DISCUSSION
DISCUSSION

The newly constructed Amravati University Reservoir is one such water body which is constructed to conserve water and for becoming self-sufficient in the daily water needs. But, once a water body gets established, it forms a definite ecosystem with its own physico-chemical characteristics and accordingly various fauna and flora develop into it and get established forming a complicated food chain.

In the present investigations, analysis of water samples from Amravati University Reservoirs was carried out during year 1999 and 2000 and the results are summarised in tables 1 to 71.
Temperature measurements are useful in indicating the trends of biochemical and biological activities in water body. Biological activities are enhanced by higher temperature. The rate of oxidation of organic matter is much greater during summer than in winter. During the period of present study water temperature followed more or less the similar trend as that of atmospheric temperature being low during winter and higher during summer and postmonsoon. These results are well in agreement with those of Ingole and Dhargalkar (1998).

Present results showed a range of water temperature 20.22°C to 31.5°C. In the present investigation temperature has shown a negative correlation with dissolved oxygen. At sampling spot No. 5, the water temperature has also shown a significant inverse correlation with conductivity, alkalinity, hardness, chlorides and cladocerans.

Hydrogen ion concentration expresses the intensity of acidity and alkalinity of water. It plays a limiting role in the growth of flora and fauna of the aquatic body. According to Basu et al. (1973), the measurement of pH has great importance because chemical and biochemical reactions in an aquatic body take place at a particular pH. According to Goldman and Horne (1983) H⁺ ion concentration controls the chemical state of many nutrients including carbondioxide, phosphate, ammonia and trace elements. Present results showed a range of pH 7.76 to 9.05. Throughout the period of investigation, it was noticed that pH values were always higher than 7 (neutral) which confirms the alkaline nature of the reservoir. During summer months (March and April) less pH values were recorded and during winter
months higher pH values were recorded (Table - 1). Sahai and Srivastava (1976) have reported the pH values ranging from 7.2 to 8.7. They also obtained lower values during summer and higher values in winter months. Meshram, (1996) has also reported lower pH values during summer and higher pH during rainy season. The present results of pH could be due to increased rate of decomposition at higher temperature. Sastry et al. (1970), George (1976), Saran (1980), Singhai (1986) and Gupta (1988) have reported a reverse type of seasonal variations as they observed increased photosynthesis during summer. A narrow range of pH and irregular fluctuations indicate feeble relationship between the two variables (Temperature and pH) as has been reported by most of the workers. Singh (1986) has obtained an insignificant direct relationship between water temperature and pH. It seems that the influence of temperature on other variables causes change in pH values. Table - 8 indicates that the pH shows almost an insignificant negative correlation with all the parameters studied except TDS, DO and transparency. It appears that the negative relationship obtained during the present investigation is a result of interactions between various physico-chemical variables.

Conductivity determines the total amount of ionisable salts in water. It is due to ionisation of dissolved inorganic solids. Seasonal fluctuations in this factor were caused mainly by variations in the ionic precipitations and the diluting effect of rains (Welch, 1952). Present results showed a range of conductivity in Amravati University Reservoir water from 37 to 107 \text{\mu mhos/cm}. According to Ellis (1937) the conductivity of the inland water should range between
150 to 450 μmhos/cm to flourish good flora and fauna. During the present investigations higher values of conductivity were recorded in summer months (Table-1). This may be due to evaporation of water which is in confirmation with the observations of Meshram, (1996).

Statistically, conductivity showed a significant positive correlation with DO, alkalinity and chlorides at all the spots and with Mg hardness and sulphates at spot No. 5 (Table 3 to 7).

Total dissolved solids when present in excess in the water may create an imbalance for the aquatic life. According to Reid (1961) total dissolved solids were important for the productivity of the aquatic environments. Present results showed a range of total dissolved solids 262.6 to 833 mg/l in water of Amravati University Reservoir. During the present investigation maximum values of total dissolved solids were recorded during June, September and October months which could be due to runoff from soil in catchment area during rains. Khan and Khan (1985) also found total dissolved solids concentrated during June. Turbidity and total dissolved solids having common effect in reducing light penetration thereby suppressing primary producers in the form of algae and macrophytes.

The primary effect of dissolved oxygen in water is an oxidation reduction reaction involving iron, manganese, copper and compounds that contain nitrogen and sulphur. Depletion of the level of dissolved oxygen approximately 80% saturation leads to an increased consumer complaints especially regarding taste, odour and colour of water. There are many disadvantages in distributing water.
low in dissolved oxygen, it is therefore recommended that water in a
distribution system should always contain adequate dissolved oxygen.
It is difficult to recommend a strict permissible value, however, other
constituents in the water influence its acceptable level.

Dissolved oxygen (DO) ranged between 4.12 mg/l to
8.76 mg/l in the Amravati University Reservoir. Its minimum values
were recorded in June 99 and maximum during December 99. Michael
(1969) has reported minimum values in June and maximum in April.
Munawar (1970) has observed higher values of DO in winter and lower
in summer. Qadri and Yousuf (1978); Jana (1979); Singh et al. (1980);
Meshram, (1996); Unni (1982); Saha et al. (1985); Saha and
Srivastava(1986) have reported similar seasonal variations in dissolved
oxygen content of water. But Bhatt and Negi (1985) have reported
higher values in summer associated with the rise in phytoplanktons
and low level during winters with depletion in planktonic population.
Meshram, (1996) have reported minimum values in January and higher
values in April. He was of the view that higher values of April were
due to higher photosynthetic activity by macrophytes and lower oxygen
consumption in respiration due to low population of zooplanktons. In
the present investigation minimum values of dissolved oxygen have
been recorded in rainy season and summer and maximum during winter
(November and December, Table 1). Hence, an inverse relationship
was obtained between water temperature and D.O. (\( r = -0.6423 \) see
Table 8; \( r = -0.7824 \) see Table - 3; \( r = -0.6328 \) see Table - 4; \( r = -
0.5589 \) see Table -7).

Transparency is an important factor in the
development and distribution of flora and fauna in the freshwaters. Pechlaner (1971) and Singh (1984) have used the transparency values as an index of eutrophy. The transparency of water is directly related to light penetration. George (1976) reported high turbidity due to degeneration of blue-green algae which reduced the light penetration, while Sreenivasan (1970) found even distribution of blue-green algae especially the species of *microcytes*, responsible for low transparency of water. In the present investigation transparency (E) varied from 6.624 cm to 14.072 cm in Amravati University Reservoir. The minimum transparency in rainy season may be attributed to the turbid conditions of water, influx of suspended silt with colloidal particles, high waves, wave action and cloudy weather. Singhai (1986); Meshram (1996); Bhatt et al. (1999) also recorded minimum transparency during rainy season. In the present investigation, reduced transparency is also recorded during March and April months which could be due to less water in the reservoir saturated with more zoo and phytoplankton. Barker (1970) reported that the density of phytoplankton was probably the principal factor affecting the Secchi disc value at Pupuka lake, Auckland.

Hammer (1971) pointed out that increase in transparency during the post-monsoon period in Quapalle lake, in Canada was due to continuous surface sweeping and run off in rainy season. George (1976) found the transparency variation from 47.4 cms to 85.6 cms in lower lake of Bhopal. Bhatnagar (1984) observed a mean value of transparency as 66 cms. Unni (1985) reported a range of 17 to 130 cms transparency, in different reservoirs of M.P. and Singhai (1986) reported a range of 25 cms to 162 cms transparency.
in newly constructed Tawa reservoir.

Statistically, transparancy showed a negative correlation with water temperature and chlorides (Table - 8) in the present study. Singhai (1986) and Hussainy (1967) have also reported inverse relationship between water temperature and transparancy and Singhai (1986) reported an inverse correlation with chlorides.

The absence of free carbondioxide is either due to its complete utilization in photosynthetic activity by the phytoplanktons (Shrenivasan, 1965; Sahai and Sinha, 1969) or being inhibited by the presence of appreciable amount of carbonates in the water (Sahai and Sinha, 1969). Further, the absence of free carbondioxide also indicates the absence of weeds in the reservoir. Boyd and Litchkoppler (1979) suggested that waters with total alkalinities between 26 to 150 ppm contain adequate quantities of CO$_2$ to permit plankton production for fish growth. However, the alkalinity values in the reservoir under study are reported to be very high indicating presence of appreciable amount of carbonates in the water for which free carbondioxide might have been utilized.

The term alkalinity is defined as the quality of ions in water which react to neutralise hydrogen ions. It is measured as carbonates, bicarbonates and total alkalinity. It is observed that carbondioxide is inversely proportional to carbonate and directly proportional to bicarbonates. It is also noticed that when either of the two (CO$_3$ or HCO$_3$) is absent the value of remainder is equivalent to that of total alkalinity.
The phenolphthalein alkalinity varied between 28 to 108 mg/l. The maximum values were recorded during summer, which might be the result of increased photosynthesis, increase in the productivity and rise in temperature. Singhai (1986) noticed the similar trends. Total alkalinity of water is usually caused by the carbonates, bicarbonates, hydroxyl ions and less frequently by borates, silicates and phosphates (APHA, 1998). Present results showed a range of total alkalinity 114.8 - 348.4 mg/l. Low values were recorded during rainy season. This may be due to greater dilution of reservoir water during rainy season. Sreenivasan (1974) and Kannan and Job (1980) recorded low alkalinity values due to influx of rain water. Unni (1972) reported low bicarbonate concentration by the surface dilution due to the rain in the Doodhadhari lake, Raipur (M.P.).

The presence of total hardness is governed by the contents of calcium and magnesium salts, largely combined with bicarbonate, carbonate, sulphate and chloride. Values of hardness in water above 60 mg/l show hard water condition and according to Barrett (1953) hard water is more productive than the soft water. Present results showed a range of total hardness 175.6 - 366.2 mg/l. Maximum values of total hardness were recorded during winter and summer and minimum during rainy season. Similar observations were noticed by Singh (1965); George (1976). The increase of total hardness of the reservoir water in winter may be attributed to the starting of evaporation of the surface water when summer comes. The decaying of zoo and phytoplanktons result into increased calcium and magnesium in the water.
In the present investigation, total hardness showed a significant positive correlation with magnesium hardness at almost all the sampling spots indicating that magnesium salts are the main cause of such high hardness of the water under investigation. However, a weakly positive correlation (Table - 8) was also seen between total hardness and CaCO_3 hardness (r = 0.6377), Calcium hardness (r = 0.6194) and chlorides (r = 0.6945). Total hardness in the present investigation showed negative correlation with pH (r = -0.6290). Similar results are quoted by Singh et al., 1980; Meshram, 1996.

Calcium is essential for metabolic processes in all living organisms. Lund (1965) suggested calcium, main effect on phytoplankton by buffering pH of water. The present results showed a range of 49.77 to 63.57 mg/l calcium hardness. The increase in calcium hardness during summer may be again attributed to evaporation of the surface water. The excessive dilution by heavy rains can be responsible for lowering down the hardness of water in monsoon (Bagde and Verma, 1985).

Boyd and Litchkopplar (1979) suggested that total alkalinity and total hardness values are normally similar in magnitudes and desirable levels of these parameters for fish culture generally fall within the range of 20 to 300 ppm. The reservoir under investigation has water with high values of total hardness and total alkalinities which are similar in magnitude but being very high, the reservoir water may not be suitable for fish culture. In the present
investigation from January onwards (upto April) total hardness was found to be more than 310.4 mg/l. The maximum value being 366.2 mg/l in the month of April (Table - 1). January to March are the months of growth of the major carps like rohu and catla. Therefore, though all other factors are suitable, still the water at present is not very good for intensive fish culture of major carps. But, during the natural process, the ecosystem under investigation may change its characters reducing the total hardness.

Magnesium is the important source of hardness to water. The demand for magnesium in metabolism is minor in comparison to quantities generally available in fresh waters. Singhai (1986) reported a positive correlation between magnesium and total hardness. In the present study also, positive correlation between magnesium and total hardness ($r = 0.9897$) was seen (see Table 8). Even at all sampling spots 1 to 5 significant positive correlation was seen in the present investigation (Table 3 to 7). The magnesium hardness was always observed lower than calcium hardness. Magnesium hardness ranged between 12.38 mg/l to 52.19 mg/l and calcium hardness ranged between 49.77 mg/l to 63.57 mg/l. However, comparatively higher values of magnesium hardness are seen in Amravati University Reservoir when compared to the magnesium hardness values of other reservoirs. It is this excess magnesium which gets percolated and is found in the wells of Amravati University campus making the well waters not so suitable for drinking. According to drinking water standards the magnesium hardness above 30 mg/l is not good for drinking. Chlorides occur in most water as the salts of
sodium and calcium. Studies on the seasonal variations of chloride contents in water bodies have been reported by many workers. Chlorides ranged between 7.6 to 31.59 mg/l during the present investigation on the Amravati University Reservoir.

Maximum values of chlorides are reported during summer and minimum values during rainy season. Precipitation and evaporation are the main factors governing fluctuations in chlorinity, former leads to dilutions and low levels of chlorides while later tends to have an opposite effect. The present observations are in confirmation to that of George (1961); Khan and Siddique (1970); Munawar (1969). Singh (1986) has also reported positive correlation between DO and chlorides. DO and conductivity, DO and alkalinity, DO and Mg hardness similar to the present observations. The presence of low chloride contents indicate the purity of water. Varma and Shukla (1970) found a relationship between chloride level and growth of phyto and zooplanktons. In the present investigation also a significant positive correlation is recorded between chlorides and total zooplanktons except at spot - 4 (Tables 3, 4, 5, 7 and 8).

Sulphates ranged between 0.004 to 1.06 mg/l. Maximum values are reported during June - 99 and minimum in December - 99. These values are negligible as Wetzel (1975) has mentioned that the usual range of sulphate ion in natural waters ranges between 5 to 30 mg/l. With the negligible quantity sulphate content in Amravati University Reservoir has not shown any correlation with any other parameters studied. Munawar (1970) has stated that
the presence of sulphur in water partly depends on the concentration of free carbon dioxide. Hence, absence of free carbon dioxide might have affected the sulphate content in the water under investigation.

The role of phosphorus and nitrogen for the phytoplankton production in tropical ponds (Heper, 1962; Subbamma and Ramasarma, 1992) is well known. The observed low values of nitrates and phosphates are not to be taken as indicative of low productivity. In the present reservoir, nitrates and phosphates were at low levels, but fall within the productive range as is evident from a very good biodiversity of zoo and phytoplanktons.

The overall observation with respect to nutrients like $\text{PO}_4^-$, $\text{SO}_4^-$ and $\text{NO}_3^-$ present in the water of Amravati University Reservoir, indicates the low trophic status of the reservoir during the period of investigation. However, the zooplankton studies have indicated that the reservoir has abundant zooplankton population apportioned between protozoa (32.41 %), rotifera (34.29 %) and ostracoda (16.65 %). In most of the tropical reservoirs the high abundance of zooplankton has been attributed to the low density of fish (Duncan and Scheimer, 1987) and low predation pressure (Fernando, 1980). It may be noted that the third tropic level in the plankton food chain is solely occupied by ostracod predators which prey on other planktons like protozoans and small sized cladocerans (Moina) and have become prominent among all the zooplanktons in Amravati University Reservoir.

Zooplanktons become a major link in energy transfer
at secondary level, plays a significant role in transformation of food synthesised by phytoplanktons to the higher trophic level. It is evident from tables 9 to 68 that composition and density of zooplankton vary from season to season among the four groups and depended on limnological characters of the reservoir. Arora, 1964; Rao et al., 1988, 1989; Pandey et al. 1993, Kodarkar, 1994; Katiyar, 1995, Ejasmont - Karabin, 1996; Katiyar and Belsare, 1997; Witek, 1998; Pathak, 1999; Bini et al., 1999 have studied zooplankton biodiversity of various lakes and reservoirs and were also of the opinion that limnological characteristics of any water body alter the zooplankton biodiversity inhibiting in it.

The maximum number of organisms of all the groups of zooplanktons are recorded during summer months in the Amravati University Reservoir. This might be attributed to the high water temperature and low water level. Though water temperature was maximum during rainy season yet the zooplankton population was comparatively very less in the rainy season. Dilution is the main factor which minimised the density of zooplanktons during rainy season. At high temperature, the multiplication, reproduction and metabolic activities of the zooplanktons are increased resulting in their abundant growth.

Jyoti and Sehgal (1979) reported that low dissolved oxygen, high free CO₂ and low water temperature reduce the zooplankton population. In Amravati University Reservoir these factors are favourable for better growth of zooplanktons. Both conductivity and TDS were maximum during summer in the reservoir
under study which might have also promoted the zooplankton's growth. According to Silva and Davis (1986) and Elewa (1985), the amount of dissolved solutes play an important role directly or indirectly to control the zooplankton's growth. In the University Reservoir, the high pH and alkalinity of water also indicates the high density of zooplanktons population at all the spots of the reservoir under present study (Tables- 3 to 8 ) as is evident from the significant positive correlation between total alkalinity and total zooplankton. Byars (1960) also reported that zooplanktons prefer the alkaline nature of water. Chlorides and phosphates were also maximum during summer months which might have favoured the growth of zooplanktons. Total zooplanktons in the present investigation have shown significant positive correlation with chlorides at all the sampling spots and also with phosphates at spot 1 and 2. ( Table - 3 to 7 ). In the composite water sample chlorides exhibited significant ( P < 0.01) positive correlation ( r = 0.8727) with total zooplankton. Similarly PO₄ showed moderately significant ( P < 0.05 ) positive correlation ( r = 0.7271) with total zooplankton ( Table 8 ). Dissolved oxygen and hardness (total and magnesium ) of water were also quite favourable for better production of zooplanktons during summer in the present investigation. Both these chemical factors of Amravati University Reservoir water have shown positive correlation with abundance of total zooplankton ( Table - 3 to 8 ).

The minimum number of organisms of all groups of zooplanktons ( except rotifers and ostracods ) were observed during winter ( October to December ) months in Amravati University Reservoir. This could be due to the low water temperature and
comparatively high water level than during summer which minimised the density of organisms (Takamura et al., 1989).

The rotifers, characterised by the presence of an anterior wheel like rotating corona, form large communities in Indian waters (Yousuf and Qadri, 1981; Saksena and Kulkarni, 1986; Ali et al., 1990; Dhanapathi, 2000). In the present study also rotifers dominated the Amravati University Reservoir showing presence of 64 species throughout the year 1999-2000. The changes in the physico-chemical, inter-specific and intra-specific composition, pollution level and the presence or absence of planktovorous and piscivorous fauna are some of the factors influencing rotifer species composition and structure in any ecosystem. Species richness, however, is a good indication of dynamic state of the communities. Penak (1957) has pointed out that when more than one genus of the same group occur in any water body, one genus is more abundant than the others. In the present study, *Brachionus* occurred as the most abundant genus with seven species. Green (1972), Sharma and Saksena (1981), Saksena et al. (1986); Singhal et al. (1989); Ali et al. (1990); and Kaushik and Saksena (1995) have also reported abundance of genus *Branchionus* in the various water bodies. *Keratella* was found to compete with *Branchionus* in the present study as far as the qualitative as well as quantitative abundance was concerned. Warren (1971) suggested that the continued persistence of a species at a particular location is a sure evidence of favourable environment for its existence, but its absence is not always indicative of unfavourable conditions.

Large number of rotifers in Amravati University
Reservoir is due to favourable parameters like conductivity, DO, alkalinity and chlorides as all these parameters have shown a significant positive correlation with the abundance of rotifers. Among biological parameters abundant protozoans also might have assisted the growth of rotifers. Similar observations have been made by several workers (Arora, 1964; Nasar, 1973; Sharma, 1980; Ejsmont - Karabin, 1996; Dhanapathi, 2000).

Among the total zooplanktonic organisms protozoans come second in the order of abundance (36.02%). They exhibited a bimodal pattern with a major peak in March/April and minor peak in August and the least population occurred in June. Abraham (1980); and Joshi (1987) reported protozoans throughout the year in Bhavasagar reservoir and Sagar lake respectively. Ayyappan and Gupta (1980) reported protozoans in February from Ramasamudra tank. Rao et al. (1987) reported protozoan population abundance throughout the year but least population occurred in July and August months. In the present investigation also, abundant protozoan population was observed with less number during June, July and August months. The abundant protozoan population could be due to favourable physico-chemical characters along with abundant diatoms and bacteria. Since they are primarily bacterial feeders, they serve as important indicators of organic pollution. In the catchment area of the reservoir under study, grazing of herds of cow was seen throughout the year. Further large number of visiting birds and wild animals like barking deer, hyna are found to come to the reservoir particularly during night. This might have resulted into organic pollution of the reservoir.
In the present investigation protozoans have shown strong positive correlation with conductivity, alkalinity, total hardness, magnesium hardness, chlorides, PO$_4$ (Table -1, Plates, 1 to 10 ) and negative correlation with water temperature and pH. Pathak (1999) has studied the seasonal fluctuations in population density of protozoans, has also reported negative correlation between protozoans and water temperature as well as protozoans and pH. Thus, the present results are in harmony with that of Pathak (1999).

Ostracoda comes third in the order of abundance (18.3%). Eleven species of ostracoda were recorded during the present investigation (Table 57 to 67 ). They showed almost constant population during winter and summer months i.e. from September to March and during rainy season their count was minimum. The abundance of this group provide very good food for the fishes. They are the intermediate hosts for tapeworms of water fowl. Their abundance in the present reservoir could be because of their reproduction habits, absence of predators like fishes and favourable physico-chemical conditions. These forms reproduce by parthenogenesis, by sexual as well as parthenogenetically and also by syngamy (Tonapi, 1980). Because of favourable conditions and abundant food they might have multiplied parthenogenetically in such a large number. Secondly, the absence of fishes (predators) might have further increased their population. Conductivity, DO, alkalinity, hardness, chlorides, phosphates and protozoans are some of the favourable parameters for their growth ( Table - 8 ).

Copepods (3.76%) come next in the order of
abundance after ostracods. They are represented by eight species of calanoids and seven species of cyclopoids. They go on increasing in their number from June to February and lateron decline. The genus *Diaptomus* is represented by six species and *Cyclops* by four species (Table 45 to 55). A negative correlation of copepod was observed with water temperature, transparancy, total dissolved solids and pH. The present results of copepod population are somewhat different than the results of earlier workers who have studied copepods in lakes and reservoirs. This difference might be because of the age of the reservoir. The reservoir under study is newly constructed and is yet to be established as an ideal aquatic ecosystem. Therefore, the reasons of less count of copepods could not be explained at least at this stage.

Cladocera forms an important component of zooplankton and forms the most dominant group of fish food organisms (Rao and Choubey, 1997). Sixteen different species of cladocera are recorded during the present investigation with dominance of *Bosmina, Daphnia* and *Moina*. Table 33 to 43 include details of the cladoceran species recorded from five different spots of Amravati University Reservoir. The annual periodicity of the cladoceran species seems to be highly variable depending on the reproductive cycles of these organisms, physico-chemical characteristics of the reservoir water and the gross climatic factors. However, they were the last in the order of their abundance (3.74%).

Investigations on phytoplanktons in fresh water is one of the most important steps in the complex analysis of aquatic ecosystem, because phytoplanktons being the primary producers
form the basic food source of the reservoirs which supports the aquatic animals. During the study period 60 species of phytoplankton belonging to three major groups were identified (Table - 69). During the study period, some problem creating phytoplanktons such as *Anabaena, Chlorella, Closterium, Cymbella, Fragillaria, Navicula, Nitzschia, Spirogyra, Synedra, Ulothrix* were noted (Table - 69) in the water samples collected. They create severe problems in water like taste and odour, colouration in water, corrosion in concrete structures, persistence in distribution system, interfering with coagulation. The forms like *Cosmarium, Pediastrum* and *Nitzschia* are responsible for high turbidity noted in the present investigation (Palmer, 1980). However, occurrence of such a large number of phytoplankton species is indicative of good productivity which may prove of great use for fisheries activities.

Macroinvertebrates are very important organisms in the aquatic environment and occupy almost all conceivable habitats, having wide range of habits. They are important components of food web in an ecosystem. Their interaction with other biotic communities and with abiotic factors within their microhabitat make them interesting and valuable indicators of water quality. They form exclusive stable diet of higher animals like amphibians, reptiles, birds and mammals (Tonapi, 1980; Thirumalai, 1999).

In the present study insects are represented by six orders (Table - 70). The majority of insect species found in average eutrophic body of water can tolerate a broad range of physico-chemical conditions of water which render them useless and some of them adapt...
and become indicators of the water quality (Roback, 1962). David and Ray (1966) observed that nymphs and hemipteran bugs were found inhibiting in the comparatively well oxygenated zone. Crosswell (1949) observed that Epheropteran nymphs and larvae, odonates, dipterans, beetales and water bugs require low oxygen, while some others like Caddis flies and May fly larvae require higher oxygen contents. Nebeker (1971) reported that increased temperature accelerate the emergence of aquatic insects. Macrophytic vegetation present around the reservoir also might have played a major role in their abundance.

Vinikour (1980) found that macroinvertebrate community was dominated by *Chironomus* larvae and insects other than chironomids were minor components of the fauna. According to Juergens et al. (1999), the chironomids form a significant portion of the macroinvertebrate fauna in most fresh water habitats. They are the important link in the food chain like algae, macroinvertebrate and the fish. Gaufin and Tarzwell (1956); Paine and Gaufin (1956) and Curry (1965) have reported that *Chironomus* larvae are able to live in waters with low dissolved oxygen concentration. The present results show that *Chironomus* larvae were frequently found at all sampling stations. Generally, the *Chironomus* larvae are considered as a common inhabitants of mud (Hynes, 1960) which is rich is organic contents. Adoni (1985) suggested that the presence of chironomids in high densities indicated highly eutrophic condition. However, the present study of Amravati University Reservoir has indicated very less nutrients and hence can not be eutrophic, but can be said as mesotrophic with very good density of zooplankton with very less
macro-predators or even the absence of fish predators.

The odonata nymphs include those of dragon flies *Boyeria, Hagenius* and damsel flies *Coenagrion* which are found in all freshwater habitats where there is abundance of oxygen and unpolluted water (Tonapi, 1980). In the present investigation, all the above mentioned odonata nymphs were observed during the period of investigation (Table - 70). According to Roback (1962), the odonata are not sensitive, but, they cannot tolerate high changes in pH and BOD. According to David and Ray (1966) being air breathers, most of the odonates can survive even in highly deoxygenated environment. The respiration also occurs through the body surface in Damsel flies nymphs.

Hynes (1970) pointed out that the trichopterans are delicate tool in assessment of pollution. The order trichoptera is an important and abundant component of the benthic macro-invertebrates community. It is in great conformity with the present study, as there were large number of *Caddis* flies larvae and *Hydropsyca instabilis* indicating unpolluted status of the reservoir at present. Dad (1981) also noticed that the trichopteran larvae were encountered only in clean waters. Roback (1962) was of the opinion that *Caddis* flies larvae appeared to be tolerant of organic loading but not toxic pollutant and they prove to be the most tolerant to very low pH.

During the present investigation period, the observations with respect to migratory birds were carried out during 1998-2000 and 70 different species of birds were recorded (Table -
Such a large number of species indicates that the reservoir is rich in aquatic insects, insect and other larvae, tadpoles, worms, crustaceans, flies midges, beetles, crabs, snails, zooplanktons and phytoplanktons. The migratory birds like little stint, grey wagtail, blacktailed godwit, white stork prefer insects and insect larvae as their food. Similarly, the migratory birds like Common teals, Common poachard, Wegen, Gargeny prefer shoots, tubers and seeds of aquatic plants, aquatic weeds indicating their abundance (Salim Ali, 1987).

The results of physico-chemical analysis of water of the selected five wells from Amravati University campus (Table 73 to 77) when compared with the standards prescribed by WHO (Appendix-III) give interesting inferences. In the case of pH, WHO Guide line value is between 6.5 - 8.5. As such, the pH of well - D (Well near Botany Department) and well - E (well behind Zoology Department) is above the prescribed range. It is 8.75, 8.7 and 8.6 during June, July and October - 99 in the water samples from well - D and 8.59 and 8.75 in August and October-99 in the water samples from well - E. Thus it is within maximum allowable limit as per ICMR (1975) (Appendix - III).

High TDS in water is mainly due to the presence of bicarbonates and carbonates and sulphates of calcium, magnesium and sodium. High TDS waters produce scales on water heaters and distillation assemblies in laboratories. Reverse osmosis, electrodialysis, ion-exchange and solar distillation may be effective processes for removal of high TDS from water.
So far as the hardness of water is concerned, most of the wells under study are with very hard water in reference to WHO guidelines (1993). The highest desirable value of hardness (as CaCO₃) by WHO is 200 mg/l. The hardness (as CaCO₃) of all the wells under study have water above 200 mg/l during most of the months of the year and the total hardness is also very high. Well - C (well from old garden) has very hard water with values above 500 mg/l during August and December - 99 (Table - 75). Thus the hardness of water of all most all the wells is above the permissible limits. The worst part of it is magnesium hardness which is above 30 mg/l (permissible level as Indian standard). The highest values recorded were 37.17 mg/l for well - A, 62.88 mg/l for well - B 54.24 mg/l for well - C, 46.43 mg/l for well - D and 67.80 mg/l for well - E. Mg hardness content, above 30 mg/l may produce gastro-intestinal irritation (Tiwari, 1999). Water quality guidelines for domestic uses are given in appendix - III.

The chloride is a pollution indicating parameter i.e. related to the sewage contamination with degradation products. Water having less than 10 mg/l of chloride is considered unpolluted (Bond Stratub, 1973). According to WHO 250 mg/l of chloride as an acceptable value on organoleptic considerations. The observed chloride values from all the well waters, though within the limits, can not certify the water as unpolluted. However, the chloride values obtained in the present investigation could also be due to excess bleeching of the water which is done every month. But, well - E which is not in use also has chloride values within a range of 20.53 mg/l to 55.06 mg/l. This well was not treated with bleeching powder for a single time during the period of investigation.
The permissible limits of Nitrate as per WHO is 10 mg/l with the highest nitrate value of 1.62 mg/l in well - C water, the same could be considered as safe for drinking. WHO does not prescribe any threshold value for dissolved phosphate. Probably the presence or absence of orthophosphate has little human hazard. The phosphorus in humans is supplied through diet. In wells from Amravati University Campus the high value of phosphate recorded was 1.77 mg/l from well - E and therefore could be considered safe for drinking, so far as phosphates are concerned. However, a proper treatment of the water can be carried out to make the water potable as per the standards prescribed by WHO, Indian standards, ICMR etc. According to the standards of ICMR the water from all wells under study have crossed limit of general acceptability with respect to the parameters, TDS, conductivity, pH, total hardness, hardness as CaCO$_3$, Mg hardness however, they are well within maximum allowable limits. However, according to Indian Standards, these parameters are beyond desirable limit.

On the basis of the present findings, it may be inferred that, Amravati University reservoir is suitable for fish culture. Among various chemical parameters, annual variation of pH (7.76 - 9.05); DO (4.12 - 8.76 mg/l) and carbonates (118.86 - 158.66 mg/l) appear as favourable for carp production though the total hardness is too high for four months of the year. Further, abundant zoo and phytoplankton with very good components of fish food chain are advantageous for the proper growth of the fishes. As such the availability of the present physico - chemical and biological parameters can be considered as optimum for fish culture (Alikunhi, 1966 and Jhingran 1982).
Therefore, in order to exploit this mesotrophic reservoir for fishery development, it is suggested that fish fingerlings (of advanced stage) of *Cyprinus caprio*, *Catla catla* and *Labeo rohita* may be introduced in the month of July and allowed to grow up to April, before harvesting. During this period of 9 to 10 months, fishes can grow successfully to table size.