# Synopsis

## Hydrobiological Studies on Reservoirs (Wetlands) of Western Khandesh (M.S.) with respect to selected Biodiversity.

### Introduction

The biosphere includes various ecosystems which in turn support diverse forms of living organisms, the biodiversity. In aquatic ecosystems, the density and diversity of these organisms depends on availability and quality of water. Water is the essence of life on the earth and it totally dominates the chemical composition of all organisms (Wetzel, 2001). The ubiquity of water in biota, as the fulcrum of the biochemical metabolism, results in its unique physical and chemical properties. The basic feature of the earth is an abundance of water as over 71 % of the earth is surrounded by it. Of the total water found on earth, 97.47 % deposited in the ocean, seas, lakes and rivers, the most important fresh water resources account for merely 2.53 %. Thus, the amount of fresh water on the earth is very small compared to seawater, of which 69.6 % is locked away in continental ice, 30.1 % in underground aquifers and only 0.26 % in rivers and lakes.

As per WWDE report (2018) the increase in population growth rate has simultaneous increased global demand for water by 1% per year. This is expected to continuously grow significantly over the coming decades mainly in the countries with developing or emerging economies. Thousands of water bodies are constructed to meet these demands. This has benefitted other organisms and at many water bodies unique aquatic ecosystems have been created. However, in long run many of these systems are also facing threats due to excessive drainage as well as pollution.

The aquatic ecosystem includes oceans, bays, rivers, streams, ponds, lakes, swamps, marshes and also the manmade structures like irrigation reservoirs, barrages on the rivers, lakes, ponds, etc. with their associated organisms which have evolved and adapted to aquatic habitats over millions of years. Many of these organisms occupy the zone between land and water known as Wetland. The IUCN defined wetlands very broadly for the purpose of the Ramsar Convention on Wetlands of International Importance (IUCN, 1971) as “Wetlands are areas of marsh, fen, peat land or water, whether, natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water the depth of which at low tide does not exceed six meters". Cowardin *et al*. (1979), on the other hand, used detailed scientific criteria to define wetlands in United State as: 'Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water'.

IUCN (1971) describes Wetlands and lakes as essential components of human civilization; meeting many crucial needs for life on earth such as drinking water, fish and shellfish production, water quality improvement, sediment retention, aquifer recharge, flood control, transport, recreation, climate stabilizers, etc.

**Threats to Wetlands**

Globally, wetlands are degrading rapidly at a rate, which is undesirable. Despite the governments acceptance of the fact that these invaluable natural resources need to be conserved, wetland loss and degradation continue unabated. Wetlands have been lost and degraded in many ways that are not as obvious as direct physical destruction or degradation. This can be due to conversion of wetland to non-wetland areas or impairment of wetland functions. Other major problems include the hydrological manipulations and diversions, disposal of degraded or fill material, sewage inflows, encroachment for developmental activities and construction of dykes or levees impacting wetland quality, species composition and functions. The largest threats today, however, are in the developing world where uncoupling of the traditional linkages between human communities and ecosystem functioning are likely to result in irretrievable losses.

Wetlands are one of the most threatened habitats of the world. Wetlands in India, as elsewhere, are increasingly facing several anthropogenic pressures. Thus, rapidly expanding human population, large scale changes in land use/land covers, burgeoning developmental projects and improper use of watersheds have all caused a substantial decline of wetland resources in the country (Prasad *et al*., 2002).

**Conservation of Wetlands**

Gradually rising awareness and appreciation of wetland values and importance in the recent past have paved way to the signing of many agreements of which Ramsar Convention signed in Iran in 1971 is the most important Wetland Conservation Treaty that has indirectly influenced by an array of policies and legislative measures. The Convention on Wetlands is an intergovernmental treaty adopted on 2nd February 1971 in the Iranian city of Ramsar. Over the years, the Convention has broadened its scope to cover all aspects of wetland conservation and wise use, recognizing wetlands as ecosystems that are extremely important for biodiversity conservation in general and for the well being of human communities.

**Need for Ecosystem Quality Assessment of Water bodies**

The restoration, conservation and management of these water resources require a thorough understanding of what constitutes a healthy ecosystem. Monitoring and assessment provide basic information on the condition of our water bodies (US EPA, 2002).

**Objectives**

- To study ecological status of the identified reservoirs in Western Khandesh (M.S.)
- To find out quality of water by studding its physicochemical parameters and their seasonal variations and correlations within physicochemical parameters.
- To document aquatic biodiversity like phytoplankton, zooplankton and molluscs of wetlands (MD, BR and KP) with respect to their density and species richness and its seasonal variations.
- To document correlations between physicochemical parameters and biotic parameters (Phytoplankton, Zooplankton and Molluscs).
- To suggest the priorities of sustainable use and developing sustainable ecotourism

**Study area**. Three manmade water bodies of northern Maharashtra called Khandesh in Districts Dhule and Nandurbar. The Reservoirs selected for present study are located between 21$^{o}$16’ to 21$^{o}$26’ latitude and 74$^{o}$17’ to 74$^{o}$33’ longitude. The reservoirs are :

(1) Malpur dam (Amravati) (21$^{o}$ 16’43” N, 74$^{o}$ 29’40” E ; 212 AMSL)

(2) Baldane reservoir (21$^{o}$ 21’28” N, 74$^{o}$ 27’50” E ; 175 AMSL)

(3) Krishna Park reservoir (21$^{o}$ 20’41” N, 74$^{o}$ 17’49” E, 263 AMSL).

**Materials and methods**.

**a. Physico-chemical parameters:** Atmospheric as well as water temperatures, Carbon dioxide ($CO_2$), dissolved oxygen (DO), transparency of water and water cover were measured in the field itself. For other physico-chemical parameters such as TS, TDS, TSS, pH, Chloride, Total hardness, Chloride, Calcium, Magnesium, Nitrate, and

Phosphates the water samples were collected in separate sample bottles from three stations at each water bodies and carried to the laboratory for further analysis. Standard methods of analysis were used as per APHA (1998) and Michael (1984).

**b. Plankton**

**Phytoplankton and Zooplankton**

**Plankton:** Ten litres of water was filtered using a plankton net No.25 of bolting silk with mesh size 64µm and concentrated to 100ml and preserved in separate vials by adding 1ml of 4% formalin. 1ml of Lugol`s iodine was added to it for further qualitative and quantitative studies. Qualitative study of phytoplankton and zooplankton were carried out with the help of keys given by Edmonson (1963), Sarode and Kamat (1984) and Battish (1992).

**c. Molluscs:** Soil samples were collected using a unit cover, with 10 cm height and 8cm radius, inserted at each field location. These sediments containing molluscs and other macroinvertebrates were analysed as described by Michael, (1984); Dillon and Robert (2004); Tronstad *et al*., (2005). Identification of the molluscs is based on keys provided by SubbaRao (1989) and Tripathy and Mukhopadhyay (2015). The density of molluscs is calculated as numbers per meter cube ($m^3$).

**Stastical Analysis:** To study seasonal variations three seasons were considered Winter (October, November, December and January), Summer (February, March, April and May) and Monsoon (June, July and August, September). The data was subjected to ANOVA across the season with the help of Prism 3 software (Graphpad software, San Diego, California U.S.A.).

## Results

### Physico-chemical parameters

*Temperature*: During the study period, water temperature as well as atmospheric temperature, showed significant seasonal variations, with maximum temperature recorded in summer and minimum in winter months at all the three reservoirs at all three wetlands (Malpur Dam, Baldane Reservoir and Krishna Park) studied.

*Water cover*: In this monsoon deficit area of Maharashtra at all the three reservoirs minimum water cover was recorded in summer while maximum in monsoon.

*Total solids*: It includes total dissolved solids (TDS) and total suspended solids (TSS) which showed significant seasonal variations, with maximum level in monsoon and minimum in winter at the three reservoirs. TDS were recorded maximum in summer, while it was minimum in winter. TSS was recorded maximum in monsoon, while it was minimum in winter.

*Transparency*: It is important parameter which influences photosynthesis. Transparency also showed parallel significant seasonal variations at the three reservoirs with maximum in winter and minimum in monsoon, while moderate in summer.

*Water cover*: In this monsoon deficit area of Maharashtra at all the three reservoirs minimum water cover was recorded in summer while maximum in monsoon.

*Chemical parameters*:

*pH*: The pH of the water remained alkaline throughout the study period in the three reservoirs with maximum pH in summer and minimum in monsoon ranging between 7.20 and 8.18.

*Free* $CO_2$: Maximum values of $CO_2$ were recorded in summer while minimum in the months of winter at all the three reservoirs.

*Dissolved oxygen* (DO): At all the three reservoirs, maximum values of dissolved oxygen were recorded in winter while minimum in summer.

*Total hardness*: Total hardness values were recorded maximum at all the three reservoirs in summer and minimum in monsoon.

Calcium**:** Maximum calcium values were recorded in summer while minimum in monsoon.

*Magnesium:* Magnesium values were recorded maximum in summer while minimum in monsoon at all the three reservoirs.

*Chloride*: Maximum values of Chloride were recorded in summer while it remained minimum in monsoon at Malpur Dam and Baldane reservoirs. While it was recorded minimum in winter at Krishna Park.

*Nitrate* ($NO_3^-$): The nitrate values were recorded maximum in monsoon and minimum in winter.

*Phosphate* ($PO_4^{-3}$): At all the three reservoirs phosphates showed maximum values in monsoon and minimum in summer at Malpur Dam and Baldane reservoirs.

*Sulphate* ($SO_4^{-2}$): It also shows seasonal variations, with maximum values of sulphates in summer and minimum in monsoon at all the three reservoirs selected for the study.

**Phytoplanktons**

During the two year study period total 42 genera and 78 (14+22+36+6) species of phytoplankton belonging to four taxonomic groups i.e. Cyanophyceae (Blue green algae), Chlorophyceae (green algae), Bacillariophyceae (Diatoms) and Euglenophyta were recorded at all the three water bodies, Malpur dam, Baldane reservoir and Krishna park.

**Phytoplankton of Malpur Dam:** Total 66 species of phytoplanktons were recorded during the study period at Malpur dam, of which 31 species belong to Bacillariophyceae, 19 to Chlorophyceae, 12 to Cyanophyceae and 04 to Euglenophyta.

The density sequence of various groups of phytoplankton was noted in decreasing order as Bacillariophyceae > Chlorophyceae> Cyanophyceae> Euglenophyta. When seasonal variations were considered of Cyanophyceae and chlorophyceae, their densities were recorded maximum in winter, while minimum in monsoon.

The total phytoplankton species richness, administered significant seasonal variation at P>0.0001 ($F_{2\ 21}$ 63.10). Maximum species richness of total phytoplankton was recorded in summer, while minimum in monsoon. The percentage species richness of these four groups of phytoplankton exhibited decreasing order as Bacillariophyceae (51.01%), Chlorophyceae (23.98%), Cyanophyceae (18.1%) and Euglenophyta (6.21%).

The Bacillariophyceae appeared to be most dominant group among all phytoplanktons and was maximum in summer while minimum in monsoon, quantitatively as well as qualitatively. Euglenophyta is the least represented group which showed maximum species richness in monsoon and minimum in winter.

**Phytoplankton of Baldane Reservoir:** The total phytoplankton density at Baldane Reservoir, administered significant seasonal variation (P>0.0001, $F_{2\ 21}$ 47.21). When seasonal variations were consider of Cyanophyceae and chlorophyceae, their densities were recorded maximum in winter, while minimum in monsoon.

At Baldane out of total 61 species of phytoplanktons recorded 30 species belonged to Bacillariophyceae, 17 to Chlorophyceae, 11 to Cyanophyceae and only 03 to Euglenophyta. The percentage species richness of these four groups is recorded Bacillariophyceae (50), Chlorophyceae (23.3%), Cyanophyceae (21.3%) and Euglenophyta (6.2%) and administered seasonal variations at P>0.0001 ($F_{2\ 21}$ 24.7).

The species richness sequence of various groups of phytoplankton was seen in decreasing order as Bacillariophyceae > Chlorophyceae> Cyanophyceae> Euglenophyta in the present study.

Here also the Bacillariophyceae appeared to be the most dominant group among all phytoplanktons and recorded maximum density and species richness in summer while minimum in monsoon. Euglenophyta is the least represented group which showed maximum species richness in monsoon and minimum in winter at Baldane tank.

**Phytoplankton of Krishna Park:** At Krishna Park total 55 species of phytoplanktons were recorded with 26 species belonging to Bacillariophyceae, 15 to Chlorophyceae, 10 to Cyanophyceae and 04 to Euglenophyta, with same trends. Again the Bacillariophyceae dominated and recorded maximum in summer while minimum in monsoon, quantitatively as well as qualitatively. Euglenophyta is the least represented group which showed maximum species richness in summer and minimum in monsoon.

Pearson correlation of total phytoplankton density with physicochemical parameters administered significant positive correlation with Cl, MgH, pH, $SO_4$, TDS, TH, Trans. and with other phytoplankton parameters., densities of Chlorophyceae, Cyanophyceae, Bacillariophyceae, species richness of Bacillariophyceae, Chlophyceae, Cyanophyceae and species richness of total phytoplankton at all three water bodies. At KP positive correlation are noted with CaH whereas no correlation was noted with chlorides. Total phytoplankton density is negatively correlated with $PO_4$, TSS, WC and Density of euglenophyta and species richness of euglenophyta.

Pearson correlation of species richness of total phytoplankton showed positive significant correlation with Mg, pH, TDS, density of bacillariophyceae, species richness of bacillariophyceae and negative significant correlation with $PO_4$ and WC at all three water bodies. The total species richness of phytoplankton of individual water body showed significant positive and negative correlation with different abiotic and biotic factors.

**Zooplankton:**

Four different groups rotifer, cladocera, copepoda and ostracoda representing zooplankton community are considered during present study. Total 34 genera and 59 species of zooplankton were recorded, of which 29 species belong to rotifer, 12 to cladocera, 09 to copepoda and 09 to ostracoda. The two year biannual percentage density in decreasing order rotifera, cladocera, copepoda and ostracoda for Malpur dam were 36.86%, 30.79%, 25.88% and 5.45% respectively. For Baldane reservoir it was 38.4%, 30.45%, 25.74% and 5.4% while for Krishna park these values were 38.5%, 30.7%, 25.1 % and 5.86% respectively.

**Zooplankton of Malpur dam:** total 48 species belonging to 35 genera were recorded during the two year study at Malpur dam of which 25 species (11 genera) belonged to rotifer, 9 species (9 genera) belonged cladocera, 7 species (7 genera) belonged to Copepoda and 7 species (7 genera) belonged to ostracoda.

**Zooplankton of Baldane reservoir:** Similarly at Baldane reservoir a total 44 species belonging to 30 genera were recorded during the two year study at Baldane reservoir of which 23 species (11 genera) belonged to rotifer, 8 species (6 genera) belonged cladocera, 6 species (6genera) belonged to Copepoda and 7 species (7 genera) belonged to ostracoda

**Zooplankton of Krishna Park:** Total 39 species belonging to 29 genera were recorded during the two year study at Krishna Park of which 21 species (11 genera) belonged to rotifer, 7 species (7 genera) belonged cladocera, 6 species (6 genera) belonged to Copepoda and 5 species (5 genera) belonged to ostracoda. The rotifers were the dominant zooplankton recorded at all the three water bodies, whereas Ostracodes were minimum during the study period.

Among the four groups of zooplankton, rotifers constituted the dominant group at all the three water bodies with maximum density in summer and minimum in winter. The second dominant group cladocera also showed similar trends to that of rotifers with the higher density in summer and lower in winter.

The third dominant group cladocera also showed similar trends to that of rotifers with higher density in summer, 500±25.5 and lower in winter

Ostracoda, the fourth quantitative component among the four zooplankton groups at all the three wetlands also showed significant seasonal variations, but with moderately higher level in monsoon and minimum in winter.

Species richness total zooplankton was also maximum in summer, declined in monsoon and was found minimum in winter at all the three wetlands.

When correlation with physicochemical parameters (Chapter 1) is considered at Malpur dam, cladoceran and copepod density were positively correlated with AT, Cl, $CO_2$, MgH, TDS, TS, TH and WT while negatively correlated to DO, PO4, transparency and WC. When ostracodes were considered, similar results were noted except no correlation with Cl, MgH, TH, $PO_4$ and WC and positive correlation with pH. Similarly rotifers in addition showed positive correlation with pH, $SO_4$ and transparency. When total zooplankton were considered they showed almost similar correlations to that of cladoceran, copepod and rotifer, whereas ostracodes showed different results. None of the group showed any significant correlation with CaH, $NO_3$ and TSS except ostracoda.

**Molluscs:**

Total fifteen species of molluscs recorded at all three wetlands study period, belong to ten genera and six families. When temporal variations are considered, maximum densities as well as species richness were recorded in monsoon and minimum in winter.

At Malpur dam total fourteen species of molluscs were recorded belonging to nine genera. Among these six species were very common, two are common and six species were rare. The density and species richness of the molluscs showed significant seasonal variations. Maximum density and species richness of molluscs were recorded in monsoon and minimum in winter. Density of molluscs and species richness administered positive significant Pearson Correlation with humidity, $NO_3$, $PO_4$, rainfall, TS, TSS and WT while significant negative correlation with density of total phytoplankton, pH, TH and transparency.

At Baldane water body total thirteen species of molluscs were recorded belonging to nine genera**.** Among these six species were very common, two common and five rare. The density and species richness of the molluscs showed significant seasonal variations. Maximum density and species richness of molluscs were recorded in monsoon and minimum in winter. Density of molluscs showed significant positive correlation with AT, $CO_2$, humidity, $PO_4$, TS, TSS, WT and species richness, while it showed negative significant correlation with DO, pH, transparency and density of total phytoplankton. Species richness of molluscs showed significant positive correlation with AT, humidity, $PO_4$, TS, TSS, WC and density of molluscs, while showed significantly negatively correlation with $Cl^-$, pH, transparency and density of total phytoplankton.

At Krishna Park total eleven species of molluscs were recorded belonging to nine genera with six species very common, two common and three rare. Both the density and the species richness showed significant seasonal variations. Maximum density and species richness were recorded in monsoon and minimum in winter. The Pearson

Density of molluscs showed significant positive Correlation with AT, humidity, $PO_4$, rainfall, TS, TSS, WT and species richness, while significant negative correlation with pH, transparency and density of total phytoplankton. Species richness of molluscs showed significant positive correlation with density of molluscs, humidity, $PO_4$, rainfall, TS, TSS, WT and species richness. It significantly negatively correlated with pH, transparency and density of total phytoplankton.

**Discussion**:

**Physicochemical parameters:-** A physico-chemical approach to monitor the water quality gives the causes and levels of pollutants if any in the water body while, biological approach highlights the impact of pollution on the aquatic biota and the overall status of the water body.

In accordance to higher summer ambient temperature in the semi arid region of Maharashtra WT of three wetlands was also high resulting in evaporation leading to increase in TDS, pH, free $CO_2$, and increase in concentration of Ca and Mg hardness with TH and Sulphates as well. When AT declined in winter WT, TS, TSS and free $CO_2$ also declined. The monsoon rains increased the WC, churned the water increasing TS, and the agriculture run off probably added nitrate and phosphate increasing their concentration to maximum values whereas these parameters showed minimum values in summer except TS. The impacts of environmental changes are reflected as positive significantly significant or negative significantly significant correlation with almost all parameters with ambient temperature.

There are many reasons for this like the amount of light that is scattered depends on the level of TSS and turbidity in the water; it influences the productivity by influencing photosynthesis of flora. Transparency established positive significant correlation with total density of phytoplankton at all three wetland, thus physical factors influences the biotic parameters in varied ways. Various physico-chemical parameters were positively or negatively correlated with each other and on the other hand with the biotic components too, indicating the cumulative influence of the physicochemical parameters to govern the biotic components of the lake. No single common abiotic parameter could be correlated to biotic parameters studied. Similar correlations were recorded for Baldane and Krishna Park water reservoirs too as is also reported by several other field scientists (Shah and Pandit, 2012; Abdar, 2013; Nagarajan and Sarvanaraja, 2014; Ugale, 2016; Vineetha *et al*., 2016). According to

Ramchandra *et al*. (2002) the physical and chemical and biological properties of wetland are characteristics of climatic, geochemical, geomorphological and pollution conditions prevailing in the drainage basin and the underlying aquifer. The physico-chemical parameters are within the permissible limit as per WHO and ISI standards of drinking water.

**Phytoplankton:-** An important aspect of biological water quality assessment is that of the biotic community that represents “the results of summation of the prevailing conditions” (Hynes, 1971). The interaction between these communities, zooplankton and phytoplankton form an important basis of the food chain in natural and man-made lakes (Jacqueline and Mavuti, 1994).

Phytoplankton are one of the important organisms in the aquatic ecosystem and are the primary producers, playing important role in the material circulation and energy flow in aquatic ecosystems (Azari, *et al*., 2011). Phytoplankton density, diversity and their association as biological indicators in the assessment of water quality and trophic status has been studied by many workers (Narasimha and Benarjee, 2013; Murlidhar and Murthy, 2015; Sharma and Pachuau, 2016) and have expressed their role as indicator in eutrophication and pollution.

Minimum density of total phytoplankton was recorded in monsoon at all three wetlands studied. Saravanakumar *et al*. (2008) have reported that the phytoplankton population is reduced in monsoon because of heavy rainfall, high turbidity, reduced salinity, pH, temperature, cloudy skies and low nutrient concentration and parasitism etc. As it is observed in the present study high temperature, adequate sunlight and rapid tropholytic activities accelerated the multiplication of phytoplankton during summer culminate into the highest peak. Permanent bloom of phytoplankton in lakes of Indian peninsula are recorded during summer due to shallow depth, nutrients enrichment and adequate sunlight (Sugunan, 2000). However, such blooms werenot observed during our studies.

Phytoplanktons acts as producers and occupy lowest trophic level in aquatic ecosystem food chain (Murulidhar and Murthi, 2015a, b) and the productivity of aquatic environment is directly correlated with the density of phytoplankton (Narasimha and Benarjee, 2013). In post monsoon, the water cover and water level remain higher (Patil, 2011) distributing the phytoplankton and leading to decrease in their density while inverse situation is produced in summer when because of lower water cover the plankton are concentrated and hence increase in the density. Similar results of seasonal variations in density of different groups of phytoplankton have also been reported (Jagadeeshappa and Kumara, 2013) with maximum density in the summer and decreased during the monsoon period. The results were also corroborated with Deshkar, (2008), Ekhande, (2010) and Patil, (2011) during their study due to maximum photoperiod in summer which increases growth of phytoplankton in subtropics.

The positive significantly significant correlation of total phytoplankton with Cl, MgH, pH, $SO_4$, TDS, TH, Transparency while negative significantly significant correlation with NO3, $PO_4$, TSS, and WC indicates that in clear water with moderate TDS, pH and $SO_4$ the productivity is high and $NO_3$ and $PO_4$, are used up, while when TSS is high photosynthesis decreases declining phytoplankton density and when WC is high the plankton are distributed over wider area again negatively influencing the density. This is reflected by dominance of Bacillariophyceae among all phytoplanktons recorded maximum in summer while minimum in monsoon, quantitatively as well as qualitatively. Euglenophyta is the least represented group as is also reported by Ekhande (2010) and Patil (2011). Moderate density of total phytoplankton recorded in winter is due to reduced turbulence resulting in clean lake water at all three water bodies. When rainfall stops the water bodies get stabilizes in post monsoon and winter.

**Zooplanktons**, the microscopic free floating organisms of an aquatic ecosystem are cosmopolitan in nature and found to inhabit all freshwater ecosystems in the world. The knowledge of species diversity, abundance and special distribution of zooplankton in a freshwater ecosystem is very much necessary as it is important in understanding trophodynamics and trophic progression of water bodies (Pawar, 2015). They usually act as primary consumers and constitute an important link between primary producers (phytoplankton) and higher tertiary consumers like carnivore fish in aquatic food chain (Pradhan, 2014). Overall relationship of zooplankton found as Rotifera > Cladocera> Copepoda >Ostracoda supports the report of Ekhande (2010) and Patil (2011) who have reported that Rotifers are the main zooplankton in Indian waters. Zooplankton communities are very sensitive to environmental changes and thus are of considerable potential value as water quality indicators (Gannon and Semberger, 1978). Hence knowledge of zooplankton communities and their population dynamics is a major requirements for better understanding of life processes in a fresh water ecosystem since eutrophication influences both the composition and productivity of zooplanktons (Bhora and Kumar, 2004).

Maximum growth of zooplankton is reported in summer and minimum in winter because of fluctuations in light intensity and temperature, in turn affecting the food supply of zooplanktons (Malik and Panwar, 2016). Seasonal variations in density of total zooplankton indicated that during warmer months (summer) when water temperature was higher maximum density of total zooplanktons occurred as is also advocate in other studies (Salve and Hiware, 2010; Jose and Senthilkumar, 2015). Total zooplankton showed correlations with phytoplankton densities and different physicochemical parameters with positive significantly significant correlation with Cl, density of Bacillariophyceae, Chlorophyceae, Cyanophyceae, Mg, pH, $SO_4$, TH while negative significantly significant correlation with density of Euglenophyta, $NO_3^-$, $PO_4^{-3}$, TSS and WC and positive significant correlation with AT.

The higher summer population densities of zooplanktons at all three reservoirs coincide with the peak of phytoplankton density, high temperature and low rainfall (Jagadishappa and Vijaya Kumar, 2013) indicating that the density and diversity of different groups of phytoplanktons and zooplanktons remained high in pre monsoon and decreased during monsoon period. Since all the wetlands are located under semi arid zone/region, the prevailing temperature and nutrient load by various factors enhance the population abundance of plankton.

**Mollusc**: Molluscs form one of the major parts of the macroinvertebrates in wetlands and many water birds and other animals feed primarily on them for their calcium requirements. Maximum density and diversity of molluscs observed in monsoon indicates their successful breeding performance, during monsoon. During this period water level is also high favouring the growth of vegetation that provide shelter to the larvae as well as juvenile stages. Comparatively the moderate temperature of monsoon can also be favourable for molluscs. However, the ambient temperature in the area falls in winter forcing molluscs to hibernate to deeper soils, when the density and species richness of molluscs are minimum at all three water bodies under study.

The local communities are structured around the sum of multiple factors including local factors such as predation stress, and regional factors such as dispersal and connectivity (Huston, 1999; Mouquet and Loreau, 2003; Heino and Muotka 2006). Environmental factors like physicochemical parameters (Garg *et al.*, 2009, Ekhande *et* *al*, 2010; Patil, 2011) availability of food, competition, predator-prey interaction (Lassen, 1975, Dillon and Robert, 2004), substrate architecture and macrophytes (Lodge *et al*.,1987; Zealand and Jeffries, 2009; Pip 2006) also affect species composition and abundance of benthic fauna including freshwater molluscs.

The physico-chemical properties of water are determinants of aquatic ecosystem although greatly influenced and modified by climate and other local factors (Hutchinson, 1975; Ekhande *et al*., 2010; Patil, 2011).

The molluscs of three water bodies under study showed significant seasonal variations in density and species richness. The seasonality of molluscs have been correlated with the temporal variations of abiotic and biotic parameters (Heino and Muotka, 2006; Pip, 2006; Garg *et al*., 2009). At three water bodies also significant correlations of molluscs were recorded with abiotic parameters indicating cumulative effect of these parameters on the density and species richness as is also reported by (Ekhande, 2010; Patil, 2011; Magare *et al*., 2016) in the nearby areas. The biotic factors also influence molluscs directly by providing different architecture and periphyton substrate which is essential for various activities of molluscs. Molluscan community occur primarily in shallow water near shore areas.

Fundamental biogeographic principle proposes that the larger lakes support more molluscs species (Carlson, 2001). The rainfall in monsoon increases water cover (area) and this may provide more microhabitat to the macrobenthos (Snails and Bivalve) and better opportunity for colonization leading to increase in their density and species richness. They are particularly vulnerable to human disturbances and changes in these microhabitats which are observed at Krishna Park where the tourism is high. Any changes in this microhabitat can influence the density and diversity of molluscs. Molluscan community of the lake is also influenced by consumers at higher trophic levels, such as fish, waterfowl and dragonfly nymphs.

## Application

The study of physico-chemical parameters are useful in water quality assessment.

Phytoplankton survey indicates the trophic status and presence of organic pollution in an aquatic ecosystem.

Study of Phytoplankton for ecological biomonitering help in the analysis of water quality trends, development of cause- effect relationships between water quality and environmental data and judgment of the adequacy of water quality for various uses.

The details for quality of water can be provided to decision makers as well as public to understand and maintain uniqueness of this aquatic ecosystem (Malpur Dam, Baldane Reservoir and Krshna Park).

For conservation of biodiversity: wetland provides the best habitats to many animals belonging to all taxonomic categories, from protozoa to mammals occur in. The Rio de Junero convention on biodiversity through National and State biodiversity boards emphasizes on documentation of biodiversity at village level. This study can give inputs for biodiversity of Malpur Dam, Baldane Reservoir and Krshna Park for certain identified groups like phytoplankton, zooplankton and molluscs. This can form a baseline data which may help any future studies with reference to changes due to anthropogenic factors like tourism, population groth or even global climatic changes.

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