STUDIES ON ZOOPLANKTON COMMUNITY STRUCTURE, COMPOSITION AND DYNAMICS IN FEW TROPICAL FRESHWATER LAKES

Thesis submitted to

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Doctor of Philosophy in Zoology

By

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Certificate

This thesis entitled **"Studies on zooplankton community structure, composition and dynamics in few tropical freshwater lakes"** submitted by **KARUTHAPANDI. M, Reg. No: 5669** for the award of degree of Doctor of Philosophy in Zoology of Manonmaniam Sundaranar University is a record of bonafide research work done by him and it has not been submitted for award of any degree, diploma, associateship, fellowship of any University or Institution.

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Declaration

I hereby declare that this thesis entitled **"Studies on zooplankton community structure, composition and dynamics in few tropical freshwater lakes"** submitted by me for the Degree of Doctor of Philosophy in Zoology is result of my original and independent work carried out under the guidance of **Dr. B. Xavier Innocent, M.A., M.Sc., M.Phil., Ph.D.,** in the Department of Zoology, St. Xavier's College (Autonomous), Palayamkottai, and it has not been submitted for the award of any degree, diploma, associateship or fellowship of any University or Institution.

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M. Karuthapandi

Contents

List of Abbreviations

APHA	American Public Health Association
APSFD	Andhra Pradesh State Forest Department
BCG-MR	Bromo Cressol Green-Methyle Red
°C	Celsius
Ca	Calcium
Cl^-	Chloride
D	Simpson's diversity
d	Dominance
EDTA	Ethylene-di-amine tetra acetic acid
H'	Shannon diversity
Hmax	Shannon maximum diversity
J'	Pielou's Evenness
Km^2	Square kilometre
LnE	Log value of evenness
LnS	Log value of species richness
Mg	Magnesium
mg/L	milligram per litre
mS	Micro semen
N	Number of individuals
NH3-N	Ammonia nitrogen
NH4	Ammonia
$N-NO_2$	Nitrite
$N-NO_3$	Nitrate
No/L	Number per litre
ppm	Parts per million
$P-PO_4$	Phosphate
Q=B/T	Quotation ratio between Brachionus and Trichocerca
r	Simple correlation
S	Species richness
µm	micron

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Chapter I
Introduction

India has water resources in terms of 29,000kms of rivers, 3.15million hectares of reservoirs, 2.35 million hectares of ponds and tanks, 0.2 million hectares of floodplain 33wetlands (Ayyappan, 2007). Freshwater environment is an important ecosystem that provides significant socioeconomic, ecological services and supports the livelihood of the local communities. These freshwater habitats harbor the rich biological resources (Vass, 2007).

Freshwater makes up only 0.01% of the World's water and approximately 0.8% of the Earth's surface. Yet this tiny fraction of global water supports at least 100000 species out of which approximately 1.8 million-almost 6% are described species (Dudgeon *et al.,* 2005). Freshwater ecosystem throughout the world is under increasing threats and pressures due to both local and global changes (Dudgeon *et al.,* 2005 and Pattnaik, 2007). Besides, freshwater bodies like rivers, lakes, tanks and ponds are overstrained and poisoning in various ways like industrial wastes, sewage, and agricultural runoff with chemical wastes and excess nutrients. Discharges of pollutants can degrade the quality of water, as well as affect the health of its aquatic ecosystem. Wetzel (1992) reported that freshwater of the world are collectively experiencing accelerating rates of qualitative and quantitative degradation. Dudgeon *et al.,* (2005) documented threats to global freshwater biodiversity under five categories like overexploitation, water pollution, flow modification, distraction and degradation of habitat and invasion of exotic species. These combined and interacting influences have resulted in the population decline and range reduction of freshwater biodiversity worldwide.

Similarly, Balian *et al.,* 2008 revealed that a freshwater ecosystem provides essential ecosystem services such as fishes, water for drinking and food production as well as transportation and cultural purposes. However, freshwater may be the most challenged ecosystem in the world and decline in biodiversity is far greater than terrestrial ecosystem (Sala *et al.,* 2000; Covich *et al.,* 2004 and Dudgeon *et al.,* 2005). Maximum biodiversity of freshwater ecosystems occurs where wetland and littoral habitat heterogenecity interfaces with pelagic region (Wetzel, 1996b). Further, global awareness of the need to conserve freshwater biodiversity seems limited. Protection of one or a few water bodies cannot serve the purpose of conservation all freshwater biodiversity within a region.

1.1 Zooplankton

Freshwater animals are extremely diverse and include representatives of all Phyla. There are several micro invertebrate animals which are restricted to surface water column and are collectively called as plankton. The term "plankton" refers to those microscopic aquatic forms having little or no resistance to currents, living free-floating and suspended in open or pelagic waters. Phytoplankton is primary producers and are grazed upon by zooplankton and other aquatic organisms. Freshwater zooplankton comprises mainly protozoans, rotifers, cladocerans and copepods (APHA, 1985 and Wetzel, 2001). They are widely varied and highly organized group covering a great diversity of life modes, adapted to exhibit a relatively passive existence, distributed throughout the water mass and feed on small food particles. They are poorly developed in running waters (Morgan, 1980).

Zooplankton are suspended in water with limited power of locomotion and subjected to dispersal by turbulence and other water movements. They feed on bacterioplankton, phytoplankton, detritus and other zooplankton. Usually denser than water and constantly sink by gravity to lower depths and have limited locomotion, but the rotifers, cladocerans and copepods (microcrustaceans) often more extensively in quiescent freshwater ecosystems. Among the various zooplankton communities, rotifers, cladocerans and copepods are the most abundant in freshwater ecosystems and constitute the food source of organisms at higher trophic level. It is a most important biotic component influencing all the functional aspects of an aquatic ecosystem, such as food chains, food webs, energy flow and cycling of matter (Dadhick and Saxena, 1999; Sinha and Islam, 2002). There are several limnological studies in India mainly focused on molluscs, fish and birds, whereas studies on zooplankton are fairly neglected (Vanjare, 2010), and their heterotrophic activity plays a key role in the cycling of organic materials in aquatic ecosystems and used as bioindicators in the assess count of species composition and community structure, which may be affected by eutrophication (Licandro and Ibanez, 2000; Rajashekar *et al.,* 2009 and 2010).

The presence and dominance of zooplankton species play a vital role in the functioning of freshwater system and the seasonal changes in zooplankton species are clearly related to the water quality and biological regime of the aquatic environments. It is probably the most uniformly distributed component of the secondary producers and relatively, is easier to study than the benthos and fish (Morgan, 1980). In general, the secondary producers consist of invertebrate and vertebrate components and portray a complex trophic relationship which may change during the life cycle of a species or from one site to another.

Physicochemical values and zooplankton community consideration of different environmental factors in the study of limnology, is basic to the growth and abundance of zooplankton. The physicochemical parameters and nutrient status of water body play an important role in governing the production of plankton which is the natural food of many species of fishes. Zooplankton populations in small ponds are subjected to extreme fluctuations, the causes of which are not adequately understood (Patil and Gouder, 1985). Zooplankton constitute important food source of many omnivorous and carnivorous fishes and also support the necessary amount of protein for the rapid growth of larval carps (Rahman and Hussain, 2008). Zooplankton has fast growth rates and therefore can provide meaningful and quantifiable indicators of ecological change in short as well as long timescales (Paerl *et al*., 2003). Hence, zooplankton can serve to evaluate the condition of water body and can be used to assess the overall health of any of the freshwater body.

Sharma and Sharma (2009) viewed that a large number of earlier works in India deal with scattered reports of various taxa or record only planktonic species. But, the zooplankton is linking the primary producers and higher trophic levels. Community size of selected major zooplankton can indicate the trophic status and also can help to understand the shifts in the trophic status (Ferdous and Muktadir, 2009). It is also known to respond quickly to environmental conditions (Schindler, 1987), only few attempts have been made to use the zooplankton community to indicate quality of aquatic ecosystems (Gaiser and Lang, 1998). The taxonomic composition of the zooplankton community should reflect the presence and distribution of submergent plants in the freshwater environment and zooplankton taxa have different preference for trophic state (Berzins and Pejler, 1989). These communities are very sensitive to environmental changes and thus are of considerable potential value as water quality indicators (Gannon and Stumberger, 1978). It can also be used as an indicator of changing trophic status of an aquatic ecosystem (Blancher, 1984 and Pinto-Coelho *et al.,* 2005). It is a good indicator of water quality, because it is strongly affected by environmental conditions and responds quickly to the changes (Pawar and Mushan, 2012 and Karuthapandi *et al.,* 2013c).

1.2 Importance of zooplankton

There are many studies which recommends zooplankton community as regional bioindicators of eutrophication (Attayde and Bozelli, 1998; Straile and Geller, 1998; Pinto-Coelho *et al.,* 2005; Burns and Galbraith, 2007; Stemberg and Lazorchack, 1994), acidification (Pinel-Alloul *et al.,* 1990), disturbances by agriculture (Dodson *et al.,* 2005; Patoine *et al.,* 2002) and nutrient loading (Dodson, 1992 and Sharma, *et al.,* 2008). The changes in zooplankton abundance, species diversity and its community composition are usually considered to be good indicator of environmental changes (Sharma *et al.,* 2008). Very few reports are available on variation of zooplankton community in the aquatic ecosystems of Northwestern part of Andhra Pradesh (Seenayya, 1971; Rao, 1972; Ahsan, 1982; Reedy, 1984; Chandrasekhar and Kodarkar, 1994, 1995 and 2008; Chandrasekhar, 2004, 2007 and Ranjan and Reedy, 2007).

1.3 Major zooplankton communities

1.3.1 Rotifera

Rotifers are pseudocoelomate animals with a size of 50-600µm and commonly known as “wheel animalcules” because of their characteristic ‘wheel organ’. They are ubiquitous, occurring in all types of freshwater and brackish water habitats and are bilaterally symmetrical, lives either single or in colonies and free moving. They feed on bacteria, detritus, micro algae and invertebrates. The morphology of the rotifers is highly variable, and usually a rotifer consists of head (very rarely there is a neck), body and foot. There are two specific organs, the corona on the head and mastax in the pharynx are the characteristic features of the rotifers, and their classification is based on these two characters. The corona helps in movement and grinding the food in coordination with the jaws. The corona locates terminally on the head in swimming and sedentary species and ventrally in species that crawl. In swimming rotifers the corona is composed of two concentric ciliated bands called the trochus and the cingulum. The head of several species of rotifers has lateral earlike ciliated appendages called auricles. The cilia of the corona are reduced in parasitic forms. Seven structural types are recognized in the organization of the mastax, which consists of a muscular sac and a series of hard jaw parts comprising the trophi. Trophi include the lamellate pair of rami fused by distal ends in the fulcrum. A pair of plates called the unci are supported proximally by the upper ends of the rami and connected distally to the club-shaped manubria. All parts of the trophi are attached by ligaments. The internal organs are located in the body cavity, including the digestive system consists of mouth, mastax, esophagus, stomach, digestive gland, intestine, cloaca, and anus; the excretory system consists of terminal cells of the protonephridium, a pair of protonephridial canals emptying into a urinary bladder.

The reproductive system consists of ovaries, yolk gland, oviduct, and cloaca. The muscle and nervous systems are well differentiated. The presence of eyespots, dorsal and lateral organs (cirri) often serve for vision and species determination. The foot is often absent in many forms, if present, it has a pedal gland and often ends in one or two toes.

Rotifers have a very fast reproductive rate and generate dense populations, sometimes even change the colour of water. Heterogenesis is often characteristic of rotifers, alternating sexual and parthenogenetic reproduction which can produce males and mictic females. Only one order, the Bdelloida, is obligate parthenogenetic. Sexual dimorphism is strongly expressed in many species especially males are dwarfed, very reduced, rarely seen, and not known in all species. Most of the rotifer descriptions, taxonomy, and classification are based on female individuals only. In sexual reproduction, the females produce mictic eggs, which can produce mictic males and females. After fertilization, resting eggs develop into mictic females, and after a resting period they give rise to amictic females. These females reproduce parthenogenetically, quickly increasing the population. Many species of rotifers are the indicators of specific environments.

Nearly, 95% of species are reported from freshwater habitats and remaining 5% from marine environment (Sharma, 1996). Phylum rotifera divided into two classes Pararotatoria and Eurotatoria. Pararotatoria consist of a single order Seisonacea, representating marine species. Class Eurotatoria is classified into subclass Bdelloidea and Monogononta. The subclass monogononta has three orders such as Plomina, Flosculariaceae and Colothecaceae, which are further classified into several families (Segers, 2002).

Rotifera play a considerable role in the food web of plankton and benthos of freshwater bodies. Their ecological success is based on their distinct pattern of reproduction: a large part of them, the Monogononta, are famous for their unique mode of reproduction with parthenogenetic females and a rather rare appearance of sexuality with males. On the other hand, the Bdelloidea completely abstain from sexuality resorting to parthenogenetic.

Rotifer comprise an integral link in the aquatic food-chain, the part played by them in the biological productivity is of considerable significance partly because of their rapid turn-over rates and metabolism and partly because many species largely feed on detritus and bacteria and are consequently to a great extent independent of autotrophic production.

1.3.2 Cladocera

Cladocerans, commonly known as water fleas, are minute crustaceans generally ranging in size from 0.2-5mm. This micro crustacean belongs to the order Cladocera, class Branchiopoda under the Phylum Crustacea are grouped into 10 families. Cladoceran is a primarily freshwater monophyletic group an important component of the microcrustacean zooplankton. The trunk and appendages of most cladoceran are enclosed in bivalve carapace. Eye and ocellus are usually present. Antennules are uniramous, while antennae are biramous with 2-4 segments per branch. Four to six pairs of trunk limbs are more or less similar in shape. The global diversity of cladocerans is more than 600 species. Whereas in India, it is about 137 species (Chatterjee *et al.,* 2013), but only close to a hundred species have been described in detail by Michael and Sharma (1988).

Cladoceran constitutes a significant component in the food web of stagnant waters. Most species are filter feeders and also feeds on smaller zooplankton, bacterioplankton and algae (Murugan *et al.,* 1998). They usually reproduce by cyclical parthenogenesis and populations are mostly dominated by female. Sexually produced diapausing egg is resistant to desiccation and other unfavorable conditions. Though cladoceran are often the target groups of zooplankton studies, only limited reports are available on their ecosystem diversity and role in aquatic productivity in freshwater environs of this country (Sharma and Sharma, 2009). Cladocerans are one of the important group for biomonitoring studies and are an important part of trophic cascades of the aquatic system and highly responsive against pollutants, it can even react to very low concentration of contaminants (Ferdous and Muktadir, 2009; Sharma and Chandrakiran, 2011).

1.3.3 Copepoda

Copepods live in all aquatic biotopes, size ranges from 4-5mm, body has different shapes like elongated, fusiform or cylindrical, and contains 16 somites. The first six are generally fused into a cephalosome; the remaining 10 are thoracic and urosomites. Antennules, antennae, mandibles, maxillules and maxillae are attached with cephalosomes, 2-6th merameres are the thoracic somites (Th1-Th5). The fifth pair is generally modified, asymmetrical or reduced. Urosomes is limbless and ending in a furca formed of two more or less symmetrical rami, adorned with setae. Copepods typically have sexual reproduction and sex is separated. The eggs hatch into a larva called nauplius, undergoes six moulting cycle to reach the adult stage. Calanoid copepod collects their food by filtration and cyclopoids generally prefer macerating their prey. These are ubiquitous components of freshwater zooplankton communities. The composition of these communities reflects the functioning of these systems. Important abiotic and biotic factors are related to interactions within plankton communities and often depend on their nutrient needs. Copepods are good biological indicators and form excellent food for zooplanktivorous fish.

1.4 Physiogeography of Northwest region of Andhra Pradesh

The state of Andhra Pradesh is blessed with 7 major (1,73,025 ha), 26 medium (48,660 ha) and 69 minor (12,584 ha) reservoirs, 4,804 perennial (1,82,861 ha) and 15,447 long seasonal (1,79,816 ha) tanks (Piska, 2001). Northwestern part of the Andhra Pradesh consists of 10 districts including capital city Hyderabad. This region has more than 5 major reservoirs and several tanks and ponds. Among the 10 districts Hyderabad is the major metropolitan city located in the heart of Dakshinapatha or the Deccan plateau of the India subcontinent at latitude 17° 20’N and longitude 78° 30’E. The Hyderabad city is fast developing and spread over 1552 km which includes many major and minor manmade wetlands (Parthasarthy, 1983). There about 169 water bodies in the Greater Hyderabad Municipal Corporation area including tanks and ponds, of which nearly 87 lakes are categorized as highly polluted in the HMDA area (Ranjan and Reedy, 2007). Hyderabad is the capital city of Andhra Pradesh with different types of freshwater ecosystem such as lakes, man-made raw water reservoirs, irrigation tanks, ponds, pools including temporary water habitats. The major man-made reservoirs in Hyderabad are Hussainsagar, Osmansagar, Himayatsagar and several other midsized lakes, tanks and ponds.

The city of Hyderabad is one of the fast growing economy as well as urbanization, due to industrial and information technology parks for sustainable development of the state as well as the country. It creates overcrowding of population beyond the bearing capacity in the city and attracts the nearby villagers for gainful employment. Further, due to unpredictable urban development and unplanted sewage system leads to pollution of the freshwater bodies, and encroachment of the freshwater habitats for human settlement and industrial development. So there is a need to explore of freshwater faunal communities and its taxonomic composition, status of freshwater ecosystem by using basic limno-ecological techniques and to find out the bioindicators in the urban/semi-urban areas, Most of the earlier studies have concentrated on major freshwater faunal groups, but the study on micro invertebrate faunal community in freshwater ecosystem is scanty.

Hence the present work was undertaken to analyze the taxonomic composition and changes in zooplankton communities, due to the changes in trophic status which has occurred over a long period and with an aim of enhancing the knowledge of freshwater zooplankton diversity in Northwest region of Andhra Pradesh. Exclusively urban water bodies were chosen for the assessment of trophic status.

1.1. Objectives

- ❖ To explore the taxonomic composition of the zooplankton from water bodies of Northwest Andhra Pradesh region.
- ❖ To assess the zooplankton community structure, composition and dynamics from three different freshwater habitats such as reservoir, tank and pond.
- ❖ To study the zooplankton diversity index that can serve as tool for trophic assessment of the freshwater habitats.
- ❖ To bring out the indicator species to assess the water quality and identify efficient management strategy of the freshwater bodies.

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Chapter II
Review of Literature

Zooplankton are heterogeneous assemblage of free floating microscopic animals, it consist of various invertebrate groups, such as protozoa, rotifera, cladocera and copepoda. They play crucial role in the food chain and energy flow in the aquatic ecosystem through interlinking the autotrophs and heterotrophs. Thus, zooplanktonic communities inhabiting different water bodies differ in their diversity and density and also upon the physicochemical conditions of water. It has been considered as bioindicator and meaningful biological tool for assessing the trophic status of the freshwater environ. Further, it would help the conservation and management of the freshwater habitats and the faunal communities. The present literature review comprises of earlier findings in relation to zooplankton community structure, composition, diversity and dynamics in freshwater ecosystems of India in particular, Andhra Pradesh.

2.1 Studies on zooplankton

A number of researchers such as Ayyappan *et al.,* (1980), Chakravarthy (1983), Balkhi *et al.,* (1987), Fasihuddin and Kumar (1990) and Choudhary and Singh (1999) reported on different aspects of zooplankton groups inhabiting Indian freshwaters ecosystem. Apart from the general works, there were specific studies made on zooplankton and their ecology by Karande and Inamdar (1961), George (1966), Nayar (1970), Krishanamurty and Visvesvara (1966), Sreenivasan (1967), Moitra and Bhowmick (1968), Michael (1968), Bernice (1971 and 1972), Seenayya (1973), Prabhavathy and Sreenivasan (1977), Nasar (1977). Studies on lifecycle of zooplankton by Michael (1962), Navaneethakrishnan and Michael (1971), Murugan and Sivarmakrishnan (1973 and 1976), Murugan (1975), Murugan and Venkataraman

(1977); on cyclomorphosis by Nayar (1964), (1965), Arora (1966), George (1966), Sharma, (1976); on feeding relationship by Arumugaswamy *et al.,* (1971), Kader and Krishnaswamy (1975), Royan (1976); diurnal variations by George (1961), Krishnamoorthi and Visweswara (1965), Michael (1966), Khan *et al.,* (1970), Saksena and Adoni, (1973), Jana (1974), Verma and Gupta (1974) and on biochemical aspects by Bernice (1971 and 1972), Khan and Siddiqui (1971).

Earlier studies on ecology and abundance of zooplankton were carried out by Rahman and Hussain (2008), Majagi and Vijayakumar (2009), diversity relation with physicochemical parameters by Das *et al.,* (2005), Sharma *et al.,* (2008), Manjare *et al.,* (2010) and Datta (2011). Physicochemical and biological parameters, abundance and seasonal variation of zooplankton were studied by Sabu and Abdul (1998), Sunkad and Patil (2004) and Islam (2007). Zooplankton studies were from floodplain wetlands of Kashmir (Khan, 1987), Bihar (Rai and Datta, 1988), South Bengal (Sugunan, 1995; Khan, 2002, 2003; Ganesan and Khan, 2008), Assam, (Sharma, 2005b, 2010 and Sharma and Sharma, 2008) from Manipur and few others (Sharma, 2009). In addition to these, further studies on zooplankton dynamics by Venkateshwarlu *et al.,* (2011), biomass by Joseph and Yamakanamardi (2011); seasonal variation composition and diversity of tropical lakes by Singh (2000); Patil and Auti (2005); Chattopadhyay and Barik (2009); seasonal abundance by Basu *et al.,* (2010) were also made. Zooplankton diversity of Jorhat district, Assam was studied by Bordoloi *et al.,* (2013). Zooplankton composition, diversity and trophic status of few freshwater habitats of Hyderabad were reported by Karuthapandi *et al.,* (2012, 2013b,c).

Apart from these, the studies on specific groups of zooplankton communities, like rotifer, cladocera and copepod were also made.

2.1.1 Rotifera

Earlier studies on rotifers in India includes the works of Donner (1949), George (1961), Pasha (1961), Arora (1961, 1962, 1963a,b, 1965, 1966), Nayar (1965, 1968), Nayar and Nair (1969), Michael (1966, 1973), Naidu (1967), Wycliffe and Michael (1968), Wulfert (1966), Vasisht and Gupta (1967), Vasisht and Dawar, (1968), Vasisht and Battish, (1969, 1970, 1971), Rajendran, (1971). Later, studies include Dhanapathi (1973, 1974a,b, 1975, 1976, 1978, 2000a,b, 2004) Das and Akhtar (1976), Sharma (1976, 1977, 1978a,b, 1979, 1980a,b, 1983, 1986, 1987, 2010, 2011) Sharma and Michael (1979), Laal and Nasar (1977), Tiwari and Sharma (1977), Patil (1978), Arshaduddin and Khan (1991), Tijare and Thosar (2008), Vanjare and Kalpana (2010) and Karuthapandi (2013a).

Ecology of freshwater rotifers of India was initiated by Sewell (1934) and since then there have been studies by a large number of workers. The Indian literature indicates proliferation of synecological studies while autecological data so far confined to fewer studies i.e., Qadri and Yousuf (1982), Yousuf and Qadri (1986), Rao and Sharma (1985), Deb *et al.,* (1987) and Sarma and Rao (1990, 1991), However, some important contributions on this aspect are those by George (1966) Moitra and Bhowmick (1968). Michael (1969), Nayar (1970), Vasisht and Sharma (1976, 1977), Tiwari and Sharma (1977), Jyoti and Sehgal (1979), Yousuf and Qadri (1981a,b), Laal (1984) Sandhu *et al.,* (1984), Sharma and Pant (1984), Chourasia and Adoni (1986), Khan *et al*., (1987), Haque *et al.,* (1988), Sharma (1992), Sharma and Dudani (1992), Ramesh (1993) and Sharma and Naik (1996). Ecology of rotifers of lake Surinsar Jammu (Jammu and Kashmir State) was reported by Slathia and Dutta, (2008).

The systematic studies on Indian freshwater rotifer were initiated more than a century ago by Anderson (1889) reported 47 species from Calcutta (Kolkata) and its environs. Later Murray (1906), Edmondson and Hutchinson (1934), Hauer (1936 and 1937), Donner (1949), Brehm (1951) and Pasha (1961) have brought to light over160 species from the Indian sub-continent and Tibet. Sharma and Michael (1980) listed 241 species and later in 1998, reviewed the taxonomic status of the Indian rotiferan fauna. The other contributions made by Sharma (1987, 1990) and Patil and Gouder (1989) are notable. The rotifer fauna of only two states *i.e.* West Bengal (148 spp.) and Meghalaya (127 spp.) are well documented. Sudzuki (1989) has listed 260 rotifer species that are reported from India in the composition of oriental fauna. An earlier synopsis on taxonomic studies of Indian Rotifera by Sharma and Michael (1980) referred 241 species belonging to 21 eurotatorian families and 48 genera. Later 310 species spread over 24 families and 60 genera were included in a state of art report by Sharma (1991a), Segers (1994) recorded about 300 species. Further 325 species (24 families and 62 genera) are documented by Sharma (1996). The recent studies on rotifers made by Sharma and Sharma (2005) upgraded the list to 354 species and later, Vanjare (2010) has further presumed over 363 species from India.

The world wide rotifera comprises about 2030 known species classified in three main groups, the marine Seisonida (3 species), the Monogononta (1570 species) and the unique, exclusively parthenogenetic Bdelloidea with 461 clonal species. Segers, (2007) reported annotated list of rotifer, the checklist and database, in its present version, contain 2127 species, of which 109 are presently considered *species inquirenda*, and some 800 synonyms or alternative genus and species level names. The vast majority of the valid names belong to Monogononta (1566), Bdelloidea (461) and Seisonida (3) is less diverse.

A number of workers (Green, 1972; Pejler, 1977; Fernando, 1980a,b; Shiel and Koste, 1983; Dussart *et al.,* 1984) reported distinct abundance of *Lecane* and *Brachionus* species in tropical fauna from different parts of world. Similarly, the greater species richness of these genera is also reported from India except northern latitudes. According to Sharma (1996), Indian literature fails to establish any definite correlation between rotifer abundance and abiotic factors, only few isolated papers deal with importance of temperature, pH and alkalinity but impact of biotic factors is mainly overlooked.

In Andhra Pradesh studies of rotifers were undertaken by Naidu (1967), Dhanapathi (1973, 1974a,b, 1975, 1976, 1978, 1997, 2000 and 2004), Rao and Chandra Mohan (1976 and 1982), Arshaduddin and Khan (1991), Chandrasekhar (2007, 2010 and 2011) were notable. Dhanapathi (2000) reported 91 species of rotifers belonging to 18 families, of which 18 species are new records to India and 9 are new species and one new genus. Where as a review study on freshwater rotifers of Andhra Pradesh by Karuthapandi *et al.,* (2013a) brought out 113 species which consists of 112 species of monogononta belonging to 03 orders, 22 families, 38 genera and only one species belongs to Eurotatoria. The species richness is high in Lecanidae which consist of 26 species followed by Brachionidae which has 24 species.

2.1.2 Cladocera

The systematic studies on Indian freshwater cladocera was initiated by Baird (1859), followed by several workers *viz*. Biswas (1964a,b, 1965, 1971) Das and Akhtar (1970), Patil (1976), Nasar (1977), Qadri and Yousuf (1977). Cladoceran of Rajasthan was studied by Biswas (1971), Nayar (1971), Venkataraman (1990), Tamilnadu by Michael (1973), Venkataraman and Krishnaswamy (1984) and

Venkataraman (1983). Little Andaman by Venkataraman (1991), West Bengal by Venkataraman (1998), Nilgiri Biosphere Reserve by Raghunathan and Rane (2001), Damodar River by Venkataraman (2003), Melghat Tiger Reserve by Rane (2005), Kashmir by Siraj *et al.,* (2006), Sharma and Chandrakiran (2011), North East India was studied by Sharma and Sharma (2009a, 2010 and 2012), Maharashtra by Padhye and Kotov (2010) and Madhya Pradesh including Chattisgarh by Rane (2011).

Fernando (1980a,b) recorded 61 species of Cladocera from India with specific information about the absence of large Cladocera. Sharma and Michael (1987) noted the presence of 87 species, later Michael and Sharma (1988) recorded 93 species from India, of which, over 60 species are from tropical and subtropical region and 15 to 20 species from altitudinal lakes and northern latitudes. Raghunathan (1989) reported 106 species and Sharma (1991b) updated the list to 109 species which was confirmed later by Murugan *et al.,* (1998). Among the 109 species of cladocera in India, three species were synonymised by Orlova (1998). 49 species of cladocera were reported from Bihar, among these 29 species are new records to Bihar and two species are new records to India (Sharma, 2001). An account of 190 species belonging to 49 genera and 10 families of cladoceran has been reported from India, of which 18 species are endemic to India (Raghunathan and Kumar, 2002). According to annotated checklist of Indian cladocera by Chatterjee *et al.,* (2013), 137 species are valid from India.

Further cyclomorphosis of cladoceran was also observed by Venkataraman and Krishnaswamy (1986) and Manimegalai *et al.,* (1986). Seasonal studies on freshwater cladocera were studied by Raghunathan (1990). Freshwater Cladocera of West Bengal was reported by Venkataraman (1991). But there is yet limited information on faunal and ecosystem diversity of these microcrustaceans from different states of India in general (Sharma and Michael, 1987; Michael and Sharma, 1988; Sharma, 1991b) and in aquatic ecosystems of its conservation areas in particular.

The global diversity of cladocerans is more than 600 species, of which 137 species have been recorded from the Indian subcontinent which extends from 6°N to 37°N latitude and covers an area of 4.5 million km^2. The equatorial region has few *Daphnia* species, all belonging to the sub-genus *Ctenodaphnia* while the more northern parts have more species of *Daphnia*. The limnetic Cladocera lacks the carnivorous Polyphemidae and Leptodoridae at lower latitudes (equatorial). The common limnetic species of the equatorial region are eurytopic and extend throughout the subcontinent (Fernando and Kanduru, 1984). *Leydigia acanthocercoides* inhabits aquatic weeds in polluted ponds (Alam and Khan, 1998). Venkataraman (2003) reported that the following species *Ceriodaphnia cornuta, Moina micrura, Macrothrix spinosa* and *Chydorus barroisi* can be used as an indicator of pollution.

Only 30 species of Cladocera belonging to 17 genera were reported from Hyderabad, Andhra Pradesh by Patil (1986), Siddiqi and Chandrasekhar (1993) and Chandrasekhar (2004). Later two more species were added *viz. Bosmina longirostris* and *Bosminopsis deitersi* by Karuthapandi *et al.,* (2013d). Further there is no extensive study on the cladoceran fauna of Andhra Pradesh.

2.1.3 Copepoda

Globally there are about 2,814 species of copepods reported from freshwater (Geoff and Defaye (2008). The studies on Indian Copepoda were made by Seghal (1960, 1967); Reddiah (1964a,b), Rajendran, (1971 and 1973), Radhakrishna and Reddy (1977a,b). Uttangi (2001) reported about 120 species of free living freshwater copepods are known from India. Studies on copepod ecology were carried out by Ray *et al.,* (1966) and Reddy (1977).

2.2 Limnoecology of zooplankton

The lentic ecosystem has been classified into different zones like littoral and limetic, of which littoral region is extremely heterogeneous and productive; often lie at the interface between the terrestrial drainage basin and the open water zone of the lake. These complex wetland-littoral areas are exceedingly important in regulating the lake metabolism (Wetzel, 1979, 1990, 1995). Since a majority of lakes of the biosphere are small and relatively shallow, they are metabolically active wetlands and littoral components dominate the productivity of majority of the world lakes.

The multipurpose use of water for rapid industrial growth, reservoir development, agriculture and aquaculture are real needs (Michael, 1980). Further, one has to place these demands in relation to inputs of natural organic wastes from human use which increasingly eutrophicate our limited freshwater. The above said reason not only affects the limnoecology but all the zooplankton diversity and its dynamics. These problems are briefly highlighted so that Indian limnologist take cognizance of the priorities to be set in lighting our country's practical demands on one hand and the pure academic pursuits of exploring and understanding the structure and dynamics of aquatic system on the other.

According to Goldman and Horne (1983) the most efficient method to advance knowledge in limnology is through comparative studies of different types of lakes within the same geographical area, and the extensive studies will be able to reveal the actual diversity of zooplankton from freshwater bodies. There is a need for complementary research to explain biological results with physicochemical features (Ka *et al.,* 2006).

Limnological studies on Hussainsagar lake have been conducted by several workers like Ahsan (1982), Babu Rao *et al.,* (1981), Muley (1987), Siddiqi and Khan

(2002), Siddiqi and Rao (1995), and Chandrasekhar (2007). Later, Chandrasekhar and Kodarkar (2008) reported the progressive change in the water quality and zooplankton community of Hussainsagar Lake in Hyderabad.

The zooplankton community of lakes, Sars, wetlands and ponds in Jammu-Kashmir Himalayas was examined (Raina and Vass, 1993) and significant variations in rotifers and crustacean distribution pattern was encountered. Some species having wide tolerance limits are more frequent while a few species due to their rigid environmental demands are restricted to few water bodies. Such species serve as good indicators of trophic evaluation.

Microcrustacea are often included in routine limnological studies undertaken from different parts of this country. Yet, a review of the published literature provides limited information on their ecology, ecosystem diversity and role in aquatic productivity. Inadequate analysis of their communities resulting in incomplete species inventories or inclusion of anomalous reports of taxan and warrants confirmations (Sharma and Sharma, 2009).

Carlin (1943) correlated the seasonal changes of zooplankton with the changes in calcium and pH. Chourasia and Adoni (1985) observed a seasonal variation within the lake was strongly influenced by the climatic conditions, principally by the rainfall. Zooplankton showed a positive correlation with pH and chloride in a shallow eutrophic lake (Sagar) in India. The maximum density of zooplankton is in summer and minimum in winter season but the species diversity of rotifer is high.

The reservoirs are a great source of aquatic biodiversity and their interrelationship plays an important role in making the system viable. Several researchers have studied various aspects of plankton population in different reservoirs. Sugunan (1980) has documented the temporal variations in plankton population of Nagarjunsagar. Zooplankton species and their dominance in Rewalsar Lake, Himachal Pradesh studied by Ramesh (1993), it also reveals rotatorians are the main contributors to the variation in species composition.

Limnological studies of a tropical freshwater tank of Jabalpur were evaluated by Patil *et al.,* (1982). Patil and Panda (2003) reported irregular distribution of rotifer population specifically in the month of January and December in fish tank at Bibinagar, Hyderabad. Raghunathan (1990) reported six species of cladocera from Chingleput tank, Tamilnadu and the most dominant species were *Ceriodaphnia cornuta, Diaphanosoma exisum* and *Moina micrura*.

There are several studies on zooplankton of ponds of India. The primary attempt on the seasonality of Indian freshwater plankton was that of Sewell (1934) on the fauna of the pond in the Indian Museum Compound, Calcutta. George (1961, 1966) studied plankton ecology of five fish ponds and rotifer from shallow pond in Delhi. Limnoecological studies on freshwater ponds of Hyderabad were carried out by Zafar (1964), Munawar (1970), Seenayya (1971) and Rao (1972). Zooplankton diversity in a temporary pond, Attapur, Hyderabad was studied by Karuthapandi *et al*., (2012).

Maruthanayagam *et al.,* (2003) studied that community size of zooplankton was the highest in rainy season while the lowest density of zooplankton was in summer due to higher temperature in Thirukkulam pond, Mayiladuthurai, Tamilnadu in India. Some hydrobiological factors affecting plankton production, seasonal periodicity in a freshwater pond in West Bengal was studied by Moitra and Bhattacharya (1965), Jana (1973). Rotifer population of two ponds at Pilani, Rajasthan was explored by Nayar (1970).

Approximately 75% of the known species occur in littoral area of lake and ponds (Pennak, 1957), besides judging from the large plankton literature, it is obvious that most plankton communities average between 40-500 rotifer per liter, with population in excess of 1000 per liter being unusual. Further, several earlier studies emphasized that the zooplankton are indicators of pollution/eutrophication (Attayde and Bozelli, 1998).

2.3 Zooplankton as biological indicator

The species assemblage of zooplankton also may be useful in assessing water quality (Gannon and Stemberger, 1978). Because of their short life cycles, plankter responds quickly to environmental changes and hence the standing crop and species composition indicates the quality of the water mass in which they are found. They strongly influence certain non biological aspects of water quality and in a practical sense; they are a part of water quality (APHA, 1985).

Cladocera have been used as indicators as well as test organisms for estimation of toxicity levels of pesticides and other environmental pollutants (Frear and Boyd, 1967; Muirhead-Thompson, 1971; Canton and Adema, 1978). Among the various zooplankton groups, rotifers respond quickly to environmental changes and are considered good indicators of water quality and trophic conditions because of their short generation time and fast population renewal (Fuller *et al.,* 1977; Pejler, 1981; Sladecek, 1983; Pontin and Langley, 1993). Many authors have suggested that both rotifer species composition and abundance could be used as indicator of trophic state and also provided lists of rotifer species that are indicative of different trophic status (Berzins and Pejler, 1989; Mateeva, 1991; Duggan *et al.,* 2001). Rotifers are considered as most sensitive indicator of water quality (Ali *et al.,* 1990), generally *Brachionus* species (Radwan, 1976; Sladecek, 1983) and particularly *Brachionus* *calyciflorus* is good indicator of eutrophication (Sampaio *et al.,* 2002). Besides the species composition, numerical abundance is considered as a more sensitive indicator of trophic status (Gunn and May, 1997; Paturej, 2008). According to few authors (Maemets, 1983; Nogueira, 2001) much abundance of *Brachionus* can be considered as a biological indicator of eutrophication. The common characteristic of the eutrophic ecosystem is the presence of few dominant species with high density (Green, 1993).

The observations on Indian indicator species were firstly made by Arora (1961, 1966), this aspect has subsequently drawn attention of several other workers and some notable reports are those by Rao and Chandra Mohan (1977b), Sampath *et al.,* (1979), Sharma (1983, 1986, 1992), Saksena (1987) and Sharma and Dudani (1992). Sladecek (1983) proposed $Q_{B/T}$ quotient based on ratios between *Brachionus*: *Trichocerca* species to depict trophic status of different ecosystem or even individual samples. Sharma and Dudani (1992) and Sharma (2000, 2010) successfully applied it to certain aquatic ecosystem under the Indian conditions.

In the oligotrophic localities the number of rotifer species does not exceed 200/L. On the contrary, in eutrophic areas the rotifer density ranges between 1000 to 2000/L. Eutrophic water body has rich rotifer diversity (Dhanapathi, 2000a).

2.4 Bio-monitoring

Fast urbanization and industrialization in India is leading to steep increase in waste generation. The waste management is not adequately addressed resulting in large part of uncollected and untreated wastes getting into water courses. This situation coupled with steep increase in water demand leading to degradation of water quality. Due to growing diversity of pollutants, it’s increasingly becoming difficult to measure all the pollutants. Many of the pollutants which are not regularly monitored may be very important due to their environmental significance. In applying water quality biomonitoring program, the major constraint was specialized knowledge in identification of biological communities which exist in water (Trivedi, 2007).

As the population grew, the wastewater returns runoff and precipitation mainly flow into the lake. These developments, in the contest of inadequate investment in wastewater treatment facilities, poor infrastructure maintenance, low operating capital and poor governance, have resulted in the lake reverting to hypereutrophic state, and now pose a health risk (Magadza, 2007).

The lakes are often seen as targets for development due to their fertile soil and supply of freshwater. However uncontrolled exploitation of their resources and water leads to their shrinkage (or) degradation beyond a point of recovery (Dalwani, 2007). Widespread encroachment of lentic water bodies such as lakes and reservoirs by invasive species pushed a serious threat to applicability and use of inland freshwater bodies for drinking and irrigation purposes. The infestation by invasive species reduces the economic values and productivity of the water bodies (Joshi, 2007).

Hence a detailed review of literature relevant to the present study indicate the work done in several aspects of zooplankton such as taxonomy, ecology, diurnal variation, cyclomorphosis in a specific and varied freshwater ecosystems of Indian region. But, very few well known studies were of relevance to species composition, community and dynamics of zooplankton, besides several studies exhibits zooplankton as a meaningful bioindicator and it helps to assess the trophic status of the freshwater ecosystem through assessing species composition, community, dynamics, diversity, abundance. Sukumaran and Das (2004) recommended the study of rotifer population in relation to water quality is a prerequisite to those who investigate on reservoir ecology and fisheries. The above literature clearly indicates these kinds of studies were conducted very recently in floodplain lakes of North East India, still less known to South and Central India. Especially, in Andhra Pradesh it is very much scattered and less known. So, the present study aims to investigate the structural composition, community and dynamics of zooplankton in the freshwater environs, especially in varied selected lentic systems in Andhra Pradesh to assess the trophic status and species composition.

Karuthapandi, M. 2013. Studies on zooplankton community structure, composition and dynamics in few tropical freshwater lakes. *Ph.D thesis,* Manonmaniam Sundaranar University, Tirunelveli.

Chapter III
Materials and Methods

Geographically, Andhra Pradesh is the fourth largest state in India with an area of 2,75,068 Km^2. It is bounded by Maharashtra, Chattisgarh and Odissa in the north, Bay of Bengal in the east, Tamilnadu in the South, Karnataka and part of Maharashtra in the West. It lies at a latitude of 12° 62′ 30 & 19°91′ 70N and longitudes 76°76′ 10 & 84°76′ 60E and has three physiographic zones (Plate 1). There are three major rivers of India which flow through the state the Godavari, the Krishna and the Pennar. All the rivers have many tributaries and channels and traverse through several districts of Andhra Pradesh and many of the man-made reservoirs constructed on them.

3.1 Study area

The study chose 20 different freshwater bodies (Table. 1 and Plate 2 & 3) which include major reservoirs, tanks, ponds and pools in and around Hyderabad and Northwest region of Andhra Pradesh, for qualitative assessment of the taxonomic composition of freshwater zooplankton. But for quantitative studies such as zooplankton community structure, diversity and dynamics in a man-made reservoir (Osmansagar), an irrigation tank at Ameenpur, Medak district and a perennial pond locally known as Bandam Kommu Cheruvu, Medak district were selected and trophic status of these habitats were evaluated.

Table 3.1 Geographical position of the study area

S. No	Name of the habitat/type	District	Longitude	Latitude	Total area (sq.Km^2)
1	Ameenpur tank	Medak	17°31’19.80°N	78°19’52.00°E	03.80
2	Bandam Kommu cheruvu	Medak	17°30’44.85°N	78°19’11.35°E	2
3	Bhongir tank	Nalgonda	17°30’48.53°N	78°52’31.29°E	4.01
4	Bibinagar tank	Nalgonda	17°28’47.50°N	78°47’36.22°E	04.53
5	Durgam cheruvu	Hyderabad	17°33’23.38°N	78°56’13.56°E	5.00
6	Himayatsagar	Ranga Reddy	17°18’37.70°N	78°21’38.19°E	17.00
7	Jallapally tank	Ranga Reddy	17°17’02.24°N	78°27’27.08°E	06.14
8	Manjera	Medak	17°39’54.14°N	78°04’05.71°E	-
9	Miralam tank	Hyderabad	17°20’49.99°N	78°26’10.92°E	8.42
10	Nizamsagar	Nizamabad	18°08’08.31°N	78°00’11.02°E	140.14
11	Osmania University Garden pond	Hyderabad	17°25’02.01°N	78°31’52.46°E	-
12	Osmansagar	Ranga Reddy	17°21’57.96°N	78°18’14.83°E	23.84
13	Pagadipally irrigation tank	Nalgonda	17°29’27.38°N	78°50’34.10°E	02.5
14	Pallecheruvu pond	Ranga Reddy	17°18’43.01°N	78°27’18.89°E	-
15	Rajgir pond	Nalgonda	17°33’23.38°N	78°56’13.56°E	5.00
16	Safilguda tank	Ranga Reddy	17°27′50.07°N	78°32′10.64°E	4.6
17	Singur	Medak	17°49’00.70°N	77°49’30.80°E	164.38
18	Sriramsagar	Nizamabad	19°01’51.66°N	78°12’32.28°E	-
19	Temporary pond, Attapur	Ranga Reddy	17°21’28.12”N	78°23’32.84°E	0.25
20	Umda Sagar	Ranga Reddy	17°17’44.90°N	78°27’20.17°E	05.04

3.1.1 Osmansagar

Osmansagar is one of the major man-made reservoirs of Andhra Pradesh, located between latitude 17°21'57.96°N and longitude 78°18'14.83°E, covering an area of about 23.84 km^2 in Southwest region of the city Hyderabad. The morphometric features of the reservoir are given below (Table 1). It was constructed across the river Musi during the year 1920 with the purpose of controlling flood and water supply in the twin cities of Hyderabad and Secunderabad. The surrounding landscape is undulating terrain with rocky surface. It is being mainly utilized for drinking water purpose of Hyderabad city. The rapid urbanization, increasing population pressure, sewage, industrial pollutants deteriorating the aquatic habitats and ground water in the urban areas ultimately threat the aquatic biodiversity. It is high time to assess the status and management of the Osmansagar.

Table 3.2 Morphometric features of the Osmansagar, Hyderabad

S. No	Morphometric features	Osmansagar
1	Surface area (km^2)	23.84
2	Catchment area (Km^2)	740.7
3	Capacity at storage (mcm)	304.7
4	Maximum water spread (km^2)	37.81
5	Maximum length (km^2)	11.28
6	Maximum depth (m)	30.7
7	Mean depth (m)	6.17

3.1.2 Ameenpur irrigation tank

Ameenpur irrigation tank is located at a latitude of 17°31'19.80°N and longitude 78°19'52.00°E, at Ameenpur village, Medak district, Andhra Pradesh. The area of the tank is about 2Km^2, with a maximum depth of about 8 meters. The tanks serve the purpose of irrigation, domestic and industrial purpose of local areas and also supports small fishery. The tank is surrounded by undulating terrain with rocky bottom. The study was carried out on monthly basis during the period 2010-12 to cover three major seasons such as summer, monsoon and winter.

3.1.3 Bandam Kommu cheruvu pond

Bandam Kommu cheruvu pond is located at latitude of 17°28'47.50°N and longitude 78°47'36.22°E, area about 2 km^2, shallow in nature. Abundance of macrophytic vegetations were observed the most common of which are water lily- *Nymphaea alba*, Amphibious amphibium- *Polygonum amphibium*, Bulrush- *Typha latifolia*, Red weed- *Polygonum persicaria*, water fern- *Azolla filiculoides*, Rigid horn wort- *Ceratophyllum demersum*, Duck weed - *Lemna minor* and Rootless duck weed- *Wolfoia arrhiza*.

3.2 Zooplankton collection

Zooplankton collections were made from littoral surface water column at different stations of each freshwater habitat. Qualitative collections were done by towing surface water column, quantitative zooplankton samples were collected by filtering 50Lts of water through zooplankton net made bolting silk (No 25), 62 µm mesh size (Plate 4). The collected zooplankton samples were transferred to a clean plastic container which is about 100 ml capacity, and preserved in 4% neutralized formaldehyde solution and containers were labeled.

3.2.1 Zooplankton enumeration

The quantitative zooplankton was estimated by following the Sedgwick-Rafter cell method and the results were expressed in No/L Welch (1948). Sedgwick-Rafter counting cell is marked glass slide with a rectangular cavity (50mm x 20mm x 1mm) of volume 1cm^3 (*i.e.,* 1mL capacity). The quantitative zooplankton samples were mixed thoroughly and then transferred to 1ml of sample to Sedgwick-Rafter counting cell with the help of glass dropper. It is then covered with a rectangular glass cover slip avoiding air bubbles. Allow the plankton to settle and then count under a compound light microscope. Good numbers of replicates were taken and average count per milliliter is calculated.

Calculation

$$\text{Zooplankton (units/L)} = \frac{a \times C \times 1000}{L}$$

Where, a = average numbers of zooplankton counted in one small counting cell

C = volume of concentrate in ml

L = Volume of water filtered in liters

3.2.2 Zooplankton identification

Sorted individual specimens were placed on a clean glass slide containing 1:1 ratio of glycerin and water, and by placing a cover slip semi permanent mounts were made. Identification of zooplankton species was done by using regional level literature (Battish, 1992; Michael and Sharma, 1988; Patil and Gouder, 1989; Dhanapathi, 2000; Ranga Reddy, 1994; Dussart and Defaye, 1994) under light microscope (Carl Zeiss 10×25x). The identified species were sorted under binocular microscope (Olympus SZ10) with the help of fine camel hair brush, stored in glass tubes with 4% formalin solution, labeled and Reg. No: FBRC/ZSI/N/Invert 679-867 preserved in the National Zoological Collection in Freshwater Biology Regional Centre, Zoological Survey of India, Hyderabad.

3.3 Physicochemical parameters

The ambient and subsurface water temperature, electrical conductivity, pH, total dissolved solids were recorded in the field with the help of digital electronic testers (Orlab). Water samples were collected in clean plastic containers (1 liter) for estimation of the chemical parameters. Dissolved oxygen content was estimated through Winkler's method. Total hardness, total alkalinity, calcium, chloride, total phosphate, nitrate and nitrite were analysed by using orlab water quality kits (Plate 4) following standard methods (APHA, 1985 and Wetzel and Likens, 2000).

3.3.1 Temperature

The ambient and surface water temperature was measured by a mercury thermometer of 0 to 50^0C range and with 0.2^0C least count. It was a simple method to record immediately by dipping the thermometer for about one to two minutes.

3.3.2 pH

P^H is measured with the help of digital electrode P^H meter. Standard solution of the pH was prepared by dissolving one tablet of 7pH and 4pH in100ml distilled water separately. These solutions were preserved up to 3 months for standarding the pH meter at room temperature.

3.3.3 Electrical Conductivity

Conductivity was measured with the help of conductivity meter and it was expressed in mS. Standard solution for conductivity was prepared by dissolving 0.523g potassium chloride (dried at 180°C for one hour) in 1000ml double distilled water. The specific conductance of this solution at 25°C is 1mS or 1000µS/cm.

3.3.4 Total dissolved solids

Total dissolved solid was measured through by using electronic tester made by orlab instrumentations. The value measured through dipping of the tester in the surface water column, the value expressed in parts per million (ppm).

3.3.5 Total Hardness

The hard water is generally considered to be those waters that require considerable amount of soap to produce a foam or lather. The hardness of water varies considerably from place to place. Generally surface waters are softer than ground waters. Total hardness was measured through readymade orlab water quality Kit. 10ml sample water and pour it into the cleaned conical flask. 23 drops of hardness buffer and One EBT indicator tablet to the same conical flask was added and mix thoroughly till the colour changes to wine red colour. EDTA standard solution (0.1N) was added drop wise while swirling to mix after each drop. Continue adding and counting the drops until colour changes into blue. The total hardness in mg/L as $CaCO_3$ is equal to the total number of drops of EDTA standard solution used in step 4times × 23.7 factor. Range is 25-1000mg/L.

3.3.6 Total Alkalinity

The total alkalinity of water is a measurement of its capacity to neutralize acids. Natural waters may contain appreciable amounts of Bicarbonates, Carbonates and Hydroxide alkalinity. High alkalinity is usually unpalatable. 10ml of sample water was measured and poured into the clean conical flask. One Bromo Cressol Green-Methyle Red (BCG-MR) indicator tablet was added to the conical flask and Swirl to mix. The colour will change to blue-green. Sulfuric acid standard solution (0.1N) added drop wise while swirling to mix after each drop. Continue adding and counting the drops until the colour changes to pink. The total alkalinity in mg/L as $CaCO_3$ is equal to the total number of drops of sulfuric acid standard solution used × 25.5 factors. Range is 25-700mg/L

3.3.7 Calcium

Calcium hardness is caused by the presence of calcium ions in the water. Calcium salts can be readily precipitated from water and high levels of calcium hardness tend to promote scale formation in water system. 10ml of sample water was poured it into the clean conical flask. 12 drops of calcium buffer was added to the same conical flask. One Calcium -1 indicator tablet was added and mixed thoroughly until the colour changes to pink. ETDA standard solution (0.1N) was added drop wise while swirling to mix after each drop. Continue adding and counting the drops until the colour turns to purple. The calcium hardness in mg/L $CaCO_3$ was equal to the total number of drops of EDTA standard solution × 23.7 factors. Calcium calculated as ca (mg/L) = Calcium Carbonate ($CaCO_3$) mg/L × 0.4

3.3.8 Magnesium

Magnesium is a widely occurring natural element and is found in most water supplies. Magnesium salts contribute to the hardness of water and higher levels of magnesium will be found therefore in hard water areas.

The measurement was simply a combination of total hardness and calcium procedure.

Magnesium hardness as $CaCO_3$ mg/L = Total hardness as $CaCO_3$ mg/L - Calcium as $CaCO_3$ mg/L.

Magnesium hardness Mg mg/L = Magnesium as $CaCO_3$ mg/L× 0.243

3.3.9 Chloride

Chlorides occur in all natural waters in widely varying concentration. The chloride content normally increases as the mineral content increases. The content in water usually has a considerable amount. Chlorides in reasonable concentration are not harmful to humans. Chloride content was measured by taking 10 ml of water sample in a clean conical flask. One chloride Reagent-A indicator tablet was added to the conical flask. Swirl to mix until the colour change to yellow. Chloride Reagent-B was added drop wise while swirling to mix after each drop. Continue adding the drops until the colour changes from yellow to red brown colour. To obtain the chloride content in water in mg/L as Cl^- multiply the number of drops that were added × 20.24 factor. Range: 20-1000mg/L.

3.3.10 Phosphate

The presence of phosphate in large quantities in fresh water indicates pollution through sewage and industrial wastes. It indicates the growth of nuisance causing micro organisms. Under acid concentration soluble phosphate react with ammonium molybdate and produce molybdophosphate which in turn gets reduce to molybdenum blue after addition of reducing agent stannous chloride, which is directly proportional to phosphate concentration. It was measured taking by 10 ml of sample in test tube and adding 2 drop of ammonium molybdate reagent solution and 2 drops of stannous chloride reagent. The mixture is sample and shaken well. After 10 minute, a bluish colour develops if phosphate is present. Compare the colour with phosphate a P colour chart and estimate the concentration of the sample. Express the result Phosphate as P in mg/L. Phosphate as P colour chart has been provided to measure phosphate as P in water. Range 0.00 to 3.00 mg/L phosphate. This phosphate converts into PO_4 mg/L by multiply the reading with factor 3.06.

3.3.11 Nitrate

Nitrate represents the most completely oxidised state of nitrogen commonly found in water. Drinking waters containing excessive amounts of nitrates can cause infant methenoglobinemia (blue baby disease). For this reason a maximum concentration level in drinking water has been established as 45 PPM by Bureau of Indian Standards. Cadmium metal reduces nitrates in the sample to nitrite. The nitrite ion reacts in an acidic medium with sulfanilamide to form an intermediate diazonium salt. The salt couples with NEDA to form a magenta coloured product, which is proportional to Nitrate concentration.

Nitrate was also been analyzed through Orlab water quality kid. 10 ml of water is taken in a test tube. Nitrate- A tablet and Nitrate B tablet was added to sample test tube. Test tube was closed with a rubber cork and shaken vigorously until the tablets dissolved completely for 2 minutes. After shaking, wait for 6 minutes reaction period to complete. Place the test tube on nitrate colour chart and compare with the nitrate chart provided in the left hand side. Nitrate colour chart has been provided to measure nitrate content in water. Record the nitrate value in mg/L NO_3. Range: 0.0 - 250 mg/L.

3.3.12 Nitrite

Nitrite in the water is either due to oxidation of ammonium compounds or due to reduction of nitrite. Presence of nitrite nitrogen indicates that the water is polluted recently and availability of partially oxidized nitrogenous in waste water (partially or completely oxidized). Nitrite in the sample reacts with sulfanilamide to form intermediate diazonium salt. This complies with NEDA to produce a magenta coloured complex, directly proportional to the amount of nitrite present.

Nitrite content was measured through Orlab water quality kit as follows. 10 ml of water sample was taken in a test tube. Nitrite - A tablet and Nitrite - B tablet was added to sample test tube. Close the test tube with rubber cork and shake well vigorously until the tablets dissolved completely. After shaking, wait for 6 minutes reaction period to complete. Place the test tube on nitrite colour chart and compare with nitrite chart provided in the left hand side. Nitrite colour chart has been provided to measure nitrite content in water. It records the nitrite nitrogen value in mg/L as NO_2 - N. Range: 0.00 to 2.00 mg/L. To convert nitrite nitrogen to nitrite as NO_2, multiply the value with 3.43 factors.

3.3.13 Ammonia

Ammonia is naturally present in surface and wastewaters. Its concentration is generally low in ground waters because it absorbs soil particles and is not readily leached from soil. It is produced largely by the decomposition of urea. Ammonia produces a yellow coloured compound when reacted with alkaline nessler's reagent, which is proportional to the ammonia concentration.

10 ml of water sample was taken in a test tube. 4 drops of Rochelle salt solution and 4 drops of nessler's reagent were added to the sample and shaken well. After one minute, yellow to brownish colour develops if ammonia is present. It was compared with standard ammonia colour chart and estimates the concentration of the sample. The result express as NH_3-N to ammonia as NH_3 mg/L, multiply the reading with factor 1.22. Ammonia nitrogen as NH_3-N colour chart has been provided and measure ammonia in water. Range 0.00 to 6.00 mg/L Ammonia nitrogen as NH_3-N.

3.4 Statistical analysis

Species diversity is defined as the number of species present in an area. The values can be used to assess the health of the environments. The species diversity is calculated by Shannon and Simpson diversity index the method by using *Biodiversity pro software*.

3.4.1 Shannon diversity index (Shannon, 1948)

$$H' = -\sum_{i} p_i \ln (p_i)$$

Where Pi = proportion of the number of individuals of species to the total number of individuals ($P_i = n_i / N$)

n = total number of species.

N = total number of individuals

n1and n2 are the respective number of individuals of each species

The lower the index, lower the diversity, whereas higher the index, higher the diversity, species richness and evenness. The high species diversity indicates healthy environment.

3.4.2 Simpson diversity index (Simpson, 1949)

$$D = - \sum_{i=1}^{S} \frac{n_i (n_i - 1)}{N (N-1)}$$

n_i = Individuals of the species

N = Total number of individuals

3.4.3 Species richness (S)

Species richness means number of species present in an ecosystem. Species richness S is the simplest measure of biodiversity and is simply a count of the number of different species in a given area. This measure is strongly dependent on sampling size and effort.

Two species richness indices try to account for this problem.

3.4.4 Evenness (J), Pielou (1966)

Evenness J = Hmax' /Log^2 S

Where, Hmax' = is the Shannon maximum diversity index

S = the total number of species in the sample.

It's a measure of how similar is the abundance of different species/categories in a community.

Evenness is ranged from zero to one when evenness is close to zero; it indicates that most of the individuals belong to one or a few species/categories. When the evenness is close to one, it indicates that each species/categories consists of the same number of individuals.

3.4.5 Hill Numbers (Hill, 1973)

It show the relation between the species richness indices and the evenness indices

Ho = S (species richness)

H1 = exp H' exponential of Shannon diversity Indices

3.4.6 Berger-Parker Dominance index

$d = N_{max} / N$

Nmax = the number of individuals in the most abundant species

N = the total number of individuals in the sample

It is simple measure of the numerical importance of the most abundant species. The reciprocal of the index, 1/d, is often used, so that an increase in the value of the index accompanies an increase in diversity and a reduction in dominance.

3.4.7 Sorensen's Index of similarity

Sorensen's (1948) index(S) is to assess the similarity and dissimilarity of species.

S= 2C/a+b * 100

C- Number of species common to both associations.

a- Number of species in one association.

b- Number of species in other association.

Chapter IV
Results

4.1 Taxonomic composition of zooplankton from Northwest Andhra Pradesh

Although taxonomic studies on Indian rotifers began more than a century ago, information on their diversity and distribution is still incomplete. The studies carried out on this group in India have usually been restricted to planktonic species collected from the pelagic zone, only scattered work has been done on the littoral-periphytic habitats. Keeping in view of the paucity of the studies on rotifer, cladocera and copepoda of the Andhra Pradesh, the present study aimed to appraise the taxonomic composition of rotifer and cladocera from selected freshwater habitats of the Northwest Andhra Pradesh which are least explored. The study was carried out during the years 2010 to 2012, in selected freshwater habitats from five districts of Northwest part of Andhra Pradesh viz. Hyderabad, Nalgonda, Medak, Ranga Reddy and Nizamabad. About 20 freshwater bodies including reservoirs, tanks, ponds and temporary pools are chosen for sampling (Plate 1-3).

About 350 plankton sample collections made from 20 different freshwater habitats of Northwest regions of the Andhra Pradesh (Plate 2 and 3) were analysed and identified 80 species (70.1%) of rotifers, 29 species (25.4%) of cladocerans and 05 species (4.4%) of copepoda. The systemic list of the species identified is given in the Table 4.1.1 and Fig. 4.1.1. Of the 80 species of rotifers (Plate 5-13), 66 species are under the class Monogononta, order Ploima consisting of 12 families, 12 species under order Flosculariaceae belonging to 5 families, where as 02 species under Class Eurotatoria belongs to family Philodinidae. 20 species belong to family Brachionidae, of which 15 species belong to genus *Brachionus*; 20 species belong to genus *Lecane*

Table 4.1.1 Zooplankton species recorded in Northwest regions of Andhra Pradesh

S. No	Phylum **Rotifera** Class **Monogononta** Order **Ploima**
1	**Asplanchnidae** *Asplanchna brightwellii* Gosse, 1850
2	**Brachionidae** *Anuraeopsis fissa* Gosse, 1851
3	*Brachionus angularis* Gosse, 1851
4	*Brachionus bidentatus* Anderson, 1889
5	*Brachionus budapestinensis* Daday1885*
6	*Brachionus calyciflorus* Pallas, 1776
7	*Brachionus caudatus* Barrios & Daday, 1894
8	*Brachionus diversicornis* Daday 1883
9	*Brachionus durgae* Dhanapathi, 1974
10	*Brachionus falcatus* Zacharias, 1898
11	*Brachionus forficula* Wierzejski, 1891
12	*Brachionus plicatilis* Muller, 1786*
13	*Brachionus patulus com nov.,* Segers *et al.,* 1993
14	*Brachionus quadridentatus* Hermann, 1783
15	*Brachionus quadridentatus melhemi* Barrios & Daday 1894
16	*Brachionus rubens* Ehrenberg, 1838
17	*Brachionus urceolaris* Muller, 1773
18	*Keratella cochlearis* Gosse, 1851
19	*Keratella tropica* (Apstein, 1907)
20	*Keratella procurva* (Thorpe, 1891)*
21	*Platyias quadricornis* Ehrenberg, 1832
22	**Euchlanidae** *Euchlanis dilatata* Ehrenberg, 1832
23	*Euchlanis oropha* Gosse, 1887
24	*Dipleuchlanis propatula* (Gosse, 1886)
25	*Tripleuchlanis plicata* (Levander, 1894)

	Epiphanidae
26	*Epiphanes clavulata* (Ehrenberg, 1832)
	Lecanidae
27	*Lecane aculeata* (Jakubski, 1912)
28	*Lecane bulla* (Gosse, 1851)
29	*Lecane closterocerca* (Schmarda, 1859)
30	*Lecane crepida* Harring, 1914*
31	*Lecane curvicornis* (Murray, 1913)
32	*Lecane furcata* (Murray, 1913)*
33	*Lecane haliclysta* Harring and Myers 1926*
34	*Lecane hamata* (Stokes, 1896)
35	*Lecane leontina* (Turner, 1892)
36	*Lecane ludwigii* (Eckstein, 1883)
37	*Lecane luna* (Muller, 1776)
38	*Lecane lunaris* (Ehrenberg, 1832)
39	*Lecane papuana* (Murray, 1913)
40	*Lecane pawlowskii* Wulfert, 1966*
41	*Lecane pyriformis* (Daday, 1905)*
42	*Lecane quadridentata* (Ehrenberg, 1832)
43	*Lecane ruttneri* Hauer, 1938*
44	*Lecane stenroosi* (Meissner, 1908)
45	*Lecane unguitata* (Fadeev, 1925)
46	*Lecane ungulata* (Gosse, 1887)
	Lepadellidae
47	*Colurella obtusa* (Gosse, 1886)
48	*Lepadella (Lepadella) biloba* Hauer, 1958*
49	*Lepadella (Lepadella) ovalis* (Muller, 1786)*
50	*Lepadella (Heterolepadella) ehrenbergii* (Perty, 1850)
51	*Lepadella (Lepadella) triba* Myers, 1934*
52	*Lepadella (Heterolepadella) heterodactyla* Fadeev, 1925*
53	*Squatinella lamellaris* (Muller, 1786)*

54	**Mytilinidae** *Mytilina acanthophora* Hauer, 1938*
55	*Mytilina ventralis* Ehrenberg, 1832
56	**Notommatidae** *Cephalodella forficula* (Ehrenberg, 1830)
57	*Cephalodella gibba* (Ehrenberg, 1830)
58	**Scaridiidae** *Scaridium longicaudum* (Muller 1786)
59	**Synchaetidae** *Polyarthra indica* Segers & Babu, 1999
60	*Ploesoma lenticulare* Herrick, 1885
61	**Trichotriidae** *Macrochaetus sericus* (Thorpe, 1893)
63	*Trichotria tetractis* (Ehrenberg, 1830)
63	**Trichocercidae** *Trichocerca bicristata* (Gosse, 1887)*
64	*Trichocerca pusilla* (Jennings, 1903)*
65	*Trichocerca rattus* (Muller, 1776)
66	*Trichocerca similis* (Wierzejski, 1893)*
	Order **Flosculariaceae**
67	**Conochilidae** *Conochilus (Conochiloides) dossuarius* Hudson 1885
68	*Conochilus (Conochilus) unicornis* Rousselet, 1892
69	**Hexarthridae** *Hexarthra intermedia* (Wizniewski, 1929)
70	*Hexarthra mira* (Hudson, 1871)
71	**Filiniidae** *Filinia longiseta* (Ehrenberg, 1834)
72	*Filinia opoliensis* (Zacharias, 1898)
73	*Filinia terminalis* (Plate, 1886)
74	**Flosculariidae** *Sinantherina socialis* (Linnaeus, 1758)

	Testudinellidae
75	*Testudinella parva* (Ternetz, 1892)
76	*Testudinella patina* (Hermann, 1783)
77	*Pompholyx complanata* Gosse, 1851*
78	*Pompholyx sulcata* Hudson,1885*
	Class **Eurotatoria** Subclass **Bdelloidea**
	Philodinidae
79	*Rotaria neptunia* Ehrenberg, 1832
80	*Rotaria rotatoria* (Pallas, 1766)
	Phylum: **ARTHROPODA** Subphylum: **CRUSTACEA** Class: **Branchiopoda** Subclass: **Phyllopoda** Order: **Diplostraca** Suborder: **Cladocera**
	Bosminidae
81	*Bosmina longirostris* (O. F. Muller, 1776)*
82	*Bosminopsis deitersi* Richard, 1895*
	Chydoridae
83	*Alona affinis* (Leydig, 1860)
84	*Alona costata* Sars, 1862*
85	*Camptocercus rectirostris* Schoedler, 1862*
86	*Chydorus sphaericus* (O. F. Muller, 1776)
87	*Coronatella rectangula rectangula* (Sars, 1862)
88	*Dunhevedia crassa crassa* King, 1853*
89	*Ephemeroporus barroisi* (Richard, 1894)*
90	*Euryalona orientalis* (Daday, 1898)*
91	*Indialona ganapati* Petkovski, 1966*
92	*Karualona karua* (King, 1853)*
93	*Kurzia (Rostrokurzia) longirostris* (Daday, 1898)
94	*Leberis davidi* (Richard, 1895)

95	*Leydigia* (*Neoleydigia*) *acanthocercoides* (Fischer, 1854) *
96	*Pleuroxus aduncus* (Jurine, 1820)
97	*Pseudochydorus globosus* (Baird, 1843)*
98	**Daphniidae** *Ceriodaphnia cornuta* Sars, 1885
99	*Daphnia (Ctenodaphnia) lumholtzi* Sars, 1885
100	*Scapholeberis kingi* Sars, 1903
101	*Simocephalus* (*Echinocaudus*) *exspinosus* (De Geer, 1778)
102	*Simocephalus (Simocephalus) vetulus* (O. F. Muller, 1776)
103	**Macrothricidae** *Macrothrix spinosa* King, 1853
104	**Ilyocryptidae** *Ilyocryptus spinifer* Herrick, 1882*
105	**Moinidae** *Moina micrura* Kurz, 1874
106	*Moinodaphnia macleayi* (King, 1853)
107	**Sididae** *Diaphanosoma excisum* Sars, 1885
108	*Diaphanosoma sarsi* Richard, 1894
109	*Latonopsis australis* (Sars, 1888)*
	Subphylum : Crustacea **Class: Maxillopoda** **Subclass: Copepoda** **Order: Calanoida**
110	**Diaptomidae** *Heliodiaptomus viduus* (Gurney, 1916)
111	*Phyllodiaptomus blanci* (Guerne and Richard, 1896)
112	*Tropodiaptomus orientalis* (Brady, 1886)
113	*Sinodiaptomus (Rhinediaptomus) indicus* Kiefer, 1936
114	**Order: Cyclopoida** **Cyclopidae** *Mesocyclops leuckarti* (Claus, 1857)

Species marked with Asterisk (*) are new records to Andhra Pradesh

Table 4.1.2 Family wise zooplankton composition in Northwest regions of Andhra Pradesh

Family	Genera	Species
Rotifera		
Asplanchnidae	1	1
Brachionidae	4	20
Euchlanidae	3	4
Epiphanidae	1	1
Lecanidae	1	20
Lepadellidae	3	7
Mytilinidae	1	2
Notommatidae	1	2
Scaridiidae	1	1
Synchaetidae	2	2
Trichotriidae	2	2
Trichocercidae	1	4
Conochilidae	1	2
Hexarthridae	1	2
Filiniidae	1	3
Flosculariidae	1	1
Testudinellidae	2	4
Philodinidae	1	2
Cladocera		
Bosminidae	2	2
Chydoridae	14	15
Daphniidae	4	5
Macrothricidae	1	1
Moinidae	2	2
Sididae	3	3
Copepoda		
Cyclopidae	1	1
Diaptomidae	4	5

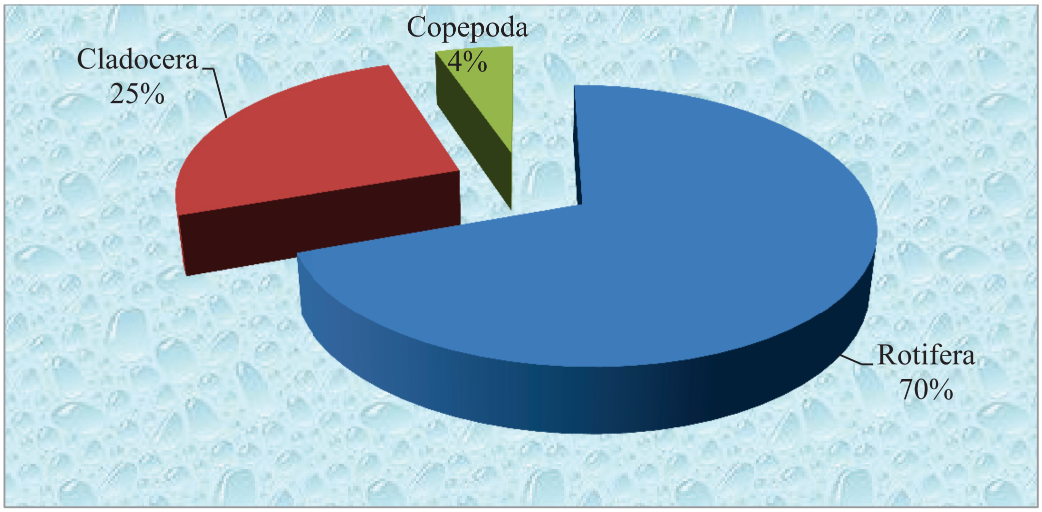


Fig. 4.1.1 Zooplankton composition recorded from Northwest Andhra Pradesh

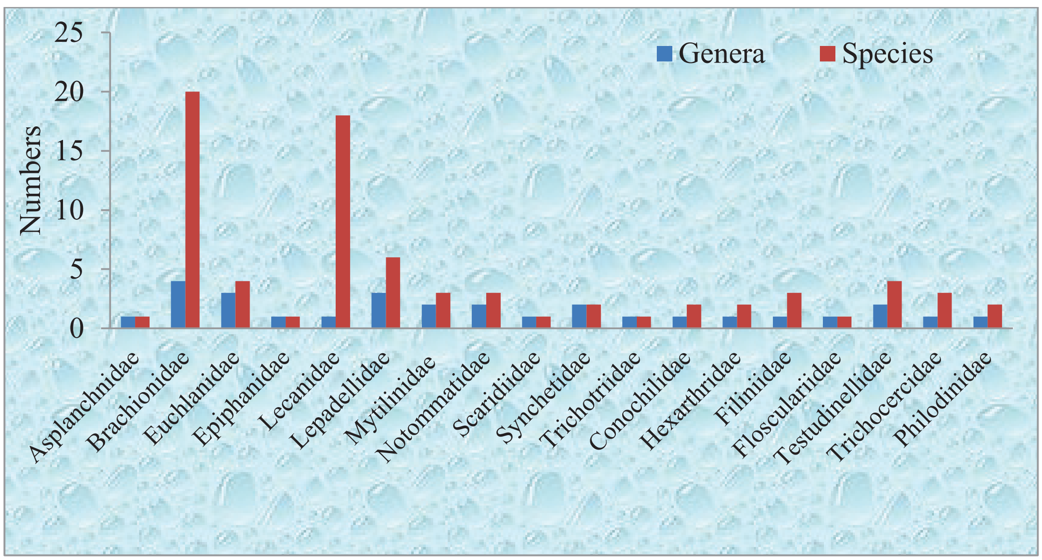


Fig. 4.1.2 Family wise species composition of rotifers

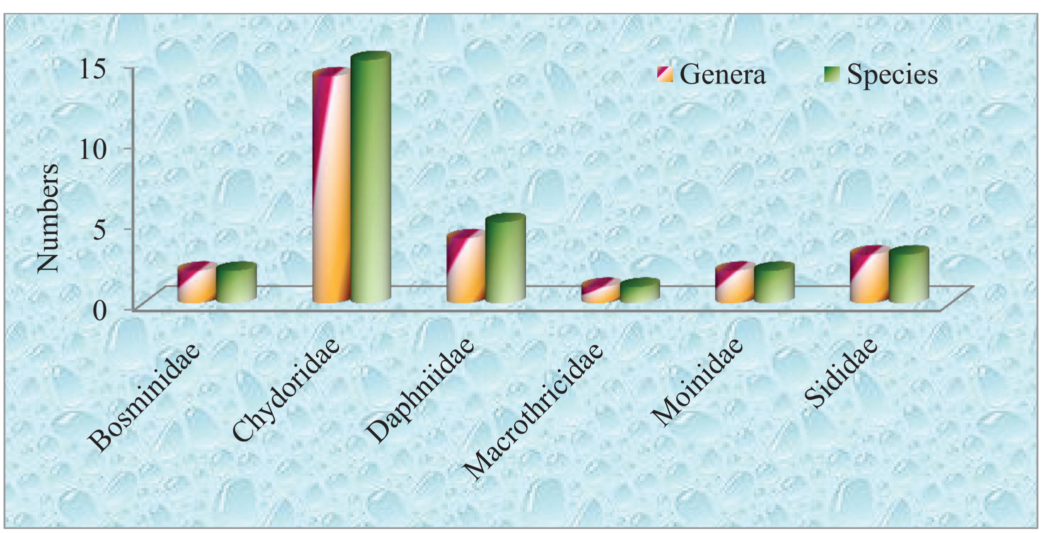


Fig. 4.1.3 Family wise species composition of cladoceran

family Lecanidae, 07 species under Lepadellidae, 04 species belonging to Euchlanidae Testudinellidae and Trichocercidae, 03 species belonging to Filiniidae, 02 species from each family of Mytilinidae, Notommatidae, Synchaetidae, Conochilidae, Hexarthridae, Trichotriidae and Philodinidae and one species from each family of Asplanchnidae, Epiphanidae, Flosculariidae and Scaridiidae (Table 4.1.2 and Fig. 4.1.2).

Among the various rotiferan species *Brachionus angularis, B. calyciflorus, B. caudatus, B. diversicornis, Keratella tropica* are the most common species found in all the sampling sites, and many of the recorded species are cosmopolitan in distribution. Interestingly, out of the 80 species of rotifers reported, 20 species are proved new to Andhra Pradesh (Table. 4.1.2). Some of the rotiferan species observed morphological variations within the same species such as *Brachionus calyciflorus, B. falcatus, B. diversicornis, B. quadridentatus*, and *B. caudatus* was observed (Plate 22).

About 29 species of cladocera belonging to 26 genera under the 7 families have been recorded during the study (Plate 14-18). The family Chydoridae is represented by 15 species, followed by Daphniidae with five species, Sididae and Macrothricidae with three species, with three species, Bosminidae and Moinidae each with two species and Ilyocryptidae with one species (Fig.4.1.3). The cladoceran species, *Indianola ganapati* which is endemic to central India has been recorded during the study. Out of the 29 species of cladocerans recorded, 13 species have new distributional record in the state of Andhra Pradesh. The species *Diaphanosoma sarsi, Ceriodaphnia cornuta,* and *Moina micrura* are the most common by recorded species in all study sites. *Daphnia lumholtzi* both male and female with ephippia were recorded from Osmansagar during the winter collection.

05 species of copepod were recorded (Plate 19-21), of which 05 species belong to diaptomidae under calanoid copepod and a single species represented by cyclopoidae. *Sinodiaptomus indicus* from Ameenpur tank, *Tropodiaptomus orientalis* from Bandam kommu cheruvu and *Phyllodiaptomus blanchi* from Osmania University pond were recorded exclusively in these habitats. *Mesocyclops leuckarti* was observed from the study areas and most commonly occurred.

4.2. Zooplankton community structure, composition and diversity of Osmansagar reservoir, Hyderabad

The quantitative study was carried out during the period 2010-2012 from the Osmansagar, a man-made reservoir at Hyderabad district, Andhra Pradesh (Plate 23).

4.2.1 Zooplankton composition

A total of 73 species of zooplankton were identified from the Osmansagar reservoir (Table 4.2.1), of which 56 species of rotifer belong to 23 genera under 16 families; 15 species of cladocera belong to 13 genera under 6 families and 03 species of copepoda belong to 03 genera under 02 families (Table 4.2.2 and Fig. 4.2.1- 4.2.3). Out of the 56 species of rotifers, the family Brachionidae dominated with 15 species followed by Lecanidae with 11 species, the family Euchlanidae and Testudinellidae each with 04 species, the family Lepadellidae, Trichocercidae and Filiniidae each with 03 species and rest of the families are represented by one or two species. The species of *Brachionus* and *Lecane* are the dominant components. Out of the 15 species of cladocera, the family Chydoridae (09 species), Sididae (03 species) and Daphniidae (02 species) and rest of the three families with one species each were recorded. Whereas in copepod the family Diaptomidae and Cyclopoidae had only one species each. The rotifer component is more dominant than the cladocera and copepoda. Because of this reason family Brachionidae and Lecanidae of rotifera constitutes 40% of species composition in this reservoir. *Brachionus calyciflorus,*

Table 4.2.1 Zooplankton species recorded in Osmansagar, Hyderabad

S. No	Family/species name	2010-2011	2011-2012
	Rotifera		
	Class Eurotatoria		
	Subclass Monogononta		
	Order Ploima		
	Epiphanidae		
1	*Epiphanes clavulata* (Ehrenberg, 1832)	+	+
	Brachionidae		
2	*Anuraeopsis fissa* Gosse, 1851	+	+
3	*Brachionus angularis* Gosse, 1851	+	+
4	*Brachionus bidentatus* Anderson, 1889	+	+
5	*Brachionus calyciflorus* Pallas, 1776	+	+
6	*Brachionus caudatus* Barrios & Daday, 1894	+	+
7	*Brachionus diversicornis* Daday 1883	+	+
8	*Brachionus falcatus* Zacharias, 1898	+	+
9	*Brachionus forficula* Wierzejski, 1891	+	+
10	*Brachionus patulus* Segers *et al.,* 1993	+	-
11	*Brachionus quadridentatus* Hermann, 1783	+	+
12	*Brachionus quadridentatus melhemi* Barrios & Daday 1894	+	-
13	*Brachionus rubens* Ehrenberg, 1838	+	-
14	*Brachionus urceolaris* Muller, 1773	+	+
15	*Keratella tropica* (Apstein, 1907)	+	+
16	*Platyias quadricornis* Ehrenberg, 1832	+	-
	Euchlanidae		
17	*Euchlanis dilatata* Ehrenberg,1832	+	+
18	*Euchlanis oropha* Gosse, 1887	+	-

19	*Dipleuchlanis propatula* Gosse, 1886	+	-
20	*Tripleuchlanis plicata* (Levander ,1894)	+	-
	Mytilinidae		
21	*Mytilina ventralis* Ehrenberg, 1832	+	-
	Trichotriidae		
22	*Trichotria tetractis* (Ehrenberg, 1830)	+	-
	Lepadellidae		
23	*Colurella obtusa* (Gosse, 1886)	+	+
24	*Lepadella (Heterolepadella)ehrenbergii* Perty, 1850	+	-
25	*Lepadella (Lepadella) ovalis* Muller 1786	+	-
	Lecanidae		
26	*Lecane aculeata* (Jakubski, 1912)	+	+
27	*Lecane crepida* Harring, 1914	+	-
28	*Lecane curvicornis* (Murray, 1913)	+	-
29	*Lecane leontina* (Turner, 1892)	+	-
30	*Lecane luna* (Muller, 1776)	+	-
31	*Lecane papuana* (Murray, 1913)	+	+
32	*Lecane ungulata* (Gosse, 1887)	+	-
33	*Lecane bulla* (Gosse, 1851)	+	+
34	*Lecane hamata* (Stokes, 1896)	+	-
35	*Lecane lunaris* (Ehrenberg, 1832)	+	+
36	*Lecane stenroosi* (Meissner, 1908)	+	+
	Notommatidae		
37	*Cephalodella forficula* (Ehrenberg, 1832)	+	+
38	*Cephalodella gibba* (Ehrenberg, 1832)	+	+
	Trichocercidae		
39	*Trichocerca pusilla* (Jennings, 1903)	+	+
40	*Trichocerca rattus* (Muller, 1776)	+	+

41	*Trichocerca similis* (Wierzejski, 1893)	+	+
	Asplanchnidae		
42	*Asplanchna brightwellii* Gosse, 1850	+	+
	Synchaetidae		
43	*Polyarthra indica* (Segers & Babu, 1999)	+	+
	Order Flosculariaceae		
	Conochilidae		
44	*Conochiloides dossuarius* Hudson 1885	+	+
45	*Conochilus (Conochilus) unicornis* Rousselet, 1892	+	+
	Hexarthridae		
46	*Hexarthra intermedia* (Wizniewski, 1929)	+	+
47	*Hexarthra mira* (Hudson, 1871)	-	+
	Filiniidae		
48	*Filinia longiseta* (Ehrenberg, 1834)	+	+
49	*Filinia opoliensis* (Zacharias, 1898)	+	+
50	*Filinia terminalis* (Plate, 1886)	-	+
	Testudinellidae		
51	*Testudinella parva* (Ternetz, 1892)	+	-
52	*Testudinella patina* (Hermann, 1783)	+	+
53	*Pompholyx complanata* Gosse, 1851	-	+
54	*Pompholyx sulcata* Hudson, 1885	-	+
	Subclass Bdelloidea		
	Philodinidae		
55	*Rotaria neptunia* Ehrenberg, 1832	+	+
56	*Rotaria rotatoria* (Pallas, 1766)	+	-
	Subphylum Crustacea		
	Class Branchiopoda		
	Order Diplostraca	+	+

	Suborder Cladocera		
	Sididae		
57	*Diaphanosoma sarsi* Richard, 1895		
58	*Diaphanosoma excisum* Sars, 1885	+	-
59	*Ceriodaphnia cornuta* Sars, 1885	+	+
	Daphniidae		
60	*Daphnia (Ctenodaphnia)lumholtzi* Sars, 1885	+	-
61	*Simocephalus (Echinocaudus) exspinosus* De Geer, 1778	+	-
	Moinidae		
62	*Moina micrura* Kurz, 1874	+	+
	Bosminidae		
63	*Bosmina longirostris* (O. F. Muller, 1776)	+	-
	Macrothricidae		
64	*Macrothrix spinosa* King, 1853	+	-
	Chydoridae		
65	*Pleuroxus aduncus* (Jurine, 1820)	+	-
66	*Chydorus sphaericus* O. F. Muller, 1776	+	+
67	*Pseudochydorus globosus* (Baird, 1843)	-	+
68	*Coronatella rectangula* Sars, 1862a	+	+
69	*Leberis davidi davidi* Richard, 1895a	+	+
70	*Camptocercus rectirostris* Schoedler, 1862	+	+
71	*Leydigia acanthocercoides* (Fischer, 1854)	-	+
	Copepoda		
	Calanoida		
72	*Heliodiaptomus viduus* Gurney, 1907	+	+
73	**Cyclopoidae**		
	Mesocyclops leuckarti Claws, 1857	+	+

Table 4.2.2 Family wise zooplankton composition in Osmansagar

S.No	Families	No. of genera	No. of species
	Rotifera		
1	Asplanchnidae	1	1
2	Brachionidae	4	15
3	Epiphanidae	1	1
4	Euchlanidae	3	4
5	Lecanidae	1	11
6	Lepadellidae	2	3
7	Mytilinidae	1	1
8	Notommatidae	1	2
9	Synchaetidae	1	1
10	Trichocercidae	1	3
11	Trichotriidae	1	1
12	Conochilidae	1	2
13	Hexarthridae	1	2
14	Filiniidae	1	3
15	Testudinellidae	2	4
16	Philodinidae	1	2
	Cladocera		
17	Sididae	2	3
18	Daphniidae	2	2
19	Moinidae	1	1
20	Bosminidae	1	1
21	Macrothricidae	1	1
22	Chydoridae	7	7
	Copepoda		
23	Calanoida	1	1
24	Copepoda	1	1

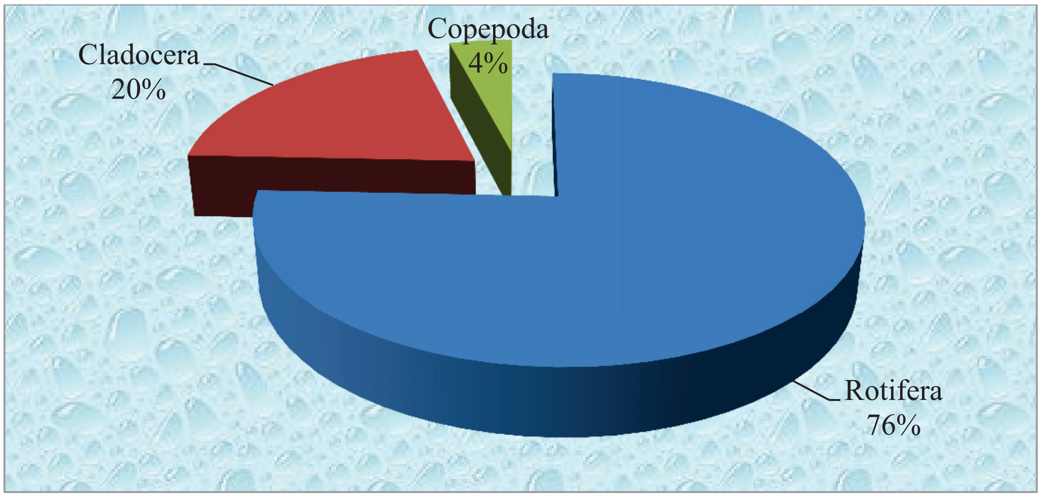


Fig. 4.2.1 Zooplankton composition in Osmansagar

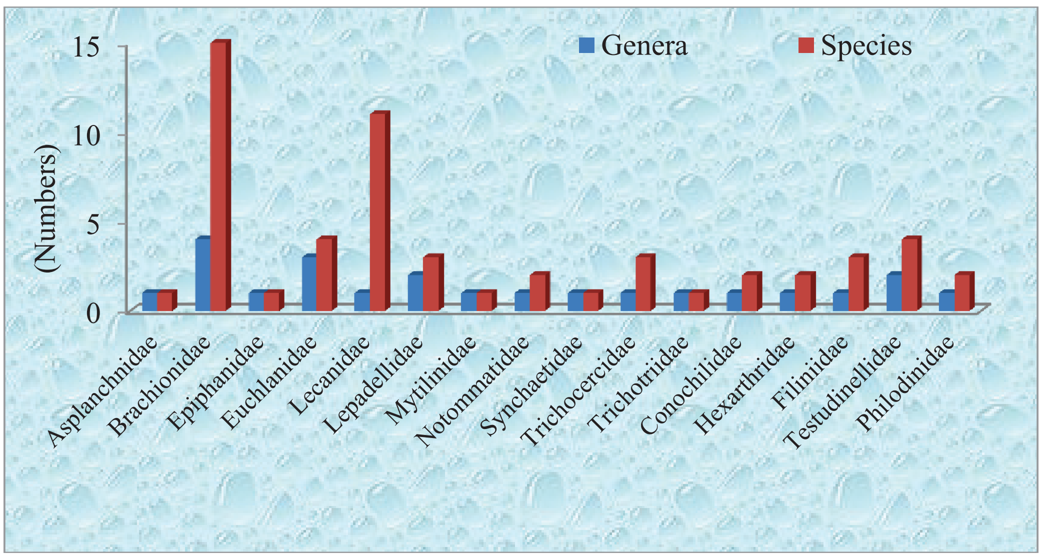


Fig. 4.2.2 Family wise composition of rotifers in Osmansagar

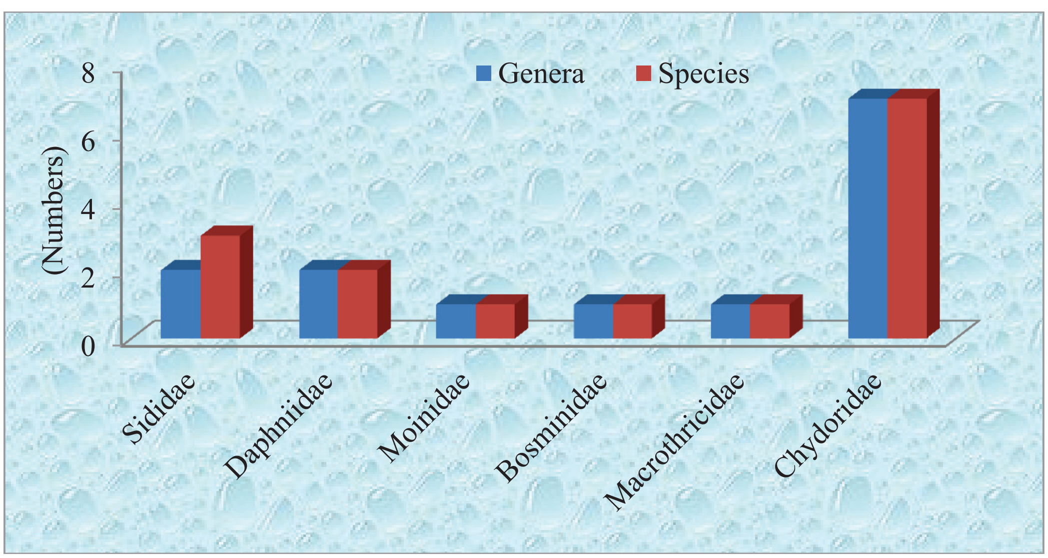


Fig. 4.2.3 Family wise composition of cladoceran in Osmansagar

B. caudatus, *B. forficula, B. diversicornis, B. quadridentatus Keratella tropica and Filinia longiseta* are the most common species recorded throughout the study period, whereas, *Pompholyx complanata, Mytilina ventralis, Tripleuchlanis plicata* and *Trichocerca rattus* occurred very rarely.

4.2.2 Density of zooplankton

Zooplankton density of this reservoir varies between 83-1080No/L, over the two years study period (Table 4.2.3 and Fig. 4.2.4). The high density of zooplankton, 1080No/L, was recorded in the month of August, 2011, followed by 1058No/L in September, 2011 and 1021No/L in November, 2011, which was the monsoon period. The reason for high density was due to high rotifer population from August, 2011 to September, 2011 (Fig. 4.2.5). The total zooplankton density was high during the period 2011-12 due to the increase in copepod population from 13-507No/L. The reason for high zooplankton density is due to the high in copepod population in the monsoon season of 2010-11 and summer and monsoon season of 2011-12. It was fluctuated between 34-763No/L over the two years period (Fig. 4.2.5 and 4.2.7). The cladoceran population was comparatively less than the rotifer and copepod population throughout the study period and in general the density of the zooplankton communities declined.

The rotifer population increased in the year 2010-11 due to the increasing number of *Brachionus forficula* (July to September), *Brachionus diversicornis* and *Keratella tropica* (August and September) and *Brachionus calyciflorus* (September). During the period 2011-12, copepod population increased in summer and monsoon due to the presence of large number of *Mesocyclops leuckarti*. In general, the high density of zooplankton population in the reservoir was due to the increasing number of the rotifer, cladocera and copepod species.

4.2.3 Diversity of zooplankton

The diversity of the zooplankton community of Osmansagar reservoir varied between H=0.679-2.631 during the two year study period (Table 4.2.3). In the year 2010-11, the high diversity during the late winter (February, 2011) and in summer months (March to June, 2011) was found which was H=2.20-2.46, and gradually declined and again raised in the month of October 2011(H=2.03). There was a sudden decrease in the month of November, 2011 (H=0.679). During the next period of investigation (2011-12) the zooplankton diversity ranged between H=1.079-2.407 and three high diversity peaks in different seasons (Fig. 4.2.8). Similarly the evenness (J) of the overall zooplankton community varies between 0.257-0.904. The high evenness was observed in the months of December, 2010 (J=0.894), October, 2011 (J=0.818), January 2012 (J=0.904), May 2012 (J=0.868) and September 2012 (J=0.901), whereas very low evenness was found in the month of November, 2011 (J=0.257) and rest of the period the value was above 0.5 (Fig. 4.2.9). Hence, the species richness was between 8-24 numbers, highest in the month of February and May, 2011(S=24 numbers) representing late winter and peak summer seasons. Relatively, in the month of August, 2011 the number was also high (S=21). In remaining months it was less (S=08-17), especially, during 2011-12. During the summer months, May and June, 2012, it was 16 and 17 respectively. Less number of species recorded in winter and monsoon periods (Fig. 4.2.10).

Dominance of the zooplankton community which was high in the month of November, 2011 was 87%, and then in March and August, 2012 which were 59% and

67% respectively. During the rest of the period the dominance was less than 50% (Fig. 4.2.12). The period 2011-12 had more dominance than 2010-11, due to the dominance of cyclopoidae copepod, *Mesocyclops leuckarti*. The abundance of zooplankton community was reciprocal to the dominance. The high abundance 64% was found in the month of February, 2011 and gradually decreased to 3.8% in the month of November 2011. The study period during 2011-12, show that the abundance values fluctuated with different seasons, where a high value was recorded in May, 2012 (46.4%). The overall abundance during 2011-12 was less than the 2010-11 (Fig. 4.2.11).

4.2.4 SHE analysis of zooplankton

SHE information analysis was in 2010-11 study period shows that species richness between S= 14-53, LnS= 2.64-3.97, H= 2.36-3.12, LnE= -0.28 to -1.36 and LnE/LnS= -0.11 to -0.34 (Table 4.2.4). The species richness increased gradually. But, diversity attained maximum when the S=45 and evenness was decreased. In 2011-12 species richness was 11-35, LnS= 2.4-3.56, H= 1.74-2.25, LnE= -0.66 to -1.52 and LnE/LnS= -0.27 to -0.43. Diversity attain high when the species richness was S=20. Further, diversity was decreased due to decrease of evenness (Fig. 4.2.13 and 4.2.14).

Table 4.2.3 Zooplankton density and diversity during study period 2010-12

Index	Duration	Dec	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov
Total Zooplankton	2010-11	135.6	227.7	229.6	308.1	289.4	239	206	405.9	810.4	904.8	80.1	740.8
	2011-12	99	72	65	570	83	184	455	239	551	195	158	704
Rotifer	2010-11	132.0	196.6	456.1	374.0	546.3	484.23	395.2	490.4	842.9	544.0	184.8	240.6
	2011-12	46.00	57.00	46.00	72.00	43.00	140.0	299.0	138.0	6.00	71.00	115.0	291.0
Cladocera	2010-11	105.6	178.0	134.2	201.92	23.00	55.60	103.00	0.00	38.50	17.00	52.00	17.00
	2011-12	0.00	0.00	6.00	23.00	0.00	2.00	0.00	3.00	38.00	32.00	9.00	9.00
Copepoda	2010-11	121.0	165.00	46.91	182.55	89.00	114.0	74.67	105.4	199.0	497.0	34.00	763.9
	2011-12	53.00	15.00	13.00	475.0	40.00	42.00	156.0	98.00	507.0	92.00	34.00	404.0
Shannon H' Log Base 2.718	2010-11	2.36	2.29	2.631	2.464	2.44	2.271	2.205	1.918	2	1.665	2.033	0.679
	2011-12	1.74	2.167	1.84	1.264	1.654	2.407	1.983	1.623	1.079	1.873	1.952	1.487
Shannon Hmax Log Base 2.718	2010-11	2.639	2.833	3.178	3.045	3.091	3.178	2.996	2.565	3.045	2.639	2.485	2.639
	2011-12	2.398	2.398	2.303	2.303	2.197	2.773	2.833	2.303	2.079	2.079	2.398	2.398
Shannon J'	2010-11	0.894	0.808	0.828	0.809	0.789	0.714	0.736	0.748	0.657	0.631	0.818	0.257
	2011-12	0.726	0.904	0.799	0.549	0.753	0.868	0.7	0.705	0.519	0.901	0.814	0.62
Simpsons Diversity (D)	2010-11	0.102	0.131	0.088	0.121	0.111	0.161	0.159	0.194	0.203	0.298	0.16	0.761
	2011-12	0.289	0.125	0.195	0.417	0.268	0.102	0.188	0.257	0.488	0.171	0.19	0.292
Hill's Number (H_0)	2010-11	14	17	24	21	22	24	20	13	21	14	12	14
	2011-12	11	11	10	10	9	16	17	10	8	8	11	11
Hill's Number (H_1)	2010-11	43.42	39.25	64.17	50.44	48.75	38.18	34.74	22.94	25.84	15.93	27.08	3.843
	2011-12	17.76	32.90	20.50	8.931	15.68	46.49	25.21	14.99	6.844	21.50	24.09	12.32
Berger-Parker Dominance (d)	2010-11	0.155	0.213	0.152	0.249	0.22	0.322	0.302	0.313	0.347	0.503	0.275	0.872
	2011-12	0.515	0.224	0.323	0.6	0.465	0.157	0.333	0.374	0.673	0.282	0.36	0.45
Berger-Parker Dominance (d%)	2010-11	15.54	21.30	15.17	24.86	21.96	32.22	30.17	31.28	34.74	50.33	27.48	87.15
	2011-12	51.45	22.36	32.30	59.96	46.51	15.67	33.33	37.39	67.28	28.20	36.02	44.96

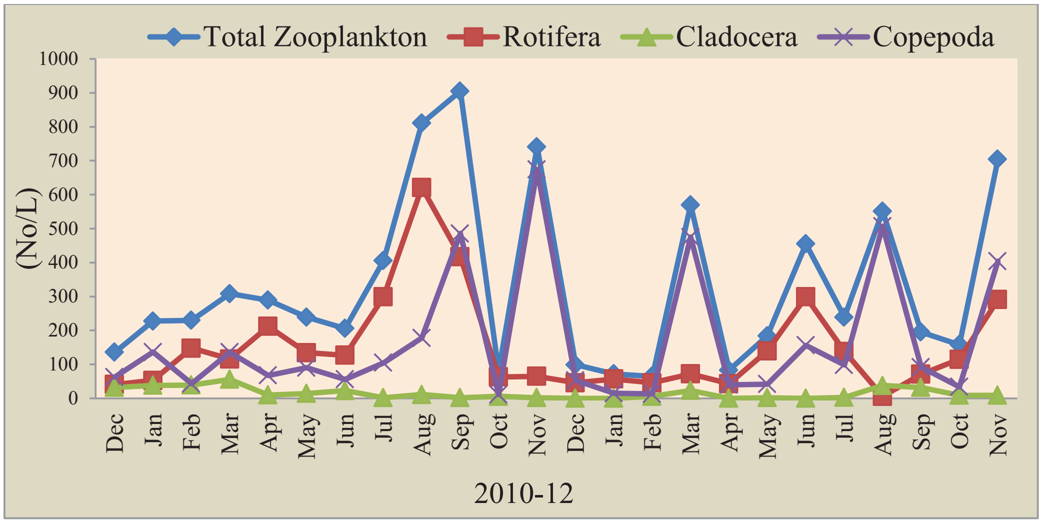


Fig. 4.2.4 Overall zooplankton density and dynamics

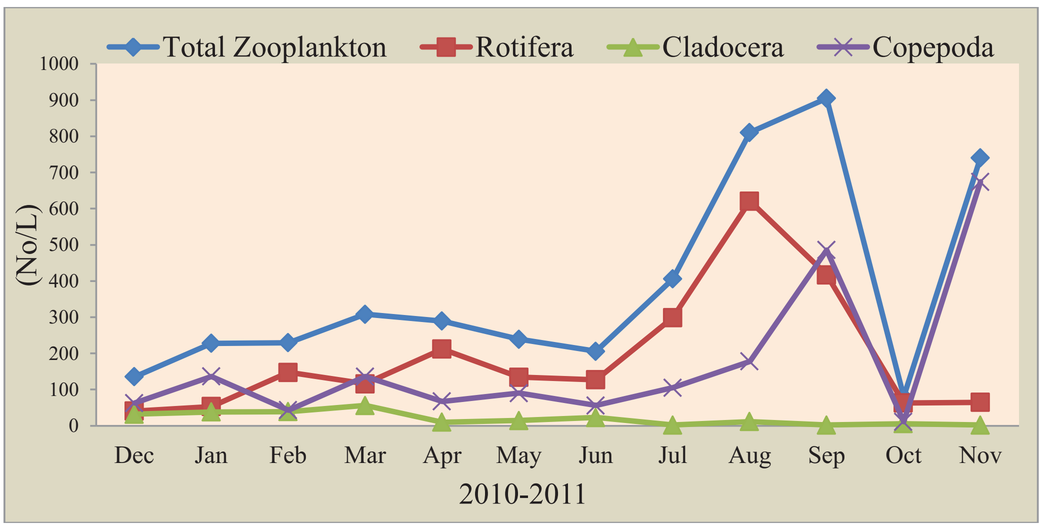


Fig. 4.2.5 Zooplankton density and dynamics 2010-11

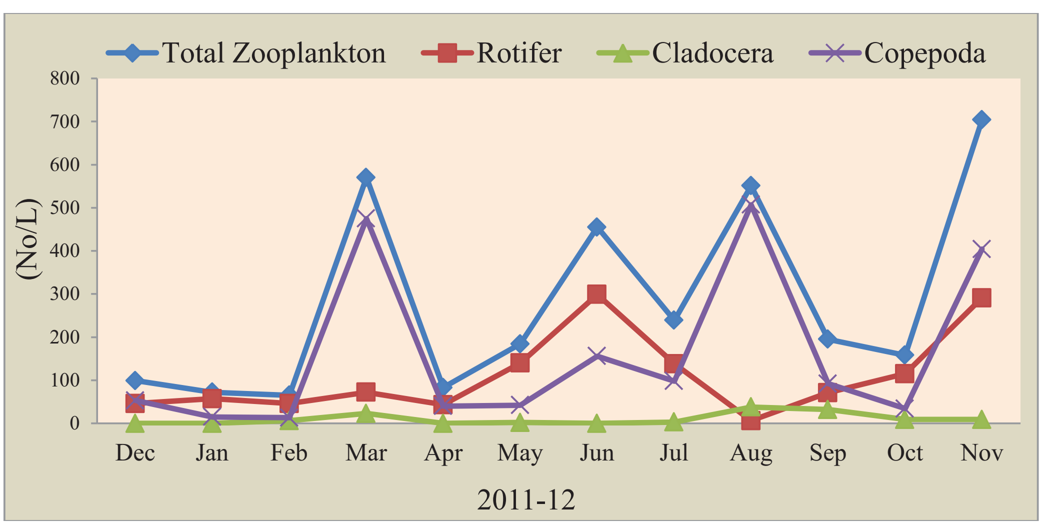


Fig. 4.2.6 Zooplankton density and dynamics 2011-12

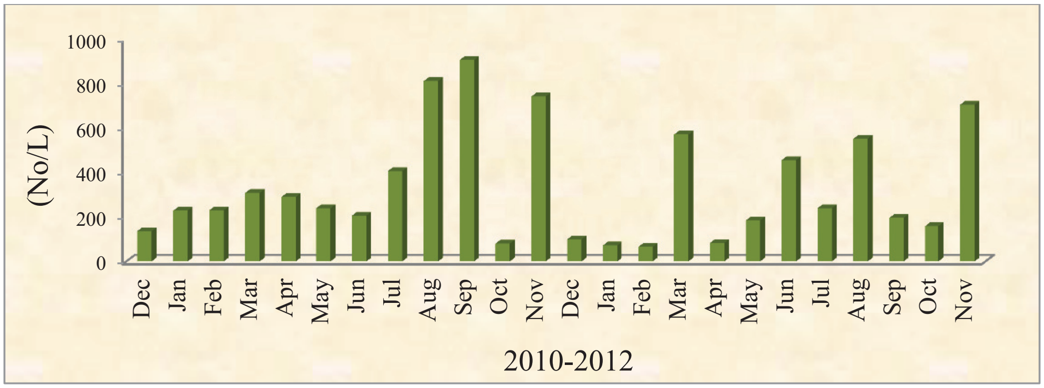


Fig.4.2.7 Overall zooplankton density

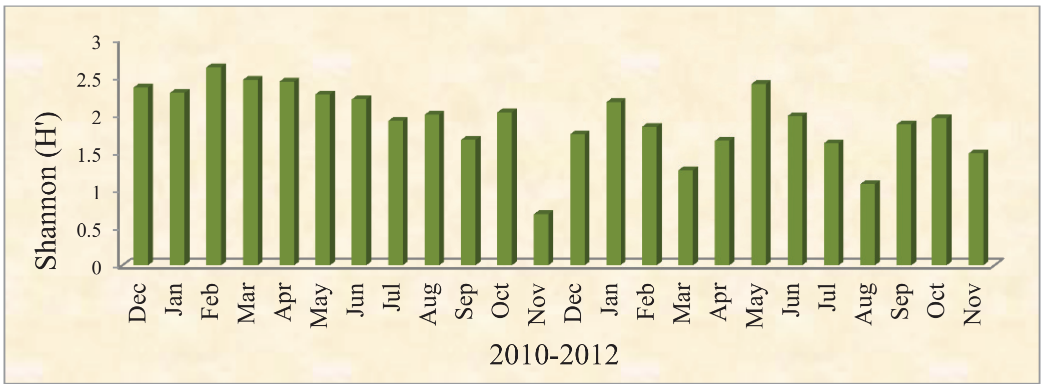


Fig. 4.2.8 Zooplankton diversity

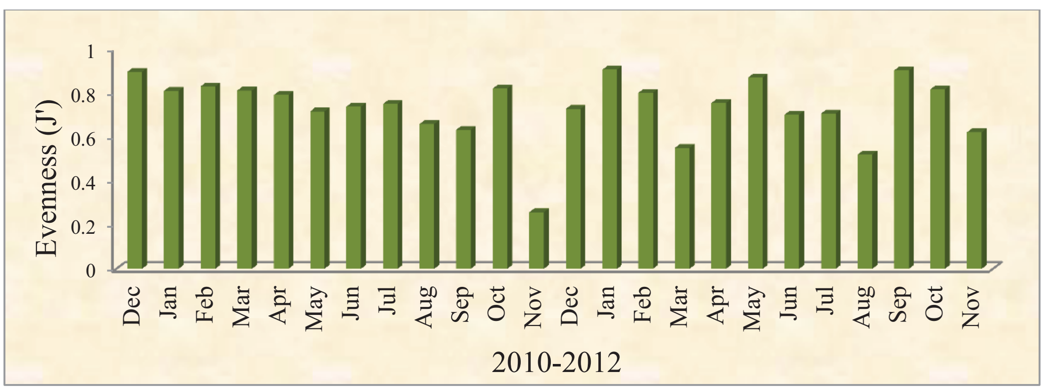


Fig. 4.2.9 Zooplankton evenness

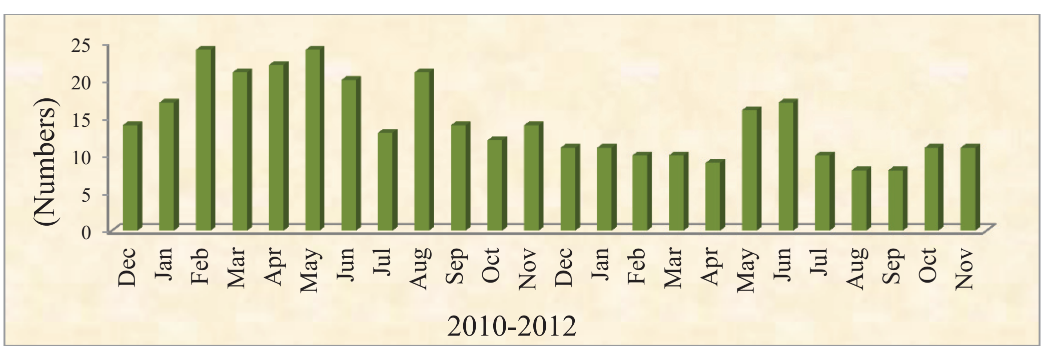


Fig. 4.2.10 Zooplankton species richness

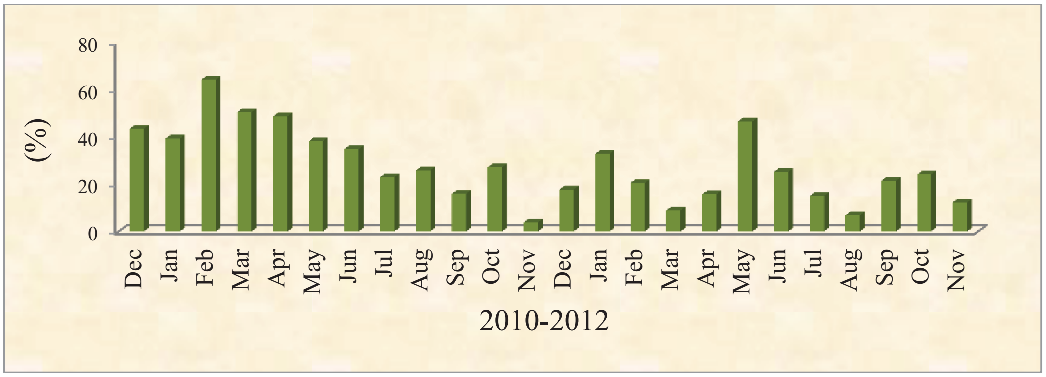


Fig. 4.2.11 Zooplankton abundance

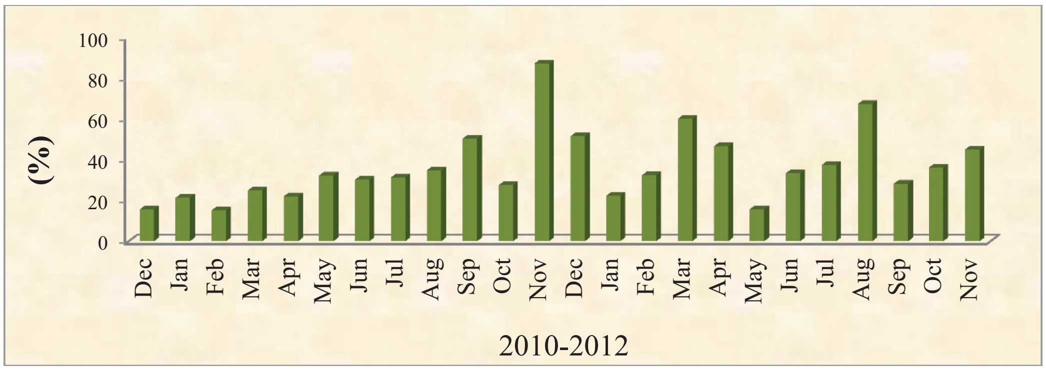


Fig. 4.2.12 Zooplankton dominance

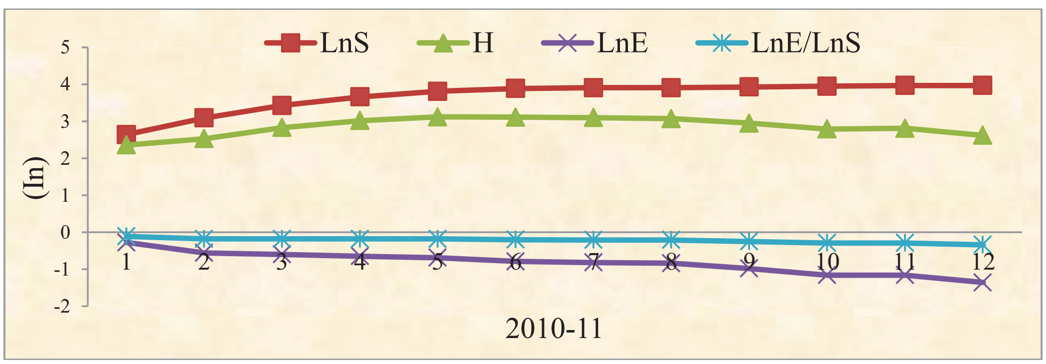


Fig. 4.2.13 SHE information analysis of zooplankton 2010-11

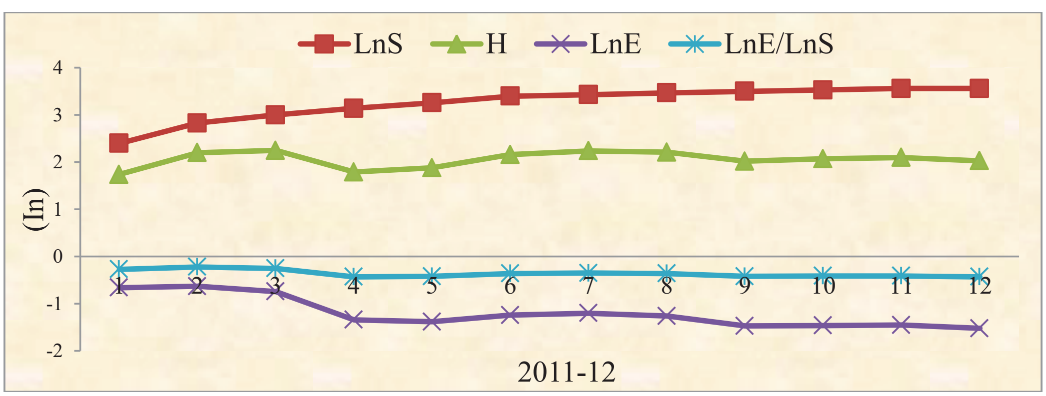


Fig. 4.2.14 SHE information analysis of zooplankton 2011-12

Table 4.2.4 SHE information analysis of zooplankton 2010-12

2010-11						2011-12					
N	**S**	**LnS**	**H**	**LnE**	**LnE/LnS**	**N**	**S**	**LnS**	**H**	**LnE**	**LnE/LnS**
208.3	14	2.64	2.36	-0.28	-0.11	103	11	2.4	1.74	-0.66	-0.27
577.5	22	3.09	2.53	-0.56	-0.18	179	17	2.83	2.2	-0.63	-0.22
901.7	31	3.43	2.83	-0.6	-0.18	244	20	3	2.25	-0.74	-0.25
1354	39	3.66	3.02	-0.65	-0.18	816	23	3.14	1.79	-1.34	-0.43
1654	45	3.81	3.12	-0.69	-0.18	902	26	3.26	1.88	-1.38	-0.42
1930	49	3.89	3.11	-0.79	-0.2	1087	30	3.4	2.16	-1.24	-0.36
2215	50	3.91	3.1	-0.82	-0.21	1546	31	3.43	2.24	-1.2	-0.35
2637	50	3.91	3.07	-0.84	-0.21	1784	32	3.47	2.21	-1.26	-0.36
3477	51	3.93	2.95	-0.98	-0.25	2380	33	3.5	2.02	-1.47	-0.42
4397	52	3.95	2.79	-1.16	-0.29	2575	34	3.53	2.07	-1.46	-0.41
4525	53	3.97	2.81	-1.16	-0.29	2736	35	3.56	2.1	-1.45	-0.41
5281	53	3.97	2.62	-1.36	-0.34	3441	35	3.56	2.03	-1.52	-0.43

4.2.5 Density of rotifers

During the study period, the density of the rotifera was recorded between 46-845 No/L (Table 4.2.5). Study during 2010-11, the density ranged between 133-845No/L. The maximum density of the rotifera was found in monsoon months of August and September, 2011, 845No/L and 545No/L respectively. This temporal changes are due to change in species composition and its abundance like *Keratella tropica* (December), *Brachionus calyciflorus, B. quadridentatus* and *K. tropica* (February), *B. calyciflorus, B. forficula* (March), *B. calyciflorus, B. caudatus, Trichocerca pusilla* and *T. similis* (April and May), *B. forficula, B. diversicornis, K. tropica, T. pusilla, T. similis, Filinia longiseta* (August and September), *B. calyciflorus, K. tropica* (October and November), whereas, during the year 2011-12, the rotifer density was about 46-301No/L, due to less number of species and their abundance, particularly presence of large number of *Brachionus calyciflorus, B. caudatus* and *Keratella tropica* especially in the month of June, July, October and November (Fig. 4.2.15).

4.2.6 Diversity of rotifers

The rotifer diversity (H) of Osmansagar was found between 0.924-2.89 during the study period (Table. 4.2.5 and Fig. 4.2.16). During the year 2010-11, the diversity was H'=1.917-2.89 and in 2011-12 was H'= 0.924-2.073. The maximum diversity values were recorded during summer in the month of April and May, 2011. But, during 2011-12 maximum diversity was recorded in summer months of May and June. The Shannon maximum (Hmax) diversity was 2.99.

The species richness of rotifers recorded between 7-20 numbers during the year 2010-11 and about 3-14 numbers during 2011-12. The maximum species richness was found in the month of April and May 2011 (19 and 20 numbers respectively). Similarly high richness was recorded in the month of May 2012 (13 species) and June 2012 (14 species) Table 4.2.5 and Fig. 4.2.17.

The evenness (J) of the rotifer was found between 0.547-0.978 during the two years study. More evenness was found during the months of December, 2010 to June, 2011 (J= 0.985-0.978) and declined in July and August, 2011 (J=0.864-0.792). It was 0.978 in September to November 2011, which was again high. In 2011-12 the evenness fluctuated with high evenness in the month of December (J= 0.94) and January (J= 0.91). Therefore, the overall evenness values were less in 2011-12 than in 2010-11 (Table 4.2.5 and Fig. 4.2.18).

The overall abundance of rotifer ranges between 5.47-94.29% during the two year study period. The abundance was between 22.9-94.29% during 2010-11 and between 8.96-33.83% in 2011-12. It clearly shows that the abundance values are being increase with the species richness, density and diversity of the rotifers. Besides, the maximum abundance was about 94.29% in summer during the year 2010-11 (Table 4.2.5 and Fig. 4.2.20).

The Berger-Parker dominance index during the entire study period was between 10.2-58.8%. It ranged between 10.2-26.39% and 20.56-58.21% during 2010-11 and 2011-12 respectively. This high dominance during 2011-12 may be due to monsoon seasons. Numerical dominance of *Brachionus forficula*, *Mesocyclops leuckarti* was noticed (Table 4.2.5 and Fig. 4.2.19).

SHE information analysis shows the variance of LnS=1.95-3.07, LnE= -0.03 to -0.57 and LnE/LnS= -0.01- to -0.16 in 2010-11 and whereas in 2011-12 the differences in LnS= 2.2-3.22, H= 2.07-2.59, LnE= -0.12 to -1.05 and LnE/LnS= -0.06 to -0.33. It appears that with the increase of rotifer species richness (S), the diversity (H) and evenness (E) also increased, but when the species richness was constant the

Table 4.2.5 Rotifer density and diversity during 2010-12

Index		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Density	2010-11	133	197	456	374	548	484	395	491	845	545	185	241
	2011-12	48	59	46	73	44	141	301	137	51	71	117	292
Shannon H' Log Base 2.718	2010-11	1.917	2.099	2.708	2.544	2.854	2.897	2.771	2.072	2.244	2.075	1.987	2.344
	2011-12	2.073	2.003	1.405	1.647	1.696	2.187	1.957	1.245	0.924	1.472	1.468	1.064
Shannon Hmax Log Base 2.718	2010-11	1.946	2.197	2.833	2.639	2.944	2.996	2.833	2.398	2.833	2.398	2.079	2.398
	2011-12	2.197	2.197	1.946	1.792	1.946	2.565	2.639	1.609	1.099	1.609	1.946	1.946
Shannon J'	2010-11	0.985	0.955	0.956	0.964	0.969	0.967	0.978	0.864	0.792	0.865	0.955	0.978
	2011-12	0.943	0.912	0.722	0.919	0.872	0.853	0.742	0.773	0.841	0.915	0.755	0.547
Berger-Parker Dominance (d)	2010-11	0.233	0.264	0.147	0.136	0.102	0.147	0.116	0.346	0.346	0.27	0.227	0.166
	2011-12	0.25	0.288	0.457	0.315	0.386	0.206	0.286	0.526	0.588	0.324	0.496	0.582
Berger-Parker Dominance (d%)	2010-11	23.30	26.39	14.69	13.63	10.21	14.66	11.64	34.62	34.55	26.97	22.70	16.59
	2011-12	25	28.81	45.65	31.50	38.63	20.56	28.57	52.55	58.82	32.39	49.57	58.21
Simpsons Diversity (D)	2010-11	0.146	0.135	0.074	0.084	0.061	0.061	0.065	0.172	0.172	0.155	0.147	0.098
	2011-12	0.124	0.146	0.309	0.202	0.21	0.13	0.179	0.355	0.435	0.235	0.305	0.439
Hill's Number (H_0)	2010-11	7	9	17	14	19	20	17	11	17	11	8	11
	2011-12	9	9	7	6	7	13	14	5	3	5	7	7
Hill's Number (H_1)	2010-11	22.92	29.79	71.77	56.66	88.61	94.29	78.57	28.68	36.72	28.80	25.34	42.46
	2011-12	28.70	25.95	10.95	15.53	16.66	33.83	24.28	8.69	5.47	12.06	12.00	6.694

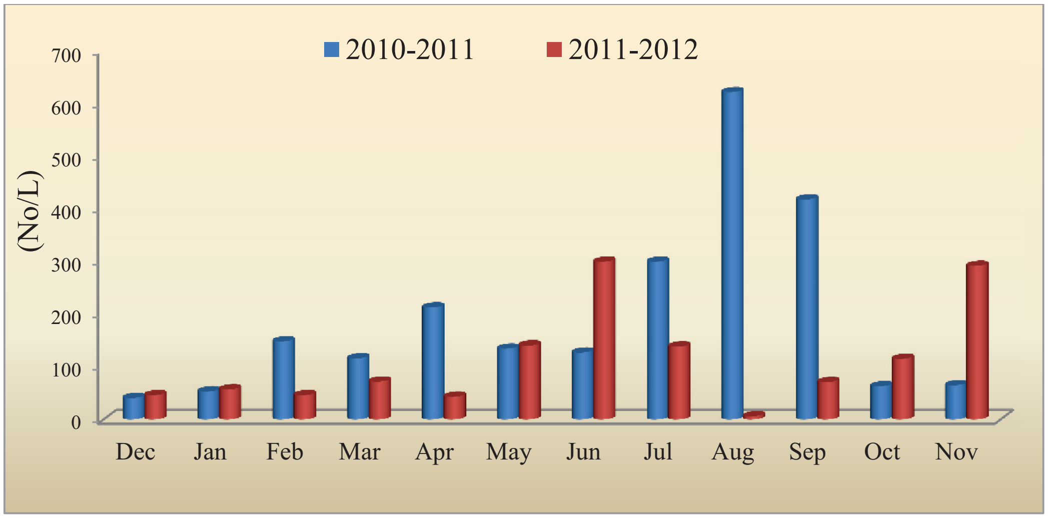


Fig. 4.2.15 Density of rotifers

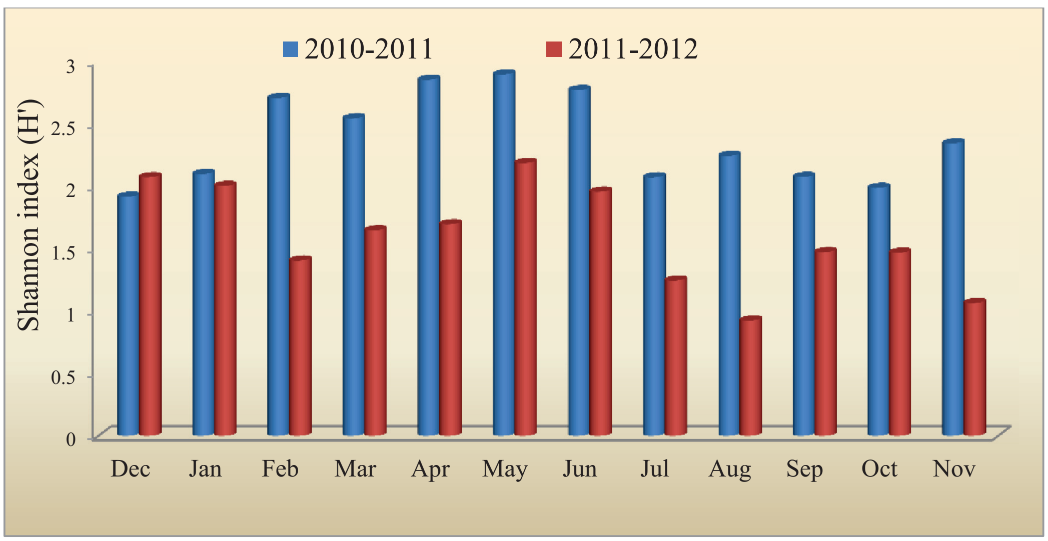


Fig. 4.2.16 Diversity of rotifers

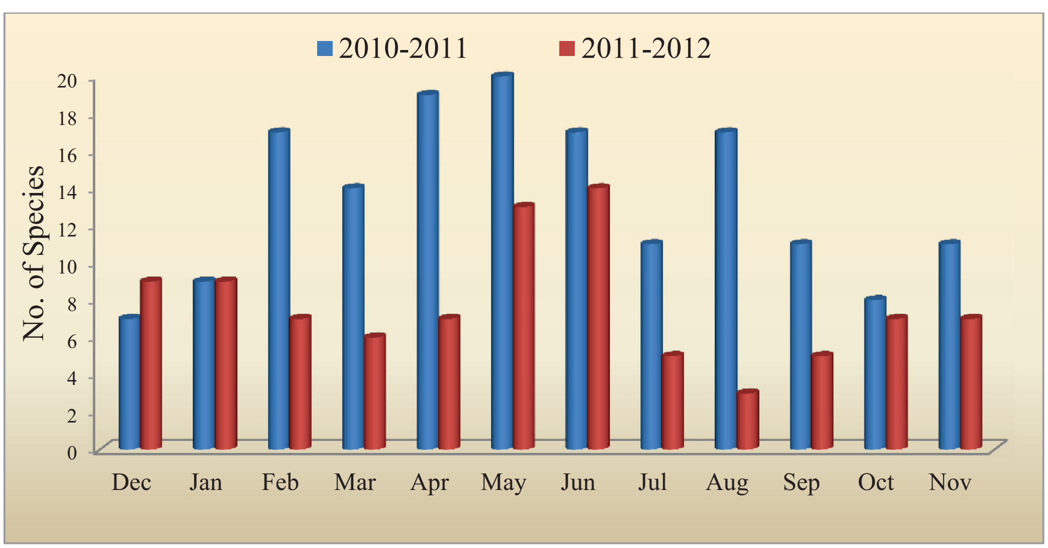


Fig. 4.2.17 Species richness of rotifers

diversity and evenness was also found constant in 2010-11. In 2011-12 the species richness (S) was constant in a particular stage and the diversity reaches the maximum. Even after the species richness was constant, the diversity decreased and the evenness increased during the period 2011-12 (Table. 4.2.8 and Fig. 4.2.21 and 4.2.22).The pooled number of rotifer species was 38 in 2010-11 (December, 2010 to November, 2011), whereas it was 25 species in 2011-12 (December, 2011- November, 2012). Therefore, the overall species richness was high during the year 2010-11 (Table 4.2.9 and Fig. 2.23).

4.2.7 Rotifers similarity index

The rotifer species similarity varies 17.8-69.8% during the period December, 2010-November, 2011 (Table 4.2.6). The high species similarity (69%) found in the summer season between June and May, where as low species similarity (20%) in winter season between December and March. Cluster analysis showed that the seasonal assemblage of species and the clusters were formed between the months of April to June representing summer season. In July to September it formed as one cluster, and October and November as one cluster. Further, October and November (monsoon) were linked with April (summer). Hence, December, January, February and March (winter) formed a cluster linked between summer and Monsoon seasons (Fig.4.2.24).

In December 2011- November 2012, study showed the similarity of the rotifer species varied between 8.22-62.29% (Table 4. 2.7). The maximum similarity (62%) of the species was between September and August, and less similarity of the species found between November with March and April 8.2% and 8.95, respectively. The cluster formation showed that the similarity of the species was unseasonal because the December is linked with March and April; January and February were connected with

Table 4.2.6 Rotifer similarity matrix 2010-11

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
December	*	46.66	39.38	20.11	34.06	36.30	42.42	26.28	16.76	24.18	10.69	29.41
January	*	*	50.53	35.72	29.79	27.60	31.75	22.38	18.04	25.33	17.80	32.87
February	*	*	*	31.08	47.21	40.42	52.40	37.80	35.05	50.94	36.50	40.45
March	*	*	*	*	42.73	29.13	32.50	32.83	21.32	23.50	32.55	40.65
April	*	*	*	*	*	53.29	59.59	39.07	37.04	38.97	23.46	38.02
May	*	*	*	*	*	*	69.85	51.07	54.02	45.48	37.96	54.62
June	*	*	*	*	*	*	*	44.69	42.74	44.68	33.79	44.65
July	*	*	*	*	*	*	*	*	53.44	58.88	39.64	40.98
August	*	*	*	*	*	*	*	*	*	61.43	26.21	41.06
September	*	*	*	*	*	*	*	*	*	*	20.54	43.76
October	*	*	*	*	*	*	*	*	*	*	*	58.68
November	*	*	*	*	*	*	*	*	*	*	*	*

Table 4.2.7 Rotifers similarity matrix in 2011-12

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
December	*	31.77	38.29	42.97	39.13	29.62	16.04	24.86	28.28	33.61	29.09	10
January	*	*	57.14	36.36	11.65	43	22.77	32.65	41.81	35.38	36.36	16.52
February	*	*	*	50.42	8.88	42.78	24.20	41.53	55.67	39.31	39.26	13.60
March	*	*	*	*	20.51	34.57	17.11	33.33	24.19	29.16	25.26	8.21
April	*	*	*	*	*	21.62	10.43	16.57	12.63	40	22.36	8.92
May	*	*	*	*	*	*	52.94	49.64	41.66	43.39	53.48	28.17
June	*	*	*	*	*	*	*	47.94	28.97	24.73	47.36	56.66
July	*	*	*	*	*	*	*	*	54.25	48.07	44.09	27.50
August	*	*	*	*	*	*	*	*	*	62.29	52.38	26.23
September	*	*	*	*	*	*	*	*	*	*	52.12	26.99
October	*	*	*	*	*	*	*	*	*	*	*	45.47
November	*	*	*	*	*	*	*	*	*	*	*	*

Table 4.2.8 SHE analyses of rotifers 2010-12

2010-11						2011-12					
N	**S**	**LnS**	**H**	**LnE**	**LnE/LnS**	**N**	**S**	**LnS**	**H**	**LnE**	**LnE/LnS**
133	7	1.95	1.92	-0.03	-0.01	48	9	2.2	2.07	-0.12	-0.06
330	12	2.48	2.37	-0.12	-0.05	107	15	2.71	2.41	-0.3	-0.11
786	19	2.94	2.74	-0.2	-0.07	153	17	2.83	2.29	-0.54	-0.19
1160	25	3.22	3.01	-0.21	-0.06	226	18	2.89	2.33	-0.56	-0.2
1708	31	3.43	3.19	-0.25	-0.07	270	21	3.04	2.5	-0.55	-0.18
2192	35	3.56	3.29	-0.26	-0.07	411	23	3.14	2.59	-0.55	-0.17
2587	36	3.58	3.3	-0.28	-0.08	712	24	3.18	2.48	-0.7	-0.22
3078	36	3.58	3.23	-0.36	-0.1	849	24	3.18	2.37	-0.8	-0.25
3923	37	3.61	3.12	-0.49	-0.13	900	24	3.18	2.33	-0.85	-0.27
4468	37	3.61	3.06	-0.55	-0.15	971	25	3.22	2.35	-0.87	-0.27
4653	38	3.64	3.07	-0.57	-0.16	1088	25	3.22	2.32	-0.9	-0.28
4894	38	3.64	3.07	-0.57	-0.16	1380	25	3.22	2.17	-1.05	-0.33

Table 4.2.9 Pooled number of rotifer species 2010-12

	2010-2011	**2011-2012**
December	13.2	9
January	19	14
February	22.6	17.2
March	25.2	18.6
April	25.8	19.6
May	28.6	21
June	31.2	21.8
July	32.8	22.6
August	34	23.4
September	35.4	24.2
October	36.8	24.2
November	38	25

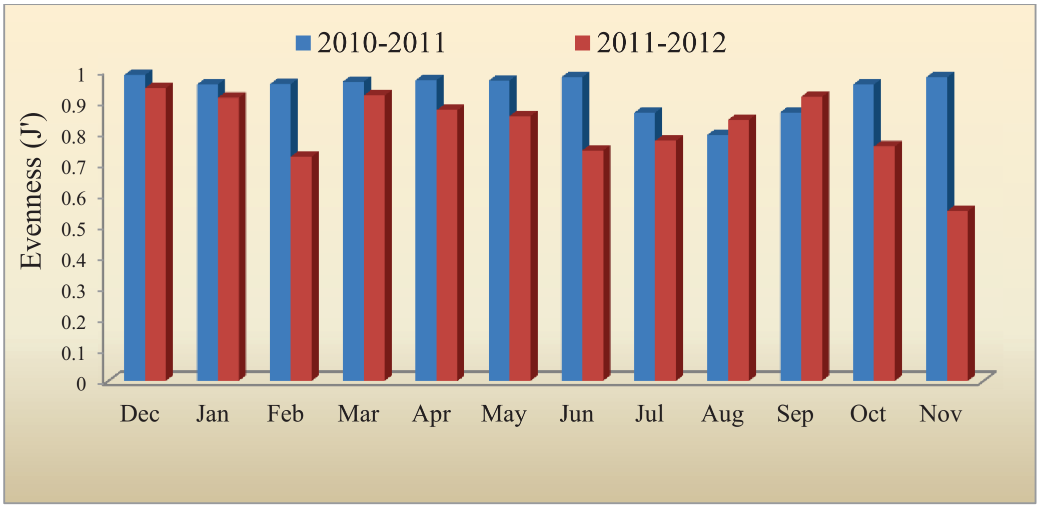


Fig. 4.2.18 Evenness of rotifers

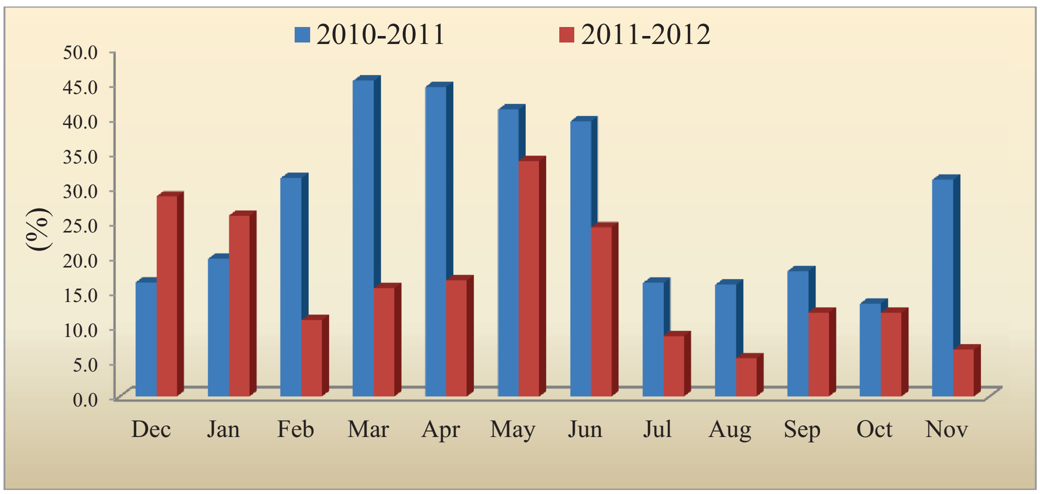


Fig. 4.2.19 Abundance of rotifers

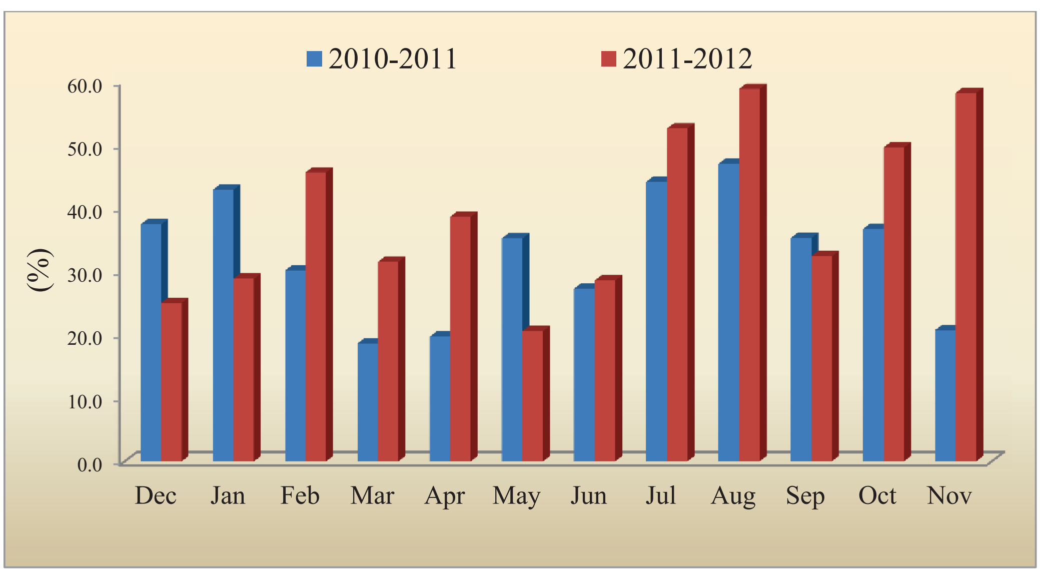


Fig. 4.2.20 Dominance of rotifers

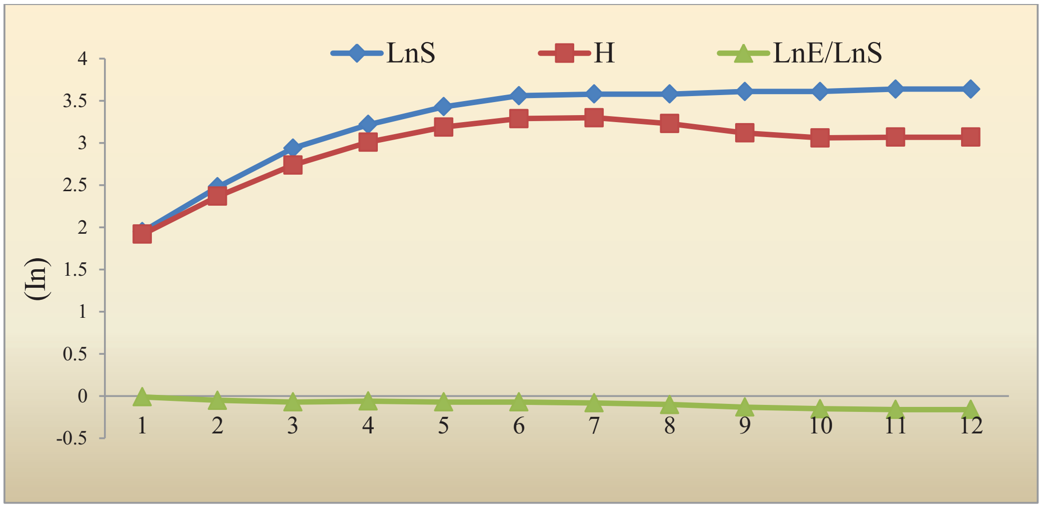


Fig. 4.2.21 SHE information analysis of rotifers 2010-11

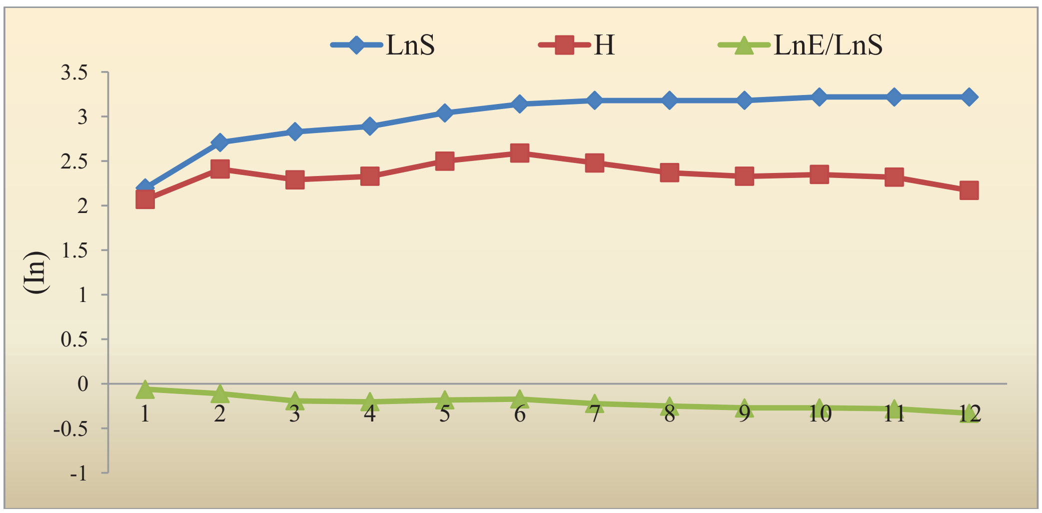


Fig. 4.2.22 SHE information analysis of rotifers 2011-12

Fig. 4.2.23 Pooled number of rotifer species

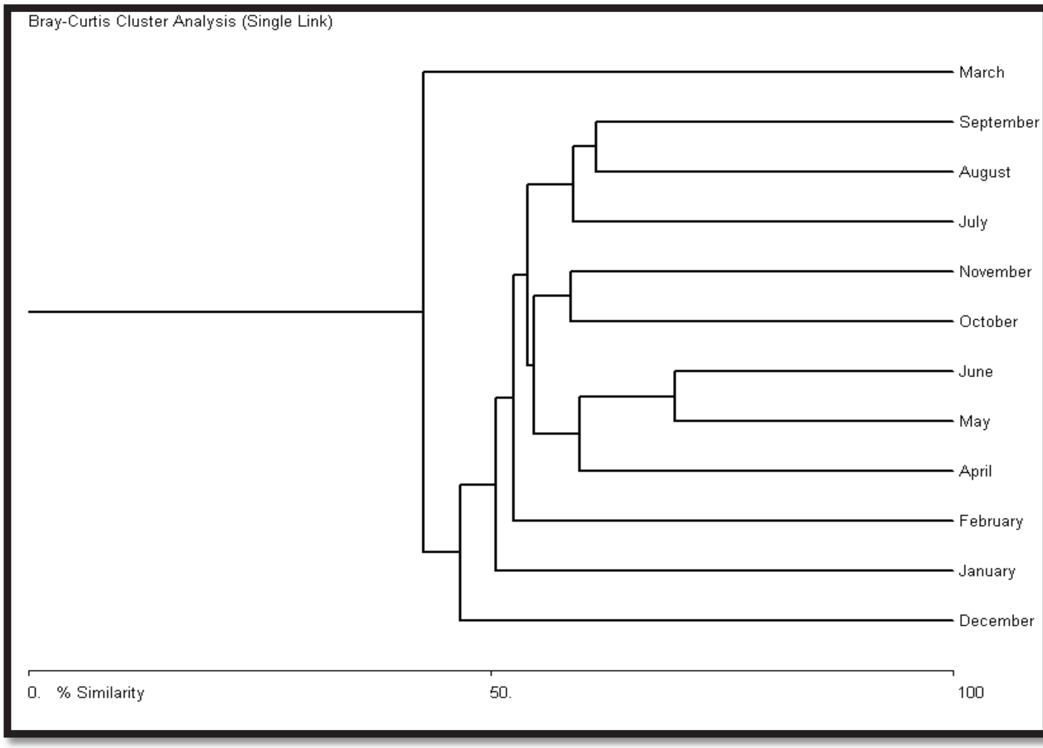


Fig. 4.2.24 Similarity index of rotifers 2010-2011

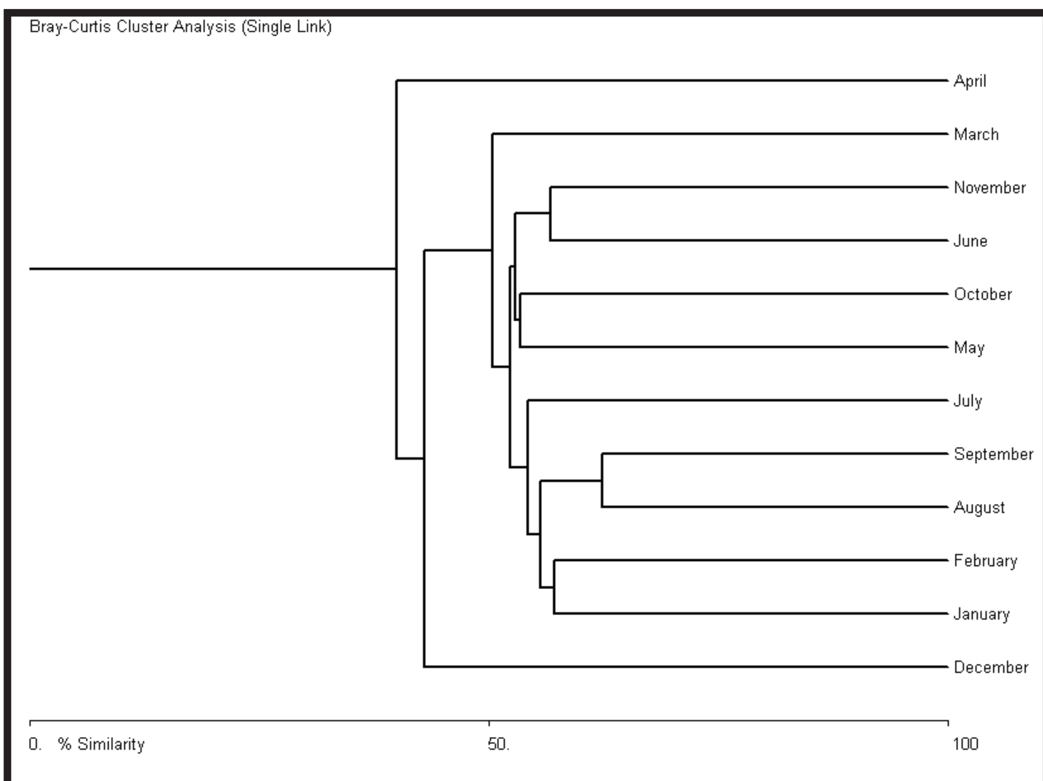


Fig. 4.2.25 Similarity index of rotifers 2011-2012

August; September and May were linked with October, while June linked with November. Therefore, the study reveals less species dissimilarity since common species frequently occur at different seasons (Fig. 4.2.25).

4.2.8 Density of cladocera

The cladoceran density was found between 2-201No/L, over two year study period. During 2010-11 the density was ranged between 17-201.8No/L, whereas in 2011-12 it was 2-38No/L (Table 4.2.10). The maximum density of cladocera (134.2-201.8No/L) was found in the month of February and March, 2011. The cladoceran population density was very less than the rotifers and copepods (Fig. 4.2.26). The temporal population changes of cladoceran were observed during 2010-11 due to *Daphnia lumholtzi, Macrothrix spinosa* (December), *Coronatella rectangula* (January-February), *Diaphanosoma sarsi* (March), *Macrothrix spinosa* (June) and *C. rectangula* (August to November). But in 2011-12 *D. sarsi* was found in more numbers in March, September, October and November, and in rest of the moths the number is very less and scattered.

4.2.9 Diversity of cladocera

The Simpsons diversity index (D) reveals that the diversity of cladocera from Osmansagar varies between D=0.198-1 (The lower the value, higher the diversity where as higher the value, lower the diversity, If the diversity values reach one, the diversity is almost nil). During the year 2010-2011 the diversity values are between 0.198-1, the high diversity values were in the month of December, 2010 to March, 2011 having D=0.198, 0.248, 0.209 and 0.374 respectively and in rest of all other months, the diversity index is less and sometimes it showed nil. High diversity was observed during winter and early summer season. In 2011-12, the index ranged

Table 4.2.10 Density and diversity of cladocera 2010-12

Index	Duration	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Density (No/L)	2010-11	105.6	178	134.2	201.8	23	56	103	17	38.5	17	52	17
	2011-12	2	2	6	23	2	2	2	3	38	32	9	9
Simpsons Diversity (D)	2010-11	0.198	0.248	0.209	0.374	1	0.5	0.7	1	0.494	1	0.551	1
	2011-12	1	1	0.467	0.763	1	1	1	1	0.851	1	0.5	0.5
Simpsons Diversity (1/D)	2010-11	5.048	4.025	4.79	2.674	1	1.9	1.4	1	2.026	1	1.814	1
	2011-12	1	1	2.143	1.311	1	1	1	1	1.176	1	2	2
Berger-Parker Dominance (d)	2010-11	0.246	0.421	0.367	0.557	1	0.6	0.8	1	0.558	1	0.673	1
	2011-12	1	1	0.667	0.87	1	1	1	1	0.921	1	0.667	0.667
Berger-Parker Dominance (1/d)	2010-11	4.062	2.373	2.728	1.794	1	1.6	1.2	1	1.791	1	1.486	1
	2011-12	1	1	1.5	1.15	1	1	1	1	1.086	1	1.5	1.5
Berger-Parker Dominance (d%)	2010-11	24.62	42.13	36.66	55.73	100	63	83	100	55.84	100	67.30	100
	2011-12	100	100	66.67	86.95	100	100	100	100	92.10	100	66.66	66.66
Hill's Number (H_0)	2010-11	5	6	6	4	1	2	2	1	2	1	2	1
	2011-12	1	1	2	2	1	1	1	1	2	1	2	2
Hill's Number (H_1)	2010-11	14.40	14.12	16.2	7.793	1.44	3.7	2.8	1.443	3.883	1.443	3.59	1.443
	2011-12	1.443	1.443	3.614	2.522	1.44	1.4	1.4	1.443	2.149	1.443	3.614	3.614
Hill's Number (H_2)	2010-11	0	0	0	0	0	0	0	0	0	0	0	0
	2011-12	0.25	0.125	0.036	0.002	0	0	0	0.002	0.001	0	0	0

between D=0.467-1, more in the month of February D=0.47, while in October and November, 2012 the diversity was D= 0.5 (Table. 4.2.10 and Fig. 4.2.27).

Species richness of the cladocera shows similar trends in diversity and dominance. The species richness was between 1- 6, more in the months of January and February, 2011 (Table. 2.11 and Fig. 4.2.28). Hence, the abundance of cladoceran is between 1.4-16.2%. The abundance value was more during winter season of 2010-11 between the months of December, 2010 to March, 2011 and during the remaining period it showed less abundance (Table.4.2.10 and Fig. 4.2.29).

The Berger-Parker dominance (d) shows that the overall dominance varies between 24.62-100%. The studies reveal less dominance when the diversity and species richness is high. Similarly the dominance is more, when the diversity and species richness is less. 100% dominance was due to the representation of few species and less dominance was observed in the winter season from December, 2010 to March, 2011. The high dominance in 2011-12 was due to presence of *Diaphanosoma sari* available through most seasons (Table. 4.2.10).

SHE information data analysis for the year 2011-12 show that the cladoceran variance of LnS = 1.61 to 2.48, H=1.6-2.2, LnE= -0.01 to 0.41 and LnE/LnS = -0.01 to -0.16. More variance in the species richness, diversity and evenness were observed. The cladoceran species richness was constant, whereas diversity values vary with the evenness of the species. The evenness was less when the diversity attains maximum value. Similarly when the evenness and diversity were constant, the species richness was also constant which was observed during 2010-11. But almost throughout the year 2011-12 only few species were represented (Table. 4.2.14 and Fig. 4.2.31). The pooled number of cladoceran species over two year study period was maximum of 12 species in 2010-11 than 06 species in 2011-12 (Table 4.2.13 and Fig. 4.2.30).

4.2.10 Cladoceran similarity index

Cladoceran similarity index was 0-96.65% and 0-100% in 2010-11 and 2011-12 respectively. May 2011 and October 2011 had more similarity, whereas September 2010 had no similarity with any other months. It is therefore, the summer and monsoon seasons have more similarity than the winter season of 2010-11. More similar species were found between summer and winter in 2011-12. It was found that in the monsoon the similarity was comparatively less, but the maximum 91.4% similarity was found in the month of August 2011 and September 2012 which were monsoon seasons (Table 4.2.11 & 4.2.12 and Fig. 4.2.32 & 4.2.33).

4.2.11 Physicochemical profile of Osmansagar

Physicochemical nature of the reservoir shows (Table 4.2.15) that atmospheric temperature between 18-31°C. Maximum temperature was recorded in the month of December, 2010 to September, 2011 (22-26°C). Minimum temperature was recorded in the month of August, 2012 (16°C) and September, 2012 (17°C) Fig. 4.2.34. The pH value was 8.05 to 9.9 over the two years study period (Fig. 4.2.35). High values are noticed during summer season from May, 2012 to August, 2012 (8.7-9.7). The pH value indicates the alkaline nature of the reservoir. Electrical conductivity was 0.41-0.96mS, with marginal variations from December, 2010 to July, 2012, but suddenly increased from 0.43mS in the Month of July 2012 to 0.96mS in the month of August, 2012 (Fig. 4.2.36). Total dissolved solid content was 233-370ppm, with the high range during summer seasons (Fig. 4.2.37). Dissolved oxygen content was uniform during the entire period of study. It was 6.68-10.79mg/L in 2010-11 and also in 2011-12 (Fig. 4.2.35). Total hardness is about 100-205.4mg/L and total alkalinity is between 102-195mg/L. Chloride content varies 45.54 to 87.7mg/L. The high

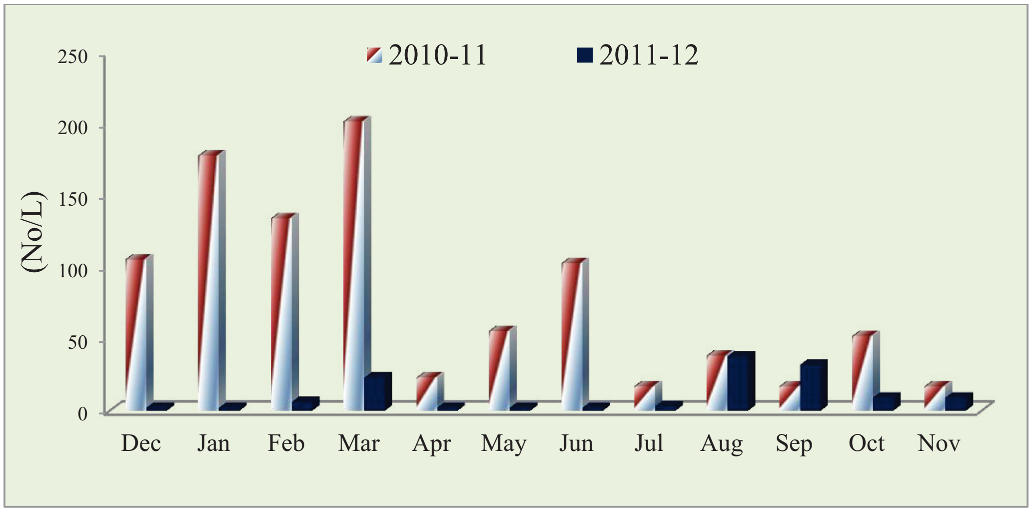


Fig. 4.2.26 Density of cladoceran

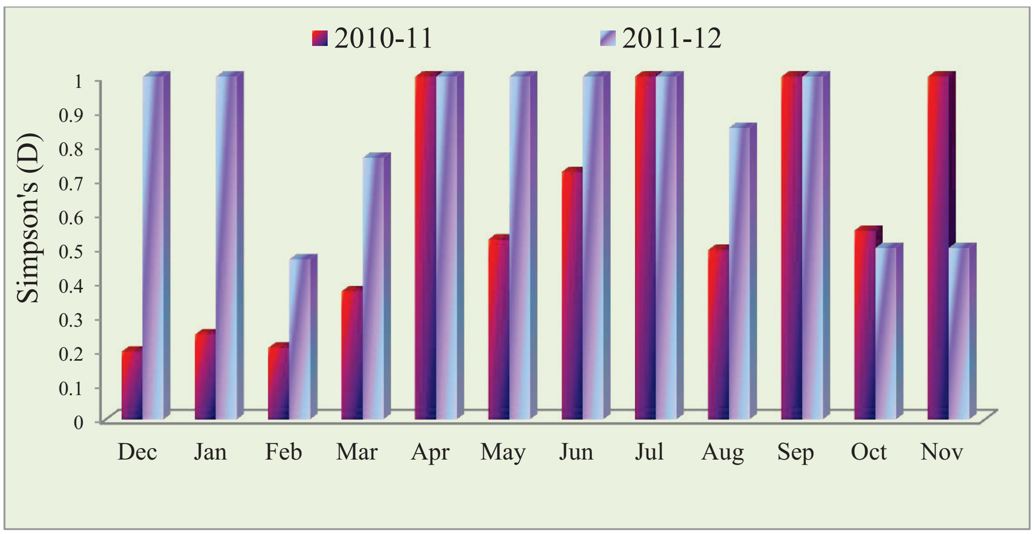


Fig. 4.2.27 Simpson's diversity of cladoceran

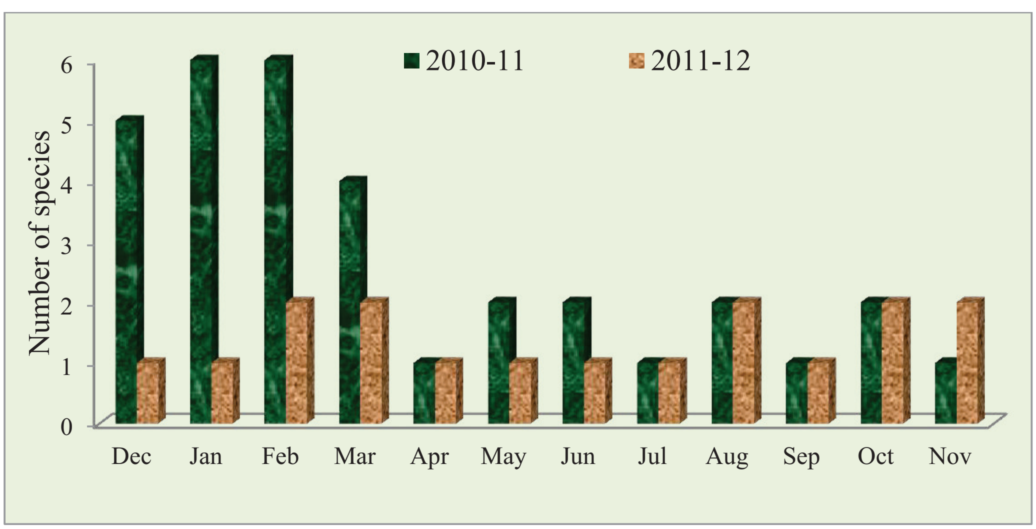


Fig. 4.2.28 Species richness of cladoceran

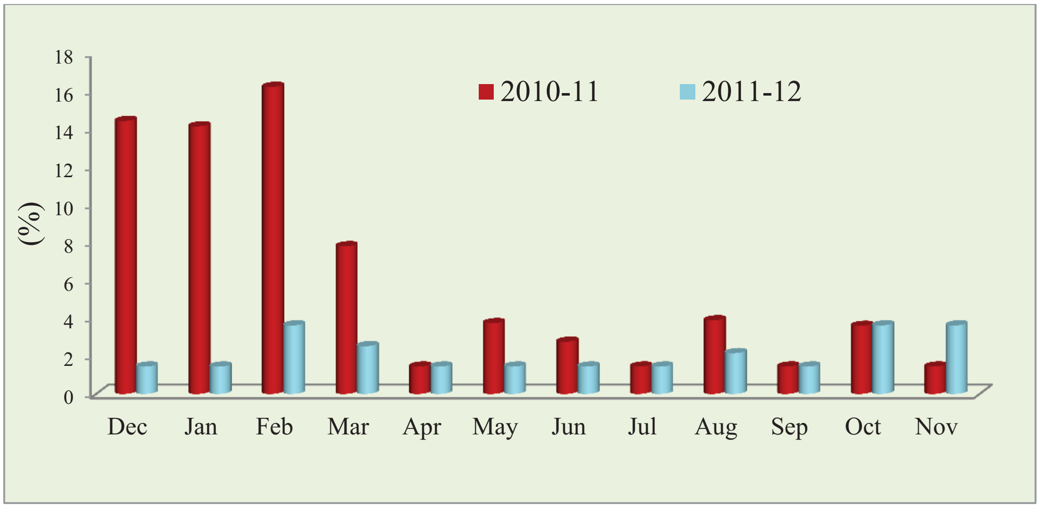


Fig. 4.2.29 Abundance of cladoceran

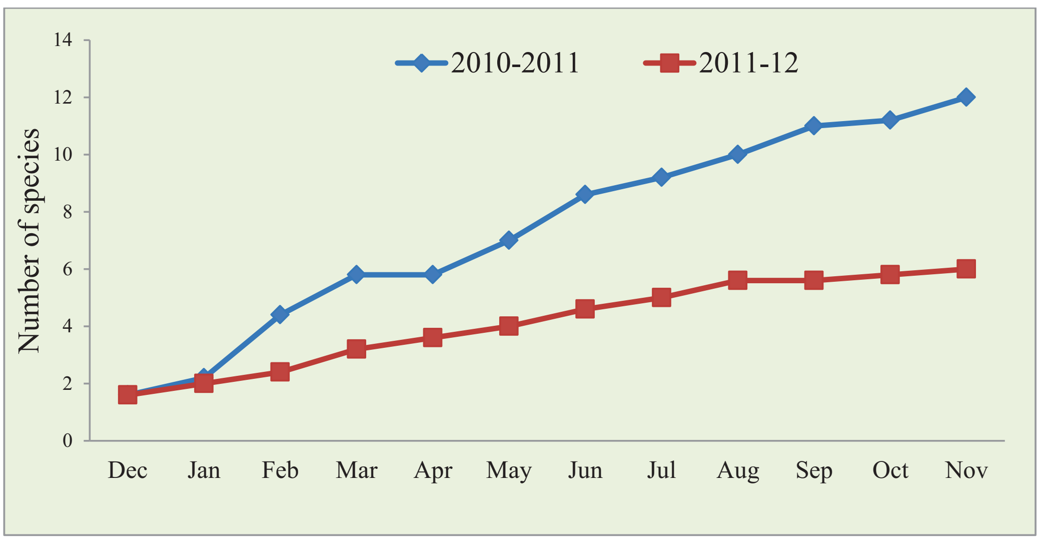


Fig. 4.2.30 Pooled number of cladoceran species

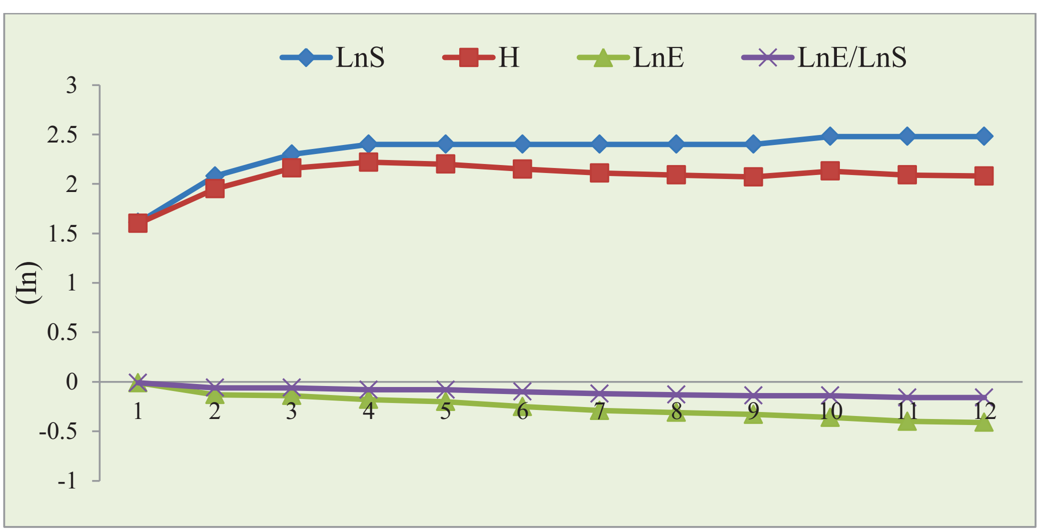


Fig. 4.2.31 SHE information analysis of cladoceran 2010-11

Table 4.2.11 Cladocera similarity matrix 2010-11

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
December	*	35.9	42.5	25.7	26.4	21.1	22	0	23.5	0	21.5	27.7
January	*	*	32.6	22.5	22.88	17.6	12	0	19.86	0	14.78	17.43
February	*	*	*	20.24	21.62	35.8	14	22	39.37	0	36.52	22.48
March	*	*	*	*	20.45	43.2	34	16	32.04	0	40.96	15.53
April	*	*	*	*	*	52.4	0	0	69.92	0	45.33	85
May	*	*	*	*	*	*	21	47	79.92	0	96.65	46.83
June	*	*	*	*	*	*	*	28	24.03	0	21.93	0
July	*	*	*	*	*	*	*	*	61.26	0	49.27	0
August	*	*	*	*	*	*	*	*	*	0	75.13	61.26
September	*	*	*	*	*	*	*	*	*	*	0	0
October	*	*	*	*	*	*	*	*	*	*	*	49.27
November	*	*	*	*	*	*	*	*	*	*	*	*

Table 4.2.12 Cladocera similarity matrix 2010-12

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
December	*	100	50	16	100	0	100	80	10	11.76	36.36	36.36
January	*	*	50	16	100	0	100	80	10	11.76	36.36	36.36
February	*	*	*	13.79	50	0	50	44	9.09	10.52	26.66	26.66
March	*	*	*	*	16	0	16	23	65.57	72.72	37.5	37.5
April	*	*	*	*	*	0	100	80	10	11.76	36.36	36.36
May	*	*	*	*	*	*	0	0	0	0	0	0
June	*	*	*	*	*	*	*	80	10	11.76	36.36	36.36
July	*	*	*	*	*	*	*	*	14.63	17.14	50	50
August	*	*	*	*	*	*	*	*	*	91.42	25.53	25.53
September	*	*	*	*	*	*	*	*	*	*	29.26	29.26
October	*	*	*	*	*	*	*	*	*	*	*	100
November	*	*	*	*	*	*	*	*	*	*	*	*

Table 4.2.13 Pooled number of cladoceran species richness

	2010-2011	2011-12
December	1.6	1.6
January	2.2	2
February	4.4	2.4
March	5.8	3.2
April	5.8	3.6
May	7	4
June	8.6	4.6
July	9.2	5
August	10	5.6
September	11	5.6
October	11.2	5.8
November	12	6

Table 4.2.14 SHE analysis of cladocera 2010-11

2010-2011					
N	S	LnS	H	LnE	LnE/LnS
105.6	5	1.61	1.6	-0.01	-0.01
283.6	8	2.08	1.95	-0.13	-0.06
417.8	10	2.3	2.16	-0.14	-0.06
619.65	11	2.4	2.22	-0.18	-0.08
642.65	11	2.4	2.2	-0.2	-0.08
698.25	11	2.4	2.15	-0.25	-0.1
801.25	11	2.4	2.11	-0.29	-0.12
818.25	11	2.4	2.09	-0.31	-0.13
856.75	11	2.4	2.07	-0.33	-0.14
873.75	12	2.48	2.13	-0.36	-0.14
925.75	12	2.48	2.09	-0.4	-0.16
942.75	12	2.48	2.08	-0.41	-0.16

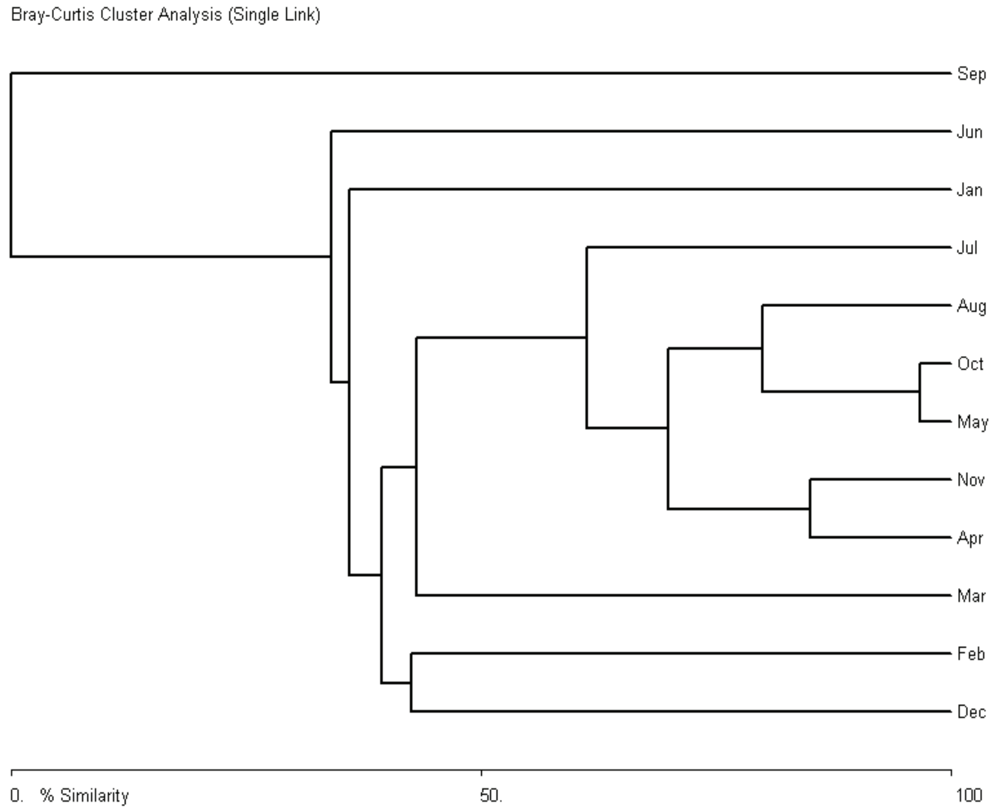


Fig. 4.2.32 Cladoceran similarity index 2010-11

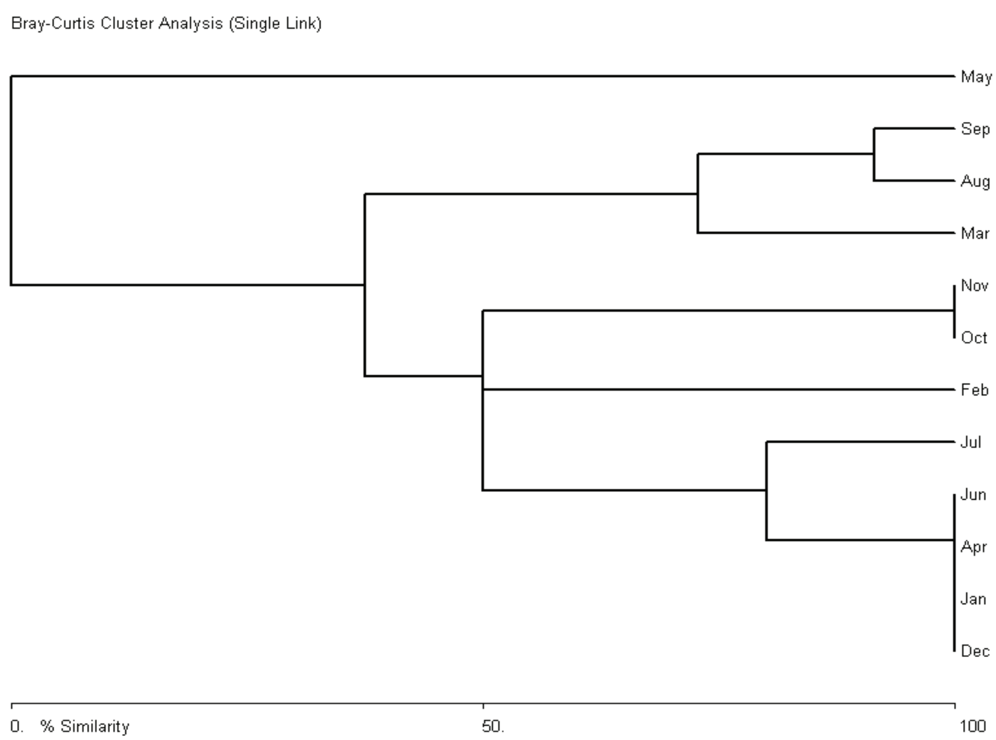


Fig. 4.2.33 Cladoceran similarity index 2011-12

concentration was recorded during monsoon of 2010-11, and in winter and summer seasons of 2011-12. More concentration of chloride was recorded in the month of October, 2011 (87.71mg/L) and March, 2012 (87.71mg/L). The calcium and magnesium values varied between 18.96-28.44mg/L and 19.95-43.1mg/L respectively (Fig. 4.2.38). Phosphate content was about 0.08-1.99mg/L (Fig. 4.2.39). Nitrate is 0.-70mg/L, recorded high in the month of September, 2011 (Fig. 4.2.40), whereas nitrite is 0-0.16mg/L, recorded high in February and September, 2011 (Fig. 4.2.41). Ammonia concentration was between 0-0.02mg/L. (Table.4.2.15 and Fig. 4.2.42). The above physicochemical profile of the reservoir infer tropical climate, alkaline nature of water and less in nutrient content except in monsoon season.

Total zooplankton density significant correlation with surface water temperature (r = 0.7539), pH (r = 0.6416), moderately correlated with total dissolved solides (r = 0.5961), nitrate (r = 0.5400) in 2010-11. Rotifer density was moderately significant correlations with surface temperature (0.5785) in 2010-12. Copepod density modeatly correlation with surface (0.5083), pH (r = 0.5455), species richness moderate correlation with total hardness (r = 0.5679), magnesium (r = 0.6694) in 2011-12. Zooplankton dominamce was correlation with pH (r = 0.6619) in 2010-11 (Table 4.2.16).

Table 4.2.15 Physicochemical profile 2010-2012

Parameters	Duration	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Ambient atmospheric Temperature °C	2010-2011	26.75	28.75	27.50	31.00	28.50	28.94	28.25	24.00	30.00	29.67	30.67	27.67
	2011-2012	27.00	27.67	27.33	26.67	25.00	22.50	21.50	21.50	18.50	19.00	18.00	24.00
Sub-surface water Temperature °C	2010-2011	22.75	24.25	23.75	26.33	24.27	24.65	26.00	26.00	26.67	28.00	20.00	26.00
	2011-2012	24.00	25.33	23.33	24.67	23.00	20.50	20.50	20.00	16.50	17.50	15.50	23.33
PH	2010-2011	8.05	8.93	8.90	8.87	8.69	8.85	9.03	8.93	9.17	9.03	8.67	9.37
	2011-2012	9.03	8.90	8.80	8.87	8.35	8.70	9.50	9.90	9.70	9.10	9.30	8.87
Electrical conductivity (mS)	2010-2011	0.43	0.42	0.41	0.44	0.43	0.42	0.44	0.43	0.42	0.46	0.00	0.41
	2011-2012	0.40	0.43	0.43	0.44	0.45	0.44	0.41	0.43	0.96	0.93	0.92	0.95
Dissolved Oxygen (mg/L)	2010-2011	8.81	6.68	8.00	9.78	8.32	8.19	8.55	8.43	9.45	10.79	0.00	10.05
	2011-2012	10.25	10.39	9.24	9.92	9.62	8.80	7.59	10.63	8.81	10.12	10.73	9.31
Total Dissolved Solids (ppm)	2010-2011	327.5	302.5	307.5	290.0	306.8	301.7	342.5	360.0	349.6	370.0	306.6	316.6
	2011-2012	296.6	333.3	333.3	353.3	355.0	350.0	345.0	340.0	285.0	260.0	275.0	233.3
Total Hardness (mg/L)	2010-2011	100.7	159.9	159.9	158.0	144.6	155.6	189.6	197.5	158.0	205.4	197.5	173.8
	2011-2012	165.9	181.7	158.0	150.1	154.0	177.7	177.7	165.9	142.2	130.3	118.5	134.3
Total Alkalinity (mg/L)	2010-2011	102.0	172.1	172.1	170.0	154.0	167.0	153.0	170.0	161.5	195.5	187.0	170.0
	2011-2012	178.5	170.0	187.0	170.0	191.2	165.7	165.7	140.2	153.0	153.0	153.0	144.5
Chlorides (mg/L)	2010-2011	45.54	60.72	65.78	60.72	58.19	61.35	60.72	67.47	60.72	40.48	87.71	60.72
	2011-2012	80.96	60.72	67.47	87.71	40.48	50.60	70.84	40.48	40.48	20.24	40.48	47.23
Calcium (mg/L)	2010-2011	18.96	23.70	30.81	28.44	25.48	27.11	28.44	22.12	28.44	28.44	28.44	28.44
	2011-2012	28.44	28.44	28.44	22.12	18.96	18.96	18.96	28.44	28.44	28.44	18.96	28.44
Magnesium (mg/L)	2010-2011	19.95	33.25	31.52	31.61	29.08	31.37	39.32	42.79	31.61	43.18	41.25	35.47
	2011-2012	33.54	37.39	31.61	31.23	32.96	38.75	38.75	33.54	27.76	24.87	24.29	25.83
Phosphates (mg/L)	2010-2011	0.25	0.15	0.20	0.43	0.26	0.26	0.23	0.31	0.15	0.36	0.18	0.10
	2011-2012	0.13	0.15	0.12	0.15	0.08	1.69	1.99	0.31	0.24	0.15	0.18	0.12
Nitrates (mg/L)	2010-2011	6.75	0.00	7.50	0.33	3.65	2.87	0.00	0.33	0.04	70.00	1.33	0.00
	2011-2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitrites (mg/L)	2010-2011	0.06	0.00	0.11	0.01	0.05	0.04	0.00	0.00	0.00	0.16	0.03	0.00
	2011-2012	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03
Ammonia (mg/L)	2010-2011	0.02	0.01	0.01	0.00	0.01	0.01	0.00	0.10	0.00	0.00	0.00	0.00
	2011-2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.2.16 Simple correlation between zooplankton and physicochemical parameters of Osmansagar

	Duration	S.Temp	pH	EC	DO	TDS	TH	TA	Cl	Ca	Mg	PO_4	Nitrate	Nitrite	Ammonia
Total Zooplankton (No/L)	2010-11	0.7539	0.6416	0.3609	0.5862	0.5961	0.3291	0.3624	-0.4406	0.2900	0.3110	-0.0199	0.5401	0.2059	-0.0917
	2011-12	-0.0656	0.2871	0.4133	-0.4172	-0.3244	-0.2717	-0.5059	0.1033	0.0432	-0.2711	0.1191	0	0.2356	0
Rotifer (No/L)	2010-11	0.5785	0.4287	0.3597	0.4158	0.4373	0.1787	0.2389	-0.1618	0.3593	0.1440	0.1546	0.1959	0.1221	0.0542
	2011-12	0.0048	0.1646	0.0682	-0.4520	-0.1701	0.0748	-0.4191	0.0393	-0.2544	0.1284	0.5668	0	0.4037	0
Cladocera (No/L)	2010-11	-0.1469	-0.2198	0.1112	-0.0365	-0.5750	-0.3566	-0.1620	-0.0002	0.0257	-0.3792	0.1683	-0.2658	-0.1254	-0.3063
	2011-12	-0.4922	0.2894	0.6694	-0.0094	-0.4342	-0.5918	-0.3686	-0.3316	0.2935	-0.6343	-0.2981	0	-0.0652	0
Copepoda (No/L)	2010-11	0.5083	0.5455	0.2431	0.4736	0.2279	0.2144	0.2542	-0.3861	0.1968	0.2016	-0.1679	0.3898	0.0998	-0.2226
	2011-12	-0.0464	0.2422	0.4164	-0.2733	-0.2740	-0.3236	-0.3714	0.1284	0.1603	-0.3471	-0.1227	0	0.0841	0
Shannon H' Log Base 2.718	2010-11	-0.3230	-0.5686	0.0375	-0.1903	-0.3358	-0.4025	-0.2803	0.0582	-0.1377	-0.4072	0.3552	-0.1882	0.1352	0.0162
	2011-12	0.0405	-0.2761	-0.3393	-0.0252	0.2408	0.4380	0.1881	-0.0493	-0.3244	0.4936	0.5067	0	-0.0281	0
Simpsons Diversity (D)	2010-11	0.3302	0.5958	0.0572	0.2779	0.1577	0.2777	0.2326	-0.0862	0.2210	0.2654	-0.3822	0.1041	-0.1351	-0.1208
	2011-12	-0.0409	0.2663	0.2621	-0.0508	-0.1465	-0.3294	-0.1180	0.1696	0.2184	-0.3657	-0.3853	0	-0.0676	0
Hill's Number (H_0)	2010-11	0.1655	0.1286	0.3905	0.2776	-0.3999	-0.3190	-0.0556	-0.0532	0.4118	-0.3869	0.0821	-0.2452	0.0278	-0.3114
	2011-12	0.0935	-0.0125	-0.4138	-0.5765	0.3509	0.5679	0.0506	0.3605	-0.5541	0.6694	0.9122	0	-0.0279	0
Hill's Number (H_1)	2010-11	-0.3282	-0.4923	0.1256	-0.0759	-0.5412	-0.5252	-0.3106	0.0377	-0.0157	-0.5516	0.2538	-0.2692	0.1724	-0.0906
	2011-12	0.0062	-0.2723	-0.3101	-0.1269	0.2875	0.4862	0.1424	-0.0388	-0.3622	0.5484	0.5933	0	-0.1034	0
Berger-Parker Dominance (d%)	2010-11	0.4374	0.6619	0.0754	0.3139	0.2475	0.3900	0.3353	-0.1249	0.2959	0.3745	-0.2766	0.2199	-0.0835	-0.1461
	2011-12	-0.0051	0.2025	0.2348	-0.0037	-0.1724	-0.3619	-0.0121	0.2212	0.1648	-0.3852	-0.4304	0	-0.0108	0

Fig. 4.2.34- 4.2.42 Physicochemical features in 2010-2012

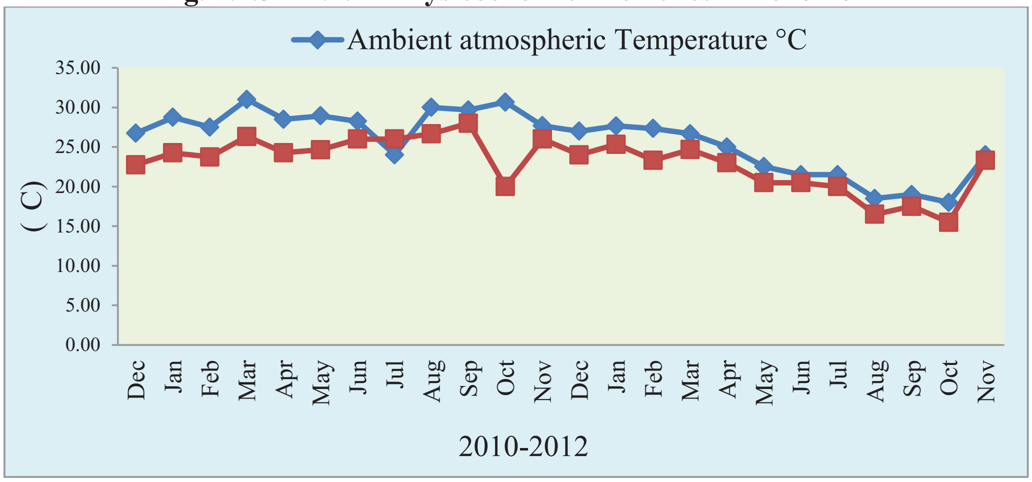


Fig. 4.2.34 Temperature

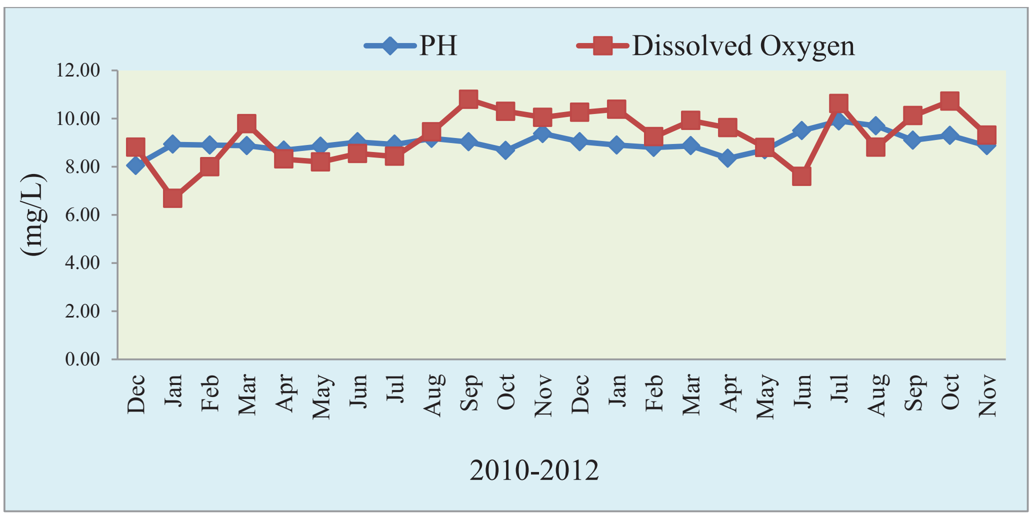


Fig. 4.2.35 pH and Dissolved Oxygen

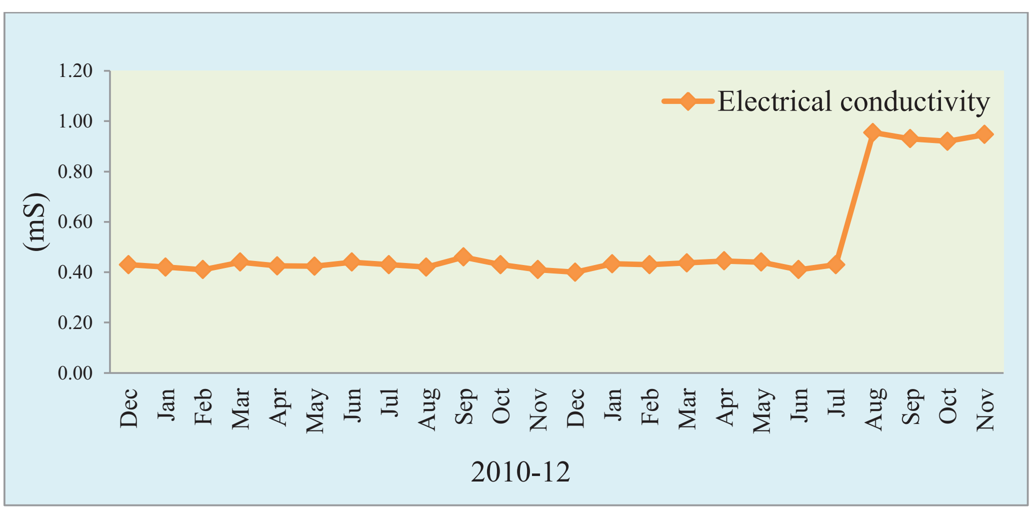


Fig. 4.2.36 Electrical conductivity

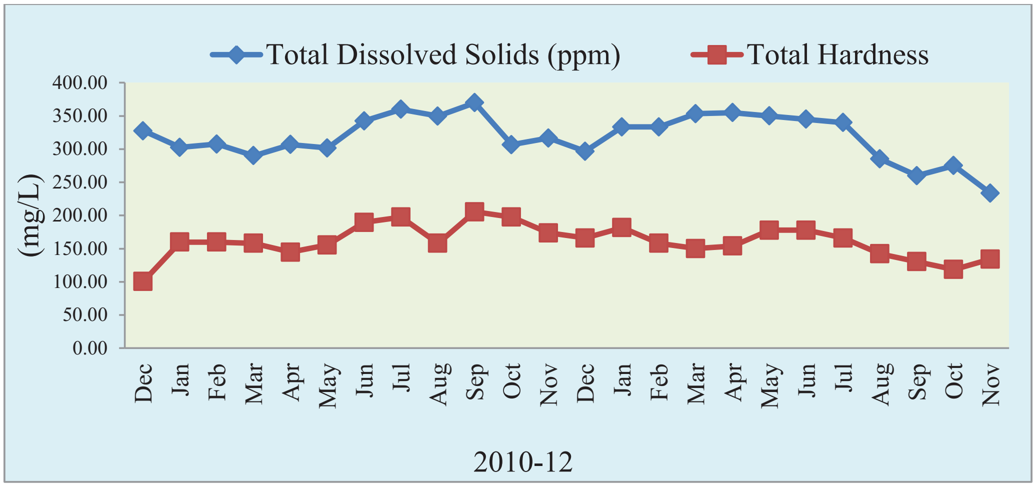


Fig. 4.2.37 Total dissolved solids and hardness

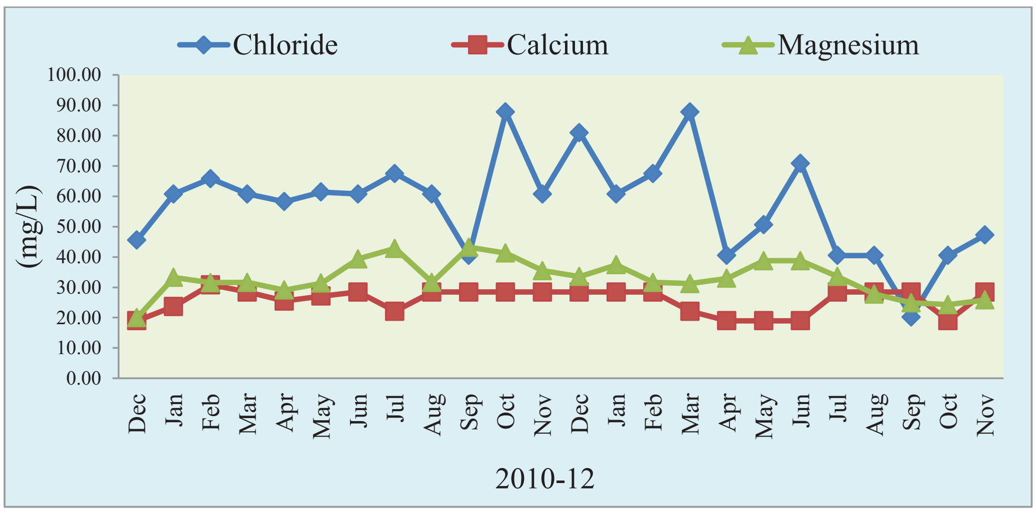


Fig. 4.2.38 Chloride, Calcium and Magnesium

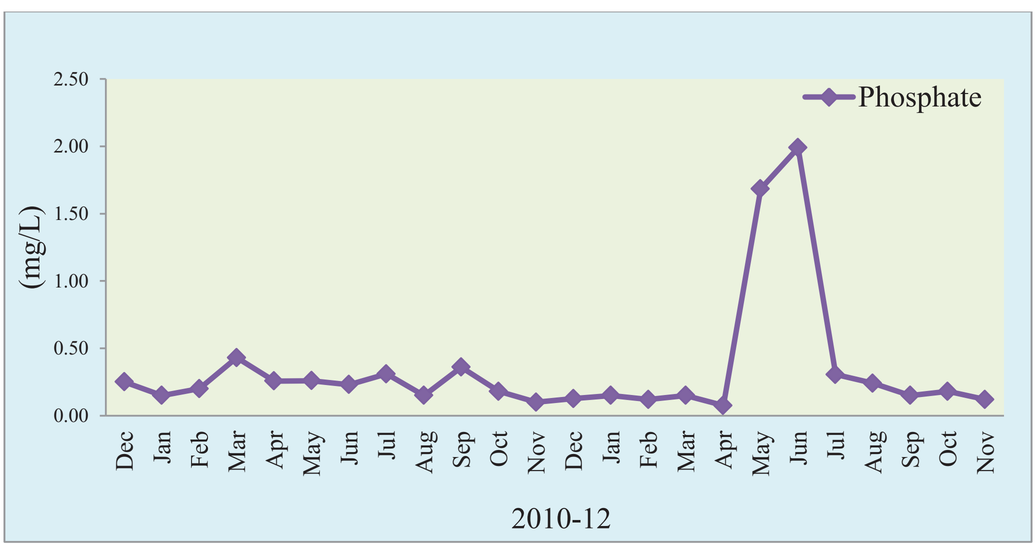


Fig. 4.2.39 Phosphate

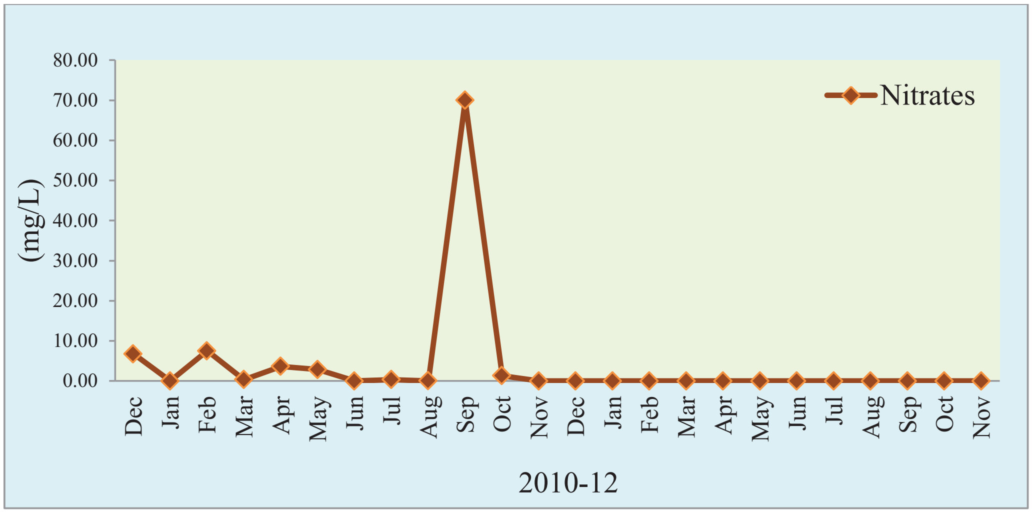


Fig. 4.2.40 Nitrate

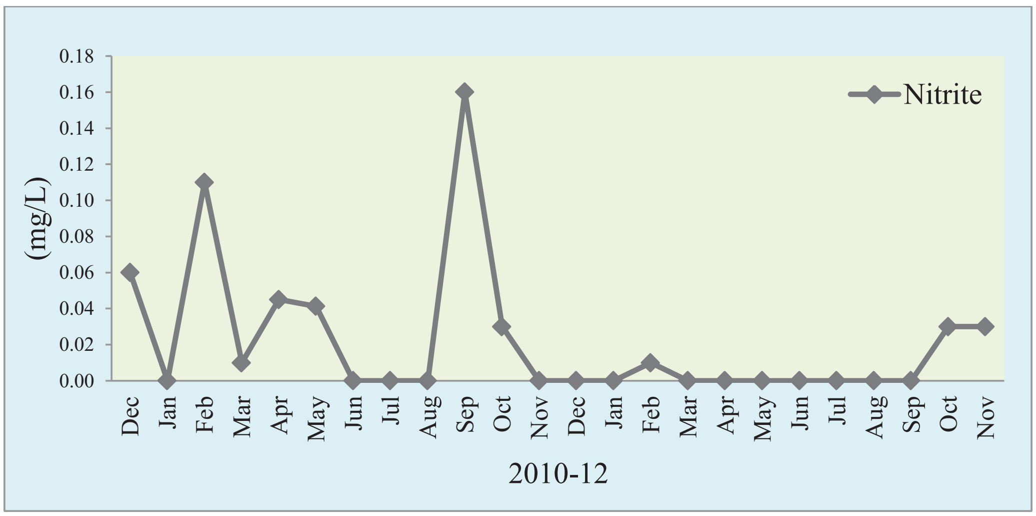


Fig. 4.2.41 Nitrite

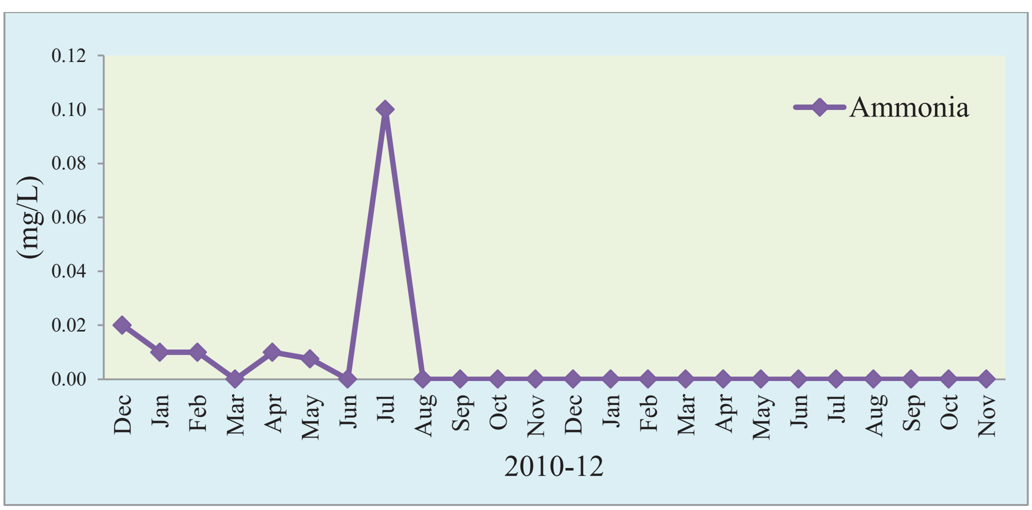


Fig. 4.2.42 Ammonia

4.3 Zooplankton community structure, composition and diversity of Ameenpur irrigation Tank, Medak District

Generally the tanks are small water bodies with moderate depth and play an important role in socio-economic development of the area. Generally water receives from rain fed channels from surrounding areas, especially during the monsoon. Sometimes the tanks are connected to other tanks and ponds for diverting the water. During monsoon the agricultural runoffs and pesticides enter into this small fragile ecosystem and affect the water quality and fauna and flora of the water body. Very little is known about microinvertebrate fauna, especially zooplankton community and its diversity in such habitats.

The present study assessed the zooplankton composition, density, diversity as well as its trophic status with reference to their physicochemical features of an irrigation tank from Ameenpur village, Medak district (Plate 24), which was very closer to the Hyderabad Municipal Corporation surrounded by many industries.

4.3.1 Zooplankton composition

61 species of zooplankton groups were recorded during the study period from this irrigation tank, of which rotifers are dominant with 43 species belonging to 15 genera and 14 families followed by Cladocera with 17 species belonging to 14 genera and 06 families, and copepod with 03 species belonging to 03 genera under 02 families (Table 4.3.1 and Fig. 4.3.1).

Among the various rotifer species, family Brachionidae contains more number of species, especially genus *Brachionus* (12 species) and family Lecanidae genus *Lecane* (08 species). In Cladocera, family Chydoridae has more number of species with 05 genera and 05 species, Daphniidae has 03 species, Sididae, Moinidae and Macrothricidae has 02 species and Bosminidae has only one species. In copepod, family Diaptomidae has 02 genera and 02 species and Cyclopoidae contain 01 genera and 01 species (Table 4.3.2 and Fig. 4.3.2 & 4.3.3).

Table 4.3.1 Zooplankton species composition in Ameenpur tank

	Rotifers Class **Eurotatoria** Subclass **Monogononta** Order **Ploima**	2010-2011	2011-12
1	**Asplanchnidae** *Asplanchna brightwellii* Gosse, 1850	+	+
2	**Brachionidae** *Anuraeopsis fissa* Gosse, 1851	+	+
3	*Brachionus angularis* Gosse, 1851	+	+
4	*Brachionus budapestinensis* Daday, 1885	+	-
5	*Brachionus bidentata* Anderson, 1889	+	+
6	*Brachionus calyciflorus* Pallas, 1776	+	+
7	*Brachionus caudatus* Barrios and Daday, 1894	+	+
8	*Brachionus diversicornis* Daday, 1883	+	+
9	*Brachionus durgae* Dhanapathi, 1974	+	+
10	*Brachionus falcatus* Zacharias, 1898	+	+
11	*Brachionus quadridentatus* Hermann, 1783	+	+
12	*Brachionus quadridentatus var Melhemi* Barrios and Daday, 1894	+	-
13	*Brachionus rubens* Ehrenberg, 1838	+	+
14	*Brachionus urceolaris* Muller, 1773	+	-
15	*Keratella tropica* (Apstein, 1907)	+	+
16	**Lepadellidae** *Colurella obtusa* (Gosse, 1886)	+	-
17	**Epiphanidae** *Epiphanes clavulata* (Ehrenberg, 1832)	-	+
18	**Euchlanidae** *Euchlanis dilatata* Ehrenberg, 1832	+	-
19	**Trichotriidae** *Trichotria tetractis* (Ehrenberg, 1830)	+	-
20	**Lecanidae** *Lecane leontina* (Turner, 1892)	+	-
21	*Lecane papuana* (Murray, 1913)	+	+

22	*Lecane bulla* (Gosse, 1851)	+	+
23	*Lecane luna* (Muller, 1776)	-	+
24	*Lecane closterocerca* (Harring and Myers, 1926)	+	-
25	*Lecane hamata* (Stokes, 1896)	+	-
26	*Lecane lunaris* (Ehrenberg, 1832)	+	-
27	*Lecane stenroosi* (Meissner, 1908)	+	+
28	**Trichocercidae** *Trichocerca pusilla* (Jennings, 1903)	+	+
29	*Trichocerca rattus* (Muller,1776)	+	-
30	**Synchaetidae** *Polyarthra indica* (Segers and Babu, 1999)	+	+
	Order **Flosculariaceae** **Conochilidae**		
31	*Conochilus (Conochiloides) dossuarius* Hudson, 1885	+	-
32	*Conochilus (Conochilus) unicornis* Rousselet, 1892	+	+
33	**Hexarthridae** *Hexarthra intermedia* (Wizniewski, 1929)	+	-
34	*Hexarthra mira* (Hudson, 1871)	+	-
35	**Filiniidae** *Filinia longiseta* (Ehrenberg, 1834)	+	+
36	*Filinia opoliensis* (Zacharias, 1898)	-	+
37	*Filinia terminalis* (Plate, 1886)	+	+
38	**Testudinellidae** *Testudinella parva* (Ternetz, 1892)	+	-
39	*Testudinella patina f. intermedia* Hermann, 1783	+	+
40	*Pompholyx complanata* Gosse, 1851	-	+
41	*Pompholyx sulcata* Hudson, 1885	+	+
	Subclass **Bdelloidea** **Philodinidae**		
42	*Rotaria neptunia* Ehrenberg, 1832	+	+
43	*Rotaria rotatoria* (Pallas, 1766)	+	+
	Subphylum: **Crustacea** Class **Branchiopoda**		

	Order **Diplostraca** Suborder **Cladocera** **Sididae**		
44	*Diaphanosoma sarsi* Richard, 1895	+	+
45	*Diaphanosoma excisum* Sars, 1885	+	+
	Daphniidae		
46	*Ceriodaphnia cornuta* Sars, 1885	+	+
47	*Daphnia (Ctenodaphnia) lumholtzi* Sars, 1885	+	+
48	*Simocephalus vetulus* (O. F. Muller, 1776)	+	-
	Moinidae		
49	*Moina micrura* Kurz, 1874	+	+
50	*Moinodaphnia macleayi* (King, 1853)	+	-
	Bosminidae		
51	*Bosmina longirostris* (O. F. Muller, 1776)	+	-
	Macrothricidae		
52	*Macrothrix spinosa* King, 1853	+	+
53	*Ilyocryptus spinifer* Herrick, 1882	+	-
	Chydoridae		
54	*Chydorus sphaericus* (O. F. Muller, 1776)	-	+
55	*Coronatella rectangula* Sars, 1862a	+	+
56	*Leberis davidi davidi* Richard, 1895a	+	-
57	*Leydigia acanthocercoides* (Fischer, 1854)	+	-
58	*Indialona ganapati* Petkovski, 1966	+	+
	Copepoda **Calanoida** **Diaptomidae**		
59	*Heliodiaptomus viduus* (Gurney, 1916)	+	+
60	*Sinodiaptomus* (*Rhinediaptomus*) *indicus* Kiefer, 1936	+	+
	Cyclopoidae		
61	*Mesocyclops leuckarti* Claus, 1857	+	+

Table 4.3.2 Family wise zooplankton composition in Ameenpur tank

Family	No. of Genera	No. of Species
Rotifer		
Asplanchnidae	1	1
Brachionidae	3	14
Lepadellidae	1	1
Epiphanidae	1	1
Euchlanidae	1	1
Trichotriidae	1	1
Lecanidae	1	8
Trichocercidae	1	2
Synchaetidae	1	1
Conochilidae	1	2
Hexarthridae	1	2
Filiniidae	1	3
Testudinellidae	2	4
Philodinidae	1	2
Cladocera		
Sididae	1	2
Daphniidae	3	3
Moinidae	2	2
Bosminidae	1	1
Macrothricidae	2	2
Chydoridae	5	5
Copepoda		
Diaptomidae	2	3
Cyclopoidae	1	1

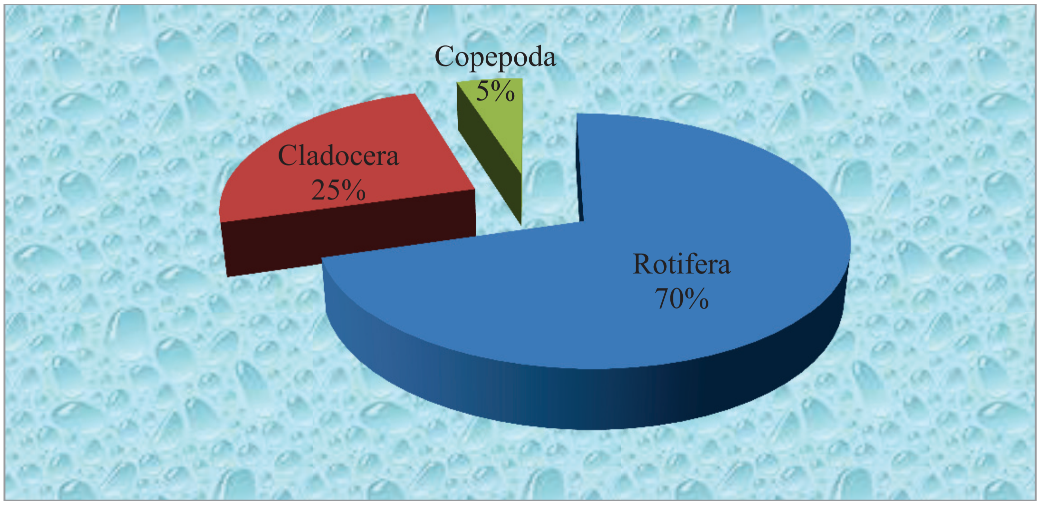


Fig. 4.3.1 Zooplankton composition in Ameenpur tank

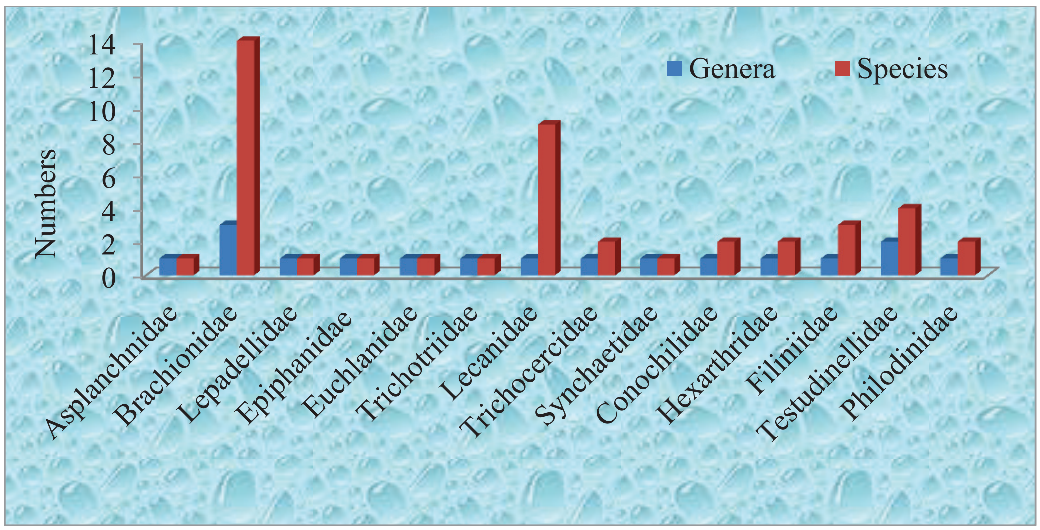


Fig. 4.3.2 Family wise rotifer species composition in Ameenpur tank

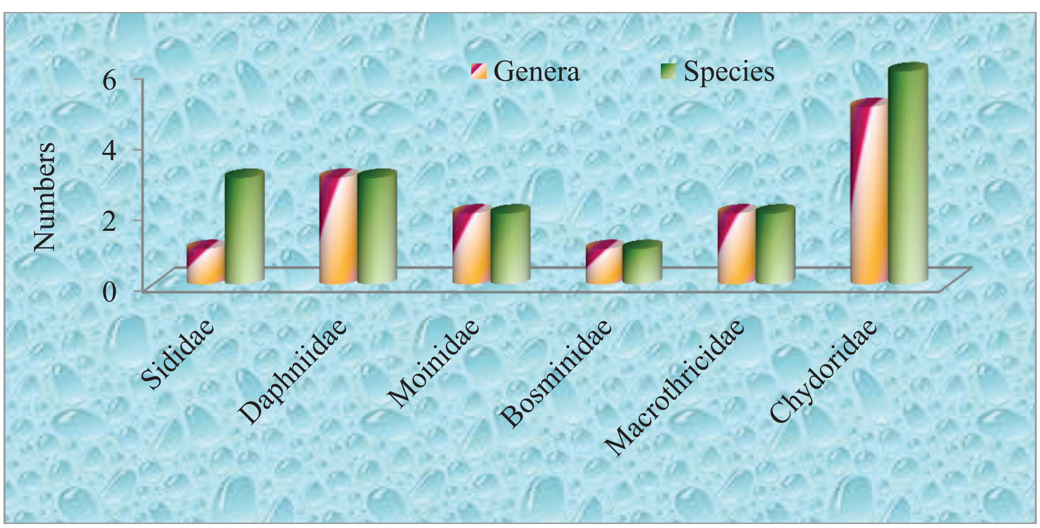


Fig. 4.3.3 Family wise cladoceran species composition in Ameenpur tank

Rotifer species like *Brachionus angularis, B. calyciflorus, B. caudatus, B. rubens* and *Keratella tropica*, *Filinia longiseta, Rotatoria neptunia, Rotatoria rotatoria, Polyarthra indica*, cladocera species like *Ceriodaphnia cornuta, Diaphanosoma sarsi, Moina micrura* and copepoda species like *Mesocyclops leuckarti* were found common in the tank.

4.3.2 Zooplankton density and diversity

The overall zooplankton density was 195-5500No/L throughout the study period (Table 4.3.3). The high population density of zooplankton was observed during the months of December, 2011 (5500No/L), March (3525No/L), April (3854No/L) and May, 2012 (2214No/L) Fig. 4.3.4 & 4.3.7. The high density of zooplankton is due to the high population of rotifer during entire study period. Rotifer populations increased during December, 2011 March, April, and May, 2012 and are about 5293, 2209, 2873 and 1095No/L respectively. The cladoceran population has comparatively less density than rotifer and copepod. However cladoceran population is higher than copepod during summer (April and May, 2011, March and May, 2012 is about 322, 314, 1200 and 611No/L.) and also high in monsoon (October and November, 2011, September and November, 2012) and copepod is more in summer period (April, May, 2011, April and May, 2012 is about 401, 614, 682, and 508 No/L) Fig. 4.3.4, 4.3.5 & 4.3.6.

The density of zooplankton population is due to numerical abundance of *Brachionus angularis*, *B. calyciflorus*, *B. caudatus*, *B. falcatus* and *B. rubens* in summer season of both the years, whereas in monsoon the density is due to the *Keratella tropica*. Cladoceran density is due the *Ceriodaphnia cornuta*, *Moina micrura*, *Bosmina longirostris* and *Indialona ganapati*. The high density of copepod is due to the abundance population of *Mesocyclops leuckarti* in both the years.

The overall zooplankton community diversity of this tank varies between H= 0.6-2.45. A high diversity was observed in the month of March, 2011 (H= 2.45), and less diversity in the month of December, 2011 and April, August, November, 2012 (H= 0.6, 1.2, 1.045 and 1.24 respectively). The diversity was high in 2010-11 compared to 2011-12 and diversity was recorded during summer and monsoon seasons (Table 4.3.3 and Fig. 4.3.7). The evenness (J) of zooplankton community of this tank varies between 0.212-0.80, the more evenness in the month of January, 2011 (J=0.80). The evenness is less (J= 0.48 and J=0.21) in December, 2010 and 2011 respectively which represent winter season. The evenness values are equally high in both the years and particularly high during summer and monsoon (Table 4.3.3 and Fig. 4.3.8). Species richness value was between 5-27 numbers, high in summer (May, 2011) and less in monsoon (August, 2012). More species richness is observed in 2010-11 than in 2011-12 which shows that the species richness was in decline and fluctuated (Table 4.3.3 and Fig. 4.3.9). Similarly the abundance of zooplankton community is found between 3.34-49.7%. In the month of March, 2011 the value is about 49.7% and less in the month of December and August, 2012 (3.42% and 6.5%). Regarding abundance high values were observed in 2010-11, whereas less value was recorded in 2011-12. Summer and monsoon seasons have more abundance than winter season (Fig. 4.3.10). Dominance of zooplankton community of this tank shows that the 18.4-88.7% variance during the year 2010-2012. Less dominance in the month of March, 2011, high during December, 2012 could infer from the data. The dominance is less in 2010-11 when compared to 2011-12 (Fig. 4.3.11).

Table 4.3.3 Zooplankton density and diversity during 2010-2012

Index	Duration	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Total zooplankton (No/L)	2010-11	1023	872	530	1203	1883	1378	988.46	816.5	511.6	742.6	615.3	1451
	2011-12	5500	881	650	3525	3854	2214	847	354	195.6	1083	931.3	681.9
Rotifera (No/L)	2010-11	91.74	555	197	932.9	1158	450.1	625.89	350.8	194.2	391.2	217.8	1012
	2011-12	5293	636	224	2209	2873	1095	487	115	34.4	408.8	769.9	14.1
Cladocera(No/L)	2010-11	453.2	225	138	95	322.8	314.2	173.01	65	55.3	86.3	197.9	381.8
	2011-12	64.3	62.8	372	1200	299	611	66	63	34.5	316.9	46.1	443.7
Copepoda(No/L)	2010-11	478.4	92.3	195	175	401.7	614	189.56	400.7	262.1	265.1	199.6	57.4
	2011-12	142.5	182	55	115.3	682	508	294	176	126.7	357.3	115.3	224.1
Shannon H' Log Base 2.718	2010-11	1.462	2.242	2.116	2.455	2.263	1.923	2.105	1.618	1.73	2.047	2.072	1.947
	2011-12	0.6	1.845	1.748	1.508	1.278	1.699	1.751	1.734	1.045	1.67	1.865	1.249
Shannon Hmax Log Base 2.718	2010-11	2.996	2.773	3.045	3.219	3.091	3.296	2.944	2.833	2.89	2.996	2.996	3.091
	2011-12	2.833	2.773	2.944	2.639	2.303	2.639	2.398	2.398	1.609	2.303	2.708	2.485
Shannon (J')	2010-11	0.488	0.809	0.695	0.763	0.732	0.584	0.715	0.571	0.598	0.683	0.692	0.63
	2011-12	0.212	0.666	0.594	0.572	0.555	0.644	0.73	0.723	0.649	0.725	0.689	0.503
Simpsons Diversity (D)	2010-11	0.327	0.141	0.194	0.107	0.129	0.244	0.159	0.306	0.304	0.189	0.187	0.21
	2011-12	0.789	0.239	0.315	0.272	0.409	0.216	0.224	0.275	0.463	0.233	0.214	0.39
Hill's Number (H_0)	2010-11	20	16	21	25	22	27	19	17	18	20	20	22
	2011-12	17	16	19	14	10	14	11	11	5	10	15	12
Hill's Number (H_1)	2010-11	11.89	36.65	30.55	49.79	37.764	23.12	30.077	14.88	17.49	27.65	28.65	23.92
	2011-12	3.428	20.66	17.95	12.71	9.122	16.74	18.03	17.59	6.516	16.06	21.28	8.745
Berger-Parker Dominance (d)	2010-11	0.467	0.251	0.368	0.185	0.213	0.445	0.245	0.491	0.512	0.349	0.319	0.361
	2011-12	0.887	0.419	0.528	0.337	0.603	0.271	0.347	0.489	0.648	0.327	0.35	0.537
Berger-Parker Dominance (d%)	2010-11	46.74	25.1	36.78	18.49	21.34	44.54	24.47	49.07	51.23	34.91	31.93	36.12
	2011-12	88.71	41.94	52.76	33.65	60.28	27.09	34.70	48.85	64.77	32.73	34.97	53.70

Table 4.3.4 SHE information analysis of zooplankton

N	S	LnS	H	LnE	LnE/LnS
1023.2	20	3	1.46	-1.53	-0.51
1895.7	29	3.37	2.26	-1.1	-0.33
2425.8	32	3.47	2.39	-1.08	-0.31
3628.7	35	3.56	2.61	-0.94	-0.26
5511.1	41	3.71	2.69	-1.03	-0.28
6889.4	44	3.78	2.68	-1.11	-0.29
7877.9	47	3.85	2.71	-1.14	-0.3
8694.4	48	3.87	2.65	-1.22	-0.31
9206.0	48	3.87	2.62	-1.25	-0.32
9948.6	48	3.87	2.61	-1.26	-0.33
10563.9	48	3.87	2.61	-1.26	-0.33
12015.1	48	3.87	2.64	-1.23	-0.32
17515.3	48	3.87	2.34	-1.53	-0.4
18396.2	50	3.91	2.38	-1.54	-0.39
19046.6	50	3.91	2.41	-1.5	-0.38
22572.3	50	3.91	2.48	-1.44	-0.37
26426.5	50	3.91	2.43	-1.49	-0.38
28640.3	50	3.91	2.45	-1.47	-0.37
29486.8	50	3.91	2.46	-1.45	-0.37
29840.3	50	3.91	2.46	-1.45	-0.37
30035.9	50	3.91	2.46	-1.45	-0.37
31118.9	50	3.91	2.47	-1.45	-0.37
32050.2	51	3.93	2.47	-1.46	-0.37
32732.1	52	3.95	2.48	-1.47	-0.37

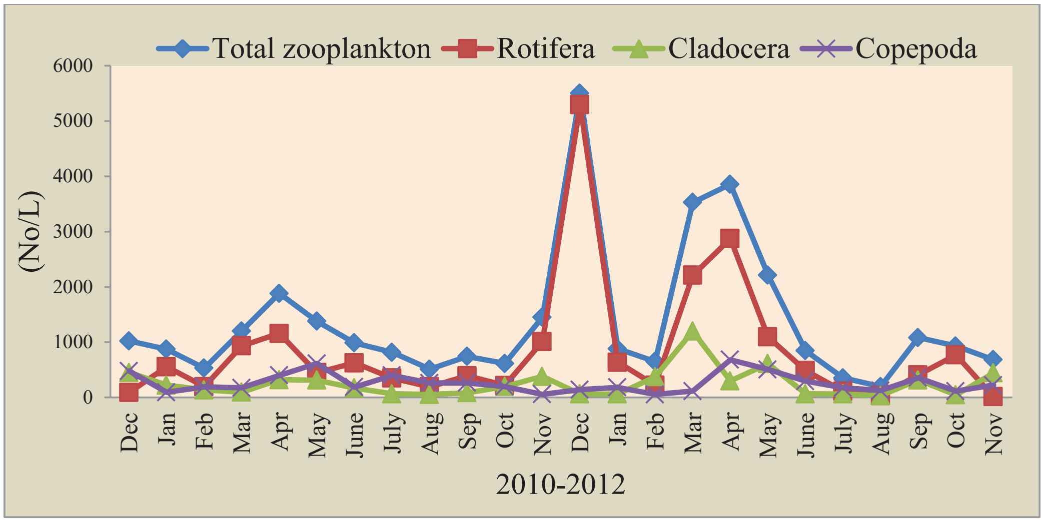


Fig. 4.3.4 Overall zooplankton dynamics 2010-12

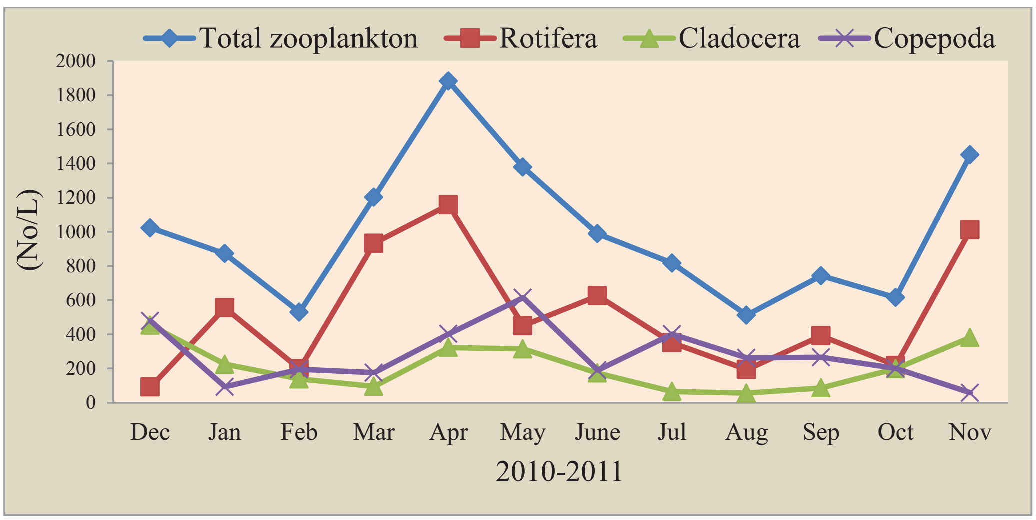


Fig. 4.3.5 Zooplankton density 2010-11

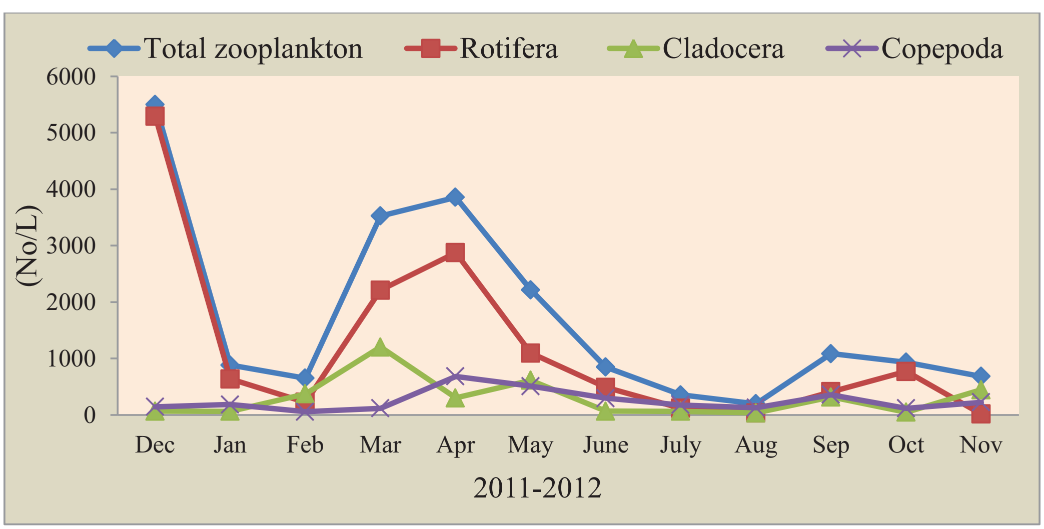


Fig. 4.3.6 Zooplankton density 2011-12

Fig. 4.3.7 Zooplankton diversity

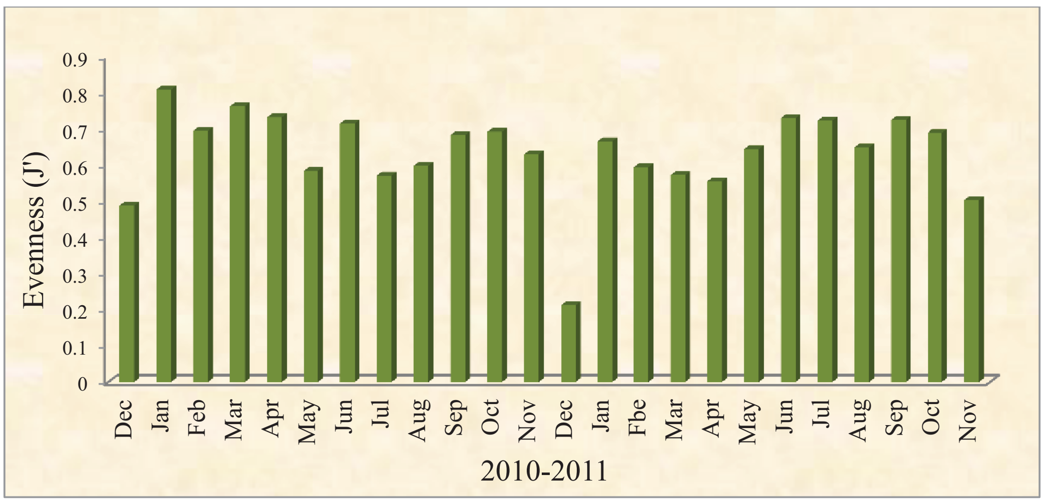


Fig. 4.3.8 Zooplankton evenness

Fig. 4.3.9 Zooplankton species richness

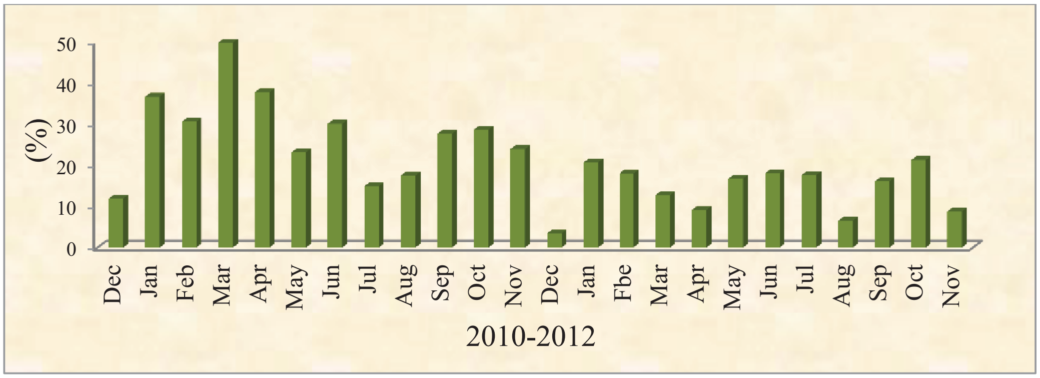


Fig. 4.3.10 Zooplankton abundance

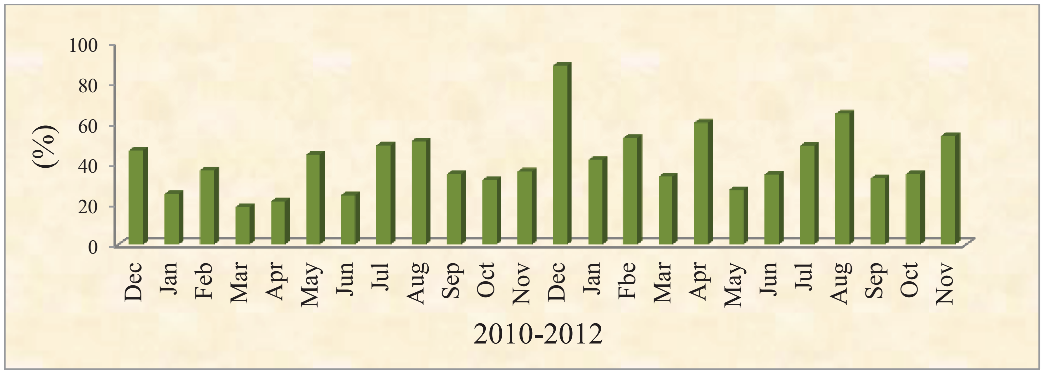


Fig. 4.3.11 Zooplankton dominance

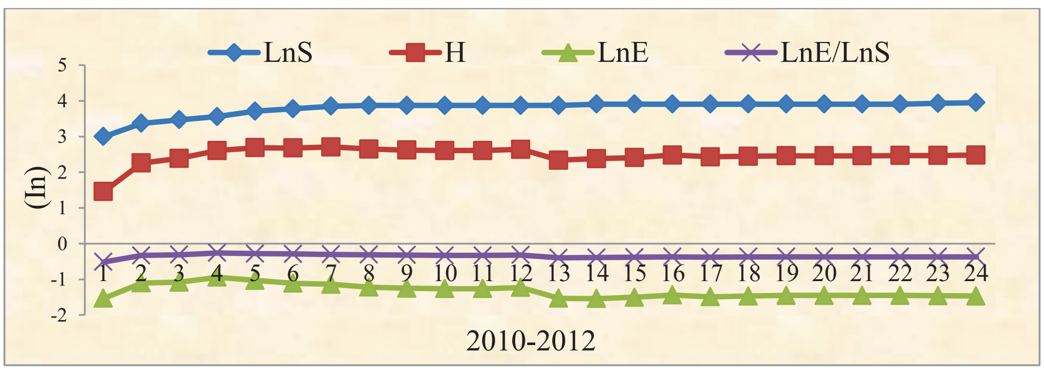


Fig. 4.3.12 SHE information analysis of zooplankton

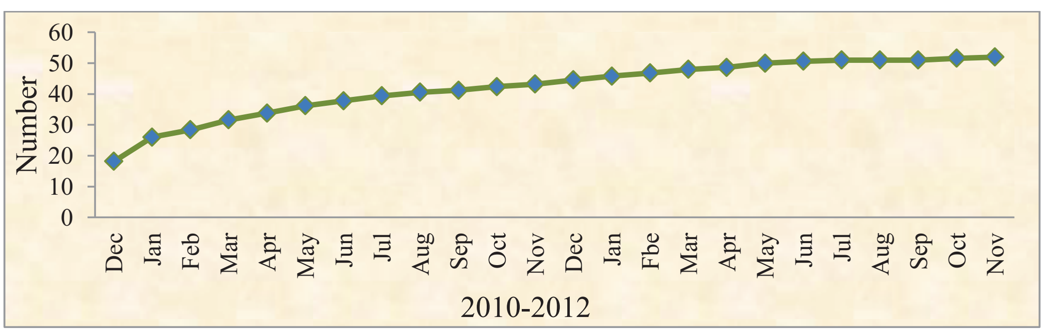


Fig. 4.3.13 Pooled number of zooplankton species

SHE analysis of zooplankton community shows that the LnS value varies between 1.5- 2.2, H= 1.5-2.5, LnE= -1.1 to -1.9 and LnE/LnS = -0.5 to -0.3. The species richness increased throughout the study, whereas the diversity increased in 2010-11. It decreased further due to the decrease of evenness, which implies that the zooplankton diversity of this tank depends on the evenness (Table 4.3.4 and Fig. 3.12). The pooled number of species over the study period increased and reaches maximum 52 species (Fig. 4.3.13).

4.3.3 Rotifer density and diversity

Rotifer density varies between 14.1-5293No/L throughout the study period of 2010-12. The rotifer range of 2010-11 remained 91.74-1158No/L, whereas in 2011-12 it was 14-5293No/L. It was observed that during 2011-12 possessed more number of individuals with wide range of fluctuation, irrespective of the months and seasons (Table 4.3.5 and Fig. 4.3.14). The rotifer density was high during winter and summer seasons, a high density of rotifer 5293No/L was observed in the month of December 2011, due to numerical dominance of *Keratella tropica*. Less density (14.1No/L) in the month of November 2012 was noticed though it was winter because of less number of species. The overall rotifer density showed that the summer holds more density than other seasons except December, 2011.

Rotifer diversity (H) ranged between 0.86-2.214 over the two year study period of 2010-12. In 2010-11 more diversity was noted especially during the summer (February, March and April, 2011, the H’= 2.158, 2.214 and 2.133 respectively) and rarely in monsoon (October 2011, high diversity H’= 2.063). In 2011-12, the diversity values ranged between H’= 0.416-1.61, and the high diversity were recorded in the month of January, February, June, July, September and October, 2012. The less diversity values were noted when compared to 2010-11, especially in the month of December, 2011 and August, 2012. Shannon maximum diversity index value shows that the H max = 1.3-2.9, the overall diversity of this tank (Table 4.3.5 and Fig. 4.3.15).

The evenness of rotifer species obtained between J= 0.3-0.79, throughout study period (Table 4.3.5). More evenness was observed in 2010-11 than in 2011-12. The less evenness value during April, 2012 (J = 0. 354), where as more evenness value was observed in July and November 2012, J= 0.898 and J=0.959 (Fig. 4.3.16). Similarly, the overall species richness varied between 03-20 species, high in 2010-11 during the month of March, April and May, 2011 between 19-20 species. 2011-12 had less species richness of 3-12 species (Fig. 4.3.17). Abundance of rotifer species was more in February, March, April, 2011 (31-32%) and also had more abundance in the overall study period. On the other hand less abundance was observed in 2011-12 during the month of March to May, 2012 and ranged between 3.89-8.82% (Fig. 4.3.18). The Berger-Parker dominance index showed that 2011-12 had more dominance than 2010-11, especially in the month of December, 2011 (d= 0.99) due to the *Keratella tropica*, and in April, 2012 (d= 0.80) due to *Brachionus calyciflorus*. Dominance values of 2010-11 was between d= 0.22-0.51, whereas in 2011-12, it was d= 0.29-0.92 (Fig. 4.3.19).

2010-11, the species richness (34species) and LnS (3.53) were constant. The diversity (H) values attain maximum H= 2.62, later it decreases slightly. The LnE fluctuated between -0.71 to -1.1 and it showed that even if the species richness was constant the diversity values were controlled by the evenness (Fig. 4.3.20). In 2011-12, species richness was between 11-23 and LnS 2.4 to 3.14. The H also increased with species number, H=0.42-1.71 and evenness (LnE) value was 1.35-1.98, when less diversity and less evenness were observed. The ratio of LnE/LnS showed variance between -0.45 to -0.83 (Fig. 4.3.21). It reveals that the S and E increase while the H and the LnE/LnS remains constant (Table 4.3.6). The pooled number of species was 15-34 and 11-23 in 2010-11 and 2011-12 respectively (Table 4.3.7 and Fig. 4.3.22).

4.3.4 Rotifer similarity index

Rotifer similarity index 2010-11 showed that similarity range was between 5.22-73.49%. The maximum similarity is between August and October, 2011 (73.49%), and high similarity of the species during the monsoon season. Summer and winter showed less similarities of the species (December, 2010 and January, 2012), Table 3.8 and Fig. 3.25. But in 2011-12, the similarity of the species ranged between 0.4- 65.49%; similarity of the species was high between September and October, 2012 (65.49%) and less similarity between December, 2011 and November, 2012 (0.4%). The overall species similarity showed that more similar species were reported in 2010-11, particularly during monsoon in both the years of study. The cluster shows the seasonal pattern of the similarity of the rotifer species (Table 4.3.8 & 4.3.9 and Fig. 4.3.23 & 4.3.24).

4.3.5 Cladoceran density and diversity

Cladoceran density ranges from 35.5 to 1200 No/L over the period of 2010-2012. In 2010-11 cladoceran density recorded 55.3-452.8No/L, and in 2011-12 it was 35.5 to 1200No/L (Table 4.3.10). It revealed that in 2011-12 cladoceran population density was more with wider fluctuation. The high density 1200No/L was observed in the month of March 2012, during summer due to the numerical dominance of *Moina micrura*. A less density was observed i.e. 35.5No/L in the month of August 2012 during monsoon (Fig. 4.3.25). The overall density of cladocera was more in summer as well as in winter and less in monsoon, due to the quantitative occurrence of *Ceriodaphnia cornuta* and *Diaphanosoma sarsi.*

Table 4.3.5 Rotifer density and diversity 2010-12

Indices	Duration	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Density (No/L)	2010-2011	91.74	555.1	196.7	932.9	1157	450.1	625.89	350.8	194.2	391.2	217.8	1012
	2011-2012	5293	636	223.9	2209	2873	1095	486.7	115.2	34.4	408.8	769.9	14.1
Shannon H' Log Base 2.718	2010-2011	2.003	1.807	2.158	2.214	2.133	2.063	1.506	1.476	1.713	1.82	2.063	1.362
	2011-2012	0.416	1.417	1.806	1.121	0.689	1.255	1.445	1.61	0.865	1.419	1.462	1.329
Shannon Hmax Log Base 2.718	2010-2011	2.708	2.398	2.708	2.944	2.944	2.996	2.303	2.398	2.398	2.639	2.639	2.708
	2011-2012	2.398	2.398	2.485	2.303	1.946	2.197	2.079	1.792	1.099	1.792	2.303	1.386
Shannon (J')	2010-2011	0.74	0.754	0.797	0.752	0.724	0.689	0.654	0.615	0.714	0.69	0.782	0.503
	2011-2012	0.174	0.591	0.727	0.487	0.354	0.571	0.695	0.898	0.787	0.792	0.635	0.959
Simpsons Diversity (D)	2010-2011	0.2	0.228	0.152	0.138	0.147	0.172	0.283	0.337	0.258	0.218	0.169	0.356
	2011-2012	0.851	0.374	0.256	0.404	0.672	0.371	0.302	0.211	0.487	0.304	0.294	0.227
Simpsons Diversity (1/D)	2010-2011	4.989	4.378	6.567	7.251	6.816	5.816	3.528	2.968	3.874	4.585	5.917	2.809
	2011-2012	1.175	2.676	3.913	2.473	1.488	2.697	3.316	4.749	2.053	3.293	3.407	4.407
Hill's Number (H_0)	2010-2011	15	11	15	19	19	20	10	11	11	14	14	15
	2011-2012	11	11	12	10	7	9	8	6	3	6	10	4
Hill's Number (H_1)	2010-2011	25.93	19.57	32.46	35.16	31.30	28.30	12.66	12.13	17.08	19.93	28.30	10.29
	2011-2012	2.631	11.14	19.54	7.274	3.899	8.827	11.59	14.71	5.024	11.18	11.894	9.817
Berger-Parker Dominance (d)	2010-2011	0.395	0.395	0.286	0.239	0.224	0.287	0.386	0.525	0.449	0.376	0.31	0.518
	2011-2012	0.922	0.581	0.464	0.537	0.809	0.542	0.462	0.299	0.669	0.479	0.423	0.404
Berger-Parker Dominance (d%)	2010-2011	39.53	39.45	28.57	23.85	22.35	28.74	38.64	52.53	44.85	37.55	30.99	51.80
	2011-2012	92.17	58.09	46.36	53.69	80.86	54.22	46.23	29.94	66.86	47.94	42.30	40.42

Table 4.3.6 SHE information analysis of rotifer

2010-11						2011-12					
N	**S**	**LnS**	**H**	**LnE**	**LnE/LnS**	**N**	**S**	**LnS**	**H**	**LnE**	**LnE/LnS**
91.74	15	2.71	2	-0.71	-0.26	5293	11	2.4	0.42	-1.98	-0.83
646.8	22	3.09	2.18	-0.91	-0.29	5929	16	2.77	0.8	-1.97	-0.71
843.5	24	3.18	2.35	-0.82	-0.26	6153	18	2.89	0.89	-2	-0.69
1776	26	3.26	2.49	-0.77	-0.24	8363	19	2.94	1.34	-1.61	-0.55
2934	32	3.47	2.61	-0.85	-0.25	11236	19	2.94	1.43	-1.52	-0.52
3384	34	3.53	2.62	-0.91	-0.26	12331	20	3	1.58	-1.42	-0.47
4010	34	3.53	2.58	-0.95	-0.27	12818	20	3	1.64	-1.36	-0.45
4361	34	3.53	2.54	-0.99	-0.28	12933	20	3	1.65	-1.35	-0.45
4555	34	3.53	2.53	-1	-0.28	12967	21	3.04	1.65	-1.4	-0.46
4946	34	3.53	2.5	-1.02	-0.29	13376	21	3.04	1.67	-1.37	-0.45
5164	34	3.53	2.5	-1.03	-0.29	14146	22	3.09	1.71	-1.38	-0.45
6176	34	3.53	2.43	-1.1	-0.31	14160	23	3.14	1.71	-1.42	-0.45

Table 4.3.7 Pooled number of rotifer species richness

	2010-11	**2011-12**
December	14	9.2
January	20	12.8
February	24	14.6
March	27	15.4
April	29.6	17
May	31.2	17.6
June	31.8	18.4
July	32.4	19.6
August	32.8	20.8
September	33	21.8
October	34	22.6
November	34	23

Table 4.3.8 Rotifer similarity matrix 2010-11

	Dec	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov
Dec	*	5.22	21.28	9.43	4.98	11.97	8.51	12.16	14.42	12.53	16.98	3.12
Jan	*	*	31.76	32.51	13.32	18.441	11.46	11.23	15.50	10.41	23.00	21.53
Feb	*	*	*	31.10	23.88	39.146	15.02	27.25	32.54	37.69	33.63	9.01
Mar	*	*	*	*	44.65	41.763	39.50	25.37	19.30	31.99	25.28	29.09
April	*	*	*	*	*	47.64	38.13	43.28	28.51	45.27	28.85	26.08
May	*	*	*	*	*	*	47.20	58.93	57.48	63.68	56.83	25.57
June	*	*	*	*	*	*	*	65.80	40.84	55.47	41.40	59.80
July	*	*	*	*	*	*	*	*	64.77	67.43	58.67	36.07
Aug	*	*	*	*	*	*	*	*	*	57.56	73.49	24.34
Sep	*	*	*	*	*	*	*	*	*	*	50.64	39.55
Oct	*	*	*	*	*	*	*	*	*	*	*	23.04
Nov	*	*	*	*	*	*	*	*	*	*	*	*

Table 4.3.9 Rotifer similarity matrix in 2011-12

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Dec	*	5.37	4.70	5.58	4.78	3.47	6.67	2.42	0.86	7.13	9.52	0.42
Jan	*	*	42.98	31.52	25.29	28.05	26.89	16.13	4.05	14.22	10.18	2.61
Feb	*	*	*	14.28	10.67	23.94	41.12	47.47	20.05	34.55	20.82	9.49
Mar	*	*	*	*	47.62	26.03	18.83	9.08	1.30	16.63	22.45	1.01
April	*	*	*	*	*	14.58	14.21	5.78	0.39	9.56	14.97	0.58
May	*	*	*	*	*	*	19.61	15.68	1.00	35.24	33.99	1.53
June	*	*	*	*	*	*	*	34.45	3.26	39.17	33.40	4.51
July	*	*	*	*	*	*	*	*	7.62	37.48	24.06	13.14
Aug	*	*	*	*	*	*	*	*	*	12.95	7.13	11.54
Sep	*	*	*	*	*	*	*	*	*	*	65.49	5.34
Oct	*	*	*	*	*	*	*	*	*	*	*	2.88
Nov	*	*	*	*	*	*	*	*	*	*	*	*

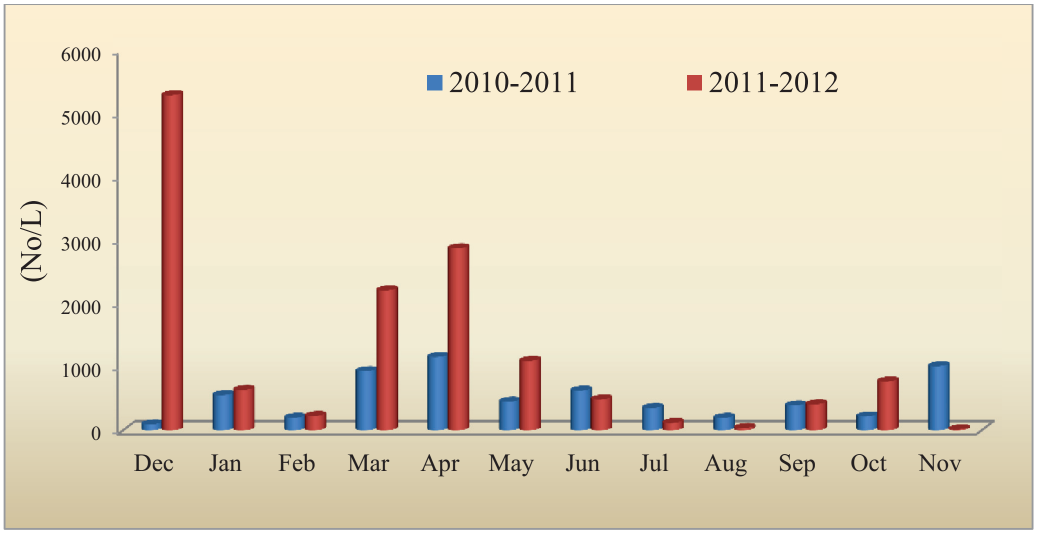


Fig. 4.3.14 Rotifer density

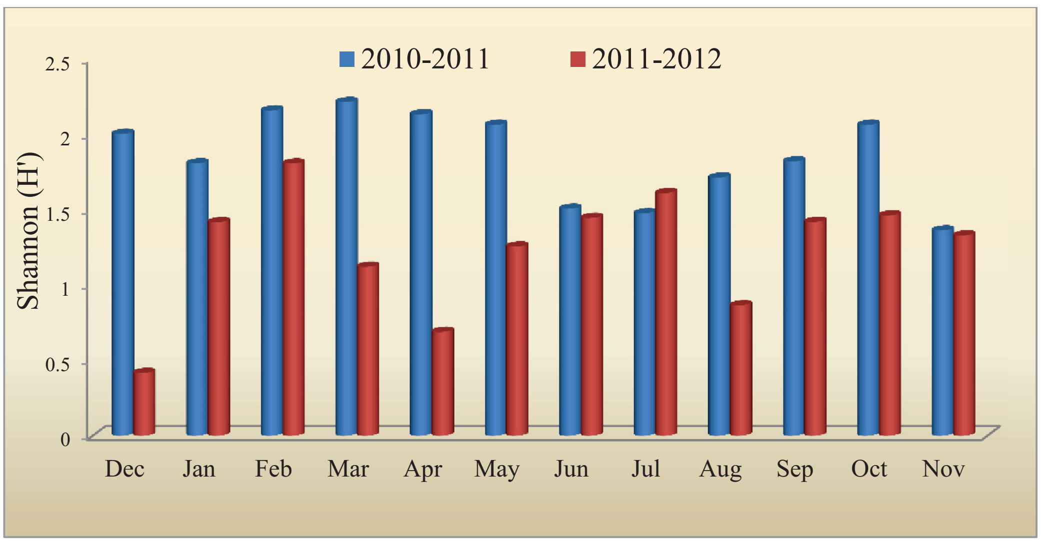


Fig. 4.3.15 Rotifer diversity

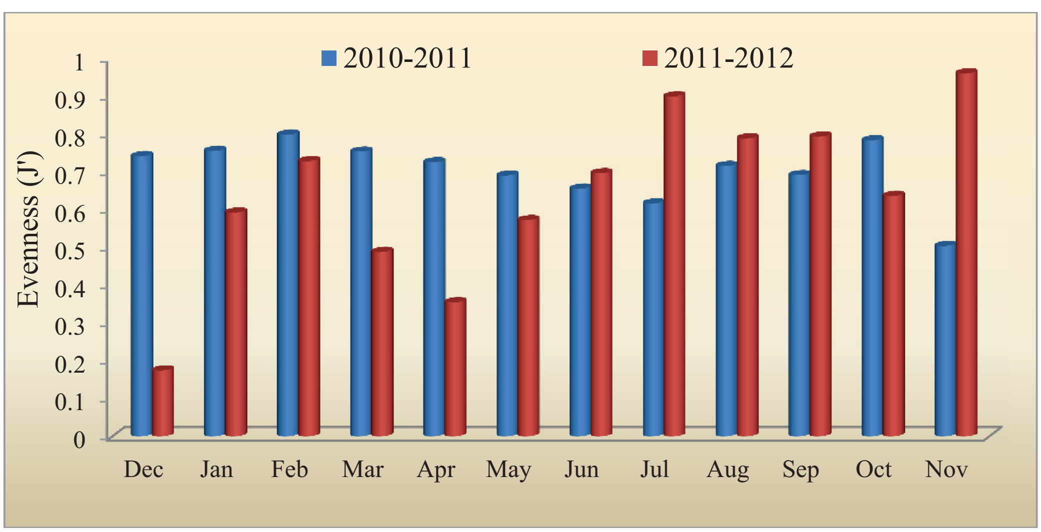


Fig. 4.3.16 Rotifer evenness

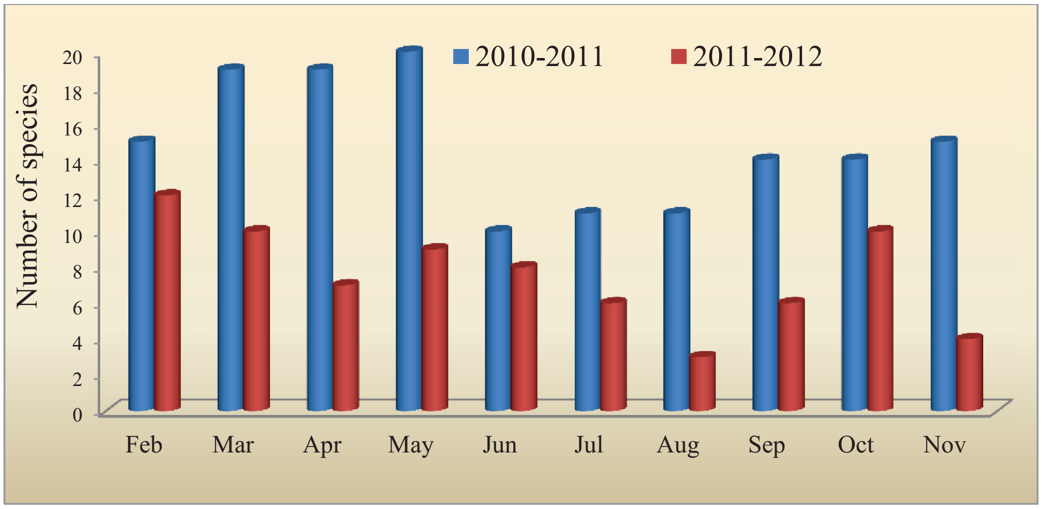


Fig. 4.3.17 Rotifer species richness

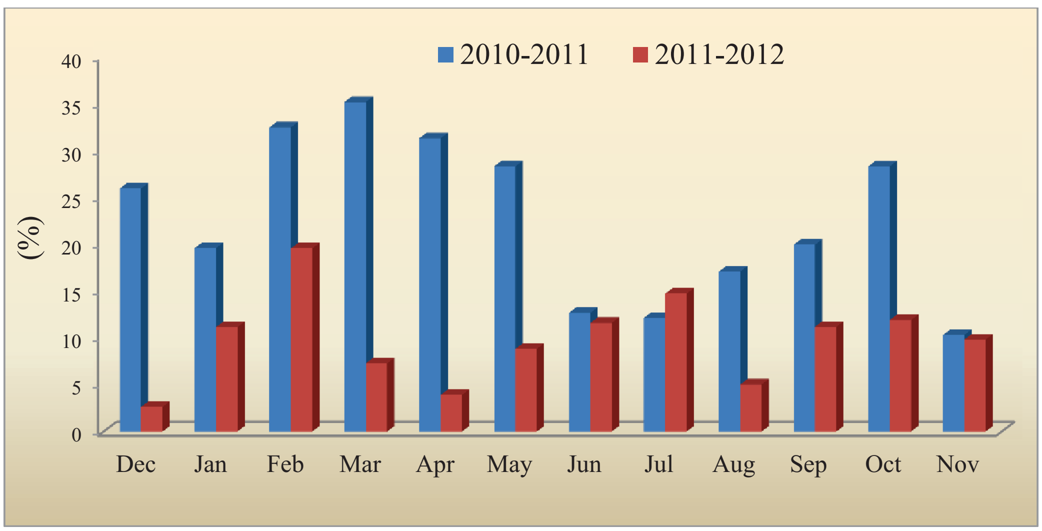


Fig. 4.3.18 Rotifer abundance

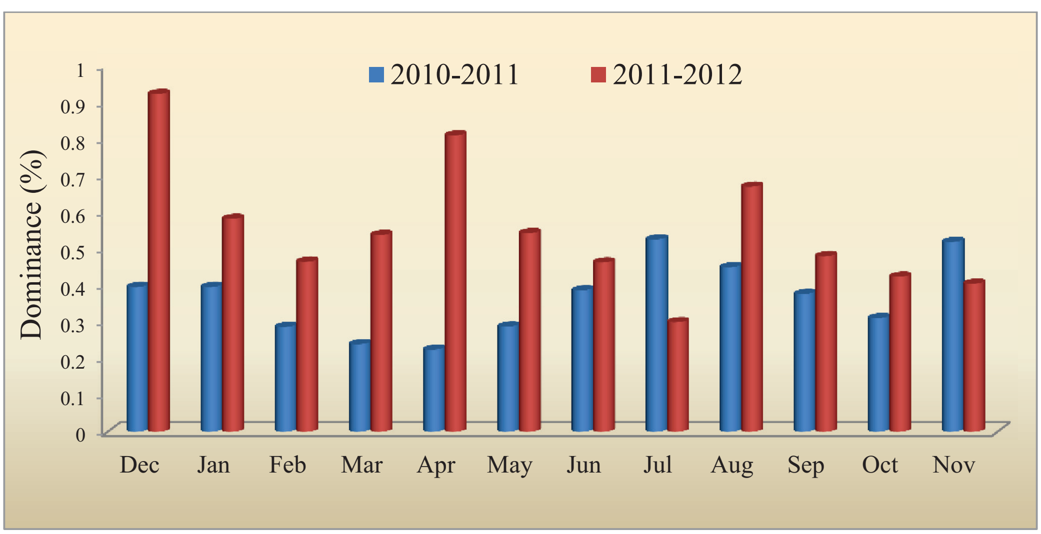


Fig. 4.3.19 Rotifer dominance

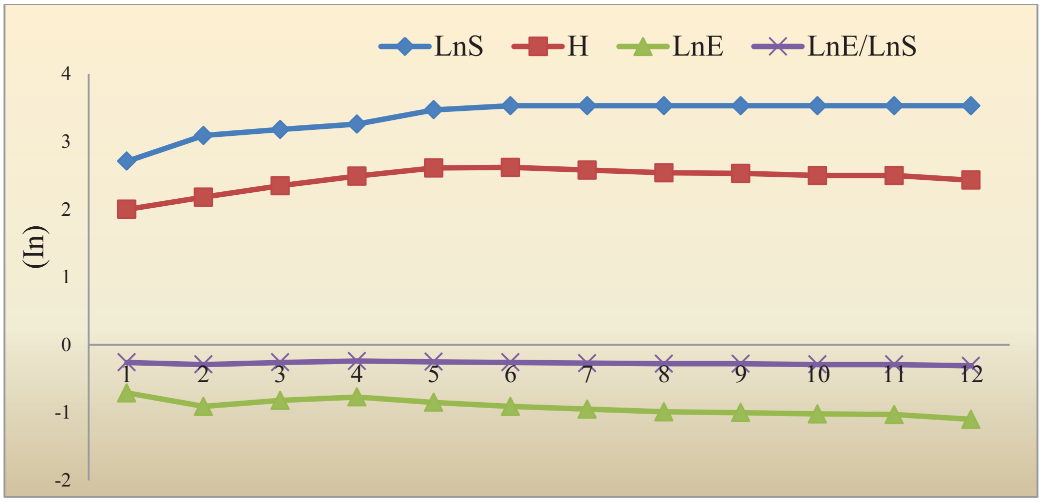


Fig. 4.3.20 SHE information analysis of rotifer 2010-11

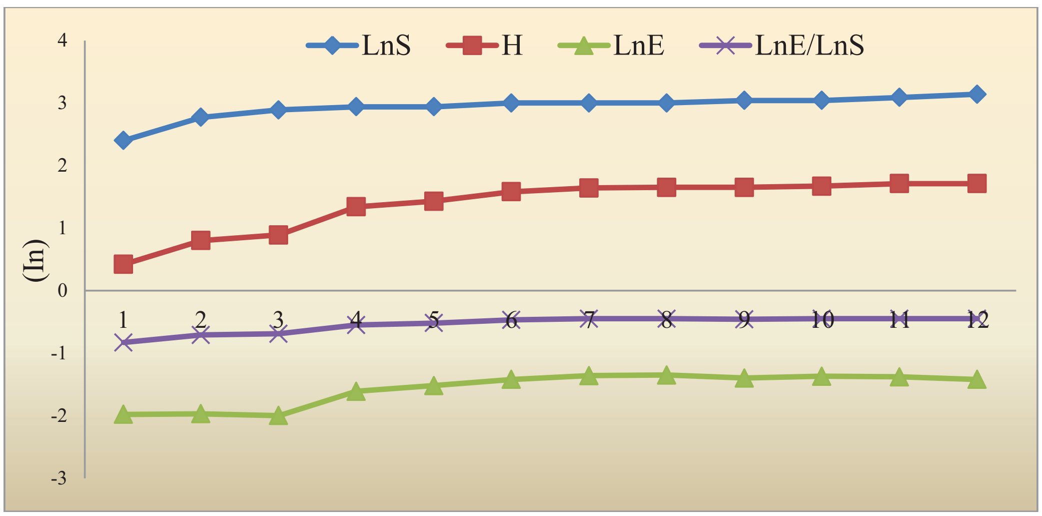


Fig. 4.3.21 SHE information analysis of rotifer 2011-12

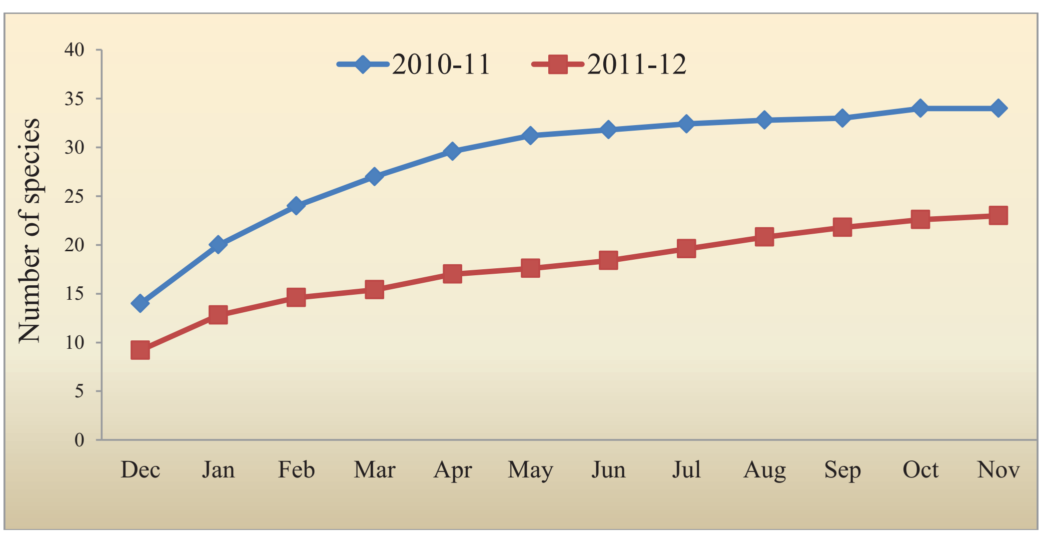


Fig. 4.3.22 Pooled number of rotifer species

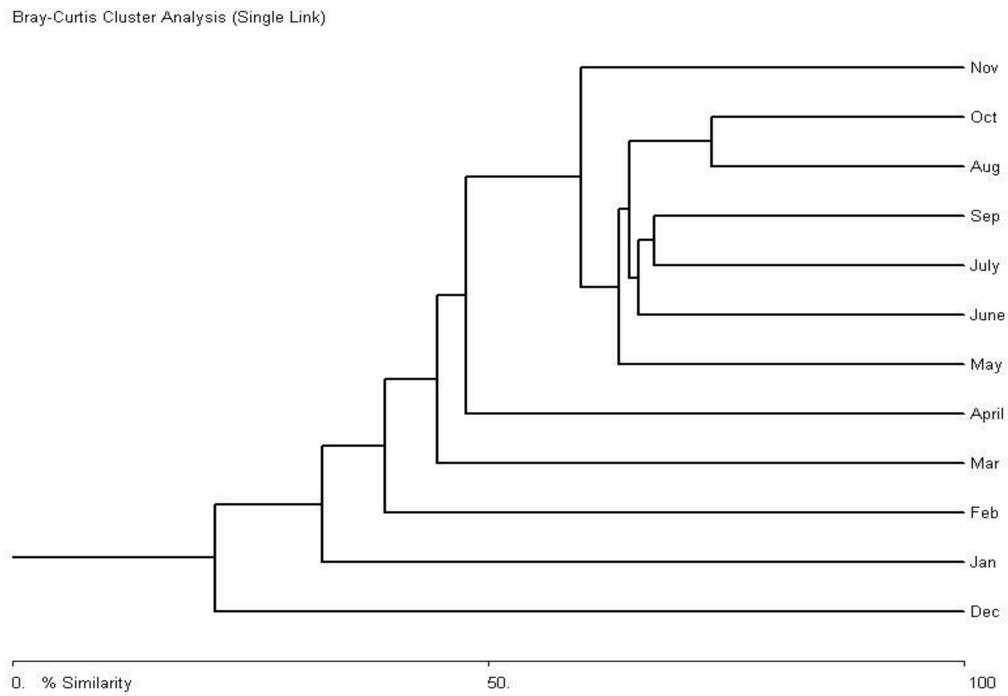


Fig. 4.3.23 Rotifer similarity index 2010-2011

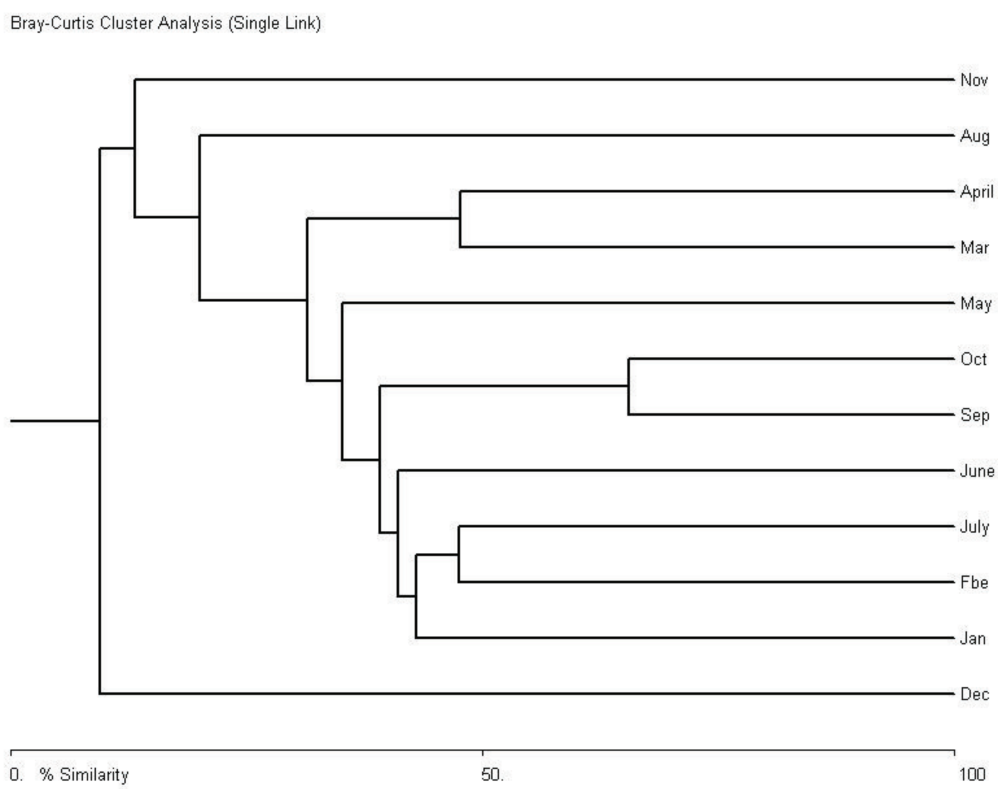


Fig. 4.3.24 Rotifer similarity index 2011-12

Cladoceran diversity of this tank is H’ = 0.09- 1.188, during the study period. In 2010-11 it was H’=0.11-1.188 and in 2011-12, it was H’= 0.09-1.04. Cladoceran diversity was high in 2010-11 when compared to 2011-12. Maximum diversity were observed in the month of August 2011 (H’ = 1.188) representing the monsoon season, and less diversity in the month of September 2012 (H’= 0.09), Table 4.3.10 and Fig. 4.3.26. Shannon maximum cladoceran diversity richness was between Hmax= 0.693-1.792

The evenness of cladoceran ranged between E= 0.09-0.95 over the period of 2010-12. More evenness was observed in 2010-11 than 2011-12, especially during winter than summer (Fig. 4.3.27). The species richness varied from 2-6 during winter and monsoon and had equal number of species richness in both years of study. However summer season had more number of species richness than other period especially in 2010-11. But in June to August 2011, it represented 5-6 species. Less species richness was noted in 2011-12 (Fig. 4.3.28).

The abundance of cladocera varied between 1.6 -6.507% (Fig. 4.3.29), it showed less abundance of cladocera which might be due to the less species richness and density. Further, the Berger-Parker dominance showed that the dominance ranged between 43.8-98.28%. The months April 2011, February, March, May, August and September 2012 recorded above 90% of dominance. The dominance of cladoceran was more in 2011-12 (Fig. 4.3.30).

Cladoceran SHE analysis showed that in 2010-11 (Table 4.3.14), the species richness ranged between S= 4-9, LnS=1.39 to 2.2, H= 0.79 to 1.164, LnE= -0.21 to -0.43 and LnE/LnS= -0.21 to -0.43. When the species richness was constant, the H increases with increasing of evenness (Fig. 3.31). In 2011-12, the species richness was between S= 4-7, LnS= 1.39 -1.95, H= 0.38-1.02, LnE= -0.36 to -1.13 and LnE/LnS =-0.29 to -0.76 (Fig. 3.32). Pooled number of rotifer species high in

2010-11 (34 species), wereas in 2011-12 it was 23 species (Table 4.3.13 and Fig. 4.3.33).

4.3.6 Cladoceran similarity index

The cladoceran species similarity composition showed that the maximum similarity between the months of May and October 2011 (75.12%), August and July is about (74.64%), and less similarity of cladocera between October, November and March 2011 (1.91% to 1.17%) in 2010-11. The maximum similarities of the cladoceran species were observed in monsoon season (Table 4.3.11 and Fig. 4.3.34). 2011-12 showed maximum similarity (89.06%) between December 2011 and July 2012, and 87.6% of similarity were observed between December 2011 and January 2012, 83.32% in November and September 2012 (Table 4.3.12 and Fig. 4.3.35). The similarity of the species showed that monsoon and winter season possessed more similarity, whereas summer season had less similarity of species when compared to other seasons.

4.3.7 Physicochemical profile of Ameenpur tank

Physicochemical features of the Ameenpur tank showed in Table 4.3.15. Atmospheric temperature varied between 19.5 to 33°C and surface water temperature ranged between 18-28°C. High surface water temperature in 2011-12 reveals the tropical climate (Fig. 4.3.36). pH of the tank ranged from 7.9-10.1 (Fig. 4.3.37), it reflected the alkaline nature of the water body and the less pH during winter. Electrical conductivity was 0.83-3.4mS, in 2010-11, and less in 2011-12. The maximum value 3.4mS was attained in the May 2012, besides 2011-12 electrical was conductivity apparently higher than the 2010-11 (Fig. 4.3.38). Dissolved oxygen content was 6.6-14.2mg/L in the year 2010-11, whereas 4.3-19.0mg/L in the year 2011-12(Fig. 3.37). The wide variation of dissolved oxygen is observed in the 2011-12 year. Hence, the high amount of dissolved oxygen 19.0mg/L were recorded

Table 4.3.10 Cladocera density and diversity 2010-12

	Duraion	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Density (No/L)	2010-11	452.8	225.1	138.4	95	322.8	311.4	173.0	65	55.3	86.3	197.9	381.8
	2011-12	64.3	62.8	371.9	1200	299	611.2	66	62.8	35.5	316.9	46.1	443.7
Shannon (H')	2010-11	0.79	0.844	0.877	0.673	0.117	0.775	0.896	0.877	1.188	0.819	0.666	0.948
	2011-12	0.985	1.021	0.375	0.1	0.526	0.106	0.458	0.835	0.128	0.09	1.044	0.647
Shannon H max	2010-11	1.386	1.386	1.609	1.386	0.693	1.609	1.792	1.609	1.792	1.386	1.099	1.609
	2011-12	1.386	1.386	1.609	1.099	0.693	1.099	0.693	1.099	0.693	0.693	1.099	1.609
Shannon (J')	2010-11	0.57	0.609	0.545	0.485	0.169	0.481	0.5	0.545	0.663	0.591	0.607	0.589
	2011-12	0.71	0.737	0.233	0.091	0.759	0.096	0.66	0.76	0.185	0.13	0.95	0.402
Simpsons Diversity (D)	2010-11	0.546	0.572	0.568	0.608	0.951	0.548	0.542	0.559	0.418	0.51	0.618	0.517
	2011-12	0.43	0.424	0.853	0.964	0.656	0.963	0.712	0.459	0.944	0.965	0.353	0.693
Berger-Parker Dominance (d)	2010-11	0.701	0.742	0.74	0.751	0.975	0.69	0.712	0.734	0.622	0.651	0.763	0.695
	2011-12	0.58	0.602	0.923	0.982	0.781	0.981	0.829	0.545	0.972	0.982	0.438	0.825
Berger-Parker Dominance (d%)	2010-11	70.14	74.18	73.98	75.05	97.49	69.01	71.15	73.38	62.20	65.12	76.30	69.48
	2011-12	58.00	60.19	92.28	98.15	78.06	98.13	82.87	54.45	97.18	98.20	43.81	82.53
Hill's Number (H_0)	2010-11	4	4	5	4	2	5	6	5	6	4	3	5
	2011-12	4	4	5	3	2	3	2	3	2	2	3	5
Hill's Number (H_1)	2010-11	4.51	4.872	5.116	3.808	1.709	4.413	5.258	5.114	8.011	4.7	3.773	5.662
	2011-12	5.974	6.295	2.477	1.667	3.082	1.68	2.793	4.813	1.736	1.643	6.507	3.67

Table 4.3.11 Cladoceran similarity matrix 2010-11

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
December	*	39.85	44.70	33.97	27.95	11.41	21.03	14.12	17.57	9.94	10.81	8.43
January	*	*	25.53	57.61	63.92	7.53	22.24	9.03	15.12	8.41	5.53	5.27
February	*	*	*	30.25	8.54	13.92	21.57	25.37	32.52	20.38	14.51	9.38
March	*	*	*	*	34.13	5.57	24.98	5.25	16.37	3.09	1.91	1.17
April	*	*	*	*	*	5.24	15.64	4.90	8.30	3.96	3.11	2.30
May	*	*	*	*	*	*	44.23	30.43	27.88	42.40	74.71	42.21
June	*	*	*	*	*	*	*	47.72	45.11	32.97	28.55	50.63
July	*	*	*	*	*	*	*	*	74.65	45.60	39.56	27.84
August	*	*	*	*	*	*	*	*	*	50.00	34.68	20.09
September	*	*	*	*	*	*	*	*	*	*	59.75	36.87
October	*	*	*	*	*	*	*	*	*	*	*	36.54
November	*	*	*	*	*	*	*	*	*	*	*	*

Table 4.3.12 Cladoceran similarity matrix 2011-12

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
December	*	87.64	8.66	4.42	23.78	5.12	39.14	89.06	71.14	22.56	77.35	24.72
January	*	*	11.73	4.32	27.80	7.09	34.62	76.43	72.22	22.91	67.76	24.20
February	*	*	*	44.86	71.27	72.13	7.81	6.57	3.28	3.31	9.66	13.36
March	*	*	*	*	31.63	67.25	4.67	3.94	0.77	1.25	4.94	7.91
April	*	*	*	*	*	52.53	6.19	20.45	21.22	21.30	15.01	29.24
May	*	*	*	*	*	*	5.02	4.21	2.07	2.45	6.11	10.31
June	*	*	*	*	*	*	*	44.40	1.97	2.97	51.56	13.45
July	*	*	*	*	*	*	*	*	71.61	21.01	73.82	23.69
August	*	*	*	*	*	*	*	*	*	19.58	44.60	14.81
September	*	*	*	*	*	*	*	*	*	*	12.61	83.32
October	*	*	*	*	*	*	*	*	*	*	*	18.82
November	*	*	*	*	*	*	*	*	*	*	*	*

Table 4.3.13 Pooled number of cladoceran species richness

	2010-211	2011-12
December	4.8	3.8
January	6.4	4.4
February	7.2	4.6
March	7.6	5
April	7.8	5.4
May	8	5.6
June	8.2	5.6
July	8.2	6.2
August	9	6.2
September	9	6.2
October	9	6.4
November	9	7

Table 4.3.14 SHE information analysis of cladoceran

2010-2011						2011-2012					
N	S	LnS	H	LnE	LnE/LnS	N	S	LnS	H	LnE	LnE/LnS
452.8	4	1.39	0.79	-0.6	-0.43	64.3	4	1.39	0.98	-0.4	-0.29
677.9	6	1.79	1.18	-0.61	-0.34	127.1	4	1.39	1.02	-0.36	-0.26
816.3	7	1.95	1.4	-0.55	-0.28	499	5	1.61	0.87	-0.74	-0.46
911.3	7	1.95	1.38	-0.56	-0.29	1699.7	5	1.61	0.41	-1.2	-0.75
1234.1	7	1.95	1.24	-0.71	-0.36	1998.7	5	1.61	0.45	-1.16	-0.72
1545.5	7	1.95	1.54	-0.4	-0.21	2609.9	5	1.61	0.38	-1.23	-0.76
1718.5	8	2.08	1.59	-0.49	-0.23	2675.9	5	1.61	0.45	-1.16	-0.72
1783.5	9	2.2	1.6	-0.59	-0.27	2738.7	5	1.61	0.5	-1.11	-0.69
1838.8	9	2.2	1.61	-0.58	-0.27	2774.2	5	1.61	0.52	-1.09	-0.67
1925.1	9	2.2	1.63	-0.57	-0.26	3091.1	5	1.61	0.68	-0.93	-0.57
2123.0	9	2.2	1.63	-0.57	-0.26	3137.2	5	1.61	0.7	-0.91	-0.56
2504.8	9	2.2	1.64	-0.56	-0.25	3580.9	7	1.95	0.82	-1.13	-0.58

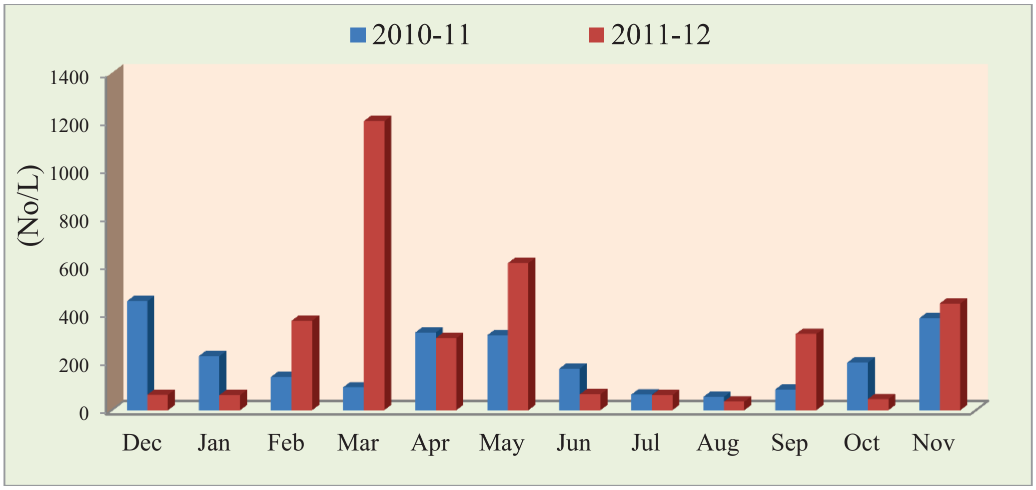


Fig. 4.3.25 Cladoceran density

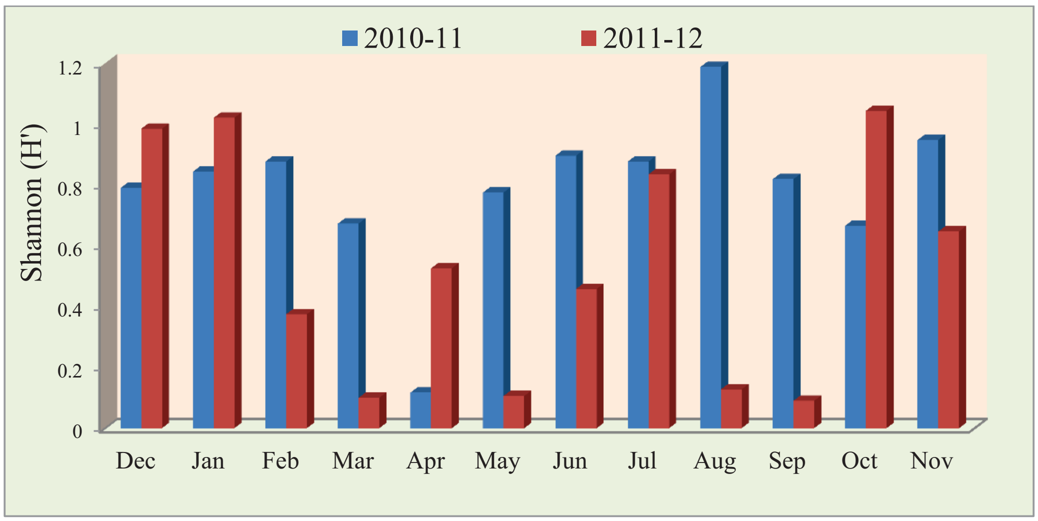


Fig. 4.3.26 Cladoceran diversity

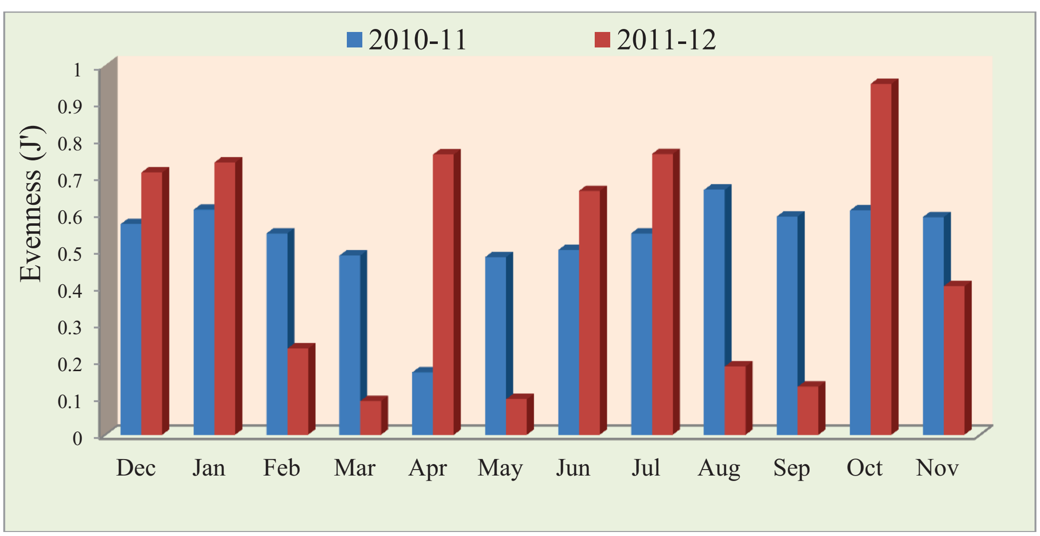


Fig. 4.3.27 Cladoceran evenness

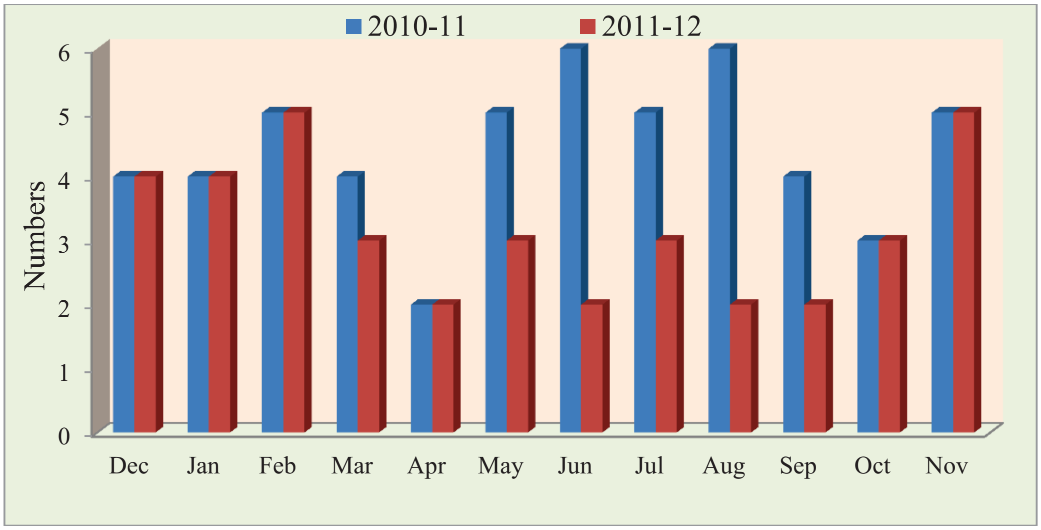


Fig. 4.3.28 Cladoceran species richness

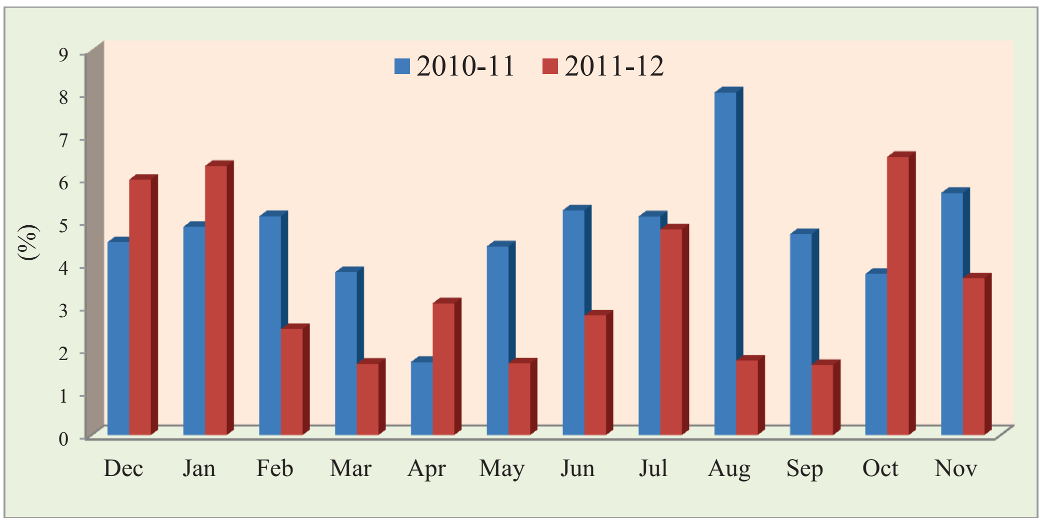


Fig. 4.3.29 Cladoceran abundance

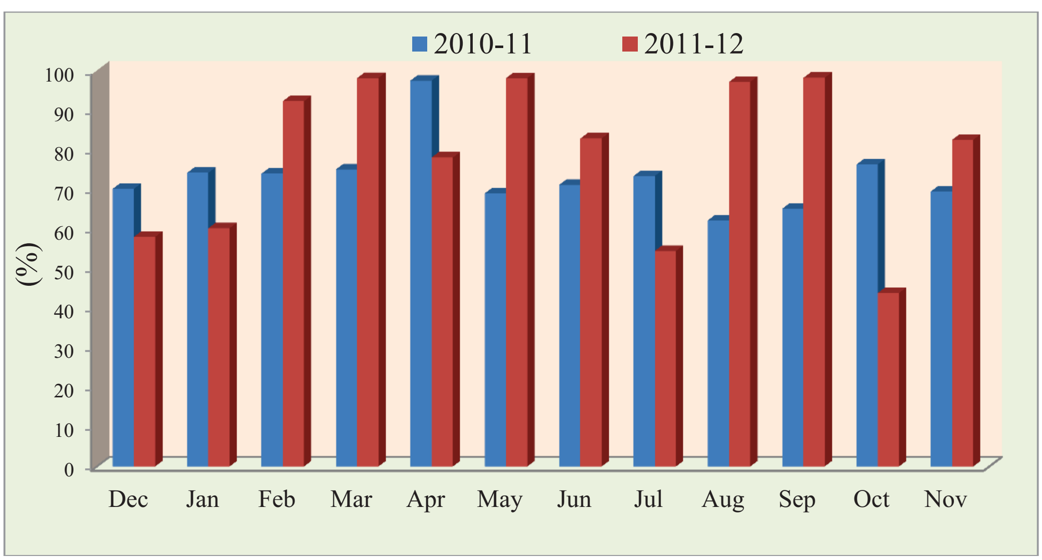


Fig. 4.3.30 Cladoceran dominance

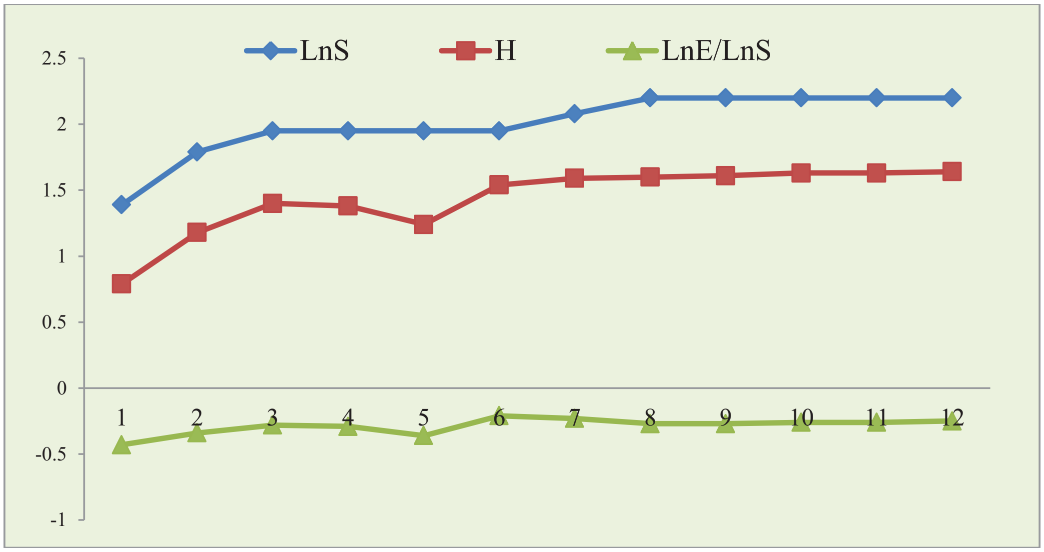


Fig. 4.3.31 SHE information analysis of cladoceran 2010-11

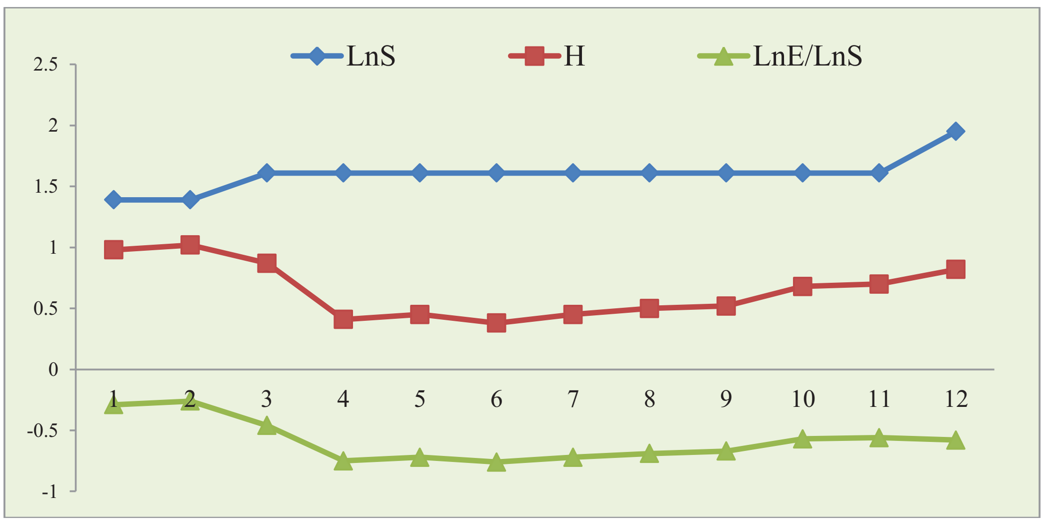


Fig. 4.3.32 SHE information analysis of cladoceran 2011-12

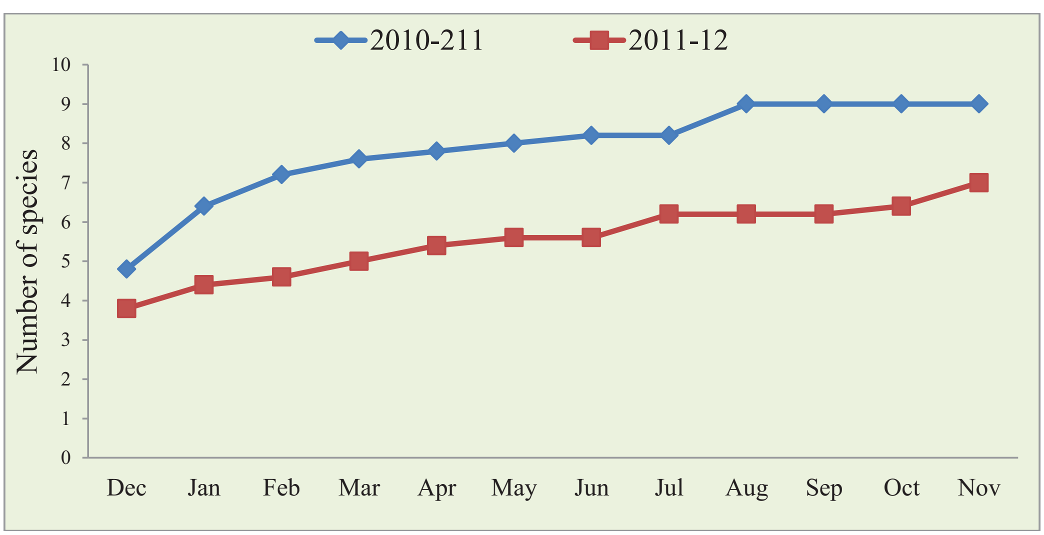


Fig. 4.3.33 Pooled number of cladoceran species

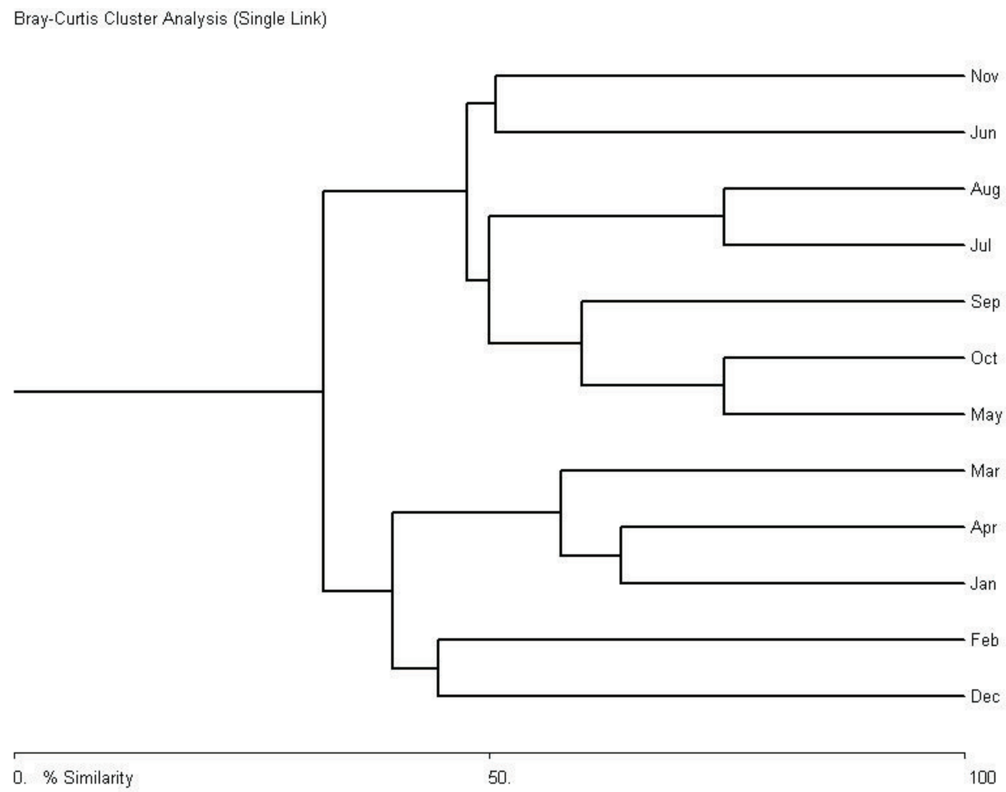


Fig. 4.3.34 Cladoceran similarity matrix 2010-11

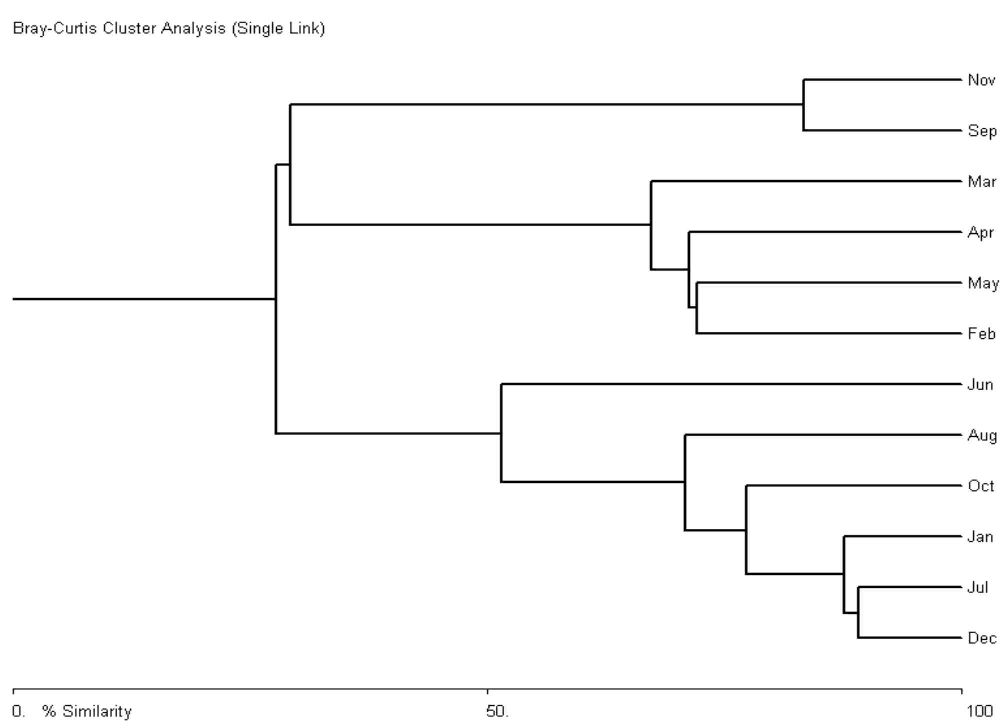


Fig. 4.3.35 Cladocera similarity matrix 2011-12

in the month of February 2011 during winter, whereas less amount was reported (4.3mg/L) in the month of April and May 2011 during summer. The total hardness value ranged between 154.05-320mg/L (Fig. 4.3.39). Total hardness was low in 2010-11, and it was high during summer and monsoon in 2011-12. Total alkalinity also showed the similar trend of total hardness, the alkalinity ranged from 127.5-318.8mg/L, high content was noticed in 2011-12 (Fig. 4.3.39). Chloride content ranged 166.9-688mg/L, in the year 2010-12 (Fig. 4.3.39). The high content was observed during summer, whereas it declined during monsoon. Calcium and Magnesium contents were between 22.12-47.4mg/L, 26.02-71.1mg/L respectively, high content of calcium were observed in 2011-12, especially during monsoon. Similarly, the Magnesium concentration was also high in 2011-12, besides the high content of Magnesium was noticed during summer and monsoon (Fig. 4.3.40).

Nutrient such as total phosphate, nitrate, nitrite and ammonia content were analyzed (Table 3.15). It recorded a total phosphate content of 0.28-10.7mg/L (Fig. 4.3.41), nitrate 0.01-105mg/L (Fig. 4.3.42), nitrite 0.001-0.305mg/L (Fig. 4.3.43) and ammonia content 0.05-12.19mg/L (Fig. 4.3.44). A high content of phosphate was observed during May 2012 (10.7mg/L) and in September-October 2012, it was 1.5 and 1.07mg/L. Similarly a high content of Nitrate was observed in June 2012 (105mg/L), whereas Nitrite was high from May-July and October 2012 (0.1-0.3mg/L). Besides, the ammonia content was also high during March- May 2012 (0.1-5.5mg/L) during summer season.

Copepoda density was significant correlation with ammonia ($r = 0.8466$) in 2011-12. Zooplankton abundance was moderate correlation with nitrite ($r = 0.6431$) in 2010-11, species richness with surface temperature ($r = 0.6982$) in 2011-12. Evennees moderate correlation with nitrite ($r = 0.5849$), ammonia in 2011-12. Over zooplankton diversity was moderate correlation with nitritre ($r = 0.5717$) in 2010-11 (Table 4.3.16).

Table 4.3.15 Physicochemical parameters 2010-2012

Parameters	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Ambient atm. Temperature °C	28.50	25.00	26.50	33.00	30.33	30.25	29.3	27.3	27.75	30.50	29.75	25.25
	24	29.5	27.7	32.7	25.3	26.0	18.5	21.5	19.5	19.5	22.5	24.5
Sub-surface water Temperature °C	23.75	23.00	23.00	28.00	28.67	28.75	26.0	27.3	25	28.50	27.25	22.00
	23	24.3	24.7	24.7	22.0	21.5	15.5	18.5	18	18.5	20.5	22.5
P^H	8.75	8.45	7.90	8.68	8.83	8.78	9.1	9.1	8.725	8.88	9.43	9.05
	9.175	8.8	9.0	8.9	8.9	9.2	8.4	10.1	8.9	8.95	8.7	9.55
Electrical conductivity (mS)	0.83	0.84	0.93	0.94	1.11	1.28	1.4	1.4	1.35	1.49	1.43	1.64
	1.64	1.6	2.1	2.4	2.5	3.4	2.75	1.9	1.955	1.945	1.4	1.435
Dissolved Oxygen (mg/L)	8.65	7.69	10.17	6.68	14.24	11.23	10.0	12.0	10.7	11.03	10.58	0.00
	12.54	9.8	19.0	12.3	4.3	4.5	6.98	13.96	12.04	7.59	11.94	11.13
Total Dissolved Solids (ppm)	615.0	655.0	682.5	675.0	843.	972.5	960.0	1125	1095	1270	1102	1252
	1382	1425	1550	1786	2000	2000	1976	1080	1045	1055	1070	1175
Total Hardness (mg/L)	165.90	165.9	130.35	136.2	142.2	177.7	242.9	219.2	201.4	254.78	314.0	237.0
	254.7	231.1	221.2	229.1	292.3	320.0	296.2	154.0	225.1	201.4	213.3	237
Total Alkalinity (mg/L)	191.2	127.5	165.75	133.8	153.0	172.1	210.4	178.5	184.8	210.3	261.3	191.2
	210.3	204.0	187.0	187.0	263.5	318.8	216.7	242.2	191.2	191.2	204	178.5
Chlorides (mg/L)	166.9	131.5	172.0	177.1	269.8	303.6	328.9	328.9	349.1	278.3	0.00	475.6
	435.1	470.6	667.9	613.9	688.2	678.0	313.7	151.8	182.1	212.5	323.8	283.3
Calcium (mg/L)	37.92	37.92	33.18	33.18	22.12	26.07	30.8	30.8	37.92	37.92	30.81	28.44
	37.92	30.8	37.9	37.9	28.4	28.4	37.92	47.4	42.66	47.4	47.4	47.4
Magnesium (mg/L)	31.23	31.23	23.71	25.15	29.30	37.01	51.8	46.0	39.9	52.92	69.10	50.89
	52.91	48.9	44.7	46.7	64.4	71.1	63.03	26.02	44.52	37.59	40.48	46.26
Phosphates (mg/L)	0.28	0.46	0.92	0.23	0.22	0.42	1.0	0.3	0.315	0.35	0.39	0.33
	0.465	0.5	0.3	0.1	1.0	10.7	0.61	0.655	0.34	1.53	1.07	0.15
Nitrates (mg/L)	0.00	37.50	0.00	7.00	0.83	0.00	5.3	0.0	8.75	43.25	1.00	17.25
	5.75	0.0	0.0	0.0	0.0	12.5	105	9	5	0	12.5	5
Nitrites (mg/L)	0.00	0.19	0.00	0.23	0.04	0.00	0.0	0.0	0.06	0.12	0.00	0.11
	0.03	0.0	0.0	0.0	0.0	0.1	0.24	0.305	0	0	0.17	0.02
Ammonia (mg/L)	0.06	12.19	0.00	0.05	0.00	1.20	1.2	0.1	0.06	0.06	0.01	0.34
	0.07	0.0	0.1	0.1	3.5	5.5	0	0.365	0	2.44	0.05	0

Table 4.3.16 Simple correlation between zooplankton and physicochemical parameters

	Duration	S	pH	EC	TDS	DO	TH	TA	Cl	Ca	Mg	PO_4	Nitrate	Nitrite	Ammonia
Total zooplankton (No/L)	2010-11	0.2525	0.1661	-0.0117	-0.0860	-0.1218	-0.3205	-0.3553	0.3501	-0.7334	-0.2532	-0.3453	-0.1576	0.1236	-0.0658
	2011-12	0.4184	-0.0742	0.1814	0.4421	-0.2282	0.4192	0.2456	0.5250	-0.4612	0.4396	0.0841	-0.1829	-0.3113	0.2478
Rotifera (No/L)	2010-11	0.1656	0.1345	0.1040	0.0227	-0.2999	-0.2219	-0.4160	0.3731	-0.6058	-0.1662	-0.2172	0.0972	0.4728	0.0495
	2011-12	0.3626	-0.0775	0.0359	0.3171	-0.1328	0.3399	0.1717	0.4060	-0.3887	0.3587	-0.0209	-0.1506	-0.2514	0.1103
Cladocera (No/L)	2010-11	-0.2937	0.0810	-0.1737	-0.2381	-0.3174	-0.1432	-0.0006	0.0462	-0.3265	-0.1135	-0.1724	-0.1805	-0.1974	0.0625
	2011-12	0.4881	0.0245	0.4106	0.4236	-0.0427	0.1698	0.0352	0.5368	-0.2043	0.1806	0.2371	-0.2500	-0.3517	0.2556
Copepoda (No/L)	2010-11	0.5166	0.0650	-0.1124	-0.0740	0.5894	-0.2170	-0.0036	0.0458	-0.2870	-0.1905	-0.2659	-0.4594	-0.5421	-0.3214
	2011-12	-0.1682	-0.0642	0.5866	0.5515	-0.8700	0.6188	0.7133	0.3427	-0.5240	0.6253	0.5033	0.0736	-0.0512	0.8466
Shannon H' Log Base 2.718	2010-11	0.2227	-0.1969	-0.1802	-0.2320	-0.0583	-0.1995	-0.3411	-0.2626	-0.2553	-0.1761	0.1738	0.2561	0.5717	0.2712
	2011-12	-0.1127	-0.1460	0.1924	0.0968	-0.0380	-0.1633	0.1273	0.0483	0.0168	-0.1481	0.2018	0.2162	0.3980	0.1048
Shannon (J')	2010-11	0.0762	-0.1958	-0.1965	-0.2247	-0.0257	-0.1116	-0.3267	-0.3116	-0.0707	-0.1051	0.2420	0.4101	0.5849	0.4923
	2011-12	-0.5078	-0.1484	0.2281	-0.0648	-0.1783	-0.2165	0.0989	-0.2806	0.1695	-0.2171	0.1361	0.2832	0.4113	0.1204
Simpsons Diversity (D)	2010-11	-0.1945	0.1057	0.1561	0.2226	0.0869	0.1323	0.2780	0.2531	0.2789	0.1067	-0.1939	-0.2903	-0.5394	-0.2934
	2011-12	0.1980	0.1676	-0.2977	-0.1316	0.1979	0.0841	-0.1445	-0.0089	-0.0351	0.0802	-0.2653	-0.2232	-0.3265	-0.2024
Hill's Number (H_0)	2010-11	0.3962	-0.0586	-0.0114	-0.0789	-0.1087	-0.2810	-0.1343	0.0911	-0.5262	-0.2328	-0.1470	-0.3291	0.0467	-0.4164
	2011-12	0.6982	-0.0334	-0.1211	0.1927	0.4034	0.0394	-0.0406	0.5410	-0.2475	0.0702	0.0654	-0.1525	-0.0902	-0.1314
Hill's Number (H_1)	2010-11	0.2353	-0.2219	-0.3156	-0.3622	-0.0713	-0.3124	-0.4397	-0.3120	-0.1985	-0.2942	0.0700	0.2014	0.6431	0.2556
	2011-12	-0.0958	-0.1776	0.1011	0.0404	0.0251	-0.1842	0.1128	0.0220	0.0192	-0.1670	0.1860	0.2361	0.4456	0.0290
Berger-Parker Dominance (d%)	2010-11	-0.1692	0.0178	0.2317	0.3173	0.0978	0.1409	0.2633	0.2870	0.2570	0.1173	-0.1525	-0.2191	-0.5150	-0.2822
	2011-12	0.1770	0.2318	-0.4010	-0.2162	0.3165	-0.0524	-0.1945	-0.0653	0.0009	-0.0465	-0.4061	-0.2536	-0.2759	-0.3009

Fig. 3.36-3.44 Physicochemical features

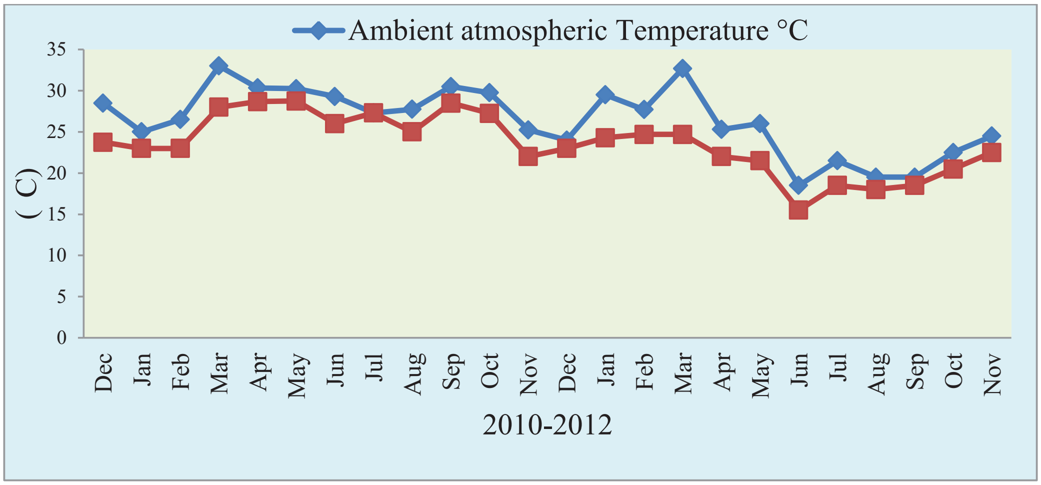


Fig 4.3.36 Temperature

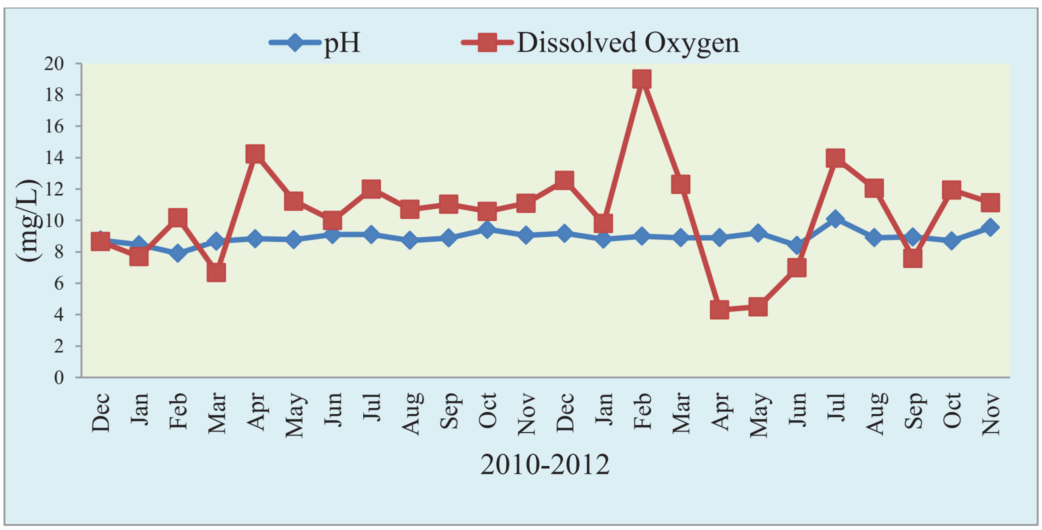


Fig. 4.3.37 pH and dissolved Oxygen

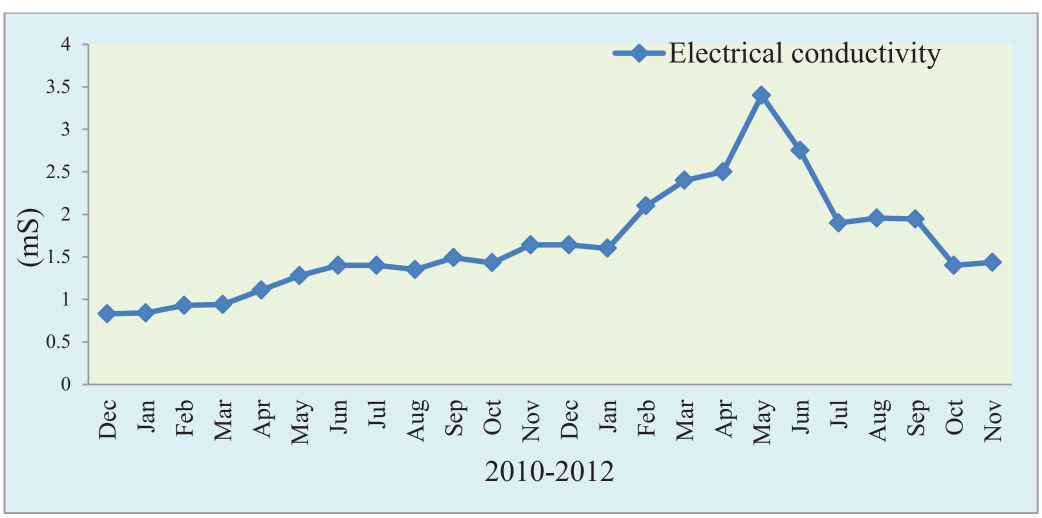


Fig. 4.3.38 Electrical conductivity

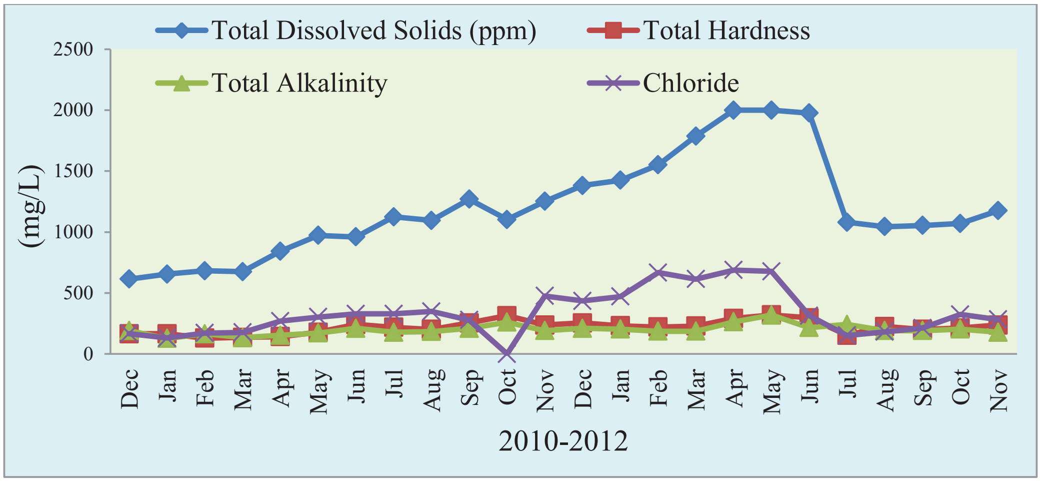


Fig. 4.3.39 Total dissolved solids, hardness, alkalinity and chloride

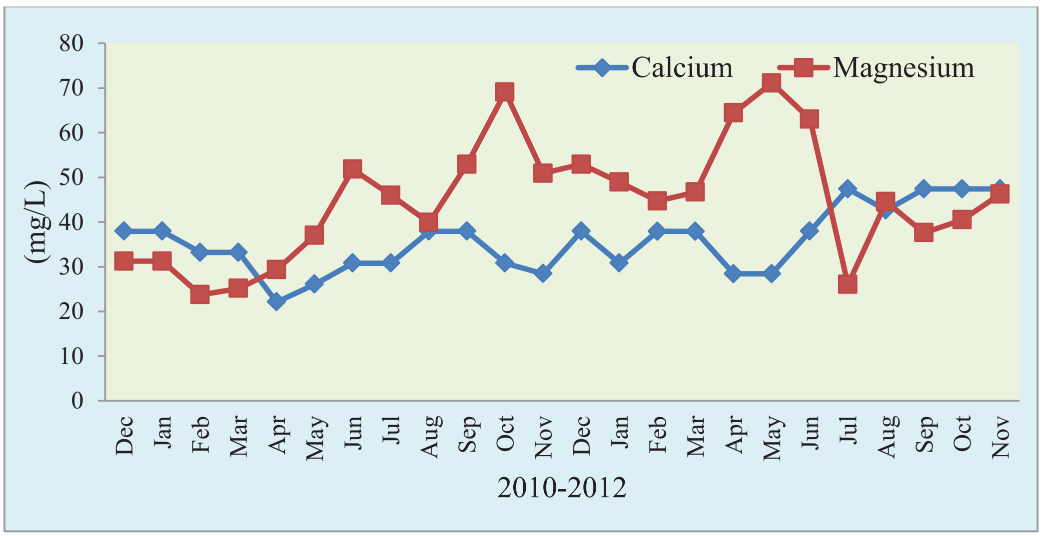


Fig. 4.3.40 Calcium and Magnesium

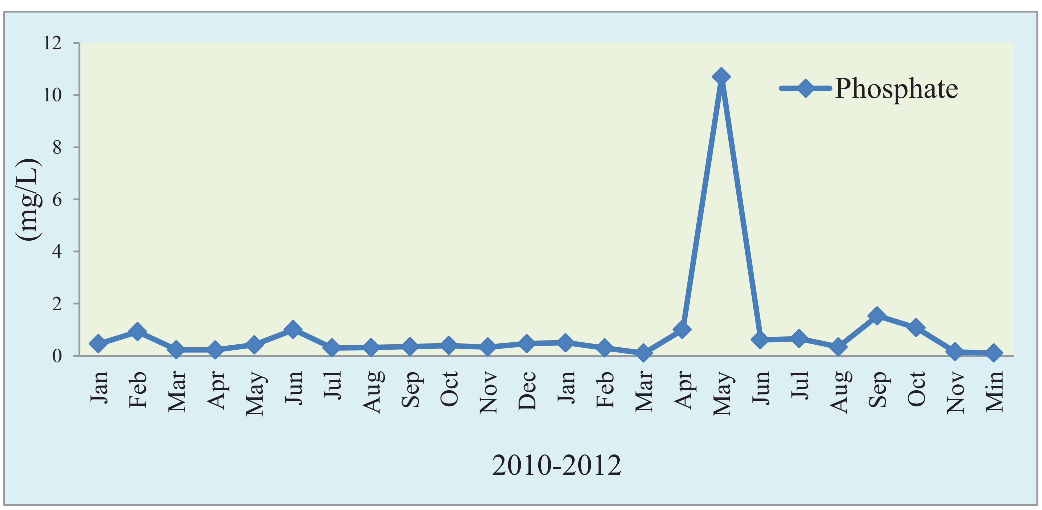


Fig. 4.3.41 Phosphate

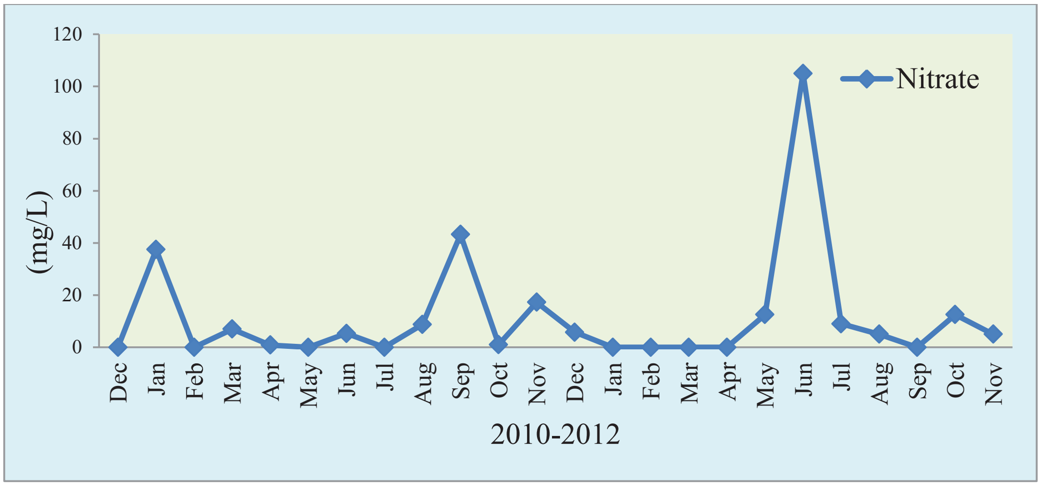


Fig. 4.3.42 Nitrate

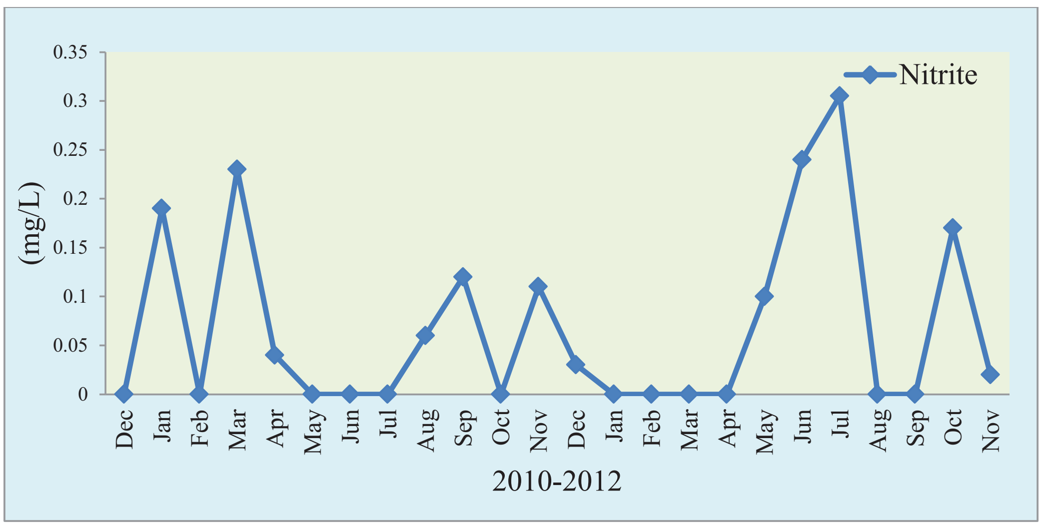


Fig. 4.3.43 Nitrite

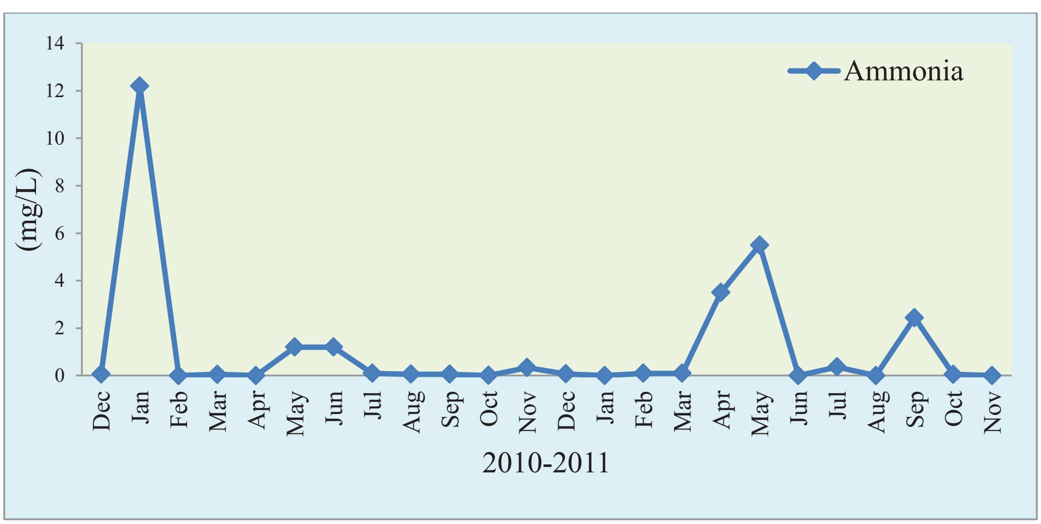


Fig. 4.3.44 Ammonia

4.4. Zooplankton community structure, composition and diversity of Bandam kommu cheruvu, Medak district

In the present study, a shallow weedy pond (Bandam Kommu cheruvu) from Medak district, Andhra Pradesh (Plate 25) was chosen to evaluate the zooplankton composition, community structure and diversity along with physicochemical profile.

4.4.1 Zooplankton composition

It reveals that 83 species of various zooplankton communities were observed from this pond between 2010-2012 (Table 4.4.1 and Fig. 4.4.1), of which rotifer consist of 63 species belonging to 24 genera and 17 families (Fig. 4.4.2). Cladocera has 18 species belonging to 19 genera and 5 families (Fig. 4.4.3). Copepod comprises of 02 species belonging to 02 genera and 02 families (Table 4.4.2). Among the various rotifer species, 17species belong to Brachionidae and 24 species belong to Lecanidae, these two families have more number of species richness than other zooplankton communities in this pond. In cladocera, family Chydoridae and Daphniidae has more number of species. Copepoda has only two species which belongs to Cyclopedia and Diaptomidae represented by one species each.

Brachionus forficula, Trichotria tetractis, Macrochaetus sericus, Lecane ruttneri, L. simonneae, L. pyriformis, Scaridium longicautadum, Conochilus dossrianus, Hexarthra intermedia, Testudinella patina, Daphnia lumholtzi, Pseudochydorus globosus occurred only during 2010-11, and species like *Epiphanies clavulata, Brachionus bidentata, B. plicatilis, Lecane aculeata, Karualona karua* and *Kurzia longirostris* were recorded in 2011-12.

4.4.2 Zooplankton density and diversity

Total zooplankton density was 119-26463No/L (Table 4.4.3 and Fig. 4.4.4). The high density of zooplankton communities was mainly due to the rotifer

Table 4.4.1 Zooplankton composition of Bamdam Kommu cheruvu

S. No	Name of the species	Study period	
		2010-2011	2011-2012
	Rotifera		
	Epiphanidae		
1	*Epiphanes clavulata* (Ehrenberg, 1832)	-	+
2	**Brachionidae** *Anuraeopsis fissa* Gosse, 1851	+	+
3	*Brachionus angularis* Gosse, 1851	+	+
4	*Brachionus bidentatus* Anderson, 1889	-	+
5	*Brachionus budapestinensis* Daday, 1885	+	+
6	*Brachionus calyciflorus* Pallas, 1776	+	+
7	*Brachionus caudatus* Barrios & Daday, 1894	+	+
8	*Brachionus diversicornis* (Daday, 1883)	+	-
9	*Brachionus durgae* Dhanapathi, 1974	+	+
10	*Brachionus falcatus* Zacharias, 1898	+	+
11	*Brachionus forficula* Wierzejski, 1891	+	-
12	*Brachionus plicatilis* Muller, 1786	-	+
13	*Brachionus patulus com nov.,* Segers *et al.,* 1993	+	+
14	*Brachionus quadridentatus* Hermann, 1783	+	+
15	*Brachionus quadridentatus melhemi* Barrios & Daday 1894	+	+
16	*Brachionus rubens* Ehrenberg, 1838	+	+
17	*Keratella tropica* (Apstein, 1907)	+	+
18	*Platyias quadricornis* (Ehrenberg, 1832)	+	+
	Euchlanidae		
19	*Euchlanis dilatata* Ehrenberg, 1832	+	+
20	*Tripleuchlanis plicata* (Levander, 1894)	+	+
	Mytilinidae		
21	*Mytilina acanthophora* Hauer, 1938	+	+

22	*Mytilina ventralis* (Ehrenberg, 1832)	+	+
	Trichotriidae		
23	*Trichotria tetractis* (Ehrenberg, 1830)	+	-
24	*Macrochaetus sericus* (Thorpe, 1893)	+	-
	Lepadellidae		
25	*Colurella obtusa* Gosse, 1886	+	+
26	*Lepadella (Lepadella) ovalis* (Muller, 1786)	+	+
27	*Lepadella (Lepadella)triba* Myers, 1934	+	+
28	*Lepadella (Heterolepadella)ehrenbergii* Perty, 1850	+	+
	Lecanidae		
29	*Lecane aculeata* (Jakubski, 1912)	-	+
30	*Lecane bulla* (Gosse, 1851)	+	-
40	*Lecane closterocerca* (Harring and Myers, 1926)	+	+
41	*Lecane curvicornis* (Murray, 1913)	+	+
31	*Lecane haliclysta* (Harring and Myers, 1926)		+
32	*Lecane hamata* (Stokes, 1896)	+	+
43	*Lecane leontina* (Turner, 1892)	+	+
33	*Lecane ludwigii* (Eckstein, 1883)	+	+
34	*Lecane luna* (Muller, 1776)	+	+
35	*Lecane lunaris* (Ehrenberg, 1832)	+	+
44	*Lecane papuana* (Murray, 1913)	+	+
36	*Lecane pyriformis* (Daday, 1905)	+	
42	*Lecane quadridentata* (Ehrenberg, 1832)	+	+
45	*Lecane ruttneri* Hauer, 1938	+	-
37	*Lecane simonneae* (Segers, 1993)	+	-
38	*Lecane stenroosi* (Meissner, 1908)	+	+
46	*Lecane unguitata* (Fadeev, 1925)	+	+
47	*Lecane ungulata* (Gosse, 1887)	+	+

	Notommatidae		
39	*Cephalodella gibba* Ehrenberg, 1832	+	+
48	*Cephalodella forficula* (Ehrenberg, 1830)	-	+
	Scaridiidae		
49	*Scaridium longicaudum* (Muller, 1786)	+	-
	Asplanchnidae		
50	*Asplanchna brightwellii* Gosse, 1850	+	+
	Synchaetidae		
51	*Polyarthra indica* (Segers and Babu, 1999)	+	+
	Flosculariaceae		
	Conochilidae		
52	*Conochilus (Conochiloides) dossuarius* Hudson, 1885	+	
53	*Conochilus (Conochilus) unicornis* Rousselet, 1892	+	+
	Trichocercidae		
54	*Trichocerca pusilla* (Jennings, 1903)	+	+
	Hexarthridae		
55	*Hexarthra intermedia* Wizniewski 1929	+	
	Filiniidae		
56	*Filinia longiseta* Ehrenberg 1834	+	+
57	*Filinia opoliensis* (Zacharias, 1898)	+	+
58	*Filinia terminalis* (Plate, 1886)	-	+
59	*Squatinella lamellaris* (Muller, 1786)	-	+
	Testudinellidae	+	+
60	*Testudinella parva* (Ternetz, 1892)		
61	*Testudinella patina* (Hermann, 1783)	+	-
	Eurotatoria		
	Bdelloidea		
	Philodinidae		
62	*Rotaria neptunia* Ehrenberg, 1832	+	+

63	*Rotaria rotatoria* (Pallas, 1766)	+	+
	Cladocera		
64	**Sididae** *Diaphanosoma sarsi* Richard, 1895	+	+
65	**Daphniidae** *Ceriodaphnia cornuta* Sars, 1885	+	+
66	*Daphnia (Ctenodaphnia) lumholtzi* Sars, 1885	+	-
67	*Scapholeberis kingi* Sars, 1903b	+	+
68	*Simocephalus ((Echinocaudus) exspinosus* De Geer, 1778.	+	+
69	**Moinidae** *Moina micrura* Kurz, 1874	+	+
70	**Macrothricidae** *Macrothrix spinosa* King, 1853	+	+
71	*Ilyocryptus spinifer* Herrick, 1882	-	+
72	**Chydoridae** *Chydorus sphaericus* (O. F. Muller, 1776)	+	+
73	*Pleuroxus aduncus* Jurine, 1820	+	+
74	*Dunhevedia crassa crassa* King, 1853	+	+
75	*Pseudochydorus globosus* Baird, 1843	+	-
76	*Coronatella rectangula* Sars, 1862a	+	+
77	*Leberis davidi davidi* Richard, 1895	+	+
78	*Alona costata* Sars, 1862	+	+
79	*Karualona karua* King, 1853	+	+
80	*Euryalona orientalis* Daday, 1898	+	+
81	*Kurzia (Rostrokurzia) longirostris* (Daday, 1898)	-	+
82	**Copepoda** **Diaptomidae** *Tropodiaptomus orientalis* (Brady,1886)	+	+
83	**Cyclopoidae** *Mesocyclops leuckarti* Claws, 1857	+	+

Table 4.4.2 Family wise zooplankton composition in Bandam Kommu cheruvu

Families	Genera	Species
Rotifera		
Asplanchnidae	1	1
Brachionidae	4	17
Epiphanidae	1	1
Euchlanidae	2	2
Lecanidae	1	18
Lepadellidae	2	4
Mytilinidae	1	2
Notommatidae	1	2
Scaridiidae	1	1
Synchaetidae	1	1
Trichotriidae	2	2
Conochilidae	1	2
Filiniidae	1	3
Hexarthridae	1	1
Testudinellidae	1	2
Trichocercidae	1	1
Philodinidae	1	2
Cladocera		
Sididae	1	1
Daphniidae	4	4
Moinidae	1	1
Macrothricidae	2	2
Chydoridae	10	10
Copepoda		
Diaptomidae	1	1
Cyclopidae	1	1

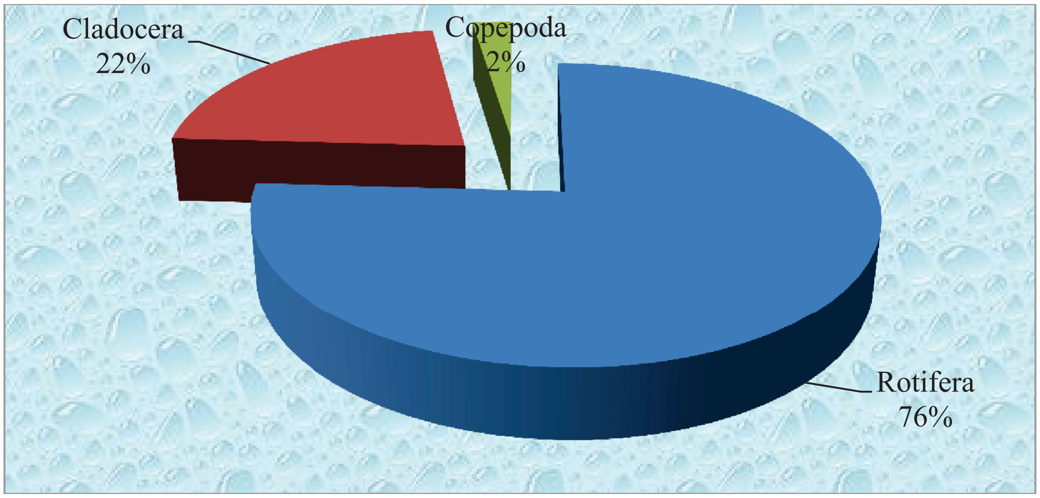


Fig. 4.4.1 Zooplankton composition in Bandam Kommu cheruvu

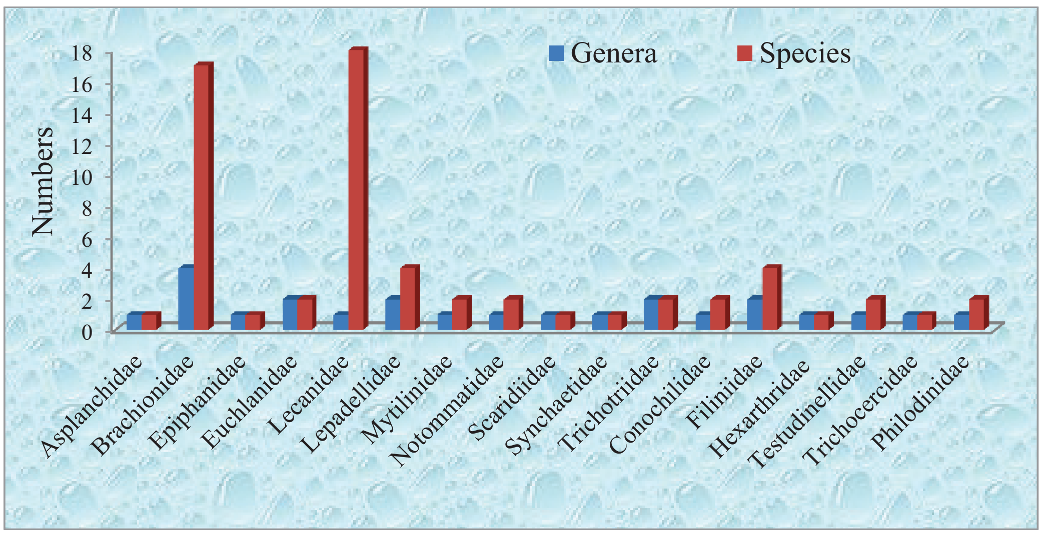


Fig. 4.4.2 Family wise rotifer composition in Bandam Kommu cheruvu

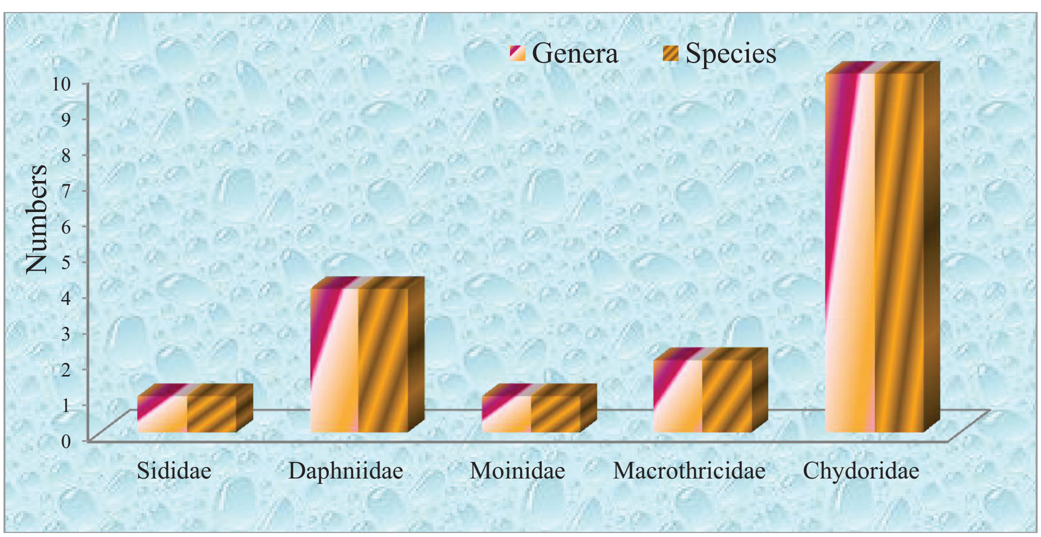


Fig. 4.4.3 Family wise cladoceran composition in Bandam Kommu cheruvu

population in June 2011 and 2012 (4354No/L, 26463No/L) and October 2012 (1534No/L), these months are representing summer of 2010-11 and monsoon season of 2011-12. Cladocera were more in February 2012 (337No/L), May 2012 (1003No/L), September 2012 (725No/L) and October 2012 (1088No/L). Copepod was more in February 2012 (657No/L), May 2012 (1072No/L), and November 2012 (639No/L). The high density of copepoda was due to the presence of *Mesocyclops leuckarti* (Fig. 4.4.5and 4.4.6).

Diversity of zooplankton was H= 0.893-2.683 (Table 4.4.3). High diversity of zooplankton was observed during monsoon season. In 2011-12 had more diversity than 2010-11 study periods (Fig. 4.4.7). Evenness of the zooplankton was J= 0.47-0.961 (Table 4.4.3), less in the month of December 2010 and September 2011 (winter) and high during February and March 2011 (late winter and summer) Fig. 4.4.8. Richness of the species obtained between 5- 21 (Table 4.4.3), high in November 2011 (21 species) and October 2012 (20 species). High species richness was observed during the monsoon period (Fig. 4.4.9). Similarly the abundance was also high in November 2011 and October 2012, which was 69.2% and 55.2% respectively (Fig. 4.4.10). Dominance of zooplankton of the pond varied between 18.6-74.1% and the values were reciprocal to the abundance. When the abundance was high the dominance was less and *vice versa* (Fig. 4.4.11).

SHE analysis showed that the diversity (H) depends upon the evenness of the individuals rather than richness. When the evenness decreases, the diversity also decreases. LnE/LnS showed that the variance between species richness and evenness was less and balanced (Table 4.4.4 and Fig. 4.4.12). The pooled number of species in the pond over the two year period showed an increase in number (Fig. 4.4.13).

Table 4.4.3 Zooplankton density and diversity during 2010-12

		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Total Zooplankton (No/L)	2010-11	519	535.6	136	119	1037	2909	26463	242	188	397.1	381	1054
	2011-12	445	431	1165	207	1223	730	4716	428	599	1498	2968	1272
Rotifer (No/L)	2010-11	485	467.3	85	85	172.6	833.5	25930	138	68	34.3	208	760
	2011-12	411	276	171	103	810	447	4354	188	170	687	1534	308
Cladocera (No/L)	2010-11	34	51	51	34	501.2	1003	103	34.6	51	68.3	51.6	225
	2011-12	34	34	337	52	68	59	34	86	239	725	1088	325
Copepoda (No/L)	2010-11	0	17.3	0	0	363	1072	430	69.2	69.2	294.5	121	69
	2011-12	0	121	657	52	345	224	328	154	190	86	346	639
Shannon H' Log Base 2.718	2010-11	0.763	1.835	1.733	1.475	1.387	1.726	1.551	1.747	1.638	0.893	2.046	2.683
	2011-12	2.368	1.588	1.635	1.924	2.114	1.678	1.436	2	2.259	1.972	2.527	1.848
Shannon Hmax Log Base 2.718	2010-11	1.609	2.398	1.792	1.609	2.079	2.565	2.485	1.946	1.792	1.609	2.303	3.045
	2011-12	2.639	2.079	2.565	2.079	2.773	2.485	2.398	2.197	2.639	2.565	2.996	2.639
Shannon (J')	2010-11	0.474	0.765	0.967	0.917	0.667	0.673	0.624	0.898	0.914	0.555	0.889	0.881
	2011-12	0.897	0.764	0.637	0.925	0.762	0.675	0.599	0.91	0.856	0.769	0.844	0.7
Simpsons Diversity (D)	2010-11	0.652	0.265	0.181	0.259	0.315	0.254	0.267	0.201	0.221	0.571	0.163	0.092
	2011-12	0.115	0.274	0.348	0.162	0.177	0.272	0.37	0.154	0.15	0.212	0.101	0.277
Hill's Number (H_0)	2010-11	5	11	6	5	8	13	12	7	6	5	10	21
	2011-12	14	8	13	8	16	12	11	9	14	13	20	14
Hill's Number (H_1)	2010-11	4.335	20.35	17.57	12.11	10.67	17.41	13.52	17.94	15.32	5.234	27.61	69.24
	2011-12	43.95	14.27	15.26	23.16	30.46	16.24	11.44	25.83	37.52	24.83	55.26	20.75
Berger-Parker Dominance (d)	2010-11	0.801	0.485	0.25	0.429	0.417	0.369	0.357	0.286	0.368	0.742	0.318	0.2
	2011-12	0.186	0.418	0.569	0.25	0.276	0.45	0.58	0.241	0.317	0.404	0.163	0.496
Berger-Parker Dominance (d%)	2010-11	80.11	48.54	25	42.85	41.66	36.85	35.74	28.63	36.76	74.16	31.77	19.96
	2011-12	18.61	41.78	56.88	25	27.60	45.02	57.98	24.06	31.72	40.38	16.30	49.56

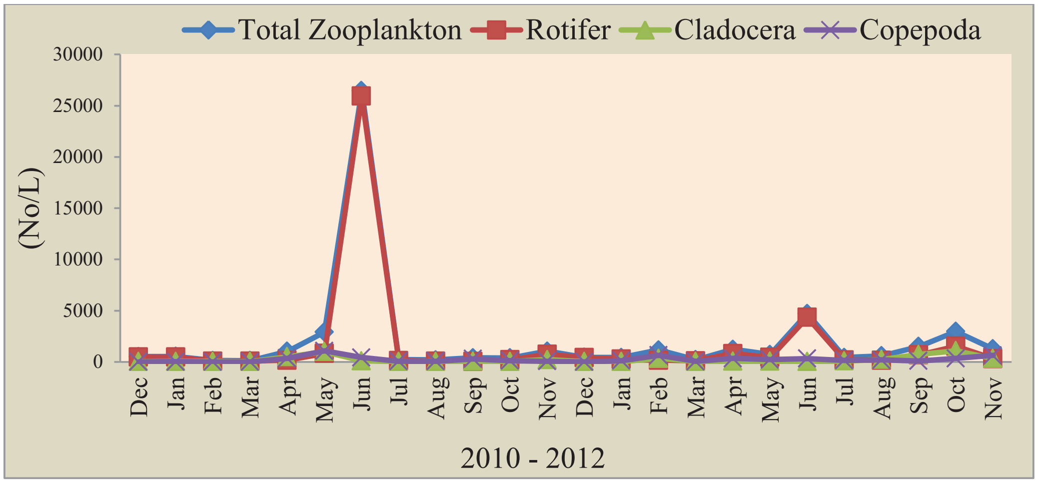


Fig. 4.4.4 Overall zooplankton density and dynamics

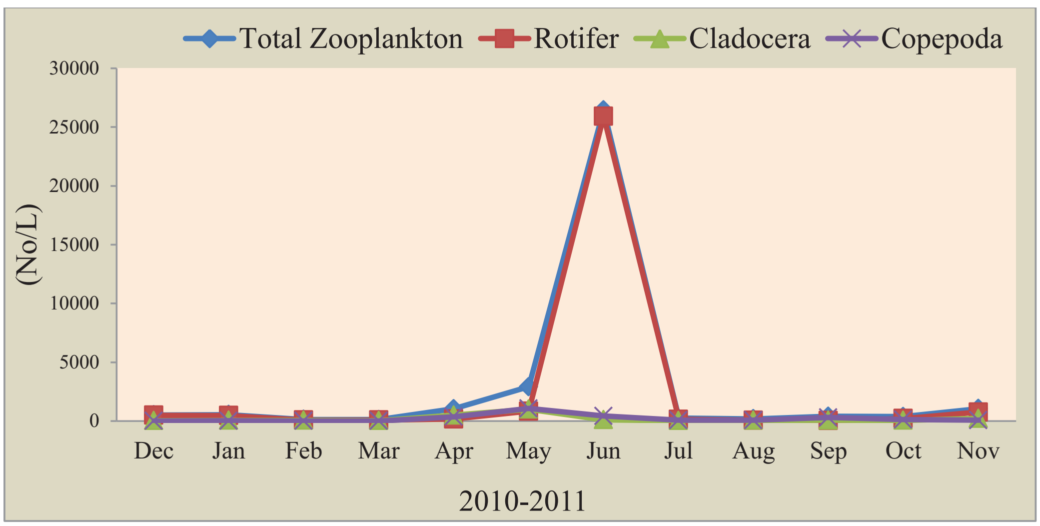


Fig. 4.4.5 Zooplankton density 2010-11

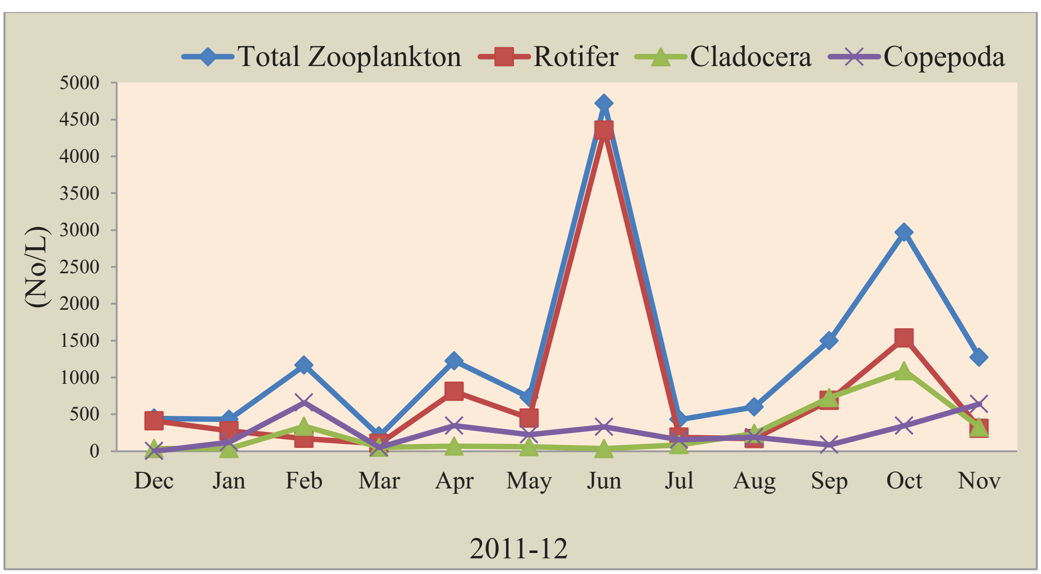


Fig. 4.4.6 Zooplankton density 2011-12

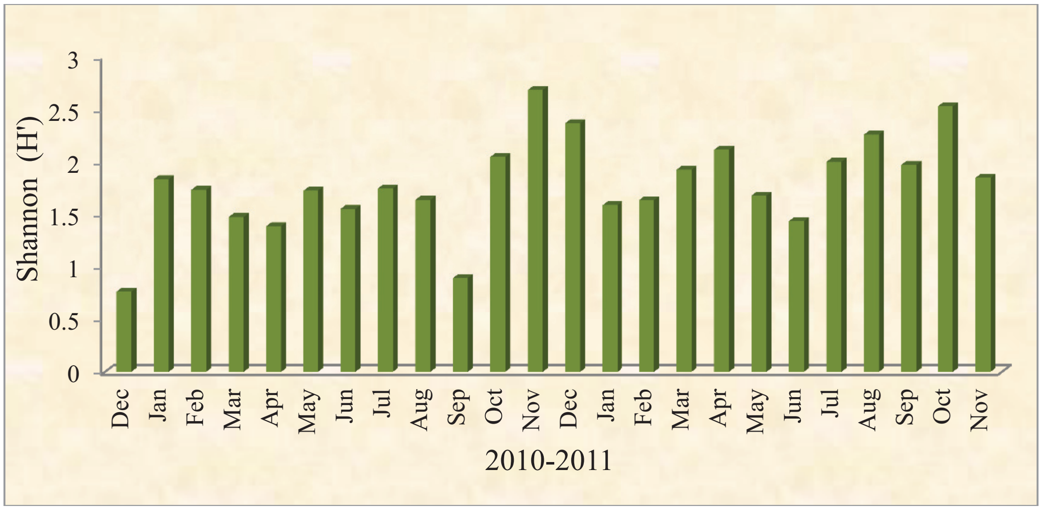


Fig. 4.4.7 Zooplankton diversity

Fig. 4.4.8 Zooplankton evenness

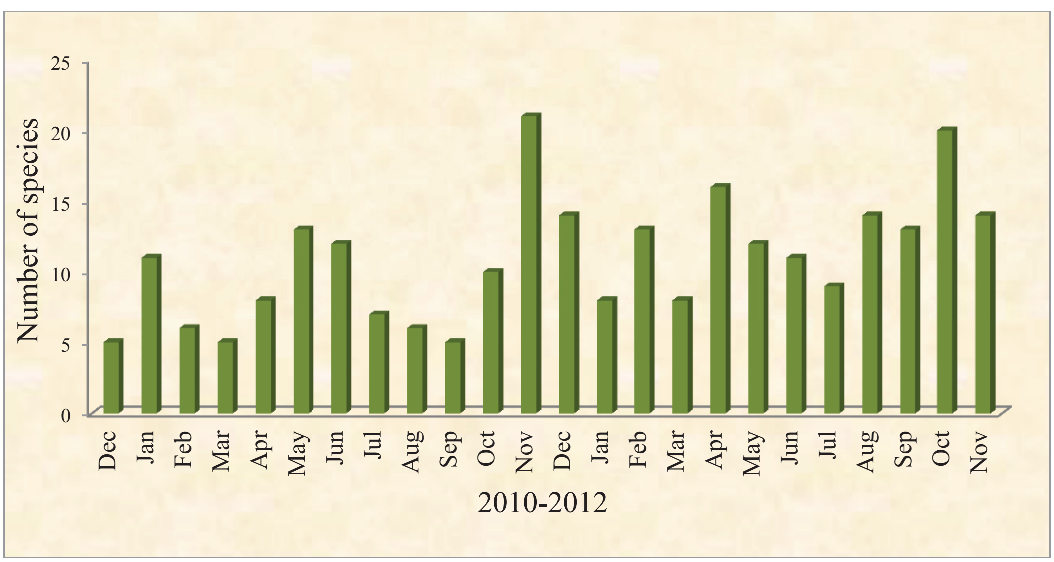


Fig. 4.4.9 Zooplankton species richness

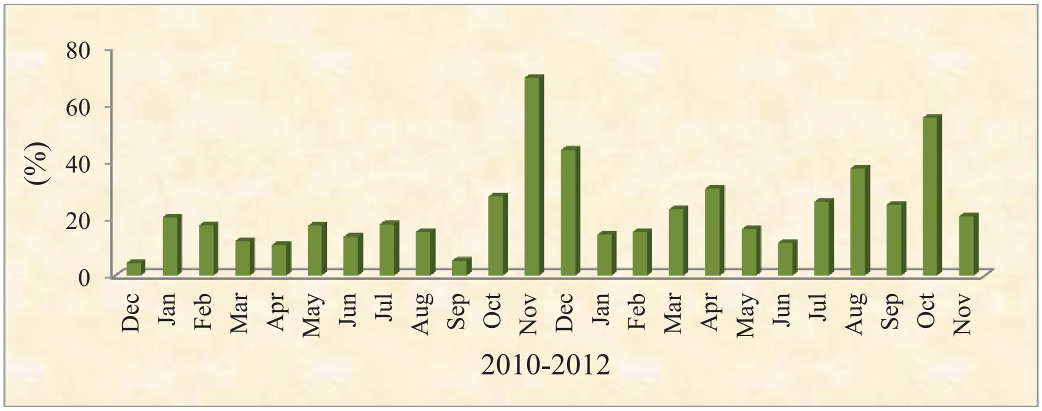


Fig. 4.4.10 Zooplankton abundance

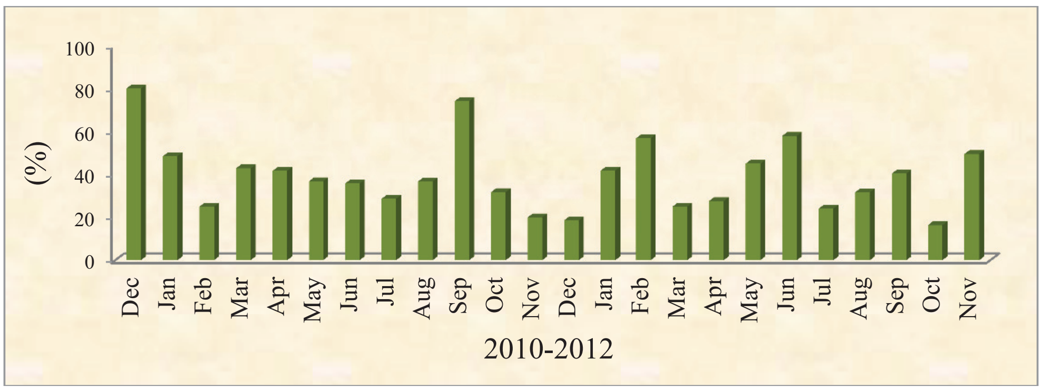


Fig. 4.4.11 Zooplankton dominance

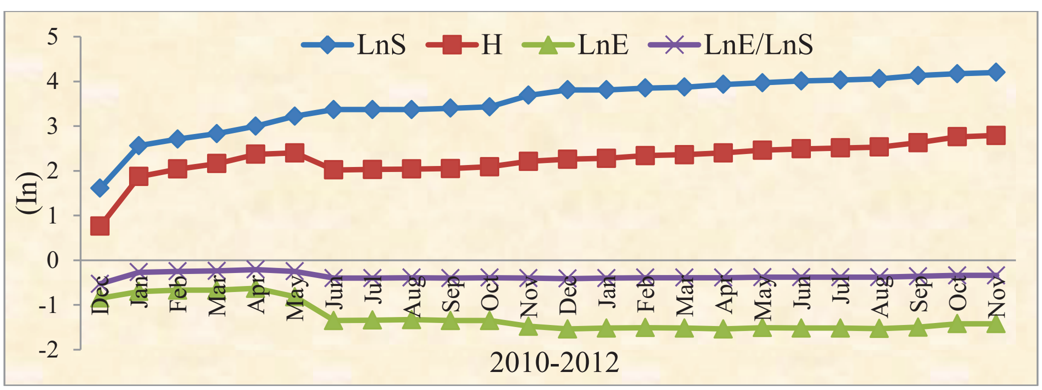


Fig. 4.4.12 SHE analysis of zooplankton

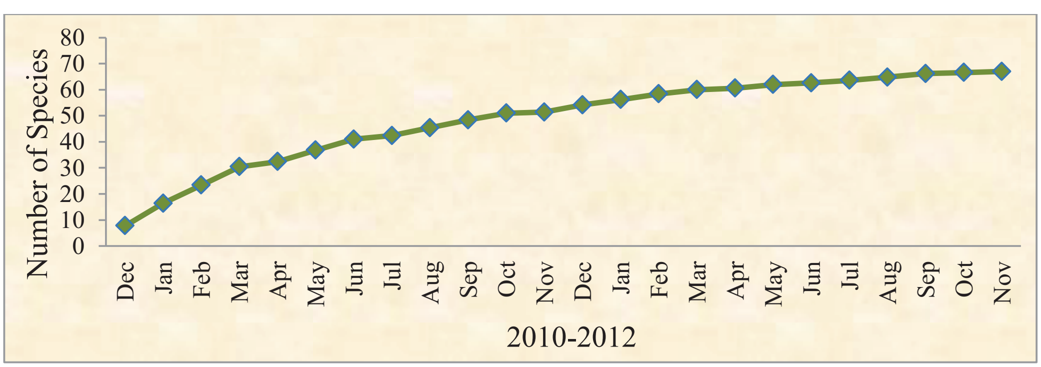


Fig. 4.4.13 Pooled number of zooplankton species

Table 4.4.4 SHE information analysis of zooplankton

2010-12	N	S	LnS	H	LnE	LnE/LnS
Dec	519	5	1.61	0.76	-0.85	-0.53
Jan	1054.6	13	2.56	1.87	-0.7	-0.27
Feb	1190.6	15	2.71	2.04	-0.67	-0.25
Mar	1309.6	17	2.83	2.16	-0.67	-0.24
Apr	2346.4	20	3	2.37	-0.63	-0.21
May	5254.9	25	3.22	2.4	-0.82	-0.25
Jun	31717.9	29	3.37	2.02	-1.35	-0.4
Jul	31959.6	29	3.37	2.03	-1.34	-0.4
Aug	32147.8	29	3.37	2.04	-1.33	-0.39
Sep	32544.9	30	3.4	2.05	-1.35	-0.4
Oct	32925.7	31	3.43	2.09	-1.35	-0.39
Nov	33962.8	40	3.69	2.21	-1.48	-0.4
Dec	34424.8	45	3.81	2.26	-1.54	-0.41
Jan	34838.8	45	3.81	2.28	-1.52	-0.4
Feb	35993.8	47	3.85	2.34	-1.51	-0.39
Mar	36269.8	48	3.87	2.36	-1.52	-0.39
Apr	37457.8	51	3.93	2.4	-1.54	-0.39
May	38723.8	53	3.97	2.46	-1.51	-0.38
Jun	42869.8	55	4.01	2.49	-1.52	-0.38
Jul	43297.8	56	4.03	2.51	-1.52	-0.38
Aug	43896.8	58	4.06	2.53	-1.53	-0.38
Sep	45394.8	62	4.13	2.63	-1.5	-0.36
Oct	48362.8	65	4.17	2.76	-1.42	-0.34
Nov	49617.8	67	4.2	2.79	-1.42	-0.34

4.4.3 Rotifer density and diversity

The density of the rotifers ranged from 34.3-25930No/L (Table 4.4.5 and Fig. 4.4.14). It was maximum during in the month of June 2011 and 2012, minimum in the month of August and September 2011. Wide variations of rotifer population density were observed between summer, monsoon and winter seasons of the entire period of study. High density of rotifer is due to *Brachionus angularis*, *B. calyciflorus*, *B. caudatus*, *B. plicatilis, B. quadridentatus, B. rubens, Keratella tropica*, *Filinia terminalis* and *Epiphanies mucronata*.

Rotifer diversity (H') was 0.64-2.327 (Table 4.4.5). Maximum diversity of rotifers was observed during the winter season in the month of November 2011 (H= 2.3) and December 2011 (H= 2.1) Fig. 4.4.15. Shannon maximum diversity index showed that Hmax= 1.09-2.485. Evenness was J = 0.465-1, more in 2011-12 during summer and monsoon. The maximum evenness was in the month of February, March 2011 and 2012 (J=0.865, 0.892) and August, September, October 2011 (J= 0.946, 1, and 0.95). When the diversity was high, the maximum evenness was between 0.809-0.891. But during September 2011 the diversity was less (H'= 0.693), the evenness was more (J= 1), which may be due to the low species richness (Fig. 4.4.17). The species richness was 2- 15, maximum in the month of November 2011- December 2012 and the study shows more species richness in the year 2011-12 (Fig. 4.4.16). The abundance varied 3- 41.4% (the high abundance during the month of November 2011and December 2012 were 41% and 31% respectively), due to more species richness and diversity (Fig. 4.4.18). During these periods the *Lecane bulla, L. luna, Rotatoria rotatoria* were noted. Berger-Parker dominance between d= 0.2-0.857 (Fig. 4.4.19), maximum dominance was observed when diversity was less, minimum dominance were noted when the diversity was high. The high dominance were observed during the various months December 2010, March, April 2011, January, May, June and November 2012 was due to the numerical abundance of the *Rotatoria rotatoria*, *R. neptunia, Keratella tropica, Brachionus calyciflorus* and *B. plicatilis*. Dominance during July 2012 (80%) and September (83%) was due to the *Simocephalus exspinosus* and *Karualona karua*.

The SHE analysis of 2010-11 recorded a species richness at 3-29, LnS =1.1 to 3.37, diversity H = 0.5 to 2.37, evenness LnE = -0.46 to - 1.49 and LnE/LnS = -0.54 to -0.16 (Table 4.4.6 and Fig. 4.4.20). It reveals that the species richness increased throughout the period but the diversity attain maximum while species richness was 17, LnS= 2.37. It may be due to the more evenness LnE= -0.46 and the ratio of LnE/lnS = -0.16, though the species richness increased the diversity attained maximum when evenness and LnE/LnS were high; further when the evenness decreased the diversity also decreased. Similarly, LnE/LnS value also decreased with evenness. In 2011-12, it was noted that the species richness increased 11-36; diversity attained maximum when the species richness was high at 36. The evenness was about LnE= -0.92 and the ratio of LnE/LnS = -0.26 (Fig. 4.4.21). But evenness was high, when the H=2.14 and LnS= 2.4. It reveals that the diversity increased with species richness rather than the evenness in 2011-12. Pooled number of species was maximum 36 species in 2011-12, and 29 species in 2010-11 (Table 4.4.7 and Fig. 4.4.22).

The rotifer similarity index of 2010-11(Table 4.4.8) showed less similarity between the month of June, November, and December. More similarity was observed in the month of January, February, and October 2011 (Fig. 4.4.23). In 2011-12, it was reported that the similarity was between 30-60% (Table 4.4.9). The more similarity of the species could be derived by three clusters October and September 2011; April, May and July 2011 and February and March 2011 (Fig. 4.4.24). Comparatively overall rotifer similarity was less

Table 4.4.5 Density and diversity of rotifer 2010-12

Rotifer	Duration	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Density (No/L)	2010-11	485	467.3	85	85	172.6	833.3	25930	137.9	68	34.3	208.2	760.6
	2011-12	411	276	171	103	810	447	4354	188	170	687	1534	308
Shannon H' Log Base 2.718	2010-11	0.509	1.513	1.332	0.95	0.64	1.861	1.471	1.212	1.04	0.693	1.704	2.327
	2011-12	2.135	1.241	1.493	1.237	1.844	1.37	1.442	1.411	2.025	1.853	1.995	1.45
Shannon Hmax Log Base 2.718	2010-11	1.099	2.079	1.386	1.099	1.099	2.197	2.197	1.386	1.099	0.693	1.792	2.708
	2011-12	2.398	1.792	1.792	1.386	2.303	1.946	2.197	1.609	2.079	2.197	2.485	1.792
Shannon J'	2010-11	0.463	0.728	0.961	0.865	0.583	0.847	0.669	0.874	0.946	1	0.951	0.859
	2011-12	0.891	0.693	0.833	0.892	0.801	0.704	0.656	0.877	0.974	0.843	0.803	0.809
Simpsons Diversity (D)	2010-11	0.745	0.341	0.271	0.433	0.657	0.183	0.278	0.339	0.366	0.485	0.191	0.135
	2011-12	0.141	0.422	0.298	0.33	0.221	0.374	0.347	0.287	0.135	0.195	0.181	0.309
Berger-Parker Dominance (d)	2010-11	0.857	0.556	0.4	0.6	0.8	0.29	0.365	0.5	0.5	0.504	0.25	0.272
	2011-12	0.209	0.627	0.503	0.505	0.405	0.579	0.552	0.457	0.2	0.326	0.304	0.503
Berger-Parker Dominance (d%)	2010-11	85.73	55.63	40	60	79.95	29.04	36.48	50.03	50	50.43	24.97	27.21
	2011-12	20.92	62.68	50.29	50.48	40.49	57.94	55.21	45.74	20	32.60	30.443	50.32
Hill's Number (H_0)	2010-11	3	8	4	3	3	9	9	4	3	2	6	15
	2011-12	11	6	6	4	10	7	9	5	8	9	12	6
Hill's Number (H_1)	2010-11	3.005	12.80	9.86	5.683	3.632	21.15	12.04	8.288	6.466	3.921	16.86	41.41
	2011-12	31.415	8.649	12.44	8.595	20.63	10.40	11.54	11.04	26.80	20.90	25.63	11.68

Table 4.4.6 SHE information analysis of rotifer

2010-11						2011-12					
N	**S**	**LnS**	**H**	**LnE**	**LnE/LnS**	**N**	**S**	**LnS**	**H**	**LnE**	**LnE/LnS**
485	3	1.1	0.51	-0.59	-0.54	411	11	2.4	2.14	-0.26	-0.11
952.3	9	2.2	1.58	-0.61	-0.28	687	13	2.56	2.24	-0.32	-0.13
1037.3	10	2.3	1.71	-0.59	-0.26	858	17	2.83	2.39	-0.44	-0.16
1122.3	11	2.4	1.8	-0.6	-0.25	961	18	2.89	2.4	-0.49	-0.17
1294.9	13	2.56	1.93	-0.64	-0.25	1771	21	3.04	2.53	-0.51	-0.17
2128.2	17	2.83	2.37	-0.46	-0.16	2218	23	3.14	2.53	-0.6	-0.19
28058	21	3.04	1.71	-1.33	-0.44	6572	26	3.26	2.15	-1.11	-0.34
28196	21	3.04	1.72	-1.32	-0.43	6760	26	3.26	2.16	-1.09	-0.34
28264	21	3.04	1.73	-1.32	-0.43	6930	30	3.4	2.24	-1.16	-0.34
28298	22	3.09	1.73	-1.36	-0.44	7617	34	3.53	2.45	-1.08	-0.31
28507	22	3.09	1.76	-1.33	-0.43	9151	35	3.56	2.64	-0.92	-0.26
29267	29	3.37	1.88	-1.49	-0.44	9459	36	3.58	2.66	-0.92	-0.26

Table 4.4.7 Pooled number of rotifer species

	2010-11	**2011-12**
December	7.4	9.2
January	9.8	13.2
February	12.2	17.4
March	14.8	20.4
April	17.8	22.6
May	19.8	25.8
June	24.6	28.6
July	26.8	29.8
August	27	31.8
September	28.6	33.2
October	28.8	35
November	29	36

Fig. 4.4.14 Density of rotifer

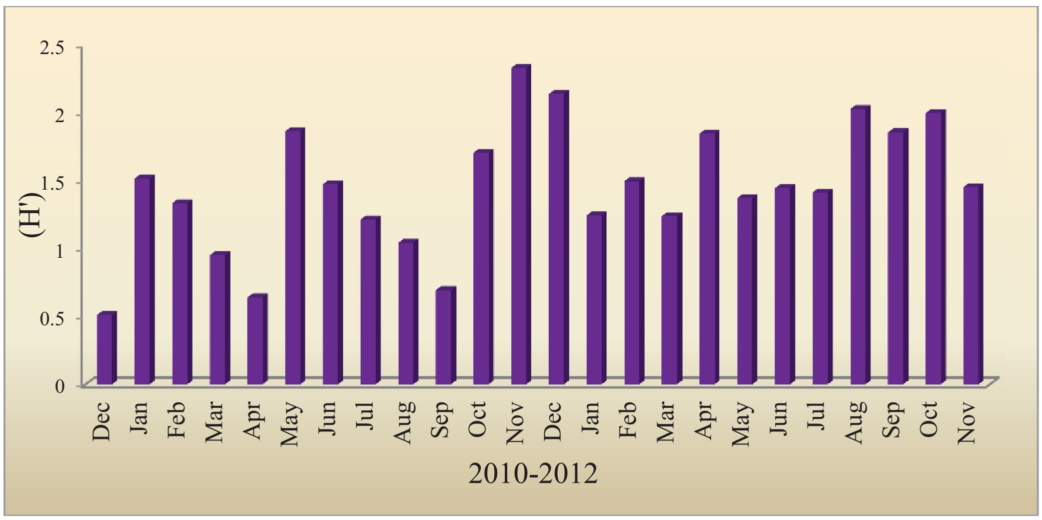


Fig. 4.4.15 Diversity of rotifer

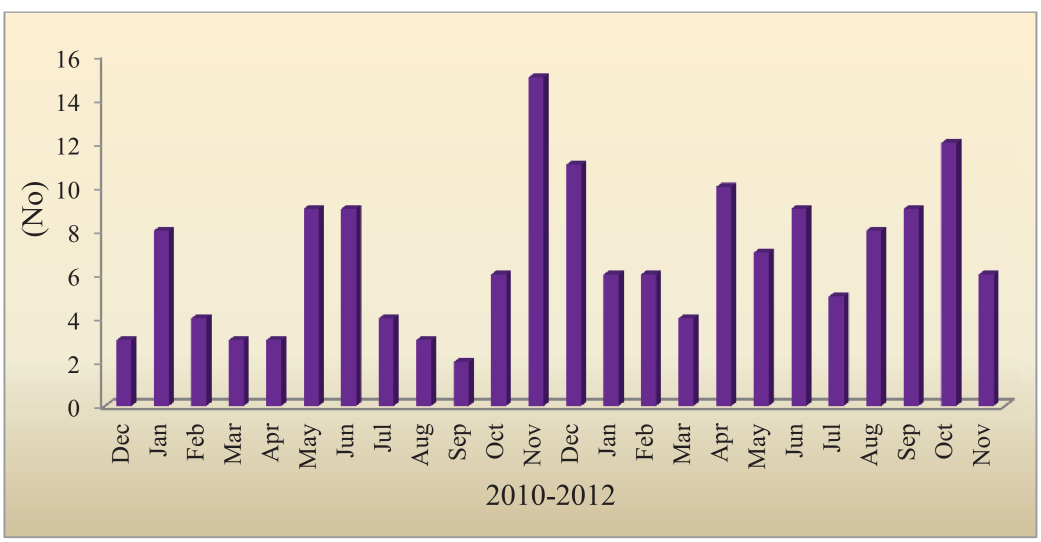


Fig. 4.4.16 Species richness of rotifer

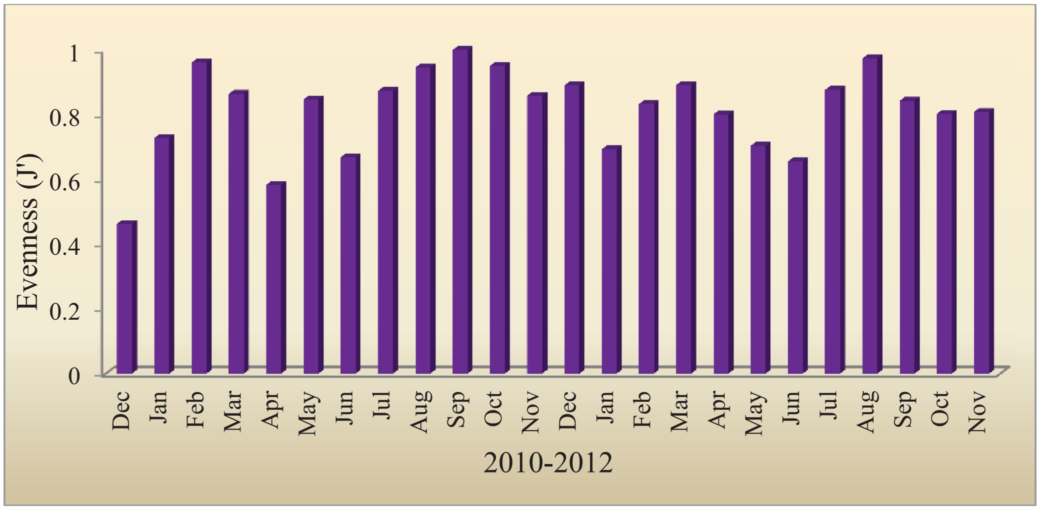
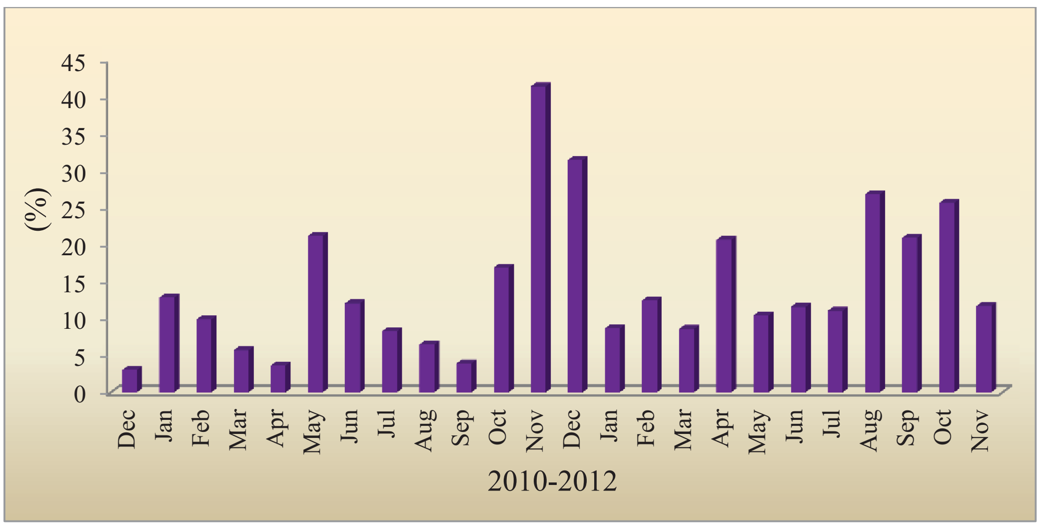


Fig. 4.4.17 Evenness of rotifer



Fig, 4.4.18 Abundance of rotifer

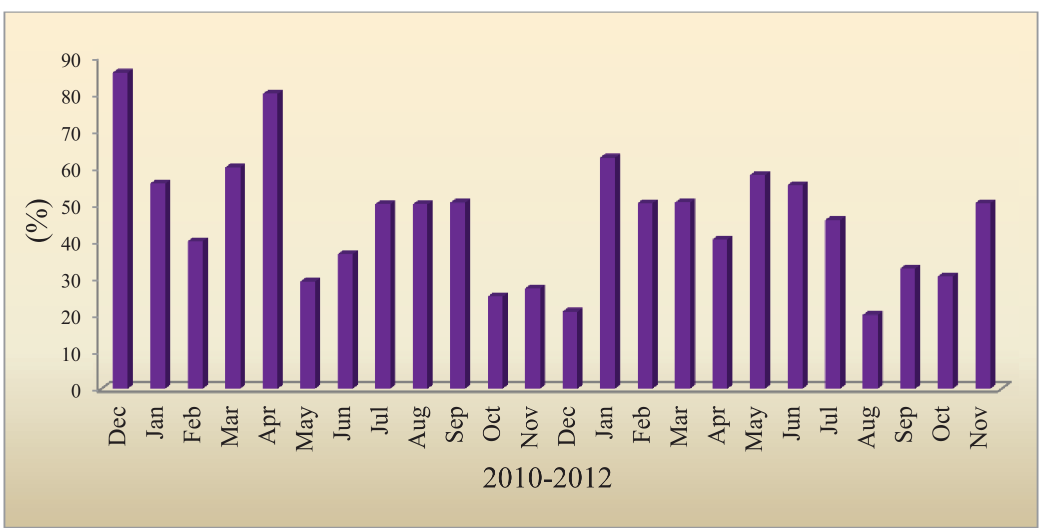


Fig. 4.4.19 Dominance of rotifer

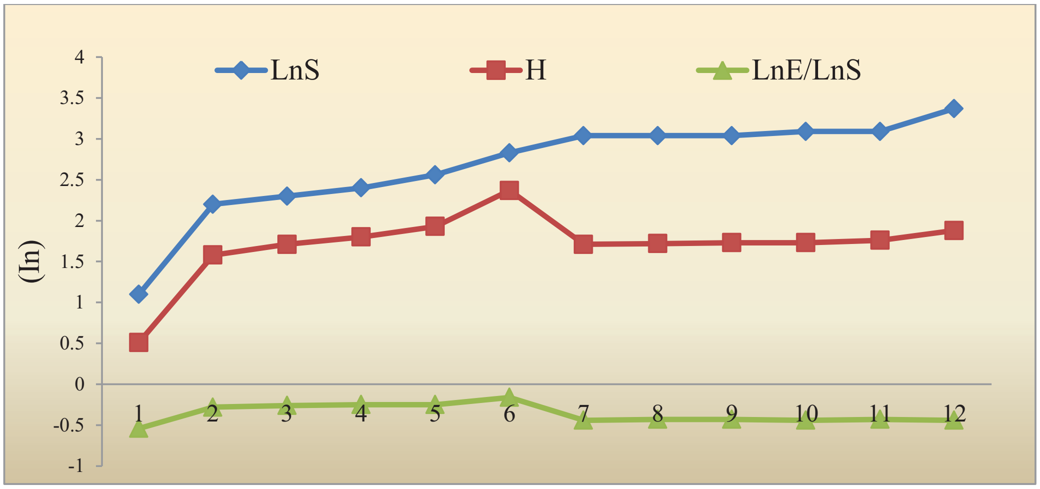


Fig. 4.4.20 SHE information analysis of rotifer 2010-11

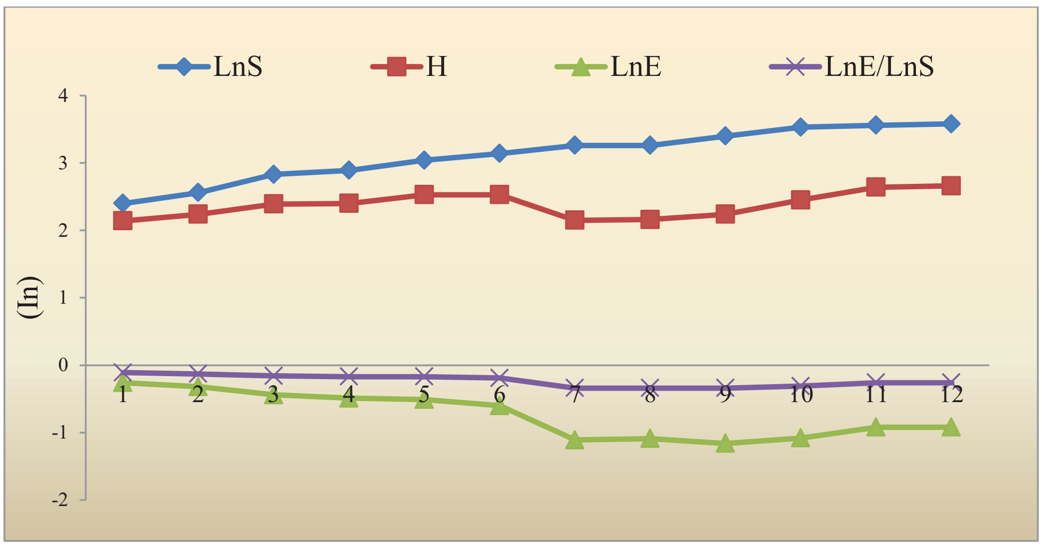


Fig. 4.4.21 SHE information analysis of rotifer 2011-12

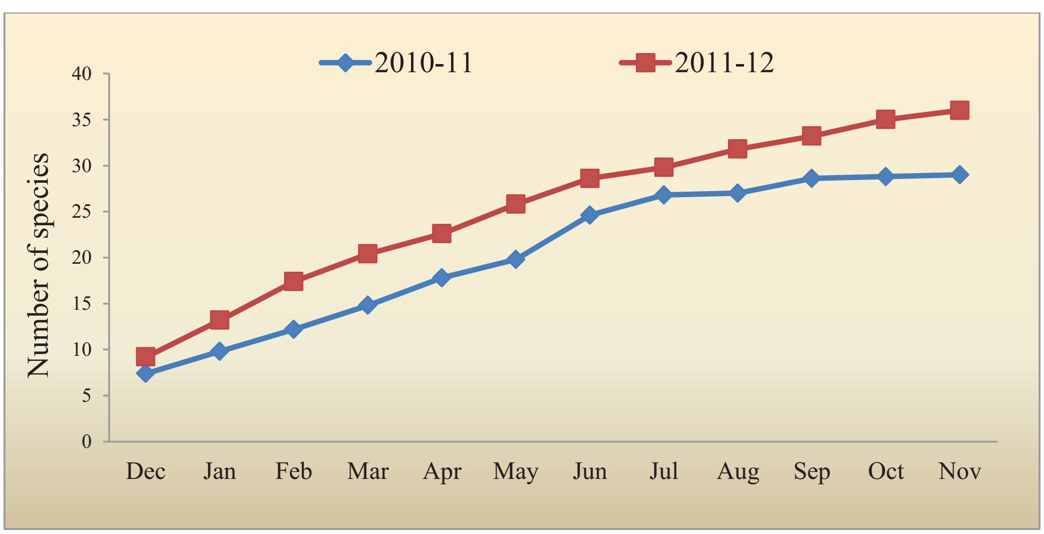


Fig. 4.4.22 Pooled number of rotifer species richness

Table 4.4.8 Rotifer similarity matrix 2010-11

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
December	*	7.266	11.93	5.965	0	0	0	16.56	0	0	0	5.555
January	*	*	18.46	6.156	0	2.614	0	5.618	0	0	35.97	16.85
February	*	*	*	60	26.39	7.405	0.261	45.76	22.22	28.5	11.59	8.041
March	*	*	*	*	39.59	14.81	0.522	46.29	44.44	28.5	0	0
April	*	*	*	*	*	34.31	1.057	22.28	14.13	16.43	0	3.643
May	*	*	*	*	*	*	4.939	10.68	15.08	3.918	6.644	6.399
June	*	*	*	*	*	*	*	0.398	0.523	0.131	0.264	0.127
July	*	*	*	*	*	*	*	*	33.02	19.74	0	3.784
August	*	*	*	*	*	*	*	*	*	33.23	0	0
September	*	*	*	*	*	*	*	*	*	*	14.26	4.352
October	*	*	*	*	*	*	*	*	*	*	*	14.36
November	*	*	*	*	*	*	*	*	*	*	*	*

Table 4.4.9 Rotifer similarity matrix 2011-12

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
December	*	25.03	35.39	33.46	19.65	16.08	1.427	22.70	29.25	21.85	28.27	18.91
January	*	*	23.26	18.46	12.70	14.38	2.203	14.65	22.87	7.269	5.745	17.80
February	*	*	*	37.95	27.93	27.83	2.254	18.94	29.91	20.04	14.07	35.49
March	*	*	*	*	15.11	25.09	2.288	35.05	24.90	17.46	8.430	24.81
April	*	*	*	*	*	38.18	21.34	27.45	10.40	11.48	13.13	24.32
May	*	*	*	*	*	*	13.58	37.79	11.02	12.16	8.682	13.50
June	*	*	*	*	*	*	*	6.781	1.503	1.348	1.154	8.108
July	*	*	*	*	*	*	*	*	28.49	7.771	7.897	20.56
August	*	*	*	*	*	*	*	*	*	19.83	13.96	21.33
September	*	*	*	*	*	*	*	*	*	*	49.52	10.25
October	*	*	*	*	*	*	*	*	*	*	*	11.07
November	*	*	*	*	*	*	*	*	*	*	*	*

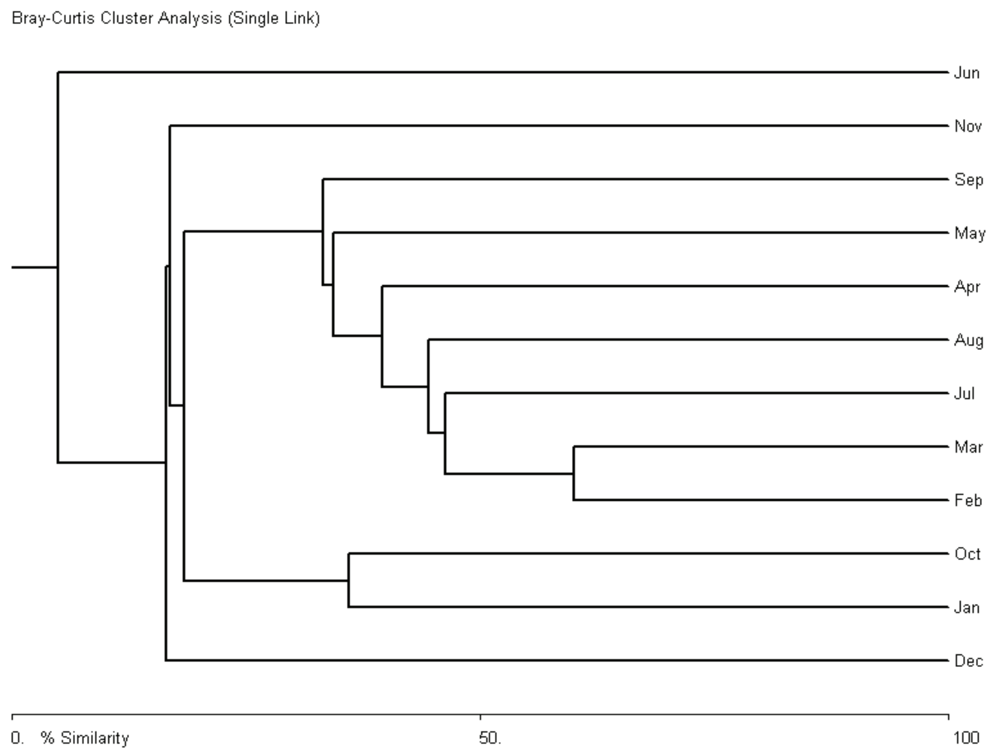


Fig. 4.4.23 Similarity matrix of rotifer 2010-11

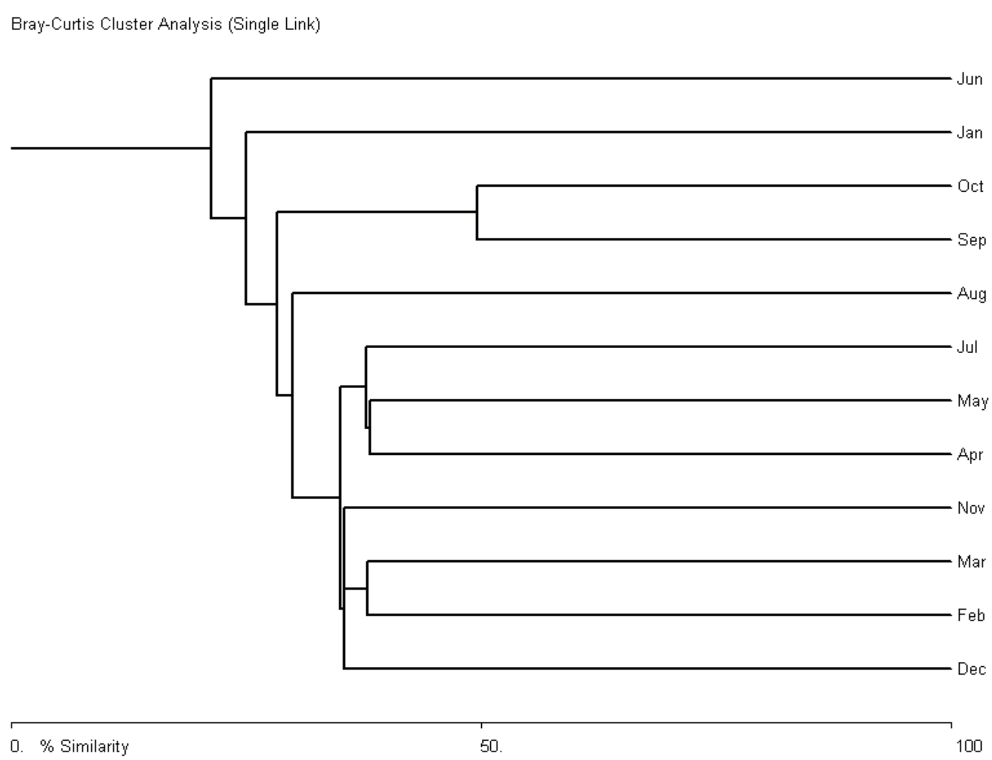


Fig. 4.4.24 Similarity matrix of rotifer 2011-12

during 2010-11. In 2011-12 showed the seasonal similarly which gave three clusters between February and March (winter), another cluster April, May and July (summer) and the third cluster September and October (monsoon).

4.4.4 Cladoceran density and diversity

Cladoceran density was 34-1088No/L (Table 4.4.10). High diversity of cladocera were recorded in the month of April 2011 (501 No/L), May 2011 (1003 No/L), October 2011 (51.6No/L) and November 2011 (224.8No/L), August 2012 (239No/L), September 2012 (725No/L), October 2012 (1088No/L) and November 2012 (325 No/L), respectively (Fig. 4.4.25). This high population was due to the numerical abundance of the occurrence of the following species *Daphnia lumholtzi, Diaphanosoma sarsi, Ceriodaphnia cornuta, Macrothrix spinosa, Moina micrura, Ceriodaphnia cornuta, Karualona karua, Simocephalus exspinosus.* In 2010-11, summer season holds more density, whereas in 2011-12, monsoon holds more density of Cladocera. This high population was due to the abundance of *Diaphanosoma sarsi*, *Moina micrura*, *Macrothrix spinosa* and *Karualona karua*.

Cladoceran diversity was H'=0.29-1.737 during entire study period (2010-11 H'=0.29-1.411) and (2011-12 - H'=0.497-1.737) Table 4.9 and Fig. 4.4.26. A high diversity was observed in the year 2011-12. Monsoon season had high diversity in both the years of study. Shannon maximum diversity showed that the Hmax values ranged between 0.693-1.946. The evenness was J=0.264-1. A more evenness was observed in the winter seasons between the months of December (E=1), January (E=0.918-1), February (E=0.89-0.92), March (0.91-1) of both the years of study (Fig. 4.4.27). In general high evenness was noted in 2011-12 and also in the monsoon seasons of 2010-11(July to October (J=0.81-1).

Berger-Parker dominance index value was d= 26.3-93.10%. More dominant value was observed in the month of May 2011(93.10%), less dominance in February 2012 (26.3%) fig. 4.30. In the year 2010-11 from April- June 2011 more dominance (83-93%) was noticed when compared to other months (Fig. 4.4.28). This may be due to numerical dominance of *Ceriodaphnia cornuta* and *Diaphanosoma sarsi.* A species richness of 2-7 was recorded in both the years (Fig. 4.4.29). In the monsoon season of 2011-12 more species richness were found than other seasons. The species abundance was 2.1-17.6%, particularly in November 2012 (17.69%) Fig. 4.4.30.

SHE analysis of 2010-11, recorded a species richness of 2-11, LnS= 0.69-2.4, H=0.69-1.48, LnE= 0 to -0.92, and LnE/LnS = 0 to -0.43 (Table 4.4.11 and Fig. 4.4.31). The diversity was attained maximum when the species richness was high and evenness was less. In 2011-12, species richness was 2-15, LnS= 0.69-2.71, H= 0.69-2.17, LnE = 0 to -0.55 and LnE/LnS= 0 to 0.22 (Fig. 4.4.32). The diversity attained maximum when the evenness was high LnE = -0.21 and the species richness was 11. It revealed that the cladoceran diversity in the year 2011-12 was dependent upon the species richness and evenness. The pooled number of species attained maximum 11 species in 2010-11 and 15 species in 2011-12 (Table 4.4.12 and Fig. 4.4.33).

Cladoceran similarly index of 2010-11 (Table 4.4.13), exhibited wide variations with cluster analysis very little scatterness was identified. Less similarity was due to less number of species in the month of April and May 2011. A more similarity was due to the same species (Fig. 4.4.34). Only 40% similarity was exhibited by the species during 2011-12. The clusters formed depend on seasonal factors (Table 4.4.14 and Fig. 4.4.35).

Table 4.4.10 Density and diversity of cladocera 2010-12

Index		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Density (No/L)	2010-11	34	51	51	34	501.2	1003.2	103	34.6	51	68.3	51.6	224.8
	2011-12	34	34	327	52	68	59	34	86	239	725	1088	325
Shannon H' Log Base 2.718	2010-11	0.693	0.637	0.637	0.693	0.545	0.29	0.448	0.693	0.637	0.566	1.099	1.411
	2011-12	0.693	0.693	1.6	0.632	1.386	0.868	0.693	0.497	1.492	0.516	1.464	1.737
Shannon Hmax Log Base 2.718	2010-11	0.693	0.693	0.693	0.693	1.386	1.099	0.693	0.693	0.693	0.693	1.099	1.792
	2011-12	0.693	0.693	1.792	0.693	1.386	1.099	0.693	0.693	1.609	1.099	1.946	1.946
Shannon (J')	2010-11	1	0.918	0.918	1	0.393	0.264	0.646	1	0.918	0.816	1	0.787
	2011-12	1	1	0.893	0.912	1	0.79	1	0.717	0.927	0.47	0.752	0.893
Simpsons Diversity (D)	2010-11	0.485	0.547	0.547	0.485	0.75	0.87	0.722	0.485	0.547	0.616	0.32	0.334
	2011-12	0.485	0.485	0.222	0.551	0.239	0.454	0.485	0.679	0.243	0.717	0.293	0.201
Berger-Parker Dominance (d)	2010-11	0.5	0.667	0.667	0.5	0.862	0.931	0.835	0.5	0.667	0.747	0.335	0.538
	2011-12	0.5	0.5	0.263	0.673	0.25	0.576	0.5	0.802	0.36	0.834	0.445	0.317
Berger-Parker Dominance (d%)	2010-11	50	66.66	66.66	50	86.19	93.10	83.49	50	66.66	74.67	33.52	53.82
	2011-12	50	50	26.3	67.30	25	57.62	50	80.23	35.98	83.44	44.48	31.69
Hill's Number (H_0)	2010-11	2	2	2	2	4	3	2	2	2	2	3	6
	2011-12	2	2	6	2	4	3	2	2	5	3	7	7
Hill's Number (H_1)	2010-11	3.922	3.614	3.614	3.922	3.167	2.191	2.753	3.922	3.614	3.264	7.039	11.04
	2011-12	3.922	3.922	14.51	3.59	10.66	5.045	3.922	2.956	12.42	3.038	11.91	17.69

Table 4.4.11 SHE information analysis of cladocera

2010-11						2011-12					
N	**S**	**LnS**	**H**	**LnE**	**LnE/LnS**	**N**	**S**	**LnS**	**H**	**LnE**	**LnE/LnS**
34	2	0.69	0.69	0	0	34	2	0.69	0.69	0	0
85	3	1.1	0.95	-0.15	-0.14	68	2	0.69	0.69	0	0
136	4	1.39	1.07	-0.31	-0.23	395	7	1.95	1.72	-0.22	-0.11
170	5	1.61	1.23	-0.38	-0.24	447	8	2.08	1.77	-0.31	-0.15
671	6	1.79	1.13	-0.67	-0.37	515	9	2.2	1.87	-0.33	-0.15
1674	7	1.95	1.11	-0.83	-0.43	574	10	2.3	1.96	-0.35	-0.15
1777	7	1.95	1.16	-0.79	-0.41	608	10	2.3	1.97	-0.33	-0.15
1812	7	1.95	1.16	-0.79	-0.4	694	10	2.3	2.01	-0.29	-0.13
1863	7	1.95	1.17	-0.78	-0.4	933	11	2.4	2.18	-0.21	-0.09
1931	7	1.95	1.18	-0.77	-0.4	1658	11	2.4	1.9	-0.49	-0.21
1982	8	2.08	1.24	-0.84	-0.4	2746	13	2.56	2.01	-0.55	-0.22
2207	11	2.4	1.48	-0.92	-0.38	3071	15	2.71	2.17	-0.53	-0.2

Table 4.4.12 Pooled number of cladoceran species

	2010-11	**2011-12**
December	2.2	4
January	3.6	6.2
February	4.2	8
March	5	10.6
April	6.4	11
May	7.6	11.8
June	8	12.6
July	8	13.4
August	8.2	14
September	9	14.4
October	9.8	14.6
November	11	15

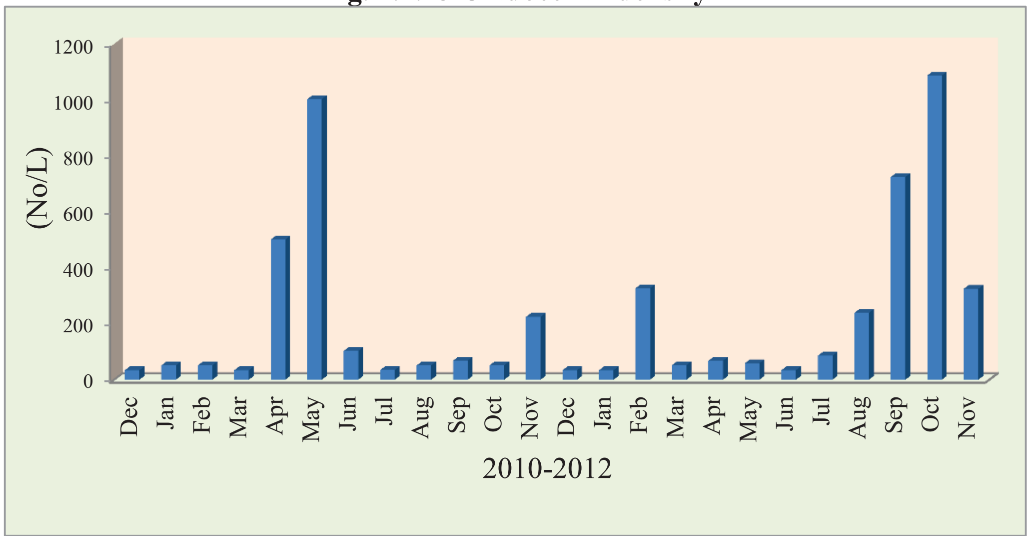
Table 4.4.13 Cladocera similarity matrix 2010-11

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
December	*	40	40	50	6.35	3.27	24.81	49.56	40	33.23	0	26.27
January	*	*	66.66	40	6.26	6.45	44.15	40.42	66.66	56.99	33.13	24.65
February	*	*	*	40	12.42	6.45	44.15	40.42	66.66	56.99	0	24.65
March	*	*	*	*	12.70	6.55	49.63	99.12	80	66.47	39.71	26.27
April	*	*	*	*	*	6.89	11.35	12.91	12.42	12.15	6.15	9.53
May	*	*	*	*	*	*	12.45	6.66	9.67	12.74	3.22	8.45
June	*	*	*	*	*	*	*	49.85	66.23	79.39	21.99	31.48
July	*	*	*	*	*	*	*	*	80.14	67.24	39.44	26.67
August	*	*	*	*	*	*	*	*	*	85.49	33.13	36.98
September	*	*	*	*	*	*	*	*	*	*	28.35	35.41
October	*	*	*	*	*	*	*	*	*	*	*	12.30
November	*	*	*	*	*	*	*	*	*	*	*	*

Table 4.4.14 Cladoceran similarity matrix 2011-12

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
December	*	100	9.41	39.53	33.33	36.55	0	28.33	12.45	4.47	3.03	9.47
January	*	*	9.41	39.53	33.33	36.55	0	28.33	12.45	4.47	3.03	9.47
February	*	*	*	18.46	25.82	12.95	9.41	0	18.02	6.65	7.34	31.59
March	*	*	*	*	28.33	37.83	0	0	0	0	2.98	0
April	*	*	*	*	*	33.07	33.3	0	22.14	0	2.94	0
May	*	*	*	*	*	*	36.5	23.44	2.68	8.67	6.62	0
June	*	*	*	*	*	*	*	28.33	0	4.47	3.03	0
July	*	*	*	*	*	*	*	*	31.38	8.38	14.65	24.81
August	*	*	*	*	*	*	*	*	*	10.58	15.37	42.19
September	*	*	*	*	*	*	*	*	*	*	41.91	6.47
October	*	*	*	*	*	*	*	*	*	*	*	12.03
November	*	*	*	*	*	*	*	*	*	*	*	*

Fig. 4.4.25 Cladoceran density



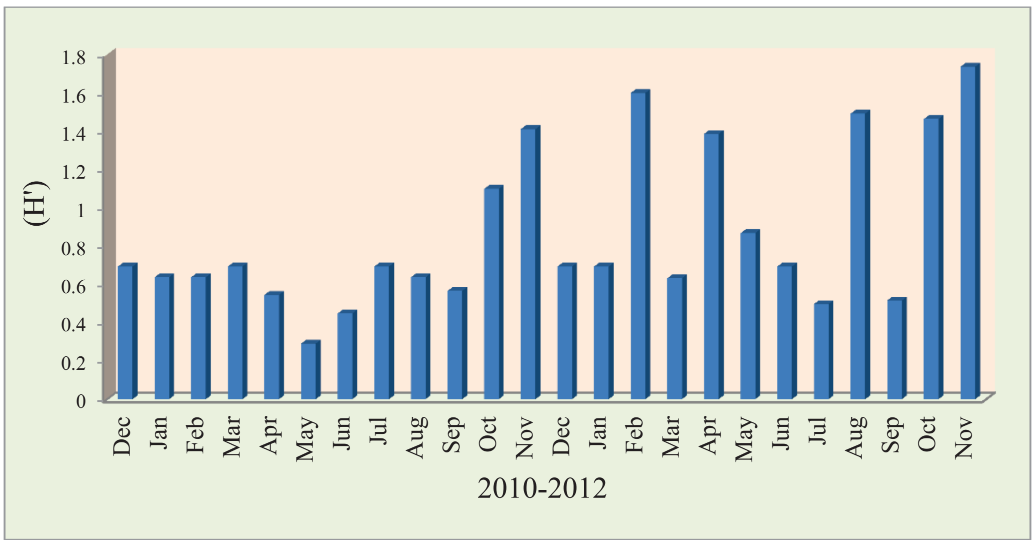


Fig. 4.4.26 Cladoceran diversity

Fig. 4.4.27 Cladoceran evenness

Fig. 4.4.28 Cladoceran dominance

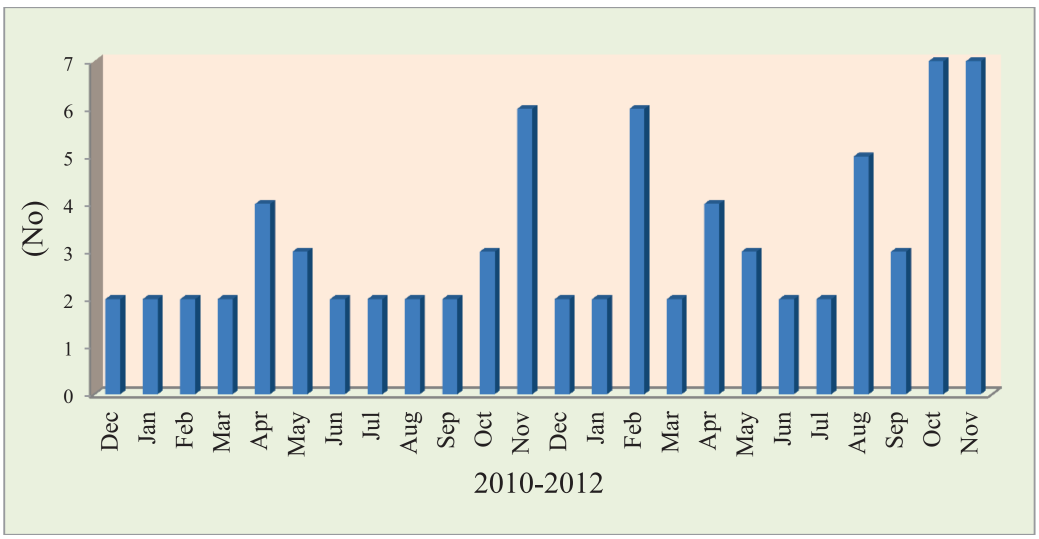


Fig. 4.4.29 Cladoceran species richness

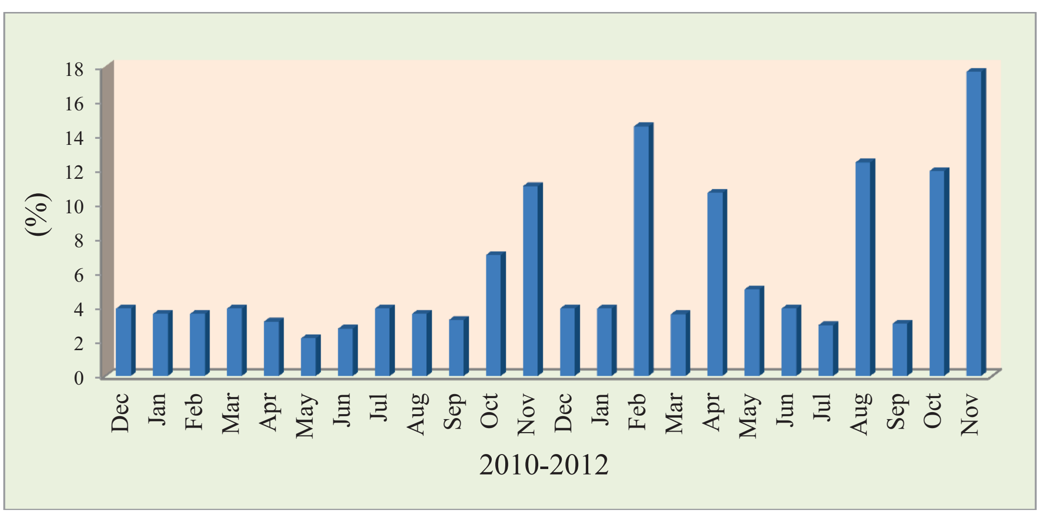


Fig. 4.4.30 Cladoceran abundance

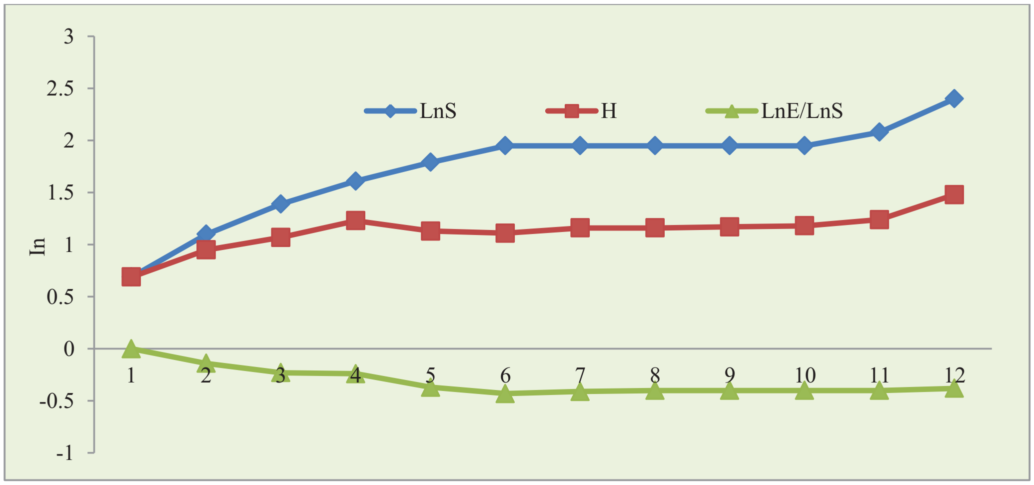


Fig. 4.4.31 SHE information analysis of cladoceran 2010-11

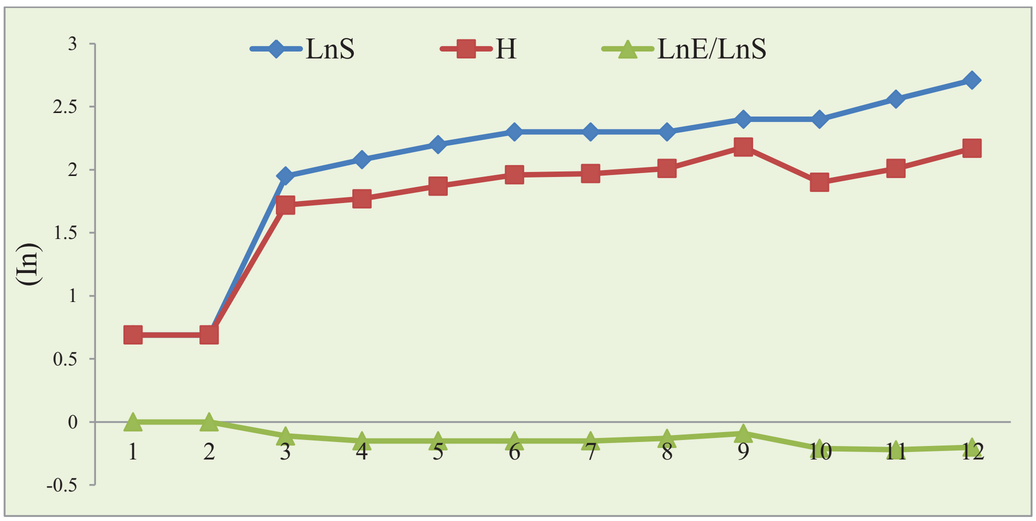


Fig. 4.4.32 SHE information analysis of cladoceran 2011-12

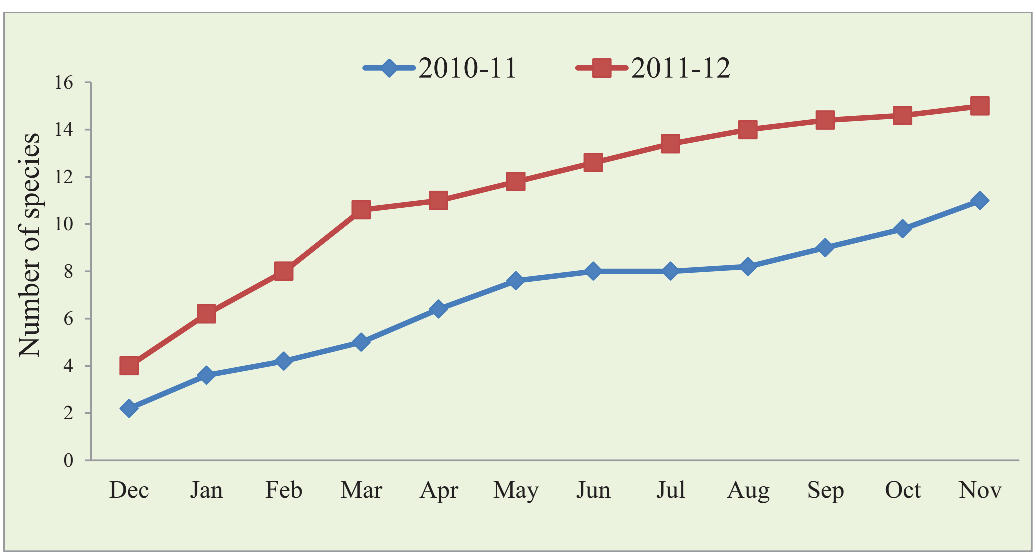


Fig. 4.4.33 Pooled number of cladoceran species

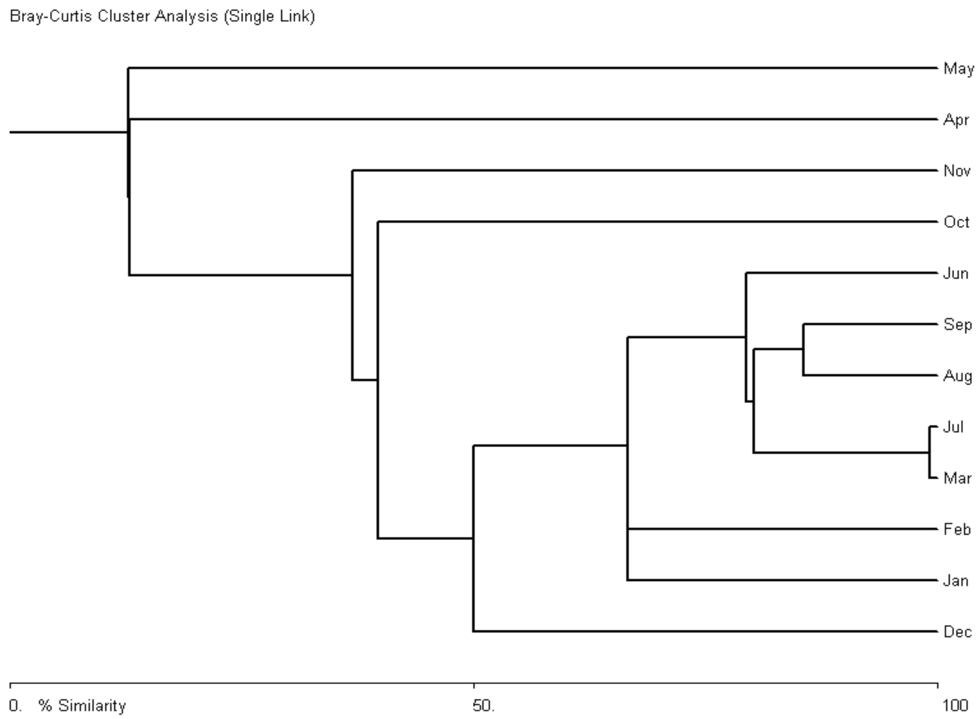


Fig. 4.4.34 Similarity matrix of cladoceran 2010-11

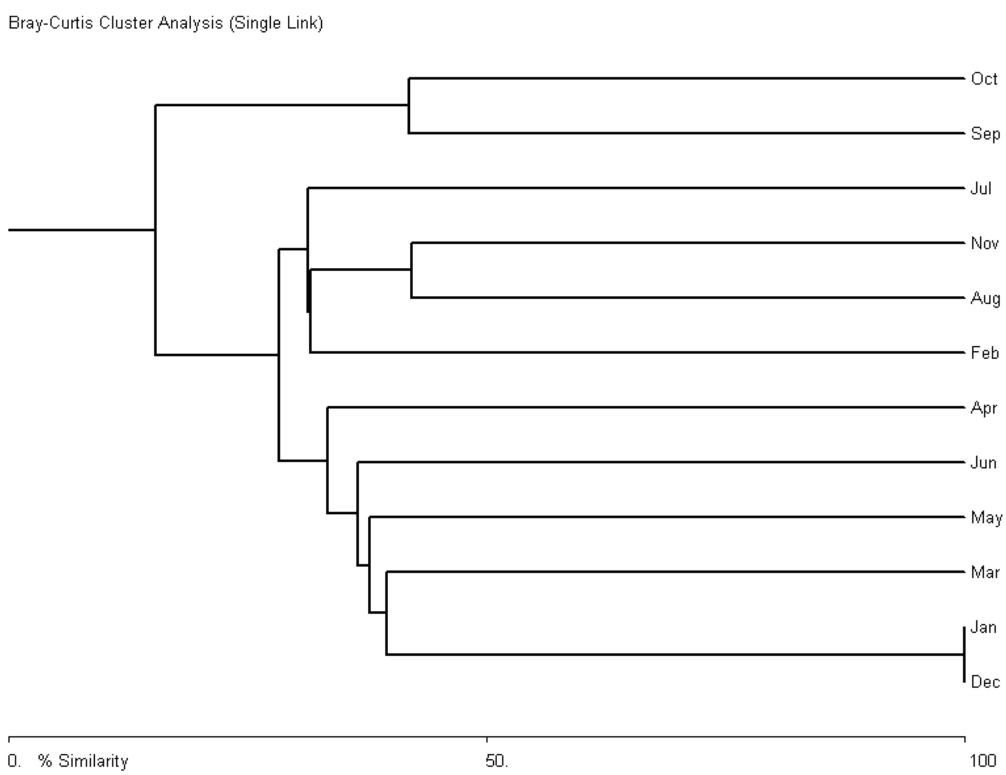


Fig. 4.4.35 Similarity matrix of cladoceran 2011-12

4.4.5 Physicochemical profile of Bandam Kommu cheruvu pond

The physicochemical feature of this pond (Table 4.4.15) expressed an atmospheric temperature range of 25-33°C, maximum during summer and minimum during winter. Surface water temperature ranged from 19-25°C (Fig. 4.4.36), which expressed the tropical climatic conditions. pH of the pond was high during summer between 8.3-8.9 (Fig. 4.4.37), less during monsoon and winter (7.5-7.8). Electrical conductivity was high in summer (1.9mS), and less during winter (Fig. 4.38). Dissolved oxygen content was high in winter and summer which ranged between 6.1-9.7mg/L, but in monsoon it varied between 0.8-4.9mg/L (Fig. 4.4.37), and it was very low in the month of October 2011 and maximum in August, 2012 (12.35mg/L). Total dissolved solids ranged between 690-2000ppm, which was less in the initial months and it raised upto 2000ppm in February to May 2012 (Fig. 4.4.40). Total hardness was 189-355mg/L, maximum in monsoon seasons; alkalinity was 204-331mg/L, high during winter, less in summer (Fig. 4.4.39). Similarly, the ionic contents such as of chloride, calcium and magnesium ranged between 182-445mg/L, 28.4-47.4mg/L and 34.7-77.5mg/L respectively (Fig. 4.4.40 and 4.4.41). Nutrient content of the pond such as total phosphate, nitrate, nitrite and ammonia recorded between 0.1-0.4mg/L, 0.3-1.2mg/L, 1-40mg/L, and 1-3.7mg/L respectively (Fig. 4.4.42; 4.4.43 and 4.4.44). Maximum phosphate content was observed during summer, nitrate and ammonia content were high in monsoon and winter.

Rotifer density was moderately significant correlation with pH (r = 0.6850), evenness (r =0.5688), total hardness (r = 0.541) in 2010-11 and ammonia (r = 0.5688) in 2011-12 (Table 4.4.16). Cladoceran density was moderately correlated with temperature (r = 0.5102) in 2010-11, calcium (r = 0.7430) in 2011-12. Species richness was significant correlation with calcium (0.5044) in 2011-12 (Table 4.4.17).

Table 4.4.15 Physicochemical parameters 2010-2012

Parameters	Duration	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Average
Ambient atmospheric Temperature °C	2010-11	26.0	26.0	28.0	33.0	29.0	30.0	28.0	25.0	28.0	29.0	28.0	25.0	28.8±2.9
	2011-12	24	29	21	32	26	24	22	20	19	19	21	24	26.4±3.9
Sub-surface water Temperature °C	2010-11	19.0	19.0	22.0	25.0	28.0	29.0	26.0	27.0	25.0	27.0	26.0	22.0	25.3±4.8
	2011-12	21	23	18.5	24	22	19	18	18	17	17	19	21	21.3±2.2
pH	2010-11	7.5	7.5	7.6	7.8	7.9	8.3	8.9	8.0	7.7	8.5	7.8	7.4	7.9±0.3
	2011-12	7.8	8	8	7.8	7.9	7.8	7.6	8.5	8.7	7.6	7.8	7.7	7.9±0.1
Electrical conductivity (mS)	2010-11	1.0	1.0	1.0	1.3	1.5	1.8	1.9	1.7	1.1	1.8	1.5	1.8	1.4±0.4
	2011-12	2.14	2.69	3.1	3.47	4.8	4.62	1.92	0.9	1.9	1.88	1.45	1.51	3.7±1.
Dissolved Oxygen (mg/L)	2010-11	9.7	9.7	8.8	6.1	4.7	9.7	7.7	4.9	3.2	3.2	0.8	2.6	7.5±2.4
	2011-12	4.25	6.07	6.07	1.21	4.05	4.05	4.25	4.05	12.35	8.1	2.02	6.07	4.3±1.8
Total Dissolved Solids (ppm)	2010-11	690	690	870.0	940	1090	1380	1390	1400	880	1350	1210	1270	1025±291
	2011-12	1560	1900	2000	2000	2000	2000	1420	740	1090	1030	1210	1041	1980±176
Total Hardness (mg/L)	2010-11	189.6	189.6	189.6	189.6	189.6	237.0	260.7	284.4	284.4	284.4	355.5	260.7	201.5±21
	2011-12	331.8	308.1	332	331.8	331.8	331.8	308.1	213.3	237	189.6	260.7	260.7	327.1±9.7
Total Alkalinity (mg/L)	2010-11	331.5	331.5	331.0	255.0	255.0	229.5	229.5	204.0	204.0	204.0	306.0	229.5	267.8±48
	2011-12	280.5	255	281	331.5	331.5	255	153	178.5	153	204	178.5	204	290.7±34
Chloride (mg/L)	2010-11	182.2	182.2	182.0	202.4	384.6	404.8	506.0	364.3	242.9	344.1	323.8	445.3	293.5±113
	2011-12	546.4	728.6	648	850.0	809.6	1032	303.6	101.2	141.6	202.4	364.3	283.3	813.6±169
Calcium (mg/L)	2010-11	47.4	47.4	47.0	28.4	28.4	37.9	28.4	37.9	47.4	37.9	37.9	28.4	35.6±9.5
	2011-12	37.92	37.92	37.9	47.4	28.44	28.44	37.92	47.4	56.88	66.36	66.36	66.36	36.0±7.1
Magnesium (mg/L)	2010-11	34.7	34.7	34.0	39.3	39.3	48.6	56.7	60.1	57.8	60.1	77.5	56.7	40.5±6
	2011-12	71.71	65.92	71.7	69.39	74.02	74.02	65.92	40.48	43.95	30.07	47.42	47.42	71.0±3.1
Phosphate (mg/L)	2010-11	0.9	0.9	0.9	0.3	0.2	0.5	1.2	0.6	0.3	0.0	0.6	0.6	0.5±0.3
	2011-12	0.31	0.24	0.24	0.15	0.31	0.31	0.61	0.77	1.22	0.31	0.61	0.31	0.3±0.1
Nitrates (mg/L)	2010-11	40.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.5±18
	2011-12	0	0	0	0	0	0	5	0	8	0	0	0	0.0±0.0
Nitrites (mg/L)	2010-11	0.2	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0±0.1
	2011-12	0	0	0	0	0	0	0	0	0.03	0	0	0	0.0±0.0
Ammonia (mg/L)	2010-11	1.0	1.0	1.2	1.2	0.1	0.5	3.7	0.2	0.1	29.0	0.0	1.0	0.7±0.4
	2011-12	0.06	0.06	0.06	0.61	0	0.06	0.06	0.01	4.88	0.06	0	0	0.2±0.2

Table 4.4.16 Simple correlation between rotifer diversity indices and physicochemical features

	Duration	S. Tem	pH	EC	TDS	DO	TH	TA	Cl	Ca	PO_4	NH_4
Density	2010-11	0.1259	0.6850	0.3917	0.3425	0.1892	0.0976	-0.1769	0.5468	-0.3726	0.6184	0.0049
	2011-12	-0.2708	-0.4147	-0.1629	-0.0912	-0.2019	0.0776	-0.4258	-0.2083	-0.0866	0.1609	-0.1831
Shannon (H')	2010-11	-0.0203	-0.0817	0.338	0.3665	-0.1023	0.3287	-0.0513	0.4199	-0.1972	0.1296	-0.3213
	2011-12	-0.3521	0.1144	-0.2033	-0.3125	0.3153	-0.2469	-0.1761	-0.3536	0.2817	0.3881	0.3439
Shannon (J')	2010-11	0.3192	0.0589	-0.4907	0.3288	-0.4907	0.541	-0.3436	-0.0104	0.0742	-0.2908	0.3198
	2011-12	-0.12	0.5530	-0.2631	-0.3453	0.3372	-0.3512	0.0333	-0.3601	0.4005	0.3771	0.5688
Hill's Number (H_0)	2010-11	-0.1576	-0.051	0.3720	0.3183	0.0132	0.1311	-0.0636	0.5319	-0.3328	0.2359	-0.2696
	2011-12	-0.2582	-0.2689	-0.076	-0.1269	-0.0068	-0.0291	-0.1813	-0.1566	0.0909	0.1744	-0.0263
Hill's Number (H_1)	2010-11	-0.0993	-0.2063	0.3675	0.3444	-0.1989	0.2525	-0.1051	0.4618	-0.3036	0.0118	-0.2323
	2011-12	-0.2743	0.1287	-0.2066	-0.2756	0.2859	-0.1925	-0.1383	-0.311	0.2549	0.3719	0.3616

Table 4.4.17 Simple correlation between cladoceran diversity indices and physicochemical features

	Duration	S. Tem	pH	EC	TDS	DO	TH	TA	Cl	Ca	PO_4	NH_4
Density	2010-11	0.5102	0.2417	0.3743	0.3678	0.2436	-0.1359	-0.2292	0.4293	-0.2469	-0.3482	-0.1467
	2011-12	-0.3871	-0.193	-0.3942	-0.4076	0.0370	-0.5185	-0.3733	-0.3837	0.7430	0.1190	-0.0448
Shannon (H')	2010-11	-0.3503	-0.5691	0.0208	0.0009	-0.5999	0.3560	0.1166	0.0523	-0.1788	-0.0966	-0.1637
	2011-12	-0.0635	0.1347	0.0663	0.0254	0.2567	0.0866	-0.0428	-0.0435	0.2265	0.1676	0.2755
Shannon (J')	2010-11	-0.5568	-0.4525	-0.2057	-0.4321	-0.2057	0.1635	0.3113	-0.5969	0.3983	0.2130	0.0060
	2011-12	0.5345	0.0860	0.2994	0.5015	-0.102	0.7308	0.3225	0.3635	-0.5533	-0.0383	0.1399
Hill's Number (H_0)	2010-11	0.0515	-0.2885	0.3566	0.2914	-0.401	0.0962	-0.1568	0.5025	-0.5199	-0.3336	-0.1926
	2011-12	-0.205	0.0267	-0.152	-0.186	0.1955	-0.1602	-0.2071	-0.2063	0.5044	0.1527	0.1543
Hill's Number (H_1)	2010-11	-0.2826	-0.4912	0.1517	0.1180	-0.5581	0.3455	0.0236	0.2052	-0.2706	-0.1037	-0.1579
	2011-12	-0.0757	0.1199	-0.036	-0.0689	0.2767	0.0002	-0.084	-0.1321	0.3186	0.1427	0.2375

Fig. 4.4.36 - 4.4.44 Physicochemical features in Bandam Kommu cheruvu 2010-12

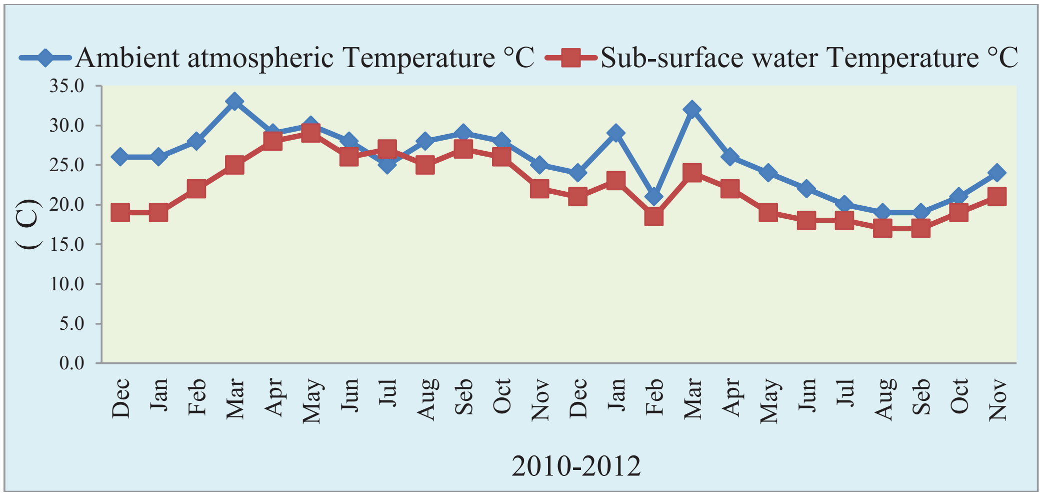


Fig. 4.4.36 Temperature

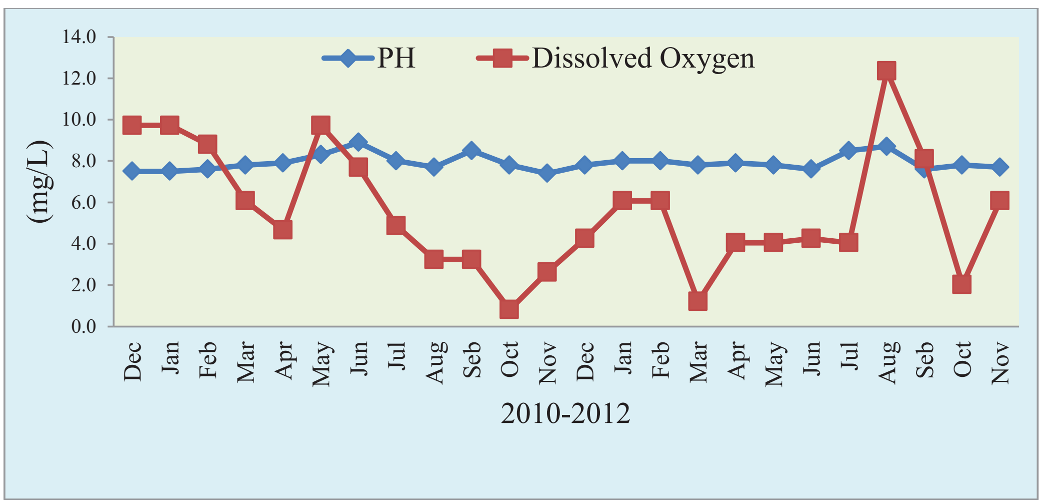


Fig. 4.4.37 pH and dissolved oxygen

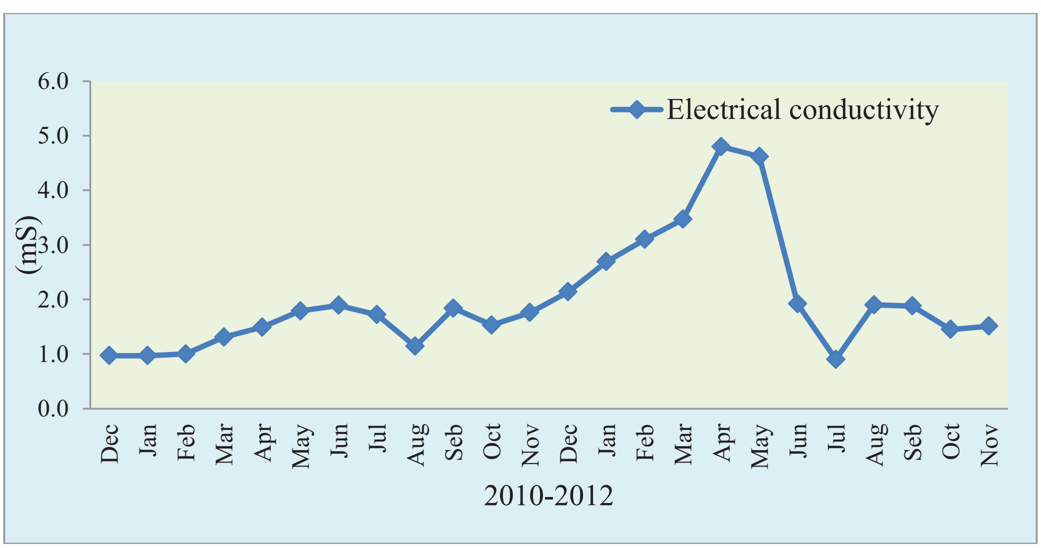


Fig. 4.4.38 Electrical conductivity

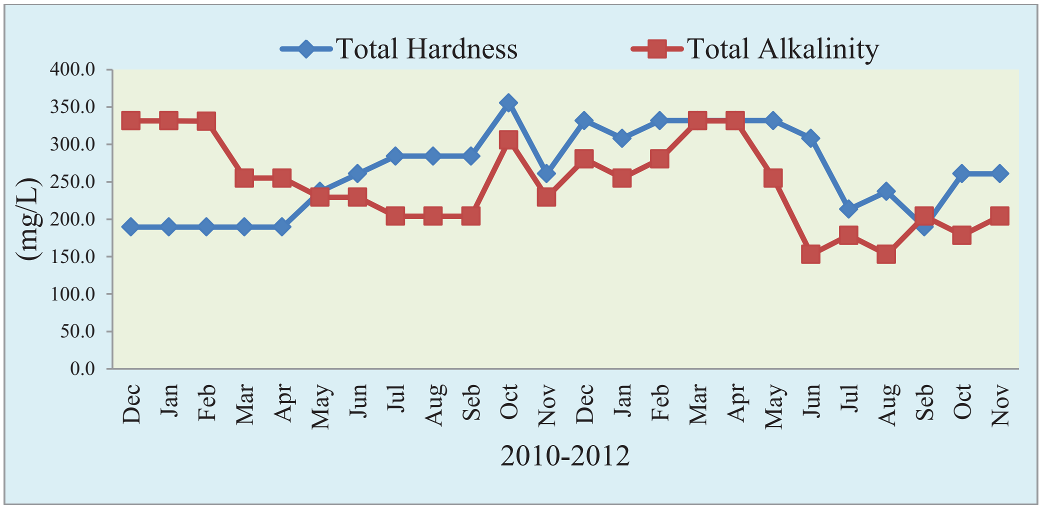


Fig. 4.4.39 Total hardness and alkalinity

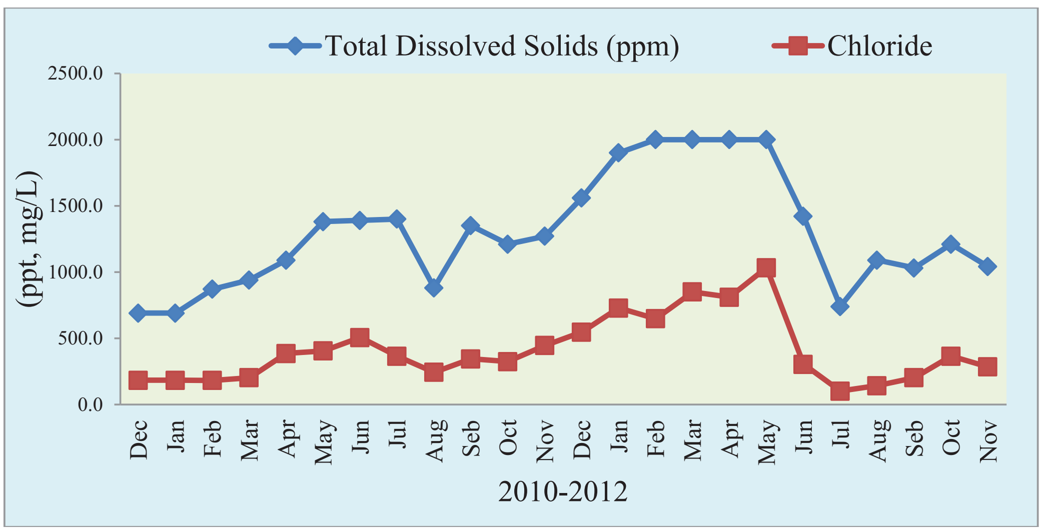


Fig. 4.4.40 Total dissolved solids and chloride

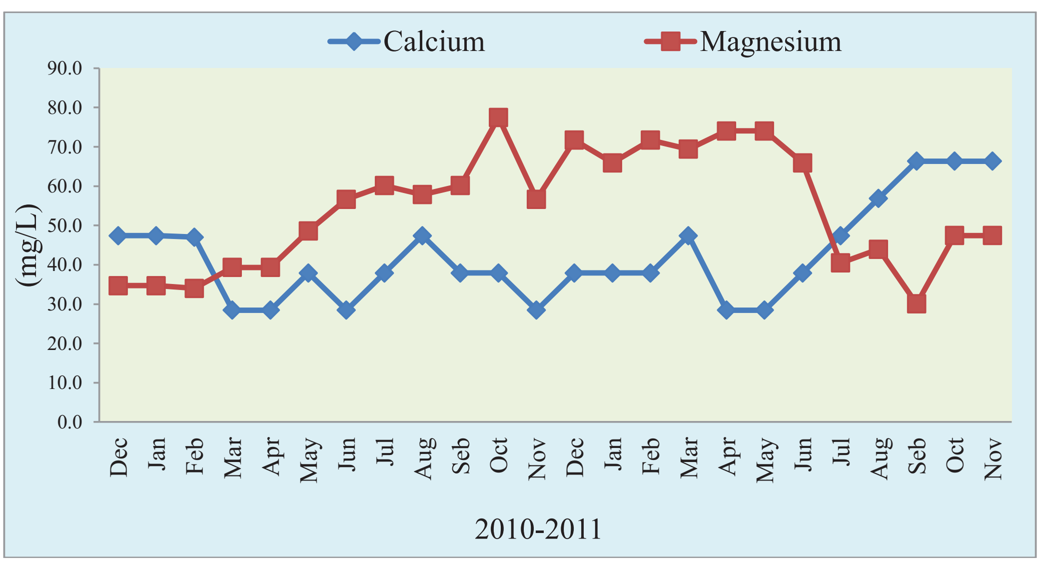


Fig. 4.4.41 Calcium and Magnesium

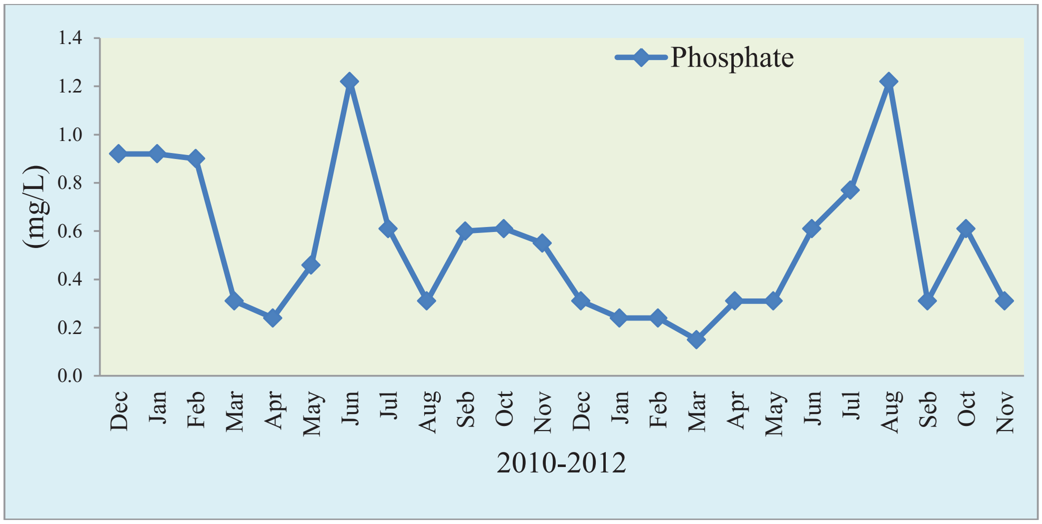


Fig. 4.4.42 Phosphate

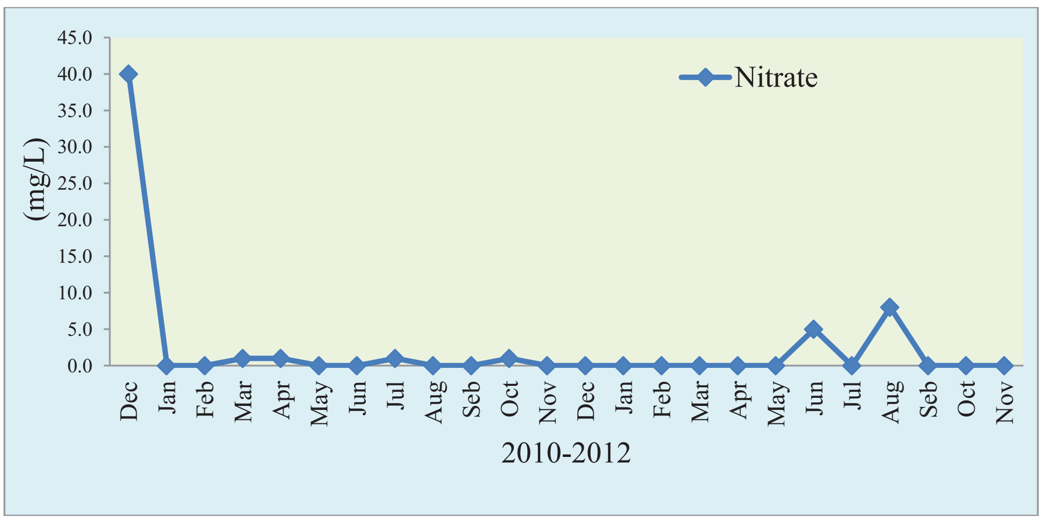


Fig. 4.4.43 Nitrate

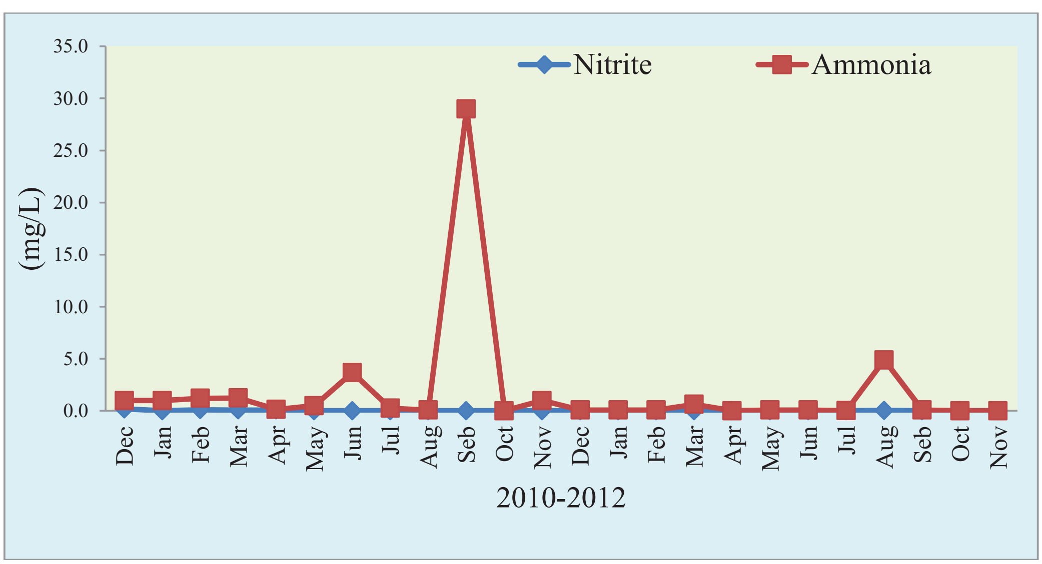


Fig. 4.4.44 Nitrite and Ammonia

4. 5. Trophic status of Osmansagar, Ameenpur tank and Bandam Kommu cheruvu pond

Zooplankton population density varied with their habitats such as Osmansagar (207.5No/L), Ameenpur tank (1046No/L), and Bandam Kommu cheruvu (2351No/L). It showed a high density of zooplankton only in the pond than the reservoir. Even through the area is small comparing to the reservoir, the pond has high density. Among the various zooplankton communities, rotifer density was 102.8No/L in Osmansagar, 925±1163No/L in Ameenpur and 2254No/L in Bandam kommu cheruvu. Cladoceran density was 13.52No/L in Osmansagar, 216258No/L in Ameenpur tank and 246No/L in Bandam Kommu cheruvu. Besides, copepods in Osmansagar, Ameenpur tank and Bandam kommu cheruvu were 165, 264 and 196No/L respectively. The high density of zooplankton in Ameenpur and Bandam kommu cheruvu was due to the high density of rotifer population, whereas in Osmansagar high density was due to copepoda and rotifer than cladocera (Table 4.5.1 and Fig. 4.5.1).

The overall zooplankton diversity was high in Osmansagar (H=1.917±0.47), whereas in Ameenpur and Bandam kommu cheruvu it was H=1.74±0.42 and 1.78±0.45 respectively. The high evenness was observed in Bandam kommu cheruvu (J=0.77±0.14), less in Osmansagar and Ameenpur tank (Fig. 4.5.2). The species richness was high in Ameenpur tank with 16 species, Bandam kommu cheruvu with 14 species and Osmansagar with 11 species (Fig. 4.5.3). Dominance of zooplankton was more in Ameenpur tank (d=41.46±15%), and Bandam kommu cheruvu (d=39.75±18%) less in Osmansagar 11.48±13 (Table 4.5. 1).

Rotifer diversity was more or less equal in all the habitats and varied between H=1.45-1.59. Evenness was equally high in Osmansagar and Bandam kommu cheruvu (J= 0.81), less in Ameenpur tank (J= 0.67). Dominance of rotifer was equally high in Ameenpur and Bandam kommu cheruvu (d=46%) less in Osmansagar (d=39%). The abundance of rotifer was more in Ameenpur tank (11.29%) and less in

Osmansagar and Bandam kommu cheruvu (Fig. 4.5.4). Genus *Brachionus* and *Lecane* have the more number of species in all the habitats. $SQ_{B/T}$ ratio is low value in Osmansagar (3), and high in Ameenpur and Bandam kommu cheruvu (6 and 14 respectively).

A more cladoceran diversity, abundance and species richness was found in Bandam kommu cheruvu, is about D= 0.49, S= 6.37, less in Osmansagar and Ameenpur tank. The dominance was less in Bandam kommu cheruvu (57.5%), high in Ameenpur and Osmansagar.

Physicochemical profile (Table 4.5.2) of these three habitats showed an atmospheric temperature range of 25.6-26.44°C and surface water temperature 22.1-23.5°C. The variation in temperature between atmospheric and surface water was about 2-3°C. pH was 7.9-8.98, a high value in tank and reservoir than the pond. The dissolved oxygen content was high in tank (10.42mg/L) and reservoir (9.28mg/L). Electrical conductivity (0.51mS), total dissolved solids (318mg/L), Total hardness (160mg/L), alkalinity (164mg/L), chloride (57.41mg/L), calcium (25.66mg/L), magnesium (32.95mg/L), phosphate (0.34mg/L), nitrate (3.87mg/L), Nitrites (0.02mg/L) and Ammonia (0.01mg/L) were less in Osmansagar reservoir when compare to Ameenpur tank and Bandam kommu cheruvu pond. However, total dissolved solids, electrical conductivity, hardness, alkalinity and chloride contents were high in tank and pond. The high nutrient enrichment were observed in the tank like phosphate (0.94mg/L), nitrate (11.48mg/L), nitrite (0.07mg/L), and ammonia (1.14mg/L). High content of calcium (42.25mg/L), magnesium (53.23mg/L) and moderate level nutrient like phosphate (0.54 mg/L), nitrite (0.02mg/L), besides high concentration of Ammonia (1.87mg/L) were observed in the Bandam kommu cheruvu pond (Table 4.5.2).

Table 4.5.1 Comparative analysis of zooplankton community in three different habitat of Andhra Pradesh

Contents	Osmansagar				Ameenpur tank				Bandam Kommu Cheruvu			
Zooplankton	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
Total zooplankton (No/L)	65.00	904.8	331.3	253.0	195.6	5500	1364	1256	119.0	26463	2930	5293
Rotifera (No/L)	6.00	621.0	150.8	143.8	14.10	5293	847	1163	34.30	25930	2488	5253
Cladocera (No/L)	0.00	56.10	14.9	16.22	35.50	1200	253	258.0	34.00	1088	246	307.6
Copepoda (No/L)	11.33	674.0	165.6	189.9	55	682	264	172.1	17.3	1072	196	261.6
Shannon H' Log Base 2.718	0.68	2.63	1.91	0.47	0.60	2.46	1.74	0.42	0.76	2.68	1.78	0.45
Shannon (J')	0.26	0.90	0.73	0.14	0.21	0.81	0.63	0.12	0.47	0.97	0.77	0.14
Simpsons Diversity (D)	0.09	0.76	0.22	0.15	0.11	0.79	0.27	0.14	0.09	0.65	0.26	0.13
Hill's Number (H_0)	8.00	24.00	14.5	5.11	5.00	27.00	16.7	5.22	5.00	21.00	11	4.44
Hill's Number (H_1)	3.84	64.17	25.5	15.44	3.43	49.80	20.89	10.89	4.34	69.25	24	15.34
Berger-Parker Dominance (d%)	15.18	87.16	36.1	17.47	18.50	88.71	41.46	15.82	0.00	80.12	39.75	18.12
Rotifera Shannon H' Log Base 2.718	0.92	2.19	1.59	0.40	0.42	2.21	1.54	0.47	0.51	2.33	1.45	0.47
Shannon (J')	0.55	0.94	0.81	0.11	0.17	0.96	0.67	0.17	0.46	1.00	0.81	0.13
Simpsons Diversity (D)	0.12	0.44	0.25	0.11	0.14	0.85	0.309	0.17	0.14	0.75	0.33	0.15
Berger-Parker Dominance (d%)	20.57	58.82	39.19	13.02	22.35	92.18	45.75	16.84	20.00	85.73	46.6	16.94
Hill's Number (H_0)	3.00	14.00	7.66	3.13	3.00	20.00	11.29	4.52	2.00	15.00	6.8	3.33
Hill's Number (H_1)	5.47	33.83	16.7	9.08	2.63	35.17	16.28	9.48	3.01	41.42	14.97	9.57
Cladocera Shannon H' Log Base 2.718	-	-	-	-	0.09	1.19	0.638	0.34	0.29	1.74	0.87	0.42
Shannon (J')	-	-	-	-	0.09	0.95	0.50	0.24	0.26	1.00	0.82	0.21
Simpsons Diversity (D)	0.20	1.00	0.72	0.30	0.35	0.97	0.641	0.20	0.20	0.87	0.49	0.18
Berger-Parker Dominance (d%)	24.62	100.0	79.49	23.90	43.82	98.20	75.89	15.17	25.00	93.10	57.5	19.62
Hill's Number (H_0)	1.00	6.00	2	1.56	2.00	6.00	3.7	1.28	2.00	7.00	3	1.72
Hill's Number (H_1)	1.44	16.20	4.07	4.44	1.64	8.01	4.13	1.77	2.19	17.69	6.37	4.38

Table 4.5.2 Physicochemical profiles of three freshwater habitats in Andhra Pradesh 2010-2012

Parameters	Osmansagar reservoir				Ameenpur tank				Bandam Kommu cheruvu pond			
	Min	Max	Ave	SD	Min	Max	Ave	SD	Min	Max	Ave	SD
Ambient atmospheric Temperature (°C)	18.00	31.00	25.85	3.88	18.50	33.00	26.44	4.06	19.00	33.00	25.67	3.93
Sub-surface water Temperature (°C)	15.50	28.00	23.03	3.31	15.50	28.75	23.54	3.63	17.00	29.00	22.19	3.74
PH	8.05	9.90	8.98	0.39	7.90	10.10	8.93	0.42	7.40	8.90	7.92	0.39
Electrical conductivity (mS)	0.40	0.96	0.51	0.19	0.83	3.40	1.65	0.63	0.90	4.80	1.99	1.05
Dissolved Oxygen (mg/L)	6.68	10.79	9.28	1.08	4.30	19.00	10.42	3.20	0.81	12.35	5.57	2.99
Total Dissolved Solids (ppm)	233.3	370.0	318.4	34.30	615.0	2000	1199	415.1	690.0	2000	1297	428.4
Total Hardness (mg/L)	100.7	205.40	160.7	25.19	130.3	320.0	219.3	54.15	189.6	355.5	264.6	56.63
Total Alkalinity (mg/L)	102.0	195.50	164.4	19.45	127.5	318.8	198.9	41.65	153.0	331.5	246.4	58.54
Chlorides (mg/L)	20.24	87.71	57.41	16.19	0.00	688.2	333.4	186.0	101.2	1032	407.3	247.4
Calcium (mg/L)	18.96	30.81	25.66	4.08	22.12	47.40	35.77	7.16	28.44	66.36	42.25	12.17
Magnesium (mg/L)	19.95	43.18	32.95	5.97	23.71	71.10	44.79	13.49	30.07	77.49	54.23	14.97
Phosphates (mg/L)	0.08	1.99	0.34	0.47	0.10	10.70	0.94	2.11	0.15	1.22	0.54	0.31
Nitrate (mg/L)	0.00	70.00	3.87	14.24	0.00	105.0	11.48	22.90	0.00	40.00	2.38	8.23
Nitrite (mg/L)	0.00	0.16	0.02	0.04	0.00	0.31	0.07	0.09	0.00	0.17	0.02	0.04
Ammonia (mg/L)	0.00	0.10	0.01	0.02	0.00	12.19	1.14	2.71	0.00	29.00	1.87	5.90

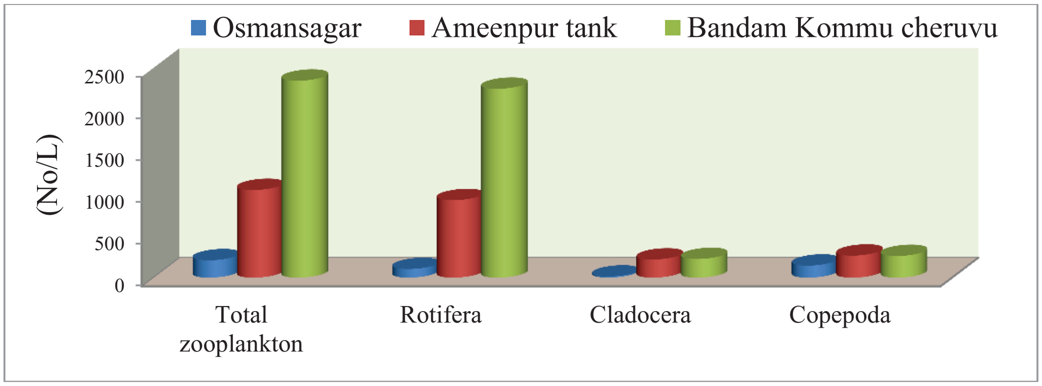


Fig. 4.5.1 Density of zooplankton in three freshwater habitats

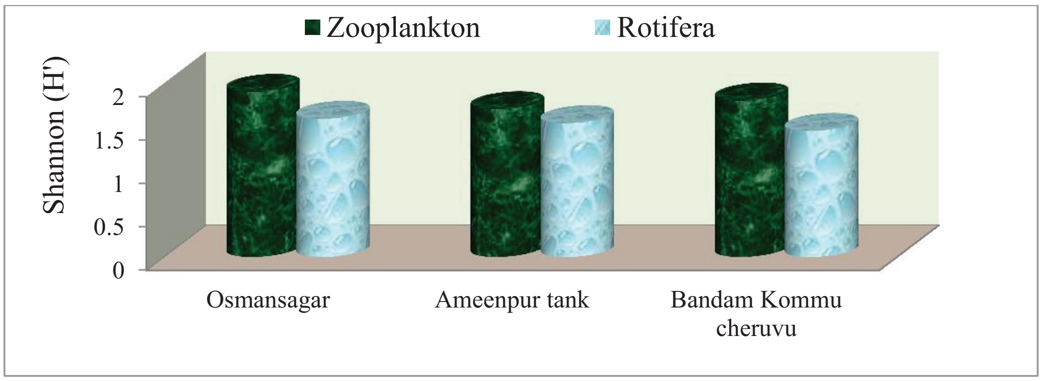
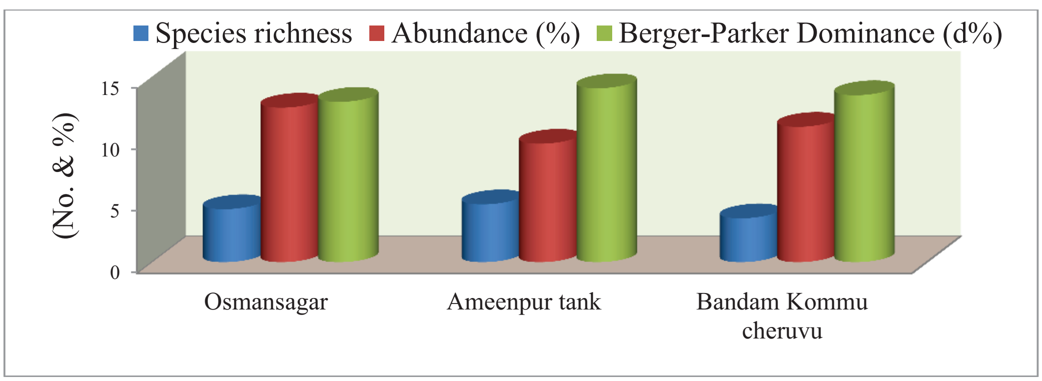
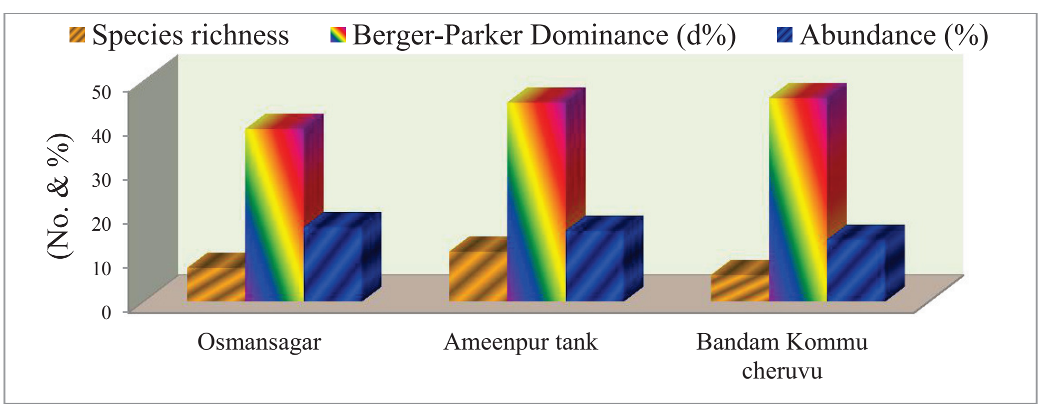


Fig. 4.5.2 Diversity of Zooplankton



4.5.3 Species richness, abundance and dominance of zooplankton in three freshwater habitats



4.5.4 Species richness, dominance and abundance of rotifera in three freshwater habitats

Karuthapandi, M. 2013. Studies on zooplankton community structure, composition and dynamics in few tropical freshwater lakes. *Ph.D thesis,* Manonmaniam Sundaranar University, Tirunelveli.

Chapter V
Discussion

5.1. Taxonomic composition of zooplankton from Northwest Andhra Pradesh

The freshwater zooplankton community is one of the most diverse taxon in the aquatic ecosystem. It constitutes mainly rotifers, cladocerans and copepods. The zooplankton studies made in the 20 selected freshwater habitats of Northwest Andhra Pradesh revealed the occurrence of 80 species of rotifers, 29 species of cladocera and 05 species of copepoda. In addition, 20 species of rotifers and 15 species of cladocera are recorded for the first time in the state of Andhra Pradesh. Highest number of rotifers, about 177 species are reported from Tamil Nadu (Sharma and Sharma, 2009b) followed by 154 species from Deepor Beel, Brahmaputra river basin (Sharma and Sharma, 2001a), 100 species from Maharashtra (Tayade and Dabhade, 2011) and 78 species from Manipur state (Sharma and Sharma, 2011), whereas, a review study on rotifers of Andhra Pradesh by Karuthapandi *et al.,* (2013a) indicates the occurrence of about 114 species. In addition to that, the present study added 20 species as new distributional records and the total rotifer record of Andhra Pradesh is raised to 134 species. With this the state of Andhra Pradesh becomes the third richest center for rotifer diversity.

The abundance of *Brachionus* species in tropical rotifer faunae has been pointed out by Green (1972), Chengalath *et al.,* (1974), Pejler (1977) and Fernando (1980a). This generalization also hold true for Indian Rotatoria (Sharma and Micheal 1980). *Brachionus angularis, B. calyciflorus, B. quadridentatus* and *B. caudatus* are widely distributed in India. Cyclomorphosis has been observed during the study in

B. calyciflorus, B. quadridentatus, B. diversicornis, and B. falcatus from different water bodies. This morphological variation in various regions of this country was reported by Sharma and Michael (1980) and Dhanapathi (1977). Most of the *Brachionus* species reported from India are pantropical or cosmopolitan in nature. So far no endemism is reported in India (Sharma, 1983).

Lecane simonneae, *Lecane unguitata* are biogeographically interesting elements in the oriental region (Sharma, 2009). *Mytilina acanthophora* exhibit discontinuous distribution in India and so for reported only from few places of India (Sharma, 2000). Further the present study recorded *Mytilina acanthophora* for the first time from this region. Dussart *et al.,* (1984) stressed the presence of many species of *Lecane*, the characteristic feature of the rotifer communities of tropical Asia and Australia. The present study has also recorded the high species richness of *Lecane* among the rotifer species, the qualitative predominance of *Lecane* and *Brachionus* species are broadly tropical character to the rotifer fauna of Andhra Pradesh.

There are several sub-species which have been described based on morphological variation; it might be due to cyclomorphic changes during the course of development due to environmental changes. It was the opinion of Wesenberg-Lund (1900, 1926) that cyclomorphosis will be due to the changes in the temperature of water, besides Ostwald (1902) also attributed the phenomenon to the physicochemical changes in water. During the present study, morphological variations in *Brachionus* species are observed in different seasons and in different ecosystems. These variations are not only due to seasonal changes but also due to physicochemical changes and predatory influence. The cyclomorphic variations of *Brachionus calyciflorus* was first reported in India by Arora (1966). The variation in form confuses the taxonomical identification of species. The recent literature confirmed that some of the forms were synonymised due to the interspecific variation among the species (Segers, 2007). Morphological variation and introgressive forms were described among various rotifer species. These variations are clinal *i.e.* continuous local variations of one or several characters or geographical, in which no clines can be traced or discontinuous (Plejler, 1957). In the present study some forms and varieties of *Brachionus* species are served which are synonymised by Segers (2007). The present study also confirmed the interspecific variation of species of Brachionidae from India. Hutchinson (1967) observed that *Brachionus* species are very common in temperate and tropical water, which indicates alkaline nature of the water bodies. Interestingly the species of *Brachionus* has high adaptive nature and survive in all harsh environments, a good indicator for pollution and eutrophication of the freshwater bodies (Sampaio *et al.,* 2002).

Chandrasekhar (2004) recorded 30 species of cladocera belonging to 17 genera from Hyderabad, whereas the current study reported 29 species, of which 13 species are reported for the first time from the state of Andhra Pradesh. Among the various cladoceran families Chydoridae have high species richness than of other families. According to Forro *et al.,* (2008) cladoceran has immense indirect economic impact on important fish food and phytoplankton controlling group. Besides, a high diversity of the Cladocera can be found in the littoral zone of stagnant and in temporary water bodies. These habitats are often negatively influenced by human activities and especially the loss of temporary water may lead to decrease of diversity and even local extinction of some species. In the present study, the cladoceran species such as *Diaphanosoma sarsi*, *D. excisum*, *Daphnia lumholtzi*, *Ceriodaphnia cornuta*, *Moina micrura* and *Moinodaphnia macleayi* are recorded from most of the study habitats and are common, but the family Bosminidae occurs rarely.

Bosmina longirostris and *Bosminopsis deitersi* are reported recently from Andhra Pradesh by Karuthapandi *et al.,* (2013d). The Daphniids and Chydorids are responsible for higher diversity in the water bodies of India (Sharma and Michael, 1987). *Indialona ganapati*, the endemic taxa, restricted to central India has been recorded from Ameenpur irrigation tank, Andhra Pradesh, during the present study. The document evidence shows that the females of *Daphnia lumholtzi* are common and dominant, but notably the male forms are also observed from Osmansagar reservoir. Similarly, more number of species from Bandam kommu cheruvu and Attapur, temporary pond are deserved. Fernando and Kanduru (1984) reported that *Camptocercus* occurs in equatorial India, whereas it has been observed from Osmansagar reservoir. Hence, Venkataraman (1991) reported that *Leydigia acanthocercoides* occurrence is rare, *Dunhevedia crassa*, *Chydorus parvus, Bosminopsis deitersi* are not common from this region and this was evidenced. In copepod *Mesocyclops leuckarti* found most commonly from all the study habitats.

5.2 Zooplankton community structure, composition and diversity of Osmansagar reservoir, Hyderabad

Generally the freshwater zooplankton community is dominated by three major groups such as rotifer, cladocera and copepod, of which rotifers are larger communities in Indian waters (Yousuf and Qadri, 1981a,b; Saksena and Sharma, 1981; Saksena and Kulkarni, 1986 and Ali *et al.,* 1990). The present study recorded 74 species of various zooplankton communities from the Osmansagar reservoir. Of these, 56 species of rotifer belonging to 23 genera under the 16 families were recorded where the species of *Brachionus* and *Lecane* were dominant. Taxonomic dominance of rotifer was reported in several water bodies particularly in tropical and subtropical water bodies (Nogueira, 2001; Cavlli *et al.,* 2001; Sampaio *et al.,* 2002; Neves *et al.,* 2003 and Kudari *et al.,* 2005). Out of 15 species of cladocera recorded, 09 species belonging to family Chydoridae was dominant. Chandrasekhar (2004) reported 08 species of cladocera from Osmansagar reservoir earlier. The present study added another 09 species to the list. Sharma and Michael (1987) reported that Chydorids and Daphniids are responsible for the high diversity of cladoceran in Indian water bodies. Santos-Wisniewski *et al., (*2002) revealed that in the littoral zone the members of chydoridae represent major part of cladocerans, usually associated with macrophytes, periphyton or sediment. About 05 species of copepods were also recorded from this reservoir.

The present study revealed that the overall zooplankton population of this reservoir is depending on rotifer and copepod communities. The record of high density during the 2010-11 study was due the abundance of rotifer population, whereas in 2011-12 it was due to high copepod population. There was no seasonal abundance of any particular community of zooplankton population, but the overall density was high during the monsoon than in the other seasons, with high abundance of rotifers and copepods during 2010-11 and only copepods in 2011-12. The rotifer abundance was mainly due to the numerical abundance of *Brachionus forficula, Brachionus diversicornis, Brachionus calyciflorus, Keratella tropica, Trichocerca similis and T. pusilla.* The cladoceran dominance was due to *Diaphanosoma sari.* The similar species dominance of rotifer and cladocera was also observed by Majagi and Vijayakumar (2009). In copepods, the dominance was due to *Heliodiaptomus sp*. and *Mesocyclops leuckarti.* The study also observed abundance of the rotifer population due to the genus *Brachionus* and *Trichocerca*. Nogueira (2001) and Mulani *et al.,*

(2009) revealed that *Brachionus* species considered typical for and most frequent in tropical environment. Kurasawa (1975) noted that copepods are found to be dominant in oligotrophic lakes. Pennak (1957) had pointed out that when more than one genera of the same group occurs in any water body, one genus is more abundant than the other. In the present study, *Brachionus* was to be found more abundant among rotifers and *Mesocyclops* in copepods. Green (1972), Sharma and Saksena (1981), Saksena and Kulkarni (1986), Singhal *et al.,* (1989) and Ali *et al.,* (1990) had also reported abundance of genus *Brachionus* in the various water bodies of India.

Several species which were reported in the 2010-11study are absent in the 2011-12, especially *Brachionus patulous, B. quadridentatus, Platyias quadricornis, Dipleuchlanis propatula, Tripleuchlanis plicata, Trichotria tetractis, Lepadella ehrenbergii, L. ovalis, Lecane crepida, L. curvicornis, L. leontina, L. luna, L. ungulata, L. hamata, L. lunaris, Testudinella parva*, and *Rotaria rotatoria*, where as the occurrence of *Pompholyx complanata, P. sulcata* were noticed in 2011-12 study. Similarly in Cladocera, *Bosmina longirostris, Macrothrix spinosa* were absent in 2011-12 and *Camptocercus rectirostris* occurred in 2011-12. It may be due to the physicochemical changes and lack of littoral vegetation because of drastic decrease in the water level of the reservoir. Warren (1971) suggested that the continued persistence of a species at a particular location is a sure evidence of favorable environment for its existence, but its absence is not always indicative of unfavourable conditions.

The population density of zooplankton is constant and varied throughout the year, more variation was recorded in 2010-11, might be due to the abundant population of rotifers. Biswas and Konar (2001) revealed fluctuation of the zooplankton population in every month and high during monsoon season might be due to the rainfall as evidenced by Sadguru *et al.,* (2002). The predominance of rotifer and copepods over the other groups of zooplankton was found in the present study. The same phenomenon was also reported earlier in different water bodies by Mukhopadhysay *et al.,* 2000; Prakash and Srivastava, 2001.

The Shannon diversity index value of rotifer lies between H=1-2.9, the diversity index was high in 2010-11 and less in 2011-12. Balloch *et al.,* (1976) and Ismael and Dorgham (2003) advocated that the diversity index (Shannon's) was found to be suitable indicator for water quality assessment. When the diversity was high, the evenness and abundance of individuals was also shown high in the present study. The rotifer had high diversity with wide fluctuations, whereas cladocera low diversity. Vanjare (2010) observed the wide variation in rotifer diversity and high during the rainy season in freshwater bodies of Pune, Maharashtra. Sharma (2011) revealed that zooplankton is characterized by high species diversity, high evenness and lower dominance from Loktak lake, Manipur. The overall diversity of the rotifers is due to the dominance of *Brachionidae* and *Lecanidae* was observed by Sharma (2005a,b). The similar observation also made by present study and it is corroborating the earlier findings.

The present study shows that the less cladoceran diversity (Simpson diversity index) which may be due to the less number of species and density.

The quantitative dominance of the rotifer was reported by Sharma (2000, 2005a,b); Sharma and Sharma (2001, 2005, 2008). The present study found that there was no definite pattern of periodicity of richness in this reservoir, the similar observation also made by Sharma (2011) in the Loktak lake, Manipur. The species richness of rotifer was also high in the 2010-11 than in the 2011-12 and the high richness during monsoon. According to Dumont (1999) the higher species richness is characterized by larger food chain. Vanjare (2010) noticed that the high species richness of rotifers during monsoon in freshwater habitats of Pune, Maharashtra. Cladoceran species richness less when compared to rotifers, and the maximum cladocera richness recorded when macrophytic vegetation was more, and the species richness and density was less when the vegetation was less due to the receding of the water level, *etc.,*

The evenness in both the rotifer and cladoceran is high when the diversity is high. Among these two zooplankton communities, rotifer has more evenness during the monsoon. Similar observations made by Vanjare (2010). The high evenness was due to the more diversity and species richness. When the dominance is more the species richness, diversity and evenness is less which might be due to representation of few species and its numerical dominance.

The study showed no definite seasonal periodicity of abundance. Rotifer abundance was found in 2010-11 and whereas copepods are more abundant in 2011-12. The cladoceran abundance was comparatively less than rotifer. Brooks and Dodson (1965) reported that low abundance of large-bodied cladoceran may also be caused by size selective fish predation. The low abundance of large-sized zooplankton in many tropical lakes and reservoirs may thus be an indication of strong fish predation (Duncan, 1984 and Fernando, 1994).

Sharma (2011) revealed that the wide variation of similarity index showed that the diverse composition of zooplankton, where less similarity may be due to less divers species. The high level of similarity suggests limited monthly variations in species composition and less similarity due to decreased species richness. The present study observed that the rotifer similarity in 2010-11 shows the seasonal similarly, whereas it was declined in 2011-12, might be due to the less species richness. There was a more dissimilarity in the cladoceran species in both the years due to the less species richness and diversity.

Physicochemical profile of Osmansagar

Temperature is the most important external factor and has deep influence on an ecosystem. During the study it was found that the temperature varied between 18-28°C on the surface water column and fluctuated with seasons. The pH value is alkaline in nature. Similar observation was made in Krishna sayer in Burdwan by Chattopadhyay (2007). The high content of the dissolved oxygen is an indication of healthy system (Bilgrami and Datta Munshi, 1979). The present study shows moderate dissolved oxygen content which maintain the aquatic life of the reservoir. The hardness content is within the permissible limit with no much fluctuation. Similarly the total dissolved solids and alkalinity are less, shows that less influence of the pollution and buffer action of the water body except during monsoon due to runoff. The ionic components like chloride, calcium and magnesium are also lies in the permissible limit, except fluctuations in the chloride during winter and monsoon periods. The nutrient content such as phosphate is low in concentration throughout the study period except in summer period of 2011-12. The nitrate, nitrite and ammonia concentrations were slightly raised during monsoon period of 2010-11; it may be due to the runoff. The overall physicochemical parameters were more are less similar in both the years except minor fluctuations indicate the acceptable water quality and healthy aquatic ecosystem.

In general, lakes with well developed macrophyte community are characterized by a more diverse community of zooplankton (Timms and Moss, 1984). The absence of a well developed macrophytic community and the decrease levels of oxygen under the canopy of water hyacinth (Rommens *et al.,* 2003) may be adverse for zooplankton richness and abundance.

In conclusion, the two year study shows that among the different zooplankton communities, the rotifer had more diversity, species richness, and evenness than cladocera and copepoda. The copepods were numerically abundant than rotifers and cladocera in 2011-12. This community change over the year may be due to the nutrient content like phosphate, nitrate, nitrite and ammonia. When the nutrient is high, the overall zooplankton density is also high and the species richness is high in the rotiferan community. The receding water level in the reservoir is mainly due to exploitation of water for drinking purpose and low rainfall leads to disappearances of the macrophytic vegetation in the littoral region and increasing ionic content affecting the zooplankton population and diversity. There is no seasonal periodicity observed in any of the zooplankton communities over the two year period in the Osmansagar reservoir, Hyderabad.

5.3 Zooplankton community structure, composition and diversity of Ameenpur irrigation Tank, Medak District

Zooplankton community structure is shaped primarily by the physical and chemical environment. However, these communities are also modified by biological interactions (Blancher, 1984). The present study assessed the zooplankton community structure, composition and dynamics from an irrigation tank. It revealed that there are 61 species of various zooplankton recorded from this tank, the zooplankton density variation found between 41-5434No/L, of which rotifer had more number of species composition and density than cladocera and copepoda. The genus *Brachionus* and *Lecane* had more species among the rotifers. Similar observations were also made by Sampaio *et al.,* (2002), Kudari *et al.,* (2004) and Kudari *et al.,* (2006). The population density of zooplankton of this tank showed wide fluctuation and high population during winter and summer seasons of 2011-12. A high density of the zooplankton is due to the high population of rotifers, which is due to the numerical abundance of *Keratella tropica* with unusual bloom in winter and *Brachionus angularis,* and *B. calyciflorus, B. caudatus, B. rubens* in summer. Joti and Sehgal (1979) also reported similar observations. Kiran *et al.,* (2007) revealed that the numerical variations in rotifers may apparently be influenced by the water quality. Negi and Pant (1983) reported that the dominance of rotifer by *Keratella tropica* is a conspicuous feature of the tropical plankton assemblage, whereas genus *Brachionus* and particularly *B. calyciflorus* is considered to be a good indicator of eutrophication (Sladecek, 1983 and Sampaio *et al.,* 2002) and its abundance is considered as a biological indicator for eutrophication (Nogueira, 2001). The abundance of rotifers among the zooplankton is taken as an index of eutrophy (Michael, 1966 and Schinler and Noven, 1971).

There was huge fish kill noticed between March-June 2012, it may be due to the depletion of dissolved oxygen, high nutrient content as well as algal bloom. This may be due to lack of rainfall, unusual climatic changes, drastic receding of water level, and high input of pollutants from the adjacent industries (*viz*. pharmaceutical and beverage companies). It has been evidenced with high chloride discharge from the industries which enters into the system. During this time the species richness of the both rotifer and cladocera are less when compared to other months. The numerical abundant populations of few species were noticed such as *B. angularis, B. calyciflorus, B. rubens* and *B. caudatus* in rotifer, *Moina micrura* in cladocera.

Rotifer diversity is high during initial period of the study due to more species richness and evenness, later it declined due to less species richness and evenness.

Further the diversity is more decreased in 2011-12, due to less species richness and evenness, though the density is high. The dominance value is more when less diversity is less due to the single species dominance of *Keratella tropica* in December 2011, *Brachionus calyciflorus* and *B. angularis* from March to May 2012. Michael (1966) reported that the *Brachionus* and *Keratella* were predominant generally. SHE analysis reveals that the high diversity is due to the species richness and evenness of this tank. Hence, the rotifer diversity increases with species richness and evenness, whereas the dominance increases when diversity and evenness decreases. However, the present investigation of this tank diversity reveals that the diversity increased with the evenness rather than the species richness. Even the species richness increases, diversity runs parallel towards the evenness of individuals.

In cladocera family Chydoridae holds high number of species. The abundance of cladocera is due to the frequent occurrence of *Ceriodaphnia cornuta*, *Moina micrura*, *Bosmina longirostris* and *Indialona ganapati* at different seasons, The cladoceran diversity is less than the rotifer, and reaches a maximum diversity H'=1.2 in monsoon and summer. The evenness and diversity of cladoceran is less, though the species richness is high. When the dominance values are more, the diversity and evenness is less, especially in summer season due to numerical abundance of single species of *Moina micrura*. Similar observation was reported by Bandyopadhyay and Datta (1987). SHE analysis shows that diversity of the cladoceran species increases with evenness rather than the species richness. The abundance of cladocera corresponds with the onset of rain (Kannan and Job 1980, and Negi and Pant, 1983). Perhaps the addition of allochthonus nutrients through surface runoff triggers the production of cladocerans. According to Uttangi (2001) cladocera prefer to live in clear waters.

The cladoceran and copepod population are less than the rotifer. Copepod is more in the monsoon, mainly due to the abundance of *Mesocyclops leuckarti* and cyclopids formed the dominant component of copepod. This was reported earlier by Khan (1987), Sanjer and Sharma (1995), Sharma and Sharma (2011) and Sharma (2011)

Physicochemical profile of the tank shows a tropical climatic with ranged temperature and pH which is alkaline. Wide fluctuations in electrical conductivity, total dissolved solid and dissolved oxygen are due to the high ionic content and low temperature. On the other hand as the water level recedes, increases the concentrations of pollutants. The total hardness shows hard water nature, increased alkalinity which may be due to the increased pollutants. The calcium and magnesium increases the hardness. Chloride concentration is high due to the anthropogenic pressure and animal wastes. According to Sharma and Dudani (1992) the high concentration of total hardness, alkalinity and chloride could be attributed to the influx of sewage waters and pollutants. A key factor in the eutrophication of a water body is the phosphate concentration (Shapiro, 1970). Phosphate content is high due to high nutrient content which was also evidenced with high concentration of nitrate, nitrite and ammonia. According to Seenayya and Zafar (1979) the present tanks has high phosphate content due to polluted habitat.

However, the zooplankton community composition and structure are affected by eutrophication. It is also evident with the fluctuating physicochemical nature of the tank takes for study; these communities also have potential value as indicators implying trophic conditions. Pramila *et al.,* (2007) reported different patterns of dominance of indicator plankton community and species along with physicochemical parameters of a habitat.

5. 4 Zooplankton community structure, composition and diversity of Bandam kommu cheruvu, Medak district

The study reported 84 species of different zooplankton species and it comprised of 63 species of rotifers, 19 species of cladocera and 02 species of copepod. Among the various zooplankton communities, rotifer constitutes more species, especially family Brachionidae and Lecanidae. Green (1972), Pejler (1977), Dumont (1983), Dussart *et al.,* (1984), Sharma (1987, 1991a, 1996), Sharma and Naik (1996) and Segers (1996) were reported that the representation of *Brachionus* and *Lecane* were general tropical charater. In Cladocera family Chydoridae and Daphniidae has more number of species than other families. However, copepod has only two species *viz*. *Tropodiaptomus orientalis* and *Mesocyclops leuckarti* belonging to two different families.

A high density of zooplankton was noted during June 2011 and 2012 with major peaks, it and was also observed in October 2011 and November 2012. The high peak during summer may be due to high temperature and in monsoon due to heavy rainfall. Singh *et al.,* (2002) reported that higher rotifer population occurs during summer and winter might be dominant due to hypertrophical conditions of the pond at temperature and low level of water. The high density of the overall zooplankton communities is due to the abundance of rotifer population, especially due to the occurrence of the following species *Brachionus angularis*, *B. calyciflorus, B. caudatus, Keratella tropica, Filinia terminalis* and *Epiphanies mucronata* which were abundant in June 2011 and 2012. Chattopadhyay and Barik (2009) reported that rotiferan populations was more abundant than other net zooplankton groups, because of their ability to withstand and survive in varying limnological conditions prevailing at different seasons. Hutchinson (1967) and Edmondson (1992) stated that the genus

Brachionus is characteristic of hard water. *Brachionus calyciflorus, B. caudatus, Filinia longiseta* have been considered as indicators of Eutrophiction of ponds was revealed by Mudgal *et al.,* (1989). Cladoceran species are abundant during monsoon due to *Macrothrix spinosa, Karualona karua, Moinodaphnia macleayi* and copepod abundance is due to *Mesocyclops leuckarti*. Goswami *et al.,* (2007) also noted similar observation from a pond at East Kolkata. The abundance of copepods is indicative of stable aquatic environmental conditions (Basu *et al.,* 2010). Yadav *et al.,* (2003) noticed high rotifer peak in summer which correlates with the present study.

The diversity of the rotifer is high during the monsoon and winter season, due to high species richness and evenness. Similar observation was also made by Rajagopal *et al.,* (2010). When the dominance was high, diversity and species richness were less which may be due to the numerical dominance of few species. Green (1993) noted that few dominant species with high density is common characteristic of the eutrophic ecosystem. When the abundance of rotifer was more, diversity and species richness was also high. Taxonomic richness of rotifers are common in tropical freshwaters was revealed by Sampaio *et al.,* (2002); Kudari *et al.,* (2004) and Kudari *et al.,* (2006). Odum (1983) revealed that the diversity is directly related to abundance of equalibility and the dominance value is inversely proportional to values of diversity, evenness and species richness. SHE analysis of rotifer shows that as the species richness increases, the diversity also increases. After attain maximum species richness and even if it increased further, diversity remains constant at a particular level. Hence it could be inferred that diversity of zooplankton depends an evenness rather than species richness. Similarity of the rotifer shows seasonal influence cluster formation and it is less when the number of species is more.

The density of cladocera is high in summer (2010-11) and monsoon (2011-2012) which is due to influence of temperature and rainfall. The diversity is high during summer and monsoon of 2011-2012, which may be due to high species richness and abundance. The evenness of the cladocera species is almost high, except April and May 2011 due to the high density and less species richness. SHE analysis shows that the cladoceran diversity depends upon the species richness and evenness of individuals, where the diversity decreases the evenness also decreases. Similarity of cladocera does not show any definite pattern which may be due to less number of species.

The physicochemical profile of the pond shows tropical climatic condition; mild alkaline pH, which is high in summer and high electrical conductivity due to the perishing of macrophytic vegetation and receding of the water level. Total dissolved solid is high due to more ironic contents in the pond, decreasing water level and due to pollutants, whereas in monsoon it decreases. The dissolved oxygen is widely fluctuated and less in the second year of the study period. Total hardness, alkalinity, is high due to variation in the ionic content and changes in the climatic condition. According to Philipose (1960) the water bodies with alkalinity value above 100mg/L are nutrient rich. Rotifers utilize nutrients more rapidly to build their population (Saboor and Altaf, 1995). Similar observation was also made by Jeelani *et al.,* (2005). Chloride content is high due to the anthropogenic pressure, agricultural runoffs and moreover the water received from the upstream tank has high chloride content. The nutrient enrichment is due to the high content of the phosphate and nitrates, especially during summer.

5. 5. Trophic status of Osmansagar, Ameenpur tank and Bandam Kommu cheruvu pond

Freshwater environments is the serious concern in the current scenario over worldwide for management and conservation, due to increasing threats to the habitats such as distraction and degradation, overexploitation, pollutants, anthropogenic pressure, industrial effluents, agricultural runoff. It affects the water quality as well as the faunal communities, especially in the urban areas of the country. The faunal communities play a vital role in the aquatic environment and its composition, community structure and diversity changes with intrinsic and extrinsic factors. Generally physicochemical tool is used to assess the trophic status and water quality of any aquatic habitats use the, but it is not helpful for evaluating the faunal community. Hence, there are several studies that recommend zooplankton communities as biological tool for biomonitoring, assessing the trophic status and water quality. They are primary consumers which interlink the food chain in the freshwater ecosystem.

The physicochemical parameters are useful in detecting effects of pollution on the water quality but changes in trophic conditions of water which are reflected in the biotic community structure including species pattern, distribution and diversity (Kaushik and Saksena, 1995). There are many studies indicating influence of eutrophication on changes in the abundance and composition of zooplankton (Gliwicz, 1969; Patalas, 1972 and Maier, 1998). Since zooplankton community composition and structure are affected by eutrophication, these communities have potential value as indicators of changing trophic conditions (Blancher, 1984). They are very sensitive to environmental changes and thus are considerable potential value as water quality indicators (Pejler, 1981, 1983). It may serve as bioindicator and it is a well suited tool for understanding water pollution status (Contreras *et al.,* 2007).

Similarly, Sharma *et al.,* (2008) reported the variations as a result change in their abundance, species diversity or community composition can provide important indication of environmental change or disturbance.

The present comparative study on zooplankton community of three freshwater habitats of Andhra Pradesh showed that the Osmansagar reservoir has high diversity, abundance of individuals with less dominance and density. In the Ameenpur tank and Bandam kommu cheruvu has high density and more dominance is due to the numerical abundance of individuals, less diversity, abundance and evenness. There are several earlier studies which revealed that the zooplankton community tends to decrease, in the presence of few dominant species with high density. Large population of small herbivorous zooplankton like rotifers and cladoceran are the common characteristic of the eutrophic ecosystem Hrbacek *et al.,* (1961), Kajak (1983), Green (1993), Rogozin (2000) and Paturej (2006), Gannon and Stemberger (1978). Oligotrophic systems are typified by populations of Copepods (Allan, 1976). Similarly the present study also observed a high density of zooplankton community which may be due to the high population of rotifer and cladocera, especially in Ameenpur tank and Bandam kommu cheruvu.

Rotifers are usually considered to be useful indicators of water quality, and its composition and abundance as indicators of lake trophic status. The density of rotifers significantly increased with increasing nutrient concentration. Low values of Shannon diversity index and assemblage of *Brachionus* is indicator of eutrophication on Ameenpur tank and Bandam kommu cheruvu pond. The present study shows similar observation in which was evidenced by the findings of Maemets (1983), Gunn and May (1997), Paturej (2008), Nogueria (2001) and Tasevska *et al.,* (2010). According to Pontin and Langley (1993), Sladecek (1983) rotifers respond quickly to environmental changes and are considered good indicators of water quality and trophic condition because of their short generation time and fast population renewal. Hence, the present study observed the rotifer diversity is equally high in all the three habitats. High rotifer abundance in Bandam kommu cheruvu, and high dominance in both Ameenpur tank and Bandam kommu cheruvu pond indicate the trophic status which is classified as Berzines and Pejler (1989), Matveeva (1991) and Dugan *et al.,* (2001) suggested that both rotifer composition and abundance could be used as indicators of trophic state. The dominance is due to the dominant species like *Brachionus angularis, B. calyciflorus*, *B. caudatus, Filinia longiseta*, *Diaphanosoma sarsi, Ceriodaphnia cornuta* and *Moina micrura.* Sampaio *et al.,* (2002) reveled that *Brachionus calyciflorus* is considered to be good indicator of eutrophication. *B. forficula, B. angularis, B. calyciflorus* and *B. rubens* are the indicators of eutrophic state of the water bodies of the country and also invariably found in alkaline water bodies (Sharma, 1983). Some eurytopic Brachionids species such as *Brachionus angularis, B. calyciflorus, B. diversicornis, B. falcatus* and *B. forficula* are highly tolerant to wide pH variation (Koste, 1978). The nutrient contents are also high both in tank and pond habitats. The density of rotifer increases with nutrient likes phosphates (Lauridsen and Hansson, 2002). Dominance is generally inversely related to diversity. In considering the total possible range of dominance for a given number of species the mean values are surprisingly restricted. An abnormally high dominance for a number of species can be an indication of pollution or some other form of environmental stress (Green 1993).

According to Saksena (1987) the occurrence of the following rotifers *Brachionus angularis, Trichocerca cyindrica, Polyarthra euryptera, Pompholyx sulcata, Rotaria rotatoria, Filinia longiseta* in water bodies act as bioindicators of heavy pollution (Eutrophy). *Ascomorpha ovalis, Asplanchna herricki, Synchaeta grandis, Ploesoma hudsoni, Anuraeopsis fissa, Lecane bulla* and *Lecane hamata* are indicator of fresh and clean water (Oligotrophy) while variety of rotifers including *Brachionus, Keratella spp*. are inhabitants of moderately clean waters (mesotrophy).

Arora (1966) has pointed out that *Brachionus angularis, B. calyciflorus*, *Filinia longirostris*, and *F. terminalis* are common forms predominantly occupying eutrophic water. Davis (1969) reported that the abundance of *Brachionus* is conclusive of the eutrophic nature. Mateeva (1983) revealed that a mesotrophic lake had a rotifer community consisting of *Trichocerca, Synchaeta, Polyarthra, Keratella, Conochilus, Filinia, Asplanchna* and *Euchlanis*. Highly eutrophic lakes usually exhibit large population of small herbivorous zooplankton like rotifers and cladocerans (Hrbacek *et al.,* 1961; Gannon and Stumberger, 1978).

Cladoceran diversity is high in the Bandam kommu cheruvu, less in Osmansagar with high dominance due the less species richness and abundance. Michael (1986) stated that cladocerans are rich in eutrophic waters. Cyclopoid copepods are relatively more abundant in eutrophic lakes than calanoid copepods (Patalas, 1972), also the dominance of cyclops in eutrophic water (Kulshrestha *et al.,* 1992). The copepod density is equally high with rotifer density in Osmansagar, whereas in the other two habitats the copepod is too less than the rotifer. According to Allan (1976), oligotrophic systems are typified by population of copepods.

According to Pennak (1957) aquatic biologists have been searching many years for the ideal common species or group of indicator species which would separate the trophic nature of the freshwater habitat. The effect of eutrophication on individual species occurrence is well documented and a number of species have been proposed as trophic indicators (Deevey, 1942; Hasler, 1947; Patalas, 1972). However, use of species indicator is particularly limited by regional specificity (Andhroson, 1974; Patalas, 1972). Hence, changes in the major groups of zooplankton have been proposed as a more meaningful indicator of trophic conditions (Gannon and Stemberger, 1978). The present study observed *Brachionus calyciflorus, B. forficula and Keratella tropica* are more dominant and frequently occurred throughout study period from Osmansagar. The presence of the above species indicates the alkaline and tropical climatic condition. $SQ_{B/T}$ ratio of the reservoir point out that it is mesotrophic. A few dominant species like *Brachionus angularis, B. calyciflorus*, and *Moina micrura* are indicators of eutrophication of Ameenpur tank and Bandam kommu cheruvu. Further it is evident on an analysis of the physicochemical profile of the habitats and it rich nutrients. Similar observation was also reported by Karuthapandi *et al.,* (2013c) in Safilguda tank, Hyderabad. Hence the study recommends these species could be used as bioindicators of eutrophic water bodies. Further a change in community composition of zooplankton will be helpful for further biomonitoring, better management and conservation of freshwater faunal diversity and the water quality.