Physico-Chemical Study

In an aquatic ecosystem, physico-chemical factors have profound influence and controls on diversity, biomass and spatial distribution of biotic communities in time and space. The infection level of any parasite depends not only on the changes in ecological stability of the host, but also on the certain external factors such as temperature, humidity, rainfall etc. In order to correlate the macro and micro climate, host stability, occurrence of parasite population etc. the study of physico-chemical parameter is undertaken. These factors have profound effect on the living system. The physico-chemical characteristics of water have direct impact on prevailing organisms as well as on human being. Keeping this view in mind the present study was started with a rational to find out seasonal or monthly variation and their effect on host and parasites.

Zooplanktons are used as food by many fishes and are very important in food chain i.e. tropic level of an aquatic ecosystem. They are serving as an intermediate hosts for many helminth parasites. Hence by keeping in mind the importance of planktons in the survival of host and also parasites, the study has been incorporated in the present work. This study will help for the researchers working on life cycle of helminth parasites by knowing the planktonic fauna prevailing in that water resources, acting as an intermediate host and the occurrence of parasites among the fish population.

3.1 Observations and Result

The physico-chemical analysis of water is most important aspect to determine the quality of lentic water ecosystems for its best uses to human and other animal consumption, agricultural purposes and plants. These also explore the hydro-biological and ecological interrelationship. The main object of physico-chemical analysis of water is to determine the status of medium. Since it contains dissolved and suspended constituents in varying proportion. They often have different physical and chemical properties along with the biological variations because of the water level showed fluctuations in different seasons.
The present fresh water bodies under investigations are man made reservoirs, which are tropical lentic water bodies in Nasik, Aurangabad and Nanded District. (M.S. India). The results and observations of physico-chemical properties of four sampling stations as follows:

1) Gangapur Dam- Station I
2) Ramkund, Panchvati, Nasik- Station II
3) Kaygaon phata- Station III
4) Vishnupuri Dam- Station IV

1. Air temperature (°C):

In the present investigation the air temperature was found to vary between 24.4 to 32.4 (°C) during the year of study period. It was observed minimum (24.4) in the month of Dec. 06 at station-II and maximum (32.4) in the month of April 07 at station II and IV during the year of study period. The yearly average values of air temperature at station I, II, III and IV are 27.73, 28.35, 28.33 and 28.35 during 2006-07. During winter seasonal mean values of air temperature at four sampling stations were 25.68, 25.73, 25.68 and 25.78 during 2006-07 respectively. During the summer season mean values of air temperature were 28.63, 30.45, 30.43 and 30.48 where as during the monsoon season the mean values of air temp. at four sampling stations were observed 28.88, 28.88, 28.88 & 28.8 respectively during the study period.

2. Water temperature (°C):

In the present investigation the water temperature was found to vary between 22.3 to 30.5 (°C) during the year of study period. It was observed minimum (22.3) in the month of Jan. 07 at station-III and maximum (30.5) in the month of May 07 at station I during the year of study period. The yearly average values of water temperature at station I, II, III and IV are 25.56, 26.25, 26.10 and 26.38 during 2006-07. During winter seasonal mean values of water temperature at four sampling stations were 23.58, 23.83, 23.35 and 23.95 during 2006-07 respectively. During the summer season mean values of water temperature were 26.9, 28.13, 28.18 and 28.38 where as during the monsoon season the
mean values of water temp. at four sampling stations were observed 26.2, 26.78, 26.78 & 26.8 respectively during the study period.

3. pH:

In the present studies it has been found that the pH varies between 7.3 to 8.8. The pH was found to be minimum in rainy and maximum in summer season. During the year of study period it was observed minimum (7.3) at station I during the month of Aug.07. and maximum (8.8) during the month of May 07 at station IV. The mean values of pH at station I, II, III and IV were 7.85, 7.80, 7.82 and 7.79 during 2006-07.

During winter the seasonal mean values of pH at four sampling stations were 7.63, 7.58, 7.65 & 7.53 during 2006-07 respectively. During the summer season mean values of pH were observed 8.25, 8.23, 8.25 & 8.3 where as during the monsoon season the mean values of PH were recorded 7.68, 7.6, 7.55 and 7.55 respectively during the study period.

4. Specific Conductivity (µ Mhos/cm):

The specific conductivity of present water bodies were ranging between 0.173 to 0.722 among four sampling stations. It was observed minimum (0.173) at station IV in the month of Nov-06 and maximum (0.722) at station IV in the month of Apr.-07. The mean values of conductivity at four different stations are 0.431, 0.428, 0.388 & 0.380 respectively during 2006-07.

During winter season average mean values of conductivity at station I, II, III and IV were 0.357, 0.402, 0.255 & 0.245 respectively during the study period. In the summer season the average mean values of conductivity were observed 0.479, 0.459, 0.524 & 0.555 respectively during the year where as during monsoon season the average values of specific conductivity were 0.457, 0.423, 0.386 and 0.340 respectively during 2006-07.

5. Turbidity (NTU):

Turbidity was ranging between 2 to 22 in the study year. It was observed minimum (2) at station II in the month of Feb. 07 and maximum (22) at station II in the month of Sept. 07. The yearly mean values of four stations were 13.5, 15, 15.42, & 15.08 during
2006-07. During the winter season average mean values of Turbidity at four stations were 13.75, 15.25, 14.5 and 14.5 during the year respectively. Average values of Turbidity in the summer season were recorded 12.25, 11.25, 13.75 & 15 during 2006-07 respectively where as the average values of Turbidity in monsoon season were observed 14.5, 18.5, 18 and 15.75 respectively during the study period. Turbidity were observed maximum in rainy season followed by winter and summer.

6. Total Dissolved Solids (TDS) (mg/lit):

   The TDS was ranging between 113 to 533 in the study year. It was observed minimum (113) at station IV in the month of Aug. 07 and maximum (533) at station IV in the month of May 07. The yearly mean values of four stations were 249.75, 250.42, 244.33 & 258.75 during 2006-07. During the winter season average mean values of TDS at four stations were 188.75, 195.75, 207 and 201.75 during the year respectively. Average values of TDS in the summer season were recorded 384.25, 382.75, 351.75 & 443 during 2006-07 respectively where as the average values of TDS in monsoon season were observed 176.25, 172.75, 174.25 and 131.5 respectively during the study period. The TDS were observed maximum in summer followed by winter and monsoon.

7. Dissolved oxygen (DO) (mg/lit):

   Dissolved oxygen from the Godavari River recorded between 1.9 to 11.18 during the study period (2006-07). It was observed lowest (1.9) at station II in the month of May-07 and highest (11.18) at station I in the month of Jul.-07. Yearly mean values of DO at four sampling stations were 9.27, 4.69, 8.86 & 8.22 during 2006-07 respectively. The seasonal mean values of DO at four different stations during winter season were 8.88, 4.95, 8.8 & 7.99 during the study period respectively. In the summer season the mean values of DO were recorded 8.67, 3.7, 7.80 & 7.29 during the year 2006-07 where as in monsoon mean values of DO were observed 10.26, 5.43, 9.98 & 9.38 respectively during the year 2006-07. Peak values of DO were observed in rainy followed by winter and least in summer season.
8. **Free CO₂ (mg/lit):**

In the present investigation the free CO₂ was observed between 2.1 to 13.8. It was observed minimum (2.1) in the months of Feb.-07 at station I, while it was observed maximum (13.8) during the month of Jun-07 at station II. The CO₂ values were found maximum in rainy season followed by winter and summer.

The yearly mean values of CO₂ at station I, II, III & IV were 5.92, 10.08, 7.03 & 9.72 during the study period. During winter season mean values of free CO₂ at four sampling stations were 5.23, 9.05, 6.03 & 8.6 during 2006-07 respectively. In the summer season average values of free CO₂ were recorded 4.1, 8.43, 5.4 & 8.3 where as in monsoon the mean values of CO₂ were observed 8.43, 12.75, 9.65 and 12.25 during study period respectively.

9. **Total Alkalinity (mg/lit):**

In the present investigation total alkalinity was ranging between 115 to 280. The total alkalinity of water was due to carbonates and bicarbonates. It was observed maximum during the months of winter followed by summer and monsoon. It was found lowest (115) during month of Oct. 06 at station III and highest (280) during the month of Jan. 07 at station II during the study period (2006-07). The yearly mean values of total alkalinity at four sampling stations were 174.75, 196.17, 188.5 & 196.42 respectively.

The seasonal mean values of total alkalinity during winter at station I, II, III & IV were 214.25, 220, 212 & 217.25 where as in summer season the mean values were observed 167.75, 221.5, 215.5 & 224.25 respectively. During the monsoon season the mean values of total alkalinity were recorded 142.25, 147, 138 & 147.75 in the year 2006-07 respectively.

10. **Total Hardness (mg/lit):**

The total hardness of water from four stations under investigation was varied between 94 to 187 during the study period. It was found highest (187) at station I during the month of May 07 and lowest (94) at station II during the month of Jan 07. The hardness of water was observed highest in summer followed by monsoon and winter. The
average mean values of total hardness at four sampling stations during 2006-07 were 151.58, 142.5, 142.92 and 145 respectively.

During winter the seasonal mean values of total hardness at station I, II, III & IV were 131.5, 110, 110.25 & 113.25 in the year 2006-07. In summer season the total hardness was recorded 172.25, 164.25, 169 & 167.75 where as in monsoon season the average values of total hardness was observed 151, 153.25, 149.5 & 154 during the study period respectively.

11. Chlorides (mg/lit):

During the period of investigation chlorides at four different stations was ranged between 12.21 to 54.33 during the study period 2006-07. Chlorides were recorded minimum (12.21) at station II in the month of Jun.07 and maximum (54.33) at station II in the month of Jan. 07 during study period. During the study period average values of chlorides observed at four stations were 36.75, 35.54, 34.54 & 34.18 respectively. The seasonal mean values of chlorides at four different sampling stations during winter season were 43.96, 43.40, 43.32 & 39.82 where as in summer season the mean values of chlorides were observed 46.11, 44.48, 40.70 & 43.77 during 2006-07 respectively. In monsoon period these values were observed 20.19, 18.73, 19.61 and 18.95 during the study period respectively. Chlorides were recorded highest in summer followed by winter and monsoon.

12. Phosphates (mg/lit):

During the present investigation phosphates were recorded between 0.021 to 0.432 during 2006-07. It was observed minimum (0.021) at station I in the month of Nov. 06 and maximum (0.432) at station IV in the month of May 07. The yearly average values of phosphates at four different stations were observed 0.070, 0.138, 0.181 & 0.321 during the study period respectively. The seasonal mean values of phosphates at four different stations during winter season were 0.058, 0.089, 0.222 & 0.281 during 2006-07 respectively. In the summer season the mean values of phosphates were observed 0.089, 0.21, 0.160 & 0.357 whereas during monsoon the mean values were recorded 0.062, 0.114, 0.16 & 0.326 during 2006-07 respectively.
13. Nitrates (mg/lit):

In the present investigation the nitrates were recorded 0.9 to 9.82 during the study period 2006-07. It was observed minimum (0.9) at station I in the month of Aug. 07 and maximum (9.82) in the month of Jun. 07 at station IV.

The mean values of nitrates at four different stations during 2006-07 were 4.41, 6.16, 6.55 & 7.71 respectively. The seasonal mean values of nitrates during winter were 4.98, 6.71, 8.46 and 8.27 where as in the summer season the average values were observed 5.69, 6.05, 5.81 and 8.26 during the study period respectively. The seasonal mean values of nitrates in the monsoon season were recorded 2.56, 5.71, 5.39 and 6.59 respectively during 2006-07.

Zooplankton Fauna:

Zooplankton is an important group of microorganisms found in aquatic ecosystems. These are microscopic and free swimming animalcule components of aquatic ecosystems which occupies an intermediate position in the aquatic food web. Many zooplanktons feed upon algae (i.e. producers) and in turn are being fed by carnivorous fishes in the food web. They play an important role in transferring the energy from producers to consumers and acts as links in the food web of aquatic ecosystems. They are also indicating the tropic status of water body and some of them are also acting as bio-indicators of organic and inorganic pollution of water body.

Monthly water samples from four different sites were collected to study qualitative and quantitative data of various zooplanktons. During the investigation the zooplanktons are studied for about one year from Oct. 2006 to Sept 2007. The sampling was done for the analysis of diversity, density and seasonal fluctuations of zooplanktons at four different stations. The sampling was done in each month between 8.00 am. to 10.00 am. Plankton samples were collected with the help of conical plankton net of nylon cloth of 200 mesh. per square centimeter to which a rimless test tube was attached at the bottom. Plankton samples were collected by towing the net through surface layer of water. The plankton samples were preserved in 4 % formaldehyde. These samples were studied for the diversity under research binocular microscope by using standard keys.
For the quantitative studies, samples collected by filtering 40 liters of water through the net. The collected samples were preserved in 4% formaldehyde in 100 ml bottles. The zooplankton density was determined with the help of Sedgwick Rafter Cell and by Drop method. On an average three counts were made for each sample and the main concentration were calculated for zooplankton forms. From this data the total count was calculated and various plankters were considered as units of organisms/litre of water. The study for diversity and density of zooplankton revealed that there are number of species belonging to different groups of zooplanktons such as Rotifera, Cladocera, Copepoda and Ostracoda.

**Diversity of Zooplanktons:**

Critical examinations of water samples reveals that near about 12 genera belonging to different groups of zooplanktons inhabit in the four stations under investigation. There are four genera belonging to Rotifera, five genera belonging to Cladocera, two genera belonging to Copepoda and single genus belonging to Ostracoda were observed during the study period.

Among the total zooplanktonic organisms group Rotifera was observed most diversified including four genera viz. *Brachionus, Keratella, Filinia, Lecane*. Five genera observed from group Cladocera were *Diaphanosoma, Chydorus, Simocephalus, Daphnia, Moina* and in Copepoda, *Mesocyclops & Cyclops* were recorded. Only single genus *Cypris* was observed belonging to the group Ostracoda.

The total population density of rotifer varied between 168 to 298 no. individual/litre during winter season. For the summer season, it fluctuated between 179 to 322 no. individual/litre and during rainy season varied between 18 to 175 no. individual/litre.

The composition of cladocera population showed distinct peaks in the winter season during the present study. Total six species were found among the cladocera. *Daphnia sp.*, *Moina sp.*, *Chydorus sphaericus* are more dominant than other individuals. The lowest population among cladocerans represented by *Diaphanosoma sarsi, Simocephalus vetulus*.  

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The total population density of cladocera varied between 142 to 227 no. individuals/litre during winter season. For the summer season, it fluctuated between 28 to 135 no. individuals/litre and during rainy season it varied between 38 to 145 no. individuals/litre.

The composition of Copepoda population showed distinct peaks in the summer season. Total three species of copepod were found. The population density of Copepoda varied between 127 to 175 no. individuals/litre. For the summer season, it varied between 152 to 244 no. individual/litre and during rainy season it varied between 28 to 212 no. individuals/litre.

The composition of Ostracoda population showed distinct peaks in the winter season during the present study. Only single species recorded among the Ostracoda group. The total population density of Ostracoda varied between 22 to 75 no. individuals/litre. For the summer season, it fluctuated between 2 to 32 no. individuals/litre and during rainy season, it varied between 12 to 41 no. individuals/litre.
3.2 Discussion

The water bodies present under investigation are also under the influence of different anthropogenic activities and other developmental factors of human being. The biotic components present in the water bodies are influencing by fluctuating different physicochemical parameters. Water contains dissolved and suspended constituents in varying proportion. The physicochemical environment of the water bodies found to be the limiting factors for controlling diversity and density of zooplanktons and other microorganisms. The present study helped to understand the effect of different physicochemical parameters and their interactions among themselves in deciding the final biotic and biotic environment of the water bodies.

For the present study four different sampling stations were selected. In the present work air temperature, water temperature, conductivity, Turbidity, TDS, dissolved oxygen, free CO$_2$, total alkalinity, total hardness, chlorides, nitrates and phosphates were studied for one year. Beside this diversity and density of zooplanktons also studied. In the following discussion except the temperature ($^\circ$C), conductivity (milli Mhos), Zooplanktons (No./L) all other parameters are expressed in mg/lit.

The temperature is one of the most important abiotic factors which regulate the self purification capacity of water bodies. Increase in atmospheric temperature increases water temperature. Particularly in shallow water bodies the water shows close relation with atmospheric temperature. Welch (1952). The temperature affects the biological reactions in water and chemical and biochemical reactions in the organisms within the water. (Trivedy and Goel, 1998). The temperature is the most important factor for calculating the solubility of the oxygen and the carbon dioxide, bicarbonate and carbonate equilibrium. Rise in temperature affect the physical and chemical properties of water. Increase in temperature of water body leads to decrease in dissolved oxygen of the water body which adversely affects the aquatic life. Rise in temperature leads to the speeding up the chemical reactions in water reducing the solubility of gases and amplifies the taste and odor.
In the present water bodies under investigation, water temperature followed the same pattern of seasonal change according to atmospheric temperature. During the study period (2006-07) atmospheric temperature ranges between 24.4 °C to 32.4 °C where as water temperature ranges between 22.3 °C to 30.5 °C. The difference between atmospheric temperature and water temperature was 1.0 °C to 3.2 °C throughout study period. Both atmospheric and water temperature were observed least in winter followed by monsoon and maximum in summer.

According to Bangale (1999) higher summer temperature is due to greater solar radiation, low level of water and clear atmosphere. Chavan R.J. (2002) observed similar range of temperature from Manjra project water reservoir in Beed district.

The temperature of water bodies under investigation ranges between 24.4 °C to 32.4 °C during the study year indicates favorable conditions for growth of fishes. Some species of fishes prefer temperature below 30°C. Major carps tolerates range of temperature between 18.3°C to 37.8 °C. Temperature below 16.7 °C and above 38 °C proves fatal to them. Jhingran (1993).

According to Das (1988) the upper lethal temperature limit of air breathing fishes like C. punctatus, C. batrachus lies between 39 °C to 41 °C. The aquarium species like P. ticto, P. sophore can grow better at 24 °C to 29 °C range of temperature.

Trivedy and Goel (1988) have reported that the temperature was higher in March and lower in November of few water bodies of Satara district. Mahajan Anjana and Kanhere (1995) noted that water temperature of pond at Barwani (M.P) was maximum (38.5°C) during May and minimum (13°C) during January. Mathew Varghese & Naik (1992) showed air temperature was maximum in summer (41°C-44°C) and winter (29°C-30°C) and water temperature recorded maximum (36°C) in June and minimum (20°C) in the month of December. He stated that summer increase and winter decline of surface water temperature indicates close parallel relation between air and water temperature in the water body.

The hydrogen ion concentration of natural water is an important abiotic factor which is linked with all process of life and also influences the colonization of aquatic macro fauna in the water body. Hutchinson (1957) opined that the neutral pH of the water
is regulated by the carbon dioxide and bicarbonates. The pH is affected not only by the
carbon dioxide but also by the organic and inorganic solutes present in the water. The
possible source of pollution or other unusual explanation is sought when values are
outside the 6.5 to 8.5 range, most fishes tolerate both wide ranges and rapid changes of
acidity and alkalinity as expressed on the pH scale (Lagler, 1978). According to Welch
(1952) pH is a very important factor and it cannot be ignored when other parameters are
in favourable range. It plays a role in the growth of flora and fauna of the aquatic body.
According to Goldman and Horne (1983) hydrogen ion concentration (pH) control the
chemical state of many nutrients including carbon dioxide, phosphate, ammonia and trace
elements.

In the present investigation, it was observed minimum 7.3 at station I during Aug. 07
and maximum 8.8 at station IV in the month of May 07. The mean values of pH at four
different stations were 7.85, 7.80, 7.82, 7.55 and 7.79 during 2006-07 respectively.

It was observed maximum during summer season, moderate in winter and least in
rainy during study period. According to Jhingran and Sugunan (1990), the pH range
between 6.0 to 8.5 were medium productive reservoirs, more than 8.5 were highly
productive and less than 6.0 were less productive reservoirs. In the present study the
average values were observed 7.3 to 8.8, this indicates the present stations are highly
productive type.

pH recorded in summer is associated with a high photosynthetic activity in water.
depends on the prevailing biological activity. High values of pH are usually associated
with higher photosynthetic activity which results in utilization of CO$_2$ from bicarbonates
alkaline pH in two water bodies throughout year due to high buffering capacity.

pH of water also plays an important role in the development and growth of fish.
Many species of fishes lives better comfortable in the range of pH between 7 to 8.6. The
result of present investigation showed that the pH range was observed between 7.3 to 8.8
which was favorable for growth. The range of pH between 6 to 8 is preferable to
aquarium species of genera like *Puntius, Devario, Brachydanio, Osteobrama, Rasbora, Chela* etc.

Electrical conductivity is the ability of a substance to conduct the electric current. Conductivity of water is an index of electrolyte content of water. It is due to ionization of dissolved inorganic salts. Seasonal fluctuations in Electrical Conductivity causes mainly by variations in the ionic precipitation and the diluting effects of rain waters (Welch, 1952).

In the present investigation, it was observed minimum (0.173) at station IV during Nov. 06 and maximum 0.722 at station IV in the month of Apr. 07. The mean values of conductivity at four different stations were 0.431, 0.428, 0.388 & 0.380 during 2006-07 respectively.

During winter season average mean values of conductivity at four stations were 0.357, 0.402, 0.255 & 0.245 respectively during the year 2006-07. In the summer season the average mean values of conductivity were observed 0.479, 0.459, 0.524 & 0.555 respectively. Where as during monsoon season the average values of specific conductivity were 0.457, 0.423, 0.386 and 0.340 respectively. It was observed maximum during summer season, moderate in monsoon and least in winter during study period.

Conductivity values were high due to contamination of water by sewage, domestic waste, industrial waste and high built of salts. The conductivity might be higher during summer due to increased chlorides and dissolved solids due to evaporation of water resulting in increased concentration of salts. Rise in electric conductivity is due to increased TDS observed by Megha Rai and Shrivastava (2006), Nalina and Puttaiah (2006). Similar results were noted by Trivedy and Goel (1988), Patil (2002).

value of conductivity in Summer and lowest in winter at Tank Morna in Sangali district and the lake in Ashti, Dist.Beed respectively.

Turbidity of the lake water ranged between 2-22 NTU. Turbidity values were high in monsoon due to the addition of silt load with the influx of monsoon run off and earthen bundh (Patil et.al., 2002, Pailwan and Muley, 2006). However, contrast results were reported by Thorat, 2000; Kadam et.al., 2005.

Total suspended solids are the solids present in the suspended state. High concentration of total dissolved solids increase water turbidity. This in turn decreases the light penetration and thus affects the photosynthesis by suppressing the primary producers in the form of algae and macrophytes. This in turn affects the micro and macro invertebrates, which are dependent directly or indirectly on plants for food requirements. Total solids in irrigation water can induce the formation of saline and alkaline waste lands. On evaporation, the salts are left behind on the soil surface in the form of a thin crust or fine border. High concentration of total dissolved solids increase water turbidity. According to Reid (1961) total dissolved solids will be playing an important role for the productivity of the aquatic environment. Dissolved solids vary qualitatively and quantitatively depending upon season, location and other factors. Rain water also contains 30 to 40 ppm dissolved solids. Welch (1952).

In the present study, it was observed minimum (113) at station IV in the month of Aug. 07 and maximum (533) at station IV in the month of May 07. The yearly mean values of TDS at four stations were 249.75, 250.42, 244.33 & 258.75 during 2006-07 respectively. During the winter season average mean values of TDS at four stations were 188.75, 195.75, 207 and 201.75 during the year respectively. Average values of TDS in the summer season were recorded 384.25, 382.75, 351.75 & 443 respectively. Where as the average values of TDS in monsoon season were observed 176.25, 172.75, 174.25 and 131.5 during 2006-07 at four stations respectively. The TDS were observed maximum in summer followed by winter and least in monsoon. High values of TDS in summer might be due to evaporation of water resulting in increased concentration of salts and in monsoon, it was due to addition of sewage, domestic wastes with the influx of monsoon run off and earthen bundhs. Similar results were recorded by Deshmukh and Ambore
All the organisms require oxygen for the maintenance of life. Dissolved oxygen in water is one of the most important biotic parameters to indicate water quality and its relation to the distribution and abundance of various algal species. The presence of $O_2$ in water is mainly due to diffusion from air and photosynthetic activity of organism like algae and submerged plants. Diffusion of $O_2$ in water from air depends on various factors like wind action, temperature, salinity etc.

The dissolved oxygen of water in low concentrations can kill fish and other organisms present in water. Low oxygen concentrations are generally associated with heavy contamination of organic matter. DO is an index of physical and biological process going in water. It is most important parameter indicating health of water body. DO in water is greatly influenced by the biological activity such as photosynthesis by green algae and plants or from air due to turbulence of water surface by the wind action which is dissolved in to water surface. The variation in DO depends upon temperature and other organic contents of the water body. Khatavkar, et.al., (1989), Bhosale, et al., (1994), Kadam (1999), Sanjay Sathe, et.al., (2001).

It was observed lowest (1.9) at station II in the month of May-07 and highest (11.18) at station I in the month of July 07. Yearly mean values of DO at four different sampling sites were 9.27, 4.69, 8.86 & 8.22 during 2006-07 respectively. The seasonal mean values of DO at four different sites during winter season were 8.88, 4.95, 8.8 & 7.99 respectively. In the summer season the mean values of DO were recorded 8.67, 3.7, 7.80 & 7.29 during the study period respectively where as in monsoon mean values of DO were observed 10.26, 5.43, 9.98 & 9.38 during 2006-07 at four different stations respectively. Peak values of DO were observed in rainy season followed by winter and summer.

High values of DO in rainy would be due to low temperature of water. The low DO in summer was because of its enhanced utilization of microorganisms in the decomposition of organic matter and high temperature. Trivedy and Goel (1988), Thorat.

Dissolved oxygen is one of the most important factors for the aquatic life. The need of DO is vary according to fish species. For cyprinid its range is favorable between 6 to 7 mg/lit. The present study showed the wide range of DO from 1.9 mg/lit. to 11.18 mg/lit. Maximum values of DO were observed in rainy season that were favourable for growth of carps. Alikunhi (1952) reported that DO between 3 to 5 ppm is quite favorable for most of the indigenous fishes. Present study reveals that the DO was always with a favorable range except at station-II. During unfavorable supply of oxygen, food intake is reduced, weight of fish reduces and total health becomes poor.

Free Carbon dioxide is one of the essential components of the aquatic ecosystems. In freshwater bodies its presence is mainly due to the respiratory activity of the aquatic organisms and also due to decomposition of organic matter. It is also present in the form of carbonates and bicarbonates. The amount of CO$_2$ in water mainly depends upon temperature, pressure and mineral contents of the water. Free CO$_2$ is used by algae and aquatic plants for their photosynthetic activity. The concentration of CO$_2$ differs in different water bodies depend on the basis of pH, temperature and other environmental factors.

The yearly mean values of CO$_2$ at four stations were 5.92, 10.08, 7.03 & 9.72 during the year 2006-07 respectively. During winter season mean values of free CO$_2$ at four sampling stations were 5.23, 9.05, 6.03 & 8.6 during study period respectively. In the summer season average values of free CO$_2$ were recorded 4.1, 8.43, 5.4 & 8.3 respectively at different sampling stations where as in monsoon the mean values of CO$_2$ were observed 8.43, 12.75, 9.65 and 12.25 during the year of study period (2006-07)
respectively. The CO₂ values were recorded maximum in rainy season followed by winter and summer.

Lagler (1978) mentioned that the amount of free carbon dioxide in water is important in fish management because it is perhaps the best single criterion of environment suitability for fishes. High concentrations of free carbon dioxide which are toxic to fish are usually accompanied by low values for dissolved oxygen. Free carbon dioxide in excess of 20 ppm. may be regarded as harmful to fishes, although lower values may be equally harmful in waters of low oxygen content (less than 3 to 5 ppm.). The absence of free CO₂ may be due to its utilization in photosynthetic activity. Sreenivasan (1974). Similar results were also observed by Chavan R.J.(2002), Abdar M.R. (2007), Khaire (2009).


Total alkalinity in water is usually caused due to the presence of carbonate and bicarbonate. According to Lagler (1978) total alkalinity in water depends on the geology of the region. The fish may be affected by total alkalinity because waters with low values are generally biologically less productive than those with high values of alkalinity.

It was found lowest (115) during month of Oct. 06 at station-III and highest (280) during the month of Jan. 07 at station II during the year of study period. The yearly mean values of total alkalinity at four sampling stations were 174.75, 196.17, 188.5 & 196.42 respectively. The seasonal mean values of alkalinity during winter were 215.88, Summer 207.25 and monsoon 143.75 respectively.

Total alkalinity was observed maximum during winter followed by summer and monsoon. Similar findings were obtained by Deshmukh (2001). According to Jhingran and Sugunan (1990) the highly productive reservoirs have the carbonate content more than 80 ppm. and total alkalinity more than 90 ppm. During the present investigation, the total alkalinity was more than 100mg/l. Hence, the present river is highly productive.
Hardness in water is due to the natural accumulation of salts from contact with soil and geological formation or it may enter from direct pollution by industrial effluents. The total hardness of water is mainly due to the presence of various salts of calcium and magnesium. Khulbe (1981), Prasad and Singh (1982), reviewed the status of Total hardness of water and its indirect role in the growth and occurrence of aquatic micro and macro organisms.

It was found highest (187) at station I during the month of May 07 and lowest (94) at station II during the month of Jan. 07. The hardness of water was observed highest in summer followed by monsoon and winter. The average mean values of total hardness at four sampling stations during 2006-07 were 151.58, 142.5, 142.92 and 145 respectively.

During winter the seasonal mean values of total hardness at four stations were 131.5, 110, 110.25 & 113.25 in the year 2006-07. In summer season the total hardness was recorded 172.25, 164.25, 169 & 167.75 at four stations respectively. Where as in monsoon season the average values of total hardness was observed 151, 153.25, 149.5 & 154 respectively at four different stations. The maximum values of hardness in summer may be due to presence of high concentration of carbonates and bicarbonates. Similar results were observed by Lendhe & Yeragi (2004), Thorat (2000), Chamundeshwari Devi (2001), Patil (2002), Sakhare & Joshi (2003), Abdar M.R. (2007), Khaire (2009).

According to Hutchinson (1957), Chloride as an important ionic factor as it is one of the essential ions in assessing the status of natural water bodies. Chloride ions are essential for plants and animals. The chloride concentration is higher in organic waste and its higher level in natural water is definite indication of pollution from domestic sewage.

It was observed lowest (12.21) at station II in the month of Jun. 07 and highest (54.33) at station II in the month of Jan. 07. Yearly mean values of Chlorides at four different sampling stations were 36.75, 35.54, 34.54 & 34.18 during 2006-07 respectively. The seasonal mean values of chlorides were 42.63 (winter), 43.77 (summer) and 19.37 (monsoon). Peak values of chlorides were observed in summer followed by winter and least in rainy season.
High values of chlorides in summer could be due to their concentration as a result of evaporative water loss. Lower values in rainy could be attributed to dilution effect and renewal of water mass after summer stagnation. Similar results were obtained by Yeole and Patil (2005), Khaire (2009).

Phosphorus is one of the major nutrients responsible for biological productivity. In natural water phosphates are present small quantities. Excess of phosphate mixed in to natural water through untreated domestic sewage and agricultural runoff. They are main nutrients responsible for the process of eutrophication that leads to ultimate environmental degradation. Kodarkar (1995).

In the present study, it was observed minimum (0.021) at station I in the month of Nov. 06 and maximum (0.432) at station IV in the month of May 07. The yearly mean values of phosphate at four stations were 0.070, 0.138, 0.181 & 0.321 respectively during 2006-07. During the winter season average mean values of phosphate at four stations were 0.058, 0.089, 0.222 & 0.281 during the year respectively. Average values of phosphate in the summer season were recorded 0.089, 0.21, 0.160 & 0.357 respectively. Where as the average values of phosphate in monsoon season were observed 0.062, 0.114, 0.16 & 0.326 during 2006-07 at four stations respectively. It was observed maximum during summer followed by monsoon and winter. Similar results were obtained by Wagh, N. (1999) and Salaskar & Yeragi (1997). Chavan R.J. (2002).

Nitrate is very important in measuring the pollution status of water body. An aquatic ecosystem in urban environment receives excess of nitrates through untreated domestic sewage and along with phosphates is responsible for the process called eutrophication. Kodarkar (1995). Its concentration in water increases due to addition of domestic sewage mixing of agricultural runoff etc.

In the present study, it was observed minimum (0.9) at station I in the month of Aug. 07 and maximum (9.82) at station IV in the month of Jun. 07. The yearly mean values of phosphate at four stations were 4.41, 6.16, 6.55, and 7.71 respectively during 2006-07. During the winter season average mean values of phosphate at four stations were 4.98, 6.71, 8.46 & 8.27 during the year respectively. Average values of phosphate in
the summer season were recorded 5.69, 6.05, 5.81 & 8.26 respectively where as the average values of phosphate in monsoon season were observed 2.56, 5.71, 5.39 & 6.59 during 2006-07 at four stations respectively. It was observed maximum during winter followed by summer and monsoon. Similar results were obtained by Wagh, N. (1999), Raghunathan, et.al., (2000).

In an aquatic ecosystem zooplankton plays an important role not only in converting plant food to animal food but also provide an important food source for higher organisms including fish. Thus, in any aquatic ecosystem zooplankton not only take part in transferring food from primary to secondary level but also switch over conversion of detritus matter into edible animal food. The zooplankton species having short life cycles were recognized by modern workers to be used traditionally on bio indicator of quality of water as they respond more quickly with the changes of environmental conditions.

In the present investigation the zooplanktons recorded from present water bodies have been found to be comprises of four major groups viz., Rotifera, Cladocera, Copepoda and Ostracoda. The study of diversity and density revealed that there are number of species belonging to 12 genera of different groups of zooplanktons are inhabiting different water bodies. There are four genera belonging to Rotifera, five genera belonging to Cladocera, two genera belonging to Copepoda and a single genus belonging to group Ostracoda. Many species of zooplankton were observed throughout study period but some were not observed regularly.

During the present investigation zooplanktons comprised of rotifera, cladocera, copepoda and ostracoda. The total zooplankton population was dominated by rotifers (39 %) followed by copepoda (30 %), cladocera (25%) and ostracoda (6%).

In the present investigation 10 species of rotifera has been identified from Godavari River. The seasonal mean values recorded during study period were 868.75, 1021.5, 309.5 in winter, summer and rainy seasons respectively. B. angularis, B. caudatus, B. calyciflorus, B.falcatus, Keratella tropica were dominant among the rotiferans. High population was observed during summer season followed by winter season and lowest population observed during rainy season. The species B. falcatus absent during Aug. to November while B. quadridentatus, Filinia longiseta, Lecane
bidenata were absent during rainy season. Brachionus sp. was dominated among rotifers during the study period. Population of Rotifers falls during monsoon. Similar results were recorded by Meshram (2005), Sabu Thomas & Abdulazis (1999), Chavan, et.al., (2004), Abdar M.R. (2007), Patil (1985). Higher population of Rotifers during summer may have indicated the pollution because of organic matter from direct entry of untreated domestic sewage from surrounding area. Presence of Brachionus and Lecane genera indicate pollution. Rotifers have been generally considered indicators of trophic status of water body. Abdar M.R. (2007). Low diversity of species and lower density during monsoon period was due to reflection of environmental stress. Sabu Thomas & Abdulazis (1999).


Seasonal fluctuations in Rotifer population are influenced by interrelated climatic and biotic parameters which vary from place to place. Several studies have been made pertaining to ecology of Rotifers in different water bodies of Indian sub continents by Jyoti and Sehagal (1979), Gupta & Sudan (1985), Dhanapathi (2000, 2001), Kour (2002), Pradhan, et.al., (2006), Mediha Shefiq & Zubair (2006).

Cladocera constitute an important group. The greater significance of cladocera in the aquatic food chain as food for both young and adult fish was emphasized much earlier (Pennak, 1978). In the present investigation the cladoceran population was maximum in winter season followed by monsoon and summer. The seasonal mean values recorded during study period were 711.75, 339.25, and 365.5 in winter, summer and rainy seasons respectively. Cladocerans were observed maximum during winter may be due to favorable temperature and availability of food in the form of bacteria. Abdar M.R. (2007), Jaybhaye & Madlapure (2006).
The total 6 species of cladocera were identified in the present study. *Diaphanosoma excisum, Moina sp. Daphnia sp., Simocephalus vetulus* were more dominant during the present study. *Chydorus* were observed throughout the study period on investigations. *Chydorus & Daphnia* were the major contributors. *Simocephalus & Diaphanosoma* were observed in less quantity during the year. Maximum population of *Moina* was recorded during winter.

According to Sugunan and Yadava (1991) *Daphnia sp.* and *Chydora sp.* were the dominant planktonic organisms among cladocerans in Nongmahir reservoir, Meghalaya. Chandrasekhar and Kodarkar (1997) have reported high density of *Moina micrura* and *Diaphanosoma sarsi* at mid-day there by indicating surface ward migration of this zooplankton in the day time.

The abundance of Cladocera in winter may be due to favorable temperature and availability of abundant food in the form of bacteria. Jaybhaye & Madlapure (2006). The studies have shown that the temperature of water was between 18.8 °C to 27.0 °C which might be have controlled hatching and growth rate of Cladoceran. Venkatraman (2000). The pH of water body ranged between 8.1 to 8.7 which might have positively affected the population. Venkatraman (2000).

In the present study the Copepodan population was maximum during summer season followed by winter and rainy season. The seasonal mean values recorded during study period were 747.25, 614.75 and 470.25 in summer, winter and rainy seasons respectively. The total 3 species of copepods were identified in the present study. *Cyclops sp., Mesocyclops leuckarti, Mesocyclops hyalinus* were more dominant during present study. The summer peak may be due to the abundance of diatoms and blue green algae, minor peak in winter may be attributed to the abundance of phytoplankton in the present study. The peak counts of Copepoda in summer observed by Patil (2002) and in winter by Meshram (1996),) Kamble & Meshram (2005). *Cyclops and Microcyclops* were found abundantly throughout study period. *Cyclops and Microcyclops* were observed abundantly might be due to the abundance of diatoms and blue green algae. Meshram (1996).
In the present study the Ostracods populations were maximum in winter followed by rainy and summer. The seasonal mean values recorded were 155.25, 110 and 50.75 in winter, rainy and summer seasons respectively. Only one species *Cypris decaryi* were identified in the present study. Peak numbers of *Cypris* was observed in winter indicates unpolluted water body where as their least count in summer indicates polluted water quality. The temperature of water body and availability of food may affect the population of Ostracoda.
3.3 Conclusion

The atmospheric temperature ranged between 24.4 °C to 32.4 °C where as water temperature was ranged between 22.3°C to 30.5°C throughout study. Water temperature was observed higher in summer and monsoon as compare to winter. Summer increase and winter decline of surface water temperature indicates close parallel relation between air and water temperature.

The pH of water bodies under investigation ranged between 7.3 to 8.8. pH showed minor seasonal variations. It was recorded maximum during summer and is associated with high photosynthetic activity in water. Present study shows pH range favourable for aquatic life, irrigation and domestic use. Turbidity ranged between 2 to 22. It was observed maximum in rainy season followed by winter and summer season.

The conductivity of present water bodies varied between 0.173 to 0.722 milli Mhos. The conductivity values were high in summer and least in winter. Conductivity values were high due to contamination of water by sewage, domestic waste and high built of salts. Rise in conductivity is due to increased chlorides and TDS because of evaporation of water resulting in increased concentration of salts.

Dissolved oxygen ranged between 1.9 to 11.18 mg/lit. at all stations under investigation throughout study. Peak values of DO were high in rainy season might be due to low temperature of water where as low DO observed during summer because of its inhaled utilization of micro organisms in the decomposition of organic matter.

In the present study the free CO₂ values varied between 2.1 to 13.8 mg/lit at all stations under investigation. The CO₂ values were recorded maximum during rainy season. High CO₂ level indicates higher organic load which might be due to incorporation of fertilizers and organic manure in water.

Total alkalinity values were recorded 115 to 280 mg/lit. throughout study. It was recorded maximum during winter and summer months. A decline in total alkalinity was observed during monsoon which may be due to dilution effect.

Total hardness was ranged between 94 mg/lit. to 187 mg/lit. at stations under investigation. Total hardness was observed maximum in summer followed by monsoon.
and least in winter. The maximum values of hardness in summer might be due to presence of carbonates and bicarbonates.

Chlorides was ranged between 12.21 to 54.33 mg/lit. High values of chlorides were recorded during summer. High values of chlorides recorded in summer may be due to increased organic decomposition of animal origin or it might be due to loss of water by evaporation.

In the present investigation phosphates and nitrates were recorded in minute quantities. Their concentration in water increases due to untreated domestic sewage and mixing of agricultural runoff.

The study of diversity revealed that there are 12 genera observed belonging to zooplankton groups Viz. Rotifera, Cladocera, Copepoda and Ostracoda. Among the total zooplanktonic groups, Rotifera was observed more diversified including four genera viz. Brachionus, Filinia, Keratella, Lecane. Cladocera was represented by five genera including Diaphanosoma, Simocephalus, Daphnia, Moina, Chydorus. The group Copepoda was represented by 2 genera viz. Mesocyclops and Cyclops whereas only single genus Cypris was observed belonging to group Ostracoda.

Maximum Zooplankton diversity was observed during summer months. Among the Rotifers Brachionus were dominated in all water bodies under investigations throughout study. Cyclops and Mesocyclops were dominant Copepods. Belonging to Cladocera, Chydorus and Daphnia were recorded dominantly.

The annual population density of zooplankton group was observed with decreasing order as Rotifera, Copepoda, Cladocera and Ostracoda.

Maximum density of Cladocera was observed during winter might be due to favourable temperature conditions and availability of abundant food in the form of bacteria. Favourable range (8 to 8.7) of pH also positively affects the population of Cladocerans.

The temperature of water and availability of food affect the population of Ostracoda. Peak number of Cypris was observed in winter indicates unpolluted nature of water body. Where as their least count in summer indicates polluted water quality. With few exceptions all the parameters were within the permissible limit as per WHO and ISI.