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LIMNOLOGICAL INVESTIGATION AND DISTRIBUTION OF MICRO AND MACRO INVERTEBRATES AND VERTEBRATES OF FOX SAGAR LAKE, HYDERABAD

RAMAKRISHNA
Zoological Survey of India, M-Block, New Alipore, Calcutta 700 053

INTRODUCTION

The demand for the proper management of inland water resources has increased with the increase of population and industrialisation. India abounds in confined water bodies but majority of these remain neglected, or if cultivated, not effectively managed and exploited. Effective management of the impounded water requires continuous monitoring and limnological surveillance to predict ecological alterations for the efficient water utilisation for agriculture and aquaculture.

In India, pioneering efforts on limnology of impounded water were initiated by Ganapati (1940) and by Madras State Fisheries Department (Raj, 1941). Later on a number of publication on the limnology of freshwater of India have appeared. Rao and Govind (1964), Hussainy (1967), Vasist (1968) and others investigated different limnological aspects of impounded water in India. Sreenivasan (1964, 65, 66) made an extensive study on the limnology of freshwater impoundments in Tamilnadu in relation to productivity. Notable contributions towards the limnology of freshwater around Hyderabad are those of Zafar (1966, 1986), Venkateswarulu (1969), Senayya (1971), Reddy et.al. (1986) and others. Most of these contributions are confined to the ponds, rivers, streams or manmade lakes covering different dimensions.

Hyderabad district of Andhra Pradesh is located at the centre of the Deccan plateau of the subcontinent, and lies approximately betweeen 18°30' and 18°20' North latitude and between 77°30' 79°30' East longitude. The district is largely hilly and sparcely wooded. The Ananthagiri hill range straddles the district from Mahaboob Nagar border in the south to Darur area in Vicarabad taluk in the north. The hill range, mainly of high-grade laterite and in addition isolated hillocks and massive boulders are the characteristic of the district.

The chief river of the district is Musi, which rises from the hills of the adjacent Medak district and flows from west to east in the city limits. Two reservoirs namely Osman sagar across river Musi and Himayat sagar across river Esi (a tributary of river Musi) are situated close to the city. These two reservoirs are the main drinking water source of the city. In addition, a vast water body, namely, Husain sagar is located between the twin cities of Hyderabad and Secunderabad. Apart from these, quite a large number of tanks and smaller water bodies are located in the district of which several are maintained by the State Fisheries Department as nursery and stocking ponds.

In view of the expansion of the city limits forming industrial belts and residential localities, the size of many smaller water bodies have become non existent in recent years.

GEOLOGY

Hyderabad district is generally surrounded by rocky hills made mostly of granites of relatively fresh rock and the rocks are exposed all over the district (518 – 628 m above msl). Patches of low lying flood plains formed by the river Musi and Husain sagar streams are located in the city limits. Granites form the archean crystalline complex consisting of porphyritic, equigranular massive banded and streaky with erratic distribution of pegmatite veins. These granites contain Quartz, Felspar frequently giving rise to sandy plains with poor soil but rich in alkalies. In addition to granites, banded gneisses, megmatites, pegmatites, quartz veins and dolerite dykes are common in the district. A little alluvial land fit for cultivation with only wide expanse of undulating granite country and rocky knoll are present in many parts of the district.

Major soil groups of the district is the red earth comprising of loamy sands (Dhaba), sandy loams (Chalk) and sandy clay loams. The thickness of the soil cover range down to 1.5 m in the case of laterite and sandy clay loams and to 5 m in the case of alluvial black soil. The analysis of soil suitability of the district reveals that the soil is highly permeable and excessively drained, the application of the organic manures, tank silt, compost is recommended to improve its water holding as well as productive capacity.

CLIMATE

Data on solar radiation compiled by the Smithsonian Institute of USA indicates that Hyderabad is located in a region, whose radiation gain is to the tune of 3.9 g/cm/m in the months following August. From February onwards, the radiation gain gradually decreases till it completely balances against the radiation loss, in July. If biological function is taken as a function of radiation gain, Hyderabad could be regarded as continuously productive throughout the year (Zafar 1968). The study area falls in the semi arid region of the Deccan plateau and enjoys a tropical climate, being warm and dry in most part of the year.

Atmospheric temperature at Hyderabad is consistently high and varies slightly in the annual cycle. From about the mid February, the maximum and minimum temperature begins to increase steadily, May is the hottest month, with a mean daily temperature of 39.6^0 Celsius. During April and May, before the onset of monsoon, the day temperature often raches 40^0 Celsius and above. With the onset of southwest monsoon in mid June, a gradual drop in the temperature is noticed. December is the coldest month in the area with a mean daily maximum of 28.6^0 Celsius and mean daily minimum temperature of 13.6^0 Celsius. The diurnal range of temperature becomes narrower in the rainy season of June to September.

Hyderabad district is situated at a distance of about 265 km from the eastern seacoast, as a result, the marine climate becomes gradually peninsular, and the air becomes drier and the amount of rainfall decreases. The district is further situated in the interior rainfall region of the Indian peninsula and experiences a single south-west monsoon setting in the month of June, reaches its peak during August – September. Long term averages of rainfall in the district varies from 672

to 800 mm/year of which 70% is received from the south-west monsoon, with an average of 48 rainy days/year. Variation from the long term averages are also not uncommon i.e., high values (1380 mm), or scanty rainfall leading to drought (600 mm/year), thus making it an atypical rainfall year.

Like most other meteorological parameters, wind direction and velocity show a regular seasonal pattern. It is generally light to moderate with some increase in velocity during southwest monsoon. During post monsoon months and winter, wind is generally light and variable in direction in the morning hours and mostly north-easterly to easterly in the afternoon, however, during the months of January to March the direction being easterly to south eastern. Land breezes, local winds and squalls in the vicinity of thunderstorms with a speed of 50 – 75 km/hour and wind speed covering a large area controlled by prevalent synoptic situation with a speed over 40 km/hour are absent in the area.

The annual mean relative humidity at Hyderabad is 55.5 percent; one of the reasons for such a low percentage is due to the semi-arid condition prevailing in the area. The maximum and minimum relative humidity at Hyderabad is respectively 86% in the month of September and 19% in the month of April. The summer is the driest part of the year, the humidity generally between 30 – 35% in the afternoon hours.

The rate of evoparation is dependent on both temperature and humidity of the atmosphere as well as wind stress on the water surface. It has been estimated that the present rate of evoparation at Hyderabad is around 2172 mm/year, which gives a daily average of 6 mm.

FOX SAGAR LAKE

Fox Sagar Lake commonly known as Jeedimetla tank is an impoundment specially constructed for the purpose of irrigation in the year 1897 by the then rules of Hyderabad. It is situated one kilometer west of Hyderabad – Nizamabad road at a distance of 15 km from the Hyderabad City. The lake is mainly rainfed with a total catchment area of 47 sq. km. The gross capacity of the lake is ten million cubic meters when full, the details of the lake is in the Table-1. The lake holds water throughout the year but the level decreases from the month of October due to letting out of water for irrigation. Lake is open on all three sides; littoral region is shallow and retains water throughout. The catchment area has vegetable fields, grape gardens and some agricultural lands cultivating dry crops like Jowar, maize etc. Jeedimetla Industrial Estate, one of the fast growing industrial belts is coming up with in a kilometer radius and therefore, the suburban growth depends for its water requirement on the lake in future. Furthermore, the lake is used for fishery purpose by the local fisheries department and all major carps; *Tilapia* and *Channa* species are stocked for breeding and culturing. In recent years, the lake margin is utilised as dumping ground for the city garbage, and brick making industry, as a result of this anthropogenic activity in the lake vicinity, water quality deterioration is noticed affecting the biota of the lake ecosystem.

Table-1. Technical details of Fox sagar lake, Hyderabad.

1. Volume	:	10 million m^3
2. Full tank level	:	568.8 m msl
3. Maximum water level	:	569.8 m msl
4. Tank bund level	:	570.0 m msl
5. Sill level	:	558.5 m msl
6. Top bund width	:	3.6 m
7. Free catchment area	:	6.5 sq. km
8. Integrated catchment	:	40.0 sq. km
9. Total catchment area	:	46.5 sq. km
10. Maximum flood discharge	:	194.6 m^3/sec.
11. Settled ayacut	:	128.7 Ha
12. Length of the canal	:	1.5 km

MATERIAL AND METHODS

Water samples were collected from three sampling stations on the littoral regions of the lake as in Figure-1. Monthly samples were collected for a period of two years at regular intervals between 9 am to 12 noon. Air and water temperature was recorded by using Elico Water Analysis Kit, pH by portable pH meter (Systronics, pH ep make) in the field and in the laboratory. Analysis of dissolved oxygen (Modified Winkler's method), carbondioxide, carbonate, bicarbonate, chloride, calcium, magnesium hardness, total dissolved solids, specific conductance, nutrients such as phosphate, nitrate, sulphate were estimated as per methods in Standard Methods for Examination of Water and Waste Water, A P H A 17th edition, (1985) and results are expressed in mg/l unless otherwise mentioned. Seasonal observation on the transparency using Secchi disc and productivity of the lake using dark and Light Method were undertaken during the investigation.

Plankton samples were collected from three sampling stations of the lake with the help of plankton nets of suitable mesh size. 40 litres of water was filtered through these nets at the sampling stations to obtain individual representatives. Suitable preservative was added and for phytoplankton a drop of Lugol's Iodine was used for better preservation of plankton material. Qualitative analysis of the plankton was made by sweeping the plankton net back and forth covering a maximum part of the sampling station. Estimation of absolute planktonic densities were made by using "Sedgewick Rafter Cell" under Stereo binocular microscope (Carl-Seiz, Technival – II) after preservation. Enumeration of phytoplankton was made by employing drop method under binocular microscope of 40X objective and 10X eyepiece. An average of three counts was taken for each sample and the mean was calculated for both zooplankton and phytoplankton. With the mean value of the concentration, the total count per litre was calculated and annual percentage was taken. The bottom macrofauna were collected with the help of dredges

and brought to the laboratory, washed in enamel trays, in order to get benthic samples and finally sorted and preserved. Periphyton communities were collected directly from the macrophytic vegetation by scraping and by handpicking.

WATER QUALITY PARAMETERS

Monthly variation in the surface water temperature at three sampling stations of Fox sagar presented in the table agrees with the general temperature pattern of other water bodies of similar meteorological conditions (Munawar 1970; Seenayya 1971). The water was clear generally during summer and winter months and muddy during monsoon, due to surface run-off from the adjacent agricultural land and brick industry. Transparency of the water recorded with Secchi disc indicated minimum during monsoon (Zsd – 62 cm) and maximum during winter (Zsd 1.65 m) with an annual average of 1.02 m.

The hydrogen ion concentration (pH) of the surface water at all sampling stations of the lake throughout the period of investigation was found to be in the alkaline range and the value varied between 7.2 to 9.8. The difference between surface and bottom layers of the lake was comparatively low varying between 0.3 – 0.5 unit. Carbon dioxide content was found to vary between nil to 58 mg/l indicating the presence of carbonate and bicarbonate in varying proportions. In vertical profile of water, carbon-dioxide was found to increase with the depth indicating the biogenic activity of the lake ecosystem. Relationship of pH, carbondioxide and bicarbonate in general was in agreement with the findings of Gonsalves and Joshi (1946), Rao (1953), Lakshminarayana (1965), Sreenivasan (1968), Seenayya (1971). Of all the chemical substances in natural water, oxygen is one of the most significant parameter, as it is essential for the existence of all forms of life, and also an important indicator of lake ecosystem. Dissolved oxygen varied between 1.5 – 8.6 mg/l during the period of study in surface layers, bottom layer exhibiting varying amount during different seasons. Peaks of dissolved oxygen were different in different years and fluctuation thus noticed was due to photosynthetic activity of phytoplankton and macrophytes.

Based on the work of Brown, Skongstad and Fishman (1970), the lake water in general are moderately hard to hard and in the present study the total hardness varied from 84 – 384 mg/l at different sampling stations. Variation in vertical and horizontal profiles of water was not much appreciable in quantity. Chloride content of the lake water, which is indicative of the extent of pollution entering into it from animal and plant refuse from the catchment area, varied between 38 – 132 mg/l with no appreciable variation in surface and sub surface layers. Specific conductance of the surface water indicates the ionic composition and the values obtained from different sampling stations are presented in the figure. The highest recorded was in the range of 1282 Uho/cm^2 in the month of January and minimum (400 Umho/cm^2) was in the month of May. The key chemical nutrient promoting the growth of plants and animals are in different soluble forms of phosphorous and nitrogen, the values so obtained was in the range of 0.8752 – 1.0876 mg/l and 0.8764 – 2.162 mg/l respectively indicating the productivity of the lake, which can sustain a rich growth of algal population.

SEASONAL AND DIURNAL VARIATIONS

Seasonwise data of the various parameters according to the depth of the lake clearly indicates that the thermal stratification was not much significant, however, during summer months the thermal difference was in the range of 1.5 – 1.8 degree Celsius in the samples collected during midday indicating that the lake is not homothermal but a thermal gradient does exist in Fox sagar. Transparency varied again with the season, the lowest during the month of monsoon and highest during winter. Free carbondioxide was limited to morning and late night hours and further increase in carbondioxide content from surface to bottom layer was well marked. Presence of carbondioxide during summer months, according to Singh (1983) is related to the surplus release during rapid decomposition of the organic matter in the sediments owing to the low depth, greater intensity and longer duration of sunlight and ultimately more heat budget in the system. Changes in the alkalinity over 24 hours showed an increase normally in the early hours (07 am) in the bottom samples and 11 am in the surface and gradual decrease in the late afternoon. The water was mainly bicarbonate type, with a limited presence of carbonate, pH in the range of 7.5 – 8.6, a gradual increase in the bicarbonate and carbondioxide in deeper layers are indicative of higher values for the lake during to summer months. According to Welch (1975), increase in bicarbonate in summer months is due to the decomposition of organic matter in the sediments.

Dissolved oxygen concentration showed a definite trend with a peak at 15 hours and minimum before sunrise. Percentage saturation varied between 22.16 – 114 percent in surface and 19 – 71 percent in deeper layers. Lower values in the early hours and during night could be attributed to the respiration and higher values during the day to the photosynthetic activity. Furthermore, utilisation of oxygen in deeper layers for the formation of bicarbonate may also be the reason for their limited availability as described by Hutchinson (1957). Calcium and magnesium ion of the lake water remained almost uniform throughout the day and the hardness ranged from 75 – 320 mg/l, the surface water exhibiting more than that of deeper layers. Chloride content was in the range of 40 – 108 mg/l again deeper layers exhibiting lower values. Dissolved nutrients, Nitrate-nitrogen was in the range of 0.8764 – 2.162 mg/l and soluble phosphorous from 0.8752 to 1.0876 mg/l. Values of nutrients may not indicate the low productivity, but perhaps a high productivity due to the rapid assimilation of available nutrients by the luxuriant growth of macrophytes in the lake. The inconsistency in the ionic composition of the lake investigated show that they are subjected to the maximum anthrapogenic activity. On the basis of available cations and anions, the lake water was clearly in the hardwater range and judging from the availability of calcium, nitrate-nitrogen, phosphate and humus formed by the senescent macrophytic vegetation, Fox sagar fits into the eutrophic category.

ANNUAL HEAT BUDGET OF THE LAKE

Annual heat budget of the lake is the measure of heat energy input from the lowest heat content during the winter to the greatest heat content during summer, thus it is the annual heat gain in the system. Heat budget of the lake is calculated by using the formula (Lind, 1975).

$$Qba = z\ (Ts - Tw)$$

Wherein z = mean depth, Ts and Tw are the maximum summer mean and the minimum

winter mean temperature and the values of the heat budget are expressed in C/Cm^2/Year. On the basis of the above formula, the heat budget of Fox sagar have been 1125/C/Cm^2/year.

BIOLOGICAL PARAMETERS

Lakes of south India resemble some of the tropical counterpart in sustaining rather dense population of phytoplanktons all the year round and the seasonality of the phytoplankton is more obviously and intimately related to temperature changes (Zafar 1986). Ecological details of various orders of phytoplankters and factors affecting their distribution in the lakes of Hyderabad under different trophic status has been studied by Seenayya and Zafar (1979), Rao (1979), Zafar (1986) and others. Seasonality of freshwater phytoplankton is presented in the figures.

Myxophyceae : *Anabaena, Oscillatoria, Lyngbya, Spirulina, Microcystis* are the most important myxophycean members of the lake. *Oscillatoria* and *Microcystis* recorded throughout the year and their abundance increased from the month of December to March. *Spirulina* and *Lyngbya* species appear in larger percentage during summer months of February to March, thus indicating their distribution is related to temperature, this is in conformity with the observation made already by Zafar (1986).

Chlorophyceae : In comparison to other groups of phytoplanktons, chlorophycean members exhibit greater diversity but with a limited abundance. Seasonality also varies to that of myxophycean members, their number show relative abundance during pre-monsoon and monsoon periods and the highest concentration was noticed during the months of September and October. The filamentous forms such as *Spirogyra* and *Hydrodictyon* are distributed during the months of January to May in patches of water columns but the desmids such as *Staurastrum*, *Selenastrum*, *Closterium*, *Cosmarium*, *Scenedesmus* dominated during the pre monsoon, monsoon and post monsoon months. *Chara* species found to flourish well throughout the year except for the month of March to May. *Volvox globator*, is the only species among the chlorophycean members dominating the summer months.

Bacillariophyceae : Diatoms dominated the winter months of December to February. In comparison to Chlorophycean members, diatoms are represented by five genera, however, the percentage composition of the group on the higher side.

MACROPHYTES

Aquatic macrophytes provide extreme simple, cheap and efficient way of treating waste water to decrease the nutrient content and in this regard many of the macrophytes can remove a number of pollutants and heavy metals (William, 1983). Macrophytes also constitute a significant biotype of the aquatic ecosystem and the trophic level of the food chain from aquatic to terrestrial life. It was also found that the macrophytic vegetation of the lake harbors a considerable number of cladocera, copepoda, rotifera, insect and Insect larvae, crustaceans, molluscs and fishes offering food, shelter or other benefits to these groups directly or indirectly. One of the striking feature of the lake is the total absence of floating plants belonging to the family Nymphaceae (*Nymphea*, *Nymphoides*) and *Nelumbo* species; family : Araceae (*Pistia* sp.); family : Pontederiaceae (*Eicchornia crassipes*), the last mentioned has invaded all other major ponds, lakes and tanks of

Hyderabad. From the list of macrophytic vegetation harbouring the lake, *Jussiea* was found in patches during summer months and submerged vegetation of *Ceratophyllum*, *Chara* and *Hydrilla* found throughout the year at all places. The marginal amphibious species of *Polygonum*, *Cyperus*, and *Paspalidium* were found occasionally submerged during monsoon months.

Table-2. Macrophytic vegetation of Fox sagar, Hyderabad.

Submerged species :	
1. *Ceratophyllum demusrssum* (L.)	Ceratophyllaceae
2. *Hydrilla verticillata* (L.)	Hydrocharitaceae
3. *Blyxa octandra* (Roxb.)	Hydrocharitaceae
4. *Potamogeton crispus* (L.)	Potamogetanaceae
5. *Chara* sp	Characeae (Algae)
Marginal Amphibious species :	
6. *Jussiea repens* L.	Onagraceae
7. *Polygonum glabrum* L.	Polygonaceae
8. *Cyperus platystylis*	Cyperaceae
9. *Paspadidinum germinatum* (Forsk)	Poaceae
10. *Marselia quadrifolia* L.	Marseliaceae
Marginal Terrestrial Species :	
11. *Amarantahus spinosus* L.	Amaranthaceae
12. *Tridax procumbens* L.	Poaceae
13. *Croton bonplandianum* Baill	Euphorbiaceae
14. *Argemone maxicana* L.	Argemonaceae
15. *Cassia fistula* L.	Caesalpeniacae
16. *Acanthospermum* sp	Acanthaceae

Table-3. Phytoplankton composition of Fox sagar, Hyderabad

MYXOPHYCEAE

1. *Lyngbya gracilis* (Menegh) Raben
2. *Anabaena sphaerica* Bornet et. Flahault
3. *Spirulina major* Zanard et. Gomant
4. *Microcystis aeruginosa* Kurtz.
5. *Oscillatorca* sp.

CHLOROPHYCEAE

6. *Vovox globator*
7. *Hydrodictyon reticulatum* (L.) Lagerh
8. *Senedesmus quadricauda var longispina* (Chodat) Smith
9. *Senedesmus quadricauda var bicaudatus* Hansgirg
10. *Selenastrum acuminatum*
11. *Cosmarium striatum*
12. *Cosmarium auriculatum* Reinsch
13. *Closterium monoliferum* (Borg.) Ehren
14. *Closterium acutum* Ehrenberg
15. *Zygnaema* sp
16. *Euglena acus* Ehrenberg
17. *Euglena* sp
18. *Spirogyra hyalina* Cleve
19. *Spirogyra paludosa* Czurda

BACILLARIOPHYCEAE

20. *Melosira* sp
21. *Cyclotella* sp
22. *Navicula* sp
23. *Cymbella* sp
24. *Fragilaria* sp

ZOOPLANKTON

Qualitative and quantitative analysis of zooplankton population reveals the presence of protozoa, rotifera, cladocera, and arachnida distributed throughout the period, the details of which is summarised below :

Protozoa : Protozoa are represented by members belonging to class mastigophora, ciliata and rhizopoda. Ciliates are generally present in small Patches among the senescent and putrefying

vegetation while rhizopoda are distributed in open water. The species distribution together with the taxonomic status is as under:

Sub kingdom	:	PROTOZOA
Phylum	:	SARCOMASTIGOPHORA
Sub phylum	:	MASTIGOPHORA
Class	:	PHYTOMASTIGOPHORA
Order	:	EUGLENIDA
Suborder	:	EUGLENINA
Family	:	EUGLENIDAE
		Euglena acus Ehrenberg
		Euglena viridis Ehrenberg
Subclass	:	TESTACEALOBOSA
Order	:	ARCELLINIDA
Family	:	ARCELLIDAE
		Arcella gibbosa Penard
Family	:	DIFLUGIDAE
		Diflugia elegans Penarad
		Diflugia globosa Dujardin
Class	:	OLIGOHYMENOPHOREA
Subclass	:	HYMENOSTOMATIA
Order	:	HYMENOSTOMATIDEA
Suborder	:	PENICULINAE
Family	:	PARAMECIIDAE
		Paramaecium caudatum Ehrenberg
Subclass	:	PERITRICHA
Order	:	PERITRICHIDA
Suborder	:	SESSILINAE
Family	:	VORTICELLIDAE
		Vorticella companula Ehrenberg
		Carchesium sp
Family	:	EPISTYLIDAE
		Epistylis sp

Rotifera : Six species of rotifera are recorded from the lake of which *Keratella tropica* and *Brachyonus calcyflorus* dominated, forming nearly 64% of the total rotifer population. The species represented and their taxonomic positions are as under :

Phylum	:	ROTIFERA
Class	:	MONOGONATA
Order	:	FLOSCULARIDAE
Family	:	TESTUDINELLIDAE
		Filinea longiseta (Ehrenberg)
Order	:	PLOIMA
Family	:	BRACHIONIDAE
		Anuraeopsis fissa Gossae
		Brachyonus calcyflorus Pallas
		Brachyonus quadricaudatus Hermann
		Keratella tropica (Apstein)
Family	:	PHILODINIDAE
		Rotaria sp.

Cladocera : Members of the cladocera distributed in the lake are the tropical representatives and are present during summer months. Abundance of cladocera increases from February till the onset of monsoon. However, *Chydorus* and *Diaphanosoma* found throughout the year, but the abundance decreases during the monsoon period of July to September. The species representation and their taxonomic position are as under :

Class	:	CRUSTACEA
Order	:	CLADOCERA
Family	:	SIDIDAE
Genus	:	***Diaphanasoma*** Fischer 1850
		Diaphanasoma sarsi Richard 1894
Family	:	MOINIDAE
Genus	:	***Moina*** Baird 1850
		Moina micrura Kurz 1874
Family	:	DAPHNIDAE
Genus	:	***Ceriodaphnia*** Dana 1853
		Ceriodaphnia cornuta Sars 1855
Genus	:	***Simocephalus*** Schoedler 1858
		Simocephalus vetulus O. F. Mueller
Family	:	CHYDORIDAE
Genus	:	***Chydorus*** Leach 1816
		Chydorus sphaericus (O. F. Mueller)
Genus	:	***Alona*** Baird 1852
		Alona pulchella Sars 1862.

Copepoda : Copepoda fauna are represented by two species viz. *Heliodiaptomus* and *Mesocyclops*. Diversity of this group in the lake though low, abundance among zooplankton population is quite high specially during summer months. The adults occur during post monsoon months till the end of summer, however, their nauplii occur during the months of August to September. Species representation and their status are as under :

Class	:	CRUSTÁCEA
Order	:	CALANOIDEA
		Heliodiaptomus viduus (Gurney 1916)
Order	:	CYCLOPOIDEA
		Mesocyclops cf. Leucaartii (Clauss)

Miscellaneous zooplankton : Ostracoda are represented by two species of microbenthic forms whose dominance is noted during the different periods of the year. Species representation in the lake are 1. *Cypris globosa* and 2. *Hemicypris* species. The members of the shrimp (Decapoda : Attyidae) *viz. Macrobrachium rosenberghii*, *Cardenia* species found in abundance among the macrophytic vegetation of *Chara* and *Hydrilla* species. The other microbenthic invertebrate encountered during summer months is red mite belonging to *Hydrachna* species.

MACRO INVERTEBRATES

Diptera : Dipterans are represented by several aquatic and semi aquatic forms in freshwater ecosystems, however, in Fox sagar only three main genera viz. *Chironomus*, *Aedes* and *Culex* species are encountered. *Chironomus* species are distributed during the months of October to November in the shallow areas of the lake. The abundance of these species is indicative of the pollution status of the lake, as these are known to be indicator organisms in freshwater ecosystem. Mosquito larvae belonging to *Culex* and *Aedes* species are abundant in the months of November and June i.e., post monsoon months and in summer months. In comparison to *Chironomous* species, mosquito larvae are limited in their abundance and this may be related to the abundance of macrophytic vegetation especially *Chara* species in the lake, as mosquito repellant property of *Chara* species is already established to the limited extent by Kachroo (1983).

Odonata : Biological examination of net samples of Fox sagar revels the presence of odonate larvae throughout the period of investigation, maximum during the months of March to May and second peak being September and October, the minimum being November to January. However, the distribution pattern of the larvae in the second year of investigation decreased.

Larval growth of aquatic insects are affected significantly by physical factors like temperature and sunshine hours. Temperature can affect growth directly by its influence on the rate of feeding, assimilation, respiration food conversion etc. (Sweeny 1978). Corbet (1957) proposed a model to describe how odonate could use seasonal changes in temperature and photoperiod during the larval development. The interpretation concerning these results is that the increased day length at a given temperature increses overall feeding period of odonate species especially since, most of them are visual predators (Sweeny & Vancote, 1981). In the present study, the lake in particular is situated in the semi-arid region with atmospheric temperature varying from 25 – 45^{0} Celcius

and average sunshine hours of exceeding 10 hours/day, the larval dominance was maximum during the months of March to May. Post monsoon months of September and October were also ideal as the availability of food, light and temperature were in the favourable range.

Distribution of odonate larvae is largely governed by the larval adaptation to the physico-chemical characters of the water body and ability to withstand the adverse breeding condition is a measure of distributional potentiality of the species (Werger, 1978). According to Arthington and Watson (1982), faunistic studies on dragonflies based on the larval condition pose several taxonomic problems. According to these authors, the occurence of sexually mature odonata found at the freshwater site is a strong evidence to show that they breed there. The adult specimens collected from the lake environs and their taxonomic positon are as under :

Class	:	INSECTA
Order	:	ODONATA
Suborder	:	ZYGOPTERA
Family	:	COENAGRIIDAE
Subfamily	:	COENAGRIINAE
		Ischnura elegans (Vander Linden)
Suborder	:	ANISOPTERA
Family	:	GOMPHIDAE
Subfamily	:	GOMPHINAE
		Ichtinogomphus rapax (Rambur)
Family	:	LIBELLLULIDAE
Subfamily	:	LIBELLULINAE
		Brachythemis contaminata (Fabricius)
		Crocothemis servelia servelia (Drury)
		Pantala flavescens (Fabricius)
		Trithemis pallidinervis (Kirby)

Members of Odonata are believed to be excellent indicators of water quality. Based on the Helsenhoff's tolerance score (Lehmul 1979) the biotic index falls between 0–5; members with zero tolerance score (Agrionidae, Gomphidae 0.5) are highly sensitive and taxa with the score of 3 are moderate in tolerance (Lestidae and Coenogrionidae – 3). Hence, natural, undistutbed aquatic ecosystem will have greater diversity of the species and such water bodies include many sensitve species. Present investigation confirms the above facts with the presence of *Ictinus rapax* (Gomphidae) widely distributed in many oligotrophic lakes of Hyderabad. *Pantàla* and *Brachythemis* being eurytypic in the environs of Hyderabad are also present in Fox sagar.

Hemiptera : Literature pertaining to the seasonal distribution and role of aquatic hemiptera in freshwater ecosytem is meagre. However, taxonomic account of Indian hemiptera are studied by Distant (1903), Pruthi (1929), Pradhan (1947), Hafiz and Pradhan (1947), Tonapi (1959), Venkateshan and Raghunatha Rao (1980). Stray instances of taxo-ecological studies on the group are attempted by Julka (1977), Goel (1978), Bist and Das (1983), Rupavathi and Radhakrishna (1983), Tirumalai (1988) and others.

List of Hemiptera and taxonomic position is presented in the Table-4. Faunal analysis reveals the presence of 19 species of heteroptera (Hemiptera) belonging to 9 genera. Family nepidae represented by 5 species, notonectidae, corixidae and belostomidae represented by 3 species; pleidae by two species; naucoridae, validae and gerridae with one species each. It is interesting to note that the studies on the aquatic hemiptera of Fox sagar establishes the existance of seasonal variation and periodicity of several members. From the point of view of abundance and diversity, post monsoon months represent an ideal period. *Anisops*, *Micronecta*, *Laccotrephes*, *Ranatra* and *Diplonychus* showed predominance during monsoon months. Furthermore, the latter three species showed abundance among the macrophytic vegetation of *Chara* and *Hydrilla* species. However, *Notonecta glauca* showed predominance during summer months. Speices belonging to valide (*Microvelia*); naucoridae (*Heliochoris*) and gerridae (*Gerris*) exhibitted discontinuous occurrence. Among the members of the pleidae, *Plea pallescens* exhibitted limited abundance in comparison to *Plea frontalis*.

Abundance and composition of the aqutic hemiptera are related to the change in the physico-chemical conditions by various workers. Goel (1978) observed that the abundance of hemiptera in general is related to tempeature and humidity rather than rainfall. However, Tonapi (1959), Julka (1977), are of the opinion that temperature and rainfall appeared to be important and have augmentative effect on the fluctuation in the population of the aquatic hemiptera. Carter (1960) opines that in tropics, amount of rainfall plays a significant role in regulating various biological rhythms. Differences in the temperature requirement have been considered by many workers to account for most of the distributional pattern (Macan, 1958; Hynes 1970). In tropics, as in the present case, temperature changes are usually minimum in limited areas of single habitat and hence this factor may have a very little bearing on th micro-distribution of hemiptera, since the thermal regimes of the lake exceeded 20^{0} Celcius at all seasons.

During the present study, rainfall appeared to play a signifiant role as its controls the water level fluctuation in the lakes of Hyderabad, Andhra Pradesh, India. Rainfall affects the concentration of chemical constituents by dilution effect which in turn influences the quantity of plankton and primary production of the lake. Apart from dilution effect, rainfall has direct role in drying and reflooding of the water body. According to Bridges and Mahler (1985), drying and reflooding enhances the nutrient release which stimulates the macrophytic productivity. It is also evident from the present study, the rainfall deviated from the long term averages during the second year of investigation (nearly 480 mm instead of average of nearly 800 mm/year). This is further aggravated by the gross evaporation from the lake surface (5.91 mm/day during the first year and 6.01 mm/year during the second year of investigation), resulted in the water level reduction. This affected the water quality parameters, phyto-zooplankton population, macrophytic productivity which in turn affected the distribution of hemipteran population. A near bloom conditon of the lake due to the abundance of *Microcystis aeruginosa* and *Oscillatoria* species of algae afffected the hemipteran population, as the alga formed a continuous mat on the surface of water inhabiting distribution of other species.

It is therefore, reasonable to assume that changes in some water quality parameters due to the reduction in the water level, abundance of phytoplankton blooms, excessive predation by birds in the lake margin, changes in the food-web composition due the reduction in the macrophytic productivity are the factors responsible for the species distribution and abundance. The ability of

hemipterans to migrate appear to be another factor causing fluctuation in the population as suggested by Julka (1977).

Table-4. Systematic list of Aquatic Hemiptera of Fox sagar, Hyderabad.

Class	:	INSECTA
Order	:	HEMIPTERA
Suborder	:	HETEROPTERA
Family	:	CORIXIDAE
Genus	:	***Corixa*** Mueller
		Corixa heiroglyphica Dufont
Subfamily	:	MICRONECTIDAE
Genus	:	***Micronecta*** Kirkaldy
		Micronecta (Sigmonecta) quadristrigata Bred
		Micronecta (Sigmonecta) striata Fieb.
Family	:	PLEIDAE
Genus	:	***Plea Leach***
		Plea frontalis (Fieber)
		Plea pallescens Distant
Family	:	NOTONECTIDAE
Subfamily	:	NOTONECTINAE
Genus	:	***Notonecta***
		Notonecta glauca
Subfamily	:	ANISOPSINAE
Genus	:	ANISOPS SPINOLAE
		Anisops breddini Kirkaldi
		Anisops exigera Howarth
Family	:	NEPIDAE
Subfamily	:	RANATRINAE
Genus	:	***Ranatra*** Fabricius
		Ranatra filiformes Fabricius
		Ranatra gracilis Montondon
		Ranatra sordidula Dohrn
Subfamily	:	NEPINAE
Genus	:	***Laccotrephes*** Stal
		Laccotrephes elongatus Montondon
		Laccotrephes griseus (Guerin)
Family	:	BELOSTOMIDE
Subfamily	:	BELOSTOMINAE
Genus	:	***Diplonychus*** Amyot & Serville
		Diplonychus rusticus (Fabricius)
		Diplonychus annulatum (Fabricius)
		Diplonychus molestum (Dufont)

Family	:	NAUCORIDAE
Subfamily	:	LACCOCORINAE
Genus	:	***Heliotrophis*** Stal
		Heliochoris breviceps Montondon
Family	:	GERRIDAE
Subfamily	:	GERRINAE
Genus	:	***Gerris***
		Gerris spinolae Lethierry & Severin
Family	:	VELIIDAE
Subfamily	:	MICROVELINAE
Genus	:	***Microvelia*** Westwood
		Microvelia senghlensis Kirkaldy

Coleoptera : Free moving predacious pond insects are best exemplified by diving insects. These gradually range in number and frequency in inverse proportion to their size, smaller the species more often numerous the medium sized animals. Coleoptera, though a largest group among insects, represented by three species viz. *Hydatian fabricii* Macleay, *Cybister* sp. and *Rhantaticus* species.

Crustacea : Crustaceans are represented by *Macrobrachium rosenberghii* and *Cardenia* species. These two species exhibitted abundance during the peak macrophytic productivity. *Macrobrachium* showed discontinuous distribution, as they are not cultured in the lake, however, *Cardenia* were more abundant and the size varied from 2 – 3.5 cm and hence, not much of commercial value except that it forms the link in the food chain for many aquatic animals.

Mollusca : Compared with the deeper zone, shallow water habitats usually and structurally more complex and are characterised by greater "Substratum heterogeneity" (Wetzel, 1975). This warrants for the abundance and diversity of macrobenthic forms especially molluscs. The shallow water region of the lake Fox sagar harbours seven species of gastropods with an interesting feature being the absence of bivalves. Of the seven species, *Bellamya bengalensis* and *Indoplanorbis exustus* are the dominant species, the former prefering the rocky bed while the later prefers an extensive growth of macrophytic vegetation. The distribution of *Bellamya* species on the rocky and hard substratum can be explained by it clinging ability to the surface with the help of adhesive foot and feeding on the organic matter formed by the epiphytic algae and plankton from the incoming water by wave action. Presence of cladocera, copepoda and epiphytic algae on the vegetation are the reasons for their abundance of the later species.

According to Boycot (1966), 50% of the molluscan species are hardly ever found in water with less than 20 mg/l of calcium ions and he treats this as the lower limits. It is also evident from the work of Furtado and Mori (1982), species of mollusca are absent in Tasek Bera lake in Malayasia due to its soft water with calcium deficiency. Fox sagar lake being eutrophic lake, calcium ion is not a limiting factor as these always occcur in abundance (> 150 mg/l), the reason being, the area is full of laterite soil having greater percentage of calcium, magnesium, sodium and potassium.

Table-5. Molluscan Fauna of Fox sagar and its sysematic status

Class	:	GASTROPODA
Order	:	MESOGASTROPODA
Family	:	VIVIPARIDE
Subfamily	:	BELLAMYINAE
Genus	:	***Bellamya*** Joussaeume 1886
		Bellamya bengalensis (Lamarck, 1882)
		Bellamya crassa (Benson 1836)
		Bellamya dissimilis (Muelleer 1774)
Family	:	BITHYNIIDAE
Subfamily	:	BITHYNINAE (BULININAE)
Genus	:	***Gabbia*** Tyron 1865
		Gabbia orcula var producta (Neville 1884)
Subclass	:	PULMONATA
Order	:	BASSAMATOPHORA
Family	:	LYMNAEIDAE
Genus	:	***Lymnaea*** Lamarck 1799
		Lymnaea (Pseudosuccenia) acuminata Lamarck
		Lymnaea (Pseudosuccenia) luteola Lamarck
Family	:	PLANORBIDAE
Subfamily	:	BULININAE
Genus.	:	***Indoplanorbis*** Annandale & Pershad 1929
		Indoplanorbis exustus Deshayes 1834

Ichthyofauna : In recent years, State Fisheries Department utilised Fox sagar as the centre for stocking and culture site for fishes, as a result, the species composition of the natural population altered considerably. This was further aggravated by the introduction of *Tilapia* species in the lakes of Hyderabad. Species composition has also altered due to the change in the drainage pattern, due to the development of industrial area around the lake ecosystem, utilising the lake margin for the brick making as well as dumping site for the city garbage. These anthropogenic activities resulted in the alteration of species composition, sensitive species being replaced by the hardy ones. This is in confirmity with the findings of Baburao (1984) in the lakes of Hyderabad of similar status. Carnivorous and detrivorous species are more prominent (*Mystus*, *Chela*, *Channa*, *Wallago*, *Notopterus*, *Clarias*, *Tilapia* etc.) than the sensitive species.

Recordings of the abundance and frequency of the individual species was not available, as the lake was mainly used as stocking and nursery site, however, the systematic account of the ichthyofauna of Fox sagar, Hyderabad revealed the presence of 17 species belonging to 14 genera under 10 families. The species representation was similar to that of other freshwater lakes of Hyderabad of similar status. During the present investigation, due to the decrease in the general lake waterlevel, a large area of the lake bed was exposed, offered an excellent site for aquatic and semi aquatic birds, which was hitherto not recorded in our earlier investigation, feeding mainly on fishes.

Table-6. Fish Fauna of Fox sagar, Hyderabad and its Taxonomic status

Sl.No.	Order	Family	Species
1.	Cypriniformes	Clupeidae	*Notopterus notopterus* (Hamilton)
		Cyprinidae	*Chela labuca* (Hamilton)
			Puntius ticto (Hamilton-Buchnan)
			Puntius chola (Hamilton- Buchnan)
			Puntius sophore (Hamilton-Buchnan)
			Rasbora daniconius (Hamilton)
			Amblypaharyngodon mola (Hamilton)
			Garra malya (Sykes)
		Cobitidae	*Lepidocephalichtyes guntea* (Hamilton)
2.	Siluridae	Bagridae	*Mystus vittatus* (Bloch)
		Heteropneustidae	*Heteropneustes fossilis* (Bloch)
		Siluridae	*Wallago attu* (Bloch)
3.	Ophicephaliformes	Ophicephalidae	*Channa punctatus* (Bloch)
			Channa gachua (Hamilton)
4.	Perciformes	Gobidae	*Glossogobius giuris* (Hamilton)
		Claridae	*Clarias batrachus* (Linnaeus)
		Cichlidae	*Sarcotherodon mosambicus* (Peters)

Amphibia : Annandale and Rao (1918) and Parker (1934) have recorded amphibian from different parts of India, however, the information on the amphibian fauna of Hyderabad district is very scanty. During the present investigation only three species of amphibians were recorded form the lake the systematic position of these are as below :

Class : AMPHIBIA
Order : ANURA
Family : BUFONIDAE
Genus : ***Bufo Laurenti*** 1768
Bufo melanogaster Schneider

Family : RANIDAE
Genus : ***Rana*** Linnaeus, 1758
Rana limnocharis Boie
Rana cyanophlyctis Schneider

Of the three species found in the lake, *Bufo melanosticus* is the big sized toad, nocturnal in habit and found in abundant number during the monsoon and post monsoon months. *Rana limnocharis* and *Rana cyanophlyctis* are the two smaller species found inside the lake margin and among the macrophytic vegetation. *Rana tigrina*, the bull frog not recorded in the lake, though common in many other lakes of Hyderabad.

Avifauna : Information on the avifauna of the lakes and other water bodies of Hyderabad

district is very scanty and therefore, a faunal inventory of the lake was undertaken in addition to their seasonal abundance and distribution. The list prepared is based on the observation for a period of two years. During the field trip, assistance of Dr. M. Vasanth, an eminent field ornithologist was taken, the list presented is complete or near complete. The present study also revealed that the majority of the birds are resident type and only about 12 species visited during winter (22% of the total are winter visitors). It was also observed for the first time that the Acacia trees in the lake margin formed an excellent site for the painted storks to nest and breed in the area. *Ardea alba* (large egret) was the only species found to be rare, as it was sighted twice in the entire period of two years.

Table-7. Avifauna of Fox Sagar, Hyderabad.

Family	Scientific and Common Name	Status
PODICIPIDIDAE	*Podiceps rufficolis* (Pallas) (Dab Chick)	Winter visitor, visits in small groups of 5 – 8
PHALACROCORACIDAE	*Phalacrocorax niger* (Viellot) (Little cormorant)	Winter visitor, visits in small groups of 4 – 6
ARDEIDAE	*Ardeola grayeii* (Sykes) (Pond Heron)	Common in summer
	Ardea cinera (Linnaeus) (Grey Heron)	Common throughout the year
	Ardea alba (Linnaeus) (Large egret)	Rare
	Egretta garzetta (Linnaeus) (Little egret)	Common and abundant
	Egretta intermedia (Wagner) (Common egret)	Abundant
	Bubulcus ibis (Linnaeus) (Cattle egret)	Common
CICONIDAE	*Nycterrenia leucocephala* (Penmant) (Painted stork)	Found in large number, Nests on Acacia trees in large nos.
ACCIPETRIDAE	*Nephron perenopterus* (Linnaeus) (Scavenger vulture)	Present in large nos. Common throughout the year due to the presence of garbage
	Milvus migrans (Boddaert) (Pariah kite)	Common in the lake margin throughout the year in large numbers & in catchment area

Family	Scientific and Common Name	Status
JACANIDAE	*Hydrophasianus chirugris* (Scopoli) (Pheasant Tailed Jacana)	Winter visitor,small number present on macrophytes
CHARADRIDAE	*Vanellus indicus* (Boddaert) (Redwattled lapwig)	Common throughout the year
	Charadrius dubius Scopoli (Little ringed plover)	Common in winter
RECURVIROSTRIDAE	*Himantopus himantopus* (Linnaeus) (Blackwinged stilt)	Common in winter
COLUMBIDAE	*Streptopelia chinensis* (Scopoli) (Indian Spotted dove)	Common in summer in marginal vegetation
	Streptopelia decaocto (Frivaidzky) (Ring dove)	Common in summer in lake margin
PSITTACIDAE	*Psittacula krameri* (Scopoli) (Roseringed parakeet)	Common in fruit gardens of the catchment area
CUCULIDAE	*Eudynamys scolopacea* (Linnaeus) (Koel)	Common throughout in the bushes & trees of lake margin
	Centropus sinensis (Stephens) (Coucal or Crow Pheasant)	Common throughout in the marginal vegetation
	Clamator jacobinus (Boddaert)	Common throughout (Pied crested cuckoo)
CAPRIMULGIDAE	*Caprimulgus asciaticus* Lanathum (Indian Nightjar)	Present during post monsoon and winter months
STRIGIDAE	*Athene brama* (Temminck) (Spotted owlet)	Common throughout in the lake margin and catchment
APODIDAE	*Cypsiurus paravus* (Lichtenstein) (Palm swift)	Common throughout the year
HIRUNDINIDAE	*Hirundo rustica* Linnaeus (Common swallow)	Common throughout the year
UPUPIDAE	*Upupa epos* Linnaeus (Hoopoe)	Common in winter
COERACIDAE	*Coracias benghalensis* (Linnaeus) (Blue Jay)	Common throughout the year
MEROPIDAE	*Merops orientalis* Latham (Green bee eater)	Winter visitor

Family	Scientific and Common Name	Status
ALCEDINIDAE	*Alcedo atthis* (Linnaeus) (Blue Kingfisher)	Common throughout the year
	Halcyon smirnensis (Linnaeus) (white brested Kingfisher)	Common throughout the year
PICIDAE	*Dinopium bengalenis* (Linneus) (Golden backed woodpecker)	Post monsoon & Winter
MOTACILLIDAE	*Motacilla flava* (Linneus) (Yellow wagtail)	Common in winter and summer
	Motacilla maderaspatensis Gmelin (Large pied wagtail)	Common in summer
ALAUDIDAE	*Eremopterix grisea* (Scopoli) (Ashy crowned Finch lark)	Common in winter and winter
	Alauda gulgula Franklin	Common in summer
	Galerida cristata Linnaeus (Indian small Skylark)	Winter visitor
DICRURIDAE	*Dicrurus adsimilis* (Bechstein) (Black drongo)	Common throughout the year
STURNIDAE	*Acridotherus tristis* (Linnaeus) (Indian common myna)	Common throughout the year
COIRVIDAE	*Corvus macrorhynchos* Wagler (Jungle crow)	Common throughout the year
	Corvus splendens Vielliot (Indian House crow)	Common throughout the year
	Dendrocitta vagabunda (Latham) (Tree Pie)	Common in the bushes, trees in lake margin & catchment
PYCNONOTIDAE	*Chloraopsis aurifrons* (Temminck) (Goldfronted Chloropsis)	Winter visitor
	Pycnonotus cafer (Linnaeus) (Redwiskered Bulbul)	Common throughout the year
TIMALINAE	*Turdoides caudatus* (Dumont) (Common Babler)	Common throughout the year
	Turdoides affinis (Jerdon) (Whiteheaded Babler)	Common throughout the year
SILVINAE	*Prinia socialis* Sykes (Ashywren Warbler)	Common throughout the year

Family	Scientific and Common Name	Status
TURNIDAE	*Saxicoloides fulicata* (Linneus) (Indian Robin)	Common throughout the year
NECTARINIDAE	*Nectarinia asciatica* (Latham) (Purpled Sunbird)	Common throughout the year
PLOCEIDAE	*Lonchura malbarica* (Linnaeus) (White throated Munia)	Common throughout the year
	Passer domesticus Linnaeus (House sparrow)	Common throughout the year

SUMMARY

Fox sagar, a perennial freshwater lake situated in the sub-urban environs of Hyderbad city, mainly constructed to irrigate the agricultural lands in the lower catchment area. The lake margin, in recent years has been employed to dump city gabage thereby causing deterioration in the water quality, affecting the fauna, flora and human health. It was also observed, that a large number of Pariah kites (*Milvus migrans* Boddaert) are hovering over the lake area, because of the abundant supply of food from the city garbage piled up in the area, in turn may cause serious damage to the air crafts (Airport is at an aerial distance of 3 – 4 km).

Suburban growth, development of Jeedimetla Industrial Estate, release of effluents from the industries are the subject matter of discussion in recent years. This is true in case of Fox sagar lake also. Enough precautions are to be taken before the release of untreated effluents in the lake catchment area. A minor industry viz. Brick making industry is directly operating in the lake margin. The impact of these are to be looked into before developing the same in the area.

The water quality is found to be conducive for the developemnt of fisheries in the state. However, in recent years the introduction of *Tilapia mosambica* in the lake, the fishermen operating in the area often complain that many carps which were once flourished in the lake have dwindled.

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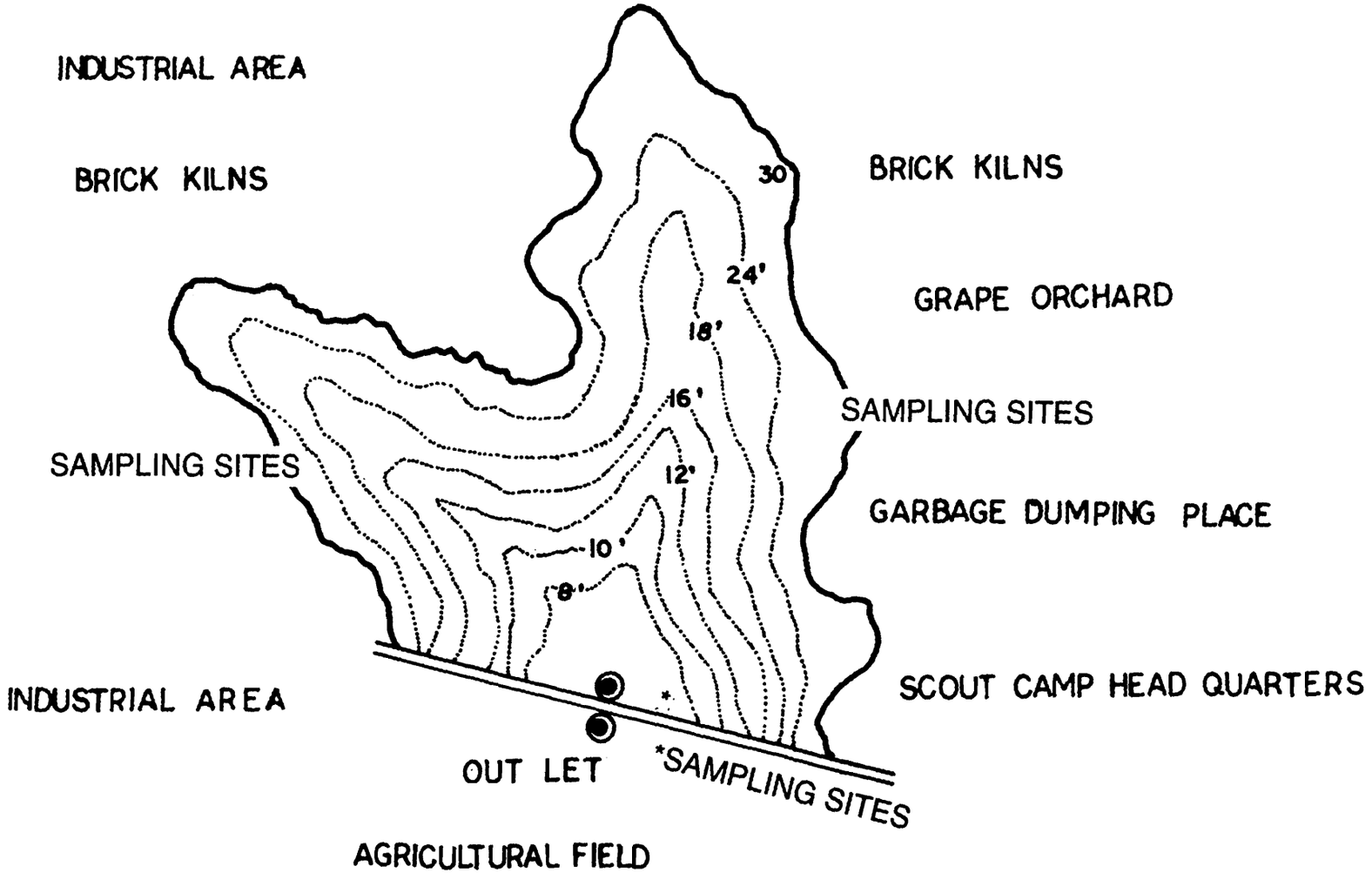
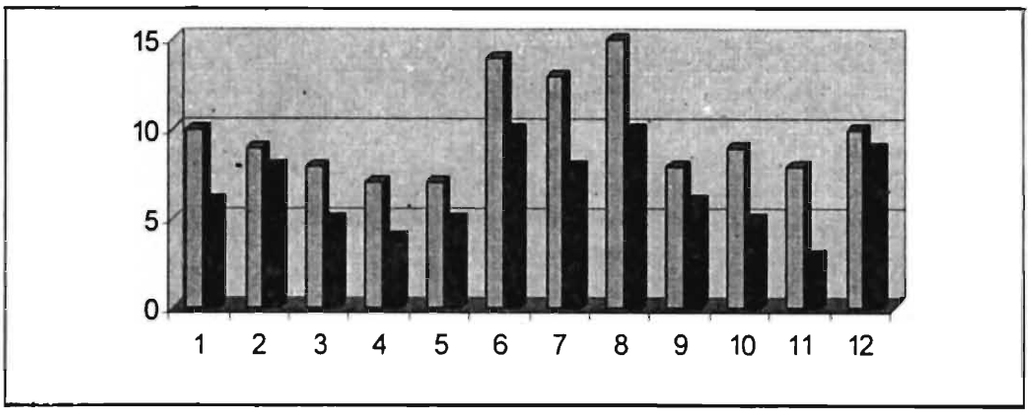
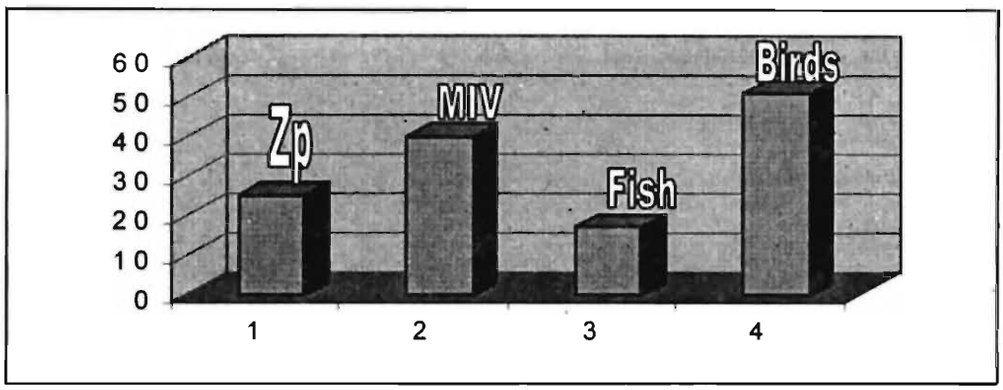


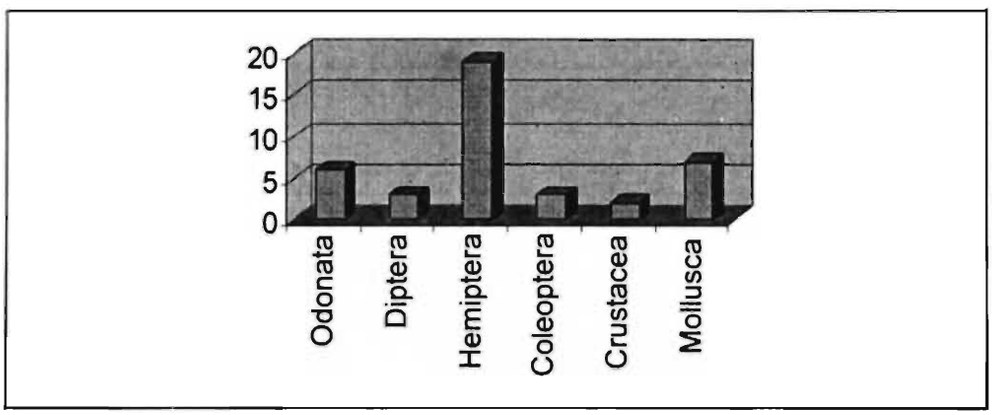
FIGURE 1 CONTOUR MAP OF FOX SAGAR, JEEDIMETLA, HYDERABAD.



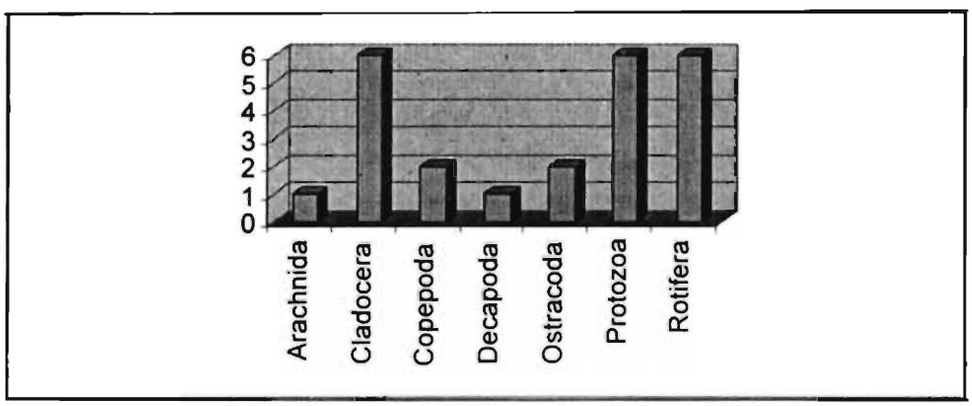
Species Composition of Aquatic Hemiptera in Fox Sagar Lake



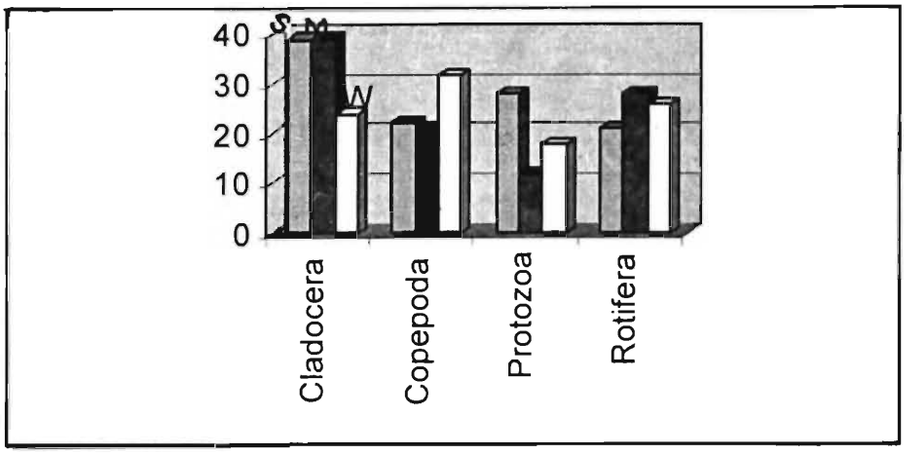
Species Composition of Micro-Macro Invertebrates & Vertebrates



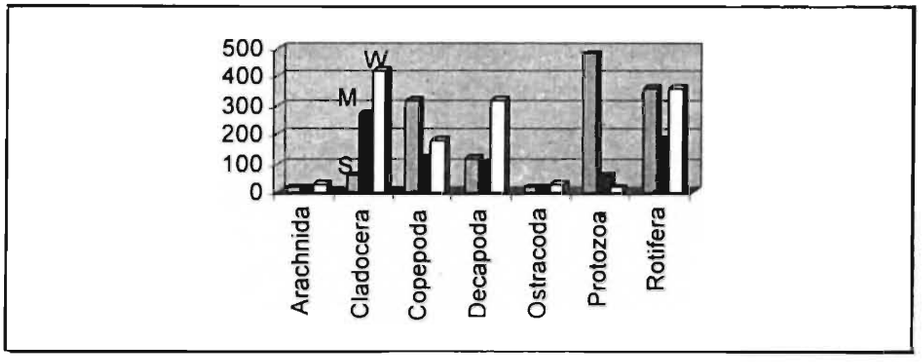
Species Composition of Macro-Invertebrates in Fox Sagar



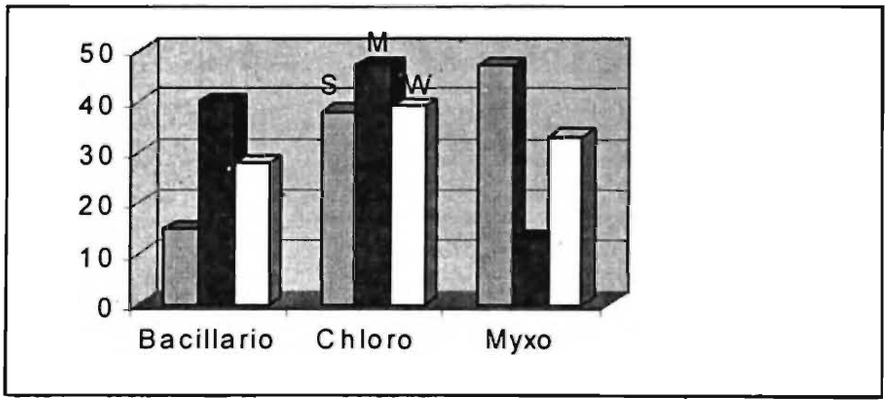
Species Composition of Zooplankton in Fox Sagar



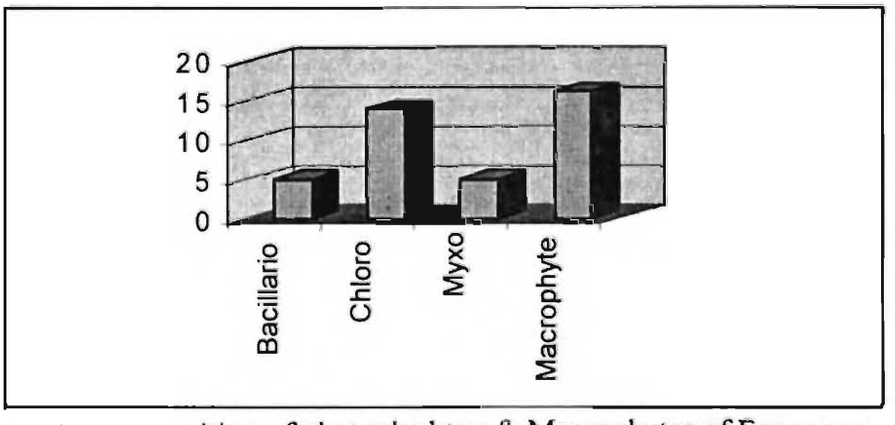
Seasonal Variation of Zooplankton (Percentage Composition)



Seasonal Variation of Zooplankton (number)



Seasonal Variation of Phytoplankton (Percentage Composition)



Species composition of phytoplankton & Macrophytes of Fox sagar