CHAPTER 1

INTRODUCTION

Biological diversity is the term given to the variety of life on Earth and the natural patterns it forms. This term was introduced in its portmanteau form in the mid-1980s by Warren G. Rosen and it has grown steadily in popularity since then. The biodiversity we see today is the fruit of billions of years of evolution, shaped by natural processes and, increasingly, by the influence of humans. It forms the web of life of which we are an integral part and upon which we so fully depend. This diversity is often understood in terms of the wide variety of plants, animals and microorganisms. So far, about 1.8 million species have been identified. Scientists reckon that there are actually about 13 million species, though estimates range from three to 100 million. Biodiversity also includes genetic differences within each species. Yet another aspect of biodiversity is the variety of ecosystems such as those that occur in deserts, forests, wetlands, mountains, lakes, rivers, and agricultural landscapes. In each ecosystem, living creatures form a community, interacting with one another and with the air, water, and soil around them. It is the combination of life forms and their interactions with each other and with the rest of the environment. These vast array of interactions among the various components of biodiversity make the planet habitable for all species, including humans (Convention on Biological Diversity, 2010).

Currently, the planet is inhabited by 5 to 15 million species in about 100 different phyla (May, 2000; Dirzo and Raven, 2003). Of these, about 1.8 million have been so far described by scientists (Hilton-Taylor et al., 2008). It has also been documented that new species are also evolving at present and over 15,000 new species are being described each year (Dirzo and Raven, 2003). Although new species continue to appear and existing species are facing extinction at a rate 1000 times that of species formation (Wilson, 2002), many biologists earlier agreed that we are in the midst of a mass extinction, a time when 75% or more of species are lost over a short geological time scale (Raup, 1994). Hambler (2004) has also reported that modern extinction rates are high at 100 to 1000 times greater than background extinction rates calculated over the eras. The last great mass extinction was 65 million years ago, at the end of the Cretaceous, when the dinosaurs went extinct. At present, it is estimated that 22% of known mammals, 14% of birds, 32% of amphibians, and 32% of gymnosperms (all well-studied groups)
are threatened with extinction (Hilton-Taylor et al., 2008). Species that were abundant within the last 200 years have gone extinct, e.g., passenger pigeons, which numbered three to five billion in the mid 1800s (Ellsworth and McComb 2003) are now extinct. India is a veritable emporium of medicinal and aromatic plants and is one among the 25 hot spots of the richest and highly endangered eco-regions of the world. It is also endowed by nature with ecosystems and tremendous genetic as well as species diversity. Because of rich diversity, India has been assigned the status of mega diversity nation along with 17 other countries of the world. India’s rich biological heritage comprises of nearly 89,451 species including 60,000 species of insects, 5070 species of mollusks, 2546 species of fishes, 209 species of amphibians, 456 species of reptiles, 1232 species of birds and 390 species of mammals (Alfred, 1998; Narang, 2000; Saharia, 2002; Bhushan and Dhawan, 2006).

For centuries, among animals, birds have held a fascination for the human world and have been a subject of study. These form a diverse group, and their colours, distinct songs and calls, and showy displays add enjoyment to our lives. From ancient civilization, these winged wonders inspire great awe, especially for their ability to fly, their ability to build extraordinary intricate nests, and not least, the brilliant colours of their plumage—feature that no human being can replicate. There are about 10,000 bird species in the world (Grimmett and Inskipp, 2003). From the poles to the equatorial forests, from the deserts to the centers of the oceans, from the highest mountains to the hearts of our cities, everywhere birds are amongst the most conspicuous forms of animal life. Of all the animals, birds have been the most well-known taxon because these act as pollinating agents and human beings have used them for feeding, communication, and also decorate their homes. Also, birds are important means of biological control of important insects, reptiles and rodents.

From time to time, large number of studies have been conducted throughout the world by various ornithologists to report avian diversity in specific regions or alternatively on different aspects of ecology, behaviour and biology of specific bird species (Tayler, 1887; Whistler, 1915; Whistler, 1928; Ali, 1941; Bell, 1946; Jones 1948; Fleming, 1968; Overton, 1972; Tekke, 1972; Realini, 1974; Vernon and Martin, 1975; Parkes, 1975; Norse and McManus, 1980; Fannes, 1981; Spina, 1982; Toor et al., 1982; Brichetti and Massa, 1984; Hussain et al., 1984; Martin, 1987; Ripley, 1988; Lainer, 1990; Daniels, 1991; Bibby et al., 1992; Gill, 1995; Andrews, 1996; Grinnell, 1999; Rahbek and Graves, 2001; Azam and Shafique, 2005; Beresford et al., 2005;
Indian sub-continent, region of rich geographical diversity, includes countries such as India, Pakistan, Bangladesh, Sri Lanka, Nepal, Bhutan and Maldives. This region has been explored for biodiversity studies including avian diversity. As per estimates of Woodcock (1980), the Indian subcontinent comprises more than 1250 species of birds. Ali and Ripley (1987) reported 1260 species of birds and Inskipp et al. (1999) later mentioned 1299 species of birds, mostly from India, accounting for about 13-14 per cent of the world’s total avian diversity.

It is worth mentioning that most of the studies were focused on general avian diversity but Ramsar convention, an intergovernmental treaty adopted in 1971 in Iranian city of Ramsar, directed the attention of ornithologists towards wetland birds. Ramsar Convention is adopted for conservation and management of wetlands along with wetland fauna especially wetland birds. This convention has defined wetlands as areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including area of marine water, the depth of which at low does not exceed to six meter. The wetlands are defined as lands transitional between aquatic and terrestrial ecosystem where the water table is usually at or near the surface or the land is covered by shallow water. These wetlands are known as “biological supermarkets” as well as “kidneys of landscape” because of extensive food chains and rich biodiversity they support by providing unique habitats for wide range of flora and fauna (Mitch and Gosselink, 1986). Wetlands are important habitats for birds and the latter use these wetlands for feeding, roosting, nesting and rearing young ones (Weller, 1978; Stewart, 2001).

According to Buckton (2007), wetlands are among the most productive ecosystems in the world and their functions include flood control, aquifer recharge, nutrient absorption and erosion control. In addition, they provide home for huge diversity of wildlife such as birds, mammals, fish, frogs, insects and plants. Birds which are ecologically dependent on wetlands are broadly defined as water birds such as water fowl, waders. However, there are several birds like some passerines, kingfishers and raptors which are dependent on wetlands and are called as wetland dependent birds (Kumar et al., 2003). Later, Kumar et al. (2005a) defined water birds and wetland dependent birds as ‘wetland birds’.
In India, in particular different habitats especially wetlands are being affected largely due to industrial development as well as anthropogenic pressure. Wetlands in India cover an area of 58.2 million hectares and are facing tremendous anthropogenic pressures as anywhere else (Prasad et al., 2002) which can greatly influence even the structure of bird community (Kler, 2002; Verma et al., 2004; Reginald et al., 2007). The bird assemblage is affected by various factors like the food availability, the size of the wetlands (Paracuellos, 2006) and the abiotic changes in the wetlands (Jaksic, 2004; Lagos et al., 2008). A great variety of species depends on wetlands. Most of these wetlands are essentially natural ecosystems stabilised over the years. The predominant wetland types in India include flood plains of major rivers, estuaries, saline expanses, freshwater lakes, mangroves, tanks, marshes, swamps, jheels, terai and man-made water bodies such as reservoirs. But wetlands are not only shrinking in surface area but are also experiencing deterioration of water quality. This poses a serious health hazard to wildlife in general, and birds in particular. Due to a number of ecological changes mainly induced by human pressure, the health and very life of these water bodies is threatened. These wetlands are under threat due to encroachment, silting, weed infestation, pollution and indiscriminate development of aquaculture. The combined threat of these factors has given rise to problems such as decrease in biological diversity, deterioration of water quality, sedimentation and shrinkage in area. It has also led to decrease in migratory bird populations, fish and other faunal productivity and prolific growth of invasive aquatic weeds. Think of a world without birds; singing, humming, flying, fluttering, flocking, diving, hopping, dipping, gliding, playing around, and spreading colour in the sky, on the ground and on water, making each day interesting and beautiful - the fascination never ends. Bird migration superbly demonstrates the complexity and the wonder of the web of life. The evolution of individual migratory strategies of many different bird species over the past tens of thousands of years represents the delicate balance of nature, which is very sensitive to the impacts of human activity (Ali and Akhtar, 2006).

In India, great efforts have been put in by amateur British India Ornithologists in comprehending avian biodiversity across its boundaries in the form of varied research papers and also some epoch making books (Dewar, 1923; Baker, 1922-30; Ali, 1941; Ali and Ripley, 1987). Similarly, Indian Ornithologists (Dharamkumarsingh, 1965; Abdulali, 1978; Chaudhary, 2001) also made efforts to explore the avian diversity before and after Independence. At this point, it
will be appropriate to recall the contributions of Salim Ali who not only pioneered avian research in India, but also accelerated it to a point of Zenith by both bringing out research papers as also historical books in Ornithology (Ali and Futehally, 1967; Ali and Ripley, 1968; Ali and Ripley, 1972; Ali and Ripley, 1983; Ali and Ripley, 1987; Ali, 1996; Ali, 2002). Bombay Natural History Society has played its remarkable role in bringing this research work by serving as the nodal centre of ornithology in Asia, in the first place, and world in its entirety.

The interaction of man with wetlands during the last few decades has been of concern largely due to the rapid population growth - accompanied by intensified industrial, commercial and residential development further leading to pollution of wetlands by domestic, industrial sewage, and agricultural run-offs as fertilizers, insecticides and feedlot wastes. The fact that wetland values are overlooked has resulted in threat to the source of these benefits (Modi et al., 2013). Therefore, it becomes critically important to assess the wetlands in terms of biodiversity as biotic factors especially birds act as important indicators of health of any ecosystem because of their ability to fly away from degraded and atrophied environmental conditions.

In the state of Haryana, a lot of work has been done on various aspects of avian diversity in different regions of Haryana (Yadav and Malewar, 1978, 1981; Gupta and Bajaj, 1997; Kalsi, 1998; Gupta and Kumar, 2009; Chopra and Sharma, 2012; Chopra et al., 2013). Whistler (1915) prepared the first ever checklist of 10 species of birds from city Hisar (Haryana). Later on, 105 species of birds were recorded from district Ambala (Jones, 1927). Yadav and Maleywar (1978, 1981) reported 203 species of avian fauna from Haryana. Kalsi (1998) recorded 161 species of avian fauna at Kalesar Wildlife Sanctuary, Haryana. However, scanty information is available on the avian diversity of wetlands, particularly in the north-west districts of Haryana. Therefore, present study was planned in district Fatehabad (Haryana) with the following objectives:

1. To identify the avian diversity in study area and to prepare birds’ inventory.
2. To assess the status and abundance of different avian species.
3. To study physico-chemical characteristics and aquatic biodiversity of selected lentic water bodies in the study area.
4. To evaluate seasonal variations in the wetland avian species of the study area.
5. Analysis of various factors (natural as well as anthropogenic) affecting the biodiversity of the selected wetlands in the study area.
CHAPTER 2
REVIEW OF LITERATURE

Birds, the most beautiful creatures of nature, are a group of vertebrates which have feathers, wings and hollow bones as aerial lifestyle adaptations. They are the most liked animals owing to their rich colouration, song, easy identification and liveliness. Out of nearly 10,000 different kinds of birds in the world, about 13 per cent are found in Indian sub-continent. The main reason for the rich bird life in India is the presence of varied habitats, from the hot arid deserts of Rajasthan to the thick tropical rain forests of the Western Ghats and northeast India (Grimmett and Inskipp, 2003). Birds are considered as important health indicators of the ecological conditions and productivity of an ecosystem (Desai and Shanbhag, 2007). Birds also play important role in wetland ecosystem and use wetlands for breeding, nesting, as a source of drinking water, for feeding and resting (Balapure et al., 2012). Any change in the physical, chemical and biological factors of wetlands affects the density, diversity and richness of avian fauna. A lot of research has been conducted worldwide on various aspects of avian fauna but only selected literature has been quoted in the present attempt laying major emphasis on wetland birds.

2.1 AVIAN DIVERSITY

Tremendous work has been done on various aspects of avian diversity across the world (Ali, 1941; Fleming, 1968; Overtone, 1972; Tekke, 1972; Vernon and Martin, 1975; Parkes, 1975; Pearson, 1975; Norse and McManus, 1980; Woodcock, 1980; Fannes, 1981; Spina, 1982; Ali and Ripley, 1983; Hussain et al., 1984; Brichetti and Massa, 1984; Grinnell, 1990; Bibby et al., 1992; Sibley and Munroe, 1993; Gill, 1995; Andrews, 1996; Raja et al., 1999; Rahbek and Graves, 2001; Anderson and Baldock, 2001; Azam and Shafique, 2005; Kumar et al., 2006; Surana et al., 2007; Lepage, 2008; Bahadauria et al., 2012; Bibi and Ali, 2013; Soka et al., 2013). Birds occur on land, sea and freshwater, and in virtually every habitat, from the lowest deserts to the highest mountains. Our knowledge of bird species can tell us a great deal about the state of the world and wider biodiversity. Patterns of bird diversity are driven by fundamental biogeographic factors, with tropical countries supporting the highest species richness (Bird Life International, 2013).

Mayr (1935) estimated 8500 species of avian fauna belonging to 2600 genera throughout the world. Ali (1941) documented 8600 bird species all over the world, whereas, Parkes (1975)
estimated about 8900 avian species belonging to 27 orders and 166 families. Some evidences are there in the favour of at least 9672 species of birds organized into 2057 genera, 144 families and 29 orders (Sibley and Munroe, 1993). A worldwide total of over 10,000 different species of birds were recognised by Bird Life International (2013), the majority (80%) occurring in continental regions, the remainder on the islands. However, the distribution of birds was reported to be uneven as the different biogeographic realms vary substantially in terms of the numbers and types of bird species they hold. By far the richest was the Neotropical realm, which held 36% of all known land bird species. This was followed by the Afrotropical (21%), Indomalayan (18%), Australasian (17%), and then the Palearctic (10%), Nearctic (8%) and Oceanic (2%) realms (Bird Life International, 2013). Recently, scientists have described well over 1.7 million of the world's species of animals, plants, insects and algae, out of which 10425 species belonged to birds (World Conservation Union, 2014).

Various researchers have documented the avian fauna of different regions of the world in the form of checklist. An inclusive list of 365 bird species in Netherland (Tekke, 1972); 120 bird species in Morton island, Australia (Vernon and Martin, 1975); 72 species in Tremiti islands, Italy (Spina, 1982); 462 species from Italy (Brichetti and Massa, 1984); 157 species of birds from Pakistan (Raja et al., 1999); 109 bird species from Chimdi lake, Nepal (Surana et al., 2007).

Giri and Chalise (2008) recorded 39 waterbird species belonging to 17 families from Phewa lake, Pokhara, Nepal. Out of this, 15 species were winter visitors, 10 resident, and 4 rare winter visitors. The highest Shannon’s index of diversity was found in February and lowest in June. Simpson’s index of dominance was found to be highest in June and lowest in February. Zakaria et al. (2009) recorded 13872 birds belonging to 100 species and 32 families in Paya Indah Wetland Reserve, Peninsular, Malaysia. Ardeidae was the most dominant family with nine species and also revealed that wetland bird species adapted a fairly unique set of microhabitat characteristics such as vegetation composition and vegetation structures, and microclimate variables were the key factors that influenced the species abundance, distribution, and diversity. Mekonnon and Aticho (2011) recorded 36 bird species from Boye wetland, Ethiopia. Among these, two species; Poicephalus flavifrons and Macronyx flavicollis were endemic to Ethiopia. Lameed (2011) recorded 135 bird species in 40 families from Dagona-Waterfowl Sanctuary at 3
different lake sites in Nigeria. Out of total, seventy-four percent were found in Gastu Lake, sixty-three per cent in Maram Lake and seventy-one per cent in Oxbow Lake. Meyrick and Colleen (2012) studied the breeding of large water-associated colonial nesting birds of north-eastern region of KwaZulu-Natal, South Africa.

Kumaran et al. (2012) periodically surveyed the Avian fauna in the selected sites of the Ousudu lake and revealed the presence of 41 species belonging to 18 families. Bibi and Ali (2013) recorded 171 species of birds from Taunsa Barrage Wildlife Sanctuary, Pakistan. Shannon-Weiner Diversity Index (H') and Simpson’s Diversity Index (D) were reported to be 3.39 and 0.93 respectively. As far as abundance status was concerned, 12 species were very abundant, 19 were abundant, 62 were very common, 16 were common and 41 species were found to be fairly common. Habitat degradation, pesticide usage and illegal hunting were identified as main threats to survival of birds.

Indian subcontinent has rich variety of avian fauna with more than 1260 species (Ali and Ripley, 1983), contributing about 14 per cent (Martin, 1987) to the total number of 9648 bird’s species of the world (Sibley and Monroe, 1990). A number of workers have made efforts to enlist the avian diversity from time to time in different geographical regions of India (Davidson and Wenden, 1878; Tayler, 1887; Barnes, 1897; Whistler, 1928; Bell, 1946; Jones 1948; Gauntlett, 1971; Yadav and Maleywar, 1978; Toor et al., 1982; Sharma et al., 1983; Bellrose and Trudeau, 1988; Joshua and Johningh, 1988; Ripley, 1988; Gupta and Shukla, 1990; Pittie, 1990; Patel, 1990; Lainer, 1990; Daniels, 1991; Raja et al., 1992; Choudhury, 2001; Harris, 2001; Dirzo and Raven, 2003; Harvey, 2003; Srinivasan and Prashanth, 2005; Chatterjee, 2008; Kumar and Gupta, 2009; Chopra and Kumar, 2011; Gupta et al., 2011; Chopra et al., 2012, Chopra et al., 2013; Chopra and Sharma, 2014).

Mishra and Humbert-Droz (1998) identified 34 bird species including 14 of water birds from Tsomoriri Lake and adjoining Nuro Sumdo Wetland in Ladhakh, India. Jayson (2000) recorded 41 species of birds belonging to 25 families in Manglavanam mangroves and reported that major detrimental factors to the ecosystem were dumping of waste in the lake, encroachment of land and uncontrolled growth of weeds. Kumar (2002) reported 18 species of birds from large lake in zoological garden Thiruvahanthapuram. Kumar et al. (2006) assessed 310 wetland bird species from India. Dhakate et al. (2007) reported 149 wetland bird species in Corbett Tiger Reserve. Anatidae and Scolopacidae were the
dominant families followed by Ardeidae and Charadriidae. There were 40 wetland bird species that visited Corbett landscape in winter and returned to Eurasia for breeding.

Mohan and Gaur (2008) assessed the avian diversity around Jajiwal wetland and recorded 62 species of birds belonging to 15 orders and 26 families. Out of these, 26 species were water-birds and 36 were water-associated birds. Waders like Pond Heron, Purple Heron, Red-wattled Lapwing, Black-winged Stilt, Egrets and Bitterns were the dominant water-birds, whereas, Kites, Kingfishers and Passerines were reported to be the major water-associated birds. They further reported that highest number of birds species were observed during winter season when anthropogenic activities were minimum.

Yardi et al. (2008) studied the avifauna of the Jaikwadi Sanctuary and observed 64 residential and 24 non-residential bird species. They further reported that the shore water covered with weeds provided habitat for bird species like Pheasant-tailed Jacana, Egrets, Herons and Purple Moorhen; shallow clear water provided habitat for species like Northern Pintail, Gadwall, Northern Shoveller, Brahminy Duck and Spot-billed Duck; deep water supported Common Coot, Common Pochard, Tufted Pochard and Red crested Pochard and rocky lands acted as habitat for species like Cormorants and Raptor birds.

Bhatt et al. (2009) studied the avifaunal diversity and density in Anekere wetland, Karnataka for a period of three years and observed 44 bird species including water birds and water-associated birds. Prominent residents were Moorhens, Jacanas, Herons and Cormorants, whereas, migratory birds included ringed plovers, wagtails and storks. They also observed high tolerance power of purple moorhen and tree ducks towards highly fluctuating habitat and human activities.

Deshkar et al. (2010) reported 53 wetland bird species from Masar village pond, Vadodara and also correlated the avian faunal diversity with physico-chemical parameters of wetland. Density and species richness of birds were reported to be highest during winter when migratory population arrived and minimum during monsoon when the migratory population left the area and the resident species were engaged in the nesting activities.

Harney et al. (2011) recorded 38 species of birds belonging to 12 orders from three waterbodies in Chandrapur district of Maharashtra. Maximum bird species were recorded during spring, early monsoon and late winter while comparatively less number of species were observed during late
summer, late rainy season and early winter. Padmavathy et al. (2011) studied the avifaunal diversity in Ousteri freshwater wetland, Puducherry, India, and recorded 109 species. Guptha et al. (2011) surveyed 27 selected wetlands from four districts of Tamil Nadu, namely Coimbatore, Trichy, Perambalore and Thiruvarur and recorded 14, 208 birds belonging to 78 species and 33 families, out of which 47 species of birds were categorized as wetland bird species and 31 species as water-associated species.

Dutta (2011) studied avian diversity in two wetlands of Jalpaiguri District, West Bengal. Although the climatic and geophysical conditions of both the wetlands were almost similar, a total of 80 bird species were recorded from one wetland and the other supported only 42 species. The relationship between habitat characteristics and community structure varied throughout the study period and it was suggested that the birds responded differently to different kinds of habitat characteristics.

Das and Saikia, 2011 revealed the presence of 39 species of water birds belonging to 16 families from Deepor Beel Ramsar site of Assam and Anatidae was found to be the most diverse family throughout the study period. While studying the diversity of avian fauna of wetlands of Gadchiroli (Maharashtra) Tijare (2011) recorded 33 species of water-birds and water-associated birds. Maximum numbers of species were observed in winter season, while relatively less number of bird species were encountered in the summer season.

Pawar (2011) reported 56 species of birds representing 46 genera, 29 families and 11 orders from the mangroves of Uran coast, Maharashtra. Avifauna of the order Passeriformes was found to be dominant and was represented by 11 families, followed by order Ciconiiformes with 5 families. The species diversity comprises 33 residents, 20 winter visitors and 3 occasional visitors. He also claimed the loss of biodiversity in the mangrove due to urbanization, industrialization and pollution caused by discharge of transporting materials along with industrial effluents.

Chilke (2012) recorded 58 species of birds belonging to 9 orders and 29 families from Bamanwada lake and its surrounding area in Chandrapur district of Maharashtra and order Passeriformes was reported to be the most diverse. Bhadauria et al. (2012) carried out a survey to understand the status of birds in 27 wetlands within 100 km radius of the Keoladeo National Park, and estimated 75 species of water-birds.
Balapure et al. (2012) made observations on the occurrence and diversity of water-birds in Barna reservoir and recorded 64 species of water birds belonging to 7 order and 12 families. Anatidae was the most dominant family in terms of species richness and population. They also correlated fourteen environmental variables with species richness of wetland birds and most of the variables were positively correlated with species richness except water depth, dissolved oxygen, total hardness and chloride. They also observed the congregation of large numbers of waterbird species for feeding, resting and roosting due to abundance of food (macrophytes, macrobenthic organisms and free swimming organisms). It was also reported that accessibility to food resources due to the shallow water, availability of exposed mudflats and shorelines for roosting, low anthropogenic activities and presence of submerged as well as emergent vegetation patches further increased prevalence of birds in the area.

Thakur and Paliwal (2012) recorded a total of 68 species of wetland birds (water-birds as well as water-associated birds) belonging to 46 genera, 15 families and 6 orders from Sukhna lake of Chandigarh.

Ekhande et al. (2012) reported 58 species of birds in and around Yashwant lake located on Toranmal Plateau in mid Western Satpura. Species richness and density of total birds was found to be highest in winter season (due to presence of migratory birds) and lowest in monsoon season. Shannon Wiener diversity index and evenness followed the same trend i.e. maximum in winter season and minimum in monsoon season. When correlation of bird density was calculated with various abiotic (physicochemical) and biotic parameters of water, a negative correlation was established with almost all parameters except DO, Transparency, water cover and total hardness. Kumaran et al. (2012) surveyed the avian fauna in the selected sites of the Ousudu lake and revealed the presence of 41 species of birds belong to 18 families.

Joshi and Shrivastava (2012) explored avian diversity of Tawa Reservoir and its surrounding area at Hoshangabad district and recorded 74 bird species belonging to 33 families and 14 orders. Availability of food in different seasons, different type of vegetation, agricultural land, water availability in surrounding areas, field activities were the favorable conditions observed for birds’ survival in this area. Modi et al. (2013) reported 11 different species of birds from Shahwadi wetland of Ahmedabad. Most of the birds recorded were either resident or resident cum local migratory species. Of all the birds recorded, cormorants were found in the highest density in the wetland. The waders (marsh birds) in the area such as Pond Herons, Red
Wattled Lapwing and Cattle Eagrets were found to be wading through the shallow waters of the pond and intermediately roaming along the dry margins of the wetland.

Bhadja and Vaghela (2013) documented 40 species of birds from Lalpari lake and Ali reservoir at Rajkot city in Gujarat. Low species diversity in the study area was attributed to human interference, constructional activities and noise due to plying vehicles because nesting and foraging sites were destroyed due to these activities which further caused migration of birds to other places and gradually decline in their population. They also reported that vegetation was important factor affecting the diversity of avian fauna. Deka and Nath (2013) recorded 99 avifaunal species from Chandubi Tectonic Lake, Assam and maximum number of avian species were recorded during the winter season and minimum during the monsoon season.

Koladiya et al. (2013) recorded 56 avifaunal species belonging to 42 genera under 25 families in Pena Thathh wetland in Greater Rann of Kachchh. Pradhan et al. (2013) recorded 61 species of water-associated and terrestrial birds belonging to 27 families in and around Ansupa lake, Odisha and proposed that control of habitat destruction, exploitation of its wilderness, human interference and pollution by tourism could be helpful in conservation of birds.

Malik and Joshi (2013) reported 21 migratory bird species in Asan wetlands of Doon Valley and revealed that availability of nutrients in wetland played a significant role in the selection of particular ecological niche by the migratory avifauna. Ghorade et al. (2014) carried out a study to have a preliminary assessment of status, distribution, food and feeding activities, migration pattern of aquatic birds in Jaikwadi reservoir at Paithan and recorded 64 residential and 24 nonresidential species of birds. Maximum number of species were recorded in winter due to more food availability and favorable climatic conditions for nesting and roosting.

Harney (2014) recorded 49 bird species belonging to 13 orders and 37 families from Dudhala lake, Bhadrawati, Maharashtra. It was also reported that avian fauna in the study area was affected by pollution, human activities and lack of maintenance of lake. Harney (2014) also observed 55 species of birds in and around Ghotnimbala lake, Maharashtra and projected that birds at the lake were affected by organic pollution, distribution by human activities and lack of maintenance of place.

Vyas et al. (2014) studied spatial variations of waterbird diversity at Upper Lake, Bhopal and recorded 68 species of water birds. It was also observed as a general trend that the birds preferred sites with ample food and least human disturbance.
Sharma and Saini (2014) revealed the occurrence of 21 species of birds belonging to 5 orders and 6 families, out of which 6 species were resident, 14 species were migratory and 1 species was occasional visitor. Correlation coefficients between different diversity indices revealed significant negative correlation between diversity and dominance, diversity and evenness and dominance and evenness.

While studying the avi-faunal diversity of Satapur water body (Telangana), Vithalrao et al. (2014) encountered 69 species of water-birds and water-associated birds and reported that undisturbed habitat supported more richness and diversity due to favorable factors like food availability, water, climate and vegetation.

Koladiya et al. (2014) observed 56 bird species from Lakhara, a fragmented wetland inside the Kachchh Biosphere Reserve (Gujarat). Out of total recorded species, the aquatic bird represented 31 species belonging to 26 genera, 14 families and 5 orders and rest of the 26 species under 18 genera, 13 families and 6 orders were terrestrial bird species.

Patel and Acharya (2015) recorded 30 species of wetland birds belonging to 5 orders and 11 families from Gota Lake of Ahmedabad (Gujarat). Ciconiiformes was found to be the most dominant order. Out of total 30 species, 20 were resident and 10 were migrant species. Most of the migratory species were winter visitors except Lesser Whistling-Duck and Pheasant-Tailed Jacana which were summer visitors. Based on the frequency of sightings, Red-Wattled Lapwing (*Vanellus indicus*), Black headed Ibis (*Threskiornis melanocephalus*), Black Ibis (*Pseudibis papillosa*), Glossy Ibis (*Plegadis falcinellus*), Cattle Egret (*Bubulcus ibis*), Little Egret (*Egretta garzetta*), Large Egret (*Casmerodius albus*), Median Egret (*Mesophoyx intermedia*), Indian Pond Heron (*Ardeola grayii*), Little Cormorant (*Phalacrocorax niger*), Common Moorhen (*Gallinula chloropus*) and White-breasted Water Hen (*Amaurornis phoenicurus*) were the common species inhabiting this Lake, while Yellow-Wagtail (*Motacilla flava*), White-Wagtail (*Motacilla alba*), Pheasant-Tailed Jacana (*Hydrophasianus chirurgus*), Darter or Snake Bird (*Anhinga melanogaster*), Lesser Pied Kingfisher (*Ceryle rudis*) and Small Blue Kingfisher (*Alcedo atthis*) were rarely sighted.

As far as avian diversity of wetlands in Haryana is concerned, many researchers took keen interest to study the wetland avifauna of the state from time to time such as Whistler (1915); Yadav and Maleywar (1978); Gupta and Bajaj (1997); Kalsi (1998); Gupta and Bajaj (1999); Harris (2001); Gupta and Bajaj (2000); Gupta and Bajaj (2002); Harvey (2003);
Bahuguna et al. (2008); Gupta and Kumar (2009); Tak et al. (2010); Chopra and Kumar (2011); Gupta and Kaushik (2011); Chopra and Sharma (2012); Chopra et al. (2012) and Chopra et al. (2013).

Gupta and Bajaj (1997) observed migratory wetland birds of Brahm Sarovar (Kurukshetra). They also reported the arrival of Wigeon and Shoveller in January, Mallard and Red-crested Pochard in December and Coots in October. Kalsi (1998) recorded 161 species of birds from Kalesar wildlife sanctuary comprising 112 resident and 49 migrant species. Gupta and Bajaj (2000) recorded migratory rare lapwing species, White-tailed Lapwing (Vanellus leucurus) at water ponds at Kurukshetra. Gupta et al. (2009) reported 92 species of birds belonging to 62 genera and 37 families, which comprises of 46 Non-Passerine and 46 Passerine bird species from Kurukshetra University, Kurukshetra (Haryana).

Kumar and Gupta (2009) studied avian fauna in six wetland habitats of Kurukshetra, namely, Brahma-Sarovar, Bhor Sidan Crocodile Sanctuary, National Fish Breeding Centre in Jyotisar, Paddy fields and village ponds situated around Kurukshetra. A total of 54 species of water-birds and water-associated birds belonging to 36 genera and 15 families distributed in 5 orders have been recorded around Kurukshetra. The rich diversity of wetland birds recorded during the study may be because of availability of varied sources of feed as well as foraging. Study had also revealed that anthropogenic activities like mass bathing in holy ponds, cutting of emergent and fringed vegetation, draining of water, release of sewage, throwing of domestic garbage, weeds, and developmental activities like construction of roads were major threats to the bird diversities of these aquatic habitats.

Tak et al. (2010) recorded 31 wetland bird species belonging to 22 genera from Hathnikund Barrage. Common Pochard (Aythya ferina), Red-crested Pochard (Rhodonessa rufina), Bar-headed Goose (Anser indicus) and Mallard (Anas platyrhynchos) were added for the first time to the checklist of the area. Forty seven wetland bird species were reported at Hathnikund barrage by Gupta and Kaushik (2011). Out of these, 25 species were winter migratory, 9 local migratory and 13 species were resident. It was revealed that unscientific mining in the river belt and encroachment on the wetland area by villagers, alleged bird watchers and ornithologists.

Gupta et al. (2012) revealed 46 species of wetland birds from Suraj-Kund, Amin village (Kurukshetra). Out of these, 13 species were resident, 22 winter migratory, 8 local migratory and
remaining 3 were summer migratory. They also mentioned that water pollution due to dumping of discarded material, decreasing water capacity of pond by siltation, encroachment and accelerated eutrophication as major threats to birds in rural ponds of Haryana.

Gupta and Kaushik (2012) studied the avian fauna of a rural pond in village “Raipur Rodan” in Karnal district in Haryana and reported 64 species of wetland birds belonging to 10 orders and 17 families. In terms of their abundance status 36 species were common, 17 species were uncommon, 6 species were very common and 5 species were rare. They further reported that this village pond was dotted with migratory birds in winter season every year upto 2008, but after that, no migratory birds were seen in the pond because of the termination of this vibrant pond into a doom caused by siltation due to run-off water and pollution of water due to the addition of over excessive decaying cow dung and other domestic organic waste.

Gupta et al. (2012) documented 164 species of birds belonging to 16 Orders and 44 families from the Khaparwas Bird Sanctuary, Haryana. Out of these, 104 species were residents, 45 species were winter migratory, 9 species of birds local migratory, 5 species were summer migratory and one species of bird was Straggler. As far as abundance status was concerned, 64 species of birds were Occasional, 60 species Common and 40 species were Uncommon.

Chopra and Sharma (2012) reported 88 species of bird species from wetlands of “Lower Shivalik Foothills”. On the basis of frequency of sighting, 37 species were designated as abundant, 30 as common, 18 as occasional and 3 as rare species. They also observed that direct human interventions were major influencing factor on distribution and composition of avian fauna in and around the wetlands.

Kaushik and Gupta (2013) observed 60 species of wetland birds belonging to 6 orders and 13 families from Asan barrage, Uttarakhand. Rudy Shelduck (*Tadorna ferruginea*) is the most dominant bird followed by Common Coot *Fulica atra*, Red-crested Pochard (*Rhodotissa rufina*), Common Pochard (*Aythya ferina*) and Mallard (*Anas platyrhynchos*). It was observed that Rudy Shelduck preferred Yamuna River waters rather than the traditional still pools, ponds and reservoirs.

Kumar and Gupta (2013) recorded 57 species of wetland birds including water-birds, water-dependent and water-associated bird species belonging to 37 genera and 16 families from Chhylchhila wildlife sanctuary situated in Kurukshetra district (Haryana). Out of these, 33 were winter migrants, 2 summer migrants and 22 were resident species. They also revealed that
anthropogenic activities like livestock grazing, soil digging, encroachment, use of forest wood as a source of fuel, cutting of emergent and fringed vegetation were the major threats to the biodiversity.

Chopra et al. (2013) reported 79 avian species of water birds and water-associated birds belonging to 56 genera, 10 orders and 23 families from Sultanpur National Park, Gurgaon. The order Anseriformes was the most dominant represented by 18.9% of the total identified wetland avian species followed by Charadriiformes (17.72%), Passeriformes (16.45%), Ciconiiformes (15.18%) and Pelecaniformes (5.06%).

Aggarwal (2014) recorded 16 species of wetland birds from three water bodies viz. Karnal lake, Kapal Mochan religious pond and Bhor Saidan crocodile breeding centre. Out of these, 12 species were reported to be water-birds and 4 species as water-associated bird species. Order Ciconiiformes was found to be most dominant followed by order Passeriformes, Coraciiformes and Gruiformes.

Kaushik and Gupta (2014) revealed 65 species of wetland birds belonging to 9 orders and 16 families from Yamuna River, Haryana. Out of these, 31 species were winter migratory, 26 species resident, 7 species were local migratory and one species of bird (Eurasian Stone Curlew) was summer migratory.

Kaushik and Gupta (2014) reported 59 species of birds representing 10 orders 17 families from Palwal rural pond, Kurukshetra. Out of these, 30 species were winter migratory, 17 species resident, 10 species were local migratory and two species of birds were summer migratory. The presence of Purple Moorhen and Common Moorhen in large numbers was indicating the over excessive growth of hyacinth and water reeds making it an ideal place for these birds which were the harbingers of total eutrophication of a certain water body. The other birds seen in the pond were White-breasted Waterhen, Red-wattled Lapwing, Large Egret and Median Egret. Pond Herons were in few numbers. Black winged Stilts were in more number thus indicating the presence of sludge in water and its shallowness.

2.2 LIMNOLOGY

Water of adequate quantity and quality is the key to integrity of an environment. Essentially, all life depends upon the water for being a major component of living organisms and an elixir of life. The extensive work of Forel (1892-1904), who is regarded as the father of
modern limnology gave an impetus to study this subject intensively. The physico-chemical characteristics of water affects the chemical and biological reactions in the aquatic organisms by light penetration for photosynthesis and oxidation the organic substances which further affect the growth, abundance and composition of aquatic organisms.

Other contributions to the limnological studies of water bodies were provided from time to time throughout the world (Hodgetts, 1921; Hutchinson, 1932; Prescott, 1938; Gonzalves and Joshi, 1946; Philipose, 1959; Philipose, 1967; George, 1966; Verma and Shukla, 1968; Venkateswarlu, 1969; Munnawar, 1970; Cole, 1975; Sprules, 1977; Verma et al., 1978; Descy, 1979; Barroin et al., 1982; Adoni, 1985; Bhati and Rana, 1987; Hosmani, 1988; Bais and Agrawal, 1993; Sinha and Sinha, 1993; Stemberg and Lazorchak, 1994; Agbeti and Smol, 1995; Canfield and Jones, 1996; Chandrasekar, 1996; Ahmad, 1996; James and Hewens, 1996; Attayde and Bozelli, 1998; Vareethiah and Haniffa, 1998; Straile and Geller, 1998; Barbieri et al., 1999; Borse and Bhave, 2000; Beaugrand et al., 2000; Li et al., 2000; Bianchi et al., 2003; Ariyadej et al., 2004; Dodson et al., 2005; Burns and Galbraith, 2007; Chellapa et al., 2008; Adesalu and Nwankwo, 2008; Bhat et al., 2009; Bhatnagar and Sangwan, 2009; Thirugnanamoorthy and Selvaraju, 2009; Shayestehfar et al., 2010; Ahmad et al., 2011; Dhembare, 2011; Purushothama et al., 2011; Senapati et al., 2011; Stomp et al., 2011; Bhuju et al., 2012; Balakrishana et al., 2013; Manral and Khudsar, 2013; Schabhuttl et al., 2013; Chopra et al., 2014).

In this part of the chapter, an attempt has been done to review the literature related to physico-chemical and biological (Phytoplankton and Zooplankton) characteristics of water.

2.2.1 Physico-chemical parameters of water bodies

The aquatic ecosystem is very crucial to mankind as these have vast uses like drinking water supply, electricity generation, transportation, fisheries, irrigation. High industrial growth and increasing population in the present era are badly influencing the physical and chemical parameters of water bodies. Therefore, a proper understanding, assessment and conservation strategies of these indispensible resources are required.

Several investigators have studied the physico-chemical dynamics of varied lentic water bodies with the intent to assess the water quality (Freiser and Feranando, 1966; Descy, 1979; Barroin et al., 1982; Vyas et al., 2007; Ekhande et al., 2013; Pushpam et al., 2013). Freiser and Feranando (1966) reported positive correlation of pH with alkalinity while Verma and Shukla
(1968) observed higher concentration of chloride in water due to organic pollution and observed that concentration increased during the summer season. Venkateswarlu (1969) and Jana (1973) also observed the similar findings.

According to Trivedy and Goel (1984), an excess amount of TDS in water tends to disturb the ecological balance due to suffocation in aquatic fauna even in presence of fare amount of DO. Free CO$_2$ limit the growth of phytoplankton species while electrical conductance, pH, total alkalinity and nitrate at higher concentration increase the productivity status of lake (Kumar and Sharma, 1991). Alkaline water with calcium, bicarbonates, phosphorus and nitrate in higher concentration trigger algal blooms and tend to increase eutrophic nature in water bodies (Sarwar and Wazir, 1991).

Bhatnagar and Sangwan (2009) studied the physic-chemical parameters of religious pond and found out that TDS, electrical conductivity, hardness, total alkalinity and chloride were above the permissible limit in temple tank because of anthropogenic activities due to washing, bathing and discharge of temple wastes by the visitors and priests.

Bhat et al. (2009) studied the water quality of ponds of Lucknow and concluded that sewage discharge, dumping of waste materials and street runoff were prominent source of pollution as indicated by the values of physico-chemical which were detected above permissible limits. Due to increased human population, anthropogenic impacts on lakes are increasing almost in every part of world which makes it mandatory to study the factors causing degradation of these natural beauties and also, to find out the ways to threat management (Bhuju et al., 2012).

Napit (2012) correlated various physicochemical parameters with aquatic biodiversity and water quality. Phani and Sreeramulu (2013) reported a positive correlation of pH with dissolved oxygen, whereas, a negative relation was observed between water temperature and dissolved oxygen.

Naik (2013) reported high concentration of chloride as pollution indicator and also observed that most important sources of chloride in the fresh water were the discharge of domestic sewage and farm drainage. Chopra et al. (2014) observed high BOD of pond water when compared with ICMR standards and water remained alkaline through the study period which can be attributed to the use of soaps and detergents during mass bathing.
2.2.2 Phytoplankton

Phytoplankton is the pioneer of an aquatic food chain. The productivity of an aquatic environment is directly correlated, with the density of phytoplankton (Narasimha, 2013) as they play an important role as primary producers and thus can affect higher trophic levels by providing nutritional bases for zooplankton and subsequently to other invertebrates, shell fish and finfish (Emmanuel and Onyema, 2007).

The physico-chemical factors are directly related with their productions. Phytoplankton have significant correlation with DO, TDS, BOD, alkalinity, pH, CO$_2$, phosphate and nitrate (Philipose, 1959; Gonzalves and Joshi, 1964). Bharathi and Hosmani (1973) surveyed hydrobiology of lakes and ponds disturbed by animal and human population. It was observed that heavily polluted ponds showed decreased production during summer and different species of algae appeared as blooms. The phytoplankton is the base of most of the lake food webs and fish production is linked to phytoplankton. Seasonal variation of productivity is related to variation in temperature and photic conditions (Sondergaard and Sand-Jensen, 1979; Spencer and King, 1989). Pandey et al. (1995) studied the relationship of seasonal abundance of phytoplankton with various abiotic factors and it was reported that Bacillariophyceae and Euglenophyceae were abundant in winter season. High turbidity reduces light availability which precludes extensive photosynthesis and resulting low phytoplankton growth and density (Ariyadej et al., 2004).

Hosmani (2008) studied the ecology of Euglenophyceae and reported that they responded to low concentration of dissolved oxygen, high temperature and oxidisable organic matter. It has been reported that diversity and density of phytoplankton acts as biological indicators for evaluating the quality of water and eutrophication status and well qualified way for water pollution studies (Hoch et al., 2008). Pollution indicator algal forms have been reported from Cyanophyceae, Bacillariophyceae and Chlorophyceae (Adesalu and Nwankwo, 2008; Chellappa et al., 2008). Wazniak and Marshall (2009) reported the dominance of chlorophytes, diatoms, cyanobacteria and cryptophytes in different seasons.

Diatoms are used in environmental assessment and monitoring because of having ranges and tolerances for pH, nutrient concentrations, suspended sediments and other human disturbances (Laskar and Gupta, 2009) thus works as good indicators of water pollution (Singh et al., 2010). Mustapha (2010) showed the total phytoplankton to be positively correlated with
phosphate, nitrate, DO, sulphate, carbon dioxide, total alkalinity, pH, conductivity and TDS. Only transparency and temperature showed negative correlation with the phytoplankton. According to Rajagopal et al. (2010) Nitzschia bilobata, Navicula membrane, Anabaena aequalis, Fragilaria oceanic and Scendesmus annatus represented the pollution indicating taxa.

Sharma et al., (2010) found positive correlation between Chlorophyceae and DO, pH and calcium whereas; calcium had negative correlation with Bacillariophyceae during winter season. The most pollution tolerant species were those of Navicula, Oscillatoria and Euglena. Nitrate and phosphate establish positive co-relation with phytoplankton density. These factors support huge growth of Cyanophyceae and sometimes produce algal bloom (Senapati et al., 2011). Mary Kensa (2011) reported 48 species of phytoplankton from two perennial ponds of Kulasekharam area, Tamilnadu and found a positive correlation of water temperature with the plankton productivity.

Ahangar et al. (2012) revealed the species richness of Anchar lake, Kashmir and reported the highest plankton density in the summer season. Species diversity was also found to be high in the summer season and the dominant members of plankton community were from Bacillariophyceae, Chlorophyceae and Cyanophyceae. Abubakar (2013) correlated various physic-chemical parameters with phytoplankton genera and observed a strong positive correlation of temperature and dissolved solids with plankton population. He also reported the dominance of Chlorophyceae over Cyanophyceae and Bacillariophyceae.

Kadam et al. (2014) reported that variation in physico-chemical parameters caused fluctuation in diversity of phytoplankton. They also concluded that dominant species acted as important environmental indicators as these species received the full impact of habitat which was effective tool to assess the changes caused by anthropogenic activities.

2.2.3 Zooplankton

The zooplankton in Indian water bodies consists of diverse assemblage of major taxonomic groups. Many of these forms have different environmental and physiological assemblage. The number, type and distribution of these organisms present in any aquatic habitat provide a clue on the environmental condition prevailing in that particular habitat. Among the zooplankton rotifers respond more quickly to the environmental changes and used as a change in water quality (Gannon and Stemberger, 1978) and widely used as bio-indicators of
environmental pollution (Sladecek, 1983) as they can easily collected, identified and also respond quickly to stressful conditions including nutrient loading (Pace, 1986) and fish densities (Canfield and Jones, 1996). Jhingran (1997) recorded positive correlation of total zooplankton with potassium, total hardness and iron.

Maximum zooplanktons were observed in winter probably due to low temperature, high content of DO and low velocity (Khanna et al., 2000). However, Salaskar and Yeragi (2003) reported inverse relationships of total zooplankton with temperature, positive correlation with free CO$_2$ and DO and negative with total hardness, phosphate and nitrate. Community size of selected major zooplankton can be used as bio-indicators of environmental changes as they are composed of organisms with high environmental sensitivity (Pinto-Coelho et al., 2005; Dodson et al., 2005). Few species of Ostracods can tolerate and flourish in highly polluted lakes due to better adaptability and decreased competition from other species (Padmanabha and Belagali, 2008). It is seen that many environmental factors interact to provide conditions for the growth of zooplankton both spatially and seasonally (Khanna et al., 2009).

Ferdous and Mukhtadir (2009) have done number of studies in different countries and reported that zooplankton population size was correlated with biotic and abiotic factors (temperature, transparency, pH, dissolved oxygen, alkalinity and chloride). Rotifers, Copepods, Cladocerans and Ostracods were found to be present in all the cases and their species variation decreased in polluted water. Brachionus calyciflorus, Thermocyclops sp. and Argyrodiaptomus sp. were found to be good indicators of eutrophic condition, whereas, Brachionus dolabrotus, Karetella tropica and Hexarthra mira were found to be good indicators of high turbidity due to suspended sediments.

Shayestehfar et al. (2010) observed negative correlation of air and water temperature with DO and an inverse relationship of DO with Cladocera, Ostracoda, Copepoda, Rotifera. Mustapha (2010) reported total zooplankton to be positively correlated with phosphate, nitrate, DO, conductivity and TDS, whereas a negative correlation was observed between total zooplankton with carbon dioxide, transparency, temperature and total alkalinity. Progressive increase in alkalinity favored the production of zooplankton along with, simultaneous presence of DO and hard water (Joshi, 2011).

The abundance of Ostracods showed significant positive correlation with pH and negative correlation with hardness. Total zooplanktons have significant positive correlation only
with pH and negative correlation with turbidity, phosphate and nitrate (Joseph and Yamakanamardi, 2011).

The diversity and density of zooplankton depends upon the nutrient condition of water body, abiotic factors, DO, food chain, soil-water chemistry and stated that to monitor the aquatic ecosystems and integrity of water the zooplankton has been used as bioindicators (Dhembare, 2011). Interspecific and intraspecific factors influence the distribution and abundance of zooplankton and availability of phytoplankton affects the zooplankton by affecting female fertility (Ahmad et al., 2011).

According to Kumar et al. (2011), rotifers are nutrient tolerant species which, in total number as well as diversity are seen to be typical for high productivity and eutrophic wetland. Rotifera was dominated among all the zooplanktonic groups in all the seasons. However the diversity of zooplankton varied from season to season and the maximum diversity was recorded in winter season while minimum was observed in monsoon season Some members of Rotifera and Cladocera are reported as pollution indicator (Mallik et al., 2011; Virani and Makode, 2011; Patrick et al., 2012; Ekhande et al., 2013).

Dutta and Patra (2013) studied the diversity and seasonal abundance of zooplankton and its relation to physico-chemical parameters (dissolved oxygen, temperature, salinity, pH and other physicochemical parameters). They also reported that various anthropogenic activities such as entry of agricultural run offs like pesticides, insecticides from surrounding agricultural fields seems to be the major cause of eutrophication and zooplankton were good bio-indicators to assess the pollution of any freshwater body.

Manoharan et al. (2013) studied zooplankton diversity of three temple ponds in Tiruparankundram, Tamil Nadu and revealed that the zooplankton community of these three ponds was found to be dominated by the copepods, rotifers, cladocerans and ostracodens respectively. High rotifer density has been reported to be a characteristic of eutrophic lakes (Balakrishna et al., 2013).

Verma et al. (2013) reported 54 genera of zooplankton from Futera anthropogenic pond of Madhya Pradesh and observed the highest number of zooplankton in the month of August and lowest in the month of January. They also revealed that dominance of rotifera and crustaceans indicated the eutrophic nature of the water body.
Gholap (2014) assessed species diversity indices of zooplankton from Sadatpur reservoir, Maharashtra and reported that protozoa, rotifer, copepod, cladocera, decapoda, branchiopoda and ostracoda mainly constituted the net zooplankton groups of the fresh water and increased their abundance during summer probably due to the water quality, decaying vegetation, increased levels of organic matter in the sediment.

Sharma et al. (2015) carried out ecological study on two perennial ponds of Jammu region and rotifers contributed maximum species diversity in both the ponds followed by cladocera, copepoda and protozoa. *Brachionus calciflorus*, *B. Caudatus*, *B. quadridentatus*, *Keratella tropica*, *Philodina*, *Filinia* and *Testudinella* were dominant and common in both the ponds. *Cerodaphnia* sp., *Alona* sp., *Daphnia* sp., showed dominance among Cladocera and *Mesocyclops leuckarti* and *Nauplius* were recorded in most of the seasons among Copepoda. Presence of *Brachionus angularis*, *B. falcatus*, *Keratella cochlearis*, *K. tropica*, *Lecane luna*, *Bosmina* sp., *Chydorus sphaericus*, *Daphnia* sp. and *Mesocyclops leuckarti* in both the ponds indicated the higher trophic status of pond as these species were indicator of eutrophication.