CHAPTER V

DISCUSSION
Physico-Chemical

The Anchar lake is situated in the low lying area (1583-1600 m) and in the flood plains of the river Sind which is the major source of water of the lake.

Depth (m)

During the course of investigation the depth of the lake fluctuated from a maximum of 1.74±0.01 during spring at site II to a minimum of 0.70±0.13 during winter at site VI.

Site VI is located in the lake where lake is fed by river Sind and the flowing waters of the river carries along its course sand and silt which gets accumulated at this site resulting in decrease in the lake bed. Further, the gentle slope at this site also helps in accumulation of sand and silt at this site. Site II is located in the centre of the lake and is the deepest portion of the lake. This site is also receiving flow from site I, V and VI, rich in nutrient contents thus accelerating rich growth of macrophytes.

Site I and V are located towards the littorals of the lake where in addition to human settlements, the SKIMS complex discharges much of its effluents and sewage into the lake leading to thick growth of macrophytes. Accumulation of decomposed vegetation and the silt coming from the
surrounding areas has resulted in raised bed of the lake. A depth of 2.75 m was recorded earlier by Zutshi et al. (1980) in the lake. Since the investigated lake has the maximum depth of 1.74 m, it can be considered as eutrophic lake (Rawson, 1955).

**Temperature (°C)**

In Anchar lake the water temperature varied from 4.8 to 27.8°C. In Anchar lake the mean seasonal water temperature was in the range of minimum 6.1±1.21 at site VI during winter 2006 and maximum 26.1±0.95 at site V during summer 2005. In overall terms, the water temperature do follow set pattern dictated by seasonal cycle i.e. maximum in July followed by gradual fall to its minimum in January and then an increase to its maximum in July.

When the temperature variations at various sites of Anchar lake were compared, it was found that site VI showed lower water temperature as compared to other sites. It may be because the water at this site is fast flowing from river Sind while at other sites water is almost standing.

At site V the temperature of water was found to be the highest because this site is rich in macrophytic growth and receives effluents from human habitation as well as from SKIMS hospital. Jolly and Chapman (1966), Venkateshwarlu and Jayanti (1968), Munawar (1970 a&b) and Mahadevan and Krishnaswamy (1983) recorded an increase in water temperature with addition of effluents. The high temperature at this site is also as a result of low water depth and consequently the volume of water in contact with air as observed by Zutshi and Vass (1971) and Pandit (1980) in other eutrophic water bodies.

Site II and III being infested with rich growth of macrophytes have temperature higher than site VI. Jamil (1990) and Dhillon et al. (1993 a&b) observed that the macrophytic plants tend to raise the water temperature of a water body by preventing the contact of air with water. Further seasonal
variations in water temperature has also been observed by Sarwar (1987), Rao (1955), Munawar (1970), Qadri and Yousuf (1978) and Shah (1988) in different water bodies of Kashmir, thus supporting our results.

Transparency (m)

In Anchar lake the values of transparency fluctuated from 0.21 m to 0.94 m. The mean seasonal values of transparency fluctuated from minimum of 0.22±0.01 at site VI during spring 2005 to a minimum of 0.93±0.01 at site III during winter 2005. At all the sites the light penetration was greatly diminished especially during spring because of silt load and fast flowing snow melting waters of river Sind (Zutshi et al., 1980). Further, results are also in consonance with the findings of Khan and Zutshi (1980) who reported turbid nature of water decreases light penetration in Nilnag lake. The high values of transparency at site III during winter is attributed to the fact that at this site the slow moving waters loose their turbid nature as the suspended material settles down or gets adhered to the vegetation coming on its way, with the result crystal clear waters at site III (Exit of lake) allows greater penetration of light.

According to Yoshimura (1933) the lakes showing transparency values of 1.50 m or less exhibit a tendency towards eutrophication. The transparency values recorded in the investigated lake indicate its eutrophic nature. Earlier Zutshi et al. (1980) recorded the transparency of the lake ranged from 0.25 m to 1.75 m. In present investigation, a decrease in transparency over these years is clear.

Dissolved Oxygen (mg/l)

Dissolved oxygen was recorded high during winter and low during summer thus showing inverse relationship with temperature. The mean seasonal value of dissolved oxygen fluctuated from highest of 9.0±0.7 at site VI during winter 2005 to a low of 0.6±0.4 at site I during summer 2005.
Lower contents of dissolved oxygen during summer is due to higher rate of decomposition of organic matter at higher temperatures. On the other hand, low temperatures during winter lead to decreased decomposition of organic matter thus results in higher oxygen content of water. Hutchinson (1957), Reid (1961), Vashist and Sharma (1975), Bhowmick and Singh (1985), Datta, et al. (1991) and Esmaeill and Johal (2005) have also given similar explanations for lower dissolved oxygen values during summer and high values during winter months. Reduction in the oxygen content of Kashmir lake waters due to *Salvinia* cover has also been reported by Zutshi and Vass (1971).

Site I and V are characterized by standing waters with rich growth of macrophytes. These sites receive sewage and sewerage from the adjoining inhabited areas and hospital sewage and effluents from SKIMS. This results in enrichment of water with organic matter, decomposition of which consumes much of dissolved oxygen leading to its sharp decline. Gonzalves and Joshi (1946), Vashist and Sharma (1975) also suggested that presence of organic matter lowers the dissolved oxygen content of water. Bhatt et al. (1988), Palharya and Malviya (1988), Rana and Palria (1988) and Goel and Chavan (1991) reported the lowering of dissolved oxygen content of water contaminated with sewage discharges.

Site II and III showed comparatively low dissolved oxygen values as compared to site VI but more than site I and V. These sites being the centre and exit of the lake and as such, does not receive any type of sewage and sewerage directly from the vicinity, but harbours intense growth of macrophytes.

Site VI is located where the Anchar lake is fed by the channels from river Sind and is characterized by shallow and flowing water and is free from any macrophytic vegetation. As this site is well aerated and the water holds
good amount of dissolved oxygen as there is no direct sewage and sewerage entering the lake. Earlier Sarwar (1999) recorded dissolved oxygen ranging from 3.2 to 13.6 mg/l during his study in 1983. Sarwar and Zutshi (1989) recorded an average of 9.8 mg/l. Thus the present low values of dissolved oxygen is an indication of a tendency towards the anoxic condition of Anchar lake.

**Hydrogen-Ion Concentration**

The pH values in the Anchar lake ranged from 6.8 to 8.8. The mean seasonal pH values fluctuated from a minimum of 7.0±0.32 at site 1 during spring 2004 to a maximum of 8.4±0.11 at site V during summer 2004. However, Zutshi and Vass (1978), Khan and Zutshi (1980) and Wanganeo et al., (1996) for Kashmir lakes and Mohanty (1975). Mishra (1988) and Narian and Chauhan (2000) for other lakes also reported high pH values during the summer months.

The pH values indicate water to be on alkaline side in the Anchar lake. This is attributed to the macrophytic infestation at several regions of the lake Sarwar (1987, 1991), Qadri and Yousuf (1978), Khan (1979). Wanganeo et al. (1996). Furthermore, the high pH value is probably due to high production of bicarbonates in the rock beds of the catchment area. Earlier records of Zutshi et al., (1980) and Sarwar and Zutshi (1989) also reported pH of this lake was towards more wide range of alkalinity.

**Specific Conductivity (μS cm⁻¹)**

The conductivity values in the Anchar lake ranged from 280 to 630 μscm⁻¹. Anchar lake is a drainage type of lake and overall conductivity values depict high ionic concentration ranging from mean seasonal minimum of 289±13.89 at site VI during summer 2004 to a maximum of 538±82.09 at site V during autumn 2005. The lower values recorded during summer is attributed to locking up of nutrients by macrophytes etc. and higher values during
autumn is attributed to release of nutrients by decomposition process of organic matter. The minimum value was recorded at site VI as it is almost free from human habitations and thus water is least contaminated.

The maximum value was recorded at site V as this site receives sewage from catchment area and the effluents from SKIMS hospital thereby increasing the organic and inorganic load in water. All these factors enrich the water with dissolved solids thereby increasing the conductivity values. Decomposition of organic matter further release free ions into the water thereby increasing conductivity values. Trivedi and Goel (1986), Sarwar et al., (1996), Bhatt et al., (1999), Sarwar (1999), Das et al., (2003) have also opined that higher values are related to the abundance of nutrients which are released due to decomposition.

The conductivity values recorded in 1983 range from 122 to 526 $\mu$scm$^{-1}$ (Sarwar, 1999). During the later study by Sarwar and Zutshi (1989) the average conductivity value recorded was 316 m in Anchar lake. However the conductivity values recorded during the present study clearly indicate that the ionic load is increasing in the lake due to various anthropogenic pressures. Thus it is concluded that conductivity values show a definite increase trend from summer $\rightarrow$ autumn $\rightarrow$ winter and spring and then a sharp decline from spring to summer.

**Total Dissolved Solids (mg/l)**

The total dissolved solids in Anchar lake fluctuated from 160-450 mg/l. The mean seasonal value of Total Dissolved Solids ranged from a minimum of 187±24.00 mg/l at site VI during summer 2004 to a maximum of 436±32 mg/l at site V during winter 2006.

The low values of total dissolved solids at site VI is because this site is free from human interferences and only contribution of Total Dissolved Solids at this site might be from the natural waters. Total
Dissolved Solids are represented by carbonates, bicarbonates, chlorides, phosphates, sulphates and nitrates of calcium, magnesium sodium and potassium (Trivedi and Goel, 1986). At site I and V the highest TDS values seems to be due to addition of sewage, sewerage and hospital wastes (James et al. 1990).

**Calcium (mg/l)**

The calcium concentration in Anchar lake ranged from 25.0 mg/l at site VI (October, 2004) to 60 mg/l at site V (March, 2005). The mean seasonal value of calcium ranged from a minimum of 26.3±1.61 mg/l at site III during autumn 2004 to a maximum of 56.5±3.04 mg/l at site V during spring 2005. The calcium concentration at all the sites has been recorded maximum in spring while as low values were observed during summer and autumn.

This is in accordance with the findings of Sarwar (1987) and Shyam Sunder (1988) who opined the rise in calcium contents during colder months of the year could be attributed to its high solubility at lower temperature. While as its utilization by the phytoplankton during hotter months has been observed by Swarup and Singh (1979).

The low values of calcium at site VI may be because of the reason that at this site the only source of calcium is the rocks from which the calcium salts dissolve in water while flowing over them. This has been suggested by Thomson (1952), Zutshi (1968). Zutshi et al., (1980), Kundangar and Zutshi (1985), Sarwar (1987), Sarwar and Wazir (1988), Sarwar and Rifat (1991). The low values at site III during autumn which is the exit of the lake is attributed to uptake of carbon dioxide during photosynthesis resulting in precipitation of calcium as calcium carbonate (Berner 1965).

The high values of calcium at site V is attributed to the flow of sewage and sewerage from the adjoining human habitation and effluents from SKIMS. The increase in calcium content due to addition of sewages has also been

**Magnesium (mg/l)**

The range of magnesium recorded in Anchar lake lies between 4.1 mg/l and 28.0 mg/l. The presence of magnesium follows the same trend as calcium but is low as compared to calcium. This may be possibly due to its uptake by the plants in the formation of chlorophyll-magnesium-porphyrin metal complex and in enzymatic transformations (Wetzel, 1975) thereby confirming 3:1 ratio far calcium and magnesium recorded for other water bodies (Kaul and Anand, 1978; Zutshi et al., 1980).

The mean seasonal values of magnesium fluctuated from a minimum of 6.1±2.77 at site VI during autumn 2004 to a maximum of 25.6±1.15 at site IV during spring 2005. Thus a definite trend of increase is observed from autumn to winter till it reaches to its maximum in spring and then a decline towards summer and autumn.

At site VI low magnesium value is attributed to zero human interference and the only source of magnesium at this site is the rocks from which magnesium salts dissolve in water while flowing over them. This has also been suggested by Zutshi et al., (1980) for Kashmir lakes. Trevedi and Goel (1986) and Meybeck et al., (1992). At site IV the magnesium content was recorded to be the highest and this is the site where from hospital wastes and sewage are directly poured into the lake. The contribution of sewage to magnesium contents of water has also been reported by Sing et al., (1969). Munawar (1970 a&b) and Syal (1996). The present values of magnesium seem to be much higher as compared to the values recorded by Sarwar (1999), and Sarwar and Zutshi (1989).
Total Alkalinity (mg/l)

The buffering capacity of water is measured by alkalinity, comprising of both carbonates and bicarbonates. Its concentration has been recorded maximum in autumn which is maintained till late winter after which it shows a sharp decline to reach minimum in summer. The range of total alkalinity in Anchar lake varied from 118 to 395 mg/l. However, the mean seasonal value ranged from 126±6.11 mg/l at site VI during summer 2005 to 353±50.68 mg/l at site IV during autumn 2005.

The low values of alkalinity in summer may be due to absorption of nutrients by the macrophytes which attain their maximum growth during this season. High values of alkalinity at site IV is because of the hospital wastes and sewage. Sarwar and Zutshi (1987 a&b), Sarwar (1991 a&b) and Valarmathi et al., (2002) also reported increase in alkalinity due to addition of sewage.

Qadri and Yousuf (1980 a&b) have suggested that \( \text{H}_2\text{CO}_3 \) predominates in water when pH is 6.0 or below 6.0, \( \text{HCO}_3 \) predominates when the pH is between 6.0 and 10 and \( \text{CO}_3 \) predominates when pH is above 10. Since the pH values were found in the range of 6.8-8.8 during present investigation suggesting that alkalinity was primarily due to bicarbonates. Zutshi et al., (1980) made similar observations on Kashmir lakes.

Moyle (1946) while classifying lake waters on the basis of the total alkalinity labelled waters having alkalinity upto 40 mg/l as soft, with 40 to 90 mg/l as medium and above 90 mg/l as hard. On the basis of this categorization, the Anchar lake can be considered as medium to hard water lake with values ranging from 118 to 395 mg/l. Sarwar and Rifat (1991) on the other hand suggested that total alkalinity level of 40 mg/l provides a dividing line between soft and hard water. Spence (1964) classified the lake as nutrient
rich if the bicarbonate alkalinity is more than 60 mg/l. Based on this classification, the Anchar lake can be considered nutrient rich and productive.

Earlier Sarwar (1999) recorded alkalinity of 58 to 275 mg/l in the Anchar lake in a study conducted in 1983. Sarwar and Zutshi (1989) recorded average alkalinity to be 149 mg/l. Thus the present study revealed higher values of alkalinity due to various anthropogenic pressures over these years.

**Chlorides (mg/l)**

The concentration of chloride in Anchar lake ranged from a minimum of 16.0 mg/l to a maximum of 89.0 mg/l. The mean seasonal values fall in the same pattern with a minimum of 20.2±2.00 mg/l at site VI during autumn 2004 and a maximum of 82.7±6.5 mg/l at site 1 during spring 2005. Thus the concentration of chlorides increased from autumn to winter till it attained its maximum in spring followed by decline towards summer till it reached minimum in autumn. Zutshi and Vass (1978) however, recorded lower chloride values during autumn in Dal lake, Kashmir. Furthermore Ownbey and Kee (1967) and Ajmal et al., (1985) recorded higher chloride values during the winter months and lower during summer.

In general, the high chloride concentration of the lake may be related to the presence of large amounts of organic matter of both allochthonous and autochthonous origin and sewage contamination. High chloride content was due to sewage contamination (Blum, 1957) and is related to organic pollution of animal origin (Haresh et al., 1944). The low values at site VI are because of no human interference while as site I is the littoral of the lake densely populated receiving heavy load of drainage containing raw sewage from the local inhabitants thus leading to high chloride content at the site. Our results have been also supported by Gonzalves and Joshi (1946), Zafar (1964), Cole (1975), APHA (1989) and Sarwar (1999). Hospital wastes are also instrumental in increasing chloride contents of water as has been observed by
James et al., (1990). It must be noted that the present study reveals high chloride content in the lake as compared to the reports given by Sarwar (1999) and Sarwar and Zutshi (1989) suggesting that the lake water has undergone progressive deterioration during the last few decades.

**Phosphorus (µg/l)**

Phosphorus is regarded as key nutrient in the productivity of aquatic ecosystems and during the present study maxima was recorded during colder months and the minima during hotter months.

**Ortho-phosphate Phosphorus**

The mean seasonal value for OPP was recorded to fluctuate from a minimum of 54±9.16 µg/l at site III during summer 2004 to a maximum of 186±22.86 µg/l at site V during winter 2006.

**Total phosphate Phosphorus**

Like OPP, total phosphate phosphorus also showed the maxima during winter and minima during summer. During study period the mean seasonal value fluctuated from 228±12.58 µg/l at site III during summer 2004 to 575±60.70 µg/l at site V during winter.

During summer months, aquatic plants like *Typha* spp., *Ceratophyllum demersum* seemed to grow vigorously. Due to high growth rate, phosphate which is one of the important constituent needed for growth is picked up thereby decreasing its concentration in water. This has also been reported by Welch (1952), Ruttner (1953), Hutchinson (1957), Zutshi and Vass (1978) and Bhatt et al., (1999).

The highest values of phosphorus at site V during winter is attributed to the agricultural run-off, domestic wastes and hospital wastes from SKIMS at this site. All these wastes are likely to contain large amounts of phosphates and thus increasing its concentration. Same type of increase in phosphate
content due to sewage has also been reported by Welch (1952), Blum (1956, 1957), Zutshi and Vass (1978), Sarwar (1991), Khabade et al. (2003) and Prasanna Kummari et al., (2003).

Sawyer (1947) reported that presence of TPP beyond 300 μgm/l result in algal blooms indicative of eutrophicated status of the water bodies. Vollenweider (1972) regarded phosphorus as key element in the process of eutrophication. The US Department of Interior Division of Technical Support (1969) reported that to prevent biological nuisance, the TPP concentration in the lake should not exceed 50 μgm/l. The TPP concentration in the Anchar lake remained above the threshold limit and hence really a nuisance for the lake.

Earlier Sarwar (1999) recorded TPP value to be between 100 and 250 μg/l during his study conducted in 1983. During the present study the TPP values are so high that the lake can be placed in the moderate eutrophic category (Strem, 1930; Vollen Veider, 1972). ISI (1986) has recommended maximum permissible limit of TTP not to be more than 500 μgm/l. The present data revealed that values are higher particularly towards littorals of the Anchar lake.

**Nitrate-Nitrogen (μg/l)**

Like phosphorus, nitrogen also plays a vital role in the productivity of aquatic ecosystems as it is used in the synthesis and maintenance of proteins. Further nitrate-nitrogen was found to be minimum in summer and higher in autumn and winter at all the study sites. However, the concentration of nitrate-nitrogen varied from a minimum of 170 μg/l at site VI during June 2004 to a maximum of 570 μg/l at site V during September 2005.

The mean seasonal values of nitrate-nitrogen in Anchar lake during study period ranged from a low of 200±30 μg/l at site VI during summer 2004.
to a high of 521±43.68 µg/l at site V during autumn. The minimum value recorded during summer season may be attributed to its uptake by phytoplankton and macrophytes as it is also a key element in the growth of plants. This is in accordance with the findings of Ajmal et al. (1985), Adoni and Joshi (1987) Vashist and Sharma (1975) who also observed low values during summer season.

The high concentration of nitrate nitrogen at site V during autumn and winter is attributed to the sewage from the local inhabitants agricultural run off and effluents from SKIMS rich in sewage and nitrate contents. Thresh et al. (1944), Jolly and Chapman (1966), Trivedi and Goel (1986) have also observed high nitrate contents in water bodies contaminated with sewage. James et al. (1990) reported an increase in nitrate concentration in waters as a result of hospital waste contamination in Tirucherrapalli, Tamil Nadu.

Inspite of rich growth of macrophytes, which pickup nitrates for their growth, the nitrate concentration remained very high which is attributed to rich input of this nutrient by multiple source of pollution at this site. According to Ali Kunhi (1957) presence of 60-100 µg/l of nitrate nitrogen indicate water to be highly productive. Nitrate-nitrogen is considered to be the primary factor for enrichment of waters. In view of these statements, the Anchar lake may be regarded as a highly productive and nutriently rich water body.

Earlier Sarwar (1999) recorded nitrate-nitrogen concentration ranging from 20 to 360 µmg/l during the study carried out in 1983 while Sarwar and Zutshi (1989) recorded an average value of 91 µgm/l. A comparison with the present study clearly depicts that nitrate-nitrogen concentration has increased due to anthropogenic pressures especially towards banks of the lake.
Ammonical-Nitrogen ($\mu$g/l)

In the Anchar lake ammonical-nitrogen ranged from 195 to 690 $\mu$g/l. The mean seasonal values of ammonical nitrogen ranged from $214 \pm 7.93 \mu g/l$ at site VI during spring and summer 2004 to $660 \pm 26.45 \mu g/l$ at site V during autumn and winter months. Hence concentration showed an increase from spring to summer till it reached maximum in late autumn, followed by decline till it attained its minimum in summer.

The low values of ammonical nitrogen during spring and summer at site VI is because, whatever ammonical nitrogen is present, besides the natural source comes by microbial decomposition and excretory products of the biota present at this site. Wetzel and Likens (2000) and Bhatt et al., (1999) also suggested that ammonical nitrogen is added by microbial decomposition and excreta of biota present in water.

High concentration of ammonical nitrogen at site V is attributed to the flow of effluents from SKIMS, sewage from local inhabitants and agricultural run-off from the adjacent fields and floating gardens. Thresh et al., (1944), Trivedi and Goel (1986), Sarwar (1991) and Bhatt et al., (1999) also observed high concentration of ammonical nitrogen in waters contaminated with sewage. Further, James et al., (1990) also reported high ammonical-nitrogen contents in hospital wastes. Earlier Sarwar and Zutshi (1989) recorded average value of 160 $\mu$gm/l for ammonical-nitrogen which is much lower than the values recorded during the present study thereby showing concentration of ammonical-nitrogen on its rise.

Free Carbon Dioxide (mg/l)

In the Anchar lake, free-carbon dioxide varied from minimum of below detection level at many sites to a maximum of 60 mg/l at site VI during June 2005. Increase in free-carbon dioxide during summer can be attributed to the decomposition of bottom materials and to the lakes shallowness. Previous
studies regarding pCO$_2$ measurements suggest that respiration and decomposition of organic sediments are the primary sources of carbon dioxide for lakes (Striegl et al. 2001). A model predicting lake gases (CO$_2$ and O$_2$) in temperate lakes based upon plankton biomass suggested that there is a base line respiration in water column fueled by allochthonous carbon, which is independent of phytoplankton production (Delgiorgio et al., 1999). Further studies have reported that free carbon dioxide shows remarkable change from hour to hour as the activity of the green plants varies with the amount of sunlight (Tressler et al., 1930).

**Fish**

After examining the fish hosts collected from Anchar lake, the helminth parasites recovered were cestodes, trematodes and acanthocephala.

**Cestodes**

Two genera of cestode viz., *Adenoscolex* and *Bothriocephalus* were recovered from fish hosts of Anchar lake. *Adenoscolex* spp.

As per the present investigations, the highest prevalence of *Adenoscolex* infection in fish was recorded in spring followed by winter. The results were in accordance with the findings of Kennedy (1969) who reported that *Caryophyllaeus laticeps* exhibits a well defined seasonal cycle in its definitive host, the dace *Leuciscus leuciscus*. He observed that the infection of fish is restricted to cold winter months and the parasite matures in spring and winter before disappearance in summer. Further Kennedy and Walker (1969) have shown experimentally that at low temperature *Caryophyllaeus laticeps* is better able to establish itself in the Dace and survives for longer periods than at high temperatures, thus supporting results arrived during the present investigation. Williams and Dennis (1979) while working on seasonal incidence of parasites in white suckers reported that the prevalence and mean intensity of *Glaridaea*
laruci and G. castastomi in Oyster river hosts was highest in spring (1975-76) and winter (1976-77).

According to Dhar and Peerzada (1992), Adenoscolex oreini showed a seasonal cycle in maturation Juveniles, Post-juveniles and sexually mature adults during different seasons. Juveniles were abundant during September while the adults were abundant during late winter and spring thus supporting our results. Furthermore they related the change in the infra population densities of Adenoscolex oreini with the change in water temperature. According to Anderson (1986) the seasonal incidence was related to host feeding habits and temperature dependent immune response which may have accounted for the death rate of adult parasites.

In nature embryogony occurs in summer and development in the intermediate host in the fall and winter. Fishes feed intensively after the winter starvation, eating many tubifexes – the parasite intermediate hosts. Derzhavin (1918) and Dogel and Bykhovskii (1939) observed mass Caryophyllaenus infection in spring thus supporting the present observations. The same results have been observed by Wunder (1939) in artificial carp ponds. They explained this regularity by the absence of Tubifex from the hibernating places, and their presence in the fattening and breeding ponds where failing other food, the carp feed on them, thus supporting the present observations.

*Bothriocephalus* spp.

During the present investigation the prevalence of cestode-Bothriocephalus was observed to be highest during autumn and lowest during winter months. Similar results were given by Nakajima and Egusa (1977) in cultured carp where highest prevalence was reported in autumn season and infection started to decrease in winter months. Granth *et al.* (1983) reported that prevalence and density of B. achielognathi in its fish host, was lowest during
summer months, sharply rising in autumn and peaked by early winter, after which it began decline thus supporting results arrived.

Amin (1978) attributed incidence of infection with feeding habits of the fish and availability of intermediate host in the habitat. Mezhzherin (1988) gave the importance of Copepods, which were responsible for the transmission of the Bothriocephalus in fishes. Nakajima and Egusa (1977) while working on the cultured carp in Sanami district Japan discussed the role of temperature on the hatching of eggs and reported that no coracidium formation occurs during winter and spring seasons, thus attributing the lowest incidence of Bothriocephalus infection in these seasons, thus supporting present investigation.

Trematodes

Two genera of trematode parasites viz., Diplozoon and Clinostomum were recovered from fish hosts of Anchar lake.

Diplozoon spp.

During the present investigation the highest prevalence of monogenean trematode, Diplozoon was observed during summer and early autumn and subsequent decrease during cold winter months. According to the findings of Layman (1948, 1951) the developmental stages in case of Diplozoon is completely arrested at a temperature of 4°C. The optimum temperature for Diplozoon vastator varies between 24 and 26°C. At that temperature the egg production is at its peak. According to Bauer (1953) embryonic development takes 3-5 days and hatching takes place during the warm period of the day. The results observed in the present study are also in accordance with the early investigation of Zeller (1872) about the impact of Diplozoon paradoxum on cyprinid fishes where the author observed that the reproduction of the worm is temperature dependant and functionless at low temperatures of winter. Production of eggs begin in spring with rise in temperature, reaches its peak in summer. Dogiel and Bykhovsky (1939) attributed decrease in the incidence of
Diplozoon to a decrease in the number of intermediate or final hosts. Mo et al. (1997) also arrived at the same conclusion that the prevalence and intensity of Gyrodactylus derjavina increased and decreased correspondingly with the rise and fall in temperature. Further the observations are supported by Nybelin (1925) Nordquist (1925) and Wunder (1929) who opined that Dactylogyrus vastator disappeared in winter and the new infection started with the eggs which survived. Thus it can be concluded that temperature plays an important role in the occurrence of Bothriocephalus and low temperature of winter makes the reproductive system of the worm functionless.

Clinostomum spp.

During the present study period the Clinostomum infection was of low intensity and highest prevalence was observed in spring followed by summer and low in winter months. The results are in agreement with the findings of Hazen and Esch (1978) who reported Clinostomum infection in Micropterus salmoides varied seasonally, being highest from January to June till it reached maximum, then leading to a steady decline in December. Shingin (1957) found adult Clinostomum only in the spring and not in other seasons. According to Khidr (1990) Enterogyrus cichlidarium in Tilapia nototica showed the highest prevalence and mean intensity in spring and the infection was surprisingly low in winter, thus supporting our observations. Grabda Kazubska (1974) noted occurrence of adult C. complanatum in herons in Poland. However in Lichenskie lake, near Konin, in Central Poland, the water was utilized in cooling system of a power station and had an average water temperature of 7.7°C in February and 29.16°C in July which lead to hatching of the eggs of C. complanatum and the occurrence of metacercariae of C. complanatum in Perca fluviatilis and Rutilus rutilus. Dubonina (1949) found the metacercariae of Clinostomum species in Cyprinus carpio in the Volga delta, USSR in the spring of 1941, and at no other time (Spring, Summer 1940, Winter 1941). Molnar 1966 found one metacercaria of C. complanatum
in *Gymnocephalus caruva* at lake Balaten, Hungary in June 1961, and in no other months, thus supporting results arrived.

**Acanthocephala**

A marked seasonal occurrence was shown by two genera of Acanthotephala viz. *Pomphorhynchus* and *Neo-echinorhyncclus*. During the study period prevalence of *Pomphorhynchus* was found throughout the year with peaks during spring followed by summer months while as the highest prevalence in case of *Neo-echinorhyncclus* was recorded during autumn followed by late summer and early winter. Andryuk (1979), while working on seasonal dynamics of Acanthocephalan infection of fish, observed that infection was highest (47.5%) during spring season. The *Neo-echinorhyncclus prolizoides* studied were mostly recruited during late summer, early autumn, reached sexual maturity by spring and continued its simultaneous activity and growth through summer into the following autumn (Amin, 1986). The author observed the recruitment of *N. cylindratus* in late autumn and summer. The author also observed that the intensity of infection increased from low in the autumn to higher levels in warmer months and reached a maximum usually in summer after studying the ecology and host relationship of *P. bulbocollis*. Muzzal and Wilbur (1978) have observed that the prevalence of *Neo-echinorhyncclus saginatus* was high above 44% (in all months sampled) and fluctuated irregularly throughout the sampling period. In (1975, 1976) the prevalence declined from high in June to low in January and March and then exhibits a tendency to increase again towards July. Amin (1986) reported *Leptorhynchoides thecatus* from *Micropterus salmoides*, the author observed that the egg presence, worm recruitment and maturation appear to occur throughout the year with maximum recruitment in the autumn while as maturity and reproduction in spring and summer.

Brown (1989) reported the incidence of *P. leavis* in its intermediate host and preferred definitive host (*Leuciscus cephalus*). Cystacanths were
available in all seasons, but rate of parasitic growth, maturation and mortality but not establishment increased with water temperature. *Channa striatus* shows greater proportion of infection with *Pallisentis ophiocephali* in spring and males are more heavily infected than females, as reported by Khan *et al.* (1991) while working on acanthocephalan parasites of *Labeo rohita*. Seasonal variations in incidence of acanthocephantians have been linked with many ecological factors including water temperature, feeding behaviour and diet of the host (Tedla and Fernando 1969). Mann (1971) observed *N. rutilii* appear from middle of November onwards, grow up in three months and again disappear from the intestine after 4-4½ months. Tedla and Fernando (1969) observed incidence and maturation of *E. salmonis* in yellow perch in the Bay of Quinte, Lake Ontario, and marked a seasonal cycle related to water temperature. The author also reported that the fish became infected in autumn thus supporting their observations. Moravec (1984) found that *N. rutilii* in carp, *Cyprinus carpio*, acquire new infections mainly in autumn, thus in corroboration with our results. Trejo *et al.* (2000) reported that the pattern of infection shows seasonality with recruitment in winter and reproductive period during spring and summer. There was no significant difference between proportion of male and female worms. The percentage of gravid female acanthocephalaus increased with temperature.

**Amphibian**

After extensive study of amphibians for helminth parasitism, cestode, trematode and nematodes were collected from them.

*Nematotaenia* spp.

During the present study highest prevalence mean intensity and relative density of *Nematotaenia* species was observed in summer followed by autumn and spring. This is in accordance with the findings of Vashetko *et al.* (1999) who reported *Nematotaenia dispar* in the small intestines of toads irrespective of the type of habitat, mainly in summer and autumn. Yildirimhan *et al.* (1999)
reported presence of *N. dispar* in *Bufo viridis* while studying heminth parasitism of *Bufo viridis* (L). *N. dispar* was found to be the most dominant species of cestodes, parasitizing species of Bufonidae, ranidae and hylidae (Al-Sorkhy and Zuhair, 2003). *N. dispar* covers broad geographical region throughout the countries of North Africa, middle east, Europe, India and South-east Asia (Jones, 1987). Another species *N. chantalae* was reported from *B. bufo* in Morocco, Algeria and Yemen (Soler, 1945).

**Ganeo spp.**

The parasite was recovered from the stomach wall of amphibian hosts. The intensity of infection was higher during autumn followed by spring and summer. A higher prevalence of *Ganeo* spp. in frogs has been earlier reported by Sharma *et al.* (1996). Further, the parasite has been reported to cause pathogenecity to the stomach wall causing desquamation, ulceration and necrosis (Sinha and Sinha, 1989).

**Rhabdias spp.**

During the present study the parasite was found to harbour lungs of the hosts especially during summer and autumn. The results are in corroboration with the findings of Goater and Ward (1992) who reported presence of the parasite in all areas of the world where its hosts species of frogs and toads occupy. The author reported that these are parasitic in lungs and deposit their eggs within the lungs. Vashetko and Siddikov (1999) while studying distribution of helminths in toads reported this species as most widespread helminth spp., found in 191 toads out of 272 examined. The author reported intensity of infection more in areas with high anthropogenic load than areas with less anthropogenic load. Individuals without infection of helminth were rarely found (3%). Goldberg *et al.* (1995 b) reported *Rhabdias* species from lungs of *Bufo marinus* from Brazil and Guatemala. Furthermore, the level of infection was found 63% (Kloss, 1971) similar to that reported by Linzey *et al.* (1998) for species collected in Bermuda (67%). Gendron *et al.*
(2003) studied infection dynamics of lung worm *Rhabdias* species in adult leopard frogs (*Rana pipiens*) exposed to a mixture of agricultural pesticides and reported high concentrations of pesticides leads to establishment of twice as many adult worms in the lungs of frogs 21 days post infection. Furthermore, it was observed that lung worms mature and reproduce earlier in frogs exposed to pesticides compared to frogs that were not exposed to pesticides.

**Cosmocerca spp.**

The parasite was reported from the first half of the gut. During the present study *Cosmocerca* species were found in amphibian hosts with high prevalence in autumn followed by summer and spring. Same results have been observed by Vashetko and Siddikov (1999) while studying ecology of toads on the distribution of helminthes and recorded this nematode in toads irrespective of the level of anthropogenic load. Further, hosts were mostly infected during autumn.

**Duck and Goose**

After extensive study of bird hosts viz., duck and goose for helminth parasitism, different species of parasites belonging to cestodes, trematodes, nematodes and acanthocephalans were collected from them. Further, the ecto parasites collected from both the hosts dominated the parasitism in the hosts.

**Notocotylus spp.**

*Notocotylus* species was recovered from the caeca and rectum of the host (Goose) of Anchar lake Kashmir with highest records of infection during autumn followed by summer but with low prevalence in colder months. These results are as per the findings of Kullisic *et al.* (2004) who studied trematodes of the Eurasian Coot (*Fulica atra* L) in the Belgrade area. The author reported *Notocotylus attenuatus* from the caecum of the host and considered *N. attenuatus* as most wide spread trematode species 22.88% after *Echinostoma*
sarcinum and Notocotylus pacifera. Further, it is reported that rate of infection depends on the age of the host as young birds were found with six species of trematodes while as older birds with nine. Buscher (1965), Wilkinson et al. (1977) and Broderson et al. (1977) reported *N. attenuatus* to be more frequently present in ducks collected in the fall. Turner and Threlfall (1975) while studying metazoan parasites of green winged teal and blue winged teal from Eastern Canada reported this parasite in 31% of *A. crecca*.

Crichton and Welch (1972) reported *N. attenuatus* from both adult and Juvenile mallards, *Anas platyrhynchos*, and Pintails, *Anas acuta* apparently collected in the summer in the Delta Marsh, Manitoba, thus supporting the results arrived during the present study. Farias and Canaris (1986) while studying Gastro intestinal helminths of the Mexican Duck from Central Mexico and United States reported *N. attenuatus* among the 25 species of helminthes recovered from the gastro-intestinal tract of 129 hosts studied. Fayaz and Chisti (1995) while studying Avian trematode parasites of Kashmir reported three species of *Notocotylus* from intestinal caeca of *Anas penelope, Phalacrocorax carbo sinesis* and *Anser anser domesticus* from Hokarsar Wetland and Dal lake Kashmir. Lapage (1961) and Person et al. (1974) reported *N. attenuatus* inhabiting the intestinal caeca of birds, causing pathology, serve disease and death of waterfowl and domestic fowl

Radlett (1980) while studying the structure and possible function of the ventral papillae of *N. attenuatus* reported that adult flukes in the caecum use their ventral papillae as hold fast organs, freeing the oral sucker for feeding. Contrary to this observation he always found adult flukes in the lumen of the distal caeca feeding on caecal debris. All the above findings thus confirming our results

**Echinostoma spp.**

*Echinostoma* species is one of the dominant groups of endoparasites of duck and Goose. During the study period highest prevalence was observed
during summer followed by winter. The parasite was mostly recovered from the rectum and caeca of the host. The above results are supported by the findings of Canaris et al. (1981) while studying parasites of waterfowl from Southwest Texas: III, when the author reported that *Echimonstoma revolutum* is a common parasite of waterfowl and is found in all groups of green-winged teal. Canaris et al. (1981) while studying gastrointestinal helminthes of the Mexican duck reported. *E. revolutum* as one of the six species of trematodes with highest prevalence of infection (10.8). Kulisic et al. (2004) while studying trematodes of Eurasian Coot in the Belgrade area reported *Echinostoma sarcinum* most widespread with an intensity of infection (44.92%), followed by notocotylus species.

Robert (2002) while studying gastrointestinal helminthes of *Larus dominicanus* in New Zealand reported *E. revolutum* as one among nine species of gastrointestinal helminthes. Further *Echinostoma revolutum* has been found in many species within anseriformes, as well as in the rock pigeon *Columba livia* (Weekes, 1982; McKenna, 1998). Rind (1974) stated that no host specificity is shown by many parasites common in Anatidae including *Echinostoma revolutum*. Shaw and Alan (1980) reported *Echinostoma revolutum* as dominant species while studying heminth fauna of waterfowl in Oklahoma.

**Heterakis spp.**

*Heterakis* species were recovered from the caeca of duck as well as goose collected from Anchar Lake. Permin and Nansen (1996) after studying Danish organic Poultry farming reported increased infestation of internal parasites including *Heterakis gallinarum*. The author further stated species of nematodes like *Heterakis* and *Ascaridia* are widely distributed, causing non-specific clinical signs of infection, such as loss in appetite and growth, a general loss in condition and, on occasions death. Permin *et al.* (1999) in his recent survey in Denmark concluded that there was a high risk of helminth
infection in free range/organic poultry systems and that prevalence may also
be high in deep-litter systems. Nokana et al. (1991) during survey of helminth
parasites in back yard flocks in Michigan by Litter examination also showed
relatively high Contamination rates. Wilson et al (1994) reported prevalence
of *H. gallinarum* in the range of 10% on commercial farms in the state of
Arkansas, thus confirming our observations.

**Amidostomum** spp.

*Amidostomum* species were recovered from beneath the keratinized
layer of gizzard, proventriculous and rarely from oesophagus. The parasites
were highly recorded during autumn followed by spring. Our results are in
accordance with the findings of Canaris et al. (1981) while studying parasites
of waterfowl from Southwest Texas III in which author reported 9%
prevalence of *Amidostomum* and recovered from fall and spring adults thus
supports our results. Crichton and Welch (1972) found *Amidostomum* species
in adult and juvenile mallards and pintails collected in Manitoba. Prevalence
was high (53%) particularly among juvenile 62%.

Canaris et al. (1981) reported gizzard nematode *Amidostomum acutum*
was collected from birds in the northern most area of Mexico but one
specimen was also recovered from the intestine of a bird from Jalisco Mexico
presuming range of helminth may extend throughout range of Mexico. Mc
Kelvey and Macneill, (1981) while working on mortality factors of wild swans
in British Colombia, Canada, revealed that *Amidostomum* species was the
most Common one with prevalence of 63%. Kobulej (1983) gave an account
on pathology and epidemiology of *Amidostomum anseris* infection in Geese.
Gokcen et al. (2002) while studying prevalence of nematodes in geese
reported *Amidostomum anseris* at the rate of 15.09%.

**Ascaridia** spp.

*Ascaridia* were recovered from the small intestine of infected birds and
more numerous occur in young birds than adults. The highest intensity of
parasitism was reported during summer followed by autumn and no infection was detected during winter months. Ackert (1931), Anderson (1992) stated *A. galli* a nematode occurred in the small intestine of chickens, goose, Guinea fowl and a number of birds. Permin *et al.* (1997) reported that prevalence of gastrointestinal helminthes are high whether in tropical or temperate climate. Further it can be concluded that *A. galli* is highly prevalent in free range/organic, deep litter and scavenging backyard systems, whether in Denmark or in Tanzania. Further it can be concluded that the success rate of *A. galli* is less dependent on climate conditions compared to parasites with intermediate hosts.

Edgar (1953) reported the presence of a wide range of helminth in chickens including *A. galli*. In more recent study by Wilson *et al* (1994) the prevalence of *A. galli* was in the range of 40% on commercial farms in the state of Arkansas. Long (1977) while studying *A. galli* in broiler chickens reported majority of 16000 broiler chickens were infected with *A. galli* at the age of 23-39 days. Brglez (1989) studied the cestode, *Memato-parataenia southwelli* in *Cygnus* species in Yugoslavia. Tenora *et al.* (2002) while analyzing the heavy metal Concentrations in gravid tape worm species parasitizing aquatic birds revealed that effects of heavy metals on tape worm morphological and anatomical features were used as indicators of the environmental conditions.

*Raillietina spp. / Choanotaenia spp.*

Konanenko and Khaizade (1983) while working on the helminth fauna of charadriiformes and Anseriformes reported prevalence of cestode, nematode, trematode and acanthocephalan infections as 50, 45, 13.3 and 1.6% respectively.

Dogiel (1964) performed extensive studies on the helminth fauna of various orders of birds and observed that the first group of parasites acquired
by chicks tended to be cestodes. In the present investigation, cestodes were found to be dominant than rest of the parasites. Further, seasonal variation in the abundance of the parasites with more intensity during summer was also observed. Threlfall (1967) examined herring gulls in north-wales and found seasonal diversity of helminth parasites and attributed the differences to changes in the diet of the gulls over the course of the year, caused by an altered availability of the intermediate hosts. Furthermore, he suggested that seasonal fluctuations in the abundance of infective stages in the environment may also play a contributing role in differences observed. Threlfall (1968) demonstrated seasonal variation of helminths recovered from herring gulls. Some helminths were not prevalent early in the summer while others peaked in July.

In waterfowls the density and magnitude of helminth infection increase and peak in late summer (Busher, 1965 and McLaughlin and Burt, 1979). Infection levels decline throughout fall staging and migration periods and during the stay on the wintering grounds. Generally no recruitment of replacement species occurs at this time due to changes in diet and limited availability of infective stages in intermediate hosts (Wallace and Pence, 1986).

Acanthocephala

Spakulova et al. (1991) while working on seasonal changes in the species composition of nematodes and acanthocephalans of Anas platyrhynchos revealed that the majority of helminth species found in wild ducks also parasitized domestic ducks. Fedynich and Pence (1994) reported that mallards had higher mean abundance of helminth in summer than winter. Zuchowska (1997) while studying helminth fauna of anseriformes reported prevalence of nematodes > Cestodes > trematodes as 20.28%, 13.5% 1.16% respectively.

Ectoparasites

The prevalence of ectoparasites collected from different parts of the body of domestic water birds viz., duck and goose observed in the present
study is in consonance with earlier reports (Aguirre, 1984). All water and shore birds seem to be heavily infested with *Mallophaga* (*Ichnocerans*) with large land birds more infested than smaller land birds except the gregarious ones (Peters, 1928). Further, the ectoparasites of water birds have been reported to occur in land birds (Kellogg, 1899) and has been explained by the fact that land and water birds are frequently observed perching close together so it would be very easy for some migration of parasites to occur.

**Fish Haematology**

**Haemoglobin**

The results of haemoglobin observed during the present investigation are supported by earlier workers. Ivasik and Virepo (1969) in carp infected by sanguinicolosis in which haemoglobin got reduced by 20% in mild infection and by 61% in serious cases. Similar results were found by Evans (1974) in cut throat trout due to *Sanguincola kiamathensis*; Skvortosva (1977) in carp infected with *Dilepis unilaterals* larvae; Natrajan and Balakrishnan (1977) in *Hemirhamphus xanthopterus* infected with *Lernaeenicus hemirhamiphi*. Cruian carp infected by *Diplozoon nipponicum* also showed decline in haemoglobin concentration (Kawatsu 1978). Silver Carp infected with *Posthodiplostomum cuticola* revealed reduction in haemoglobin concentration by 2.5% (Denisov 1979). Saxena and Chauhan (1993) in *Heteropneustes fossils* infected with *Lucknowia indica* observed haemoglobin level reduced by 8.1%. Same results were observed by Ogawa *et al.* (1997) in cultured tiger Puffer infected with *Heterobothrium okamotei*. Sinha (2000) reported decrease in haemoglobin concentration by 20% in *Clarias batrachus* infected with helminthes. Japanese flounder infected with *Neo heterobothrium hirame* revealed decrease in haemoglobin concentration as reported by Yoshinaga *et al.* (2001).
Erythrocyte (RBC) and Leukocyte (WBC) Count

During our study, the results of decrease in RBC count and increase in WBC count is also as per the findings of Voznyi et al. (1975) for carp with parasitic infections; Natranjan and Balakrishnan (1977) also observed decrease in RBC count in Hemirhamphus xanthopterus infected with Lernaeenicus hemirhamphi. Our results are also supported by the observations of Denisov (1979) in silver carp infected with Posthodiplostomum cuticola where RBC count decreased by 25%. Decrease in RBC count was also observed by Agarwal et al. (1989) for a freshwater fish Rita rita with trematode infection and Engelhordt et al. (1989) in Rainbow trout infected with Proteocephalus neglectus. Saxena and Chauhan (1993) observed erythrocyte count reduced by 8.6% in Heteropneusteus fossils infected with Lucknowia indica. Sinha (2000) in Clarias batrachus carrying helminth infection observed decrease in erythrocyte count by 20% and same results were observed by Mushiake et al. (2001) in Japanese flounder infected with Neoheterobothrium hirame. An increase in neutrophil and monocyte values were also observed by Skvortosva (1977) in carp infected with Dilepis unilaterals larvae. Observations are in corroboration with Denisov (1979) in silver carp infected with Posthodiplostomum cuticola which lead TLC to rise by 44%. Saxena and Chauhan (1993) in Heteropneusteus fossils infected with Lucknocisa indica found TLC increase by 2.77%. A higher degree of eosinophilia was observed in Clarias batrachus carrying helminth infections Sinha (2000).