Summary and Conclusion

Discussion:

Chapter3- Study of 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.

Physical parameters:

Temperature: During the study period, both 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 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 cove***r*: 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 was maximum in summer and minimum in monsoon. ***Calcium Hardness*****:** Maximum calcium hardness were recorded in summer while minimum in monsoon. ***Magnesium Hardness****:* 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.

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 of almost all parameters with ambient temperature.

The amount of light that is scattered depends on what is 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. 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 reported by several other field scientists (Shah and Pandit, 2012; Abdar, 2013; Nagarajan and Sarvanaraja, 2014; Ugale, 2016; Vineetha *et al*., 2016). According to Ramachandra *et al*., (2002) the physical, 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.

Chapter 4- Study of 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”. The interaction between these communities, zooplankton and phytoplankton form an important basis of the food chain in natural and man-made lakes.

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.

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 total phytoplankton density at Malpur Dam, administered significant seasonal variation $P>0.0001$ ($F_{2\ 21}$ 26.9). Maximum density of total phytoplankton was recorded in summer, while minimum in monsoon. The density sequence of various groups of phytoplankton was noted in decreasing order as Bacillariophyceae > Chlorophyceae> Cyanophyceae> Euglenophyta. The percentage density of these four groups of phytoplankton exhibited decreasing order as Bacillariophyceae (42.16%), Chlorophyceae (32.82%), Cyanophyceae (22.5%) and Euglenophyta (2.52%). When seasonal variations of Cyanophyceae and chlorophyceae are considered, 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.

Similar trend in seasonal variations of total phytoplankton density and species richness of various group of phytoplankton were also recorded at Baldane Reservoir and Krishna Park. The density and species richness of phytoplankton of individual water body showed significant positive or negative correlation with different abiotic and biotic factors.

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. Phytoplankton density, diversity and their association as biological indicators in the assessment of water quality and trophic status and uttered their role as indicator in eutrophication and pollution.

Minimum density of total phytoplankton was recorded in monsoon at all three wetlands studied. 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 activities accelerated the multiplication of phytoplankton during summer culminate into the highest peak. Permanent blooms of phytoplankton in lakes of Indian peninsula are recorded during summer due to shallow depth, nutrients enrichment and adequate sunlight but such phytoplankton bloom were not observed during present study.

In monsoon, the water cover and water level remain higher 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 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, Transparancy 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 in present study. 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.

Fortunately, in the present investigation the density of cyaophyceae is positively significantly correlated with total density of phytoplankton, density and species richness of chlorophyceae while its species richness is positively significantly correlated to density and species richness of chlorophyceae, indicating that the members of cyanophyceae are not dominating the wetlands under study. Apart from nutrients, many other variables are also involved in the development of cyanobacterial blooms and their ecological success are probably at lower levels in three water bodies studied. The cyanobacterial dominance can be prevented or reduced and prerequisite is almost always a reduction of the nutrient load from the catchment to wetlands. WHO has suggested that 1µg/l as the upper safe limit of *Microcystis*. The cyanobacterial toxin in the recreational waters may compose hazards to swimmers, sailors and anglers on ingestion of scum (bloom). Site managers are expected to give periodic warnings or banning public access to water by considering the extent of bloom.

Desmids, a group of chlorophycea such as *Cosmarium, Clostridium, Staurastrum* are the indicator of good quality of water and they are absent in polluted water. This flora is observed in the present study indicating that the wetlands are yet non-polluted. Dominance of chlorococales indicates eutrophication. However in present study inverse situation was observed, the species of desmids are dominated which can be suggestive that the wetlands under study are within control and not polluted. However, the monitoring of wetlands, under study is required because the pollutant tolerant species though rare, are observed during study. These species are *Spirogyra*, *Ulothrix* and *Zygrema*. Assessment of chlorophyceae is well integrates with physical, chemical and biological parameters of fresh water ecosystem studied. Green algae contain many species making data useful for statistical applications to assess water quality. It could provide powerful monitoring tool.

Diatoms shows quick responses to the altered physicochemical and biological factors, hence are used as reliable environment indicators. *Nitzschia* group of diatoms is large, diverse and ecologically versatile genus that occurs in oligotrophic water. However the clean diatoms taxa *Cymbell, Pinnularia, Amphora, Asterionella* have been recorded in the present study. This indicates that though the wetlands are not yet polluted, can get polluted if proper care is not taken.

Though the tolerant species of euglenophytes were recorded from three wetland studied, their density and species richness were very poor, but continuous monitoring of water can play vital role in the proper management of these wetlands.

Chapter 5 - Study of 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. 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. Overall relationship of zooplankton found as Rotifera > Cladocera> Copepoda >Ostracoda Zooplankton communities are very sensitive to environmental changes and thus are of considerable potential value as water quality indicators. Hence knowledge of zooplankton communities and their population dynamics is a major requirement for better understanding of life processes in a fresh water ecosystem.

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. Seasonal variations in density of total zooplankton indicated that during warmer months (summer) when water temperature was higher maximum zooplankton occurred. Total zooplankton showed correlations with phytoplankton densities and different physicochemical parameters.

The higher summer population densities of zooplanktons at all three reservoirs coincide with the peak of phytoplankton density, high temperature and low rainfall 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.

Chapter 6. Study of 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 molluscs of three water bodies under study showed significant seasonal variations in density and species richness. The three water bodies also showed signignificant correlations of molluscs with abiotic parameters and the cumulative effect of these parameters on the density and species richness as is also reported during the present study. 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.

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 and the status of any water body.

Phytoplankton survey indicates the trophic status and presence of organic pollution in an aquatic ecosystem. Study of Phytoplankton and zooplankton 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. 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 growth or even global climatic changes.