bhatt (2008) with the physic-chemical, biological and microbiological parameters. The physic-chemical parameters show N max up to 3.4 mg/l, total phosphates 1.45 mg/land BOD 33 mg/l. The pond is full of algal growth. Microbiological analysis show positive result for *E. coli*, *Vibrio species* and many other pathogenic bacteria. These in water increase pollutants in terms of nutrients, organic matter and toxic substance in water bodies and disturb its ecosystem.

Zushi et al., (2008) studied the anthropogenic impact on the lake ecosystem in Hi-tech city Bangalore, Karnataka. A Hi-tech city Bangalore originally had 290 lakes many decades ago and today about 81 are left and of these 21 are said to be live. Lakes in and around urban areas of Bangalore receive considerable effluents and sewage inflow. The result are very evident showing depletion in oxygen level, high level of chlorophyll 'a', TDS, BOD, phosphate, sulphates, ammonia and high alkalinity etc. which inturn has altered the nutrients concentration contributing to the formation of algal blooms causing high mortality of fishes. A few badly effected lakes in and around Banglore city such as Bellandur, Varthur, Ulsoor, Byramangla, Madivala, Agra and Nagawalaare the one from where in even the hardy fish species like Murrels, Clarias, singhi etc. have completely disappeared. In recent years, limnology of different water bodies of Rajasthan was studied by several workers and total 144 zooplanktonic forms were reported belonging to 3 phyla, 27 families, 64 genera and 105 species. Protozoa (13), Rotifera (39), Copepoda, Cladocera and Ostracoda were represented by 13,39,22 and 6 forms respectively. Biodiversity in the zooplankton has been calculated in the Menhinick's index and values have been discussed in relation to physico-chemical characteristics and primary productivity.

Kumar *et al.,* (2008) evaluate the physico-chemical characteristics and diatom as indicators of trophic status of wetland namely Kishore Sagar Lake of Kota Rajasthan. The Diatom community comprised of 42 species representing 8 centric forms and 34 pennate forms. *Melosira granulata, Cocconies placentula, Diatoma elongatum, Fragilara crotoneinsis, Ghomphonema olivacium, Ghomphoneis herculum, Nitzchia sp. Navicula radios* and *Synendra ulna* were the most dominant species from this wetland. Highest population density of diatoms was observed in winter season. The abundance of diatoms in cold months is probably due to the fact that they are able to grow under the condition of weak light and low temperature. The dominance and abundance of diatoms the wetland is indicative of eutrophic nature of the water body. The water quality of the lake has detroited and is potential threat to human health as well as aquatic flora and fauna.

Dube *et al.* (2010a) investigated on Community structure of zooplanktonic groups of Kishore Sagar Tank. In this investigation they recorded total 36 species of zooplankton which belong to 7 groups. Dube *et al*. (2010b) have studied the occurrence and seasonal variation of the plankton in Kishore Sagar Tank, Kota, Rajasthan and a total 60 species of planktons (twenty four species of phytoplankton and thirty six species of zooplanktons) were recorded. The ecological study of the sewage Pond of H. E .C. industrial area Ranchi has been studies by Kumar and Sahu (2012). Studies were conducted to determine the occurrence and abundance of cynobacteria in relation to Physical-Chemical characteristics of Sewage Pond. This study indicates the maximum occurrence and abundance of *Microcys oscillatoria*, a Phormidium spp. in all the sites of Sewage Pond. The physic chemical parameter show maximum nitrogen up to 35.4 mgl^2, 4.8 mgl^1, Phosphate 147.131 mgl^1 Cl and alkaline nature of water throughout the year favour the growth of *cyanophean* members and promote algal bloom formation of *Microcysis aeruginosa, O. princeps* and otenus in pond. The algal diversity of the Sewage pond is bio indicator of organic pollution.

Tidame and Shinde (2012) studied the zooplankton diversity in the temple pond of Nasik District. Different Zooplanktons were noticed during the study period, amongst them rotifers are more dominant. Total 17 genera were reporded from rotifers and genus *Brachionus* in abundant and more common to both the ponds. In amrutkund 21 species of rotifers were recorded belonging to 15 genera while in pond Ramkund 23 species to 14 genera. The maximum diversity of rotifers was observed in the monsoon season in both Amrit Kund and Ram Kund Pond. Banerjee *et al*. (2014) analyzed zooplankton abundance in ponds under different fish farming system in west Bengal. The identified zooplanktons were under 4 orders namely Copepoda, Rotifera, Cladocera and Diaptomus.

Among these four orders Copepoda and Cladocera were dominant and represented by cyclops species and daphnia species respectively.

Physico-chemical parameters and plankton diversity of Konda (open pond) pond of Bharatpur is studied by Singh (2015). Physico-chemical parameters of pond are water temperature 24-25.6 ˚c ,transparency 0.2-0.4 m , pH 7.3-7.4 ,total dissolved solids 143.8-159.5 mg/L, conductivity 290.8-391.5 µmhos, salinity 0.11-0.19 %,dissolved oxygen 0.7-1.8 mg/L, and alkalinity 0.8-1.7 mg $CaCo_3$ mg/L, five families of phytoplankton are identified at the time of study Cyanophyceae, Colorophyceae, Euglenophyceae, Bacillirophyceae and dinophyceae. Three groups of zooplanktons are also identified namely copepods, Cladocerons and Rotifers. Pond is likely polluted as some pollution indicator species are present such as Microcystis, phacus, Oscillatoria, Anabeana, Euglena.

Sharma *et al*. (2015) studied the diversity of zooplankton and macro benthic invertebrates in Jhakhand Dilli pond. 29 species of zooplanktons were identified viz. Protozoan, Rotifers, Cladocerons, Copepods and Ostracods.

Biswas (2015) studied the relationship between the physico- chemical properties and zooplankton in Dhakuria Lake. 31 species of zooplankton comprising of 4 groups were reported viz. Rotifera (17 species), Cladocera (10 species), Copepoda (3 species), Ostracoda (1 species). copepodes were dominant. There is positive relationship between high level of physico-chemical parameters such as total hardness, Do, BOD, COD, sulphate and phosphate with the abundance of Cladocera, Copepoda and total zooplankton population.
Manikam et al. (2015) studied the zooplankton diversity and physico-chemical parameters of Barur Lake, Krishnanagri district Tamil nadu. 47 species of zooplankton were reported of which 18 species of Rotifers, 11 species of Cladocera, 11 species of Copepoda and 7 species of Ostracoda were observed. Rotifera was dominating group among all species.

Seasonal variation of zooplankton diversity of Majalgaon reservoir Maharashtra was assessed by Pawar (2016) During the study period 23 species were recorded among them Rotifers (8 species), Cladocera (6 species), copepod (5 species), Ostracod (2 species) and Protozoa (2 species). During summer season number of zooplankton were highest and lowest during winter season. Lucas *et al*.(2017) studied the microbiological and and physico-chemical parameters of water bodies of Desiroto de los leones National Park located in central region of the Mexico city. They identified five bacterial genera (*Escherichia, Pseudomonas, Klebsiella, Shigella and Salmonella*). Result of testing of water is as follow: pH 5.5-5.9, turbidity 10.7-32.3, Nephlometric turbidity units (NTU's), chemical oxygen demand (COD) 106-450 mg/L, total coliforms 98-956 colony forming units (CFU'S), faecal coliforms 78-807 CFU'S, 90% isolated bacteria were resistant to ampicillin while 25% resistant to ciprofloxacin.

Yadav and Singh (2017) studied the zooplankton diversity of Chhapakaiya pond Birgunj Nepal. A total 27 taxa from different classes of zooplankton were identified. The zooplankton were reported maximum (774.4 unit/L) during summer and minimum (539.2 unit/L) during rainy season in Chapakaiya pond. Triest and Stier (2017) studied the impact of non-native plant species on phytoplankton and zooplankton communities in temperate pond. Investigation shows the relationship between the three aquatic nonnative invasive species (*Hydrocotyle ranunculoides, Ludwigia randiflora* and *Myriophyllum aquaticum*), zooplankton and phytoplankton density Jacob *et al*. (2017) studied the odanata (dragonflies and damselflies) as bio indicators of water quality of 30 ponds of Maanachil taluk of Kottayam district Kerala. The water quality index, Simpson's diversity index and species abundance values were calculated. Bradinopyga germinata and Trithemis festiva species were fresh water indicator species whereas Zyxomna petiolatum and Ceriagrion cerinorubellum were indicates the polluted water.

Seasonal variation of zooplanktons of pond at Lake Kollore region of Andhra Pradesh was assessed by Krishna and Kumar (2017). Zooplankton richness, evenness and diversity were observed. A total number of 16 species recorded with 9 rotifers, 3 cladocera and 4 copepods. In the rotifers genus Branchionus was the dominating group. Seasonal succession and role of temperature of zooplankton of Talpad pond and Jonu pond of Udhampur city studied by Devi (2017). Total 34 genera were identified belonging to 5 groups Protozoa (6 genera), Rotifera (12 genera), Copepoda (6 genera), Cladocera (6 genera) and Ostracoda (2 genera).

DV and HL (2017) studied the physico-chemical parameters of Nizam Sagar dam for fish production, phytoplankton and zooplankton. Water temperature, pH, total alkanity, dissolved oxygen and carbon dioxide were investigated. The pH shows alkaline trend in Nizam Sagar dam which is more suitable for fish culture.

Physico-chemical parameters and zooplankton diversity of a perennial lake, Dharampuri, Tamil Nadu assessed by Dhanasekaran *et al*. (2017). Total 29 zooplankton species were identified during the period of study among them 10 species of Rorifers, 8 species of Cladocera, 6 species of Copepoda and 5 species of Ostracoda. There is positive co-relation between physico-chemica parameters and zooplankton species. Abbai (2017) assessed the zooplankton diversity of Sogal pond in Belagavi district of north Karnataka. Total 16 species were identified belonging to 3 different groups 43% Rotifera, 36% Cladocera, and 21% of Copepoda. In winter season density of zooplanktons were high and low during summer. Diversity of zooplankton in municipal waste water contaminated urban pond of the lower gangetic plains were studied by Adhikari *et al*. (2017). 22 species of zooplankton were identified ,14 species of Rotifera, 3 species of copepoda, 4 species of Cladocera and single species of Ostracods , which suggest that municipal waste water loaded with various nutrients has influenced the zooplankton diversity and abundance.

Conclusion

On the basis of above review it can be concluded that inspite of the fact that a lot of work has been done on limnology of lotic and lentic water resources, much is to done in changing scenario of environment and climatic condition. Climate change is a distasteful truth of over time it has impact on various components of nature including natural lentic water bodies. This demands serious investigation with fresh approaches and new technologies.

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