CHAPTER: 1

INTROCUCTION

Introduction

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 available on earth, 97.47 % is deposited in the ocean, seas, lakes and rivers, while the most important fresh water resources account for a miniscule of 2.53%. Thus, the amount of fresh water on the earth is very diminutive compared to sea water, of which 69.6% is locked away in continental ice, 30.1% in underground aquifers and only 0.26 % in rivers and lakes. These rivers and lakes form aquatic ecosystems, where various flora and fauna inhabit. The density and diversity of these living organisms depend on the 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 finite water resources are being exploited and degraded at an accelerating rate by the activities of mankind. Hence, fresh waters are a restricted resource that can be amplified marginally. Desalinization of ocean water requires tremendous energy expenditures for the treatment process and distribution of the product (water) once obtained. This distribution is energetically too expensive within only short distances from marine sources (Wetzel, 2001). Freshwater utilization is governed by the strengthening relationships in which supply is constantly expanded in response to growing demands.

As per WWDE report (2018), the increase in population growth rate, increase in economic development and simultaneous change in the consumption pattern of water have increased global demand for water by 1% per year. This is expected to continuously grow significantly over the coming decades. Concurrent increase in demand of water for industrial and domestic use is much faster than demand for agriculture, although agriculture remains the largest overall user. The freshwater supply in reality is much smaller than the probable total because of many factors. Rainfall is not evenly distributed over land surfaces, and humans are not distributed over land in proportion to the availability of water. This inequality results in a great expenditure of resources and energy for distribution systems to move water from places of water abundance to places where it is scarce to support human needs. Second, total consumption has increased exponentially with demotechnic growth of human population. Extension of distribution systems to areas of low precipitation,

such as for irrigation of semiarid regions, results in excessively high losses of water due to evaporation. Third, potentially the most serious factor originating from demotechnic growth is the severe degradation of water quality due to contaminants. The effect is severe reduction of water supply available for other purposes.

The growing demand for water is expected to occur in the countries with developing or emerging economies. Man has constructed thousands of water bodies to meet these demands over thousands of years. This has benefitted other organisms too 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 ecosystems are open and require a constant input of energy in the form of organic matter. The geomorphology of the land, vegetation and soil composition, and biota, including humans, determine the characteristics drainage basin. The nutrient and organic-matter content of drainage water from the catchment area is modified depending on the landscape pattern. The productivity of ecosystems is generally low to intermediate in the terrestrial components, but highest in the wetland, the interface region between land and water, and lowest in the open-water portion of the lake.

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 term wetland is used for diverse habitats in different climatic zones of the earth that it is indeed difficult to define in simple terms. However, these are unique biotic communities supporting diverse plants and animals that are adapted to shallow water and provide food, shelter and space essential for their survival. Wetlands have been defined very broadly for the purpose of the Ramsar Convention on Wetlands of International Importance by the 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". Over the years, the 6 m depth limit for marine areas has often been interpreted to cover freshwater areas as well and has been extended even further to include all rivers, lakes and reservoirs. 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. They are also used to treat wastewater. They are globally important as natural sources of methane, as a provider of greenhouse gas to the atmosphere as it plays an important role in the regulation of climate. Wetland sediments are also valuable because they preserve a long-term record of environmental conditions and are rich in nutrients. Thus, wetlands provide many valuable services at population, ecosystem and global levels. These signify the importance of wetlands and the need for their conservation. They are extremely productive ecosystems and are crucial for preserving the biodiversity and ecological safety. The interactions of physical, chemical and biological components of wetlands enable it to perform these vital functions (NWA, 2013). Thus, wetlands form an important component of the environment. The values of wetlands though overlapping are inseparable.

Threats to Wetlands

Globally, wetlands are degrading rapidly at a rate, which is quite objectionable. 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. India has assets of these wetland ecosystems that support diverse and unique habitats and provide numerous ecological goods and services but are under tremendous stress due to rapid industrialization, urbanization and agricultural growth, manifested by the reduction in their real extent, and decline in the hydrological,

economic and ecological functions they perform (Bassi *et a*l., 2014). Also it has been established that management of wetlands has received insufficient attention in the national water sector agenda. As a result, many of the wetlands are subjected to anthropogenic pressures, including land use, changes in the catchment, pollution from industry and households, encroachments, tourism and over exploitation of their natural resources. 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 for many agreements of which Ramsar Convention is the most important Wetland Conservation Treaty that has indirectly influenced 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. The treaty - The convention on Wetlands of International Importance, especially as waterfowl habitats, reflects its original emphasis on the conservation and wise use of wetlands primarily to provide habitat for water birds. Over the years, however, the Convention has broadened its scope to cover all aspects of wetland conservation and their sustainable 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).

Ecological Assessment of wetlands

Ecological assessments of surface water bodies are essential in order to evaluate the level of degradation in freshwater ecosystems and to deal with the subsequent decline in the services that they provide. These assessments cover multiple aspects of the aquatic environment, particularly biological elements, as they are able to respond to all pressures within an ecosystem. Such assessments can enable the identification of

the multiple pressures which threaten water bodies, facilitating sustainable decisions regarding their management.

The overall condition or health of aquatic ecosystems is determined by the interaction of all its physical, chemical and biological components, which make up the system. Information on and understanding of environmental changes becomes necessary to allow the protection and remediation of ecosystems. Ecological assessment by analyzing all the components of the ecosystem aids in understanding restoration methods towards the conservation, management and sustainable use of natural resources. Chemical data measures the concentration of nutrients and pollutants etc. in the water body, whereas the ecosystem imbalances are measured by biological information. These data are essential in understanding the ecosystem integrity (Ramachandra *et al.*, 2006). Biological monitoring is the use of biological responses to assess changes in the environment. Biomonitoring is thus a valuable assessment tool that is receiving increased use in water quality monitoring programs of all types (Kennish, 1992). It involves the use of indicators, indicator species or indicator communities. An indicator signals messages, potentially from numerous sources, in simplified and useful manner. An indicator may reflect biological, chemical or physical attributes of ecological conditions. The fundamental principle behind biological indicator theory is that organisms provide information about their habitat. Biological indicators are currently used and promoted by numerous conservation agencies including the World Conservation Union (IUCN), World Conservation Monitoring Centre (UNEP), U. S. Environmental Protection Agency (USEPA) etc. as a means to monitor and assess human impacts on environments.

Further, the biodiversity inventory is the surveying, sorting, cataloguing, quantifying and mapping of entities such as genes, individuals, populations, species, habitat, biotopes, ecosystems and landscapes or their components and the synthesis of the resulting information for the analysis of patterns and processes occupying the system. Monitoring consists of repeated inventorying over time and space and therefore measuring the change. Hence, studying ecosystem with their biodiversity is the need of the day.

India has a rich variety of wetland habitats. Most of these are directly or indirectly linked with major river systems. A survey conducted by the Ministry of Environment and Forest in 1990 showed that in India wetlands occupy an estimated 4.1 million hectares of which 1.5 million hectares are natural and 2.6 million hectares are man-

made (excluding paddy fields, rivers and streams). As per the information of SAC (2011) report, total wetland area estimated in India is 15.260 Mha which is about 4.63% of the geographical area of the country. Of this, inland natural wetland accounts for 43.4%. The state of Maharashtra alone acknowledges an area of about 1014522 ha. i.e. 3.30% of its geographical area under wetlands. Though it is one of the 5th states having more than one Mha area under water, it does not possess large areas under inland wetlands/ponds but stands 3rd by area under reservoirs and barrages as well as tanks and ponds with 759 reservoirs/ barrages spread in 36813 ha and 15845 tanks/ponds in the area of 208669 ha. In Maharashtra there are 49 natural wetlands covering an area of 21,675 ha and 1004 artificial wetlands covering an area of 2,79,025 ha.

The present study proposes to evaluate 3 wetlands with their selected biodiversity in drought prone Northern part of Maharashtra State where presence of wetlands is important. These wetlands in the area have not been evaluated earlier. Hence, generation of a baseline data about the abiotic and biotic parameters becomes essential. The study undertaken is extended to enrich the scientific knowledge with respect to development of awareness in local people about the quality of water and conservation of biodiversity as well as in conservation planning, management and sustainable use of wetlands and their biodiversity i.e. the use of global motto at local level.

The availability of good quality water is an indispensable feature for preventing disease and improving quality of life. Hence quality of water in the form of physicochemical factors needs to be evaluated regularly. The main purpose of analyzing physical and chemical characteristics of water is to determine its nutrient status. Since, water contains dissolved and suspended materials in various proportions, its physical and chemical characteristics differ along with biological characteristics (Sebastian, 2012).

According to Gopal and Zutshi, (1998) there is an urgent need for long-term experimental research in managing the quality of water and aquatic biological resources for sustainable development. However, the environmental issues which dominate since the 1972 Stockholm Conference, and growing realization of the problem of water pollution, resulted in a rapid proliferation of hydrobiological studies which tend to focus on correlation between the distribution of various organisms and

degree of water pollution or understanding the effects of various organic and inorganic pollutants.

The physical properties of water in any aquatic system are largely regulated by meteorological conditions and the chemical properties of water (Panale, 2014) whereas the effect of physical forces such as light and heat are of great significance as they are solely accountable for certain phenomena, such as thermal stratification, chemical stratification, seasonal qualitative and quantitative variations in plankton diversity, micro and macro organisms and ultimately the quality of water. Chemical data measures the concentration of pollutants, etc. in the waterbody, while the ecosystem imbalances are measured by biological information. Biological and chemical data are essential in understanding the ecosystem integrity (Ramachandra *et al*., 2007).

The productivity of freshwater community in an aquatic ecosystem is usually determined by the fish growth which is regulated by the dynamics of the physicochemical parameters along with biotic environment of the ecosystem (Wetzel, 1983). As physicochemical parameters play a major role in ascertaining the distribution pattern and quantitative abundance of organisms inhibiting a particular ecosystem (Singh *et al*., 2009), it is necessary to conserve these ecosystems today.

The impact of human activities, in and around the reservoir is felt on the unique physical and chemical properties of water on which the sustenance of fish that inhibit the reservoir is based as well as to the functions of the reservoir and the water quality. It is important in providing drinking water supply, irrigation, fish production, recreation and other purposes due to which the water must have been impounded (Mustapha, 2008). A fresh water body that fulfils a variety of these human needs is full of value, only when it is not abused or polluted. Deterioration of water quality in reservoirs is mainly due to excessive input of nutrients, eutrophication, acidification, heavy metal contamination, organic pollution and obnoxious fishing practices. The effects of these "imports" into the reservoirs do not only affect the socio-economic functions of the reservoir negatively, but also damages the structural biodiversity of the reservoirs. The quality of water generally refers to the component of water present at the optimum level suitable for growth of plants and animals (Umerfaruq and Solanki, 2015). Water quality thus provides existing information about the concentration of various solutes at a given time and place (Shinde *et al*., 2011) and

water quality parameters provide the basis for judging the suitability of water for its designated uses and to improve the existing conditions.

Usually, water quality monitoring actions have focused on physical and chemical measurements. But it is widely recognized that bioindicators used in biological monitoring or biomonitoring has proved to be an important tool too in assessing the condition of aquatic ecosystems (Ramachandra and Solanki, 2007). Biological methods used for assessing the water quality include the collection, counting, and identification of the aquatic organisms (APHA, 1985). Biomonitoring in conjunction with physical and chemical observation of water quality is potentially useful in characterizing waterbodies. Chemical data measures the concentration of pollutants, etc. in a water body while the ecosystem imbalances are measured by biological information and thus essential in understanding the integrity of ecosystem.

The biological information of any aquatic ecosystem is determined by the presence of plankton. Planktons are the microscopic organisms that drift on the water currents. Plankton is the productive pedestal of both freshwater and marine ecosystems, providing food for larger animals and indirectly for humans, hence, plankton constitutes the basic food sources for any aquatic ecosystem, which supports fish and other aquatic animals (Kumar, 2015). The phytoplankton and the zooplankton both are at the lower level of an aquatic ecosystem.

Phytoplankton form the single base of food chain in an aquatic system as they act as energy transducers and convert the solar energy into chemical energy of food. Zooplankton pass these food energy to the higher trophic levels and thus provide a link between energy producers and the consumers. These organisms are important biological indicator of water quality and trophic status of aquatic ecosystem as they respond quickly to the environmental changes.

Among the biological components**,** phytoplankton communities dominate the pelagic ecosystems that cover 70% of the surface area (Reynolds, 2006). Freshwater phytoplankton are composed of algae of almost every major taxonomic group and cyanobacteria (Wetzel, 2006). Most of these microscopic algae that occur in unicellular, colonial or filamentous forms are photosynthetic and eaten by zooplankton (APHA, 2012). Phytoplankton include several thousands of microalgae belongeing to chlorophyta (green algae), cyanophyta (Blue green algae), Bacillariophyceae (diatoms) and Euglenophyta (pigmented flagellate or

phytoflagellate) etc. that respond quickly to environmental changes and are used to access the ecological status of the water bodies.

Phytoplanktons are usually used as ecological indicators to assess the ecological health and the stress effects of chemical contaminants on aquatic ecosystems and they are also necessary to sustain a healthy aquatic ecosystem (Sharma and Tiwari, 2018). According to Rajgopal *et al*. (2010) there are certain numbers of species in the chlorophyceae and cyanophyceae which are tolerant to organic pollution and resist the stress caused by pollutants. Abundance of such taxa in polluted habitats suggests their possible use as "indicator organism". It is important to consider that the phytoplankton community changes quickly in a response to changes in water quality. In the aquatic environment, the first reaction on such changes is a quantitative change of the phytoplankton community. Algal richness increases or decreases depending on the type of impacts on the water quality, which is followed by qualitative changes in the phytoplankton community. In lakes, new species colonize and some of the original species may decrease significantly based on local extinction in some cases (Gökçe, 2016).

Phytoplankton constitutes the first domain of the food chain in aquatic systems, producing high-energy organic compounds from carbon dioxide and inorganic substances by photosynthesis with the help of sunlight (Yilmaz, 2018). However, light penetration, temperature, nutrient enrichment, toxic substances, mixing of water, parasites and heterotrophic microorganism activities influence phytoplankton growth (Reynolds, 1987).

Phytoplankton and zooplankton interactions form an important link of the food chain in natural and manmade lakes (Jacqueline *et al*., 1994) and these interactions in turn govern productivity in an aquatic ecosystem. Any type of modification in phytoplankton or zooplankton biomass and diversity depends on the different limnological and trophical conditions in a water body.

Eutrophication, a global phenomenon is associated with nutrient enrichment of aquatic ecosystem. Under this enriching nutrient substances are added to water which causes the increase in biological production and unfavorable organic matter pollution, resulting in a series of unfavorable changes in aquatic ecosystems making it unfit for any use (Bhateria and Abdullah, 2015). The main elements causing eutrophication are nitrogen, phosphorus and carbon which act as bio-stimulants resulting in eutrophication or enhancement of the growth of zooplankton and phytoplankton. This

can lead to luxuriant growth of unusual plankton, that may or may not be toxic, but on decay use up oxygen from the water which causes deoxygenation (Verma *et al*, 2013). Sharma et *al*. (2016) have also reported that increased concentration in physico-chemical parameters (turbidity, total dissolved solids, nitrates and phosphates) has an adverse effect on the density of phytoplankton while in sediment load, the growth of phytoplankton is affected.

Zooplankton is the next important qualitative and quantitative component in an aquatic ecosystem. Along with phytoplankton, they are the higher tropic organisms like fishes. The interrelationships between physicochemical parameters and plankton production and fluctuations is of great importance and basically essential in fish culture (Gupta and Day, 2013). Zooplankton help in conversion of plant material in animal tissue by feeding on phytoplankton and becoming the basic food for higher invertebrate fauna and vertebrates like fishes, particularly the larval forms (Kadam *et al*. 2014).

Among all freshwater aquatic biota, zooplankton population is able to reflect the nature and potential of any aquatic system (Kumar *et al*., 2010) and as a group, they show worldwide distribution, variation in species composition and community structure. Zooplankton communities are known to be highly susceptible to a wide range of factors like environmental changes, temporal abundance and seasonal variations, and their diversity is a marker of water quality in trophic conditions in cold, temperate and tropical waters (Gannon and Stemberger, 1978). They also have enormous value as they are primary consumers of phytoplankton and regulate nutrients (Malik and Pamwar, 2016). Availability and quality of food resources in the aquatic ecosystem directly affects the phytoplankton abundance, which in turn induces changes in distribution pattern of zooplankton species (Chandrashekhar and Kodarkar, 1997). Due to their short life span, the zooplankton community often exhibits quick and dramatic changes in response to the changes in the physicochemical properties of the aquatic environment (Dar and Dar, 2009).

There is usually a natural compensatory provision for zooplankton to enhance their reproductive capacity and hence they are always present in large numbers (Goldman and Horne, 1983). They are crucial elements in a freshwater lake ecosystem as they occupy central position in an aquatic food web and become the preferred food for almost all freshwater faunal species at some stage in their life history (Lampert and Sommer, 1997).

Zooplanktons assemblages may be considered as bioindicators of eutrophication, as they are coupled with various environmental conditions, responding swiftly to changes in comparison to fishes, and are easier to identify than phytoplankton (Abdulwahab and Rabee, 2015). Recent changes in the aquatic environment accompanying anthropogenic pollution are a cause of growing concern and require monitoring of the surface waters and the biota inhabiting them (Vandysh, 2004). Zooplanktons are capable of concentrating large quantities of heavy metals from water bodies (Verma *et al*., 2013) which may be passed on and concentrated at higher trophic levels through the food chain. Hence they are considered as bioindicators of an aquatic ecosystem.

Zooplankton comprising of rotifers, cladocerans, copepods and ostracodes are considered to be most important in terms of population density, biomass production, grazing and nutrient regeneration in any aquatic ecosystem (Omudu and Odeh, 2006). These groups have been considered in this study.

Another significant component of the food chain is mollusca which accumulates calcium from the surrounding in to their shell and transfers it to a higher trophic level. Freshwater molluscs fall into two main groups, Bivalves and the Gastropods, and are found in a wide range of freshwater habitats. They have varied life-history with life-spans that vary from three months (pea-clams) to over 120 years (pearl mussels). They find their highest levels of endemism and diversity in ancient lakes, large river basins and artesian basins (Seddon, 2000).

They have been of great antiquity as their first fossils have been known from the Cambrian period about 600 million years ago. These highly successful invertebrates, in terms of ecology and adaptation, are found nearly in all habitats ranging from the deepest ocean trenches to the intertidal zone, and freshwater to land occupying a wide range of habitats (Dillon, 2004; Strong *et al*., 2008).

The non-marine forms of molluscs, characterized by low mobility, small population and patchy and isolated distribution are very sensitive to environmental changes. Ongoing and future global changes are expected to threaten their diversity (Thomas *et al*., 2004) at local, regional and global scales. In this context, an urgent need was felt to put a long-term programme into action to assess and monitor predicted changes in molluscan density and diversity. This type of monitoring has the ability to integrate sentinel ecosystem that can detect signs of stress.

Molluscs in freshwater bodies play multiple functional roles and hence for conservation and restoration of wetlands, the study of molluscs in necessary (Gutierrez *et al*., 2003; Ormerod *et al*., 2010). They also play important roles in maintaining the general health of a water body by converting organic matter such as leaf litter and detritus into food and in turn becoming the main source of food for higher animals. They generally feed on algae and detritus and use the higher plants for support (Ramchandra *et al*., 2002). Thus, they are involved in recycling and transport of nutrients from one trophic level to other. According to SubbaRao, (1991) freshwater molluscan diversity in India includes 22 families, 53 genera and 183 species. The diversity of freshwater molluscs is comparatively poor compared to land or marine molluscs.

Although the species-specific preferences for the habitats are often linked with the morphology and feeding performances and dispersal ability, the local environmental variables include area and habitat heterogenicity (Aho, 1966; Oertli *et al*., 2002; Stenert *et al*, 2008), productivity, hydro period (Tarr *et al*., 2008) and temperature (Hanson *et al*., 1988; Sharma *et al*., 2003; Hall *et al*., 2004; Garg *et al*., 2009; Ekhande, 2010; Patil, 2011). The restoration of the degraded habitats as well as the maintenance of the community composition is facilitated with the known documentation of the abundance of various species within the community. For example, genera like *Thiara* and *Indoplanorbis* thrive well in slightly polluted environment. Hence in the study of the three water bodies viz., Malpur dam, Baldane dam and Krishna Park reservoir, the documentation of molluscan diversity, as a good indicator of water quality, was also considered. Molluscs can be used effectively for studies of both organic and inorganic contaminants. This study focuses on all the physicochemical properties of these waterbodies in rain deficient north Maharashtra documenting the seasonal diversity of phytoplankton, zooplankton and molluscs.