Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 1534-1543 | ISSN:2251-6727

# Seasonal Influences on Zooplankton Diversity of A Sacred Grove Freshwater

**Venkatalakshmi. S[1*], Karpagam. R[2]**

[1*]Associate Professor, Department of Zoology, Government College for Women (Autonomous), Kumbakonam, Thanjavur (Dt), Tamilnadu, India – 612001.
[2]Research Scholar, Department of Zoology, Government College for Women (Autonomous), Kumbakonam, Thanjavur (Dt), Tamilnadu, India – 612001.
(Affiliated to Bharathidasan University, Tiruchirapalli, Tamilnadu, India)

**[*]Corresponding Author: Venkatalakshmi . S**

**(Received: 02 September 2023 Revised: 14 October Accepted: 07 November)**

**Keywords:**

Zooplankton, Diversity indices, Pond ecosystem, Cladocera, seasonal influence

**Abstract**

Zooplankton, the ecological indicator of aquatic ecosystems, was identified in Banapureeshwar temple pond (BTP) at Kumbakonam, Thanjavur district, Tamilnadu, India, from March 2018 to February 2019 to enumerate the seasonal variations in the population density of zooplankton. The study observed a total of 35 zooplankton species, of which 13 were copepods. Cladocera and rotifera comprised 8 and 11 species, respectively. The ostracoda accommodated 3 species. Shanon-Weiner diversity index (H´) (1.13 to 2.606) and Margalef's species richness index (0.7797 to 3.1) indicate moderately rich zooplankton diversity in the BTP lentic ecosystem. Among the different groups of zooplankton identified, copepoda were found to be the dominant group (45.7%), followed by rotifers (25.7%), cladocera (23.2%), and ostracoda (5.5%). The mean seasonal abundance of zooplankton was in the order of monsoon > pre-monsoon > post-monsoon > summer.

## Introduction

Till the 1980s, fish production in India was largely achieved by inland fisheries, which include both capture and culture fisheries. However, due to an increase in the number of water control structures and the degradation of natural water resources, capture fisheries have declined (Katia, 1999). Factors such as diminishing natural resources and the high cost involved in capture fishing have led to the search for a potential and cost-effective alternative to capture fisheries. Aquaculture emerged as a cost-effective alternative to capture fisheries during the last two decades and developed into a second major industry next to agriculture (Ayyappan, 2004). Globally, India ranks second, succeeding China in aquaculture. Aquaculture contributes about 44% of the global fish production (FAO, 2016) and provides approximately 50% of the fish consumed worldwide (Subasinghe et al., 2009). The fish production from inland fisheries in India was 65% during 2017–2018, out of which 50% was contributed by culture fisheries.

The major drawbacks in aquaculture are poor growth, low nutrient content, and a high rate of mortality in cultured fish. In order to overcome these issues, the larval fish are fed artificial diets. But these artificial diets are insufficient to satisfy the nutritional requirements of larval fish. Further, the underdeveloped digestive system of fish larvae, which lacks digestive enzymes, occludes their growth and development (Akbary et al., 2010). Hence, the supplementation of live feed enriched with essential nutrients is highly essential for the successful rearing of larval fish in aquaculture. Zooplankton is one such highly nutritious live feed for developing fish larvae (Koven et al., 2001). The abundance and species composition of zooplankton in aquatic environments are highly influenced by several physical, chemical, and biological factors (Bera et al., 2014). Apparently, the size of the water and water quality favour the existence of zooplanktons, as they are highly susceptible to temperature, pH, dissolved oxygen, total alkalinity and free $CO_2$. Thus, changes in the physicochemical composition of aquatic ecosystems influence the relative composition and abundance of zooplankton and hence can be used as a tool in monitoring aquatic ecosystems (Jose, 2015). The surveillance of zooplankton diversity, fecundity, size, structure, and community dynamics enumerates the extent of pollution in aquatic ecosystems (Mukhopadhyay, 2000).

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 1534-1543 | ISSN:2251-6727

Ponds represent freshwater ecosystems at a global scale (Downing, 2010) and play a major role in the conservation of biodiversity (Miracle et al., 2010; Oertli et al., 2010; De Meester et al., 2010). They are important biodiversity hotspots that harbour high numbers of local, rare and endemic species that are seldom found in other aquatic ecosystems. Pollution in this ecosystem has resulted in the accumulation of large amounts of discarded waste, which has harmed aquatic life. In this context, our study is focused on studying the species diversity of zooplanktons in the Banapureeshwar temple pond to determine the effect of seasonal variations, changes in physical and chemical factors of the pond ecosystem on the zooplankton species diversity and richness.

**Materials and methods**

**Study area**

The Banapureeshwar temple pond is located at 10°57′N latitude and 79°23′ longitude, was sampled in the present study (Fig.1). It was recently renovated in 2015 as part of an effort by the government to manage the freshwater ecosystem. The water level is constantly maintained by the municipality by filling it with water from external sources.

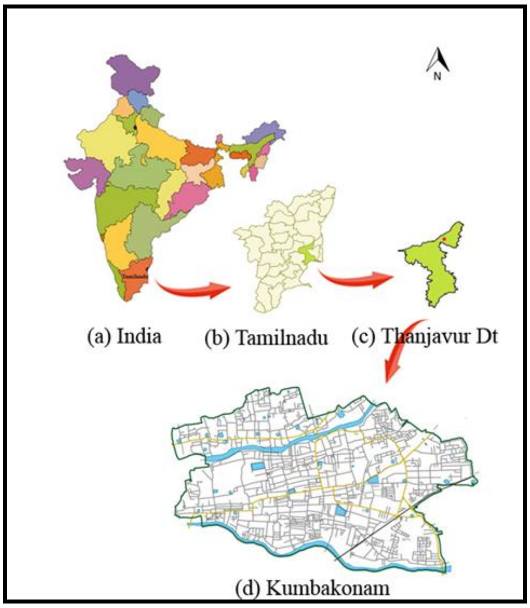


**Figure 1. Bird's eye view of study area**

**Sampling of zooplankton and water quality parameters**

Between March 2018 and February 2019, four sampling sites were chosen [BTP-North, BTP-South, BTP-East, and BTP-West] for monthly collection of zooplanktons and water quality analysis, and the results were interpreted seasonally as summer (March to May), pre-monsoon (June to August), monsoon (September to November), and post-monsoon (December to February) using Manickam et al. (2014) methodology. Water quality parameters such as temperature, pH, conductivity (EC), turbidity, salinity, dissolved oxygen (DO) and total dissolved solids (TDS) were determined in the laboratory following the standard protocol of APHA, 2005. Plankton samples were collected from the subsurface layer of Banapureeshwar temple pond in the early morning (6 a.m. to 7 a.m.) by towing method using Henson's standard plankton net (150 m mesh) in zigzag fashion horizontally at a depth of 50 to 100 cm (Davis, 1955) and preserved in 5% formalin. Zooplankton numbers were quantitatively estimated using Sedgwick Rafter counting cells.

**Identification of zooplanktons**

The planktonic biomass collected was segregated based on zooplankton groups under a binocular zoom dissection microscope with the help of a fine needle and brush. Individual species were stained with Eosin (Manickam et al., 2014) and observed using a trinocular microscope (Model BXL) attached to a USB camera (MIDCE-5C). Standard manuals, textbooks and monographs were referenced for the identification of different species of zooplankton (Sharma and Michael, 1987; Murugan et al., 1998; Altaff, 2004; Edmonson, 1959; Battish, 1992 and Reddy, 1994) using a compound microscope.

**Biodiversity indices and statistical analysis**

The seasonal variations of physicochemical variables of water were determined using a one way ANOVA and Post Hoc Turkey Test. The intra and inter-relationships between physicochemical parameters and zooplankton biodiversity indices were subjected to Pearson's correlation analysis using IBM-SPSS (v.25.0). The species diversity, richness, evenness and dominance

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 1534-1543 | ISSN:2251-6727

indices were calculated using Shanon-Weiner's (1949) index, Margalef's (1958) richness index, Pielou's (1966) evenness index and Dominance index with Paleontological Statistical software (PAST).

## Result and Discussion

### Seasonal variations in the physical and chemical parameters of freshwater ecosystem

The hydrology of a freshwater pond ecosystem highly influences the species composition and distribution pattern of planktonic organisms (Mahar, Baloch & Lafri, 2000). Especially, environmental factors such as temperature and physicochemical parameters such as pH, DO, salinity, conductivity, turbidity and TDS play a vital role in the development of phytoplanktons, which are essential for the existence of zooplankton. Table 1 presents the variations in the physico-chemical parameters of water during different seasons at BTP. The influence of seasonal variations on the physicochemical properties of BTP exhibited a significant effect on the species composition, diversity, richness, evenness and dominance of the zooplankton community. The water temperature in summer was 30.03±1.91ºC, while the post-monsoon season exhibited a minimum temperature of 28.11±2.02ºC. The increase in temperature during the summer season as observed in this study might be due to the increased length of the day and the concomitant increase in solar radiation (Das et al., 1997; Senthil Kumar et al., 2002; Santhanam and Perumal, 2003). Water temperatures between 13.5 and 32ºC are ideal for the growth of zooplankton (Kamat, 2000; Gaikwad, 2008). Temperature is the most important factor that influences the pH, salinity, conductivity, and solubility of gases in water. Further, they also trigger the dominance of small zooplankton (Singh et al., 1990; Manickam et al., 2018; Bhavan et al., 2015; Manickam et al., 2015 and 2017).

**Table: 1 Seasonal variation of physicochemical parameters of BTP**

| Water Quality variables / Season | Summer | Pre-monsoon | Monsoon | Post-monsoon | F-Value |
|---|---|---|---|---|---|
| Temperature (ºC) | 30.03±1.91$^{a}$ | 28.78±1.11 $^{ab}$ | 28.67±1.31 $^{a}$ | 28.11±2.02 $^{b}$ | 2.923* |
| pH | 7.15±0.01 $^{c}$ | 7.34±0.03 $^{b}$ | 7.74±0.14 $^{a}$ | 7.74±0.28 $^{a}$ | 74.843* |
| Dissolved Oxygen (mg $l^{-1}$) | 3.22±0.08 $^{ab}$ | 3.23±0.07 $^{a}$ | 3.24±0.04 $^{b}$ | 3.28±0.03 $^{b}$ | 4.23* |
| Salinity (ppt) | 0.80±0.03 $^{a}$ | 0.66±0.15 $^{b}$ | 0.65±0.12 $^{bc}$ | 0.76±0.06 $^{a}$ | 6.989* |
| Conductivity(µS/cm) | 14.75±0.02 $^{b}$ | 35.87±0.02 $^{b}$ | 25.67±0.02 $^{a\,b}$ | 15.39±0.02 $^{a}$ | 7.973* |
| Turbidity (NTU) | 1.64±0.99 $^{c}$ | 1.63±12.44 $^{a}$ | 1.65±9.88 $^{b}$ | 1.67±2.81 | 18.28* |
| Total Dissolved Solids (g $l^{-1}$ ) | 0.88±0.01 $^{a}$ | 1.00±0.03 $^{ab}$ | 1.03±0.06 $^{a}$ | 0.97±0.08 $^{c}$ | 22.637* |

n=3, mean ±SD. Different superscripts denote significant difference at $p < 0.001$. * Significant variation among groups at $p < 0.05$

High pH was observed during the monsoon and post monsoon (7.740±0.14 and 7.74±0.28 respectively), whereas minimum pH (7.15±0.01) was observed during the months of summer. Temperature, anthropogenic activities, and the increased rate of photosynthesis by phytoplanktons all influence the pH of water. Kurbatova (2005) stated that pH above 8.5 is considered highly productive with respect to zooplankton. The pH of BTP was found to be in the range of 7.15 to 7.74, and pH was found to be low during the summer season, with a gradual increase in pH with the progression of the monsoon was evidenced. The rise in the pH of the freshwater ecosystem was due to the decomposition of plants and organic materials (Gogoi, 2019) and because of the low temperature during the monsoon period (Pandey et al., 1993). Sharma et al., (2013) reported high pH during monsoon seasons (winter) in Birpur temple pond, which was in agreement with the present findings.

Dissolved oxygen in freshwater depends on multiple environmental factors such as temperature, salinity, air pressure and photosynthetic activity. Low temperatures increase the solubility of oxygen. Thus, in this study, a high level of DO (3.280.03 mg $l^{-1}$) was found during the post-monsoon season and a low level of DO (3.220.08 mg $l^{-1}$) during the summer. This low DO during summer might be attributed to the decomposition of organic matter and the respiration of planktonic organisms. High DO in aquatic ecosystems is an index of water quality and high productivity. Aquatic organisms are highly sensitive to salinity and an increase in the salinity of water reduces the population density and diversity of zooplankton (Dhanasekaran et al., 2017). The salinity of BTP was found to be highest during the summer (0.80±0.03 ppt) and lowest 0.65±0.12 ppt ) during the monsoon months. The increased level of salinity during the summer and post monsoon was influenced by the rise in water temperature. Water evaporating at high temperatures was the cause of salinity (Bhavan et al., 2017).

TDS and EC in aquatic ecosystems increase due to anthropogenic activities and the inflow of pollutants, leading to contaminated water (Choudhary et al., 2014; Verma et al., 2012 ; Kadam, 1990; Trivedy and Goel, 1984). BTP recorded high TDS (1.03 NTU) and low TDS (0.88 NTU) during the monsoon and summer,

respectively. The mean TDS value of BTP was much higher than the standards proposed by WHO, indicating that the BTP was polluted because of anthropogenic activities such as worship practices by devotees. The inflow of freshwater during the monsoon might be responsible for low EC at BTP. High turbidity in BTP during the monsoon months might have resulted because of the inflow of slit-laden water (Perumal et al., 2009; Gogoi et al., 2019). The one-way ANOVA (post hoc turkey test) revealed significant differences ($p<0.05$) in all of the water variables tested across seasons.

**Diversity and distribution of zooplanktons**

The zooplanktons are ecological indicators that aid in monitoring pollution, chemical, physical and biological conditions of the freshwater ecosystem. Several previous studies documented the presence and distribution pattern of zooplankton groups such as copepods, cladocera, rotifera, and ostracods in freshwater pond ecosystems (Karmakar et al., 2021; Krishna and Hemanth Kumar, 2017; Devi et al., 2013).

**Table 2: Seasonal variations in Zooplankton profile of BTP (2018-2019)**

| Taxa | Zooplanktons | Summer | Pre monsoon | Monsoon | Post monsoon |
|---|---|---|---|---|---|
| **Copepoda** | *Sinodiaptomus sarsi* | + | ++ | ++ | ++ |
| | *Mesocyclops leuckarti* | + | ++ | ++ | ++ |
| | *Thermocyclops hyalinus* | + | ++ | ++ | + |
| | *Eucyclops speratus* | + | ++ | ++ | ++ |
| | *Macrocyclops hyalinus* | + | + | ++ | + |
| | *Mesocyclops pehpiensis* | + | ++ | ++ | + |
| | *Sinodiaptomus indicus* | + | + | ++ | ++ |
| | *Cyclopes bicuspidatus* | + | ++ | ++ | ++ |
| | *Cyclopes thomasi* | + | ++ | ++ | + |
| | *Helicyclopes* | + | ++ | + | + |
| | *Sinodiaptomus vidus* | + | ++ | ++ | + |
| | *Thermocyclops decipiens* | + | + | ++ | + |
| | *Thermocyclops phepiensis* | + | + | ++ | ++ |
| **Cladocera** | *Diaphanosoma brachyurum* | ++ | + | ++ | + |
| | *Moina micrura* | + | + | ++ | + |
| | *Ceriodaphania corunuta* | + | + | ++ | + |
| | *Leydigia leydigia* | + | + | ++ | + |
| | *Daphnia magna* | + | + | + | + |
| | *Diaphnasoma sarsi* | + | + | ++ | + |
| | *Diaphnasoma exisum* | ++ | ++ | ++ | + |
| | *Ceriodaphania reticulata* | ++ | + | ++ | + |
| **Rotifera** | *Branchionus rubens* | ++ | - | + | + |
| | *Asplanchana intermedia* | + | + | + | ++ |
| | *Asplanchana brightwelli* | + | + | + | + |
| | *Branchionus calyciflorus* | + | + | + | + |
| | *Branchionus rotundiformis* | + | + | + | + |
| | *Branchionus caudatus personatus* | + | + | + | + |
| | *Branchionus angulais* | + | + | ++ | + |
| | *Branchionus diversicornis* | + | + | ++ | ++ |
| | *Branchionus plicatilis* | + | + | + | ++ |
| | *Branchionus falcatus* | + | + | + | + |
| | *Keratella cochlearis* | ++ | + | ++ | + |
| **Ostracoda** | *Cypris protubera* | ++ | ++ | + | + |
| | *Euecypris bispinosa* | + | + | + | + |
| | *Cyprinotus nudus* | + | + | + | + |

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 1534-1543 | ISSN:2251-6727

The identification of zooplankton species at BTP revealed a total of 35 species belonging to 4 different groups, namely Copepoda, Cladocera, Rotifera, and Ostracoda. Copepoda dominated the zooplankton species (13 species) followed by rotifers (11 species), Cladocera (8 species) and ostracoda (3 species) (Table 2). The percentage of different classes of zooplanktons observed in BTP was copeopods (45.7%), cladocera (16.6%), rotifers (25.7%) and ostracoda (12%) (Fig.2A). The mean seasonal abundance of zooplanktons were in the order of monsoon > premonsoon > postmonsoon > summer (Fig.2B).

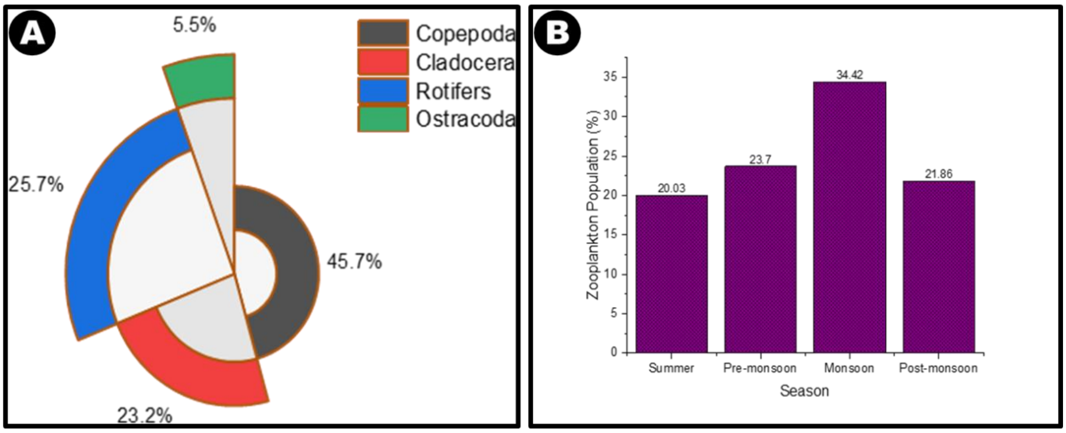


**Figure 2. A) Percentage of Zooplankton population at BTP during 2018-2019; B) Seasonal variations in Zooplankton population at BTP during 2018-2019**

In BTP, 13 species copepods dominated the zooplankton species (Fig.3), which indicates the abundance of diatoms and blue-green algae. These phytoplanktons form the basic and important food source for copepods (Lewis, 1978). Among the copepods, *Sinadiaptomus indus* was found to be the dominant species in BTP. The most commonly found copepods in South India were *Sinadiaptomus indus* (Dharani and Altaff, 2002). Cladocera recorded 8 species (Fig.3). The population of cladocera was high during monsoon season. *Daphnia magna, Moina micrura, Ceriodaphania corunuta, Leydigia leydigia* and *Diaphnasoma sarsi* reported low population density among cladocera during summer. BTP showed the presence of 8 species of *Branchionus* out of the 12 identified species of Rotifera (Fig.3), with the maximum population observed during the monsoon season. A study by Tidame and Shinde, (2012) indicated the dominance of *Branchionus* species in the temple pond at Nasik. Ostracoda was the least dominant group found in BTP (Fig.3). *Cypris protubera*, *Euecypris bispinosa* and *Cyprinotus nudus* were the only species recorded in BTP. *Cypris protubera* dominated the ostracoda population during summer and premonsoon. The maximum zooplankton population in summer and the lowest population in winter in BTP were consistent with the findings of Yadav and Singh (2018) at Chapakaiya Pond and Krishna and Kumar (2017) in the Kollore region of Andhra Pradesh. The dominance of copepods followed by rotifers in temple ponds located in West Bengal was earlier documented by Banerjee et al., (2014). Further, the presence of Mesocyclops and Thermacyclops copepods indicates the eutrophication of water bodies (Bhavan et al., 2015).

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 1534-1543 | ISSN:2251-6727

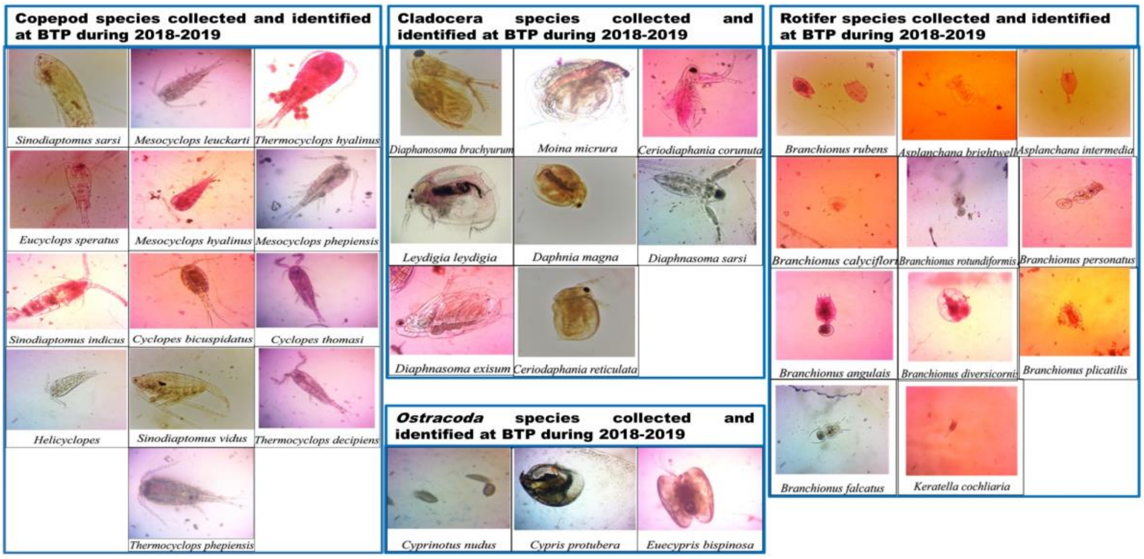


**Figure 3. Zooplanktons collected and identified at BTP during 2018-2019**

**Table 3: Inter and Intra relationship between physicochemical parameters of BTP water and population density of zooplanktons**

**Correlations**

| | Temperature | pH | DO | Salinity | Conductivity | Turbidity | TDS | Copepoda | Cladocera | Rotifers | Ostracoda |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | 1 | | | | | | | | | | |
| **pH** | -0.400 | 1 | | | | | | | | | |
| **DO** | 0.572 | -0.383 | 1 | | | | | | | | |
| **Salinity** | -0.316 | -0.125 | -0.347 | 1 | | | | | | | |
| **Conductivity** | -0.560 | 0.431 | **-.698*** | **.590*** | 1 | | | | | | |
| **Turbidity** | 0.183 | 0.085 | 0.534 | **-.890**** | **-.639*** | 1 | | | | | |
| **TDS** | -0.087 | **.676*** | 0.217 | -0.556 | -0.096 | **.598*** | 1 | | | | |
| **Copepoda** | -0.135 | 0.360 | 0.244 | -0.572 | -0.113 | **.652*** | **.725**** | 1 | | | |
| **Cladocera** | -0.350 | 0.252 | **-.594*** | -0.326 | 0.146 | 0.123 | 0.199 | 0.129 | 1 | | |
| **Rotifers** | 0.197 | 0.277 | 0.003 | -0.223 | 0.280 | 0.004 | 0.275 | 0.210 | 0.137 | 1 | |
| **Ostracoda** | 0.489 | -0.080 | 0.087 | -0.317 | -0.229 | 0.069 | -0.003 | -0.233 | 0.125 | -0.021 | 1 |

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

Cladocerans were one of the major groups of zooplanktons in BTP. The dominance of *Diaphanosoma*, *Daphnia*, *Ceriodaphania*, *Moina* species of cladocera indicate a high nutrient load of BTP since they are found to occur in high numbers under conditions of eutrophication (Hall, 1964; Kurasawa, 1975; Boucherle and Zullig, 1983 and Balakrishna et al., 2013). Similarly, *B.calyciflorus* (Rotifer), is considered a good indicator of eutrophication (Manickam et al., 2012; 2015; 2014 and Rajagopal et al., 2010) was found throughout the year in BTP.

The relationship between the population density of zooplanktons and physic-chemical parameters of BTP was analysed using Karl pearson's correlation matrix (Table.3) Temperature showed positive correlation with the population of rotifers (r=0.197) and ostracoda (r=0.489). pH was negatively correlated with ostracoda (r=-0.080). Similarly, DO was negatively associated with cladocera (r=-0.594). Rotifers (r=0.280) amd cladocera (r=0.146) showed positive association with conductivity. Turbidity was positively associated with all the identified classes of zooplanktons. Manickam et al., (2018) reported that pH and temperature were highly instrumental for the diversity of zooplankton in Ukkadam lake, Coimbatore. The positive correlation of water temperature with population density of ostracods (r = 0.340) was in agreement with the findings of Rajagopal et al., (2010) in the perennial ponds of Virudhunagar district, Tamilnadu, India.

The PCA biplot (Fig.4) clearly indicated that temperature was correlated with the population density of rotifers. The other physicochemical variables such as pH, salinity, conductivity, DO, TDS and turbidity were highly influential on the population density of cladocera and ostracoda during the monsoon, and turbidity was positively correlated with copepoda during the premonsoon. A similar positive correlation of temperature, pH, turbidity and TDS with zooplankton diversity and abundance was reported

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 1534-1543 | ISSN:2251-6727

earlier (Manickam et al., 2018; Rajagopal et al., 2010; Kurbatova, 2005).

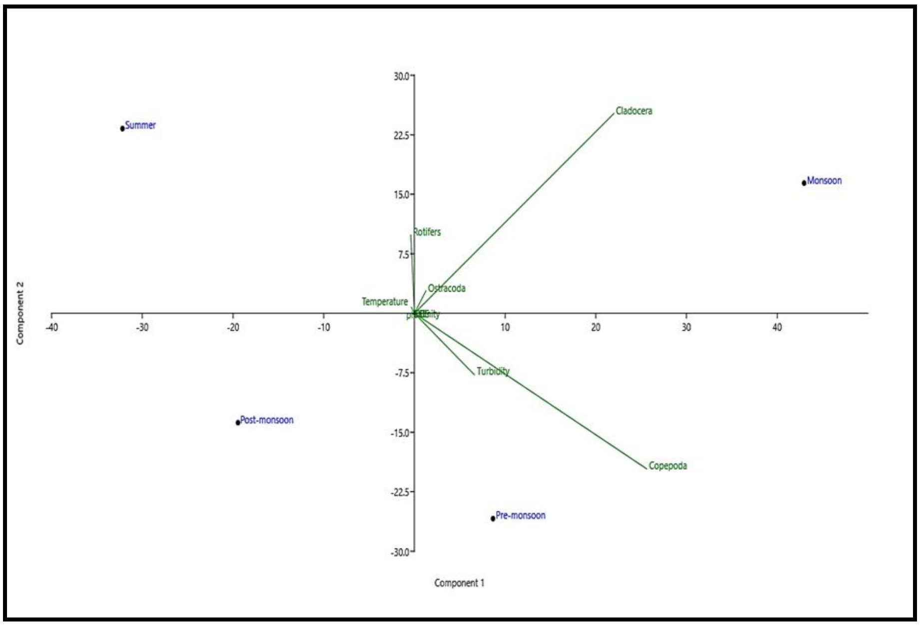


**Figure 4. PCA biplot drawn between physicochemical parameters and zooplankton species**

The measures of biodiversity indices are considered as indicators of ecological status (Cardoso et al., 2014). Devi et al., (2013) reported the biodiversity indices of zooplankton species in the Birpur temple pond, with the Shanon-Weiner diversity index ranging from 0.39-2.98, Margalef's species richness index between 2.92 to 2.96, an evenness index in the range of 0.89 to 0.91 and a dominance index of 0.86 to 0.88. In the present work, the Shannon diversity index ranged from 1.095 to 2.606; evenness was in the range of 0.8371 to 1.032; and the richness index was 0.7797 to 3.1 among the different seasons (Table.4). The current zooplankton data show a low diversity combined with high evenness and low richness. This could be due to a lower number of species diversity and a single species' dominance. But previous literature was in agreement with the present findings of low diversity and high evenness. A study by Manickam et al., (2018) in Ukkadam Lake, Coimbatore, Tamil Nadu, reported a Shannon diversity index in the range of 1.551 to 2.133 and evenness of almost 0.969. The richness index was between 0.7 and 1.217. Similarly, in a study conducted in three different ponds in Kumbakonam town, the richness index was in the range of 0.961 to 0.982, indicating moderate species richness (Praveena, 2020). Hence, it could be observed that the zooplankton showed a similar pattern of diversity indices in ponds located in Kumbakonam city. Gogoi et al., (2019) stated that the Shannon diversity index and Margalef's species richness index above 2.9 indicated moderately rich diversity, and Pielou's evenness index of > 0.98 indicated the even distribution. Based on this interpretation, it could be concluded that the diversity indices obtained from the present study revealed that BTP has moderate species diversity and is meso eutrophic in nature.

**Table : 4 Biodiversity indices of zooplankton species identified in BTP**

| Biodiversity Indices | Zooplankton Groups | Summer | Pre-monsoon | Monsoon | Post-monsoon |
|---|---|---|---|---|---|
| Shanon-Weiner Index (H) | Copepods | 2.55 | 2.597 | 2.606 | 2.59 |
| | Cladocera | 1.945 | 1.964 | 2.017 | 1.993 |
| | Rotifers | 2.406 | 2.332 | 2.395 | 2.393 |
| | Ostracoda | 1.095 | 1.13 | 1.17 | 1.222 |
| Evenness Index (E) | Copepods | 0.9851 | 1.033 | 1.042 | 1.025 |
| | Cladocera | 0.874 | 0.8371 | 0.8557 | 0.8421 |
| | Rotifers | 1.008 | 1.03 | 0.9976 | 0.9953 |
| | Ostracoda | 0.9961 | 1.032 | 1.074 | 1.131 |
| Margalef's Richness | Copepods | 3.1 | 2.58 | 2.55 | 2.70 |

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 1534-1543 | ISSN:2251-6727

| | | | | | | |
|---|---|---|---|---|---|---|
| Index (R1) | | | | | | |
| | Cladocera | 1.873 | | 2.002 | 1.584 | 2.377 |
| | Rotifers | 2.543 | | 2.574 | 2.484 | 2.480 |
| | Ostracoda | 0.8049 | | 0.8686 | 0.7797 | 1.028 |
| Dominance | Copepods | | 0.07801 | 0.07179 | 0.07043 | 0.09269 |
| | Cladocera | 0.1591 | | 0.1629 | 0.1443 | 0.1579 |
| | Rotifers | 0.08784 | | 0.0928 | 0.09091 | 0.09156 |
| | Ostracoda | 0.3333 | | 0.3111 | 0.2821 | 0.2381 |

**Conclusion**

The study clearly indicated that temperature, pH, TDS and turbidity played a major role in the zooplankton abundance and diversity in BTP. Further, the influence of pH was crucial for the high population density of zooplankton during monsoon and the pre-monsoon season. The decrease in zooplankton numbers during the summer season could be attributed to the prevailed high temperature. The study suggests continuous monitoring of pond ecosystems to predict the impact of climatic variations on the diversity and distribution pattern of the freshwater zooplankton community for the identification of sentinel and sensitive species in the process of formulating an effective conservation strategy.

**References**

1. Akbary PM, Imanpoor M, Sudagar & NM Makhdomi (2010). Comparison between live food and artificial diet on survival rate, growth and body chemical composition of *Oncorhynchus mykiss* larvae. Iranian Journal of Fisheries Sciences 9: 19-32.
2. Altaff K (2004). A Manual of Zooplankton. Department of Zoology, The New College, Chennai 19-145.
3. APHA (2005). Standard methods for the examination of water and wastewater 16th edition American Public Health association, Washington DC.
4. Ayyappan S & M Krishnan (2004). Fisheries sector in India: Dimensions of development. Indian Journal of Agricultural Economics 59:392-412.
5. Balakrishna DTR, Reddy KV Reddy, D Samatha (2013). Physico-chemical parameters and plankton diversity of Ghanpur lake, Warangal AP, India. International Journal of Zoological Research 3:44-48
6. Banerjee SR, Nur & S Barat (2014). Study on the zooplankton production in ponds under different fish farming system in West Bengal. Journal of Krishi Vigyan 3:79-83.
7. Battish SK, 1992. Freshwater Zooplankton of India. Oxford and IBH Publication, Co. Pvt. Ltd., Calcutta, India 6:233.
8. Bera A, TK Dutta BC, Patra & UK Sar (2014). Correlation study on zooplankton availability and physico-chemical parameters of Kangsabati Reservoir, West Bengal, India. International Research Journal of Environment Sciences 3: 28-32.
9. Bhavan PS, A Selvi, N Manickam, V Srinivasan, P Santhanam et al., (2015). Diversity of Zooplankton in a perennial Lake at Sulur, Coimbatore, India. International Journal of Environmental Research 5: 31-44.
10. Boucherle MM, H Zullig (1983). Cladoceran remains as evidence of change in the trophic state in three Swiss lakes. Hydrobiologia 103:141-146.
11. Cardoso SJ, F Roland, SM Loverde-Oliveira, VL de Moraes Huszar (2012). Phytoplankton abundance, biomass and diversity within and between Pantanal wetland habitats. Limnologica 42:235–241
12. Choudhary J, SN Singh, S Singh (2014). Physico-chemical and biological parameters of the three rural ponds of Sasaram of Bihar. International Journal of Applied Science and Biotechnology 2:206–210
13. Das J, SN Das, RK Sahoo (1997). Semidiurnal variation of some physico-chemical parameters in the Mahanadi estuary, East coast of India. Journal of Marine Science, 26:323–326
14. Davis CC (1955). The marine and freshwater plankton. Michigan State University Press, 562.
15. De Meester L & W Vyverman (2010). Biopool – Eurodiversity – Connectivity, dispersal and priority effects of drivers of biodiversity and ecosystem function in pond and pool communities. http://biobel.biodiversity.be/project/ show/3555.
16. Devi A & N Antal (2013). Variation in Phytoplankton Diversity and Its Relationship with Abiotic Environment of a Temple Pond in Birpur (J&K) India. Universal Journal of Environmental Research & Technology, 3: 181-189.
17. Dhanasekaran M, PS Bhavan, N Manickam, & R Kalpana (2017). Physico-chemical characteristics and zooplankton diversity in a perennial lake at Dharmapuri (Tamil Nadu, India). Journal of Entomology and Zoology Studies, 5: 285-292.
18. Dharani GK, Altaff (2002). Facultative sex reversal in the freshwater plankton *Sinodiaptomus*

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 1534-1543 | ISSN:2251-6727

(Rhinediaptomus) *indicus* Calanoida: Copepoda. Current Science, 82:794- 795.
19. Downing JA (2010). Emerging global role of small lakes and ponds: little things mean a lot. Limnetica 29: 9–24.
20. Edmondson WT (1959). Freshwater Biology. John Wiley and Sons Inc, New York 1248.
21. FAO 2016. Fishery and aquaculture stastistics 2014. Food and Agricultural Organisation, Rome, 204.
22. Gaikwad SR, KN Ingle, & SR Thorat (2008). Study of zooplankton emergence pattern and resting egg diversity of recently dried waterbodies in North Maharashtra Region. Journal of Environmental Biology, 29: 353 – 356.
23. Gogoi PA, SD Sinha, TN Sarkar, AK Chanu, SK Yadav, Koushlesh & BK Das (2019). Seasonal influence of physicochemical parameters on phytoplankton diversity and assemblage pattern in Kailash Khal, a tropical wetland, Sundarbans, India. Applied Water Science, 9:1-13.
24. Hall DJ (1964), An experimental approach to the dynamics of a natural population of *Daphnia galeata* mendotae. Ecology, 45:94-112.
25. Jose EC, EF Furio, VM Borja, NC Gatdula & MD Santos (2015). Zooplankton composition and abundance and its relationship with physico-chemical parameters in Manila Bay. Oceanography, 3:136. doi:10.4172/2332-2632.1000136
26. Kadam SD (1990). Environmental study of Lake Rankala, Jaynatinala and Lake Kotitirth from Kolhapur city.Environment and Ecology, 8:95-97
27. Kamat SV, 2000. Hydrobiological studies of two temple ponds in Ponda Taluk, Goa. Ecology, Environment and Conservation, 6: 361-362.
28. Karmakar S (2021). Phytoplankton and Zooplankton Diversity and Water Quality Assessment of Three Ponds in Hooghly District (West Bengal, India). Research Square, DOI: https://doi.org/10.21203/rs.3.rs-256542/v1
29. Katia PK (1999). Marketing and distribution of fish seed towards development of inland fisheries in India. Agricultural Economic Research Review, 12:15-23.
30. Koven WY, S Barr, I Lutzky, R Ben-Atia, M Weiss, A Harel & Tandler (2001). The effect of dietary arachidonic acid (20:4n–6) on growth, survival and resistance to handling stress in gilthead seabream *(Sparus aurata*) larvae. Aquaculture, 193:107–122.
31. Krishna PV, & K Hemanth (2017). Seasonal Variations of Zooplankton Community in Selected Ponds at Lake Kolleru Region of Andhra Pradesh, India. International Journal of Current Microbiology and Applied Sciences, 6: 2962-2970.
32. Kurasawa H (1975). Productivity of Communities in Japanese Inland Waters, Part 9, Zooplankton. JIBP. In: Mon S, Yamamoto S. (Eds.). University Press, Tokyo, 10:1-436.
33. Kurbatova, SA (2005). Response of microcosm zooplankton to acidification. Biology Bulletin, 32: 85-92.
34. Lal Babu Prasad Yadav (2018). Studies of Zooplankton in Chhapakaiya pond Birgunj, Nepal. International Journal of Graduate Research and Review, 4: 103 – 109.
35. Lewis Jr WM (1978). Comparison of temporal and spatial variation in the zooplankton of a lake by means of variance components. Ecology, 59:666-671
36. Mahar MA, WA. Baloch & SIH Jafri (2000). Diversity and seasonal occurrence of planktonic rotifers in Manchharlake, Sindh, Pakistan. Pakistan Journal of Fisheries, 1: 25–32.
37. Manickam N, PS Bhavan, P Santhanam, P Chitrarasu, A Jawahar Ali, (2012). Zooplankton diversity in a perennial freshwater lake. In: Desai PV, Roy R. (Eds.). Diversity and Physiological Processes, Goa University, Goa, India. 1: 25-37.
38. Manickam N, PS Bhavan, P Santhanam, T Muralisankar, V Srinivasan, K Vijayadevan, & R. Bhuvaneswari (2015). Biodiversity of freshwater zooplankton and physico-chemical parameters of Barur Lake, Krishnagiri District, Tamil Nadu, India. Malaya. Journal of Biosciences, 2:1–12.
39. Manickam N, P. Bhavan, P Santhanam, T Muralisankar, V Srinivasan, S Radhakrishnan et al. (2014). Seasonal variations of zooplankton diversity in a perennial reservoir at Thoppaiyar, Dharmapuri District, South India. Journal of Aquaculture & Marine Biology, 1: 1–7.
40. Manickam N, PS Bhavan, P Santhanam (2017). Evaluation of nutritional profiles of wild mixed zooplankton in Sulur and Ukkadam Lakes of Coimbatore, South India. Turkish Journal of Fisheries and Aquatic Sciences, 17: 509–517.
41. Manickam N, Bhavan P S, Santhanam P, Bhuvaneswari R, Muralisankar T, Srinivasan, V& Karthik M. (2018). Impact of seasonal changes in zooplankton biodiversity in Ukkadam Lake, Coimbatore, Tamil Nadu, India, and potential future implications of climate change. *The Journal of Basic and Applied Zoology*, *79*(1), 1-10.
42. Margalef R (1956) Information and diversity specifies the communities of organisms. Invest Pesg. 3:99-106.
43. Miracle MR, B Oertli, R Ce´re´ghino & A Hull, (2010). Pond conservation from science to practice: 3rd European Pond Workshop. Limnetica 29: 1–181.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2023) 13(4), 1534-1543 | ISSN:2251-6727


44. Mukhopadhyay SK, Chatterjee A, Gupta R & Chattopadhyay B (2000). Rotiferan Community Structure in a Tannery Effluent Stabilisation Pond in East Calcutta Wetland Ecosystem. Chemical and Environmental Research, *9*(1/2), 85-91.
45. Murugan, NP Murugavel, MS.Kodarkar (1998). Cladocera: The Biology, Classification, Identification and Ecology. *Indian Association of Aquatic Biologists* (IAAB), Hyderabad, India, 5:1-55
46. Oertli B, R Cereghino, J Biggs, S Declerck, A Hull, & MR. Miracle, (2010). Pond conservation in Europe. Developments in Hydrobiology, 210. Springer, Dordrecht
47. Pandey BN, AK Mishra, PKL Das, & AK Jha (1993). Physico-chemical characteristics of swamps of Libri river, Purnia (Bihar).Acta Ecologica sinica, 15: 98-102.
48. Perumal NV, M Rajkumar, P Perumal, KT Rajasegar (2009). Seasonal variations of plankton diversity in the Kaduviar estuary, Nagapattinam, southeast coast of India. Journal of Environmental Biology, 30:1035–1046
49. Pielou EC (1966). The measurement of diversity in different types of biological collections. Journal of theoretical biology, 13, 131-144.
50. Rajagopal T, A Thangamani & G Archunan (2010). Comparison of physico-chemical parameters and phytoplankton species diversity of two perennial ponds in Sattur area, Tamil Nadu. Journal of Environmental Biology, 31:787.
51. Reddy YR (1994). Copepoda, Calanoida, Diaptomidae. Guides to the Identification of the Macro Invertebrates of the Continental Waters of the World, SPB Academic Publishing, 221.
52. Santhanam P, P Perumal (2003). Diversity of zooplankton in Parangipettai coastal waters, Southeast coast of India. Journal of the Marine Biological Association of India, 45:144–151.
53. Senthilkumar S, P Santhanam, P Perumal (2002). Diversity of phytoplankton in Vellar estuary, southeast coast of India. In: Ayyappan S, Jena JK, Mohan JM (eds) Proceedings of 5th Indian fisheries forum, AFSIB, Mangalore & AeA, Bhubaneswar, India, 245–248
54. Shannon CE, W Weiner (1949). The mathematical theory of communication. University of Illinois, Illinois, 125.
55. Sharma BK, & RG Michael (1987). Review of taxonomic studies on freshwater Cladocera from India with remarks on biogeography. Hydrobiologia, 145: 29–33.
56. Sharma KK, A Devi, A Sharma & N Antal (2013). Zooplankton diversity and physico-chemical conditions of a temple Pond in Birpur (J&K, India). International Research Journal of Environment Sciences, 2: 25-30.
57. Simpson EH (1949). Measurement of diversity. Nature, 163:688
58. Singh CS, AP Sharma, BP Deorani (1990). Limnological studies for bioenergetic transformation in a Tarai reservoir, Nanak Sagar (UP). In: Singh HR. (Ed.). Advances in Limnology, 356-362
59. Subasinghe R, D Soto, & J Jia (2009). Global aquaculture and its role in sustainable development. Reviews in Aquaculture, 1: 2-9.
60. Tidame SK & SS Shinde (2012). Studies on seasonal variations in physico-chemical parameters of the Temple pond Nashik District (MS), India. International Multidisciplinary Research Journal, 2(5).
61. Trivedy RK, PK Goel (1984). Chemical and Biological Methods for Water Pollution Studies. Environmental Publications, Karad, India, 1-215.
62. Verma PU, AR Purohit, NJ Pate (2012). Pollution status of Chandlodia lake located in Ahmedabad Gujarat. International Journal of Engineering Research and Applications, 2:1600–1606
63. Yadav LBP & Singh A (2017). Study of Zooplankton Diversity of Chhapakaiya Pond Birgunj, Nepal. Int. J. Life Sci. Scienti. Res, 3(2), 925-931.