CHAPTER 1
INTRODUCTION

Aquatic ecosystem is the most diverse ecosystem in the world. The first life originated in the water and first organisms were also aquatic where water was principle external as well as internal milieu for organisms. Thus, water is the most vital factor for the existence of all living organisms. Water is a precious natural resource vital for sustaining all life on the planet earth and is in continuous circulatory movement as hydrologic cycle. It is uniformly distributed in time and space and has a unique place, the planet. It is impossible to substitute, difficult to depollute, expensive to transport and is truly unique gift to the life from nature. Due to multiple benefits and problems created by its excesses, shortages and quality deterioration, water as a natural resource, requires special attention (NIH, WRI). Water is also one of the most manageable of all the natural resources as it is capable of diversions, transportations, storage and recycling (Kumar *et al.*, 2005). All these properties impart water its great utility for mankind. A basic feature of the earth is an abundance of water. Over 71 % of the earth is covered by water.

On the global scale, total quantity of water available is 1600 million Cu.Km. The hydrological cycle moves enormous quantities of water about the globe. However, much of the world's water has little potential for human use because 97.5 % of all water on earth is saline water. Out of remaining 2.5 % of fresh water, most lies deep and frozen in Antartica and Greenland in the form of continental ice, while only about 0.26 % floats in rivers, lakes, in the soils and in shallow aquifers which can be readily used. The freshwaters of the world are experiencing accelerating rates of deterioration. Lakes in particular occupy less than 0.07 % of world's freshwater. India has 17,370 reservoirs covering 3,153,366 hectare area, which includes 56 large (1,140,268 hectare), 180 medium (527,541 hectare) and 19,134 small (1,485,557 hectare) reservoirs of which at least 100 have been subjected to scientific studies (Sugunan, 1989).

Out of total availability of 1869 bm^3 water resources, surface water consist of 690 bm^3 and ground water 432 bm^3. The present per capita available water resource is 1122 bm^3 and 2050 bm^3 respectively, that is likely to reduce to 748 bm^3 (Anjaneyulu and Narasimha Rao, 2004). World Water Assessment Programme indicates that, in next 20 years the quality of water available to every one is predicted to decrease by 30 % (WWDR, 2003). The water scarcity is acting as an obstacle in the continuous maintainance of aquatic ecosystem. The increasing industrialization, urbanization, rapid population growth, indiscriminate use of fertilizers and pesticides and less conscious attitude towards the environment is causing threat to all the fresh water habitats. The discharge of urban, industrial and agricultural wastes have increased the quantum of various chemicals that enter the receiving water, which considerably alter their physicochemical characteristics. Though industrialization and development in agriculture are imperative for growth of economy, at the same time it is also necessary to preserve the freshwater resources. Development has to be both people centered and conservation based. Unless we protect the structure, function and diversity of the world's natural systems on which we depend, development will be undermined. In many places where lack of food threatens human survival, it is actually the lack of water that limits food production.

In India per capita surface water availability in the years 1991 and 2001 were 2309 and 1902 m^3 respectively and these are projected to reduce to 1401 and 1191 m^3 by the year 2025 and 2050 respectively (Kumar *et al.*, 2005). It is also estimated that by the year 2025, two third population of the world would face water stress. Hence, there is a need for proper planning, development and management of this greatest asset of the country, namely water, for raising the standards of living of the millions of people, particularly in the rural area. Since water as a scarse and community shared resource, it has already started becoming the cause of conflict, the continuous monitoring of there environmental systems is required for its proper management plan.

In past, when communities were sparsely populated, water was capable of self purification by metabolizing the waste, but due to tremendous increase in pollution its self purification capacity has diminished, leading to severe other problems. The restoration, conservation and management of the water resources require a thorough understanding of what constitutes a healthy ecosystem. Monitoring and assessment with the help of water quality analysis techniques, provide basic information on the condition of our water bodies, their exact nature and, cause and levels of pollutants, if any. The physico-chemical parameters decide the quality of lake water while productivity of the freshwater community determines the health of the system generally considered in the form of fish growth. Hence, an aquatic ecosystem is regulated by the dynamics of its physico-chemical (Wetzel, 2001).

As a major element in aquatic plant, the algal community exhibits dramatic changes in response to changes to physicochemical properties (Ramchandra and Solanki, 2007), whereas among the animal biota it is the rotifer community structure that is probably shaped by the variety of environmental factors, including biological parameters such as predation or competition (Anna and Natalia, 2009). Many researchers have studied physico-chemical conditions and seasonal variations of zooplankton (Ali *et al.*, 1989; Bhuiyan and Nessa 1998; Cottenie *et al.*, 2001) indicating that the changes in the physico-chemical parameters lead to the changes in plankton density which in turn lead to changes in the faunal diversity (Ayoade *et al.*, 2009). Hence, in present study the water chemistry and its relation to selected group of Biota in "Yashwant Lake", a higher altitude lake in mid Satpura range of North West Maharashtra are evaluated.

In an aquatic ecosystem, the density and diversity of organisms depend on availability and quality of water. Thus, the water is an essence of life on the earth that 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 study of freshwater habitat, limnology, is the study of functional relationship and productivity of freshwater biotic communities as they are affected by dynamics of physical, chemical and biotic environmental parameters (Wetzel, 1975). It is a science of freshwater ecosystem or aquatic ecology comprising interdisciplinary sciences including hydrobiology, hydrophysics and geology (Golterman, 1975). Thus, Hydrobiology, the science of life and life process in water is a special division of limnology the science of inland waters (Schwoerbel, 1970). It is not a discipline on its own, but is part of biology concerned with the life of organisms in water. One of the goal of current research in limnology is the elucidation of basic environmental functions of the ecosystem in reservoirs, that are important for water quality management.

The quality of water affects the species composition, abundance, productivity and physiological conditions of indigenous population of aquatic organisms (APHA, 1985) therefore, the nature and health of the aquatic communities is an expression of quality of the water.

The accelerating rates of deterioration of fresh water systems of the world have major impact on the biodiversity. Natural factors like dust storm, runoff and weathering of minerals and Phosphorus and Nitrogen input from domestic water are slow eutrophication causing processes (Rao *et al.*, 1994). Hence, the present study deals with the ecology of a manmade reservoir at higher altitude in Western Satpura (Chapter 2). It is a tourist spot and may be developed as ecotourism centre in North Maharashtra resulting in increased anthropogenic pressures. For the development and management of this high altitude lake understanding its physical, chemical and biological properties is important. Chapter 3 deals with the physical and chemical properties (abiotic factors) of this higher altitudinal lake. Increase in human population, demand for food, land conversion and fertilizer use have led to faster degradation of freshwater resources (Hegde and Huddar, 1995; Rahman *et al.*, 1997; Ray *et al.*, 1999 Carpenter, 2005). In addition discharge of urban, industrial and agricultural

wastes have increased the quantum of various chemicals that enter the receiving water, considerably altering their physico-chemical characteristics.

Over the time, many countries have regulated their point sources of nutrients, such as municipal and industrial discharges, and replaced non-point sources of nutrients, such as run-off from the agricultural or urban land, by point sources as the driver of eutrophication-a widely recognized problem of water quality deterioration in many regions (Kim, *et al.*, 2001; Carpenter, 2005). During eutrophication, the original flora and fauna change (Padisak, 2005; Istvanovics *et al.*, 2007) and the ecosystem behaviour becomes unpredictable. In addition an excessive application of fertilizer or manure, causes accumulation of these nutrients in the soil too. These nutrient rich soils are washed into the lakes, where some get dissolves and stimulate the growth of phytoplankton and aquatic plants. Changes in the aquatic environment, accompanied with anthropogenic pollution are causing increased concern and hence require monitoring. The monitoring of quality of surface water by hydrobiological parameters is among the major environmental priorities as it permits direct assessment of the status of ecosystems exposed to deleterious anthropogenic factors (Vandysh, 2004). When pollutants enter lakes, streams, rivers, oceans and other water bodies, they get dissolved in water or suspended in life or deposited on the bed. Any system is able to withstand the pollutants up to a certain threshold, beyond which the quality of the water deteriorates, affecting the aquatic system.

A better understanding of effects of pollution is obtained when biological data are correlated with the physical and chemical parameters. However, biological indicators provide direct evidence of pollution, whereas physical and chemical data provide only indirect evidences. Recently, plankton have been used as indicators to observe and understand the changes in the ecosystem because they seem to be strongly influenced by climatic factors. (Beaugarand and Reid, 2000; Li *et al.*, 2000; Ramchandra and Solanki, 2007).

However, assessing the status of aquatic system through biological analysis is an old endeavor. Biomonitoring of water bodies at regular intervals also helps to understand the composition of biota, its dynamics and implications on trophic structure and *vice versa*. The overall processes of assessement of physical, chemical and biological nature of water in relation to normal quality, human effects and intended uses, particularly the uses which may affect human health and health of aquatic ecosystem itself are termed as water quality assessment (UNEP, 1996).

Biological methods used for assessing the water quality include the collection, counting and identification of the aquatic organisms (APHA, 1985). Biomonitoring involves the use of indicators, indicator species or indicator communities. They may reflect biological, chemical or physical attributes of the ecological conditions. The ecological indicators have been used to identify major stresses on ecosystem through their presence, conditions and numbers. The number of the types of fish, insects, plankton, amphibians and plants-the bioindicators determine the quality or status of the ecosystem (EPA, 1976). The presence or absence of a particular indicator or indicator species or indicator community reflects the environmental conditions of the water body.

Phytoplankton form good indicators of water quality as they have rapid turn-over time and are sensitive indicators of environmental stresses. Phytoplankton survey thus help to find out the trophic status and the organic pollution in the ecosystem (Ramchandra and Solanki 2007). Phytoplankton constitutes the basis of nutrient cycle of an ecosystem. Being primary producers they play an important role in maintaining the equilibrium between living organisms and abiotic factors. They are affected by physical, chemical and biological factors, making them valuable tool in monitoring programmes. On the basis of this, many workers have emphasized that algal communities as a whole serve as reliable indicators of pollution (Patrick, 1950; Palmer, 1969; Nandan and Patel, 1985). In India, many lakes and reservoirs have been studied for the water quality assessment and development of fisheries (Nurulalom and Zaman, 2006;

Ravikumar *et al.*, 2006; Shridhar *et al.*, 2006; Tiwari and Chauhan, 2006; Tas and Gonulol, 2007; Tiwari and Shukla, 2007). However, there are still many aquatic ecosystems that have remained unexplored. Several studies on phytoplankton diversity of ponds, lakes and reservoirs have also been conducted in India (Shridhar *et al*, 2006; Tiwari and Chauhan 2006; Tas and Gonulol, 2007; Senthilkumar and Shivkumar, 2008), and abroad (Round, 1985; Cleber and Giani, 2001; Sandra *et al.*, 2007) revealing the importance of this type of study.

In general, it has been established that the structure of phytoplankton communities in lakes results from the relationship which exists between the physical, chemical and biological parameters present in the water body (Benson-Evans *et al.*, 1999). The growth of phytoplankton may be controlled to a large degree by the limitation of parameters like nutrients (Tilman, 1982; Moss *et al.*, 1994), the availability of light (Philips *et al.*, 1997) and the composition and abundance of zooplankton (Carpenter and Kitchell, 1993). Fathi and Flower (2005) have observed that the water quality variables produce considerable seasonal variations and quantitative and qualitative differences in phytoplankton communities.

Zooplankton, the other group of plankton, is also influenced by the changes in a abiotic as well as biotic parameters or combination of both (Roff *et al.*, 1988; Christou, 1998; Escribano and Hidalgo, 2000; Beyst *et al.*, 2001). Being primary consumer in any aquatic ecosystem zooplankton take part in transferring food from primary to secondary level as well as in conservation of detritus matter into edible animal food. The properties of their habitat, position in the food web and biological features, make them suitable model organisms that excel the aquatic environment and to test general ecological hypothesis (Winfriend, 1997). Hence, the study of Zooplankton is also carried out at this higher altitudinal lake of mid Satpura range of North West Maharashtra.

Because of the influence of various extrinsic and intrinsic factors, the study of freshwater fauna especially the zooplankton, of a particular area play a key role in preservation and maintenance of ecological balance.

They are the minute organisms in water bodies that are present at various depths deciding their own niches in every type of ecological environment. The density of zooplankton depends upon availability of phytoplankton, organic matter, nutrients and physico-chemical parameters (Bhalla, 2006). Zooplankton species tend to have wide geographical distribution (Carter *et al.*, 1980 and Shurin, 2000), hence local differences in community do not generally result from dispersal limitation. The study of their composition, abundance and seasonal variation is helpful in planning and successful management of fisheries (Jhingran, 1974). Like phytoplankton, Zooplankton are also useful as indicators in deciding water quality including pollution. Because of their short life cycles and quick responses to environmental changes, they become good bio-indicators.

In India and abroad zooplankton communities have been investigated in numerous reservoirs, lakes and shallow water bodies (Gopal and Zutshi, 1998; Jana, 1998). Most of these studies focus on the relationship of zooplankton with water quality, particularly that of eutrophication and organic pollution. Kudari and Kanamadi (2008) studied six water bodies of Dharwad district and observed the impact of changed trophic status on the zooplankton composition during the course of time. The role of environmental factors on seasonal dynamics of zooplankton has been studied not only in fresh water systems but also in a shallow eutrophic, man made hyposaline lake by Arrora and Mehra (2009).

The relationship among nitrogen, total phosphorus and zooplankton density (Trevisan and Forsberg, 2007), eutrophication condition and ecological status (Chun *et al.*, 2007) are studied by various workers to observe nutrient status of reservoirs. The studies are also carried out on the biodiversity of the plankton (Alimov, 2001), diversity and seasonal fluctuations of zooplankton (Kiran *et*

al., 2007), Physico-chemical conditions and occurrence of seasonal variations (Ali *et al.*, 1989; Bhuiyan and Nessa 1998; Cottenie *et al.*, 2001), the zooplankton-phytoplankton relationships in shallow subtropical lakes versus temperate lakes (Havens *et al.*, 2009) and the effects of altitude on hydrology, productivity and species richness (Murugavel and Pandian, 2000), to compare and contrast the dynamics of phytoplankton, zooplankton and nutrients. However, its basic study is wanting and is absolutely necessary at regional level.

Zooplankton communities in fresh water belonged to two main groups as Rotifer and Microcrustaceans the later divided in three taxonomic groups Cladocera, Copepoda and Ostracoda. They are abundant in shallow areas of reservoirs, but only few species are abundant in open water. Because of the role played by them in natural as well as polluted environment it is necessary to study the density, diversity and species richness of zooplankton in any aquatic community, in relation with environmental parameters. Hence, with phytoplankton the present study includes the study of species richness, density, diversity and abundance of zooplankton at higher altitudinal lake "Yashwant Lake" of North West Maharashtra. Hence, chapter 4 deals with phytoplankton as well as zooplankton density and diversity of Yashwant Lake. The chapter 4 is divided into two parts, part A deals with phytoplankton while part B deals with zooplankton.

A large number of studies covering a wide variety of ecosystems and organisms suggest that species richness of various groups of animals tend to vary strongly with ecosystem production and habitat heterogenicity (Rosenzweig, 1995). Molluscs form another important group of biota in an aquatic ecosystem. They are of great antiquity as the first fossils are known from the Cambrian period about 600 million years ago. Molluscs form a structurally heterogenous group, of soft bodied animals that have colonized all possible habitats, extending from deep seas to higher altitude (4500 m). They are, however more abundant in littoral zones of tropical sea. The two large

classes, namely, Gastropoda and Bivalvia have extended into freshwater and the former even on to land. The two classes together constitute 98 % of the known living molluscan species.

Molluscs have successfully adapted to different ecological conditions too. They act as important components in the production of biomass. They are the first living creatures to have hard shells to which the earlier man was perhaps attracted. The association of man and molluscs dates back to prehistoric times as evidenced by their remains in Mohenjodaro, Harappa and other places. Besides the aesthetic appeal of their shells, the soft parts of molluscs especially Bivalvia are consumed by men, while Gastropods are removed in large quantities from the water bodies for supply to prawn fisheries as prawn feed. This has created an adverse impact on the duck and bird population for whom molluscs are a source of food (Subba Rao, 1991). Some of the molluscs are used as potential sources of biomedical compounds, which are used in the manufacture of drugs while some are essential for the production of commercially valuable products like pearl and raw material for the shell craft industry. Marine molluscs support viable fisheries in several countries, including India. Shells, snails, squids, *etc.* are foreign exchange earners for India. However, as far as freshwater molluscs are concerned, because of their drab colours they have attracted less attention. But are known to play significant role in the public and veterinary health (Welch, 1952). Certain fresh water snails serve as intermediate hosts of several trematode parasites, spreading diseases in livestock and man, hence their role has been evaluated. Certain molluscs are also known to choke the filtered water pipe systems and water inlets of coastal thermal power plants (Subba Rao, 1991).

Studies on Indian molluscs were promoted by the Asiatic Society of Bengal as early as (1784) and also by the Indian Museum, Calcutta (1814). However, the role played by mollusc in an aquatic ecosystem has not been given much importance. The diversity of molluscs varies with the ecosystem. According to Subba Rao (1991) freshwater (Wetlands) molluscan diversity in India

includes 22 families, 53 genera and 183 species. The diversity in freshwater molluscs is comparatively poor compared to land or marine molluscs.

The molluscs, like all other animal groups are threatened by habitat alteration and indiscriminate exploitation by man. The impact of habitat disturbance on mollusc populations is not known because of lack of supporting data. Molluscs, especially the non-marine forms, are characterized by low mobility, small population and patchy and isolated distribution. As they are very sensitive to environmental changes, ongoing and future global changes will threaten their diversity (Thomas *et al.*, 2004) at local, regional and global scales. In this context, it is urgent to put into action, long-term programme 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. Mountain biocoenoses are particularly sensitive to global changes (Thuillier *et al.*, 2005). High altitude aquatic ecosystems may be especially sensitive to global changes (Theurillat and Guisan, 2001) and particularly to climate warming (Sommaruga *et al.*, 1999; Gurung, 2005) because of their small size and their relatively simple community structure. Pond constitutes ideal sentinel and early warming systems (De Meester *et al.*, 2005). Hence, study of density, diversity and seasonal influence of mollusc at YSL is expected to provide a base line data for any future monitoring.

Molluscs form one of the major part of the macroinvertebrates in wetlands by playing a vital role as link in food webs, as detritus feeder by improving quality of bottom sediments and soil condition. Hence, the study of molluscan diversity of Yashwant Lake was important. The diversity of freshwater molluscs is also good indicator of quality of water. The genera like *Thiara* and *Indoplanorbis* thrive well in slightly polluted environment. Hence, consideration of mollusc to generate essential baseline data of unassessed water body like Yashwant Lake is pertinent (Chapter 5).

The shallow areas of water body are considered as wetland (IUCN, 1990) and are one of the most productive systems in the world (Ramchandra and Solanki,

2007). The birds form simple, visible and inexpensive indicators of such system (Koskimies, 1989). The influence of wetland characteristics on bird population and their species composition is a subject of aesthetic, economic as well as scientific importance and therefore, the subject of present research efforts. If wetlands are variable in number, size and quality, through either short term or long term changes, we expect variations in their capacity to attract water birds and influence their abundance and diversity. Numerous bird watchers have reported density and diversity of various species in a wetland. However, a systematic approach is lacking and hence rarely clear and non conclusive. Many variables are known to influence population estimates of the local area. The problem is amplified while dealing with long range migrants. (Weller, 1999).

Population size and density are often used as indicators of good or poor habitat. Bird population are also considered as sensitive indicators of pollution in terrestrial as well as aquatic ecosystems (Gaston, 1974; Bock, 1997). Ornithologists in particular, play key role in addressing environmental issues and hence are being asked by the people to bring conservation on scene, as birds are of interest to a large portion of the public (Senner and Drennan, 1995). Native birds in particular are more or less perennially visible while migratory birds particularly within the lake area seem to be strongly influenced by climatic changes and immediate human impact (Traut, 2003; Rathod, 2009). When consequent environmental changes exceed the tolerance limits of species, it influences the bird distribution. The study of distribution of bird species is important as it can be related to the land use and also to the value of site conservation importance. Hence, it is important as baseline information against any changes in future and essential to develop management plan to protect the system. With this view the last Chapter (6) of the present study deals with bird diversity and density with the seasonal changes in their utilization of YSL.

It is now well established fact that persistent shifts in climate are altering the structure and function of ecosystems worldwide (Root *et al.*, 2003). Despite their outstanding taxonomic diversity, many birds share several life-history traits that have made them instrumental for evaluating the consequences of changing climate. They are widely distributed, highly mobile, their annual cycles hinge on seasonal phonological cues and they have relatively short generation time.

Thus, understanding the factors that determine the spatial distribution of birds is fundamental not only to theoretical science, but also to applied aspects such as conservation and wildlife management planning (Gittleman and Harvey, 1982).

The nature conservation debate has moved on since the Ramsar Convention came into force in 1972. Increasingly the focus is on the conservation of biological diversity, not simply at the level of species, but also in the form of genetic diversity within separate population of a particular species and ecosystem diversity. This is reflected in the provisions of the Biodiversity Convention 1992. This holistic approach to the conservation of nature contrasts markedly with the segmented approach which appears on the face of Ramsar Convention, with wetlands dissociated from their catchments, waterfowl the centre of attention and a sharp distinction drawn between wetlands included in the list of wetlands of International Importance, which are to be conserved and unlisted wetlands which are to be used, albeit wisely (David and Linda, 2000). Hence, the present study of biotic and abiotic parameter is expected to give a holistic view of status of "Yashwant Lake" that can help in planning not only management but also sustainable use in the form of developing ecotourism.