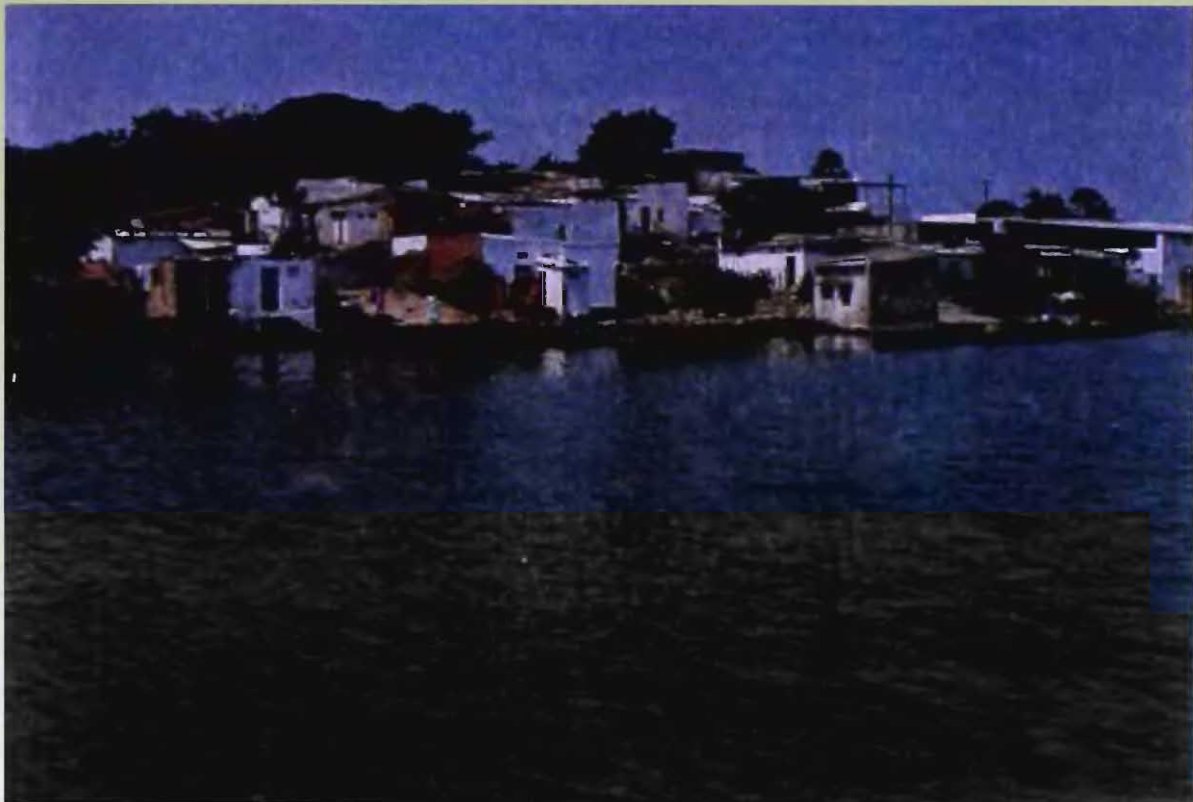


Hydrography in relation to
Benthic Macro Invertebrates in Mir-Alam Lake
Hyderabad, Andhra Pradesh

**G. ANITHA
S.V.A. CHANDRASEKHAR
M.S. KODARKAR**



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**HYDROGRAPHY IN RELATION TO BENTHIC
MACRO-INVERTEBRATES IN MIR-ALAM LAKE,
HYDERABAD, ANDHRA PRADESH**

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INTRODUCTION

The aquatic ecosystems have been a subject of great interest for ecologists for long. The stagnant and running waters are routinely studied by water supply organizations, fisheries department and pollution control authorities with various objectives. Studies on water quality monitoring are highly important, as this water is liable for direct consumption by animal and human population.

Last half of the 20th century is witness to the two phenomena of great ecological consequences : first, unprecedented population growth and second, industrialization. These two had immediate adverse impact on the fresh water manifesting in terms of gross pollution of ground and surface waters, destruction of catchments and progressive reduction of water holding capacity of water bodies. With reference to lakes and impoundments mainly created for irrigation purpose, the degradative impact was more severe particularly in the urban environments. The destructive factors include pollution from untreated domestic sewage, solid waste and industrial effluents entering from catchment. Mir-Alam lake in Hyderabad is a typical example of this manifest phenomenon and therefore, its conservation is likely to set a precedence to the ecological history of this part of the country.

Lakes maintain ecological balance of flora and fauna interrelationship, regulate surrounding climate and recharge ground water. But unfortunately they are dying. The lake is getting polluted due to inflow of domestic effluents apart from pollution resulting from washing of clothes, vehicles, buffaloes, immersion of idols in the lakes during certain festivals, etc. All these activities are deteriorating the quality of the water in the lake resulting in the accumulation of toxic chemicals and other sludges, which leads to limnological imbalance. The quality of water is decreased by its physical, chemical and micro-biological characteristics. As such an attempt is made to portray the water quality and biological characteristics of Mir-Alam Lake, the oldest man-made lake within the metropolis of Hyderabad city, to facilitate possible conservation and management measures.

The Objectives

1. Determine the taxonomic composition and relative abundance of the macro invertebrate community.
2. Establish seasonal abundance of the macro invertebrate community; and
3. Provide base line water quality data, based on macro invertebrates and several physico-chemical measurements to better understand and manage the water body of the Mir Alam lake.

Review of Literature

A historical resume of Indian limnology (Michael 1980) and review paper on Algal Hydrobiology in India (Prasad and Singh 1980) revealed that ecological studies on ponds and tanks provided the stimulus for limnological investigations. In Andhra Pradesh notable contributions were made by Ranga Reddy (1977); Dhanapathi (1978); Durga Prasad (1982) which helped to strengthen the taxonomic foundation for the study of zooplankton ecology.

Deshmukh (1964) has studied the physico-chemical characteristics of Ambazario lake in Nagpur, Maharashtra. Kodarkar and Chandrasekhar (1995) discussed the water quality and conservation aspects of five water bodies in and around Hyderabad, Andhra Pradesh. Similar studies on river waters have been conducted by a number of workers. For example physico-chemical and biological characteristics of river from western Uttar Pradesh were focus of study by Verma *et al.*, (1978). Comparative account of water quality of Tapi and Aner rivers (North Maharashtra) was given by Lohar and Patel (1998).

Fluctuations in physico-chemical and biological properties of a fresh water ecosystem have great importance in aquaculture. In India, such studies have been done by several workers (Whitton, 1962; Seenayya, 1972; Gajaria and Harishkumar, (1992). Physico-chemical parameters and physiological characterisation of fishpond have been studied by Harishkumar and Gajaria, (1995).

Limnological studies of Lotic waters have received the attention of Sala *et al.* (1977) Dutta and Singh (1978), Wangaheo *et al.*, (1984), Malhotra *et al.*, (1987), Zutshi (1992), Sreenivasan (1994) and Koul (2000).

Limnology of water bodies in and around Hyderabad received the attention of many biologists and covered many facets and aquatic ecosystems (Zafar 1969-75); Srinivasan *et al.* (1979)., Seenaya (1973), Devi (1985), Rama Devi (1997), Rao (1982), Mohan (1980), Naga Kumari (1996), Ravindra Prasad (1997), Md. Ahsan (1982), Anitha Kumari (1998). Like other ecosystems, lakes in urban environment are facing problem of environmental degradation mainly due to pollution from sewage effluents.

Studies on physico-chemical and biological characteristics of river waters has been done by many researchers from time to time (Busulu *et al.*, 1967, Chakravorthy *et al.*, 1977; Joshi and Bisht 1993; and Gill *et al.*, 1993).

Diurnal fluctuation of fresh water lakes have been studied by a number of workers (George, 1961; Verma, 1967; Bohra *et al.*, 1978; Mishra and Yadav 1978; Nasar, 1977; Malhotra *et al.*, 1987).

In India, the investigations of Ganapati, (1943), Dutta *et al.* (1954); Roy (1955); Venkateshwarlu (1969) contributed to our knowledge of the ecology of fresh water environments. Though a number of workers like Deshmukh *et al.*, (1964). David and Roy (1966); Ghosh and Basu (1968); have carried out studies on fresh waters, that data deals mainly with physico-chemical characteristics.

In India little work has been done on the biological indicators of water quality (Krishna Murthy *et al.*; Krishna Murthy and Sarkar 1979; Chandrasekhar, 1994). The term benthos includes all bottom dwelling organisms and this group presents a great assemblage of plants and animals. It must be understood that the terms benthos includes organisms of the bottom from the upper most water barring portions of the beach down to the greatest depths. As might be expected, the benthos varies widely with different conditions of bottom, both at the same level and different depths.

In fact, variations are so diverse and so marked that it is difficult to discuss them as a whole. The benthic animals inhabiting lakes constitute an extremely diverse assemblage, both taxonomically and ecologically.

In aquatic environments, the chemical effect on living organisms is very important as the organisms are in intimate contact with chemical solutions or suspension, and this passes through the body via the integument membranes, gill and mouth.

The benthic communities are usually dominated by three groups of organisms such as oligochaete worms, chironomid larvae and molluscs, and at times crustaceans and various minor insect larvae, usually occurring in rather limited numbers. The study of aquatic ecosystem without the study of its benthos is incomplete. Many of these benthic forms are detritivores and play a key role in the mineral recycling of organic matter, and many benthic insect larvae and oligochaetes are the major food sources for small and big bottom feeders.

The functional role of benthic fauna in upland streams is well realised (Zeneto and Bogdanos, 1987). They are composed of secondary producers like small crustaceans, molluscs, oligochaetes and nymphal, larval and adult forms of insects. The benthic fauna is directly preyed upon by the ultimate consumers and as such offers the very subsistence to them.

Although the benthic macro-invertebrates form essential food materials for various commercially important species of fishes, much attention has not been given to their study particularly in India (Yathesh, 1991) however, the literature on this subject contains considerable information on various aspects such as ecology, distribution, composition, variation, systematic and biology of commonly encountered benthic macro-fauna in fresh water ecosystems.

Since there is a growing competition among different sectors of the communities for the use of water for drinking, irrigation, industries *etc.* Water quality is becoming important in the present public health setup for our civilisation. With near explosion of population and the advent of industrialization, the activities of man and his livestock (Datta Roy *et al.* 1984) are adversely influencing ecosystems. Man-made eutrophication of lakes has become a world wide process, which may be evaluated from different points of view. According to Brinkhurst (1974), the trophic typology of lakes is based on the benthic communities and the tubificid worms are the most useful tool for its classification.

Besides, information on these invertebrates interpreted in terms of bio-indicators of environmental pollution is inadequate and very much scattered (Krishna Moorthy and Sarkar,

1979; Patil *et al.*, 1983; Khan, 1983; Mahadevan and Krishanswamy, 1984; Dudani *et al.*, 1988). There is very little information available in the literature on different macro invertebrates as indicators of different levels of organic pollution of aquatic ecosystems at a single area or place. In the present study attempts are made to correlate monthly variation in physico-chemical variables on the seasonal abundance of benthic macro invertebrates.

Based on the relationships, both the individual and combined effect of physico-chemical factors and anticipating that some of the dominant groups of benthic macro invertebrates would be having significant inter relationships with the physico-chemical factors (Odum, 1971), and that these organisms primarily respond to changes in their physical and chemical environment. Attempts were made to identify some of the benthic macro invertebrates as bioindicators of different levels of organic waste pollution, which may be used in future in various pollution monitoring programs and in decision making.

The water temperature was recorded high in summer was due to mixing of domestic sewage and washing activities. The water was alkaline throughout the study period. The total alkalinity showed inverse relationship with each other. The high carbonate content of water seems may be due to the constant accumulation of carbonate salts from the surroundings.

The high content of total dissolved solids elevates the density of water. The lowest values of total dissolved solids were recorded in summer and the highest in the winter this may be due to the close proximity of this lake to the inflowing drains and also may be due to the aged lake with 191 years old. The cattle pollution and human interference also contributed to the enrichment of dissolved solids.

As number of chemicals entering the aquatic environment increases, two extreme types of aquatic contamination can occur a highly enriched over productive region resulting from detergents, fertilizers and sewage, which leads to the nutrients supply and body water poisoned by chemicals.

Many factors influence the quality, some of the factors occur naturally, where as others have been resulted from man made events. Ever since biologists started taking interest in pollution ecology, marked efforts have centered round finding biological markers of water quality. Patrick (1949) emphasized the structure of the community to be important in monitoring water quality, and suggested that the total percentage of the pollution, composed criterion for judging the effect of pollution in a community, there normally exist a small percentage of dominant species (Largely accounting for energy flow) and a large percentage of rare species (Which largely determine the species diversity).

The total number of species and important values of individuals are called the species diversity indices, which tend to be low in physically controlled ecosystem (Odum, 1971). The species diversity indices have been used to detect and evaluate (Seenaya and Zafar, 1979). Most of these authors have stated that decreased diversity indicate condition of stress.

There are many published papers dealing with fauna dwelling the inter tidal sandy and muddy Indian shores. Subba Rao and Mookherjee (1964) surveyed the Mahanadi estuary and reported 21 species of molluscs of which 19 were recorded for the first time. Rajgopal (1978) reported 38 species of Archaeogastropods of the coramandal coast, Palk strait and Gulf of Mannar. More recently Subba Rao *et al.* (1995) published a detailed account of Estuarine and Marine molluscs of West Bengal. The molluscan fauna of Chilka lake, a major wet land ecosystem is reported by Subba Rao *et al.*, (1995). Benthic fauna in the Cochin back waters has been reported by several workers such as Desai and Krishnamurthy (1967); Kurian (1972), Ansari (1974); Kurian *et al.*, (1975) and Pillai (1977).

In India, although studies have been conducted on the benthic macro invertebrates of different aquatic systems (Michael, 1968; Mandal and Moitra, 1975; Vasisht and Bandal, 1979; Sarkar, 1989; Reddy and Rao, 1990), information on the use of these invertebrates as a bioindicators of environmental pollution is inadequate and very scattered (Krishna Moorthi and Sarkar, 1979; Patil *et al.*, 1983; Khan, 1983; Mahadevan and Krishna Swamy, 1984; Dudani *et al.*, 1988).

Some notable contributions on molluscs are Govind (1969) and Krishna Moorthi (1966) on the bottom macro fauna of the Tunga Bhadra reservoir; Gupta (1976) on macro benthic fauna of Loni reservoir, Bhagat (1978) on the benthos of Powar lake and Patnaik (1971) and Raman *et al.*, (1975) on benthos of Chilka and Pulicate lakes respectively.

The abundance of benthic fauna greatly depends on the physical and chemical properties of the substratum (Moyle 1946; Chakraborty *et al.* 1977; Patnaik 1971). Benthic macro invertebrates can be used as a barometer of overall bio-diversity in aquatic ecosystems. Invertebrates' communities respond to changes in water or habitat quality, and integrate impacts over time because of their extended residency period in the stream. Presence or absence of specific flora can be indicative of specific environmental and habitat factors. Invertebrates are abundant and diverse in most streams and rivers, and are relatively easy to sample and analyze. They are relatively immobile and cannot avoid 'Events' or 'Pulses' of pollutants or other forms of stress often missed by conventional water or habitat quality sampling.

Aquatic invertebrates serve as the primary food source for many stream fishes. Aquatic macro-invertebrates (Primary insects) are important biological components of fresh water systems. Aquatic macro-invertebrates are the preferred indicators of long-term water quality due to their limited mobility, one to three year life cycles and specific sensitivities to pollutants. Significant changes in the composition of the stream bottom (benthos) community indicate important alterations to the ecosystem.

Benthic macro-invertebrates are organisms without backbones that inhabit the bottom substrates (*e.g.*, Sediments, Debris, Logs, Macrophytes and Filamentous algae) of their habitats, for at least part of their life cycle (Rosenberg and Resh 1993). Macro invertebrates are visible to the naked eye and are retained by mesh sizes greater than or equal to 200 to 500 micrometers. Benthic macro invertebrates include insect larvae, annelids (leeches),

Oligochaetes (worms), Crustacean (Cray fish and shrimp), Molluscan (Clams and mussels) and Gastropods (snails). Insect larvae tend to be most abundant benthic macro invertebrates in fresh water aquatic ecosystems.

Stream dwelling invertebrates respond to changes in the physical or chemical environment. Benthic macro-invertebrates generally inhabit a localized area of a stream throughout their life cycle. Therefore, the individual organisms are continually exposed to any changes that occur in the chemical and physical environment (Roserberg and Resh 1992).

Although water resources with high water quality generally have diverse and rich macro-invertebrates fauna, certain pristine environments have low diversity of macro-invertebrates fauna because of the cold temperature and or relatively low nutrient levels (Pieczynski, 1977). Hard waters and hard water streams may have only two dominant species. Although all classes of invertebrates may be found in hard water streams, crustaceans, caddisfly, mollusc, flat worms and black flies tend to be found in such environments (Developer Lange, 1984).

Aquatic invertebrates are affected by human caused activities on land as well as activities in the water and impacts are reflected in species assemblages in streams and lakes. Aquatic invertebrates have complicated life cycles that are inextricably connected to both aquatic and terrestrial environments. The impacts of human use of land and water are reflected in species assemblages in streams and lakes. Habitat loss and degradation and the spread of 'exotic' (non-native or non-indigenous) species are the greatest threats to bio diversity in running water systems (Allan and Blecker 1993; Wilcave and Bean 1994).

Many aquatic invertebrates have specific and narrow habitat requirements and are therefore restricted to places that vary little from year to year. Others are general and can survive over a wide range of habitat types (Thorl and Covich, 1991).

A knowledge of aquatic invertebrates at the species level is essential to assess the status of bio-diversity in lake Mir-Alam. Monitoring of invertebrates at a higher taxonomic level (genera, family and order), can be useful in indicating changes in invertebrates assemblages in response to some impact if proper controls are established, but such monitoring usually cannot determine loss of species. Each species has different habitat requirements and different tolerances to environmental variables.

Aquatic invertebrates are the important source of food for birds, mammals, amphibians, reptiles and other invertebrates. Changes in terrestrial and aquatic habitats lead to changes in invertebrate assemblages, which in turn increase, decrease or change food supplies for other animals. As impact occurs in stream, species (or taxa) richness (number of species) decreases but the population size of some species may increase further, large-sized species are usually replaced by small species. Conversely, when the stream condition improves, larger invertebrate species replace small species. Such changes can have critical impacts on species that depends on invertebrates for a food supply.

In general, burrowing Chironomidae larvae (another type of midge fly in the order Diptera) and Oligochaetes (aquatic segmented worms) predominate inhabitants where sediments accumulate (Johnson *et al.*, 1993) and their number rise where streams have been converted to reservoirs, stone flies (plecoptera), found primarily in running water, are eliminated in reservoirs (Stewart and Stark, 1988).

Invertebrates drift down stream when water is rapidly lowered or raised (Minshall and Winger, 1968; Bovee, 1985). Under constant flow, sediment is not flushed from streams and other poorly understood triggers to life cycle changes and in stream migration not be present (Reisea *et al.*, 1989).

The effects of sediment on aquatic macro-invertebrates have been amply demonstrated and known for many years (Cordone and Kelley 1961; Buscemi 1966; Chutter 1969 and Waters 1995). When two hundred years ago rocky bottomed streams flowed, today sediment filled, seasonally dry stream channels (Mount 1993). A striking example of this impact is shady creek on highway 49 near North Columbia. As sediment obstructs respiration, interferes with feeding causes loss of habitat, stability and may alter production of invertebrate food sources (Johnson *et al.*, 1993).

Prainie preserve of north central Oklahoma conducted a survey on macro-invertebrates from May 1991 to March 1992, Chironomids *Fittknimyia* is reported for the first time in North America outside Florida. Species diversity values were generally high and pollution intolerant taxa were present at most stations throughout the study period indicating high quality for the water in the streams.

Biological impairment may be caused by several major factors such as organic enrichment, habitat degradation, or toxicological effects. It may be manifested in several aspects of the benthic macro-invertebrates community. These include absence of pollution-sensitive taxa, especially the EPT group *i.e.*, Ephemeroptera (May flies), Plecoptera (Stone flies) and Trichoptera (Caddisflies); in excessive dominance of pollution tolerant taxa, such as Chironomidae (midges) and Oligochaeta (Worms); in low overall taxa numbers, or with other perceptible differences in community structure relative to a reference condition.

When all the communities are considered, discrimination between sites using classification and ordination can be as effective, or nearly as effective, at the family level as at the species level. Family-level studies of rivers macro invertebrates have been used successfully for such purposes as describing biogeographical patterns across large areas and assessing responses to regulation.

It should be emphasized that the rapid techniques are not advocated as a substitute for detailed quantitative studies at the species level. Such studies will always be needed, for example where some of the researchers have relied almost entirely on the indicator organisms to study the impact of various pollutants. Chironomid larvae have been considered to be one of such biological indicators of organic pollution.

Information on their tolerance in tropical conditions is non-existing. The water quality monitoring by indicator organisms were dealt by several workers *viz.*, Harrel and Dorris (1968); Wilhm and Dorris (1968); Srivastava (1962); Verma and Dalela (1975); Pollution studies of rivers mainly depends on indicator organisms. Guafin and Tarzwell (1952 and 1956); studied the organic pollution with reference to macro invertebrate and also Brinkhurst (1965); McLachlan (1970) Walshe (1947 and 1950); Bartsch (1948). Freeman (1961) established the adaptability of chironomidae to variety of environmental conditions. Rao *et al.*, (1987) included chironomidae in the pollution studies.

In ecology the notion of diversity basis roots in consideration of the richness and variety of species in a community but the concept of diversity can be applied to the distribution of elements of any set of subjects, *e.g.*, the individuals of a unspecific population distributed in year classes; particles counted in size classes; the components of a chemical mixture counted in molecules of different kinds. Diversity can be expressed by any monotonous function having minimum when all the elements presented belong to the same class and a maximum when every one of the elements belong to a different class.

A number of surveys have demonstrated that pollution produces striking changes in biotic community. Some species may be unable to survive and others may persist in reduced coactions, certain species may be able to attain greater abundance. These structural changes can be quantified numerically and are very useful in assessment of water quality based on the principle that polluted water supports always low diversified flora and fauna while clean water supports high community diversity.

STUDY AREA

Geography of Andhra Pradesh : Andhra Pradesh is located within the tropics extending from 12° 40' to 19° 50' North latitude and 76° 45' to 84° 40' East longitude. It lies on the southeastern side of India. It covers an area of 2,75,280 square kms and is the fifth largest state of India.

The state of Andhra Pradesh can be broadly divided into three physiographic divisions:

- 1 The mountainous region consisting of Nallamalai and Erramalai hills of Rayalseema and Eastern Ghats.
2. Plateau or elevated plains having an altitude of 92 ~ 722 meters covering the entire Telengana and a part of Rayalseema.
3. The delta areas among which the Godavari, the Krishna and the Pennar are important.

As the state is situated within the tropics, the climate is hot for the major part of the year. The annual rainfall varies from 512.8 ~ 1025.6 mm. The rains are mainly due to the South West monsoon which starts in June. The rainy season is from June to September, the winter

season is from October to January. The air temperature during this period often falls to 15°C. The summer season is from February to May, which is hot and dry. The atmospheric temperature during this season often rises upto 44°C.

The lake Mir-Alam tank is located at Hyderabad city, the capital of Andhra Pradesh, where the main rocky type is seen to be granites. This city is the sixth largest city of India with an area of 202.56 square kms. It is 538.2 meters above sea level with many tanks and lakes.

Soil : The two important soil groups seen within the state are:

1. Black cotton soil
2. Red soil.

The soil at the sight of investigation is the red soil which is sandy to loomy in texture. As such, it is porous and easily drained.

MIR-ALAM LAKE

Mir-Alam lake was constructed in 1806 A.D. It is the oldest man made lake with in the metropolitan city limits of Hyderabad, A.P., industrial suburbs (17° 22 N and 78° 27 E) at an elevation of about 510m above mean sea level (MSL). This is a man made riverine impoundment intended mainly to cater to the water supply needs of Hyderabad and its Industrial Suburbs. At present it serves as standby reservoir for supplying water to the adjacent, Nehru Zoological Park. The present study has done to portray the water quality and biological characteristics and their diurnal changes under the constraints of resources. The morphometric abd physiographical features of this lake are presented in Table 1.

Table 1. Morphometric and Physiographical Features of Mir-Alam Tank

Catchment area (Km ²)	16.50
Volume (x 10 ⁶ m ³)	8.12
Surface area (Km ²)	1.70
Maximum depth (meters)	13.41
Mean depth (meters)	4.81
Maximum effective length (Km)	2.44
Maximum effective width (Km)	1.63
Length of shore line (Km)	13.70
Absolute shore development	2.66

Volume development	1.07
Location Hyderabad	Rajendra nagar, Near Zoological park,
Year of impoundment	1806 (with 21 large semi circular arches)
Purpose	Drinking, Washing and Bathing
Constructed by state of Hyderabad)	Nawab Mir Alam (Ex P.M. of erstwhile
Capacity of tank for 20 feet	0 to 10.0 milling cubic yard
Highest water level and sill of sluice	0.6 to 10 square miles
Area of Highest water level	16.8 Kms
Catchment are (Km2)	16.5km2
Level of Top of the dam	4000 feet
Total length	13.7 km
Length of shore line (Km)	2.66
Absolute shore development	1.07
Volume development	8.12 m

It is the oldest lake within the city limits of Hyderabad Metropolis and is in existence since 1806. At present it serves as a stand by reservoir for water supply to Hyderabad and also supplies water to the adjacent Nehru Zoological Park. Littoral vegetation included *Potamogeten crispus*, *Typha angustifolia*, *Ipomea aquatica*, *Nechamandra alternifolia*, *Limnophyla indica*, *Nymphaea nouchali*, *Nelumbos nucifera*, *Nymphoides indica*, *Hydrilla verticellata*, *Ceratophyllum demersum* and a few grasses.

MATERIALS AND METHODS

Collection of water samples for Physico-chemical analysis

During the period of investigation, refers to here after as

1. The first year *i.e.*, October 1998 to December 1999.
2. The second year *i.e.*, January 2000 to December 2000.

Sampling Programme

Sampling Sites : Mir-Alam lake supply the water to Nehru Zoological Park and the water is also used for domestic purposes of the people. The main aim of the study is to investigate the physico-chemical and biological characteristics of water. The sampling sites were chosen not very far from the lake keeping in view the accessible deep zone of the lake to study the water quality in the vertical profile. The surface sites were designated as Site-I and Site-II.

Site-I (Dargha) is representing the lentic systems perturbed by various anthropogenic activities, the site receiving the sewage, dirt from washed clothes, vehicles cleaning, idol immersion and animal washing activities.

Site II (Towards Indira Nagar) is near the housing colony, which receives domestic sewage and other organic matter through washing clothes.

Sampling Procedure

The preliminary monthly sampling of physico-chemical and biological analysis of the Mir-Alam lake from October 1998 to December 2000 covering summer, winter and monsoon seasons revealed a pattern of continuous fluctuations paralleling the climatic changes through seasons rather than any sudden marked varied pattern of fluctuations of anthropogenic or edaphic origin. In view of the aim to portray the water quality and biological characteristics, their diurnal changes under the constraints resources and logistics for the field work, it become necessary to evolve a reasonably Pragmatic sampling programme. After careful consideration, it was found desirable to bifurcate the sampling programme into physico-chemical sampling and biological sampling separated by a time interval of about twice in a month, so that either of the analysis could be completed with reasonable precision and accuracy within the normal time limits. Water and benthic samples were collected for two years from October 1998 through December 2000. The sites and time schedules of physico-chemical and biological samplings are furnished in below table; The criterion for choosing such a time schedule is to study an possible thermal stratification and also to examine the pattern of surfacial and vertical distribution of benthic organisms due to diurnal changes.

Table-2. Sampling time Schedules

Sites	Physico-Chemical Sampling	Biological Sampling
Site-I (Dargha)	8:30 AM to 10:30 AM	8:30 AM to 10:30 AM
Site-II (Towards Indiranagar)	10:40AM to 12:40 PM	12:40 PM to 14:40 PM

Sampling programme for the present study was started from October 1998 to December 2000. Physico-chemical parameters were analysed with the aid of the standard methods given by APHA (1986). The ecological investigation carried during October 1998 to December 2000 in Mir-Alam embodies information of physico chemical parameters of water *viz.*,

temperature, pH, sacchidisc, total alkalinity, total hardness, calcium, magnesium, chloride, nitrate, total phosphorous, sulphate, COD, BOD, conductivity, lead and iron.

Water samples for physico-chemical analysis were collected from both the stations at an interval of about 30 days 0730 AM and 0900 AM from a depth of 5 cm to 12 cms. For sampling purpose the lake, was arbitrarily divided into two sites with a view to have more comprehensive knowledge of the limnology. The sites were designated as Site I (Dargha) and Site II (Near Indira Nagar). These locations are shown in map (plate 1 & 2). Details of location of sites are listed in Table 3. The parameters like Temperatures, pH, Conductivity and total alkalinity were analysed with the help of thermometer, pH meter, conductivity meter and water analysis kit developed by the Indian Association of Aquatic Biologist, Hyderabad, in the field itself. For the analysis of chemical parameters the samples were collected in pyrex bottles with well fitting pyrex glass stoppers and were immediately transported to the laboratory. For the estimation of dissolved oxygen, samples were collected in saperate bottles with all necessary precautions needed. Oxygen was fixed on the spot.

Table 3.

No.	Distance	Topographic Description
SITE I	4.0 Km away from the lake	Located at a point where the excess effluent spills out in to the nala and Ganesh immersion takes place.
SITE II	2.0 Km away from the lake	A number of wastes from washing, bathing and vehicle cleaning activities directly enter into the nala.

Collection of Benthic Macro Invertebrate sample

During the period of investigation separate samples were collected for qualitative and quantitative estimation of benthic fauna. The counting from both the two sites was made according to Coirns (1966, 1977) and the detailed description of the collection procedure described by Reddy and Rao (1990). A core sample of 4.5 cm in diameter and 12.0 cm in length was used for scooping the sediment to a depth of 10 cm, each sample being apart from the other by a distance of 2 meters at each site of aforesaid water body. The mud samples were transferred to the laboratory in polythene bag. The collected mud is transferred to a measuring cylinder and volume is measured. To sort out organisms in sample a suspension is prepared in water and is filtered through 2 mm and 0.5 mm mesh size. The filtered residue is transferred into a tray and sugar solution (10 gms in 250 ml) is added. Due to increase in the density of water, benthic organisms float on the surface and are picked up with the help of dropper and preserved in 4% formalin for identification upto species level, species composition, population density and spatial distribution and temporal variation. The various deversity indices were worked out following Ludwig and Reynolds (1988) using their software package (SPDIVERS.BAS).

RESULTS AND DISCUSSION

Physico-chemical parameters of the water

Temperature : Among the physical parameters, water temperature is one of the most important factors (William, 1987). The monthly variation of temperature of water at the two sites of the littoral zone of the lake revealed that it was maximum 38° C in Site-I and minimum 21° C in Site-II. At Site-I temperature increased to maximum in May 2000 and decreased to minimum 22° C in December 1999. During the present investigation, the minimum temperature 21° C was recorded in winter and the maximum being recorded in summer. During summer, water temperature was higher because of low water level, low velocity, clear atmosphere and greater solar radiation. Minimum water temperature in the rainy and winter months can explained due to frequent clouds, high percentage of humidity, high current velocity and high water levels. According to Khatri (1986), the air and water temperature follow a linear pattern throughout the annual cycle. Narasimharao *et al.*, (2001) observed that high temperatures noticed from March 1998 to June 1999 result in high rate of evaporation that causes the decline of water level during these months.

pH : pH is another important parameter affecting species diversity and distribution in an ecosystem. Monthly variation of pH of water at the two sites of the littoral zone of the lake depicted that it was maximum and minimum in Site-II where it ranged from 7.0 to 8.9, the former being recorded in October 2000 and later during July, 2000. This range of pH showed that the water was alkaline in nature. It showed high fluctuations during the study period.

Khatri (1986) pointed out that any lake would be alkaline except at the bottom during October and November wherein the concentration of free Carbondioxide lowers the pH to acidic level. Anon (1989) and Reddy (1991) recorded acidic pH occasionally at a few spots in Kukatpally nala, Hyderabad which could be due to acidic effluents entering into the stream. Selvanayagam *et al.*, (1989) observed the pH of the industrial effluents was slightly acidic and salinity resembled the values of normal freshwater systems. Alkaline waters harbour more plants than waters with acidic waters. Roy (1955) suggested that high pH and alkalinity are associated with high photosynthetic activity besides favouring saturation of the dissolved oxygen. pH between 8.5 to 9.5 is unfavourable for the growth of aquatic organisms (Das, 1978; Robert *et al.*, 1940). Mohan (1980) has got 8.94 average value of this parameter on Mir Alam during his study.

Conductivity : Conductivity and dissolved solids are directly proportional to each other and these are mainly due to ionic composition of water. The factors *viz.*, rainfall, biodiversity causing changes in ionic composition and nature of bottom deposits influence the conductivity. Conductivity also depends on the amount of salts and silts carried by canals adjacent to agriculture sites.

Electrical conductivity of water at the two sites of the littoral zone of the lake was found maximum in Site-II and minimum in Site-I. In Site-I it ranged from 350 to 1800 m mhos/

cm, the maximum being recorded in December 2000 and minimum in August 2000. It showed violent fluctuations from November 1998.

Conductivity is also important factor for detecting fish community structure and it also plays a vital role in the release of nutrients and consequently the productivity of aquatic ecosystem (Koul *et al.*, 1990).

In the present investigation, maximum (1920 $\mu\text{mhos/cm}$) was recorded during winter and minimum (400) at Site-II during rainy season. The seasonal variation in the conductivity may be due to the increase in concentration of salts because of discharge of domestic effluents and organic matter from the nearby residential areas in to the lake. High levels of conductivity reflect on the pollution status as well as trophic levels of the aquatic body.

Total Dissolved Solids (TDS) : Apart from potability, turbidity and Total Dissolved Solids (TDS) play an important role in community structure due to its limiting impact on primary production and trophodynamics. TDS of water at the two sites of the littoral zone of the lake showed its maximum in Site-I and minimum in Site-I and Site-II. In Site-I, it ranged from 220 to 1240 mg/lit, the maximum being recorded in October 1998 (winter) and minimum in June 2000 (summer). It showed fluctuation in January 1999 followed by gradual decrease in May 1999. In Site-II, it ranged from 200 to 1160 mg/lit, the maximum being recorded in December 1999 and minimum in May 1999 and 2000.

A high content of TDS elevates the density of water and such medium increases osmoregulation. Its values in the range of 150 to 850 make water unfit for any use (Rana *et al.*, 1980). In the present investigation, the lowest values of Total Dissolved Solids were recorded in summer and the highest in winter, which may be due to the close proximity of this lake to the inflowing drains.

Sacchi Disc (Transparency) : The transparency of natural waters is an indicator of productivity. The factors affecting turbidity of water are silt, microscopic organisms, suspended organic matter, heavy growth of the algal blooms and sewage effluents. High turbidity of the water causes damage to benthic community.

The monthly variation in sacchi disc of water at the two sites of the littoral zone of the lake revealed that, in Site-I it ranged from 5.2 to 6.3 cm the maximum being recorded in May 2000 and minimum in August and October 2000. At Site-II, it ranged from 5.5 to 6.5 cm, the maximum being recorded in April 2000 and minimum in October 1999 and 2000. It has decreased to minimum in October 2000.

Low transparency may be due to the presence of suspended particulate matter and high plankton density (18% - 20%). Kaliya Murthy (1973) reported that high plankton density and large quantities of suspended matter reduce the light penetration in a lake. High water clarity at shore may be due to low plankton populations that develop in response to low availability of phosphorous and Iron. Dutta (1978), Zutshi (1992) and Koul (2000), Dutta *et al.* (2001) recorded an increase in suspended matter and consequent decrease in transparency during monsoon.

Dissolved Oxygen : One of the most important abiotic factors influencing life in an aquatic ecosystem is the dissolved oxygen and its depletion, perhaps, is the most critical manifestation of pollution.

Dissolved Oxygen of water at the two sites of the littoral zone of the lake depicted that, it was recorded maximum in Site-I and minimum in Site-II. At Site-I, it showed irregular fluctuations and ranged from 2.5 to 4.5 mg/lit, the minimum being recorded in May 1999 and maximum in September 1999. In Site-II, it showed irregular fluctuations and ranged from 2.0 to 4.2 mg/lit, the minimum being recorded in May 2000 and maximum in September 1999. It fluctuated more or less in similar manner without showing much fluctuation. Distribution of macroinvertebrates was influenced by a number of environmental factors and dissolved oxygen content was the major limiting factor (Ruttner, 1963).

The dissolved oxygen content of the Mir-Alam lake was maximum 4.5 mg/lit in rainy season at Site-I and minimum 2.0 mg/lit at Site-II in summer in the present investigation. During summer low values of dissolved oxygen and high phytoplankton density may be due to the decrease of photosynthetic activity. Mohan (1980) has obtained 8.25 as average value of this factor during his study on Mir Alam lake. The relationship between the dissolved oxygen and phytoplankton had been well studied by Lande (1973). It is a well known fact that the oxygen balance of a lake is related to the photosynthetic & respiratory activities of its biota and the chemical oxidation on one hand and the prevailing physico-chemical condition on other. The reason for the low values of the dissolved oxygen in Mir Alam lake water can be attributed to the presence of effluents and domestic sewage causing anoxic conditions due to the decay of organic matter. Ellis (1937) pointed out that the minimum dissolved oxygen content in water for maintaining fish life in healthy conditions, is 5 mg/lit at 20° C.

Total Alkalinity : Carbonate, bicarbonate and carbondioxide constituted major source of inorganic carbon to producers in an aquatic ecosystem and act as buffer (s), thus regulating pH of the medium. Due to the presence of carbonates and bicarbonates the total alkalinity value of water becomes high and according to Nayak *et al.*, (1982), Oomachan *et al.* (1986), Ghosh and George (1989) and Das, (1978), the higher alkalinity indicates pollution. Higher alkalinity, hardness and chlorides are found to be more productive and support rich biota particularly in summer Moyle (1946). Mohan (1980) has got an average value of 320.48 during his study on the lake.

Monthly variation in Total Alkalinity of water at the two sites of the littoral zone of the lake observed its maximum 415 mg/lit in Site-I and minimum 150 mg/lit in Site-II. In Site-I, it ranged from 150 (August, 2000) to 412 mg/lit. (October, 2000). In Site-II, it ranged from 150 to 415 mg/lit, was maximum in October 2000 and minimum in August 2000. The bicarbonate alkalinity is considered more important than temperature in influencing the density of bottom fauna (Gauvin, 1949; Armitage, 1958; Needam and Usinger 1956). Total Alkalinity from 220-360 mg/lit) indicates pollution (Das, 1978).

Occurrence of high bicarbonate values in late rainy season and early winter as was found in the present study on Mir Alam lake, may be due to inflow of mineral salts along with

the water (Choudhary *et al.* (1979). The present studies however, revealed higher values of the parameter in Mir Alam lake and this further supported by the observations of Brion Moss (1973) and Wetzel (1983) that the alkaline eutrophic waters generally rich in bicarbonates. Thus it is clear that the lake is highly productive from the alkalinity point of view.

Chloride : Chloride is one of the important anions that determines the total salinity of water and marked quantitative accumulation of this anion over a period of time is indicative of anthropogenic pollution. Gopal and Durve (1989) observed that high chloride content of water of the lake with an annual average of 83.73 mg/lit is indicator of organic pollution. Chloride and other parameters *viz.*, high values of electrical conductivity, nitrates, total dissolved solids and bicarbonates are indicative of the high nutrient load. High chloride content of the water (120 to 198 mg/lit) indicates organic pollution of animal origin (Thresh *et al.*, 1944).

Chloride content of water at the two sites of the littoral zone of the lake revealed that it was recorded 320 mg/lit maximum in May 1999 (summer) and minimum 80 mg/lit in August 2000 (monsoon) at Site-I and II. In Site-I, it ranged from 85 mg/lit. (September, 2000) to 318 mg/lit. (May, 1999). In Site-II, it ranged from 80 mg/lit (May, 1999) to 320 mg/lit. (August, 2000). Mohan (1980) has obtained 31.1 as mean value of this factor during his study on Mir Alam lake.

Verma and Dalela (1975) pointed out that presence of high amount of chloride influences the amount of dissolved oxygen and this also might adversely affect number of aquatic organisms.

The chloride content was high during the present study in Mir-Alam lake. Mohan (1986) also recorded high chloride content in Mir-Alam lake. Mir-Alam lake located close to Hyderabad was subjected to varying amount of anthropogenic and animal pollution. In addition this lake occasionally received flour wash from the nearby water works. Zafar and Seenayya (1980) linked chloride with the progression of trophy and aging of the lake of Hyderabad. In conformity to this Mir-Alam, the oldest of the lakes, had high concentration of chloride. The increase of chloride in summer was obtained due to raise in temperature and evapotranspiration occurs. This could be explained by the fact that the presence of chloride salts may interfere with other nutrients, which are being utilised in the processes of photosynthesis. In monsoon, the chlorides were recorded minimum because of heavy rain dilution of chloride. The rising concentration depends upon dumping of effluents of Municipal as well as Industrial sources or by Human activities.

Total Hardness : Total Hardness often employed as indicator of water quality depends on the concentration of carbonate and bicarbonate salts of calcium and magnesium (temporary hardness) or sulphate chloride or other anions of mineral acids (permanent hardness).

Monthly variation in Total Hardness of water at the two sites of the littoral zone of the lake depicted its minimum in Site-I and maximum at Site-II in September 2000. At Site-I, it ranged from 150 (July, 1999) to 410 mg/lit (September, 2000). In Site-II, it ranged from

160 to 420 mg/lit, the minimum being recorded August 2000 and maximum in September 2000.

Calcium : This element is an important component of the carbonic buffer system and also cycles through biotic and abiotic component of the ecosystem. As a result the ambient concentration. is under the influence of the photosynthetic precipitation, biotic utilization and tropholytic release. Calcium concentration of water at the two sites of the littoral zone of Mir Alam lake showed that, it was recorded 15 mg/lit minimum in August 1999 at Site I and II and maximum 100 mg/lit in March 2000 at Site-I. At Site-I, it ranged from 15mg/lit to 100 mg/lit in March, 2000. In Site-II, it ranged from 15 to 98 mg/lit (March, 1999). In summer, maximum concentration of calcium develops during the decomposition of organic materials that released the carbondioxide which brought calcium into the system (Jayadevi, 1985).

During the present investigation the calcium content of water was maximum during summer season and minimum in rainy season at the two sites. It increased in summer due to the fall of the water level caused by an increase of evaporation by the rise of temperature, during the season. Thus the increase of concentration of salts causes an increase in hardness. Calcium was 3rd in the order of equivalent ionic dominance in the lake.

Magnesium : The concentration of magnesium of water was maximum and minimum in Site-I and Site-II. In Site-I, it ranged from 20 to 210 mg/ lit the maximum being recorded in December 1998 and minimum in October 2000. In Site-II, it ranged from 20 to 210 mg/ lit the maximum being in December 1998 and minimum in October 2000.

Magnesium occupied the second place in the order of equivalent cationic dominance but its average of 16.36 mg/lit was only slightly lower to that of the other bivalent ion Calcium which averaged 17.2 mg/lit. In the present study maximum being recorded in winter ranging from 20 to 210 mg/lit. Similar observation was made by Seshagiri Rao (1982) on Manjira lake.

Orthophosphate : Phosphorous is an essential metabolic element, which normally occurs, in low concentration in natural aquatic ecosystem and hence, often acts as a limiting factor for primarily production (Rigler 1956). This element is known to occur in several forms (Strikland and Parsons, 1965). Among the different forms of phosphates, orthophosphate is the most available form for the phytoplankton (Fitzgerald and Faust, 1967). Orthophosphate concentration of Mir Alam lake water was found ranged from 0.1 to 0.9 mg/ lit in March 1999. Both the maximum and minimum values were found December 1999 at Site-I.

The chief source of phosphorous for Mir Alam lake is the landscape and this shallow water body habours rich littoral vegetation presents rapid flux changes of phosphate. In the present investigation on the lake, high Phosphate content is observed in summer and such high concentration may be due to contamination or domestic sewage. Similar observations were made by Reid (1961), Brinley (1942), Jolly and Chapman (1966), Young *et al.*, (1973) and have reported that an increase in the phosphate concentration in the river waters are

polluted by sewage. Mohan (1980) has got a mean value of 0.01 as orthophosphate concentration of Mir Aam lake, during his study. Due to the washing activities there is an entry of detergent into the water body. The detergent formulations normally contain a high level of phosphate and its influx to lentic water bodies removes the limiting effect of nutrients, which leads to a change in the biological characteristics of the receiving water body.

Nitrates : The Nitrogen pool of limnetic environment comprises of two components viz., the organic component consisting of organic materials liberated by the biota or generated in the heterotrophic bacterial activity upon proteinaceous substrate. The second component is made up of inorganic compounds of nitrogen such as ammonia, nitrite and nitrate. Nitrates composition of water at the two sites of the littoral zone of the lake revealed that, it ranged from 1.5 (May, 2000) to 8 mg/lit (August, 1999) at Site-I. In Site-II, it ranged from 1.8 mg/lit to 7.8 mg/lit the maximum being recorded in August 1999 and minimum in May 2000.

A great deal of work on the distribution pattern of different forms of nitrogen and their interrelationship in fresh waters have been done by Ganapati (1960), Zafar (1955b, 1964 and 1966), Lakshminarayana (1965), Roy (1965), George (1966), Venkateswarlu (1969) and Rao (1972). During the present investigation only one form of nitrogen *i.e.*, nitrate nitrogen was estimated.

Generally, the nitrates were low in summer months is due to 1). The relatively stable thermal stratification and incomplete circulation of water (Zafar, 1966). 2). The biological destruction (Seenayya, 1973), which is accelerated in summer. 3). The greater biological demand due to tremendous increase in the density of algal population. 4). The lack of incoming water. In the present study on Mir Alam lake this factor has got low values in summer. Seshagiri Rao (1982) also got similar finding on Manjira lake. Mohan (1980) has got 13.7 as mean value of this parameter during his study on Mir Alam lake.

Another reason for low summer value due to decomposing organic matter derived from littoral region and seston piled upon the sediments and generated nitrogenous organic matter and NH_4^+ -N and they constituted the major fraction of the nitrogen pool. May be inorganic nutrients were also tied up in the bacterial biomass as noted by Fenchel and Harrison (1976). In addition rainwater brought in some nitrates. Such accumulation of nitrates continues till early winter, because the littoral vegetation will not make heavy unabated demands on this nutrient. Another factor for its decline was the denitrification by facultative anaerobic bacteria that also thrive in aerobic conditions and utilize nitrate as an exogenous terminal Hydrogen ion acceptor in the oxidation of organic substances (Alexander, 1961; Bandurski, 1965).

Sulphates : Sulphur exists in a number of oxidation states, from the most oxidized sulphate to the most reduced sulphide. The biological reduction of Sulphur can take place in both aerobic and anaerobic conditions. Sulphates of water at the two sites of the littoral zone of the lake observed from 20 to 138 mg/lit the maximum in December 1998 and minimum in July-August 2000 in Site-I. In Site-II, it ranged from 20 to 125 mg/lit fluctuated

violently, and the minimum being recorded in July 2000 and maximum in December 2000.

In the present investigation, high concentrations of sulphates have been reported from the lake waters. A high concentration of sulphates stimulates the action of Sulphur reducing bacteria, which produce hydrogen sulphide, a gas highly toxic to fish life. High concentrations of sulphates and sulphides were also observed in a number of eutrophic lake waters (Kemp *et al.*, 1972). The high concentration of chlorides, sulphates, phosphates, and nitrates associated with the depletion of Oxygen led to anoxic or anaerobic conditions in the lake waters.

Biological Oxygen Demand (BOD) : Biological Oxygen Demand can be defined as the quantity of dissolved oxygen in mg/lit required under test condition for complete oxidation (by aerobic bacteria) of the organic matter in the representative sample. In unpolluted water Biological Oxygen Demand is lower while it is higher in the case of polluted water (Hynes, 1960). Biological Oxygen Demand affects the benthic diversity (Bilgrami and Siddiqui, 1983).

BOD of water at the two sites of the littoral zone of the lake observed in Site-I it ranged from 0.4 to 26 mg/lit the maximum being recorded in November 1998 and minimum in August 2000. At Site-II, it ranged from 0.4 to 25 mg/lit, maximum being recorded in November 1998 and reached minimum in December 1998, August 1999 and 2000.

In the present study the average values of Biological Oxygen Demand the waters of the lake are high. This indicates that untreated domestic sewage are being dumped into the lake, resulting in accumulation of large amounts of organic matter in the lake and thereby giving a high Biological Oxygen Demand values.

Chemical Oxygen Demand(COD) : Monthly variation in chemical oxygen demand of water at the two sites of the littoral zone of the lake revealed that, in Site-I it ranged from 10 to 120 mg /lit the maximum being recorded in January, 1999 and minimum in June, 2000. In Site-II, it ranged from 11 to 118 mg/lit the maximum recorded in January 1999 and minimum in June 2000.

Chemical Oxygen Demand test is useful in pinpointing toxic condition and presence of biological resistant substances. It is a measure of oxygen required by oxidizing organic compounds by involving a chemical oxidant such as potassium chromate permanganate. Chemically polluted samples in which micro biochemical degradation is not possible due to presence of toxicants and chemicals, Biological Oxygen Demand cannot be determined accurately. In such waters, Biological Oxygen Demand can assess degree of organic pollution. In the present investigation higher values of Chemical Oxygen Demand indicate higher microbial activities and presence of oxidizable organic matter.

Lead and Iron : In aquatic environments, metals have been termed as conservative pollutants because once added to the environment, they prevail forever. Further, the seriousness and persistence of heavy metals in water are compounded by the fact that generally they are water soluble, non-degradable and strongly bounded to many biochemical, especially polypeptides and proteins besides other materials which losses electron rich functional groups

such as sulfohydryl, amino and imidasole (Gurd and Wilcox, 1956). Further, the heavy metal salts, being stable compounds are not readily removed by oxidation, precipitation, other processes and affect the activities of the animals. Hence, the pollution of the fresh water environments by heavy metal contamination is major concern since it may lead to deterioration of natural habitats by depleting ecologically sensitive species or by eliminating commercial species (Marshall, 1985) and also pose a serious health hazard to humans. (Saha, 1972).

Monthly variation in Lead of water at the two sites of the littoral zone of the lake depicted its range from 0.1 to 0.5 mg/lit was minimum in Site-I and Site-II and maximum in Site-I. At Site-I the maximum was recorded in August 1999 and minimum in November 1998. In Site-II, the minimum being recorded in December 1998 and February and December 2000 and maximum in August 1999.

Iron content of the lake water was found ranged from 0.14 to 0.25 mg/lit and recorded minimum in Site-I and maximum in Site-II. At Site-I, the minimum being recorded in September 1999 and maximum in February 1999. In Site-II, it ranged from 0.15 to 0.27 mg/lit the minimum being recorded in September 1999, January, August and November 2000 and maximum in February 1999. Welch (1980) pointed out the Zinc, iron, cadmium, lead, copper, chromium, mercury and nickel are well known toxic heavy *met. als* that occur in various wastes including municipal effluents and urban run-off apart from industrial effluents causing either acute or chronic effects on organisms in an aquatic environment. Mohan (1980) obtained the mean value of 0.087 on Mir Alam during his study.

The heavy metals that have been reported from the Mir-Alam lake waters might have been contributed by domestic sewage being drained into the lake waters. Thus, the lake water quality survey conducted at the two different sites of the lake during the present investigation indicates its polluted state, which is obviously because of the domestic sewage brought into the lake waters.

Table 4 : Water Quality (mean values) of Mir Alam Lake obtained by Mohan (1980)

S.No.	Parameter	Mean values
1.	pH	8.94
2.	Dissolved Oxygen	8.25
3.	Total Alkalinity	320.48
4.	Chlorides	61.1
5.	Orthophosphates	0.01
6.	Nitrates	13.7
7.	Iron	0.087

FAUNAL COMPOSITION

Qualitative Composition : The benthic macro invertebrates in the lake polluted with domestic sewage, belonged to Annelida, (Oligochaeta, Naididae and Lumbricidae) Arthropod, (Diptera, Hemiptera and Notonectidae), Mollusca (Viviparidae, Thiaridae, Planorbidae, Bithyniidae and Lymnaeidae). The Annelids belonged to three species in the two sites, one being represented by *Limnodrilus hoffmeisteri* Claparede 1862, *Pristina aequisetata* Bourne, 1891 and the other is Lumbricidae (species not identified) being recorded at I and II sites. Arthropods was represented by *Notonecta glauca*, Mosquito larvae, *Chironomus circumdatus* Kieffer and *Chironomus plumosus* were presented in the two sites. Molluscs belonged to ten species in which *Bellamya dissimilis*, *Bellamya bengalensis*, *Indoplanorbis exustus*, *Thiara tuberculata*, *Thiara scabra*, *Lymnaea accuminata*, *Gyraulus convexiusculus*, *Cremnoconchus conicus*, *Faunus ater* and *Gabbia stenothyroide* was recorded in Site-I and II of the lake respectively.

Table 5 : Faunal Composition

S.No.	Annelida	Arthropoda	Mollusca
1.	<i>Limnodrilus hoffmeisteri</i>	<i>Notonecta glauca</i>	<i>Bellamya dissimilis</i>
2.	<i>Pristina aequisetata</i>	Mosquito larvae	<i>B. bengalensis</i>
3.	(Lumbricidae)	<i>Chironomus circumdatus</i>	<i>Indoplanorbis exustus</i>
4.		<i>C. plumosus</i>	<i>Thiara tuberculata</i>
5.			<i>T. scabra</i>
6.			<i>Lymnaea accuminata</i>
7.			<i>Gyraulus convexiusculus</i>
8.			<i>Cremnoconchus conicus</i>
9.			<i>Faunus ater</i>
10.			<i>Gabbia stenothyroide</i>

Quantitative Composition : The percentage composition of different benthic macro invertebrates at Site-I of the lake presented in Figure-9, 9a and 10 revealed that at the Site-I, Mollusca were dominant comprising 74.80 percent followed by Arthropod constituting 13.56 percent and the Annelids was recorded minimum comprising 8.57 percent. Among Molluscs *Gabbia stenothyroide* was maximum constituting 34.29 percent and the *Faunas ater* was recorded minimum representing only 0.5 percent of the total benthic macro invertebrates. Among Arthropod, larvae of Chironomidae, *C. circumdatus* and *Notonecta glauca* comprising 5.71 percent followed by Chironomidae plumosus constituting 2.14 percent. Among Annelids, *Limnodrilus hoffmeisteri* was maximum constituting 3.57 percent and the

Pristina aequisetata was recorded minimum representing only 2.14 percent of the total benthic macro invertebrates.

In Site-I and II, Mollusca was recorded maximum constituting 66.77 percent followed by Arthropod representing 18.36 percent and Annelida comprising 17.60 percent of the total benthic macro invertebrates. Among Mollusca, *Gabbia stenothyroide* was recorded maximum constituting 36.05 percent and the other species, each comprising of 6.12 percent i.e., *Faunas ater*, followed by *Gyraulus convexiusculus* and *Indoplanorbis exustus* comprising 5.41 percent. Annelids being represented by *Limnodrilus hoffmeisteri* and Lumbricidae constituted 7.48 percent of the total benthic macro invertebrate fauna.

SEASONAL ABUNDANCE

Total Benthic Macro-Invertebrates : Among the two sites of the lake, the total benthic macro-invertebrates was recorded maximum in August 2000 in Site-II and minimum in April 1999. The monthly fluctuation in relative abundance of total benthic macro-invertebrates in two different sites of the littoral zone of lake was presented in fig-11. In Site-II abundance ranged from $492.4 \pm 0 \text{ m}^{-2}$, $2,42,860.2 \text{ m}^{-2}$ the maximum being recorded in August 2000 and the minimum in April 1999. In January 2000, its abundance reached the second peak. Besides, the total benthic macro-invertebrates showed small peaks of abundance in July 2000, January, July and August 1999. In Site-I, the maximum $1,76,920.3 \text{ m}^{-2}$ being recorded in August 2000 and minimum in April 1999. Besides, in June 1999 their abundance reached the second peak and in July 2000, January and August 1999, it showed smaller peaks of abundance.

Annelida

I. Oligochaeta : Tubificidae : The monthly fluctuation in relative abundance of Tubificidae represented by *L. hoffmeisteri* at the two sites of the littoral zone of the lake was presented in fig.-12a, which revealed that its abundance fluctuated irregularly. In Site-I, the abundance ranged from 345.8 ± 0 to $17,236.4 \pm 165.6 \text{ m}^{-2}$, maximum being recorded in February 1999 and minimum in September, October and December 2000. In March 1999, their abundance reached the second peak and in May 1999 and March 2000, it showed smaller peaks of abundance. However, it was absent in August 1999, July and November 2000. It again appeared in September 1999 and December 2000. In Site-II, the abundance ranged from 492.4 ± 0 to $20,106.2 \pm 160.5 \text{ m}^{-2}$, maximum being recorded in February 1999 and minimum in September, October and December 2000. It reached the second peak of abundance in February 2000. Besides, it also showed smaller peaks of abundance in March 2000 and May 1999.

II. Naididae : The monthly fluctuation in relative abundance of *P. aequisetata* at the two sites of the lake was presented in fig-12b revealed that its abundance ranged from 429.4 ± 0 to $16,536.4 \pm 532.2 \text{ m}^{-2}$ at Site-I and was recorded maximum in February 1999 and minimum in October 2000. In Site-II it showed irregular seasonal abundance. It ranged from

735.0 $\pm$ 132.4 to 23,900.2 $\pm$ 712.3 m⁻². In January, March 1999 and February 2000 their abundance reached the second peak and in December 1999 and May 2000, it showed smaller peaks of abundance. However, it was absent in October 1998 and December 1998, April to June 1999, September to December 1999, November 2000 and December 2000. In Site-I the maximum was being recorded in January 1999 and minimum in October and November 1999. In February 1999, their abundance reached the second peak. However, it was absent in December 1998, April to June 1999, September 1999, December 1999, March 2000, November and December 2000.

III. Lumbricidae : The monthly fluctuation in relative abundance of earthworm presented in fig.-12c revealed that its abundance ranged from 629.4 $\pm$ 0 to 21,783.2 $\pm$ 504.3 m⁻² and maximum at Site-II. And at Site-I its abundance ranged from 429.4 $\pm$ 0 to 18,430.8 $\pm$ 396.0 m⁻² and minimum at Site-I and Site-II, it was very much irregular in its seasonal abundance. In Site-II, the maximum was being recorded in May 2000 and minimum in October 2000. However, it was not recorded in February to April 2000, June, August, September and December 1999, January to April, November and December 2000. Besides it showed smaller peaks of abundance in March 1999 and September 2000. In Site-I, the maximum being recorded in July 1999 and May 2000. Besides, it also showed smaller peaks of abundance in May and August 1999. However it was not recorded in February to April 1999, June, August to September and December 1999, January to April, November to December 2000.

Arthropoda

I. Tendipidae : Chironomidae : The monthly fluctuation in relative abundance of larvae of Chironomidae, represented by *C. circumdatus* in the two sites of lake presented in Fig.-13a revealed that in Site-I, it was maximum and minimum in Site-II. In Site-I, the abundance ranged from 492.8 $\pm$ 0 to 14,431.3 $\pm$ 263.0 m⁻² and maximum recorded in February 2000 and minimum in May 1999, although it reached the second peak of abundance in February 1999. It was not recorded in March, August, and September 1999 and May, September and November 2000, during the study period. In Site-II, its abundance ranged from 530.2 $\pm$ 0 to 17,440.3 $\pm$ 160.2 m⁻² and was recorded maximum in February 1999 and minimum in March 1999. It reached the second peak of abundance in January 2000. Besides, it showed smaller peaks of abundance in October 1998, February, October and December 1999.

C. plumosus : The monthly fluctuation in relative abundance of Chironomidae represented by *C. plumosus* in the two sites of the lake presented in Fig.-13b, revealed that in Site-II it was maximum and minimum in Site-II. In Site-I, its abundance ranged from 531.2 $\pm$ 100.2 to 7,440.2 $\pm$ 220.0 m⁻² and was maximum in March 2000 and minimum in July 2000, and reached the second peak of abundance in December 2000. Besides, it also showed smaller peaks of abundance in December 1998, March 1999 and January 2000. However it was not recorded in April, June, September 1999, June and October 2000. In Site-II, its abundance ranged from 320.2 $\pm$ 0 to 10,443.8 $\pm$ 225.3 m⁻² and the minimum being recorded in August 1999 and maximum in December 2000. Although it reached the second peak of abundance

in December 1998. Besides it showed smaller peaks of abundance in January and February 2000.

Notonectidae : *Notonecta glauca* : The monthly fluctuation in relative abundance of Notonectidae, represented by *N. glauca* presented in Fig.-13c, revealed that in Site-I, it was maximum in December 1998 and August 1999 and minimum in Site-I and II. In Site-I, it abundance ranged from 320.2 ± 0 to $8,210.4 \pm 106.3 \text{ m}^{-2}$ and maximum being recorded in December 1998 and minimum in November 1999, and reached the second peak of abundance in October 1998. Besides, it also showed smaller peaks of abundance in August 1999, December 1999 and November 1998. However it was not recorded in March 1999 and January, May, August, September and November 2000. In Site-II, It abundance ranged from 320.2 ± 0 to $11,210.2 \pm 210.6 \text{ m}^{-2}$ and the maximum was recorded in December 1998 and August 2000, and reached the second peak of abundance in October 1998. Besides, it also showed smaller peaks of abundance in March 1999, June to July 1999, October 1999 and July 2000.

Diptera : The monthly fluctuation in relative abundance of mosquito larvae, presented in Fig.-13d, revealed that in Site-II, it was maximum and minimum in Site-I. In Site-I, it abundance ranged from 320.2 ± 0 to $1,18,110 \pm 216.0 \text{ m}^{-2}$ and was maximum being recorded in August 2000 and minimum in November and December 1998, it reached the second peak in July 2000. Besides, it also showed smaller peaks in July 1999 and January 2000. In Site-II, it abundance ranged from 320.2 ± 0 to $1,20,210 \text{ m}^{-2}$ and the maximum being recorded in August 2000, and minimum in November 1998. It reached the second peak of abundance in July 2000. Besides, it also showed smaller peaks of abundance in July, August 1999 and January 2000.

Mollusca : Viviparidae

***Bellamya dissimilis* :** The monthly fluctuation in relative abundance of Viviparidae represented by *B. dissimilis*, at the two sites of the lake was presented in Fig.-14b, revealed that it was maximum in Site-I and minimum in Site-II. In Site-I, it ranged from 320.2 ± 0 to $620.0 \pm 1,845.2 \text{ m}^{-2}$ and was maximum in November 2000 and minimum in November 1998, June and December 2000. Its second peak of abundance was recorded in October and December 1999. It was not recorded in August, December 1999. However, it was recorded in January 2000. In Site-II, it abundance ranged from 320.2 ± 0 to $8,420.4 \pm 86.5 \text{ m}^{-2}$ second peak of abundance was recorded in September 1999. It did not show much fluctuation and was not recorded in November 1998. However it was recorded in January 1999. Beside, it showed smaller peaks of abundance in December 1998, August, November 1999, January, February, May, June, July, September and October 2000.

***Bellamya bengalensis* :** The monthly fluctuations in relative abundance of Viviparidae, represented by *B. bengalensis*, at the two sites of the lake presented in Fig.-14c, revealed that it was recorded maximum in Site-II and minimum in Site-I. In Site-I, it abundance ranged from 320.2 ± 0 to $7,863.2 \pm 80.2 \text{ m}^{-2}$ and was maximum in September and December

1999 and minimum in January and December 2000. It reached the second peak of abundance in June 1999. Besides, it also showed smaller peaks of abundance in June and August 1999. It was not recorded in March and November 2000. In Site-II, its abundance ranged from 320.2 ± 0 to $9,382.4 \pm 86.5 \text{ m}^{-2}$ and was maximum in August 1999 and minimum in November 2000. It reached the second peak of abundance in February and August 2000. It also showed smaller peaks of abundance in February 1999, October, December, April, July and September 2000.

Littorinidae

Cremanoconchus conicus : The monthly fluctuation in its relative abundance of *Cremanoconchus conicus* at the two sites of littoral zone of the lake presented in Fig.-15d, showed that it in Site-I, its population abundance ranged from 320.2 ± 0 to $9,315.5 \pm 175.6 \text{ m}^{-2}$ and was recorded maximum during October 1998 and minimum December 1999. It reached a second peak of abundance representing in December 1998. It showed small peaks of abundance in February, September 1999 and January, April 2000. It showed fluctuations in November 1998, March, April, May, August, September 1999 and October 2000. In Site -II the abundance ranged from 320.2 ± 0 to $10,520.2 \pm 260.4 \text{ m}^{-2}$. It being recorded during October 1998, March, May, October, December 1999 and May 2000 and maximum during September 1999. It gradually increased and reached the second peak of abundance during November 1998. It was not recorded in June 2000.

Bythiniidae

Gabbia stenothyroide : The monthly fluctuation in its relative population abundance at the two sites of littoral zone of the lake presented in Fig.-16b, revealed that its seasonal fluctuation at the two sites was irregular. In Site-I, its abundance ranged from 320.2 ± 0 to $68,435.4 \pm 430.8 \text{ m}^{-2}$, the former being recorded in February 1999 and September 2000 and the latter in November 1998. It reached the second peak of abundance in December 1998 and was not recorded in July, November 1999, February, July 2000. However, it was present in August, December 1999, March, August 2000. In Site-II, its density ranged from 320.2 ± 0 to $65,210.3 \pm 584.3 \text{ m}^{-2}$, the former being recorded in November 1999 and the latter in December 1998. It reached the second peak of abundance in November 1998. It did not show much fluctuation in its population density during the rest of the period of study. It was not recorded in July 1999.

Lymnaeidae

Lymnaea accuminata : The monthly fluctuation in relative abundance of *L. accuminata* inhabiting the two sites of the lake was presented in Fig.-14a, which showed that in Site-I, its abundance ranged from 320.2 ± 0 to $820.0 \pm 7,865.0 \text{ m}^{-2}$, and the former being recorded in August 1999 and 2000 and the latter in February 2000. It reached the second peak of abundance representing in October 1998. It was absent in November 1998, September, October, December 1999, January, May, August, October 2000. However, present in December 1998, November 1999, February, June, September and November 2000. In Site-II, it was

recorded with abundance of 320.2 ± 0 to $570.0 \pm 11,965.0 \text{ m}^{-2}$ and the former during April, September 1999 and April 2000. It recorded the second peak of abundance representing in February 1999 and was not found during the November 1999, October 2000.

Thiaridae

Thiara tuberculata : The monthly fluctuation in its relative population abundance at the two sites of littoral zone of the lake presented in Fig.-14d, revealed that it was recorded maximum in Site-II and minimum in Site-I. In Site-I, it abundance ranged from 320.2 ± 0 to $8,410.4 \pm 185.2 \text{ m}^{-2}$ and the maximum being recorded in February 1999 and minimum in October 1998 and June 2000. It reached the second peak of abundance in September 1999 and May 2000. Besides, it also showed smaller peaks of abundance in January 1999, and July 2000. It was not recorded in November 1998, June, December 1999, April, August, and November 2000. In Site-II, it abundance ranged from 320.2 ± 0 to $10,430.2 \pm 200.3 \text{ m}^{-2}$ the maximum being recorded in May 2000 and minimum in September 1999. It reached the second peak of abundance in February 1999. Besides, it also showed smaller peaks of abundance in January, September 1999 and February, October 2000.

Thiara scabra : The monthly fluctuation in its relative population abundance at the two sites of littoral zone of the lake presented in Fig.-15a, revealed that it was recorded maximum in Site-I and minimum in February, March, April, June, July and December 1999, February, October, and December 2000. In Site-I it abundance ranged from 320.2 ± 0 to $4,920 \pm 523.3 \text{ m}^{-2}$ and the maximum was recorded in September 2000 and minimum in February, March, April, June, and December 1999 and October 2000. It reached the second peak of abundance in February and April 2000. Besides, it also showed smaller peaks of abundance in October 1998 and August 2000. However, it was not recorded in August, September 1999, June and December 2000. In Site-II, their abundance ranged from 320.2 ± 0 to $12,270.2 \pm 160.5 \text{ m}^{-2}$. The maximum being recorded in August 2000 and minimum during July 1999, February, October and December 2000. The abundance reached the second peak of abundance in May 2000. They were not recorded during June 1999.

Faunus ater : The monthly fluctuation in its relative population abundance at the two sites of littoral zone of the lake presented in Fig.-16a, revealed that it in Site-I, its density ranged from $8,435 \pm 210.8 \text{ m}^{-2}$, the former being recorded in July, October 1999 and December 2000 and latter in March 2000. It reached a second peak of abundance. It was not recorded in November 1998 and September 2000. In Site-II, its density ranged from $14,632.5 \pm 210.8 \text{ m}^{-2}$ former being recorded in August 2000 and the latter in March 2000. It reached a second peak of abundance in September 1999.

Planorbidae

Gyraulus convexiscullus : The monthly fluctuation in its relative population abundance at the two sites of littoral zone of the lake presented in Fig.-15b, reveals that in Site-I, its abundance ranged from 320.2 ± 0 to $8,215 \pm 428.4 \text{ m}^{-2}$. The former being recorded in April, June, August 1999 and January, September 2000 and the latter were recorded in March and

August 2000. It reached the second peak during October 1998. It was not recorded during November, December 1999 and April, July and December 2000. In Site-II, its abundance ranged from 320.2 ± 0 to $10,115.5 \pm 138.4 \text{ m}^{-2}$. The maximum during March 2000 and minimum in June, August, November, December 1998 and October 2000. The abundance reached the second peak in October 1998. They were not recorded in November 2000. It showed low ebb in other months.

Indoplanorbis exutus : The monthly fluctuation in its relative abundance of the *I. exutus* at the two sites of littoral zone of the lake presented in Fig.-15c, which reveals that in Site-I, its abundance ranged from 320.2 ± 0 to $12,865 \pm 315.2 \text{ m}^{-2}$. It was recorded maximum in October 1998 and minimum in December 1999. It reached a second peak of abundance in February 1999. It was absent during June 2000, July and October 2000. However, it was present during June 2000, July and October 1999. In Site -II, its population abundance ranged from 320.2 ± 0 to $620.0 \pm 14,210 \pm 115.3 \text{ m}^{-2}$. being minimum in July 1999 and maximum in February 2000. It reached a second peak of abundance in February 1999. It showed small peaks of abundance in January 1999, January and June 2000.

INFLUENCE OF ABIOTIC FACTORS OF WATER

Influence of Individual and Cumulative Effects of Abiotic Factors on Benthic Fauna

Total benthic macro-invertebrates : The linear co-efficient correlation analysis between the seasonal fluctuation in the population abundance of total benthic macro-invertebrates and variation in different abiotic environmental factors at the two sites of the lake presented in Table.-5 revealed that the total benthic macro-invertebrates showed negative correlation with Total Alkalinity in Site-II ($p < 0.05$). However, it showed significant positive co-relation with Nitrates in Site-I and Site-II (Site-I ; $p < 0.02$; Site-II ; $p < 0.02$) and Lead at Site-I (Site-I; $p < 0.05$).

Estimates of multiple regression pertaining to the seasonal of total benthic macro-invertebrates and the abiotic environmental factors such as pH, Conductivity, Total Dissolved Solids, Chloride, Total Alkalinity, Total Phosphorous, Sulphate, Lead, Iron and Calcium of Site-I of the littoral zone of the lake was presented in Table-5i. In this case the value of 'R²' indicated 71 percent of variation of the seasonal fluctuation of benthic macro invertebrates being explained by the variation in the ten abiotic factors (explanatory variables). Estimates of multiple regression pertaining to the seasonally of total benthic macro invertebrates and the eleven aforementioned abiotic environmental factors such as Temperature, Conductivity, Dissolved Oxygen, Sacchi Disc, Chloride, Total alkalinity, Orthophosphate, Total Phosphorous, Sulphate, Lead and Iron of Site-II of the littoral zone of the lake was presented in Table-5i. In this case the value of 'R²' indicated 81 percent of variation of the seasonal fluctuation of benthic macro invertebrates being explained by the variation in the eleven abiotic factors (explanatory variables). Estimates of multiple regression pertaining to the seasonally of total benthic macro invertebrates. In both the sites, *i.e.*, Site-I, the calculated value of 'F' is much higher than the table value indicated the high reliability of 'R²'. Thus it may be concluded

that the regression fitted is the best fit. However, examining the values of regression co-efficient and standard errors it can be said that out of ten estimates in Site-I one is insignificant and the co-efficient of the remaining variables such as Chloride, Total Alkalinity, Sulphate and Calcium are negatively insignificant and pH, Conductivity, Total Dissolved Solids, Lead, Iron are positively significant in a statistical sense.

Estimates of multiple regression pertaining to its seasonally and the eleven environmental factors of the Site-II in the lake is presented in Table-5i. In this case the value of ' R^2 ' indicated 81 per cent of variation of its seasonal fluctuation being explained by the variation in the eleven explanatory variables. Besides, the calculated value of ' F ' is insignificant. Thus, it may be concluded that the regression fitted may not be the best fit. Moreover, examining the values of the regression co-efficient and the standard errors, it may be evident that of the eleven estimates, one is insignificant in a statistical sense, and the co-efficient of the remaining three i.e., Conductivity ($p < 0.02$), Total Phosphorous ($p < 0.01$) and Lead ($p < 0.01$) are positively significant and Temperature ($p < 0.05$), Sacchi Disc ($p < 0.05$), Chloride ($p < 0.02$), Total Alkalinity ($p < 0.01$), Orthophosphate ($p < 0.05$), Sulphate ($p < 0.01$), Iron ($p < 0.05$) are negatively significant.

Annelida (*L. hoffmeisteri*) : The linear co-efficient correlation analysis between the monthly fluctuation of its population abundance and variation in six aforementioned abiotic environmental factors at the two Sites of the littoral zone of the lake presented in Table-6 showed that the annelid is negatively co-related with Sacchi disc Site-I ($p < 0.05$), Temperature in Site II ($p < 0.05$), Iron in Site II ($p < 0.02$) and positively co-related with Orthophosphate Site-I and Site-II (Site-I; $p < 0.02$; Site-II; $p < 0.02$), Calcium in Site-I and Site-II (Site-I; $p < 0.02$; Site-II; $p < 0.05$) and Total Phosphorous in Site-I and Site-II (Site-I; $p < 0.01$; Site-II; $p < 0.02$).

Estimates of multiple regression pertaining to its seasonally and the abiotic environmental factors such as Temperature, pH, Total Dissolved Solids, Biological Oxygen Demand, Total Hardness, Magnesium, Chloride, Total Phosphorus, Sulphate and Calcium of the Site-I of the littoral zone and in Site-II Sacchi Disc, Total Alkalinity, Total Phosphorous, Sulphate and Iron is presented in Table-6i. At Site I, the value of R^2 turned out to be very high indicating 86 percent of variation of its seasonal fluctuation being explained by the variation in the ten explanatory variables. The calculated value of the ' F ' is much higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted is the best fit. However, examining the values of the regression co-efficient and standard error, it can be said that out of the ten estimates three are insignificant in a statistical sense and the co-efficient the remaining variables such as temperature, ($p < 0.05$), pH ($p < 0.05$), Dissolved Oxygen ($p < 0.05$), Chemical Oxygen Demand ($p < 0.01$), Total Alkalinity ($p < 0.02$), Nitrates ($p < 0.05$) and Iron ($p < 0.05$) are negatively significant and that of Magnesium ($p < 0.05$), Orthophosphates ($p < 0.01$) and sulphates ($p < 0.02$) are positively significant. Estimates of multiple regression pertaining to its seasonally and the six abiotic environmental factors of the Site II of the lake (Table-6i) showed that the value of R^2 which turned out be high indicating 86 percent of variation of the seasonal fluctuation of the annelid in the Site

being explained by the variation in the six explanatory variables. The calculated value of 'F' is much higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted is the best fit. However, examining the values of regression co-efficient of standard error, it can be said that out of the six estimates one is insignificant in a statistical sense and the co-efficient the remaining variables such as Sulphate ($p < 0.05$) is negatively significant and that of Secchi Disc ($p < 0.05$), Total Alkalinity ($p < 0.05$), Total Phosphorous ($p < 0.02$), and Iron ($p < 0.01$) are positively significant.

Pristina aequiset : The linear co-efficient correlation analysis between the monthly fluctuation of its population abundance and variation in different abiotic environment factors at the two sites of the lake presented in Table-6, revealed that its population density showed positive correlation with orthophosphate at Site-I and Site-II (Site-I; $p < 0.01$; Site-II $p < 0.02$), Total Phosphorous at Site-I and Site-II ($p < 0.01$; Site-II $p < 0.01$) and Iron at Site-I ($p < 0.02$).

Estimates of multiple regression pertaining to its seasonally and the aforementioned abiotic environmental factors of the Site-I in the lake is presented in Table-6ii. In this case the values of R^2 indicated 82 percent of variation of its seasonal fluctuations being explained by the variation in the explanatory variables. The calculated value of 'F' is statistically significant. However, examining the values of the regression co-efficient and the standard errors, it can be said that of the estimates one insignificant in a statistical sense, and the co-efficient of the remaining variables such as Chemical Oxygen Demand ($p < 0.05$), Total Alkalinity ($p < 0.02$), Total Phosphorous ($p < 0.01$) and Sulphate ($p < 0.05$) and Iron ($p < 0.05$) are positively significant. Estimates of multiple regression pertaining to its seasonally and the eight abiotic environmental factors of the Site-II of the lake (Table-6ii) showed. The value of R^2 which turned out to be high indicating 92 percent of variation of the seasonal fluctuation of the annelid in the site being explained by the variation in the eight explanatory variables. The calculated value of 'F' is higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted in the best fit. However, examining the values of the regression co-efficient and standard error, it can be said that out of the eight estimates one is insignificant in a statistical sense and the co-efficient the remaining variables such as Biological Oxygen Demand ($p < 0.05$), Magnesium ($p < 0.02$), Total Alkalinity ($p < 0.05$), Orthophosphate ($p < 0.01$), Total Phosphorous ($p < 0.01$), Iron ($p < 0.02$) and Calcium ($p < 0.05$) are positively significant.

Lumbricidae : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in different abiotic environmental factors at the two sites of the lake presented in Table-7, revealed that its population density showed positive correlation with Sulphate at Site-I ($p < 0.02$) and at the Site-II, Conductivity ($p < 0.02$), Total Dissolved Solids ($p < 0.02$), Chloride ($p < 0.05$) and Sulphate ($p < 0.05$).

Estimates of multiple regression pertaining to its seasonally and the aforementioned abiotic environment factors of the Site-I in the lake is presented in Table-7i. In this case the values

of R^2 indicated 62 percent of variation of its seasonal fluctuation being explained by the variation in the explanatory variables. The calculated value of 'F' is statistically significant. Thus, it may be concluded that the regression fitted is the best fit. However, examining the values of the regression co-efficient and the standard errors, it can be said that of the six estimates three are insignificant in a statistical sense, and the coefficient of the remaining variables such as Sacchi Disc ($p < 0.02$), Orthophosphates ($p < 0.05$) and Total Phosphorous ($p < 0.02$) are positively significant. Estimates of multiple regression pertaining to its seasonally and the seven abiotic environmental factors of the Site-II of the lake Table-7i showed the value of R^2 which turned out to be high indicating 68 percent of variation of the seasonal fluctuation of the annelid in the site being explained by the variation in the seven explanatory variables. The calculated value of 'F' is much higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted is the best fit. However, examining the values of the regression coefficient and standard error, it can be said that out of seven estimates two are insignificant in a statistical sense and the co-efficient the remaining variables such as Total Dissolved Solids ($p < 0.05$), Chloride ($p < 0.01$), Orthophosphate ($p < 0.02$), Nitrates ($p < 0.02$) and Lead ($p < 0.05$) are positively significant.

C. circumdatus : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in different abiotic environmental factors at the two sites of the lake presented in Table-7, revealed that its population density showed positive correlation with Iron at Site-II ($p < 0.05$) and at the Site-I, Orthophosphate ($p < 0.02$), Total Phosphorous (Site-I; $p < 0.01$) and Calcium (Site-I; $p < 0.02$).

Estimates of multiple regression pertaining to its seasonally and the aforementioned abiotic environment factors at the Site-I of the lake is presented in Table-7ii. In this case the values of R^2 indicated 50 percent of variation. The seasonal fluctuation being explained by the variation in the explanatory variables. The calculated value of 'F' is statistically insignificant. However, examining the values of the regression co-efficient and the standard errors, it can be said that of the eight estimates five are insignificant in a statistical sense, and the coefficient of the remaining variables such as Orthophosphate ($p < 0.05$), Sulphate ($p < 0.02$) and Calcium ($p < 0.05$) are positively significant. Estimates of multiple regression pertaining to its seasonally and the twelve abiotic environmental factors of the Site-II of the lake Table-7ii, showed the value of R^2 which turned out to be high indicating 86 percent of variation of the seasonal fluctuation of the annelid in the site being explained by the variation in the twelve explanatory variables. The calculated value of 'F' is much higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted is the best fit. However, examining the values of the regression coefficient and standard error, it can be said that out of twelve estimates two are insignificant in a statistical sense and the co-efficient the remaining variables such as Total Dissolved Solids ($p < 0.05$), Chemical Oxygen Demand ($p < 0.05$), Total Hardness ($p < 0.05$), Total Alkalinity ($p < 0.05$), Orthophosphate ($p < 0.01$), Total Phosphorous ($p < 0.01$), Nitrates ($p < 0.02$), Sulphate ($p < 0.02$), Iron ($p < 0.02$) and Calcium ($p < 0.05$) are positively significant.

C. plumosus : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in Table-7, showed that arthropod is negatively correlated at Site-II ($p<0.05$) and Calcium is positively correlated at Site-II ($p<0.01$). At Site-I, there is no correlation.

Estimates of multiple regression pertaining to its seasonally and the abiotic environmental factors such as Temperature, pH, Total Dissolved Solids, Dissolved Oxygen, Biological Oxygen Demand, Total Hardness, Magnesium, Chloride, Orthophosphate, Total Phosphorous, Sulphate, Iron and Calcium at Site-I of the littoral zone and in Site-II, Temperature, pH, Conductivity, Dissolved Oxygen, Sacchi Disc, Chemical Oxygen Demand, Biological Oxygen Demand, Total Hardness, Total Alkalinity, Total Phosphorous, Sulphate and Calcium is presented in Table – 7iii. At Site-I the value of R^2 turned out to be higher indicating 83 percent of variation of its seasonal fluctuation being explained by the variation in the thirteen explanatory variables. The calculated value of 'F' is higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted is the best fit. Moreover, examining the values of the regression co-efficient and the standard errors, it can be said out of the twelve estimates two are insignificant in a statistical sense, and the coefficient of the remaining variables such as Temperature ($p<0.05$), pH ($p<0.05$), Chemical Oxygen Demand ($p<0.01$), Magnesium ($p<0.05$), Dissolved Oxygen ($p<0.05$), Total Alkalinity ($p<0.02$), Orthophosphate ($p<0.01$), Nitrate ($p<0.05$), Sulphate ($p<0.02$) and Iron ($p<0.05$) are positively significant. Estimates of multiple regression pertaining to its seasonally and the twelve abiotic environmental factors of the Site-II, Table-7iii of the lake showed the value of R^2 which turned out to be high indicating 81 percent of variation of the seasonal fluctuation of the annelid in the site being explained by the variation in the twelve explanatory variables. The calculated value of 'F' is much higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted is the best fit. Moreover, examining the values of the regression coefficient and standard error, it can be said that out of six estimates one is significant in a statistical sense and the co-efficient the remaining variables such as Temperature ($p<0.05$), Conductivity ($p<0.05$), Dissolved Oxygen ($p<0.02$), Biological Oxygen Demand ($p<0.02$), Total Hardness ($p<0.02$), Total Alkalinity ($p<0.02$) and Sulphate ($p<0.02$).

Notonecta glauca : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in different abiotic environmental factors at the two sites of the lake is presented in Table-8, revealed that its population density showed positive correlation with Dissolved Oxygen ($p<0.05$), Chemical Oxygen Demand ($p<0.05$), Magnesium ($p<0.01$) and Sulphate ($p<0.05$) at Site-I and at the Site-II, Chemical Oxygen Demand ($p<0.05$) and Magnesium ($p<0.02$) also showed positive correlation.

Estimates of multiple regression pertaining to its seasonally and the aforementioned abiotic environmental factors of the Site-II in the lake is presented in Table-8i. In this case the values of R^2 indicated 61 percent of variation of its seasonal fluctuation being explained by the variation in the explanatory variables. The calculated value of 'F' is statistically significant. Thus, it is concluded that the regression is fitted is the best fit. However, examining the

values of the regression co-efficient and the standard errors, it can be said that of the seven estimates three are insignificant in a statistical sense, and the coefficient of the remaining variables such as Dissolved Oxygen ($p < 0.05$), Total Hardness ($p < 0.05$), Magnesium ($p < 0.01$) and Total Alkalinity ($p < 0.05$) are positively significant. Estimates of multiple regression pertaining to its seasonally and the nine abiotic environmental factors of the Site-I of the lake Table – 8i showed the value of R^2 which turned out to be high indicating 67 percent of variation of the seasonal fluctuation of the arthropod in the site being explained by the variation in the nine explanatory variables. The calculated value of 'F' is higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted is the best fit. However, examining the values of the regression coefficient and standard error, it can be said that out of nine estimates two are insignificant in a statistical sense and the co-efficient. The remaining variables such as Total Dissolved Solids ($p < 0.05$), Dissolved Oxygen ($p < 0.05$), Total Hardness ($p < 0.05$), Magnesium ($p < 0.02$), Chloride ($p < 0.05$), Orthophosphate ($p < 0.05$) and Lead ($p < 0.05$) are positively significant.

Mosquito larvae : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in different abiotic environmental factors at the two sites of the lake is presented in Table-8, revealed that its population density showed positive correlation with Nitrate at Site-I (Site-I; $p < 0.02$) and at Site-II, Nitrates (Site-II; $p < 0.05$), Lead (Site-II; $p < 0.05$) and Iron (Site-II; $p < 0.05$) also showed positive correlation.

Estimates of multiple regression pertaining to its seasonally and the aforementioned abiotic environmental factors of the Site-II of the lake presented in Table-8ii. In this case the values of R^2 indicated 77 percent of variation. The seasonal fluctuation being explained by the variation in the explanatory variables. The calculated value of 'F' is statistically significant. Thus, the regression fitted is the best fit. However, examining the values of the regression co-efficient and the standard errors, it can be said that remaining variables such as Temperature ($p < 0.01$), Total Hardness ($p < 0.02$), Sulphate ($p < 0.01$) and Iron ($p < 0.02$) are negatively significant and that of pH ($p < 0.05$). Total Phosphorous ($p < 0.05$) and Nitrates ($p < 0.02$) are positively significant. Estimates of multiple regression pertaining to its seasonally and the nine abiotic environmental factors of the Site-I of the lake Table–8ii showed the value of R^2 which turned out to be high indicating 77 percent of variation of the seasonal fluctuation of the arthropod in the site being explained by the variation in the nine explanatory variables. The calculated value of 'F' is higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted is the best fit. However, examining the values of the regression coefficient and standard error, it can be said that out of nine estimates four are insignificant in a statistical sense and the co-efficient. The remaining variables such as pH ($p < 0.02$), Biological Oxygen Demand ($p < 0.05$), Magnesium ($p < 0.01$), Nitrates ($p < 0.01$), Iron are positively significant.

Lymnaea accuminata : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in Site-I, there is no correlation and in Site-II, Total Phosphorous (Site-I; $p < 0.05$) showed positive correlation presented in Table-8.

Estimates of multiple regression pertaining to its seasonally and the aforementioned abiotic environmental factors such as Sacchi Disc, Total Alkalinity, Sulphate and Calcium of the Site-I of the littoral zone and in Site-II, pH, Conductivity, Sacchi Disc, Chemical Oxygen Demand, Biological Oxygen Demand, Total Hardness, Magnesium, Chloride, Orthophosphate, Total Phosphorous, Nitrates, Sulphate, Lead and Iron is presented in Table-8iii. At Site-I the values of R^2 turned out to be low indicating 36 percent of variation of its seasonal fluctuation being explained by the variation in the explanatory variables. The calculated value of 'F' is insignificant. Thus, it is concluded that the regression fitted is not the best fit. However, examining the values of the regression co-efficient and the standard errors, it can be said that out of the nine estimates four are insignificant in a statistical sense, and the coefficient of the remaining variables such as Biological Oxygen Demand ($p < 0.05$), Magnesium ($p < 0.01$) are negatively significant. Estimates of multiple regression pertaining to its seasonally and the fourteen environmental factors of the Site-II of the lake Table-8iii showed the value of R^2 which turned out to be very high indicating 91 percent of variation of the seasonal fluctuation of the arthropod in the site being explained by the variation in the fourteen explanatory variables. The calculated value of 'F' is higher than the tabulated value indicating the high reliability of R^2 . Thus, it is concluded that the regression fitted is the best fit. However, examining the values of the regression coefficient and standard error, it can be said that out of fourteen estimates two are insignificant in a statistical sense and the co-efficient. The remaining variables such as Sacchidisc ($p < 0.02$), Chloride ($p < 0.01$), Orthophosphate ($p < 0.02$), Nitrates ($p < 0.01$), Sulphate ($p < 0.01$) and Iron ($p < 0.05$) are negatively significant and that of pH ($p < 0.05$), Conductivity ($p < 0.01$), Biological Oxygen Demand ($p < 0.01$), Magnesium ($p < 0.05$) and Total Phosphorous ($p < 0.01$) are positively co-related.

Bellamya dissimilis : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in Table-9, showed that arthropods is negatively correlated with Chemical Oxygen Demand at Site-II (Site-II; $p < 0.05$). At Site-I it does not show any correlation.

Estimates of multiple regression pertaining to its seasonally and the abiotic environmental factors such as Total Alkalinity and Lead at Site-I of the littoral zone and in Site-II, pH, Conductivity, Total Dissolved Solids, Sacchi Disc, Chemical Oxygen Demand, Biological Oxygen Demand, Total Hardness, Chloride, Orthophosphate, Nitrates and Iron is presented in Table-9i. At Site-I, the value of R^2 turned out to be low indicating 20 percent of variation of its seasonal fluctuation being explained by the variation in the two estimates, none is significant. In Site-II, Chemical Oxygen Demand ($p < 0.05$) and Orthophosphate are negatively significant and the Total Hardness ($p < 0.05$) is positively significant. Estimates of multiple regression pertaining to its seasonally and the eleven abiotic of the Site-II, Table-9i environmental factors showed the value of R^2 which turned out to be very high indicating 68 percent of variation of the seasonal fluctuation of the molluscs in the site being explained by the variation in the eleven explanatory variables. The calculated value of 'F' is higher than the tabulated value indicating the high reliability of R^2 . Thus, it is concluded that the regression fitted is the best fit. However, examining the values of the regression coefficient and standard error, it can be said that out of eleven estimates eight are insignificant in a statistical sense

and the co-efficient. The remaining variables such as COD ($p < 0.05$) and Orthophosphate ($p < 0.05$) are negatively significant and that of Total Hardness ($p < 0.05$) is positively significant in a statistical sense.

Bellamya bengalensis : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in Table-9, showed that arthropod, not correlated at Site-I and at Site-II, Nitrates (Site-I; $p < 0.05$) and Lead (Site-II; $p < 0.05$) showed positive correlation.

Estimates of multiple regression pertaining to its seasonally and the abiotic environmental factors such as Conductivity, Total Dissolved Solids, Dissolved Oxygen, Chemical Oxygen Demand, Chloride, Total Alkalinity, Total Phosphorous, Nitrates, Iron and Calcium of the Site-II of the littoral zone and in Site-I, Sacchi Disc, Chloride, Total Phosphorous, Nitrates and Iron is presented in Table-9ii. At Site-I, the value of R^2 turned out to be high indicating 49 percent of variation of its seasonal fluctuation being explained by the variation in five variables. The calculated value of 'F' is higher than the tabulated value indicating the high reliability of R^2 . Thus it may be concluded that the regression co-efficient and the standard errors, it can be said that of the five estimates one is insignificant in a statistical sense, and the coefficient of the remaining variables such as Sacchi Disc ($p < 0.05$), Chloride ($p < 0.05$), Total Phosphorous ($p < 0.02$) and Nitrates ($p < 0.05$) are positively significant. Estimates of multiple regression pertaining to its seasonally and the ten abiotic environmental factors of the Site-II of the lake, Table-9ii showed the value of R^2 which turned out to be high indicating 68 percent of variation of the seasonal fluctuation of the mollusca in the site being explained by the variation in the ten explanatory variables. The calculated value of 'F' is higher than the tabulated value indicating the statistical significant. Thus, it may be concluded that the regression fitted is the best fit. However, examining it can be said that out of ten estimates three are insignificant in a statistical sense and the co-efficient. The remaining variables such as Dissolved Oxygen ($p < 0.05$), Chemical Oxygen Demand ($p < 0.02$), Total Phosphorous ($p < 0.01$) are negatively significant and that of Total Dissolved Solids ($p < 0.05$), Chloride ($p < 0.02$), Nitrates ($p < 0.01$) and Iron ($p < 0.01$) are positively significant.

Thiara tuberculata : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in abiotic environmental factors at the two sites of the littoral zone of the lake, presented in Table-9iii, showed that the mollusca is positively correlated with orthophosphate Site-I (Site-I; $p < 0.05$) and Total Phosphorous Site-I (Site-I; $p < 0.05$) and in Site-II, Total Phosphorous Site-II ($p < 0.05$) and Iron Site-II ($p < 0.05$) is also positively correlated.

Estimates of multiple regression pertaining to its seasonally and the abiotic environmental factors such as Dissolved Oxygen, Total Alkalinity, Total Phosphorous and Iron of the Site-I of the littoral zone and in Site-II pH, Total Dissolved Solids, Total Hardness, Magnesium, Total Alkalinity, Orthophosphate, Calcium is presented in Table-9iii. At Site-I, the value of R^2 turned out to be low indicating 35 percent of variation in the four explanatory variables. The calculated value of 'F' is statistically insignificant. Thus, it is concluded that the regression

fitted is not the best fit. However, examining the values of the regression coefficient and standard error, it can be said that out of four estimates two are insignificant in a statistical sense and the co-efficient. The remaining variables such as Dissolved Oxygen ($p < 0.05$) and Total Phosphorous ($p < 0.05$) are positively significant. Estimates of multiple regression pertaining to its seasonally and the seven abiotic environment factors of the Site-II of the lake Table-9iii showed the Value of R^2 which turned out to be high indicating 68 percent of variation of the seasonal fluctuation of the mollusca in the Site being explained by the variation in the seven explanatory variables. The calculated value of 'F' is much higher than the tabulated value indicating the reliability of R^2 . Thus it is concluded that the regression fitted is the best fit. However, examining the values of the regression co-efficient and standard error, it can be said that out of the seven estimates two is insignificant in a statistical sense and the co-efficient the remaining variables such as pH ($p < 0.01$), Total Dissolved Solids ($p < 0.05$), Total Alkalinity ($p < 0.05$) are negatively significant and Total Hardness ($p < 0.01$) and Orthophosphate ($p < 0.02$) are positively significant.

Thiara scabra : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in Table-10, showed that mollusca is negatively correlated with Sulphate at Site-I (Site-I; $p < 0.05$), Iron (Site-I; $p < 0.05$) are positively co-related with Total Hardness ($p < 0.05$). At Site-II, Conductivity (Site-II; $p < 0.01$), Total Dissolved Solids (Site-II; $p < 0.05$), Chemical Oxygen Demand (Site-II; $p < 0.05$), Magnesium Site-II, ($p < 0.05$), Chloride Site-II($p < 0.02$) showed positive correlation.

Estimates of multiple regression pertaining to its seasonally and the abiotic environmental factors such as pH, Total Dissolved Solids, Total Hardness, Magnesium, Total Alkalinity, Orthophosphate, Calcium at Site-II of the littoral zone of the lake in Site-I Dissolved Oxygen, Sacchi Disc, Total Hardness, Magnesium, Chloride, Total Phosphorous, Sulphate and Iron is presented in Table-10i. At Site-I the values of R^2 turned out to be high indicated 70 percent of variation of its seasonal fluctuation being explained by the variation in the eight explanatory variables. The calculated value of 'F' is higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted is the best fit. Moreover, the regression co-efficient and the standard errors, it can be said that out of the eight estimates three are insignificant in a statistical sense, and the coefficient of the remaining variables such as Total Hardness ($p < 0.02$) and Magnesium ($p < 0.05$) and positively significant Sulphate ($p < 0.05$), Iron ($p < 0.05$) and Chloride ($p < 0.02$) are negatively significant. Estimates of multiple regression pertaining to its seasonally and the six abiotic environmental factors of the Site-II of the lake Table-10i showed the value of R^2 which turned out to be high indicating 79 percent of variation of the seasonal fluctuation of the mollusca in the site being explained by the variation in the six explanatory variables. The calculated value of 'F' is much higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted is the best fit. However, examining the values of the regression coefficient and standard error, it can be said that out of six estimates one is insignificant in a statistical sense and the co-efficient. The remaining variables such as Conductivity ($p < 0.05$), Chloride ($p < 0.02$), Total Alkalinity ($p < 0.02$), and Iron ($p < 0.02$) are negatively correlated and Orthophosphate ($p < 0.02$) showed positive co-relation.

Gyraulus convexiusculus : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in Table-10, showed that *Gyraulus convexus* is negatively co-related with pH at Site-II ($p < 0.05$) and Chloride Site-II ($p < 0.02$). At Site-I there is no co-relation.

Estimates of multiple regression pertaining to its seasonally and the abiotic environmental factors such as Total Hardness, Chloride, Total Phosphorous and Iron of the Site-I of the littoral zone and in Site-II Total Dissolved Solids, Biological Oxygen Demand, Magnesium, Chloride, Total Alkalinity, Total Phosphorous, Sulphate, Iron and Calcium presented in Table-10ii. At Site-I, the value of R^2 turned out to be low indicating 43 percent of variation of its seasonal fluctuation being explained by the variation in the four explanatory variables. The calculated value of 'F' is higher than the tabulated value indicating the high reliability of R^2 . Thus, it is concluded that the regression fitted is the best fit. However, examining the values of the regression co-efficient and the standard errors, it can be said that out of the four estimates two are insignificant in a statistical sense, and the coefficient of the remaining variables such as Chloride ($p < 0.02$) is negatively correlated and Total Phosphorous ($p < 0.05$) is positively correlated. Estimates of multiple regression pertaining to its seasonally and the nine abiotic environmental factors of the Site-II of the lake showed Table-10ii the value of R^2 which turnout out to be high indicating 70 per cent of variation of the seasonal fluctuations of the mollusca in the site being explained by the variation in the nine explanatory variables. Higher than the "F" is higher than the tabulated value indicating the high reliability of R^2 . Thus it is concluded that the regression fitted is the best fit. However, examining the value of co-efficient and standard error, it can be said out of nine estimates four are in significant in a statistical sense. The remaining variables such as Chloride, Total Alkalinity, Sulphate and Iron are negatively correlated and Biological Oxygen Demand, Magnesium, Total Phosphorous and Calcium showed positive correlation.

Indoplanorbis exustus : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in abiotic environmental factors at the two sites of the littoral zone of the lake presented in Table -11, showed that molluscan is positively co-related with Total Phosphorous (Site-II; $p < 0.01$) and Iron (Site-II; $p < 0.05$) and at Site-I, Total Phosphorous (Site-I; $p < 0.05$) all showed positive correlation.

Estimates of multiple regression pertaining to its seasonally and the abiotic environmental factors such as Total Dissolved Solid, Total Alkalinity, Total Phosphorous and Calcium of the Site-I of the littoral zone and in Site-II presented in Table-11i. At Site-I, the values of R^2 turned out to be low indicated 47 percent of its seasonal fluctuation being explained by the variation in the four explanatory variables. The calculated value of 'F' is higher than the tabulated value indicating the high reliability of R^2 . Thus, it is concluded that the regression fitted is the best fit. However, examining the values of the regression co-efficient and the standard errors, it can be said that out of the four estimates one is insignificant in a statistical sense, and the coefficient of the remaining variables such as Total Dissolved Solid ($p < 0.05$) and Total Phosphorous ($p < 0.02$) showed positive significant and Total alkalinity ($p < 0.02$) showed negatively significant. Estimates of multiple regression pertaining to its seasonally

and the six abiotic environmental factors of the Site-II of the lake Table-11i showed the value of R^2 , which turned out to be very high indicating 92 percent of variation of the seasonal fluctuation of the mollusca in the site being explained by the variation in the six explanatory variables. The calculated value of 'F' is much higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted is the best fit. However, examining the values of the regression coefficient and standard error, it can be said that out of six estimates one is insignificant in a statistical sense and the coefficient. The remaining variables such as Conductivity ($p < 0.05$), Chloride ($p < 0.02$), Total Alkalinity ($p < 0.02$), and Iron ($p < 0.02$) are negatively correlated and Orthophosphate ($p < 0.02$) showed positive co-relation.

Cremnoconchus conicus : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in different abiotic environmental factors at the two sites of the lake presented in Table-11, revealed that its population density showed positive correlation with Biological Oxygen Demand at Site-II ($p < 0.05$) and Total Hardness (Site-II; $p < 0.02$) and at Site-I there is no correlation.

Estimates of multiple regression pertaining to its seasonally and the aforementioned abiotic environmental factors at the Site-I in the lake is presented in Table-11ii. In this case the values of R^2 indicated 91 percent of variation of its seasonal fluctuation being explained by the variation in the explanatory variables. The calculated value of 'F' is statistically significant. Thus the regression fitted is the best fit. However, examining values of the regression coefficient and the standard errors, it can be said that all the twelve estimates are significant in a statistical sense, and the coefficient of the variables such as pH ($p < 0.02$), Chemical Oxygen Demand ($p < 0.02$), Orthophosphate ($p < 0.02$) and Calcium ($p < 0.01$) are negatively significant and Temperature ($p < 0.01$), Conductivity ($p < 0.01$), Total Dissolved Solids ($p < 0.02$), Dissolved Oxygen ($p < 0.05$), Magnesium ($p < 0.02$), Total Phosphorous ($p < 0.01$), Nitrates ($p < 0.05$) and Iron ($p < 0.01$) are positively significant. Estimates of multiple regression pertaining to its seasonally and the aforementioned six abiotic environmental factors of the Site-II of the lake Table-11ii showed the value of R^2 which, turned out to be high indicating 84 percent of variation of the seasonal fluctuation of the mollusca in the site being explained by the variation in the six explanatory variables. The calculated value of 'F' is much higher than the tabulated value indicating the high reliability of R^2 . Thus, it may be concluded that the regression fitted is the best fit. However, examining the values of the regression coefficient and standard error, it can be said that out of six estimates one is insignificant in a statistical sense and the co-efficient. The remaining variables such as Conductivity ($p < 0.05$), Chloride ($p < 0.02$), Total Alkalinity ($p < 0.02$), and Iron ($p < 0.02$) are negatively correlated and Orthophosphate ($p < 0.02$) showed positive co-relation.

Faunas ater : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in different abiotic environmental factors at the two sites of the lake presented in Table-11, revealed that its population density showed negative correlation with Total Hardness at Site-I ($p < 0.02$) and at Site-II, Total Phosphorous Site-II ($p < 0.02$) showed positive correlation.

Estimates of multiple regression pertaining to its seasonally and the aforementioned abiotic environmental factors of the Site-I in the lake is presented in Table -11iii. In this case the values of R^2 indicated 42 percent of variation of its seasonal fluctuation being explained by the variation in the explanatory variables. The calculated value of 'F' is statistically significant. Thus, the regression fitted is the best fit. However, examining the values of the regression co-efficient and the standard errors, it can be said that out of the four estimates two are insignificant in a statistical sense, and the coefficient of the remaining variables such as Biological Oxygen Demand ($p < 0.02$) showed negatively significant and Total Phosphorus ($p < 0.05$) is positively significant. Estimates of multiple regression pertaining to its seasonally and the seven abiotic environmental factors of the Site-II of the lake, Table-11iii, showed the value of R^2 which turned out to be 53 percent of variation of the seasonal fluctuation of the molluscan in the site being explained by the variation in the seven explanatory variables. The calculated value of 'F' is much higher than the tabulated value indicating high reliability of R^2 . Thus, it may be concluded that the regression is the best fit. However, examining the values of the regression coefficient and standard error, it can be said that out of seven estimates three are insignificant in statistical sense and the co-efficient. The remaining variables such as Total Dissolved Solids ($p < 0.05$) is negatively correlated and Total Hardness ($p < 0.05$), Chloride ($p < 0.05$) and Calcium ($p < 0.05$) are positively correlated.

Gabbia stenothyroide : The linear coefficient correlation analysis between the monthly fluctuation of its population abundance and variation in different abiotic environmental factors at the two sites of the lake presented in Table -11, which showed that its abundance was negatively correlated with Magnesium Site-II ($p < 0.05$), and at Site – I Biological Oxygen Demand ($p < 0.05$) and Magnesium ($p < 0.05$) are negatively correlated. Estimates of multiple regression pertaining to its seasonally and the ten abiotic environmental factors at the Site-II of the littoral zone of the lake is presented in Table-11iv. In this case, the value of ' R^2 ' turned out to be very high indicating 91 percent of variation of the seasonal fluctuation of the population of *Gabbia stenothyroide* being explained by the variation in the ten explanatory variables. The calculated value of 'F' is also very higher than the tabulated value indicating the very high reliability of ' R^2 '. Thus it is concluded that the regression co-efficient and standard errors, it is inferred that all the ten estimates are significant and among them Chlorides ($p < 0.01$), Nitrates ($p < 0.01$), Total Hardness ($p < 0.05$), Chemical Oxygen Demand ($p < 0.02$) and Calcium ($p < 0.05$) are negatively significant and Dissolved Oxygen ($p < 0.05$), Biological Oxygen Demand ($p < 0.01$), Magnesium ($p < 0.01$) and Total Phosphorous ($p < 0.02$) are positively significant in a statistical sense. Estimates of multiple regression pertaining to its seasonally and the twelve abiotic environmental factors of the Site – I of the lake, Table: 11iv showed the value of R^2 which turned out to be 94 percent of the seasonal fluctuations of the Molluscan in the Site being explained by the variation in the twelve explanatory variables. The calculated value of 'F' is much higher than the tabulated value indicating high reliability of ' R^2 '. Thus, it may be concluded that the regression is the best fit. However, examining the values of the regression coefficient and standard error, it can be said that out of twelve estimates one is insignificant in statistical sense and the coefficient. The remaining variables such as Chemical Oxygen Demand ($p < 0.02$), Total Hardness ($p < 0.02$), Chloride

($P < 0.01$), Nitrates ($p < 0.02$), Iron ($p < 0.05$) and Calcium ($p < 0.05$) are negatively correlated and Total Dissolved Solids ($p < 0.02$), Dissolved Solids ($p < 0.02$), Biological Oxygen Demand ($p < 0.01$), Magnesium ($p < 0.01$) and Total Phosphorus ($p < 0.02$) are positively correlated.

BENTHIC MACRO INVERTEBRATES

The littoral zone of the lake were mostly eutrophic where high allochthonous inputs caused predominantly eutrophic conditions. In the two sites of the littoral zone of the lake, the quantity of the organic matter which settled down the bottom showed a relationship with the subsequent oxygen concentrations at level of the watered sediment interface, and was the main factors structuring the benthic macro invertebrate communities, particularly the oligochaet communities (Hynes, 1960; Lang, 1985). Thus, these are linked to the carbon cycle which is essential to understand the processes going on in the reservoirs (Wetzel and Richey, 1978).

Benthos of Indian lotic waters have been analysed by Ray *et al.*, (1966) and Rajan (1963). The benthos reported by these workers are oligochaetes, chironomus species, and molluscs. On the other hand, during the course of present investigation oligochaetes (3 species), chironomid larvae (4 species) and mollusca (10 species) have been recorded. This molluscan predominance in the benthos of Mir-Alam lake may be the effect of slow currents, soft organically rich bottom, alkaline nature of water (pH 7.0 to 8.9), higher concentration of calcium. Some molluscs are already known as the inhabitants of waters rich in calcium (Kownacka and Kownacka 1965) and with alkaline pH (Todd, 1970).

The composition and distribution of the littoral community along the lentic ecosystems showed significant differences. On the whole several taxa were recorded most of them having wide ecological range (Hynes, 1962). While studying temporal and spatial variation, Darlington (1977) reported the difference between the in-shore and off-shore samples of benthic invertebrate fauna of Lake George (Uganda) and stated that this difference is related to the texture and stability of substratum. Only a few taxa constituted the most important part of the community (Mastrantuono, 1986), as recorded during the present study. They are mainly oligochaetes, chironomidae and molluscans, which were the more diversified groups and constituted the major percentages, as well.

During the present investigation, in Mir-Alam lake in Site-I Mollusca represented by *Gabbia stenothyroide* were dominant constituted 34.29 percent followed by chironomidae represented by *C. circumdatus* representing 5.71 percent. While in Site-II, *Gabbia stenothyroide* were dominant constituted 36.05 percent followed by Tubificidae represented by *L. hoffmeisteri*, which is the third dominant constituting 3.57 percent at Site-I and 7.48 percent at Site-II. In Mir-Alam lake, in the two sites *i.e.*, Site-I and Site-II mollusca was recorded maximum constituting 66.77 percent followed by arthropoda representing 18.36 percent and annelida comprising 17.60 percent of the total benthic macro invertebrates.

Similar to the present findings, Gupta (1976) in Loni reservoir found that molluscs, oligochaetes and chironomids were the main groups. Mandal and Moitra (1975) found chief

components of the bottom organisms were chironomid larvae and predominated the samples followed by oligochaetes and molluscs in fish pond of Burdwan, West Bengal in major part of the year. Bhatt *et al.*, (1984) observed the benthic macro fauna consisted of insects and larvae. Gupta (1979) recorded larvae of chironomous species were highest among benthos (35.4 percent) followed by snails which were found more particularly in shallower parts. However, leeches were comparatively few. He further observed majority of the other fauna were mainly adults and juveniles of oligochaetes, leeches, insects and molluscs. Oommachan (1986) observed a rich bottom fauna mainly consisting of gastropods, oligochaetes and chironomids in Bhopal lake; other groups consisted of planaria, leech, culicoides, *cypris* etc.

Some authors *viz.*, Brinkhurst and Cook (1974), Milbrink (1980) and Saether (1979) studied how the organic enrichment of the bottom supports a quantitative increase of oligochaeta and a reduction of chironomidae in the total benthic fauna. Such a relationship is so significant that the ratio of oligochaeta or oligochaeta + chironomidae, proposed by Wiederholm (1980) can summarise the information on the benthic faunal data. The application of such a ratio in littoral zone, where Naididae are present may also be valid, considering that Naididae as detritivore play vital role similar to Tubificidae. Among the Naididae the presence of *P. aequisetia* was considered tolerant of organic loading (Learner, 1979). According to Akhrov (1974) chironomids are important constituents of bottom fauna in the reservoir and comprise 75 to 80 percent for food bottom feeding fishes.

Sarkar (1989) recorded 19 species of macro fauna. and most of them were chironomids, dragonfly nymph, dytiscus species, angulus species, tubifex species, chaetogaster species and different species of molluscs. Molluscs were dominant followed by insects and oligochaetes.

The abundance and distribution are correlated to the important factors like temperature and nature of substratum. Sarkar (1989) observed significant correlation between the abundance of benthic macro fauna and different abiotic factors. The abundance of benthos particularly oligochaetes and mollusks, was observed during summer and monsoon seasons. Similar results have also been reported by Richer (1952) and by Srivastava (1956). Biswas *et al.* (1986) recorded more benthic fauna dominated by oligochaetes (60.6 %) in summer.

During the present study, in Mir-Alam lake, the seasonal abundance of total benthic macro invertebrates was negatively influenced by alkalinity content in Site-II and it was positively by nitrates in Site-I and Site-II and lead in Site-I. In Site-I, the other factors *viz.*, chloride, total alkalinity, sulphate and calcium content of water showed significant negative influence, while pH, conductivity, total dissolved solids, total phosphorous, lead and iron being identified as prominent factor showing significant positive influence. In Site-II, the negative influence was observed with the parameters like temperature, DO, sacchidisc, chloride, total alkalinity, orthophosphate, sulphate and iron where as the positive influence was noticed with the factors like conductivity, total phosphorus and lead.

Zeneto and Bogdanos (1987) pointed out the possible associations of fauna with physico-chemical parameters, using the spearman's rank correlation coefficient and established that the only abiotic parameters associates with the number of species and specimens, is the dissolved

oxygen concentration ($p < 0.05$). So the number of species and individuals increase significantly with an increase in dissolved oxygen concentration, which is in consistence with the present findings on Mir Alam lake.

Seasonal abundance of various forms of benthic life reveals that insects were abundant during the summer monsoon seasons followed by oligochaetes (summer-winter) and molluscs (monsoon-winter). These observations confirm the views of some previous reports and to some extent, the present findings also.

According to Van Hoven (1975), the worm species choose to colonize sediment in polluted localities where there is more oxygen, than in their natural habitat. So, one can say that the abiotic factors influence their distribution of species. A species may be absent in a lentic system due to zoogeographical reasons and this absence permits another equivalent species to fill up its ecological niche and to take its role as indicator of eutrophication (Lang, 1985; Lang and Putter, 1981). In the present study on Mir Alam lake, the high percentage of mollusca and chironomids these may be due to rich in calcium (Kownacka and Kownacki 1965) and with alkaline pH (Todd, 1970). The population structure of tubificid and lumbriculid communities had been treated as a descriptive tool to define eutrophication (Milbrink, 1978; Lang, 1984; 1985; Lang and Lang Dobler, 1979).

The molluscs are useful in purification of waters and can be said as has scavengers (Preston, 1915) and also known to prefer small waters BODies with dense vegetation. Gastropods are principal constituent of aquatic invertebrate community particularly in lentic ecosystems and such event had been noticed in Polish lakes by Rai *et al.* (1981). The abundance of the molluscan fauna indicates the rich productivity of a minor estuary. The species inhabiting bottom of an estuary play an important role in converting organic matter together with the meiobenthos into biomass which in turn is consumed by the fishes. Thus the molluscs helping the secondary productivity and form important component in the food web of the estuary ecosystem (Durga Prasad, 2001).

Choubisa (1992) found 22 species of molluscs from various fresh water habitats of southern Rajasthan and considered as indicators for oligotrophic and eutrophic lakes based on their distribution and relative abundance. Harman (1974) has also pointed out the molluscs are bioindicators of water pollution. Studies on molluscan fauna of south Indian rivers are still incomplete.

The Snail distributions is dependent on interacting environmental factors as substrate type, depth, food supply inter-species composition and physico-chemical quality of water including the amount and types of pollutants present (Harman, 1974 and Krieger, 1985).

Macan (1950) observed the environmental temperature influences the seasonal cycles and abundance of gastropods in shallow water areas. The pH and total alkalinity show positive correlation ($r = +0.49$ and $+0.29$) with the biomass of aquatic vegetation and combination of all these factors probably effect the establishment of biotic community in pond water acting as major food item for the gastropod species. The extent of littoral area as well as

the chemical conditions of the pond water also plays significant role in the dynamics of gastropod population. These factors probably are directly or indirectly responsible for increase in littoral fauna (Pieczynski, 1977).

Subba Rao and Mookherjee (1964) reported w1 species of Mollusca from Mahanadi estuary 19 were recorded for the first time. Cheriyan (1968) found 51 species from the highly productive Cochin harbour area. Rajgopal and Mookherjee (1978) reported 38 species of Archaeogastropods of the Coramandal coast, Palk Strait and Gulf of Mannar. More recently Subba Rao (1992) published a detailed account of Estuarine and Marine Molluscs of West Bengal. The molluscan fauna of Chilka lake, a major wet land ecosystem is reported by Subba Rao *et al.*, 1995.

During the present study, 10 species of molluscs were found, two of them, *i.e.*, *Gabbia stenothyroide* and *Bellamya dissimilis* were perennial ones. Molluscans constituted predominant group in Mir-Alam Lake. Gupta (1979) observed the snails were found in good number in shallower parts. Oommachan (1988) reported similar findings, that contributed the major bulk of the bottom fauna. About 90 percent of the benthic fauna consisted of gastropods from the shallow areas (about 3m depth where the macrophytic vegetation was dense) of the Bhopal lake. This can be attributed to the availability of food, dissolved oxygen, optimum range of pH and alkalinity. 10 species of gastropods and one species of bivalve were collected and identified from the Lower lake of Bhopal. Dominant species among gastropods was *Vivipara bengalensis* which contributed 80 to 90 percent of total biomass of mollusca.

Krishna Murthy (1966) found them even at a depth of 16 to 22 meters in Thungabhadra reservoir. Oommachan and Balsare (1985) observed *V. bengalensis* dominated the mollusca and was distributed from the shore-line to three meters depth in all types of sediments. Its individuals were found in comparatively large number at 0.5m and 1.4m depth during March to July, where as they are more in number at 3m depth during cold period. It reached maximum population during June (1,122 /m²) at 0.5m, May (718/m²) at 1.5m and November (200/m²) at 3m depth. *Indoplanorbis exustus* was highest number in May (322 /m²). Among all, *V. bengalensis*, *V. variates* and *malanoides tuberculatus* were perennial since they represented the gastropod community of pond water throughout the year.

Shyam and Vass (1988) pointed out the percentage of mollusca in Dal lake at 1 to 3m depths was 4.43, 1.71 and 2.50 respectively. However, in Anchar Lake, the groups were not recorded at 2m depth. At 1m and 3m depth, it comprised as 1.76 and 2.63 percent respectively. In Mansbal lake, the population mollusca towards the total zoo benthic life at 1m, 2m and 3m depth averaged as 8.19, 4.88 and 2.97 respectively while in Naranbagh lake, the group averaged as 86.78 percent at 1m, 92.95 percent at 2m and 78.77 percent at 3m.

In the present investigation, of all the species, *Gabbia stenothyroide* was recorded maximum 34.29 percent of the total population in Site-I, while in Site-II it was 36.05 percent of the total population. *Faunas ater* was recorded maximum, 14,632.5+- 210.8 m⁻² in Site-II, 8,435 +- 210.8m⁻² in Site-I and minimum representing 320.2 +- 0m⁻² was recorded in Site-I and Site-II.

Michael (1968) recorded a peak of the population of *Vivipara* in April followed by a sudden decline in a pond of the West Bengal. Such peak in population was observed in the Lower lake during June. Dudani *et al.*, (1988) in Tinkonia pond showed maximum qualitative and quantitative abundance of gastropods where the level of calcium, total hardness and alkalinity appear more favourable for its growth and maintenance. Another possible reason behind gastropod abundance in Tinkonia could be the presence of thick vegetation of *Ceratophyllum demersum*, *Euryale ferox*, *Eichhonia crassipes*, *Hydrilla vesicillata* and *Potamogeton crispus* all of which provide food, shelter and suitable environment for the gastropods (Soszka, 1975; Pieczynska and Ozimek, 1976; Rai *et al.*, 1981; Vasisht and Bhandal, 1971; Ricker, 1952 and Welch, 1952). The complete absence of gastropods except a rare *Melania striatella* in Harahi lake is perhaps due to sequence of events caused by the complex interactions of various biotic and abiotic factors. The Harahi is fed with huge quantity of sewage. Ample amount of phosphorous, carbon and nitrogen present in sewage, brings about a rich algal bloom (Wetzel, 1965), which finally leads to the elimination of macrophytes by its shading effects. The disappearance of submerged macrophytes ultimately results in complete elimination of gastropods. The absence of gastropods from Harahi was possible due to the lower value of transparency and higher values of alkalinity, total hardness, magnesium and chloride.

Harman (1974) while reviewing the pollution ecology of fresh water gastropods, noted that representatives of every widespread family of fresh water snails have been considered by various species, tolerant of moderate organic pollution. He suggested that observation of changes in gastropod fauna over time as tool for assessing changing water quality than the mere presence or absence of species.

Satya Murthy (1960) observed that *V.bengalensis* inhabits polluted water bodies in large numbers especially during hot season. It was recorded buried in the mud, up to 15 cm depth to aestivate and may be found dead in the bank. One of the most important factors that seems to determine the habitats and activities of the molluscs, is the amount of dissolved salts especially calcium carbonate in water, which is the essential material for their shell formation. Alexander (1976) observed the total hardness which was mainly due to calcium, varied from 17 to 56 mg./lit. in the Lower lake. Dissolved oxygen was reported to be the limiting factor for distribution of molluscs (Pennack, 1953). Okland (1964) observed that the absence of molluscan population in shallow strata of the Lower lake indicates that the dissolved oxygen is an important environmental factor in limiting their distribution. The absence of all gastropods except *V. bengalensis* and *Pila globosa* in Nargauna pond was perhaps due to its soft waters of the pond with calcium below 7.0 mg/lit. which usually does not support gastropod life (Srivastava, 1956, 1959). This tank also had the abundance of submerged *Vallisneria spiralis*. The occurrence of rich gastropod fauna was probably related to the higher values of bicarbonate alkalinity (175.59 $\pm$ 15.41) and chlorides (75.55 $\pm$ 4.21).

Thiara scabra was the only abundant species of the rivers of southern Rajasthan followed by *I. lineata* and *I. exustus* (Choubisa, 1992). In the present study more number of molluscan species and their abundance associated with Site-I and Site-II may be due to rich vegetation

as well as less polluted nature of the lake. Kumar and Bohra (1999) made similar observation in some wet lands of Bihar.

Lymnaea accuminata : During the present investigation, in Mir-Alam Lake, none of the abiotic factors showed any influence on the seasonal abundance of *Lymnaea accuminata* in Site-I. In Site-II, it was positively influenced by total phosphorous. In Site-I, all these factors such as sacchi disc, total alkalinity, and calcium contents of water showed significantly positive influence while sulphate has shown negatively influence and at siteII pH, conductivity, biological oxygen demand, magnesium, total phosphorus and lead showed significant positive influence, while sacchi disc, chemical oxygen demand total hardness, chloride, orthophosphate, nitrate, sulphate and iron had been observed as prominent factors for its negative influence.

Bellamya dissimilis : In Mir-Alam lake, the abiotic factors have not shown positive influence on the seasonal abundance of *Bellamya dissimilis* in Site-I where as in Site-II chemical oxygen demand has shown its significant positive influence. In Site-I, negative influence was found with lead. However, its abundance was positively influenced by total alkalinity at Site-I. In Site-II, its abundance was significantly negatively influenced by pH, total dissolved solids, sacchi disc, chemical oxygen demand, Biological Oxygen Demand and orthophosphate, and its positive influence was noticed with conductivity, total hardness, chloride, nitrate and iron.

Bellamya bengalensis : In Mir-Alam lake, none of the abiotic factors showed any influence on the seasonal abundance of *Bellamya bengalensis* in Site-I. In Site-II, it was positively influenced by nitrates and lead. In Site-I, all these above factors such as sacchidisc, chlorides, nitrates and iron contents of water showed significant positive influence while total phosphorous has shown significantly negative influence and at Site-II conductivity, dissolved oxygen, chemical oxygen demand, total alkalinity, total phosphorous and calcium showed prominently negative influence with total dissolved solids, chlorides, nitrates and iron being identified as prominent factors showing significant positive influence.

Thiara tuberculata : During the present investigation, in Mir-Alam lake, the seasonal abundance of *Thiara tuberculata* positively significantly influenced by ortho phosphate and total phosphorous at Site-I and Site-II it was negatively influenced by iron and phosphorous is positively influenced. *Thiara tuberculata* was significantly positively influenced by the combined effect of abiotic factors such as dissolved oxygen, total alkalinity, total phosphorous and iron content of water, with dissolved oxygen and total phosphorous content of water being prominent and showing significant influence at Site-I. At Site-II its abundance was prominently negatively influenced by pH and total alkalinity. However, its abundance was significantly positively influenced by total dissolved solids, total hardness, magnesium, orthophosphate and calcium.

Thiara scabra : During the present investigation, in Mir-Alam lake, the seasonal abundance of *Thiara scabra* was positively significantly influenced by sulphate and iron at Site-I and

total hardness is significantly negatively influenced. In Site-II it was positively influenced by the abiotic factors such as conductivity, total dissolved solids, chemical oxygen demand, magnesium, chloride, total alkalinity and lead. In Site-I all these above factors *viz.*, sacchidisc, total hardness, magnesium and total phosphorous are influenced positively. However, its abundance was significantly and negatively influenced by dissolved oxygen, chloride, sulphate and iron at Site-I. Besides, in Site-II, its seasonal abundance was negatively significantly influenced by conductivity, chloride, total alkalinity and iron and it was positively significantly influenced by total hardness and orthophosphate.

Gyraulus convexiusculus : During present investigation, in Mir-Alam lake the seasonal abundance of *Gyraulus convexiusculus* was positively influenced by pH and chloride at Site-I and non of the abiotic factors showed any influence on their seasonal fluctuations in Site-II. It was notably positively influenced by total phosphorous and significantly negatively influenced by total hardness, chloride and iron. At Site-II Biological Oxygen Demand, magnesium, total phosphorous and calcium significantly positively influenced the seasonal abundance. However, its abundance was significantly negatively influenced by total dissolved solids, chloride, total alkalinity, sulphate and iron.

Indoplanorbis exustus : In Mir-Alam lake, the seasonal abundance of *Indoplanorbis exustus* was positively influenced by total phosphorous at Site-I and at Site-II, it was negatively influenced by iron. It was positively influenced by total dissolved solids and total phosphorous. However, its abundance was significantly negatively influenced by total alkalinity and calcium at Site-I and at Site-II it was appreciably negatively influenced by temperature, biological oxygen demand, total hardness, chloride, orthophosphate and calcium. Its abundance was significantly positively influenced by pH, conductivity, dissolved oxygen, total phosphorous and iron.

Cremnoconchus conicus : During the present investigation, in Mir-Alam lake the seasonal abundance of *Cremnoconchus conicus* was negatively significantly influenced by total hardness and significantly positively influenced by Biological Oxygen Demand at Site-II and none of the abiotic factors showed any influence on their seasonal fluctuation in Site-I. It was prominently and positively influenced by temperature, conductivity, total dissolved solids, dissolved oxygen, magnesium, total phosphorous, nitrate and iron. However, its abundance was significantly negatively influenced by pH, chemical oxygen demand, orthophosphate and calcium at Site-I and Site-II it was significantly positively influenced by conductivity, Biological Oxygen Demand, total hardness, magnesium and nitrate. Its abundance was significantly negatively influenced by Chemical Oxygen Demand, sulphate and calcium.

Faunus ater : During the present investigation, in Mir-Alam lake the seasonal abundance of *Faunus ater* was positively considerably influenced by total phosphorous at Site-II and at Site I it was positively influenced by Biological Oxygen Demand. It was significantly positively influenced by total phosphorous and negatively influenced by pH, BOD and orthophosphate at Site-I and at Site-II it was considerably negatively influenced by pH, total dissolved solids and iron. However, its abundance was notably positively influenced by total hardness, chloride, total phosphorous and calcium.

Gabbia stenothyroide : During the present investigation in, Mir-Alam lake, the seasonal abundance of *Gabbia stenothyroide* was negatively prominently influenced by Biological Oxygen Demand and magnesium in Site-I and at Site-II magnesium is negatively influenced. In Site-I, it was positively influenced by total dissolved solids, dissolved oxygen, biological oxygen, magnesium and total phosphorous and appreciably negatively influenced by Chemical Oxygen Demand, total hardness, chloride, nitrate and calcium all these above factors are considerably negatively influenced. It was significantly negatively influenced by Chemical Oxygen Demand, total hardness, chloride, total alkalinity, nitrate, iron and calcium at Site-I. However, its abundance was significantly negatively influenced by Chemical Oxygen Demand, total hardness, chloride, nitrate and calcium.

Arthropoda : Chironomid larvae are an important group of benthos. Chironomidae as a group are more or less evenly distributed throughout the shallow parts of lentic ecosystems. They were important constituents of bottom fauna in the reservoir and comprised 75 to 80 percent of the food for bottom feeding fishes (Akhrov, 1974). In Lori reservoir, Gupta (1976) recorded molluscs, oligochaetes and chironomides as the main group of which insects were dominant group constituting 35.92 percent of the total biota. As mentioned earlier Mandal and Moitra (1975) found that chironomid larvae were dominant among benthos and predominated the samples almost throughout the year. In the present investigation chironomid larvae constituted 13.56 percent 18.36 percent of the total fauna at Site-I and Site-II respectively. They were recorded highest in Site-II because of eutrophic nature.

Oommachan (1988) found that chironomid larvae as the third major group of benthic fauna of the Lower lake of Bhopal. She recorded three distinct forms of chironomid larvae i.e., *Tendipes* species, *T. kiefferulus* and chironomus species. Shyam and Vass (1988) observed the average values of Diptera in Dal lake at 1 to 3m depth as 36.62, 42.45 and 48.57 respectively, while in Anchar lake this group averaged as 54.19 percent at 1m, 50.50 percent at 2m and 48.90 percent at 3m depth. In Manasbal lake, the mean percent value of dipteran larvae at 1 to 3m depth recorded were 46.32, 43.66 and 46.90 respectively, where as in Naranbagh lake, the group averaged 12.54, 7.45 and 9.38 respectively in the above depths.

Kornijow (1988) observed in the bottom fauna of the littoral zone of the Glebokie lake and Piaseczno lake, chironomidae attained the highest density. For both lakes, the values of the mean density of the bottom fauna of littoral zone approached those reported for other lakes of similar trophy situated in North Poland (Lezczynski, 1968; Kajak, Dysoge, 1976; Pieszynski, 1977; Kentzer, 1982; Wisniewski, Dusoge, 1983; Wielgosz, 1984). In case of Piaseczno lake, there were no substantial differences in faunal density between various types of littoral and different depths. For Glebokie lake, the density of zoobenthos was higher in marsh phytolittoral than in eutrophic phytolittoral zone. In contrast, Patil and Panda (1986) pointed out that chironomid larvae were found less in the polluted tanks, may be due to low oxygen content.

They are the tolerant animals to various degrees of pollution. Due to the presence of haemoglobin in the body, they are able to live in anaerobic condition for a considerable period and in low oxygen concentration permanently. Benthic organisms, particularly chironomids, have long been used in classification on lakes and they are known to reflect in a remarkably precise way the trophic character of a water body. In spite of these, the greater diagnostic power of benthos is not used to its full extent in today's applied limnology (Wiederholm, 1978). It is somewhat difficult to ascertain degree of pollution by only the physico-chemical factors. Therefore, biological indicators of pollution have been taken into consideration and it was observed that protozoans, few rotifers, annelids, dipterans, chironomus species larvae and rat-tail maggot were common in polluted bottom samples (Verma and Dalella, 1975). The chironomids have been recognised as indicators of trophic status of pollution in various lentic systems (Humphries, 1936; Saether, 1979; Hul, 1987 and Anwar *et al.*, 1988). This is further supported by the work of Rounsefell and Everhart (1960) and Hynes (1962) who pointed out that pollution in water does not kill fish or harm them sometimes, but it changes the biological environment either by destruction of fish food or changes the type of organisms which may ultimately affected or lowered the fish fauna. Patil *et al.*, (1983) pointed out that the presence of *Chironomus tenten* and *Eristalis* species and certain genera of algae in the water body can classify the water body as eutrophic one.

Oommachan (1988) reported that the population density of Chironomid larvae was highest in the middle zone that is 1.5 to 3m depth. As the depth increases beyond 3 meters the population density decreases. However, its number will be less in the littoral zone. As the lake became more eutrophic, the two dominant groups of benthic animals recorded were, chironimid and oligochaeta.

Chironomidae represent one of the numerically most important families of fresh water insects and are widely distributed in all types of aquatic environments, where they occur in many habitat and occupy a great variety of niches. Due to these characteristics, chironomids can provide good information about classification of the lotic system and water quality assessment. Bazzante and Loret (1982) reported occurrence of *C. riparius* in abundance at a station which was organically polluted, has long been recognised as an indicator of heavy organic pollution. Yasunu *et al.*, (1985) identified some chironomid species as indicator of heavy metal pollution and Laville and Viaudchauvet (1985) recorded some chironomid associations in polluted rivers. Armitage and Blackburn (1985) considered chironomids as valuable bioindicators in a Pennine stream system effected by organic enrichment and zinc pollution.

The present results supports the observations of these authors about the importance of chironomid community analysis as a diagnostic tool for water quality assessment in lotic systems. Chironomidae comprised a large proportion of the macro invertebrate species found in lotic environment (Caffman, 1973), but they often are not identified beyond the family level. However, a detailed analysis of the chironomid community can yield much more information on water quality (Arthington and Conrick, 1980). Several investigators have suggested that chironomid species assemblages can be associated with specific types of

pollution (Mason, 1975). Pinder and Reiss (1983) indicated that *Dicrotendipes* rarely occurs in streams and rivers, but it has been found to be common in any type of “enriched” habitat, including flowing water. *D.fumidus* was an abundant member of the macro benthos of the Savannah river. Different species of chironomid larvae were used as pollution indicators by number of workers (Curry, 1962; Wilson and Bright, 1973). Specific status of the system could be assessed from the genera of chironomidae represented in that region. The occurrence of the genus *chironomus* was seen the two sites of the lake were they receiving effluents in the present study. An indicator should possess high tolerance to stress, were example pollution (Wass, 1967) and chironomids are known to be have high tolerance to wide range of physico-chemical parameters (Curry, 1962). Based on all these features, it is considered that the relative population size of chironomid larvae irrespective of the genus or species in the best biological indicator. Dispersal of chironomid larvae from areas of low oxygen concentrations has also been observed (Bay *et al.*, 1966; Sala *et al.*, 1977).

During the present investigation chironimid was maximum $17,440 \pm 120.3 \text{ m}^{-2}$ in Site-II and in Site-I $15, 108.0 \pm 120.3 \text{ m}^{-2}$. It was recorded minimum representing $320.2 \pm 0 \text{ m}^{-2}$ in both the sites.

Vasisht and Bhandal (1979) observed maximum population of *chironomus* larvae, when temperature was 18°C and organic nutrients were abundant. Substratum and temperature play an important role in controlling the abundance of the aforesaid benthic invertebrates seasonal variation in chironomid reached a peak in the cold season and a decline in hot season leading to the minimum during the south-west monsoon. Kaushik *et al.*, (1990) pointed out that the *chironomus* species was present at bottom mud in good numbers almost throughout the year indicating their tolerance of wide range of physico-chemical characteristics. Krishnamoorthy and Sarkar (1979) have also suggested that chironomid larvae though present in mesotrophic water, were never dominant. These larval population showed significant correlation with total alkalinity ($r=0.53$), total hardness ($r=0.49$) and chlorides ($r=0.26$). They showed significant positive correlation with chloride ($r=0.58$), total alkalinity ($r=0.54$) and total hardness ($r=0.36$). The insect communities as a whole in the pond have a significant positive correlation with hardness ($r=0.98$), total alkalinity ($r=0.82$) and chloride ($r=0.68$).

Chironomus circumdatus : During the present investigation, in Mir-Alam lake the seasonal abundance was *Chironomus circumdatus* was considerably positively influenced by calcium at Site-I and Site-II iron which is significantly negatively. Temperature, total hardness, orthophosphate and sulphate of water significantly negatively influenced it. Besides, its abundance was also positively significant influenced by dissolved oxygen, total alkalinity, total phosphorous and calcium in Site-I. In Site-II was notably positively influenced by conductivity, total dissolved solids, total phosphorous, nitrate and iron. However, dissolved oxygen, chemical oxygen demand, total hardness, total alkalinity, orthophosphate, sulphate and calcium significantly negatively influenced it. However, unfortunately, there is no relevant information in the literature on the combined effect of different physico-chemical factors of waters on chironomidae larvae seasonally, to compare with present findings.

Chironomous plumosus : During the present investigation, in Mir-Alam lake the seasonal abundance of *Chironomous plumosus* was positively influenced appreciably by Biological Oxygen Demand and calcium at Site-II and none of the abiotic factors showed any influence on their seasonal fluctuation in Site-I. It was significantly positively influenced by conductivity, magnesium, orthophosphate and sulphate. However, it was notably negatively influenced by temperature, pH, dissolved oxygen, Chemical Oxygen Demand, total alkalinity, nitrate, iron and calcium at Site-I and it was significantly positively influenced by temperature, conductivity, total hardness, sulphate and calcium. It was prominently negatively influenced by pH, dissolved oxygen, sacchidisc, Chemical Oxygen Oemand, Biological Oxygen Demand, total alkalinity and total phosphorous at Site-II.

Miscellaneous Groups : Other groups of arthropods were also recorded in the present investigation at sites I and II. Unfortunately, there is no information on the susceptibilities of individual species of different other arthropods to organic pollutants. However, data from elsewhere on the susceptibilities of fresh water invertebrates to specific contaminants (Wentzel *et al.*, 1977) suggest that the concentration of some heavy metals and ammonia are too low to have caused the abrupt decline in the numbers of dragon fly larvae, and other insect larvae below the out fall. On the other hand concentrations of chlorine in some cases were high enough to have been deleterious. Arthington *et al.*, (1982) reported that species of odonates, which are the obligate stream dwellers can serve as sensitive low cost indicators of water quality in streams because they remain close to their emergence sites.

During the present investigation, the seasonal abundance of *Notonecta glauca* was significantly positively influenced by pH, total dissolved solids, dissolved oxygen, magnesium and lead and was notably negatively influenced by total hardness, chloride, orthophosphate and nitrate at Site-I. It was positively influenced appreciably by pH, dissolved oxygen, magnesium and total alkalinity. However, it was significantly negatively influenced by total dissolved solids, total hardness and chloride at Site-II. The seasonal abundance of mosquito larvae also was significantly negatively influenced by temperature, biological oxygen, magnesium, total phosphorous and calcium. However, it was notably positively influenced by pH, conductivity, nitrate and iron at Site-I. At Site-II significantly positively influenced by pH, biological oxygen demand, total phosphorous and nitrate. It was negatively influenced by temperature, total hardness, orthophosphate, sulphate and iron.

Annelida : Oligochaetes (*e.g.* *Tubifex* species and *L. hoffmeisteri*) are known to be good indicators of pollution (Howmiller and Scott, 1977; Brinkhurst 1966, 1974), but their distribution is characterised by clumping Brinkhurst, (1974). Such distribution will affect decision making (Mahadevan and Krishnaswamy, 1984). Generally, oligochaetes increase with eutrophication of the water body. This is in conformity with the observations of the present study and that of Cole and Underhill (1965). Infact *L. hoffmeisteri* alone indicates pollution which is very resistant to organic matter load in water bodies (Brinkhurst and Cook, 1974)

It is apparent that pollution results in a change in the community structure of benthic macroinvertebrates (Wilhm and Dorris, 1968). In the present study, surprisingly, Tubificidae was represented by one species *L. hoffmeisteri* in the littoral zone of Mir-Alam lake.

Oommachan and Belsare (1986) recorded 14 species of oligochaetes belonging to two families in the benthic samples of the Lower lake of Bhopal. Six species belonged to the Tubificidae which form the bulk of the oligochaete fauna and eight species to the family Naididae. The dominant species of oligochaeta were *L. hoffmeisteri* and *T. tubifex*. Their presence in large numbers indicates high organic pollution. The importance of these specimens has been well documented by several workers (Brinkhurst, 1965; Milbrink, 1973; Brinkhurst and Cook, 1974).

In the present investigation Tubificidae was maximum 20,106.5 m⁻² in Site-II and 17,820.5+-710.5 m⁻² in Site-I. It was minimum 320.2 +-0 m⁻² was recorded in Site-I during summer, whereas in Site-II it was maximum in summer (February, 1999).

Oommachan and Belsare (1986) reported that their distribution showed a gradual decline from the shallow to the deepest. At 0.5 m depth the maximum average number was 9,444 m⁻² in September and the minimum was 418 m⁻² in April and October. At 3m depth the maximum average number was 5,384 m⁻² in February and the minimum number was 330 m⁻² in October. They further reported that the monthly distribution of some important oligochaeta species, *L. hoffmeisteri* was the most dominant species of Tubificidae in shallow as well as deeper water and contributed the bulk (60-70%) of the oligochaete fauna. The maximum population density was 2092 m⁻² at 0.5 m, 1888 m⁻² at 1.5m, 2863 m⁻² at 3m and 756 m⁻² at 5 m during September, October and February respectively.

Marshall (1978) reported that oligochaetes had a maximum density (2,000 m⁻²) at 4 m depth in the tropical lake Mellwainre. Okland (1964) reported the maximum oligochaete density (1,952 m⁻²) occurring at a depth of 2 m. Oommachan (1988) found that oligochaetes had two peaks in their density during monsoon and winter. The total oligochaete fauna showed correlation with sediment particle size.

As Cosser (1989) have noted the animals are seldom influenced by only one deleterious factor, but rather to a combination of them; the decrease of dissolved oxygen concentration after July and September was followed by an analogous decrease in the number of species and specimens. The effect of seasonal variations on the structure of the oligochaete communities seen highest in the littoral than in the profound zone. Lang (1978) stated that differences due to the location of the sampling stations were greater than those due to the season in a survey made in the Profundal lake, Geneva.

Correlation between the physical nature of the sediments and the occurrence of oligochaete fauna is established, as it was found that the Tubificids had a wide range of particulate preference than the Naididae. Ramesh babu (1979) observed *Tubifex* species have widest range of particle preference. A number of studies have indicated that the particulate composition and organic matter content of the sediment are correlated with the distribution and abundance of oligochaetes. The oligochaete population was most abundant at places where the organic content is highest. No significant correlation was seen with distribution of the oligochaetes and depth as they are more or less uniformly distributed down to a depth of 3 m. However,

very little information is available on the relationship of these animal with physico-chemical factors of the water (Odum,1971; and Cosser, 1989).

During the present study in Mir-Alam lake the seasonal abundance of *L. hoffmeisteri* was significantly negatively influenced by sacchidisc and it was significantly positively influenced by orthophosphate, total phosphorous and calcium in Site-I. However, at Site-II temperature and iron significantly negatively influenced and significantly positively influenced by orthophosphate, total phosphorous and in Site-I, all the above factors such as temperature, Biological Oxygen Demand, total hardness, magnesium, chloride, total phosphorous and calcium content of water showed significantly positively influenced, while pH, total dissolved solids, dissolved oxygen, orthophosphate and sulphate being identified as prominent factors showing significantly negatively influenced, and at Site-II total dissolved solids and sulphate showed significant negative influence, while sacchidisc, total alkalinity, total phosphorous and iron being identified as prominent factors showing significant positive influence. Although Odum (1971) and Cosser (1989) reported that a combination of abiotic factors influence these animals there is little information in the literature to compare with the present findings.

Limnodrilus hoffmeisteri : During the present investigation, in Mir-Alam lake, the seasonal abundance of *L. hoffmeisteri* was significantly positively influenced by orthophosphate, total phosphorus and calcium and negatively influenced by sacchi disc at Site-I and at Site-II, it was significantly negatively influenced by temperature and iron and total phosphorous, orthophosphate and calcium was significantly positively influenced. In Site-I, it positively influenced by temperature, BOD, total hardness, magnesium, chloride, total phosphorous, iron and calcium while pH, total dissolved solids, dissolved oxygen, orthophosphate and sulphate being identified has prominent factors showing significant negatively influenced and at Site-II, total dissolved solids and sulphate showed significant negatively influenced and sacchidisc, total alkalinity, total phosphorous and iron or positively significantly influenced.

Pristina aequiset : The seasonal abundance of *Pristina aequiset* on Mir Alam lake was notably negatively influenced by orthophosphate and positively influenced at Site-I and at Site-II, it was positively influenced appreciably by total phosphorous significantly negatively influenced by orthophosphate and iron. In Site-I, it positively influenced by temperature, conductivity, chemical oxygen demand, total phosphorous and iron and considerably negatively influenced by magnesium, total alkalinity, sulphate and calcium. While total dissolved solids, orthosphosphate, total phosphorous and iron are significantly positively influenced and BOD, magnesium, total alkalinity and calcium are significantly negatively influenced at Site-II.

Lumbricidae : The seasonal abundance of Lumbricidae on Mir Alam lake was significantly positively influenced by sulphate at Site-I and Site-II, conductivity, total dissolved solids, chloride and sulphate are positively significant. It was considerably negatively influenced by the biotic factors such as total hardness, total phosphorous, sulphate and lead and at Site-I sacchidisc was significantly positively influenced. At Site-II it was notably positively influenced by the bioatic and abiotic factors such as Chemical Oxygen Demand, total hardness, orthophosphate and lead. However, it was significantly negatively influenced by total dissolved solids, chloride and nitrate.

Many authors showed that the organic enrichment of the bottom support a qualitative increase of oligochaeta and a reduction in chironomidae on the total fauna in lakes (Mylinski and Ginsburg, 1977; Milbrink, 1980; Seather, 1980; McLusky *et al.*, 1980; Mastrantuono, 1986). Mastrantuono (1986) stated that the application of such concept to littoral zones may be valid. However, this concept would not be applicable to the highly organic polluted water bodies, where the annelid were completely absent in the sediment. Although this concept may be good for comparing different sites or situations of single lake or reservoir but not for comparing different lakes of reservoirs in terms of organic enrichment. Moreover, while comparing the sites even in the same reservoir or lake applying the above concept, the depth of the site have to be taken into consideration as relative density and distribution of oligochaetes are strictly dependent on depth (Bazanty and Loret, 1982).

Anwar and siddiqui (1988) pointed out that there were two peaks of the abundance of the macroinvertebrate fauna, one the winter peak, when the oligochaetes, dipteran larvae, plecoptera and odonata nymphs and shrimps were abundant, and other peak was in the monsoon due to the new recruitment of gastropods. The summer and monsoon were the seasons when peak abundance of benthic organisms recorded (Deevey, 1941; Ricker, 1952; Srivastava, 1956; and Vasisht and Bhandal, (1979). According to Sahgal (1977) the seasonal variation in the quantum of benthic fauna in streams depends upon the interplay of various environmental factors. The distribution of macro invertebrate fauna appeared to be related with temperature and dissolved oxygen of the water.

Taft and Shapovalor (1935) stated in general, high alkalinity readings are indicative of streams rich in bottom fish foods. Although some authors have established the positive correlation between benthic life with temperature (Allen, 1951; Ekman, 1911), the bicarbonate alkalinity is considered more important than temperature in influencing the density of bottom fauna (Gauvin, 1949; Armitage, 1958; Needham and Usinger, 1956).

Hul (1987) recorded 152 taxon in the benthic samples. High number of the taxa present was undoubtedly determined by low land character of the river. The inflow of domestic sewage, constituted a source of readily accessibly energy and nutrients for the micro organisms. Waters polluted with industrial waters are usually poorer, as proved by the studies in Biala Przemsza River. At most stations of the Lyna river, number of species did not vary much. More significant changes in the number of species were observed only at one of the stations where the discharge of sewage eliminated over 10% of the species. When another station was treated as a referance point in assassing the self purification process, number of mutual species increased along with increasing distance from the sewage discharge (Czapik, 1982). These findings corroborate with faunal structure of Site-II compared to other site of the sewage canal during the present study.

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The percentage composition of some of the species of benthic macroinvertebrates particularly *L. hoffmeisteri*, *P. aequiseti*, *C. circumdatus* and *Gabbia stenothyroide* in the lake received effluents is interesting and they seemed to be very tolerant of different levels of organic waste pollution. From the present investigation, it is concluded that littoral benthic macroinvertebrate community is useful in evaluating the localized effects of organic enrichment in the lentic systems, as the profundal zoo-benthos indicated the water quality as a whole (Mastrantuono, 1986). The dominance of the molluscan species and *C. circumdatus* followed by *L. hoffmeisteri* indicated relatively slightly less organic load and oxygen depleted conditions. However, more research is needed to evaluate the different types and levels of environmental pollution particularly the organic waste pollution and eutrophication in tropics with the help of benthic macro invertebrates as bio-indicators.

Nevertheless, there is an immediate need of biological monitoring of the water body before it gets deteriorated to a level that it becomes a matter of serious public concern. Thus, a preventive measure, the water body should be conserved. Particularly so as to use them for better purposes like fish culture. Besides, the water body must be protected by adopting remedial measures, such as curbing the entry of sewage water, bathing and washing of clothes on the bank, dumping garbage etc. These practices should be immediately stopped. In order to maintain the purity and cleanliness of water of different aquatic ecosystems, both lentic and lotic systems, it is necessary that different components of these ecosystems are studied well and understood properly; so that these water can be preserved for the use of future generations. If these ecosystem is not understood properly, and effective steps to prevent possible death of languishing legendary water body are not taken in time, future generations will not forgive us for this criminal complacency and an appealing apathy.

We have made the beginning and have a long and hard way to go to explicitly put -down our understanding on these aspects of benthic macro invertebrates concology of these aquatic ecosystems, particularly the benthic macro invertebrates as indicators of pollution. The study helped us to raise many pertinent questions to be answered in near future to further the insight into these aspects of benthology.

DIVERSITY OF MOLLUSCAN FAUNA OF MIR-ALAM LAKE

Most important feature of the animal communities is their diversity, which explains the organisation of a community in terms of species abundance both in qualitative and quantitative measures. The diversity of species varies quite often from one ecological condition to another.

Some notable contributions on molluscs include Ray and Mukherjee (1963), Govind (1969) and Krishna Moorthi (1966 and 1979) on the bottom macro fauna of the Tungabhadra reservoir, Gupta (1976) on macrobenthic fauna of Loni reservoir, Bhagat (1978) on the benthos of 'Powar Lake' and Patnaik (1971) and Raman *et al.* (1975) on benthos of Chilka and Pulicat lakes respectively. Clarke (1979 a and b) attempted to show the utility of molluscs in primary classification of the lakes in their various trophic stages. Choubisa (1992) has collected 22 species of molluscs from various fresh water habitats of southern Rajasthan and considered as indicators for oligotrophic and eutrophic lakes based on their distribution and relative abundance. Rajan and Murugan (2000) have collected 6 species of mollusca from Arjuna river, Sivakasi, TamilNadu.

Harman (1974) has also pointed out that molluscs are bioindicators of water pollution. Studies on molluscan fauna of south Indian rivers are still far from complete. In view of these, the present investigation was attempted to assess the presence and relative abundance of molluscan species at Mir-Alam lake in relation to environmental pollution.

The abundance of molluscan species was estimated as number of individuals per m² for the two sites in triplicates. The specimens were brought alive to the laboratory for taxonomic identification adapting standard literature (Subba Rao, 1989). From the base line data richness, diversity and evenness indices were computed using SPDIVERS.BAS statistical package in a computer (Ludwig and Reynolds 1988).

Variations in the abundance of total molluscan species (individuals/m²) for selected sites are presented in Tables. In Site-I and Site-II ten species were recorded they are: *Thiara tuberculata*, *Thiara scabra*, *Cremnoconchus conicus*, *Indoplanorbis exustus*, *Lymnaea accuminata*, *Gabbia stenothyroide*, *Faunus ater*, *Bellamya dissimilis*, *Bellamya bengalensis* and *Gyraulus convexiusculus*. From the numerical values it is evident that *Gabbia stenothyroides* was the most dominating species. The population density of other molluscs was relatively low. In the present study more number of molluscan species and their abundance associated with Site-I and Site-II is due to rich vegetation as well as slightly polluted nature of the water BODY. Similar observation was made by Kumar and Bohra (1999) in some wetlands of Bihar.

DIVERSITY INDICES

The richness, diversity and evenness indices for the abundance of molluscan species are represented in Tables of the Site-I and Site-II.

Diversity Index

Observing the diversity and dominance of benthic macro-invertebrates in natural water has always been a fascinating field of research for many reasons. The study on the seasonality of Indian fresh water plankton initiated by Sewell (1934) was followed by a long series of hydro-biological studies mostly from the central and northern parts of our country many of

which were aimed at attaining only a baseline information on plankton and water chemistry for use in fishery practices (Micheal, 1980).

Biodiversity, a synonym for the variety and variability of all forms on this earth, is a vital resource that needs to be carefully conserved for our future generation. The concept of biodiversity has been known to man ever since he began to observe minutely the living things around him. A large number of publications relating to bio-diversity seem to have a very few references to smaller organisms because biologists tend to recognise larger and visibly mobile species more rapidly than smaller forms. Aquatic organisms are especially important as they form the most sensitive component of the ecosystem and signal environmental disturbances. Several researches have worked on the bio-diversity in aquatic ecosystems; especially in the freshwaters where life originated remain neglected (Gopal and Druve 1989). Among the organisms of aquatic habitats relatively less work has been reported on the diversity of benthic macro-invertebrates from lakes that undergo environmental degradation owing to eutrophication in the urban environment. This monograph deals with the bio-diversity of benthic macro-invertebrates observed in a seasonal, tropical lake.

Richness

Richness is an unambiguous and straightforward index on species (Ludwig and Reynolds, 1988), R_1 and R_2 represent Margalef (1958) index and Menhinick (1964) index. An overall the highest and lowest values of richness indices (R_1 and R_2) are recorded respectively for Site-I and Site-II. Thus undoubtedly reflects the increase in number species in Site-II. Comparisons of richness indices for different months for the two sites are attempted.

However, the work on inorganic pollution with reference to benthic organisms is still scarce and their index value is not clearly pointed out. Benthic macro invertebrates are recognized as very important groups in water quality surveillance as these organisms are stationary and they integrate the effect of pollution unlike other organisms, which move from the site of pollution.

Diversity

Two indices namely Simpson's index ($\bar{e}$) and Shannon's index (H^0) are used to compute Hill's diversity numbers. Analysis of data reveals that in Site-II the values of ' $\bar{e}$ ' vary between 2.6771 to 13.6331. In Site-I the value is 2.2237 to 11.0298. It has been reported that the values has been reported that the values of ' $\bar{e}$ ' increased with decreasing diversity (Ludwig and Reynolds 1988). High diversity is accounted by the record of ten species in Site-I and Site-II.

Evenness

When all species in a sample are equally abundant an evenness index would be maximum and decreases towards zero as the relative abundance of the species diverge away from evenness. The computed indices for several months for different sampling sites are presented in Tables. Evenness is highly sensitive to number of species. E4 (Hill ratio) and E5 (Modified

Hill Ratio) are least ambiguous. Increase of either E4 or E5 values indicate the species co-dominance. From the data available it would be premature to predict the evenness between species or between communities.

TROPHIC STATUS OF MIR-ALAM LAKE

Mir-Alam, the oldest of three tanks created on Musi river system (other two being Osmansagar and Himayatsagar) is the only one multi arch dam of its kind in the world. Zafar (1986) has classified the major aquatic ecosystem into Oligotrophic, Mesotrophic and Eutrophic on the basis of three parameters, levels of Ortho-phosphates, Inorganic nitrogen and primary productivity. According to this classification Mir-Alam lake is described as Mesotrophic. Water bodies in the urban environment are subjected to three apparently similar degradative process; eutrophication, pollution and saprotrophication.

Eutrophication

It is a process of nutrient enrichment leading to a number of characteristics manifestations (Kodarkar and Chandrasekhar, 1995). It manifest into three directions

- 1) Siltation
- 2) Excessive accumulation of nutrients
- 3) Increase in primary production (Zutshi, 1992).

Pollution

The pollutants can be classified into toxic and non-toxic. The pollution alters the water quality so that sensitive species are killed or slowly replaced by altered conditions, will establish with higher population densities. The effects of populations due to toxicants are dramatic and populations of established communities are wiped out under its influence, while that of non-toxic pollutants the effects manifest slowly. The latter is some times referred to as cultural eutrophication.

Saprotrophication

Saprotrophy is an extreme stage of organic pollution that manifests in shallow water bodies within short period of time. Mir-Alam lake receives untreated sewage from localities in its catchment which has undergone rapid urbanization in last 30 years. The natural channels entering into the lake from other zones also bring in sewage from areas. The magnitude of nutrient enrichment can be judged from water quality records of present study with reference to select parameters.

Table-6. Bi-annual Range of Selected Chemical Parameters in the Mir-Alam Lake [1998 to 2000]

Sl. No.	Parameter	Range (mg/lit.)
1.	Chlorides	80 to 320
2.	Nitrates	1.5 to 8.0
3.	Ortho-Phosphates	0.1 to 0.9
4.	Biological Oxygen Demand	0.4 to 26
5.	Chemical Oxygen Demand	10 to 120
6.	Hardness	150 to 410

Biological assessment of water quality provides a number of advantages over chemical assessment.

These are :

- Integration of organisms and environmental conditions over a period of time, rather than instantaneous
- Integration of the effect of multiple stress to demonstrate cumulative impact
- Not all impacts are chemical in nature and finally physical factors like flow alterations habitat destruction's and siltation also affects ecosystem

The biological systems of analysis that are currently in use include various diversity and biotic indices, functional feeding group approach and ratio indices (Rosenburg and Resh, 1992).

Among freshwater communities benthic macroinvertebrate are the most common and Gaufin and Tarzwell (1952 and 56) studied the organic pollution with reference to macroinvertebrate, the merit of this group as biological indicators of water quality as follows:

- 1) The species are easy to identify and large numbers can be handled in limited space
- 2) The samples can be collected easily and processed rapidly
- 3) Expertise in benthic macroinvertebrate taxonomy can be easily achieved
- 4) They constitute important in aquatic food webs; they graze on other biotic components as primary and secondary consumers and in turn, are consumed by higher consumers like crustaceans and fishes.

Therefore any adverse effect on benthic macroinvertebrates will reflect on productivity of system. This is more applicable for situations in which aquacultural productivity is affected by adverse effects on benthic invertebrate's component due to man made pollution. To summarize, benthic invertebrates by virtue of three extreme sensitivity and key position in aquatic food web, is one of the most suitable indicator groups for assessment of any kind of aquatic pollution. The nutrient enrichment has its own impact on the biology of the lake. It sustains high density and population of blue green algae and has highest density of bacterioplankton. The presence of *Microcystis* and *Oscillatoria* species shows pollution due to organic matter.

In the present study at benthic invertebrate component level molluscan dominated both in diversity and population density throughout the study period, followed by chironomid larvae species which are the indicators of polluted waters. Oligochaetes species like *Pristina aequisetia*, *Limnodrilus hoffmeisteri* indicates richness in particulate organic matter.

Gaufin and Tarzwell (1956); Verma and Dalela (1975) reported the indicator value of chironomidae and its adaptability to polluted waters. To summarize, on the basis of water quality and benthic macro-invertebrate studies Mir-Alam lake can be described as slightly polluted mesotrophic aquatic ecosystem.

CONSERVATION OF MIR-ALAM LAKE

Conservation is sustainable use and protection of natural resources including plants, animals, mineral ores, soils, clean water, clean air, and fossil fuels such as coal, petroleum and natural gas. The benefits of conservation are long term and may accrue to future as well as present generations. Many benefits of conservation and environment quality do not neatly fit in the conventional cost-benefit analysis of economics; short-term economic interests often conflict with conservation interests, where proposed development will create environmental damage.

Hyderabad the historical city of lakes and gardens, can be called the limnological capital of India. In sheer number of major and minor water bodies in its metropolitan limits, the city occupies one of the top positions in the country historically, the impoundment created mainly to meet drinking and irrigational water needs, formed a part of meticulously designed water conservation system in this semiarid region. However, with passage of time, the water use pattern in the case of most of the aquatic ecosystems underwent a steady change from drinking and irrigation to washing, bathing and recreational demands of ever growing urban population. Due to the steady increase in population, trade and industry and with it followed the inevitable environmental degradation. Particularly urbanisation and/or industrialisation of the lake catchment had its extremely adverse impact on three major water bodies viz. Hussainsagar, Mir-Alam and Saroornagar lakes which have become the dumping sites for the untreated domestic sewage. The total water spread and depth of all the major reservoirs

including Mir Alam lake, is progressively reducing due to siltation from natural and man induced factors as follows :

- Unprecedented population growth
- Large scale industrialization
- Pollution from untreated domestic sewage entering the lake from settlements in the catchment
- Silting from cultural and other factors *viz.* silt generated due to construction activities in the catchment and every year tons of silt is being added from immersion of huge idols of Ganesh and Durga festivals. A lot of floral preparations are also immersed in the lake water during the festivals. These factors adversely affect the water holding capacity of the water body due to heavy siltation.
- Lake dependent communities like washer men, traditionally using the lake for washing and bathing purposes. Lack of dhobi ghats and washing places and similar activities also lead to pollution of the lake
- Dumping of garbage and solid waste due to lack of watch and ward the lake has become a convenient site for dumping all type of garbage from solid waste to dead animals

The lake in nature passes through the stages of Oligotrophic, Mesotrophic and Eutrophic, finally ending up in marshes and silted Lake beds. The Oligotrophic lakes are young lakes or man-made reservoirs, which usually have low levels of nutrients and low levels of biological activity. The old lakes have high levels of nutrients and biological activity. Thus eutrophic stage mean's well nourished. The mesotrophic stage is the intermediate stage of a lake when it passes from its oligotrophic nature to eutrophic stage. Mir-Alam lake falls in the category of mesotrophic.

Remedial Measures

Compared to highly polluted lake like Hussainsagar, conservation of Mir-Alam lake is quite possible by taking following measures:

- Prevention of pollution from domestic sewage: A drain should be diverted down stream immediately. All catchment colonies should have proper sewer lines.
- Desiltation; The site of idol immersion should be desilted and may be prevented from immersion activities to maintain proper depth of the water as well as water quality. Constructions of a boundary wall after proper survey to prevent further encroachment.
- Biomanipulation of trophic levels : It is considered as one of the effective tools in the management. Introduction of composite fish culture to harvest biomass in surface, column and bottom feeding niches through introduction of select fish species can

effectively reduce nutrient levels. Thus “bottom up” or “top down” approach directed through introduction of surface, column and bottom feeders will generate income and reduce nutrient levels resulting into improvement of water quality.

Factors Creating Current Interest in Public Participation

- Public participation is an important element in a democratic theory. Since water-resource development projects are for the people and seeks to benefit people, so planning for it cannot go without attention, views, values, expectations and needs of people. Search by the planning and development agency for public support. These are multipurpose projects and may at times not be for benefit for immediate neighbourhood but for far-off places. Hence, objectionable to local population. Environmental Impact Assessment and public debate for decision-making.

Policy Alternatives that can be Used to Pollution (Adopted from Carson, 1980)

➤ Internalisation of Water Pollution Externalities

- Taxes and charges
- Subsidies
- Marketable Discharge Permits

➤ Government Contributions

- Research
- Education
- Prevention encouragement
- Rehabilitation
- Preservation

Methods of Financing/Funding Lake Conservation Programs

- Government funding under National Water Conservation program
- Local Municipal Corporation Funding
- Funding by NGO'S/Corporate Sector
- Willingness to pay of the local beneficiaries from the lake
- Income from sight seeing/boating and other recreational activities
- A percentage of profit from the Fisheries income from the lake

CONCLUSION

In the last three decades, the limonitic water bodies in and around Hyderabad received the attention of many scientific workers to assess their water quality, micro-flora and micro-fauna. These aquatic ecosystems are under going many changes due to the impact of human activities and there is an imperative need to plan and initiate appropriate measures to control their degradation, negative impacts and ensure their protection.

In the present study Mir-Alam lake is selected for this purpose and investigation was carried out at two selected sites of the Lake. Water samples had been collected for physico-chemical analysis.

Quantitative analysis of Macro Benthic Invertebrate population reveals a lesser diversity as well as density during summer. Statistical analysis reveals low density of Macro Benthic Invertebrates. Some of them showed positive significant value. The reduction in the number of species may also be due to predation. The species composition show the occurrence of *Gabbia stenothyroide*, and *Faunas ater* more predominate than other species. Shallow water communities by comparison, have a low species diversity and show marked fluctuations. Low diversity in the Lake can be attributed to the environmental changes and human activity, like continuous washing and swimming activities. All these changes may have their impact on structure of Benthic Community of the Lake.

Managing water resources is an extremely important sector of environmental management. The demand for sufficient amount and required quantity of water increases progressively with increasing population and standard of living. The Mir-Alam Lake is polluted by untreated domestic sewage, dumping of garbage and silt from construction and idol immersion. Due to tremendous ecological, recreational and environmental potential there is a need to protect this water body as natural heritage. Neglect in keeping natural heritage free from degradation, particularly the water bodies. Evolvment of public in decision making for the water resource development projects, creation and enforcement of legislation's and regulations will go a long way in maintaining the lake clean and healthy.

SUMMARY

Mir-Alam lake had been constructed in 1806 A.D., is the oldest man made lake with in the city limits of Hyderabad, A.P., and is intended mainly to cater to the water supply needs of Hyderabad and its industrial suburbs. At present it serves as stand by reservoir for water supplies water to the adjacent, Nehru Zoological Park. In view of the aim to portray the water quality and biological characteristics and their diurnal changes under the constraints of resources the present study had been carried out. During the study the lake water was found more alkaline, with high values of DO, TDS, Chloride, conductivity, transparency, nitrates, sulphates and low levels of calcium. Quantitative analysis of Macro Benthic invertebrate population reveals lesser diversity.

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TABLE 7 : WATER ANALYSIS DATA FOR THE YEAR 1998 ~ 2000 : SAMPLE I

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	37.0000	22.0000	29.4815	3.6938	0.7109	12.5291
2.	pH	8.9100	7.8000	8.6333	0.3180	0.0612	3.6834
3.	Conductivity	1902.0000	350.0000	1219.2222	368.6945	70.9553	30.2401
4.	TDS	1250.0000	212.000	722.9630	288.5590	55.5332	39.9134
5.	Dissolved Oxygen	4.5000	2.5000	3.1985	0.5684	0.1094	17.7715
6.	Sacchi Disc	6.3000	5.2000	5.7815	0.2588	0.0498	4.4755
7.	COD	120.0000	6.0000	47.4444	30.7538	5.9186	64.8206
8.	BOD	26.0000	1.8000	7.0481	5.3186	1.0236	75.4616
9.	Total Hardness	420.0000	150.0000	262.6667	60.8472	11.7101	23.1652
10.	Magnesium	205.0000	18.0000	87.7407	42.7682	8.2308	48.7439
11.	Chloride	315.0000	82.0000	230.7037	69.1491	13.3078	29.9731
12.	Total Alkanility	412.0000	150.0000	278.5926	62.2354	11.9772	22.3392
13.	Orthophosphate	0.9000	0.1500	0.4848	0.2221	0.0428	45.8209
14.	Total Phosphorous	9.2000	0.1000	2.3033	3.3544	0.6455	145.6303
15.	Nitrates	8.0000	1.6000	3.6185	1.5465	0.2976	42.7376
16.	Sulphates	135.0000	20.0000	88.8889	26.5045	5.1008	29.8175
17.	Lead	0.4900	0.0100	0.0630	0.0940	0.0181	149.2379
18.	Iron	0.2500	0.1400	0.1693	0.0218	0.0042	12.8947
19.	Calcium	100.0000	15.0000	43.8333	26.4685	5.0939	60.3845

TABLE 8 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 1998 - SAMPLE I, SEASON III

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	29.0000	23.0000	26.6667	3.2146	1.8559	12.0546
2.	PH	8.7000	7.8000	8.3667	0.4933	0.2848	5.8959
3.	Conductivity	1902. 0000	1240.0000	1614.0000	339.2757	195.8809	21.0208
4.	TDS	995. 0000	780.0000	872.3333	110.6632	63.8914	12.6859
5.	Dissolved Oxygen	3.0000	2.8800	2.9533	0.0643	0.0371	2.1769
6.	Sacchi Disc	5. 7000	5.2000	5.4333	0.2517	0.1453	4.6318
7.	COD	38.0000	29.0000	33.0000	4.5826	2.6458	13.8866
8.	BOD	14.8000	8.0000	11.0000	3.0000	1.7321	27.2727
9.	Total Hardness	270.0000	250.0000	262.6667	11.0151	6.3596	4.1936
10.	Magnesium	70.0000	18.0000	39.0000	27.4044	15.8219	70.2676
11.	Chloride	225.0000	98.0000	177.6667	69.3998	40.0680	39.0618
12.	Total Alkanility	412.0000	202.0000	324.6667	109.3679	63.1436	33.6862
13.	Orthophosphate	0.3000	0.1700	0.2533	0.0723	0.0418	28.5560
14.	Total Phosphorous	0.6000	0.2000	0.4000	0.2000	0.1155	50.0000
15.	Nitrates	4.0000	2.0000	2.8333	1.0408	0.6009	36.7353
16.	Sulphates	120.0000	85.0000	101.6667	17.5594	10.1379	17.2616
17.	Lead	0.0300	0.0100	0.0200	0.0100	0.0058	50.0000
18.	Iron	0.1800	0.1600	0.1700	0.0100	0.0058	5.8824
19.	Calcium	85.0000	23.0000	44.3333	35.2326	20.3415	79.4719

TABLE 9 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 1999 - SAMPLE I - SEASON I

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	30.0000	28.0000	28.5000	1. 0000	0.5000	3.5088
2.	PH	8.9000	8.0000	8.5250	0.4113	0.2056	4.8246
3.	Conductivity	1800.0000	1240.0000	1535.0000	259.9359	129.9679	16.9339
4.	TDS	1250.0000	780.0000	970.0000	199.8333	99.9166	20.6014
5.	Dissolved Oxygen	4.2000	3.0000	3.5750	0.4924	0.2462	13.7746
6.	Sacchi Disc	5.9000	5.6000	5.8000	0.1414	0.0707	2.4383
7.	COD	120.0000	70.0000	86.2500	23.5850	11.7925	27.3449
8.	BOD	26.0000	5.0000	11.2000	9.9076	4.9538	88.4605
9.	Total Hardness	270.0000	220.0000	247.5000	20.6155	10.3078	8.3295
10.	Magnesium	205.0000	110.0000	137.5000	45.1848	22.5924	32.8617
11.	Chloride	270.0000	185.0000	216.2500	37.2771	18.6386	17.2380
12.	Total Alkanility	290.0000	220.0000	253.7500	28.6865	14.3433	11.3050
13.	Orthophosphate	0.8500	0.2000	0.4800	0.3021	0.1511	62.9383
14.	Total Phosphorous	9.2000	0.3000	2.6500	4.3684	2.1842	164.8471
15.	Nitrates	4.8000	2.5000	3.6000	1.0424	0.5212	28.9565
16.	Sulphates	135.0000	95.0000	112.0000	16.7133	8.3566	14.9226
17.	Lead	0.0800	0.0100	0.0325	0.0330	0.0165	101.6627
18.	Iron	0.1900	0.1500	0.1650	0.0191	0.0096	11.6052
19.	Calcium	55.0000	25.0000	39.5000	12.2882	6.1441	31.1094

TABLE 10 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 1999 - SAMPLE I - SEASON II

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	35.0000	29.0000	32.5000	2.6458	1.3229	8.1409
2.	PH	8.9000	8.7500	8.8125	0.0650	0.0325	0.7376
3.	Conductivity	1350.0000	875.0000	1131.2500	199.3479	99.6739	17.6219
4.	TDS	870.0000	220.0000	690.0000	314.6400	157.3200	45.5082
5.	Dissolved Oxygen	4.2000	22.5000	3.4000	0.8287	0.4143	24.3722
6.	Sacchi Disc	6.0000	5.6000	5.7750	0.1708	0.0854	2.9573
7.	CO D	75.0000	50.0000	60.0000	12.2474	6.1237	20.4124
8.	BOD	7.2000	4.2000	5.2750	1.4221	0.7111	26.9601
9.	Total Hardness	315.0000	210.0000	268.2500	44.2973	22.1486	16.5134
10.	Magnesium	120.0000	100.0000	110.5000	8.2260	4.1130	7.4443
11.	Chloride	315.0000	265.0000	290.0000	21.9848	10.9924	7.5810
12.	Total Alkanility	315.0000	240.0000	290.0000	33.9116	16.9558	11.6937
13.	Orthophosphate	0.9000	0.5200	0.7125	0.2055	0.1027	28.8403
14.	Total Phosphorous	8.6000	0.9000	4.9500	3.8232	1.9116	77.2359
15.	Nitrates	4.9000	2.2000	3.5250	1.1758	0.5879	33.3560
16.	Sulphates	100.0000	90.0000	96.0000	4.3205	2.1602	4.5005
17.	Lead	0.0800	0.0400	0.0625	0.0171	0.0085	27.3252
18.	Iron	0.2500	0.1500	0.1850	0.0451	0.0225	24.3743
19.	Calcium	100.0000	30.0000	65.0500	31.1236	15.5618	47.8456

TABLE 11 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 1999 - SAMPLE I - SEASON III

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	30.0000	28.0000	29.0000	1.1547	0.5774	3.9817
2.	PH	8.9000	8.2900	8.7275	0.2923	0.1461	3.3489
3.	Conductivity	1320.0000	1200.0000	1267.5000	53.7742	26.8871	4.2425
4.	TDS	820.0000	230.0000	512.5000	296.0152	148.0076	57.7591
5.	Dissolved Oxygen	4.5000	2.6000	3.5750	0.9179	0.4589	25.6749
6.	Sacchi Disc	6.0000	5.7000	5.8500	0.1291	0.0645	2.2068
7.	COD	65.0000	55.0000	61.2500	4.7871	2.3936	7.8157
8.	BOD	11.8000	3.2000	5.8500	4.0353	2.0176	68.9788
9.	Total Hardness	410.0000	150.0000	247.5000	114.4188	57.2094	46.2298
10.	Magnesium	128.0000	108.0000	114.5000	9.1469	4.5735	7.9886
11.	Chloride	296.0000	280.0000	288.5000	6.6081	3.3040	2.2905
12.	Total Alkanility	298.0000	270.0000	281.0000	12.0554	6.0277	4.2902
13.	Orthophosphate	0.7800	0.2900	0.5350	0.2507	0.1253	46.8534
14.	Total Phosphorous	0.4700	0.1500	0.3300	0.1349	0.0675	40.8810
15.	Nitrates	8.0000	2.5000	4.9000	2.4097	1.2049	49.1776
16.	Sulphates	100.0000	40.0000	80.0000	27.0801	13.5401	33.8502
17.	Lead	0.4900	0.0300	0.1925	0.2123	0.1062	110.3106
18.	Iron	0.1800	0.1400	0.1625	0.0206	0.0103	12.6865
19.	Calcium	63.0000	15.2000	31.5200	22.3722	11.1861	70.9666

TABLE 12 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 2000 - SAMPLE I - SEASON I

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	29.0000	22.0000	25.2500	2.9861	1.4930	11.8261
2.	PH	8.9000	8.7800	8.8225	0.0532	0.0266	0.6024
3.	Conductivity	1345.0000	920.0000	1230.0000	206.8413	103.4207	16.8164
4.	TDS	1155.0000	780.0000	893.7500	153.6975	76.8487	17.1969
5.	Dissolved Oxygen	3.2000	2.5000	2.7500	0.3317	0.1658	12.0605
6.	Sacchi Disc	6.0000	5.5000	5.8250	0.2217	0.1109	3.8066
7.	COD	85.0000	20.0000	64.5000	29.9611	14.9805	46.4513
8.	BOD	15.0000	4.0000	9.7500	4.5735	2.2867	46.9074
9.	Total Hardness	300.0000	220.0000	266.2500	33.5099	16.7550	12.5859
10.	Magnesium	115.0000	70.0000	101.2500	20.9662	10.4831	20.7074
11.	Chloride	290.0000	277.0000	281.7500	5.6789	2.8395	2.0156
12.	Total Alkalinity	310.0000	220.0000	272.5000	39.6863	19.8431	14.5638
13.	Orthophosphate	0.5200	0.1500	0.3275	0.1522	0.0761	46.4668
14.	Total Phosphorous	9.0000	0.2200	2.4925	4.3396	2.1698	174.1080
15.	Nitrates	4.8000	2.5000	3.5250	1.0689	0.5344	30.3228
16.	Sulphates	125.0000	95.0000	107.5000	13.2288	6.6144	12.3058
17.	Lead	0.1000	0.0200	0.0500	0.0356	0.0178	71.1805
18.	Iron	0.1900	0.1700	0.1825	0.0096	0.0048	5.2462
19.	Calcium	80.2000	23.0000	42.0500	25.9051	12.9526	61.6056

TABLE 13 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 2000 - SAMPLE I - SEASON II

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	37.0000	27.0000	31.2500	4.3493	2.1747	13.9179
2.	PH	8.9100	8.0000	8.5875	0.4031	0.2016	4.6941
3.	Conductivity	1500.0000	600.0000	1125.0000	411.2988	205.6494	36.5599
4.	TDS	900.0000	220.0000	676.7500	308.6890	154.3445	45.6135
5.	Dissolved Oxygen	3.4000	2.8000	3.0250	0.2630	0.1315	8.6941
6.	Sacchi Disc	6.3000	5.9000	6.1000	0.1826	0.0913	2.9930
7.	COD	16.0000	10.0000	12.0000	2.8284	1.4142	23.5702
8.	BOD	3.6000	2.4000	2.9500	0.5000	0.2500	16.9492
9.	Total Hardness	318.0000	210.0000	281.2500	48.4656	24.2328	17.2322
10.	Magnesium	79.0000	27.0000	60.7500	23.6414	11.8207	38.9159
11.	Chloride	266.0000	120.0000	213.2500	67.5839	33.7919	31.6923
12.	Total Alkanility	380.0000	190.0000	285.7500	78.1382	39.0691	27.3450
13.	Orthophosphate	0.6600	0.4000	0.5400	0.1143	0.0572	21.1684
14.	Total Phosphorous	8.5000	0.8000	4.5750	3.7491	1.8746	81.9478
15.	Nitrates	3.5000	1.6000	2.5250	0.7762	0.3881	30.7409
16.	Sulphates	108.0000	50.0000	69.5000	27.3435	13.6717	39.3432
17.	Lead	0.0800	0.0100	0.0375	0.0310	0.0155	82.5519
18.	Iron	0.1600	0.1500	0.150	0.0058	0.0029	3.7248
19.	Calcium	100.0000	25.0000	56.2500	33.7577	16.8789	60.0137

TABLE 14 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 2000 - SAMPLE I - SEASON - III

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	36.0000	29.0000	32.5000	3.5119	1.7559	10.8058
2.	PH	8.9000	8.2000	8.5250	0.2872	0.7436	3.3692
3.	Conductivity	1240.0000	350.0000	730.5000	382.7980	191.3990	52.4022
4.	TDS	780.0000	212.0000	482.7500	292.4761	146.2380	60.5854
5.	Dissolved Oxygen	3.2000	2.9000	3.0500	0.1291	0.0645	4.2328
6.	Sacchi Disc	5.8000	5.2000	5.6000	0.2828	0.1414	5.0508
7.	COD	25.0000	6.0000	11.5000	9.0370	4.5185	78.5823
8.	BOD	10.0000	1.8000	4.3000	3.8245	1.9122	88.9415
9.	Total Hardness	420.0000	180.0000	265.2500	109.1524	54.5762	41.1508
10.	Magnesium	66.0000	20.0000	38.5000	19.7569	9.8784	51.3165
11.	Chloride	210.0000	82.0000	134.2500	56.5636	28.2618	42.1032
12.	Total Alkanility	390.0000	150.0000	254.0000	108.3697	54.1849	42.6653
13.	Orthophosphate	0.6000	0.2400	0.4875	0.1688	0.0844	34.6246
14.	Total Phosphorous	0.4000	0.1000	0.2500	0.1291	0.0645	51.6398
15.	Nitrates	7.0000	1.9000	4.2250	2.2515	1.1257	53.2895
16.	Sulphates	80.0000	20.0000	58.7500	26.5754	13.2877	45.2347
17.	Lead	0.0500	0.0200	0.0350	0.0129	0.0065	36.8856
18.	Iron	0.1800	0.1500	0.1650	0.0129	0.0065	7.8242
19.	Calcium	60.0000	15.0000	28.2500	21.2662	10.6331	75.2785

TABLE 15 : WATER ANALYSIS DATA FOR THE YEAR 1998 ~ 2000 : SAMPLE II

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	35.0000	21.0000	28.3333	3.4641	0.6667	12.2262
2.	PH	9.0000	7.0000	8.6478	0.3947	0.0760	4.5644
3.	Conductivity	1920.0000	400.0000	243.2593	351.7439	67.6931	28.2921
4.	TDS	1100.0000	200.0000	689.8889	274.6199	52.8506	39.8064
5.	Dissolved Oxygen	4.2000	2.0000	2.9407	0.5693	0.1096	19.3574
6.	Sacchi Disc	6.5000	5.5000	5.8370	0.2221	0.0428	3.8056
7.	CO D	117.0000	6.5000	45.3593	29.0654	5.5936	64.0783
8.	BOD	24.0000	2.0000	6.9222	5.1581	0.9927	74.5157
9.	Total Hardness	428.0000	160.0000	262.3704	61.7869	11.8909	23.5495
10.	Magnesium	210.0000	20.0000	89.3074	41.0934	7.9084	46.0135
11.	Chloride	320.0000	80.0000	229.5158	73.6647	14.1768	32.0953
12.	Total Alkanility	415.0000	153.2000	277.8222	63.9532	12.3078	23.0195
13.	Orthophosphate	0.9000	0.1500	0.4689	0.2148	0.0413	45.8114
14.	Total Phosphorous	9.0000	0.1000	2.2633	3.2485	0.6252	143.5276
15.	Nitrates	7.8000	1.8000	3.6037	1.5276	0.2940	42.3887
16.	Sulphates	123.3000	20.0000	84.1741	26.8582	5.1689	31.9080
17.	Lead	0.4800	0.0100	0.0796	0.1161	0.0224	145.8493
18.	Iron	0.2700	0.1500	0.1778	0.0278	0.0053	15.6269
19.	Calcium	100.0000	13.8000	42.1630	26.5948	5.1182	63.0761

TABLE 16 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 1998 - SAMPLE II - SEASON III.

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	25.0000	22.0000	23.6667	1.5275	0.8819	6.4543
2.	PH	8.9000	7.0000	8.2333	1.0693	0.6173	12.9871
3.	Conductivity	1920.0000	1350.0000	1665.0000	289.6981	167.2573	17.3993
4.	TDS	1000.0000	785.0000	876.6667	110.9429	64.0529	12.6551
5.	Dissolved Oxygen	3.0000	2.8000	2.9000	0.0100	0.0577	3.4483
6.	Sacchi Disc	6.0000	5.5000	5.7667	0.2517	0.1453	4.3641
7.	COD	35.0000	30.0000	31.6667	2.8866	1.6667	9.1161
8.	BOD	14.5000	9.0000	11.5000	2.7839	1.6073	24.2777
9.	Total Hardness	273.0000	235.0000	259.3333	21.1266	12.1974	8.1465
10.	Magnesium	73.0000	20.0000	43.6667	26.9506	15.5599	31.7189
11.	Chloride	220.0000	96.0000	174.6667	68.3910	39.4856	39.1552
12.	Total Alkanility	415.0000	205.0000	329.3333	110.2104	63.6300	33.4647
13.	Orthophosphate	0.3400	0.2000	0.2800	0.0721	0.0416	25.7539
14.	Total Phosphorous	0.6500	0.2000	0.4167	0.2255	0.1302	54.1110
15.	Nitrates	4.2000	2.2000	2.9667	1.0786	0.6227	36.3566
16.	Sulphates	123.3000	100.0000	109.4333.	12.2664	7.0820	11.2090
17.	Lead	0.0300	0.0100	0.0200	0.0100	0.0058	50.0000
18.	Iron	0.1800	0.1500	0.1667	0.0153	0.0088	9.1652
19.	Calcium	75.5000	21.5000	39.6667	31.0336	17.9172	78.2359

TABLE 17 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 1999 - SAMPLE II - SEASON I.

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	30.0000	28.0000	28.5000	1.0000	0.5000	3.5088
2.	PH	8.9000	8.0000	8.5250	0.4113	0.2056	4.8246
3.	Conductivity	1800.0000	1240.0000	1535.0000	259.9359	129.9679	16.9339
4.	TDS	1250.0000	780.0000	970.0000	199.8333	99.9166	20.6014
5.	Dissolved Oxygen	4.2000	3.0000	3.5750	0.4924	0.2462	13.7746
6.	Sacchi Disc	5.9000	5.6000	5.8000	0.1414	0.0707	2.4383
7.	COD	120.0000	70.0000	86.2500	23.5850	11.7925	27.3449
8.	BOD	26.0000	5.0000	11.2000	9.9076	4.9538	88.4605
9.	Total Hardness	270.0000	220.0000	247.5000	20.6155	10.3078	8.3295
10.	Magnesium	205.0000	110.0000	137.5000	45.1848	22.5924	32.8617
11.	Chloride	270.0000	185.0000	216.5000	37.2771	18.6386	17.2380
12.	Total Alkanility	290.0000	220.0000	253.7500	28.6865	14.3433	11.3050
13.	Orthophosphate	0.8500	0.2000	0.4800	0.3021	0.1511	62.9383
14.	Total Phosphorous	9.2000	0.3000	2.6500	4.3684	2.1842	164.8471
15.	Nitrates	4.8000	2.5000	3.6000	1.0424	0.5212	28.9565
16.	Sulphates	135.0000	95.0000	112.0000	16.7133	8.3566	14.9226
17.	Lead	0.0800	0.0100	0.0325	0.0330	0.0165	101.6627
18.	Iron	0.1900	0.1500	0.1650	0.0191	0.0096	11.6052
19.	Calcium	55.0000	25.0000	39.5000	12.2882	6.1441	31.1094

TABLE 18 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 1999 - SAMPLE II - SEASON II.

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	32.0000	29.0000	30.2500	1.2583	0.6292	4.1597
2.	PH	8.9000	8.7200	8.8100	0.0739	0.0370	0.8392
3.	Conductivity	1400.0000	900.0000	1185.0000	208.7263	104.3631	17.6140
4.	TDS	890.0000	215.0000	710.0000	330.1767	165.0884	46.5038
5.	Dissolved Oxygen	4.0000	2.0000	3.1000	0.8869	0.4435	28.6110
6.	Sacchi Disc	5.9000	5.6000	5.7500	0.1291	0.0645	2.2452
7.	COD	72.0000	48.0000	54.5000	11.7047	5.8523	21.4765
8.	BOD	7.0000	4.0000	5.0000	1.4142	0.7071	28.2843
9.	Total Hardness	312.0000	208.0000	268.2500	44.8878	22.4439	16.7236
10.	Magnesium	120.0000	100.0000	111.5000	9.2916	4.6458	8.3332
11.	Chloride	320.0000	260.0000	297.5000	26.2996	13.1498	8.8402
12.	Total Alkanility	320.0000	220.0000	284.5000	44.1324	22.0662	15.5123
13.	Orthophosphate	0.9000	0.5000	0.6925	0.2119	0.1059	30.5959
14.	Total Phosphorous	8.5000	0.8900	4.8475	3.7215	1.8608	76.7719
15.	Nitrates	4.8000	2.0000	3.3750	1.2285	0.6142	36.3995
16.	Sulphates	115.0000	58.5000	78.4250	26.2638	13.1319	33.4191
17.	Lead	0.0800	0.0400	0.0550	0.0173	0.0087	31.4918
18.	Iron	0.2700	0.1600	0.2025	0.0479	0.0239	23.6402
19.	Calcium	100.0000	28.0000	62.1250	33.5966	16.7983	54.0790

TABLE 19 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 1999 - SAMPLE II - SEASON III.

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	35.0000	27.0000	30.5000	3.4157	1.7078	11.1989
2.	PH	8.9200	8.6800	8.8250	0.1170	0.0585	1.3263
3.	Conductivity	1330.0000	1250.0000	1300.0000	35.5903	17.7951	2.7377
4.	TDS	800.0000	220.0000	496.2500	298.8694	149.4347	60.2256
5.	Dissolved Oxygen	4.2000	2.6000	3.4500	0.7124	0.3862	22.3896
6.	Sacchi Disc	6.0000	5.7000	5.8500	0.1291	0.0645	2.2068
7.	COD	62.0000	52.0000	57.2500	4.5735	2.2867	7.9886
8.	BOD	11.5000	3.0000	5.7000	3.9404	1.9702	69.1296
9.	Total Hardness	420.0000	160.0000	256.2500	115.2805	57.6402	44.9875
10.	Magnesium	120.0000	108.0000	113.0000	5.0332	2.5166	4.4542
11.	Chloride	300.0000	280.0000	287.0000	9.4616	4.7258	3.2933
12.	Total Alkanility	298.0000	268.0000	279.5000	13.3041	6.6521	4.7600
13.	Orthophosphate	0.7500	0.2800	0.5200	0.2393	0.1197	46.0201
14.	Total Phosphorous	0.4500	0.1100	0.3100	0.1440	0.0720	46.4486
15.	Nitrates	7.8000	2.5000	4.7500	2.3188	1.1594	48.8161
16.	Sulphates	90.0000	24.5000	66.5000	29.4300	14.7150	44.2557
17.	Lead	0.4800	0.0200	0.1850	0.2102	0.1051	113.5993
18.	Iron	0.1800	0.1500	0.1650	0.0129	0.0065	7.8242
19.	Calcium	60.0000	15.0000	30.3250	21.0275	10.5138	69.3405

TABLE 20 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 2000 - SAMPLE II - SEASON I.

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	29.0000	21.0000	24.2500	3.4034	1.7017	14.0348
2.	PH	8.9000	8.6800	8.7625	0.1090	0.0545	1.2445
3.	Conductivity	1350.0000	1000.0000	1255.7500	170.6231	85.3116	13.5873
4.	TDS	1100.0000	790.0000	885.0000	145.7166	72.8583	16.4652
5.	Dissolved Oxygen	3.0000	2.0000	2.3750	0.4787	0.2394	20.1564
6.	Sacchi Disc	6.0000	5.5000	5.7500	0.2082	0.1041	3.6203
7.	COD	80.0000	20.2000	61.8000	27.9290	13.9645	45.1925
8.	BOD	15.0000	3.8000	9.6500	4.6687	2.3343	48.3802
9.	Total Hardness	280.0000	230.0000	266.2500	24.2813	12.1407	9.1198
10.	Magnesium	110.0000	75.0000	98.7500	16.5202	8.2601	16.7293
11.	Chloride	298.0000	268.0000	282.0000	14.3295	7.1647	5.0814
12.	Total Alkalinity	300.0000	215.0000	267.5000	39.2641	19.6320	14.6782
13.	Orthophosphate	0.5000	0.1500	0.3200	0.1435	0.0718	44.8522
14.	Total Phosphorous	8.8000	0.2200	2.4375	4.2428	2.1214	174.0630
15.	Nitrates	4.0000	2.5000	2.9500	0.7141	0.3571	24.2082
16.	Sulphates	120.0000	95.0000	107.5000	10.4083	5.2042	9.6822
17.	Lead	0.1000	0.0200	0.0500	0.0356	0.0178	71.1805
18.	Iron	0.1900	0.1500	0.1750	0.0171	0.0085	9.9004
19.	Calcium	80.0000	22.5000	40.5750	26.8140	13.4070	66.0850

TABLE 21 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 2000 - SAMPLE II - SEASON II.

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	35.0000	28.0000	31.2500	2.9861	1.4930	9.5555
2.	PH	8.7200	8.2000	8.5250	0.2253	0.1127	2.6430
3.	Conductivity	1525.0000	625.0000	1167.5000	404.3204	202.1602	34.6313
4.	TDS	915.0000	200.0000	679.2500	323.9891	161.9945	47.6981
5.	Dissolved Oxygen	3.2000	2.5000	2.8250	0.2872	0.1436	10.1674
6.	Sacchi Disc	6.5000	5.9000	6.1500	0.2646	0.1323	4.3020
7.	COD	14.0000	11.0000	12.1250	1.3150	0.6575	10.8452
8.	BOD	3.5000	2.5000	2.9750	0.4113	0.2056	13.8252
9.	Total Hardness	310.0000	205.0000	272.5000	47.3462	23.6731	17.3748
10.	Magnesium	82.5000	32.0000	65.0000	23.2415	11.6207	35.7561
11.	Chloride	265.0000	133.0000	215.7500	63.0151	31.5525	29.2492
12.	Total Alkanility	375.0000	195.0000	287.0000	73.8873	36.9437	25.7447
13.	Orthophosphate	0.6000	0.4300	0.5275	0.0780	0.0390	14.7960
14.	Total Phosphorous	8.0000	0.8000	4.4750	3.4673	1.7337	77.4826
15.	Nitrates	4.5000	1.8000	3.1500	1.1902	0.5951	37.3753
16.	Sulphates	110.0000	53.8000	73.4500	26.2350	13.1175	35.7182
17.	Lead	0.0700	0.0100	0.0325	0.0263	0.0131	80.9217
18.	Iron	0.2500	0.1600	0.1900	0.0408	0.0204	21.4868
19.	Calcium	98.5000	30.0000	55.6250	32.2707	16.1353	58.0147

TABLE 22 : WATER ANALYSIS DATA SEASON WISE FOR THE YEAR 2000 - SAMPLE II - SEASON III.

Sl. No.	Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
1.	Temperature	30.0000	28.0000	28.7500	0.9574	0.4787	3.3302
2.	PH	9.0000	8.5000	8.7500	0.2380	0.1190	2.7205
3.	Conductivity	1340.0000	400.0000	785.0000	404.4338	202.2169	51.5202
4.	TDS	790.0000	215.0000	491.2500	295.8709	147.9354	60.2282
5.	Dissolved Oxygen	3.2000	2.6000	2.9500	0.2517	0.1258	8.5309
6.	Sacchi Disc	6.0000	5.6000	5.7750	0.2062	0.1031	3.5698
7.	COD	28.3000	6.5000	12.5000	10.5511	5.2756	84.4092
8.	BOD	11.0000	2.0000	4.6500	4.2509	2.1254	91.4168
9.	Total Hardness	428.0000	165.0000	259.5000	118.5650	59.2825	45.6898
10.	Magnesium	70.0000	28.3000	42.5750	18.9241	9.4621	44.4489
11.	Chloride	218.0000	80.0000	136.0000	61.2536	30.6268	45.0394
12.	Total Alkanility	401.0000	153.2000	258.5500	112.7369	56.3658	43.6035
13.	Orthophosphate	0.6600	0.2200	0.4475	0.2153	0.1077	48.1139
14.	Total Phosphorous	0.4100	0.1000	0.2650	0.1287	0.0644	48.5704
15.	Nitrates	7.5000	2.0000	4.4250	2.3922	1.1961	54.0604
16.	Sulphates	85.0000	20.0000	62.6250	29.6286	14.8143	47.3112
17.	Lead	0.4200	0.0200	0.1675	0.1821	0.0910	108.7130
18.	Iron	0.1700	0.1500	0.1600	0.0082	0.0041	5.1031
19.	Calcium	55.0000	13.8000	27.4500	19.0782	9.5391	69.5015

TABLE 23 : LINEAR CO-RELATION BETWEEN TOTAL BENTHOIC MACRO INVERTIBRATES AND VARIOUS PHYSICO-CHEMICAL FACTORS OF THE MIR ALAM LAKE FOR THE YEAR 1998 ~ 2000 WATER ANALYSIS SAMPLE - I

Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
Temperature	37.0000	22.0000	29.4815	3.6938	0.7109	12.5291
PH	8.9100	7.8000	8.6333	0.3180	0.0612	3.6834
Conductivity	1902.0000	350.0000	1219.2222	368.6945	70.9553	30.2401
TDS	1250.0000	212.0000	722.9630	288.5590	55.5332	39.9134
Dissolved Oxygen	4.5000	2.5000	3.1985	0.5684	0.1094	17.7715
Sacchi Disc	6.3000	5.2000	5.7815	0.2588	0.0498	4.4755
COD	120.0000	6.0000	47.4444	30.7538	5.9186	64.8206
BOD	26.0000	1.8000	7.0481	5.3186	1.0236	75.4616
Total Hardness	420.0000	150.0000	262.6667	60.8472	11.7101	23.1652
Mg	205.0000	18.0000	87.7407	42.7682	8.2308	48.7439
Chloride	315.0000	82.0000	230.7037	69.1491	13.3078	29.9731
Total Alkalinity	412.0000	150.0000	278.5926	62.2354	11.9772	22.3392
Orthophosphate	0.9000	0.1500	0.4848	0.2221	0.0428	45.8209
Total Phosphorous	9.2000	0.1000	2.3033	3.3544	0.6455	145.6303
Nitrates	8.0000	1.6000	3.6185	1.5465	0.2976	42.7376
Sulphates	135.0000	20.0000	88.8889	26.5045	5.10085	29.8175
Lead	0.4900	0.0100	0.0630	0.0940	0.0181	149.2379
Iron	0.2500	0.1400	0.1693	0.0218	0.0042	12.8947

TABLE 23 Contd.

Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
Calcium	100.0000	15.0000	43.8333	26.4685	5.0939	60.3845
<i>L. hoffmeisteri</i>	17.0000	0.0000	5.6296	4.5077	0.8675	80.0705
<i>Pristina aquiseta</i>	16.0000	0.0000	3.4074	4.5086	0.8677	132.3181
<i>Lumbricidae</i>	18.0000	0.0000	2.9259	4.8272	0.9290	164.9807
<i>C. circumdatus</i>	16.0000	0.0000	3.9630	3.9368	0.7576	99.3404
<i>C. plumosus</i>	8.0000	0.0000	3.2593	2.3303	0.4485	71.4972
<i>Notonectids</i>	9.0000	0.0000	3.1481	2.6268	0.5055	83.4408
Mosquitoe Larvae	123.0000	0.0000	55.0370	37.3471	7.1875	67.8581
<i>L. accuminata</i>	9.0000	0.0000	2.6296	2.6040	0.5011	99.0240
<i>B. dissimilis</i>	18.0000	0.0000	6.0370	3.3796	0.6504	55.9810
<i>B. bengalensis</i>	9.0000	0.0000	4.3333	2.7456	0.5284	63.3606
<i>Thiara tuberculata</i>	8.0000	0.0000	3.1481	2.4605	0.4735	78.1575
<i>T. scabra</i>	6.0000	0.0000	2.1481	1.6339	0.3144	76.0592
<i>Gyraulus convexiusculus</i>	8.0000	0.0000	2.3704	2.2140	0.4275	93.7139
<i>Indo. exustus</i>	13.0000	0.0000	4.8519	3.4940	0.6724	72.0136
<i>Cremno. conius</i>	10.0000	1.0000	4.4444	1.9677	0.3787	44.2730
<i>Faunausater</i>	8.0000	0.0000	4.1111	2.1001	0.4042	51.0826
<i>G. stenothyroide</i>	68.0000	0.0000	9.7778	17.8246	3.4304	182.2975

TABLE 24 : LINEAR CO-RELATION BETWEEN TOTAL BENTHOIC MACRO INVERTIBRATES AND VARIOUS PHYSICO-CHEMICAL FACTORS OF THE MIR ALAM LAKE FOR THE YEAR 1998 ~ 2000 WATER ANALYSIS SAMPLE - II

Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
Temperature	35.0000	21.0000	28.3333	3.4641	0.6667	12.2262
PH	9.0000	7.0000	8.6478	0.3947	0.0760	4.5644
Conductivity	1920.0000	400.0000	1243.2593	351.7139	67.6931	28.2921
TDS	1100.0000	200.0000	689.8889	274.6199	52.8506	39.8064
Dissolved Oxygen	4.2000	2.0000	2.9407	0.5693	0.1096	19.3574
Sacch. Disc	6.5000	5.5000	5.8370	0.2221	0.0428	3.8056
COD	117.0000	6.5000	45.3593	29.0654	5.5936	64.0783
BOD	24.0000	2.0000	6.9222	5.1581	0.9927	74.5157
Total Hardness	428.0000	160.0000	62.3704	61.7869	11.8909	23.5495
Mg	210.0000	20.0000	89.3074	41.0934	7.9084	46.0135
Chloride	320.0000	80.0000	229.5185	73.6647	14.1768	32.0953
Total Alkalinity	415.0000	153.2000	277.8222	63.9532	12.3078	23.0195
Orthophosphate	0.9000	0.1500	0.4689	0.2148	0.0413	45.8114
Total Phosphorous	9.0000	0.1000	2.2633	3.2485	0.6252	143.5276
Nitrates	7.8000	1.8000	3.6037	1.5276	0.2940	42.3887
Sulphates	123.3000	20.0000	84.1741	26.8582	5.1689	31.9080
Lead	0.4800	0.0100	0.0796	0.1161	0.0224	145.8493
Iron	0.2700	0.1500	0.1778	0.0278	0.0053	15.6269
Calcium	100.0000	13.8000	42.1630	26.5948	5.1182	63.0761

TABLE 24 : Contd.

Parameters	Highest	Lowest	Mean	Standard Deviation	Standard Error	C.V.%
<i>L. hoffmeisteri</i>	21.0000	3.0000	8.1111	4.4750	0.8612	55.1713
<i>Pristina acquiseta</i>	23.0000	0.0000	6.2593	7.0087	1.3488	111.9740
<i>Lumbricidae</i>	22.0000	0.0000	3.3333	4.8198	0.9276	144.5949
<i>C. circumdatus</i>	18.0000	0.0000	7.0741	3.7409	0.7199	52.8818
<i>C. plumosus</i>	11.0000	2.0000	5.5556	2.3912	0.4602	43.0420
<i>Natonectids</i>	12.0000	1.0000	6.5926	2.6495	0.5099	40.1893
<i>Mosquitoe Larvae</i>	137.0000	0.0000	56.4444	39.7166	7.6435	70.3641
<i>L. acuminate</i>	12.0000	0.0000	4.2963	3.0736	0.5915	71.5417
<i>B. dissimilis</i>	10.0000	0.0000	6.0741	2.7863	0.5362	45.8722
<i>B. bengalensis</i>	10.0000	2.0000	6.2222	2.1183	0.4077	34.0440
<i>Thiara tuberculata</i>	11.0000	0.0000	5.7407	2.2970	0.4221	40.0128
<i>T. scabra</i>	12.0000	0.0000	3.5556	2.5621	0.4931	72.0577
<i>Gyraulus convexiusculus</i>	11.0000	0.0000	3.9295	2.3192	0.4463	59.0752
<i>Indo exustus</i>	15.0000	2.0000	6.2593	3.5147	0.6764	56.1524
<i>Cremno. conius</i>	10.0000	0.0000	5.0741	2.2858	0.4399	45.0494
<i>Faunus ater</i>	15.0000	3.0000	7.4074	2.7909	0.5371	37.6773
<i>G. stenothyroi</i>	63.0000	0.0000	10.5556	17.8268	3.4308	168.8855

TABLE 25 : LINEAR CO-EFFICIENT CORRELATION BETWEEN THE MONTHLY FLUCTUATION IN POPULATION ABUNDANCES OF TOTAL BENTHIC MACRO INVERTEBRATES, AND VARIATION IN DIFFERENT PHYSICO-CHEMICAL FACTORS OF THE MIR ALAM LAKE OF WATER ANALYSIS - SITE - I AND SITE II

Location	Variations	Equation	't' Value	Probability
Site-I				
	Total benthic macro invertebrates (Y)			
	Nitrates	$Y = 80.2546 + 11.32165$	3.4976	0.0018 **
Site-II				
	Total benthic macro invertebrates (Y)			
	Total Alkalinity	$Y = 218.9431 - 0.23922$	2.1668	0.0400*
	Nitrates	$Y = 107.3412 + 12.52607$	2.8661	0.0083**
	Lead	$Y = 140.6641 + 148.40424$	2.5052	0.0191*

*(p<0.05), **(p<0.02),

TABLE 26 : VALUES R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF TOTAL BENTHIC MACRO INVERTEBRATES AND VARIOUS PHYSICO CHEMICAL FACTORS OF WATER IN MIR ALAM LAKE OF SITE - I AND II

SITE-I				
$R^2 = 0.7131$				
$F = 3.9760 (10, 16)$				
Variables	Coeff.	Std. Error	T. Value	Probability
pH	75.39135	23.2730	3.239	0.005**
Conductivity (m mhos/cm)	0.04435	0.0181	2.456	0.026*
T D S (mg/lit)	0.04555	0.0214	2.126	0.049*
Chloride (mg/lit)	-0.44178	0.1161	3.805	0.002**
Total Alkalinity (mg/lit)	-0.19506	0.0747	2.612	0.019*
Total Phosphorous (mg/lit)	3.07273	1.4931	2.058	0.056
Sulphate (mg/lit)	-0.73522	0.2179	3.374	0.004**
Lead (mg/lit)	262.66281	59.1985	4.437	0.000***
Iron (mg/lit)	561.31126	231.2990	2.427	0.027**
Calcium (mg/lit)	-0.64885	0.2324	2.792	0.1013*
SITE-II				
$R^2 = 0.8179$				
$F = 6.1253 (11, 15)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Temperature ($^{\circ}$ c)	- 4.54586	1.9129	2.376	0.031*
conductivity (m mhos/cm)	0.05964	0.0200	2.986	0.009**
Dissolved Oxygen (mg/lit)	- 12.26304	8.5276	1.438	0.171
sacchi disc (cm)	- 68.62392	23.3355	2.941	0.010*
Chloride (mg/lit)	- 0.22625	0.0706	3.206	0.006**
Total Alkalinity (mg/lit)	- 0.39196	0.0837	4.683	0.000***
Orthophosphate (mg/lit)	- 87.87994	40.9968	2.144	0.0491*
Total Phosphorous (mg/lit)	12.30203	2.6549	4.634	0.000***
Sulphate (mg/lit)	- 1.49672	0.2915	5.134	0.000***
Lead (mg/lit)	269.16359	58.9569	4.565	0.000***
Iron (mg/lit)	- 441.74162	197.7940	2.233	0.041*
*(p<0.05), ***(p<0.02), ****(p<0.01)				

TABLE – 27 : LINEAR CO-EFFICIENT CORRELATION BETWEEN THE MONTHLY FLUCTUATION IN POPULATION ABUNDANCES OF LIMNODRILUS HOFFMEISTERI AND PRISTINA ACQUISETA, AND VARIATION IN DIFFERENT PHYSICO-CHEMICAL FACTORS OF THE MIR ALAM LAKE OF WATER ANALYSIS - SAMPLE I AND SAMPLE II

Location	Variations	Equation	't' Value	Probability
Site-I				
	Limnodrilus hoffmeisteri (Y)			
	Sacchi. Disc (cm)	$Y = -38.2604 + 7.59149 x$	2.4208	0.0231*
	Orthophosphate (mg/lit)	$Y = 0.2610 + 11.07352 x$	3.2562	0.0032**
	Total Phosphorous (mg/lt)	$Y = 3.5360 + 0.90897 x$	4.5918	0.0001***
	Calcium (mg/lit)	$Y = 1.4616 + 0.09509 x$	3.3651	0.0025**
Site-II				
	Limnodrilus hoffmeisteri (Y)			
	Temperature (°C)	$Y = -7.0545 + 0.53526 x$	2.2763	0.0317*
	Orthophosphate (mg/lit)	$Y = 2.9467 + 11.01417 x$	3.1143	0.0046**
	Total Phosphorous (mg/lit)	$Y = 6.3212 + 0.79082 x$	3.5056	0.0017**
	Iron (mg/lit)	$Y = -13.2990 + 120.43189 x$	5.6291	0.0000***
	Calcium (mg/lit)	$Y = 5.0089 + 0.07358 x$	2.4310	0.0226*
Site-I				
	Pristina aquiseta (Y)			
	Orthophosphate (mg/lit)	$Y = -2.2782 - 11.72733 x$	3.5399	0.0016**
	Total Phosphorous (mg/lit)	$Y = 1.3630 + 0.88761 x$	4.3969	0.0002***
Site-II				
	Pristina aquiseta (Y)			
	Orthophosphate (mg/lit)	$Y = -5.6764 + 25.45522 x$	6.2354	0.0000***
	Total Phosphorous (mg/lit)	$Y = 2.2597 + 1.76711 x$	7.1379	0.0000***
	Iron (mg/lit)	$Y = -17.7102 + 134.82835 x$	3.1615	0.0041**

*(p<0.05), **(p<0.02), ***(p<0.01)

TABLE – 28 : VALUES OF R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF L. HOFFMEISTRI AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR-ALAM LAKE WATER ANALYSIS OF SITE-I AND SITE-II

SITE-I				
$R^2 = 0.8624$				
$F = 6.2671 (13, 13)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Temperature ($^{\circ}\text{C}$)	0.4080	0.1700	2.3998	0.0321*
pH	-11.4568	3.1253	3.6659	0.0028**
T D S (mg/lit)	-0.0084	0.0029	2.8881	0.0127*
D O (mg/lit)	-1.8544	1.0188	1.8201	0.0918
B O D (mg/lit)	0.3438	0.1516	2.2683	0.0410*
Total Hardness (mg/lit)	0.0428	0.0131	3.2677	0.0061**
Magnesium (mg/lit)	0.0649	0.0231	2.8119	0.0147*
Chloride (mg/lit)	0.0308	0.0134	2.2997	0.0387*
Orthophosphate (mg/lit)	-4.9629	4.2520	1.1672	0.2641
Total Phosphorous (mg/lit)	0.8729	0.2613	3.3407	0.0053**
Sulphate (mg/lit)	-0.0892	0.0363	2.4583	0.0288*
Iron (mg/lit)	52.5192	27.8810	1.8837	0.0822
Calcium (mg/lit)	0.1121	0.0333	3.3681	0.0050**
SITE-II				
$R^2 = 0.8609$				
$F = 20.6296 (6, 20)$				
Variables	Coeff.	Std. Error	T Value	Probability
T D S (mg/lit)	-0.0041	0.0021	1.9468	0.0657
Sacchi. Disc (cm)	5.1103	1.9174	2.6652	0.0149*
Total Alkalinity (mg/lit)	0.0192	0.0068	2.8274	0.0104*
Total Phosphorous (mg/lit)	0.5068	0.1634	3.1025	0.0056**
Sulphate (mg/lit)	-0.0466	0.0209	2.2335	0.0371*
Iron (mg/lit)	102.1969	17.0974	5.9774	0.0000***

*($p < 0.05$); **($p < 0.02$); ***($p < 0.01$)

TABLE 29 : VALUES OF R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF PRISTINA ACQUISITA AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR ALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE-I				
$R^2 = 0.8272$				
$F = 9.0442 (9, 17)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Temperature	0.2773	0.1536	1.8055	0.0887
Conductivity	0.0038	0.0018	2.0554	0.0555
Chemical Oxygen Demand	0.0652	0.0267	2.4438	0.0257*
Magnesium	- 0.0300	0.0180	1.6684	0.1136
Total Alkalinity	- 0.0253	0.0084	3.0285	0.0076**
Total Phosphorous	1.0574	0.2168	4.8764	0.0001***
Sulphate	- 0.0673	0.0306	2.1962	0.0422*
Iron	59.0041	25.4788	2.3158	0.0333*
Calcium	- 0.0352	0.0272	1.2944	0.2128
SITE-II				
$R^2 = 0.9265$				
$F = 28.3716 (8, 18)$				
Variables	Coeff.	Std. Error	T. Value	Probability
TDS	0.0033	0.0026	1.2844	0.2153
Biological Oxygen Demand	- 0.2541	0.1204	2.1099	0.0491*
Magnesium	- 0.0361	0.0117	3.0954	0.0062**
Total Alkalinity	- 0.0217	0.0076	2.8663	0.0103*
Orthophosphate	12.2074	2.7792	4.3924	0.0004***
Total Phosphorous	1.0926	0.2050	5.3297	0.0000***
Iron	79.9255	21.8269	3.6618	0.0018**
Calcium	- 0.0641	0.0291	2.2051	0.0407*

*($p < 0.05$);**($p < 0.02$);***($p < 0.01$)

TABLE 30 : LINEAR CO-EFFICIENT CORRELATION BETWEEN THE MONTHLY FLUCTUATION IN POPULATION ABUNDANCES OF *LUMBRICIDAE*, *CHIRONOMUS. CIRCUMDATUS* AND *CHIRONOMUS PLUMOSUS* AND VARIATION IN DIFFERENT PHYSICO-CHEMICAL FACTORS OF THE MIR ALAM LAKE OF WATER ANALYSIS - SAMPLE I & SAMPLE II

Location	Variations	Equation	't' Value	Probability
Site-I	Lumbricidae (Y)			
	Sulphate (mg/lit)	$Y = 11.7844 - 0.09966 x$	3.2687	0.0031**
Site-II	Lumbricidae (Y)			
	Conductivity	$Y = 11.8810 - 0.00688 x$	2.9002	0.0077**
	TDS (mg/lit)	$Y = 9.9514 - 0.00959 x$	3.2635	0.0032**
	Chloride (mg/lit)	$Y = 9.7016 - 0.02775 x$	2.3413	0.0275*
	Sulphate (mg/lit)	$Y = 9.5351 - 0.07368 x$	2.2513	0.0334*
Site-I	<i>C. Circumdatus</i> (Y)			
	Calcium (mg/lit)	$Y = 0.9934 + 0.06775 x$	2.5582	0.0170*
Site-II	<i>C. Circumdatus</i> (Y)			
	Iron (mg/lit)	$Y = - 4.1281 + 63.01218 x$	2.6475	0.0138*
Site-I	<i>C. Plumosus</i> (Y)	N I L		
Site-II	<i>C. Plumosus</i> (Y)			
	Biological Oxygen Demand (mg/lit)	$Y = 6.8637 - 0.18898 x$	2.2322	0.0348*
	Calcium (mg/lit)	$Y = 3.2564 + 0.05453 x$	3.8137	0.0008***

*(p<0.05), ***(p<0.01), ***(p<0.01)

TABLE 31 : VALUES OF R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF CHIRONOMUS CIRCUMDATUS AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR ALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE-I				
$R^2 = 0.5012$				
$F = 2.2607 (8,18)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Temperature	-0.3000	0.2129	1.4093	0.1758
Dissolved Oxygen	2.7682	1.5872	1.7441	0.0982
Total Hardness	-0.0213	0.0144	1.4783	0.1566
Total Alkalinity	0.0252	0.0144	1.7506	0.0970
Orthophosphate	-12.7064	5.0804	2.5010	0.0223*
Total phosphorus	0.6605	0.3257	2.0282	0.0576
Sulphate	-0.1077	0.0369	2.9210	0.0091**
Calcium	0.0831	0.0346	2.4040	0.0272*
SITE-II				
$R^2 = 0.8620$				
$F = 7.2885 (12,14)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Conductivity	0.0031	0.0016	1.9215	0.0753
TDS	0.0071	0.0031	2.2846	0.0385*
Dissolved Oxygen	-0.9720	0.8262	1.1765	0.2590
Chemical Oxygen Demand	-0.0396	0.0170	2.3245	0.0357*
Total Hardness	-0.0231	0.0096	2.3999	0.0309*
Total Alkalinity	-0.0181	0.0076	2.3718	0.0326*
Orthophosphate	-22.9056	3.8369	5.9698	0.0000***
Total Phosphorous	1.0699	0.2376	4.5035	0.0005***
Nitrates	1.4910	0.4085	3.6502	0.0026**
Sulphate	-0.1009	0.0287	3.5185	0.0034**
Iron	71.8106	19.9066	3.6074	0.0029**
Calcium	-0.0593	0.0228	2.6054	0.0208*

*($p < 0.05$); **($p < 0.02$) ; ***($p < 0.01$)

TABLE – 32 : VALUES OF R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF CHIRONOMUS PLUMOSUS AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR-ALAM LAKE WATER ANALYSIS OF SITE-I AND SITE-II

SITE-I				
$R^2 = 0.8359$				
$F = 5.9446 (12,14)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Temperature ($^{\circ}\text{C}$)	- 0.3246	0.1131	2.8696	0.0124 *
pH	- 2.8945	1.0670	2.7126	0.0168 *
Conductivity (m mhos/cm)	0.0017	0.0010	1.6507	0.1210
D O (mg/lit)	- 1.2365	0.5526	2.2377	0.0420 *
C O D (mg/lit)	- 0.0831	0.0164	5.0820	0.0002***
Magnesium (mg/lit	0.0292	0.0115	2.5361	0.0237 *
Total Alkalinity (mg/lit)	- 0.0188	0.0051	3.6747	0.0025 **
Orthophosphate (mg/lit)	9.7313	1.9873	4.8968	0.0002 ***
Nitrates (mg/lit)	- 0.5976	0.2764	2.1621	0.0484 *
Sulphate (mg/lit)	0.0681	0.0169	4.0405	0.0012 **
Iron (mg/lit)	- 32.6370	14.5379	2.2450	0.0414 *
Calcium (mg/lit)	- 0.0205	0.0158	1.2948	0.2163
SITE-II				
$R^2 = 0.8172$				
$F = 5.2166 (12, 14)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Temperature ($^{\circ}\text{C}$)	0.3550	0.1278	2.7783	0.0148*
pH	- 1.3734	0.8758	1.5682	0.1392
Conductivity (m mhos/cm)	0.0031	0.0012	2.5371	0.0237*
D O (mg/lit)	- 1.6006	0.5208	3.0735	0.0083**
Sacchi Disc (cm)	- 2.8894	1.5839	1.8242	0.0895
C O D (mg/lit)	- 0.0207	0.0126	1.6476	0.1217
B O D (mg/lit)	- 0.2473	0.0803	3.0813	0.0081**
Total Hardness (mg/lit)	0.0195	0.0064	3.0356	0.0089**
Total Alkalinity (mg/lit)	- 0.0269	0.0068	3.9670	0.0014**
Total Phosphorous (mg/lit)	- 0.1877	0.1147	1.6363	0.1241
Sulphate (mg/lit)	0.0539	0.0151	3.5573	0.0032**
Calcium (mg/lit)	0.0363	0.0206	1.7594	0.1003

*($p < 0.05$); **($p < 0.02$); ***($p < 0.01$)

TABLE- 33 : LINEAR CO-EFFICIENT CORRELATION BETWEEN THE MONTHLY FLUCTUATION IN POPULATION ABUNDANCES OF *NOTONECTIDS*, *MOSQUITOE LARVAE* AND *LYMANAE ACCUMINATA* AND VARIATION IN DIFFERENT PHYSICO-CHEMICAL FACTORS OF THE MIR ALAM LAKE OF WATER ANALYSIS – SITE-I AND SITE-II

Location	Variations	Equation	't' Value	Probability
Site-I	<i>Notonectids</i> (Y)			
	Dissolved Oxygen (mg/lit)	$Y = -3.2582 + 2.00291 x$	2.4046	0.0239*
	Chemical Oxygen Demand (mg/lit)	$Y = 1.1856 + 0.04137 x$	2.7677	0.0105*
	Magnesium (mg/lit)	$Y = -0.0787 + 0.03678 x$	3.7382	0.0010***
	Sulphate (mg/lit)	$Y = -0.8837 + 0.04536 x$	2.5736	0.0164*
Site-II	<i>Notonectids</i> (Y)			
	Chemical Oxygen Demand (mg/lit)	$Y = 5.0716 + 0.03472 x$	2.0598	0.0500*
	Magnesium (mg/lit)	$Y = 3.4361 + 0.03534 x$	3.2771	0.0031**
Site-I	Mosquitoe larvae (Y)			
	Nitrates (mg/lit)	$Y = 9.4842 + 12.58881 x$	3.0542	0.0053**
Site-II	Mosquitoe larvae (Y)			
	Nitrates (mg/lit)	$Y = 20.0356 + 10.10317 x$	2.1086	0.0452*
	Lead (mg/lit)	$Y = 43.4918 + 162.66.53 x$	2.7037	0.0122*
	Iron (mg/lit)	$Y = 155.7874 - 558.80391 x$	2.1233	0.0438*
Site-I	<i>Lymanae accuminata</i> (Y)	N I L		
Site-II	<i>L. accuminata</i> (Y)			
	Total Phosphorous (mg/lit)	$Y = 3.4050 + 0.39378 x$	2.2885	0.0308*

*(p<0.05), ***(p<0.01), ***(p<0.01)

TABLE-34 : VALUES OF R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF NATONECTIDS AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIRALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE-I				
$R^2 = 0.8079$				
$F = 7.9441 (9,17)$				
Variables	Coeff.	Std. Error	T. Value	Probability
pH	1.8532	1.7744	1.0444	0.3109
T D S (mg/lit)	0.0030	0.0014	2.2068	0.0414*
D O (mg/lit)	1.3449	0.6365	2.1131	0.0497*
Total Hardness (mg/lit)	- 0.0150	0.0066	2.2613	0.0371*
Magnesium (mg/lit)	0.0357	0.0100	3.5659	0.0024**
Chloride (mg/lit)	- 0.0194	0.0087	2.2433	0.0385*
Orthophosphate (mg/lit)	- 4.0546	1.5390	2.6346	0.0174*
Nitrates (mg/lit)	- 0.2753	0.2801	0.9828	0.3395
Lead (mg/lit)	14.7144	5.5866	2.6339	0.0174*
SITE-II				
$R^2 = 0.6767$				
$F = 5.6815 (7,19)$				
Variables	Coeff.	Std. Error	T. Value	Probability
PH	1.5167	1.2898	1.1760	0.2541
T D S (mg/lit)	- 0.0015	.0017	0.9205	0.3689
D O (mg/lit)	1.8562	0.7054	2.6314	0.0164*
Total Hardness (mg/lit)	- 0.0210	0.0089	2.3649	0.0288*
Magnesium (mg/lit)	0.0497	0.0105	4.7190	0.0001***
Chloride (mg/lit)	- 0.0143	0.0070	2.0589	0.0535
Total Alkalinity (mg/lit)	0.0175	0.0071	2.4721	0.0231*

*($p < 0.05$); **($p < 0.02$); ***($p < 0.01$)

TABLE-35 : VALUES R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF MOSQUITOE LARVAE AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR ALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE-I				
$R^2 = 0.5012$				
$F = 2.2607 (8,18)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Temperature	- 3.0835	1.6407	1.8793	0.0775
pH	60.1133	17.8203	3.3733	0.0036**
Conductivity	0.0155	0.0159	0.9723	0.3446
B O D	- 2.3022	1.0434	2.2065	0.0414*
Magnesium	- 0.5983	0.1319	4.5349	0.0003***
Total Phosphorous	- 2.9809	1.6527	1.8037	0.0890
Nitrates	15.0052	3.4425	4.3588	0.0004***
Iron	211.5470	238.5292	2.1446	0.0467*
Calcium	- 0.4087	0.2546	1.6052	0.1269
SITE-II				
$R^2 = 0.8620$				
$F = 7.2885 (12,14)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Temperature	- 9.5044	2.0059	4.7382	0.0002***
pH	32.7168	14.2970	2.2884	0.0352*
B O D	1.7280	1.4047	1.2302	0.2354
Total Hardness	- 0.2894	0.0990	2.9217	0.0095**
Orthophosphate	- 103.1822	49.7386	2.0745	0.0535
Total Phosphorous	8.8910	3.2434	2.7412	0.0139*
Nitrates	15.5080	4.4170	3.5109	0.0027**
Sulphate	- 1.5637	0.3481	4.4923	0.0003***
Iron	- 838.8230	216.5335	3.8739	0.0012**

*($p < 0.05$); **($p < 0.02$); ***($p < 0.01$)

TABLE-36 : VALUES OF R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF LYMNAEA ACCUMINATA AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR ALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE-I				
$R^2 = 0.3685$				
$F = 3.2089 (4, 22)$				
Variables	Coeff.	Std.Error	T. Value	Probability
Sacchi Disc	2.5680	1.7936	1.4317	0.1663
Total Alkalinity	0.0174	0.0075	2.3258	0.0296
Sulphate	- 0.0361	0.0180	2.0091	0.0569
Calcium	0.0359	0.0180	1.9967	0.0584
SITE-II				
$R^2 = 0.9136$				
$F = 9.0594 (14, 12)$				
Variables	Coeff.	Std.Error	T. Value	Probability
pH	2.3711	1.0404	2.2791	0.0417*
Conductivity	0.0052	0.0012	4.4458	0.0008***
Sacchi Disc	- 5.5437	1.4463	3.8331	0.0024**
Chemical Oxygen Demand	- 0.0290	0.0166	1.7536	0.1050
Biological Oxygen Demand	0.4636	0.0967	4.7935	0.0004***
Total Hardness	- 0.0094	0.0060	1.5566	0.1455
Magnesium	0.0311	0.0125	2.4799	0.0290*
Chloride	- 0.0417	0.0066	6.3341	0.0000***
Orthopshosphate	- 11.7888	3.1807	3.7063	0.0030**
Total Phosphorous	2.3337	0.2618	8.9134	0.0000***
Nitrates	- 3.5742	0.6740	5.3031	0.0002***
Sulphates	- 0.1368	0.0226	6.0392	0.0001***
Lead	61.5904	9.4032	6.5500	0.0000****
Iron	- 32.4673	13.0635	2.4853	0.0287*

*($p < 0.05$); **($p < 0.02$), ***($p < 0.01$)

TABLE – 37 LINEAR CO-EFFICIENT CORRELATION BETWEEN THE MONTHLY FLUCTUATION IN POPULATION ABUNDANCES OF *BELLAMYA DISSIMILIS*, *BELLAMYA BENGALENSIS*, *THIARA MELANSIDEA* AND VARIATION IN DIFFERENT PHYSICO-CHEMICAL FACTORS OF THE MIR-ALAM LAKE OF WATER ANALYSIS – SITE – I AND SITE- II

Location	Variations	Equation	't' Value	Probability
Site – I	<i>Bellamya dissimilis</i> (Y)	N I L		
Site – II	<i>B. dissimilis</i> (Y)			
	Chemical Oxygen Demand (mg/lit)	$Y = 8.0744 - 0.04410 x$	2.5904	0.0158*
Site – I	<i>Bellamya bengalensis</i> (Y)	N I L		
Site – II	<i>B. bengalensis</i> (Y)			
	Nitrates (mg/lit)	$Y = 4.1327 + 0.57983 x$	2.3015	0.0300*
	Lead (mg/lit)	$Y = 5.5315 + 8.67481 x$	2.7034	0.0122*
Site – I	<i>Thiara tuberculata</i> (Y)			
	Orthophosphate (mg/lit)	$Y = 0.883 + 4.66126 x$	2.3196	0.0288*
	Total Phosphorous (mg/lit)	$Y = 2.4067 + 0.32192 x$	2.4421	0.0220*
Site – II	<i>Thiara tuberculata</i> (Y)			
	Total Phosphorous (mg/lit)	$Y = 5.0602 + 0.30066 x$	2.3489	0.0270*
	Iron (mg/lit)	$Y = -0.5002 + 35.10521 x$	2.3447	0.0273*

*(p<0.05), **(p<0.02), ***(p<0.01)

TABLE - 38 VALUES OF R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF BENGAL DISSIMILIS AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR ALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE-I				
$R^2 = 0.2033$				
$F = 3.0615 (2, 24)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Total Alkalinity	0.0200	0.0099	2.0139	0.0554
Lead	- 10.4155	6.5717	1.5849	0.1261
SITE-II				
$R^2 = 0.6816$				
$F = 2.9192 (11,15)$				
Variables	Coeff.	Std. Error	T. Value	Probability
pH	- 1.5600	1.3869	1.1249	0.2783
Conductivity	0.0017	0.0016	1.0549	0.3082
T D S	- 0.0035	0.0024	1.5039	0.1534
Sacch Disc	- 2.7826	2.0135	1.3819	0.1872
C O D	- 0.0445	0.0186	2.3906	0.0304*
B O D	- 0.2214	0.1060	2.0886	0.0542
Total Hardness	0.0226	0.0103	2.2018	0.0437*
Chloride	0.0081	0.0088	0.9261	0.3690
ORthophosphate	- 7.0238	2.8269	2.4846	0.0253*
Nitrates	0.6323	0.3559	1.7765	0.0959
Iron	19.0942	17.9582	1.0633	0.3045

*($p < 0.05$); **($p < 0.02$); ***($p < 0.01$)

TABLE - 39 : VALUES OF R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF *B. BENGALENSIS* AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR ALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE-I

$$R^2 = 0.4931$$

$$F = 4.0863 (5, 21)$$

Variables	Coeff.	Std. Error	T. Value	Probability
Sacch Disc	4.5624	1.8596	2.4534	0.0230*
Chloride	0.0152	0.0067	2.2748	0.0335*
Total Phosphorous	- 0.4539	0.1399	3.2443	0.0039**
Nitrates	0.6201	0.2968	2.0891	0.0491*
Iron	21.3010	20.5790	1.0351	0.3124

SITE-II

$$R^2 = 0.7833$$

$$F = 5.782 (10, 16)$$

Variables	Coeff.	Std. Error	T Value	Probability
Conductivity	- 0.0015	0.0010	1.5017	0.1527
T D S	0.0033	0.0013	2.6196	0.0186*
D O	- 1.1303	0.4980	2.2695	0.0374*
C O D	- 0.0327	0.0108	3.0291	0.0080**
Chloride	0.0129	0.0042	3.0865	0.0071**
Total Alkalinity	- 0.0063	0.0045	1.4050	0.1792*
Total Phosphorous	- 0.4409	0.1007	4.3779	0.0005***
Nitrates	1.0519	0.1964	5.3553	0.0001***
Iron	48.3382	11.6882	4.1356	0.0008***
Calcium	- 0.0271	0.0144	1.8834	0.0780

*($p < 0.05$);**($p < 0.02$);***($p < 0.01$)

TABLE - 40 : VALUES OF R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF THIANAMELANSIDEA AND ARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR ALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE-I				
$R^2 = 0.3568$				
$F = 3.0505 (4, 22)$				
Variables	Coeff.	Std. Error	T. Value	Probability
D O	1.6391	0.7710	2.1258	0.0450*
Total Alkalinity	0.0078	0.0072	1.0837	0.2902
Total Phosphorous	0.2943	0.1272	2.3139	0.0304*
Iron	25.7542	20.1185	1.2801	0.2138
SITE-II				
$R^2 = 0.6821$				
$F = 5.8228 (7, 19)$				
Variables	Coeff.	Std. Error	T. Value	Probability
pH	- 4.5833	0.9250	4.9547	0.0001***
T D S	0.0038	0.0017	2.2759	0.0346*
Total Hardness	0.0316	0.0078	4.0644	0.0007***
Magnesium	0.0116	0.0082	1.4225	0.1711
Total Alkalinity	- 0.0148	0.0060	2.4740	0.0230*
Orthophosphate	4.8450	1.6366	2.9604	0.0080**
Calcium	0.0389	0.0207	1.8814	0.0753

*($p < 0.05$); **($p < 0.02$); ***($p < 0.01$)

TABLE-41 : LINEAR CO-EFFICIENT CORRELATION BETWEEN THE MONTHLY FLUCTUATION IN POPULATION ABUNDANCES OF *THIARA SCABRA* AND *GYRALUS CONVESUIUS* AND VARIATION IN DIFFERENT PHYSICO-CHEMICAL FACTORS OF THE MIR-ALAM LAKE OF WATER ANALYSIS – SITE-I AND SITE-II

Location	Variations	Equation	't' Value	Probability
Site-I				
	<i>Thiara scabra</i> (Y)			
	Total Hardness (mg/lit)	$Y = -0.8134 + 0.01127 x$	2.3132	0.0292*
	SulpHate (mg/lit)	$Y = 4.2581 - 0.02374 x$	2.0862	0.0473*
	Iron (mg/lit)	$Y = 7.3008 - 30.44259 x$	2.2256	0.0353*
Site-II				
	<i>T. scabra</i> (Y)			
	Conductivity (m mhos/cm)	$Y = 9.5959 - 0.00486 x$	4.4764	0.0001***
	TDS (mg/lit)	$Y = 6.5787 - 0.00438 x$	2.6602	0.0134*
	Chemical Oxygen Demand (mg/lit)	$Y = 5.1324 - 0.03476 x$	2.1459	0.0418*
	Magnesium (mg/lit)	$Y = 5.7650 - 0.02474 x$	2.1615	0.0404*
	Chloride (mg/lit)	$Y = 7.3456 - 0.01651 x$	2.6973	0.0123*
	Total Alkalinity (mg/lit)	$Y = 9.2759 - 0.02059 x$	2.9957	0.0061**
	Lead (mg/lit)	$Y = 2.8073 + 9.39718 x$	2.3542	0.0267*
Site-I				
	<i>Gy. convexiuscullus</i> (Y)			
	pH	$Y = 31.4743 - 3.37112 x$	2.7550	0.0108*
	Chloride (mg/lit)	$Y = 6.2299 - 0.01670 x$	3.0425	0.0055**
Site-II				
	<i>Gy. convexiuscullus</i> (Y)	N I L		

*(p<0.05), ***(p<0.01), ***(p<0.01)

TABLE - 42 : VALUES R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF THIARA SCABRA AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR ALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998~2000

SITE-I				
$R^2 = 0.7071$				
$F = 5.4314 (8, 18)$				
Variables	Coeff.	Std. Error	T. Value	Probability
D O	- 0.7093	0.3885	1.8256	0.0845
Sacchi Disc	1.5874	0.8933	1.7770	0.0925
Total Hardness	0.0137	0.0038	3.5931	0.0021 **
Magnesium	0.0197	0.0075	2.6196	0.0174*
Chloride	- 0.0143	0.0043	3.3680	0.0034**
Total Phosphorous	0.0712	0.0698	1.0193	0.3215
Sulphate	- 0.0283	0.0101	2.8050	0.0117*
Iron	- 22.3311	10.2652	2.1754	0.432*
SITE-II				
$R^2 = 0.7912$				
$F = 12.7156 (6, 20)$				
Variables	Coeff.	Std. Error	T Value	Probability
Conductivity	- 0.0025	0.0009	2.8152	0.0107*
Total Hardness	0.0077	0.0048	1.6277	0.1192
Chloride	- 0.0130	0.0042	3.0935	0.0057**
Total Alkalinity	- 0.0182	0.0048	3.7663	0.0012**
Orthophospate	4.6604	1.3792	3.3791	0.0030**
Iron	- 36.4866	10.2391	3.5634	0.0019**

*($p < 0.05$); **(<0.02); ***($p < 0.01$)

TABLE-43 : VALUES R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF *GYRALUS CONVEXISCUIUS* AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIRALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE - I				
$R^2 = 0.4330$				
$F = 4.2002 (4, 22)$				
Variables	Coeff.	Std.Error	T. Value	Probability
Total Hardness	- 0.0101	0.0061	1.6478	0.1136
Chloride	- 0.0186	0.0054	3.4368	0.0024
Total Phosphorous	0.2454	0.1144	2.1452	0.0432
Iron	- 17.3890	16.9303	1.0271	0.3155
SITE - II				
$R^2 = 0.7033$				
$F = 4.4782 (9, 17)$				
Variables	Coeff.	Std. Error	T. Value	Probability
T D S	- 0.0029	0.0022	1.2913	0.2139
B O D	0.2184	0.0998	2.1884	0.0429*
Magnesium	0.0303	0.0119	2.5460	0.0209*
Chloride	- 0.0244	0.0061	4.0288	0.0009***
Total Alkalinity	- 0.0048	0.0053	0.9188	0.3710
Total Phosphorous	0.4366	0.2222	1.9647	0.0660
Sulphate	- 0.0404	0.0258	1.5692	0.1350
Iron	- 65.0882	19.5484	3.3296	0.0040**
Calcium	0.0768	0.0214	3.5910	0.0023**

*($p < 0.05$); **($p < 0.02$); ***($p < 0.01$)

TABLE - 44 : LINEAR CO-EFFICIENT CORRELATION BETWEEN THE MONTHLY FLUCTUA-TION IN POPULATION ABUNDANCES OF *INDO PLANORBIS EXUSTUS*, *CREMNO CONCNU-SCORICUS*, *FAUNUS ATER* and *GABBAI ASTENOTHYROIDE* AND VARIATION IN DIFFERENT PHYSICO-CHEMICAL FACTORS OF THE MIR ALAM LAKE OF WATER ANALYSIS - SITE I & II

Location	Variations	Equation	't' Value	Probability
Site-I				
	<i>Indo. exustus</i> (Y)			
	Total Phosphorous	$Y = 3.3128 + 0.45109 x$	2.4023	0.0240*
Site-II				
	<i>Indo. exustus</i> (Y)			
	Total Phosphorous	$Y = 4.7593 + 0.66270 x$	3.8743	0.0007***
	Iron	$Y = -4.1554 + 58.58250 x$	2.6122	0.0150*
Site-I				
	<i>Cre. concnuscorticus</i> (Y)	N I L		
Site-II				
	<i>Cre. concnuscorticus</i> (Y)			
	BOD	$Y = 3.8527 + 0.17644 x$	2.1702	0.0397*
	Total Hardness	$Y = -0.3586 + 0.02071 x$	3.3769	0.0024**

*(p<0.05),

** (p<0.02),

*** (p<0.01)

TABLE - 44 : LINEAR CO-EFFICIENT CORRELATION BETWEEN THE MONTHLY FLUCTUA-TION IN POPULATION ABUNDANCES OF *INDO PLANORBIS EXUSTUS*, *CREMNO CONCNU-SCORICUS*, *FAUNAUUS ATER* and *GABBAL ASTENOTHYROIDE* AND VARIATION IN DIFFERENT PHYSICO-CHEMICAL FACTORS OF THE MIR ALAM LAKE OF WATER ANALYSIS - SITE I & II

Location	Variations	Equation	't' Value	Probability
Site-I				
	<i>Faunausater</i> (Y)			
	BOD	$Y = 5.5557 - 0.20496 x$	3.0365	0.0055**
Site-II				
	<i>Faunaus ater</i> (Y)			
	Total Phosphorous	$Y = 6.4280 + 0.4374 x$	2.9153	0.0074**
Site-I				
	<i>Gabbaiastenothyroide</i> (Y)			
	BOD	$Y = -0.5660 + 1.46758 x$	2.4355	0.0223*
	Magnesium	$Y = -5.2317 + 0.17107 x$	2.2506	0.0335*
Site-II				
	<i>Gabbai astenothyroide</i> (Y)			
	Magnesium	$Y = -7.6822 + 0.20421 x$	2.6678	0.0132*

*(p<0.05),

** (p<0.02),

*** (p<0.01)

TABLE-45 : VALUES R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF INDOPLANORBIS EXUSTUS AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR ALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE-I				
$R^2 = 0.4722$				
$F = 4.9213 (4, 22)$				
Variables	Coeff.	Std. Error	T. Value	Probability
T D S	0.0048	0.0022	2.1936	0.0391*
Total Alkalinity	- 0.0265	0.0090	2.9530	0.0074**
Total Phosphorous	0.6174	0.1903	3.2444	0.0037**
Calcium	- 0.0483	0.0269	1.7950	0.0864
SITE-II				
$R^2 = 0.9295$				
$F = 17.9824 (11, 15)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Temperature	- 0.2040	0.0943	2.1637	0.0470*
PH	4.3406	0.9476	4.5808	0.0004***
Conductivity	0.0014	0.0009	1.5146	0.1507
D O	2.1277	0.5029	4.2311	0.0007***
B O D	- 0.2310	0.0693	3.3356	0.0045**
Total Hardness	- 0.0155	0.0052	2.9946	0.0091**
Chloride	- 0.0199	0.0049	4.0883	0.0010***
Orthophosphate	- 9.0475	1.9453	4.6510	0.0003***
Total Phosphorous	1.2251	0.1320	9.2781	0.0000***
Iron	102.5710	13.0184	7.8789	0.0000***
Calcium	- 0.1266	0.0152	8.3107	0.0000***

*(<0.05); **($p<0.02$); ***($p< 0.01$)

TABLE-46 : VALUES R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF CREMNOCONCHUS CONIUS AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR ALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE-I				
$R^2 = 0.9128$				
$F = 12.2169 (12, 14)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Temperature	0.4117	0.0710	5.7980	0.0000***
pH	-1.5904	0.6571	2.4203	0.0297*
Conductivity	0.0031	0.0006	4.9436	0.0002***
TDS	0.0033	0.0008	3.9114	0.0016**
D O	0.8062	0.3214	2.5085	0.0251*
C O D	-0.0360	0.0099	3.6364	0.0027**
Magnesium	0.0250	0.0070	3.5856	0.0030**
Orthophosphate	-5.5017	1.4183	3.8792	0.0017**
Total Phosphorous	0.4128	0.0729	5.6637	0.0001***
Nitrates	0.3956	0.1714	2.3076	0.0368*
Iron	28.6204	9.1517	3.1273	0.0074**
Calcium	-.0533	0.0112	4.7384	0.0003***
SITE-II				
$R^2 = 0.8424$				
$F = 12.0243 (8,18)$				
Variables	Coeff.	Std. Error	T. Value	Probability
Conductivity	0.0024	0.0008	3.0638	0.0067**
COD	-0.0526	0.0141	3.7406	0.0015**
BOD	0.2691	0.0584	4.6089	0.0002***
Total Hardness	0.0173	0.0037	4.7373	0.0002***
Magnesium	0.0215	0.0092	2.3442	0.0307*
Nitrates	0.7290	0.1500	4.8596	0.0001***
Sulphate	-0.0328	0.0099	3.3151	0.0039**
Calcium	-0.0203	0.0104	1.9469	0.0673

* $p < 0.05$); **($p < 0.02$); ***($p < 0.01$)

TABLE - 47 : VALUES OF FACTORS OF R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF FAUNUS ATER AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIR ALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE-I				
$R^2 = 0.4268$				
$F = 4.0951 (4, 22)$				
Variables	Coeff.	Std. Error	T. Value	Probability
PH	- 1.8816	1.1367	1.6553	0.1121
B O D	- 0.1978	0.0658	3.0074	0.0065**
Orthophosphate	- 2.9896	1.9709	1.5169	0.1435
Total Phosphorous	0.3069	0.1377	2.2285	0.0364*)
SITE-II				
$R^2 = 0.5374$				
$F = 3.1537 (7, 19)$				
Variables	Coeff.	Std. Error	T. Value	Probability
PH	- 2.5180	1.6248	1.5498	0.1377
T D S	- 0.0062	0.0025	2.4221	0.0256*
Total Hardness	0.0281	0.0101	2.7868	0.0118*
Chloride	0.0181	0.0083	2.1974	0.0406*
Total Phosphorous	0.2551	0.1694	1.5059	0.1485
Iron	-27.6948	20.4636	1.3534	0.1918
Calcium	0.0609	0.0276	2.2088	0.0397*

*($p < 0.05$); **($p < 0.02$); ***($p < 0.01$)

TABLE - 48 : VALUES OF R^2 FOR MULTIPLE REGRESSION BETWEEN SEASONAL POPULATION DENSITY OF GABBAIA STENOTHYROIDE AND VARIOUS PHYSICO CHEMICAL FACTORS OF THE MIRALAM LAKE WATER ANALYSIS SAMPLE FOR THE YEAR 1998 ~ 2000

SITE-I				
$R^2 = 0.09479$				
$F = 21.2412 (12, 14)$				
Variables	Coeff.	Std. Error	T. Value	Probability
T D S	0.0201	0.0063	3.1732	0.0068**
D O	8.5034	2.5937	3.2785	0.0055**
C O D	- 0.2731	0.0726	3.7594	0.0021**
B O D	1.4884	0.3276	4.5432	0.0005***
Total Hardness	- 0.1174	0.0299	3.9270	0.0015**
Magnesium (mg/lit)	0.4430	0.0506	8.7508	0.0000***
Chloride	- 0.1635	0.0292	5.5977	0.0001***
Total Alkalinity	- 0.0234	0.0231	1.0136	0.3280
Total Phosphorous	1.3418	0.0043	3.0196	0.0092**
Nitrates	- 3.4235	0.9289	3.6857	0.0024**
Iron	- 147.4556	66.1697	2.2284	0.0428*
Calcium	- 0.2219	0.0760	2.9190	0.0112*
SITE-II				
$R^2 = 0.9100$				
$F = 16.1767 (10, 16)$				
Variables	Coeff.	Std. Error	T. Value	Probability
D O	7.0380	2.7548	2.5548	0.0212*
SacchI Disc	6.3195	6.5580	0.9636	0.3496
C O D	- 0.3088	0.0912	3.3854	0.0038**
B O D	1.7096	0.3929	4.3515	0.0005***
Total Hardness	- 0.0522	0.0236	2.2145	0.0417*
Magnesium (mg/lit)	0.5934	0.0687	8.6372	0.0000***
Chloride	- 0.2037	0.0284	7.1626	0.0000***
Total Phosphorous	1.9191	0.6433	2.9831	0.0088**
Nitrates	- 3.3107	1.1271	2.9373	0.0097**
Calcium	- 0.2068	0.0827	2.5014	0.0236*

* $p < 0.05$; ** $(p < 0.02)$; *** $(p < 0.01)$

TABLE - 49 : DIVERSITY INDICES OF BENTHIC ORGANISMS FOR THE YEAR 1998 ~ 2000 : SITE I

Year	Species	Individual	Swinder	Himax	Diver- gence (D1)	D1 %	Even- ness	Simpson Diversity Index	Equita- bility Index	Rich ness ($\alpha 1$)	Mantinié $\alpha 2$
1998			(H1)								
Oct.	<i>T. scabra</i>	104.00	2.3092	3.5850	1.2757	35.5870	64.4143	2.6799	0.2233	2.3684	1.1767
Nov.	<i>B. bengalensis</i>	128.00	1.9985	3.3219	1.3235	39.8403	60.1597	2.3925	0.2393	1.8549	0.8839
Dec.	<i>Gyraulus convexiscullus</i>	109.00	2.0570	3.7004	1.6434	14.4119	55.5881	2.2237	0.1711	2.5579	1.2452
1999											
Jan.	<i>Faunus ater</i>	140.00	3.3829	4.0000	0.6171	15.4280	84.5720	6.5421	0.4089	3.0354	1.3522
Feb.	<i>Indoplanorbis exutus</i>	114.00	2.4173	3.8074	1.3900	36.5088	63.4912	2.6985	0.1928	2.7448	1.3112
Mar.	<i>Cremno. conicus</i>	118.00	2.8375	3.9069	1.0694	27.3721	72.6279	3.7694	0.2513	2.9346	1.3809
Apr.	<i>Gabbia stenothyroide</i>	151.00	2.8426	4.0875	1.2449	30.4554	69.5446	3.6770	0.2163	3.1890	1.3834
May.	<i>Faunus ater</i>	147.00	3.2076	4.0000	0.7924	19.8102	80.1898	5.9284	0.3705	3.0058	1.3197
Jun.	<i>Indoplanorbis exutus</i>	91.00	3.3247	3.8074	0.4827	12.6778	87.3222	7.6747	0.5482	2.8819	1.4676
Jul.	<i>Indoplanorbis exutus</i>	59.00	3.5413	3.8074	0.2661	6.9878	93.0122	9.8612	0.7044	3.1882	1.8226
Aug.	<i>Faunus ater</i>	67.00	3.6830	4.0000	0.3170	7.9242	92.0758	10.9755	0.6860	3.5674	1.9547
Sep.	<i>T. scabra</i>	108.00	2.4340	3.5850	1.1509	32.1044	67.8956	3.0171	0.2514	2.3494	1.1547
Oct.	<i>Faunus ater</i>	165.00	2.4715	4.0000	1.5285	38.2117	61.7883	2.8374	0.1773	2.9378	1.2456
Nov.	<i>Gyraulus convexiscullus</i>	159.00	1.9269	3.7004	1.7735	47.9279	52.0721	2.0456	0.1574	2.3674	1.0310
Dec.	<i>T. scabra</i>	146.00	2.2321	3.5850	1.3529	37.7379	62.2621	2.5256	0.2105	2.2072	0.9931

TABLE - 50 : DIVERSITY INDICES OF BENTHIC ORGANISMS FOR THE YEAR 1998 ~ 2000 : SITE-I

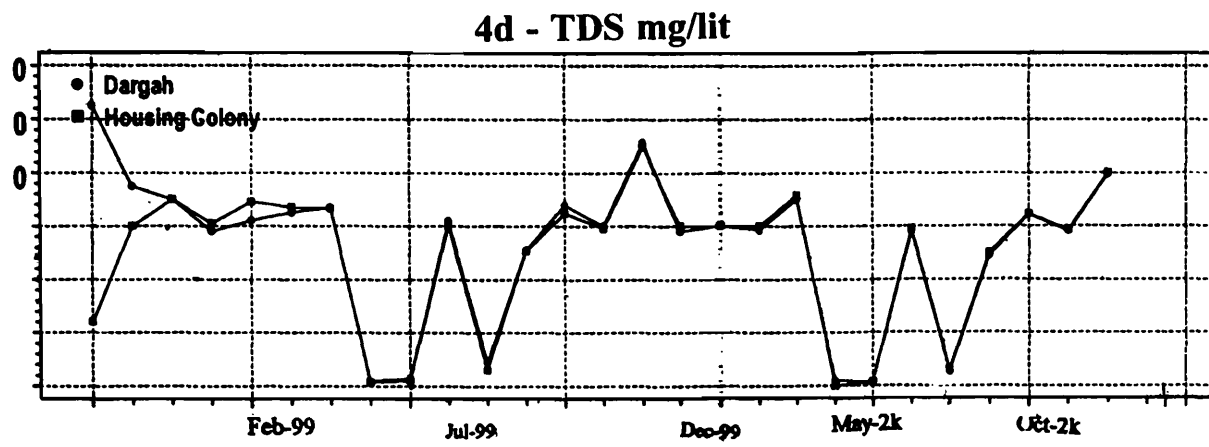
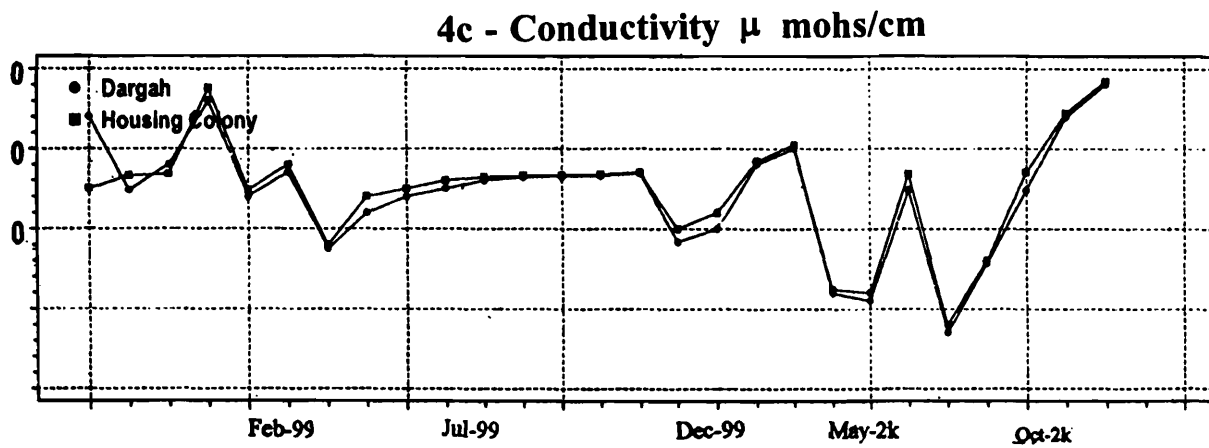
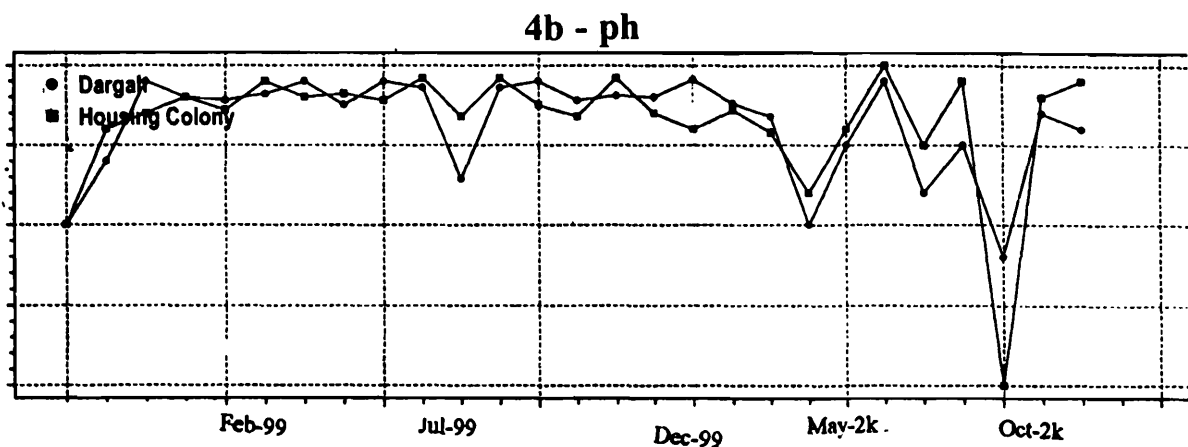
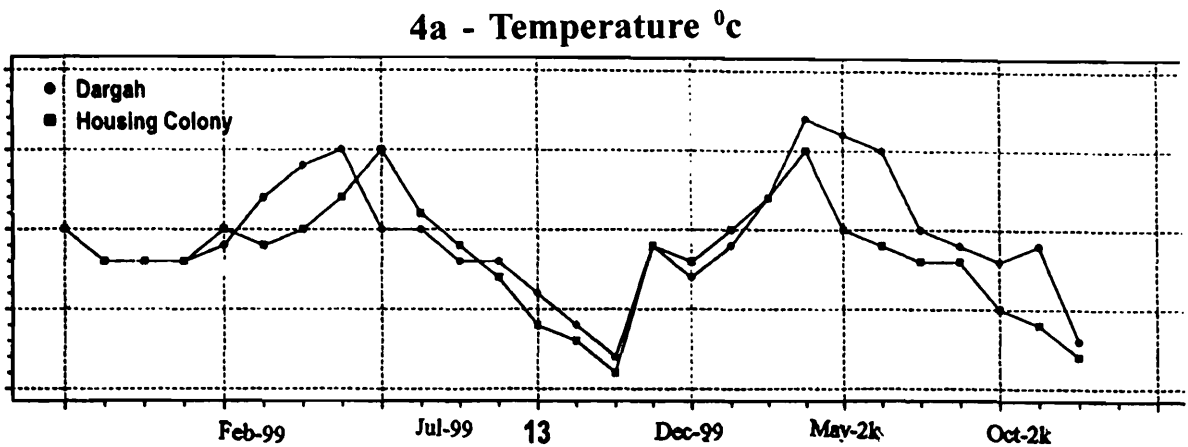
Year	Species	Individual	Swinder	Himax	Diver- gence (D1)	D1 %	Even- ness	Simpson Diversity Index	Equita- bility Index	Rich- ness ($\alpha 1$)	Mantini- e $\alpha 2$
2000			(H1)								
Jan.	<i>Cremnoconchus conicus</i>	112.00	2.8839	3.9069	1.0230	26.1845	73.8155	4.0000	0.2667	2.9670	1.4174
Feb.	<i>Gyraulus convexiscullus</i>	112.00	2.1044	3.7004	1.5960	43.1304	56.8696	2.2832	0.1756	2.5432	1.2284
Mar.	<i>T. scabra</i>	109.00	2.2884	3.5850	1.2966	36.1672	63.8328	2.7909	0.2326	2.3447	1.1494
Apr.	<i>Indoplanorbis exustus</i>	151.00	2.2275	3.8074	1.5798	41.4936	58.5064	2.4404	0.1743	2.5910	1.1393
May.	<i>Cremnoconchus conicus</i>	128.00	3.3062	3.9069	0.6007	15.3746	84.6254	6.5799	0.4387	2.8854	1.3258
Jun.	<i>Indoplanorbis exustus</i>	103.00	3.5911	3.8074	0.2162	5.6790	94.3210	10.4729	0.7481	2.0000	1.3795
Jul.	<i>Gyraulus convexiscullus</i>	72.00	3.5963	3.7004	0.1241	3.3536	96.6464	11.0298	0.8484	2.8059	1.5321
Aug.	<i>Cremnoconchus conicus</i>	91.00	3.6847	3.9069	0.2221	5.6859	94.3141	10.8532	0.7235	3.1036	1.5724
Sep.	<i>Cremnoconchus conicus</i>	125.00	2.7213	3.9069	1.1856	30.3467	69.6533	3.4228	0.2282	2.8996	1.3416
Oct.	<i>Gyraulus convexiscullus</i>	159.00	2.0877	3.7004	1.6127	43.5821	56.4179	2.2343	0.1719	2.3674	1.0310
Nov.	<i>Gyraulus convexiscullus</i>	181.00	2.0145	3.7004	1.6859	45.5593	54.4407	2.1192	0.1630	2.3084	0.9663
Dec.	<i>Gyraulus convexiscullus</i>	124.00	2.0213	3.7004	1.6791	45.3756	54.6244	2.1730	0.1672	2.4895	1.1674

TABLE - 51 : DIVERSITY INDICES OF BENTHIC ORGANISMS FOR THE YEAR 1998 ~ 2000 : SITE II

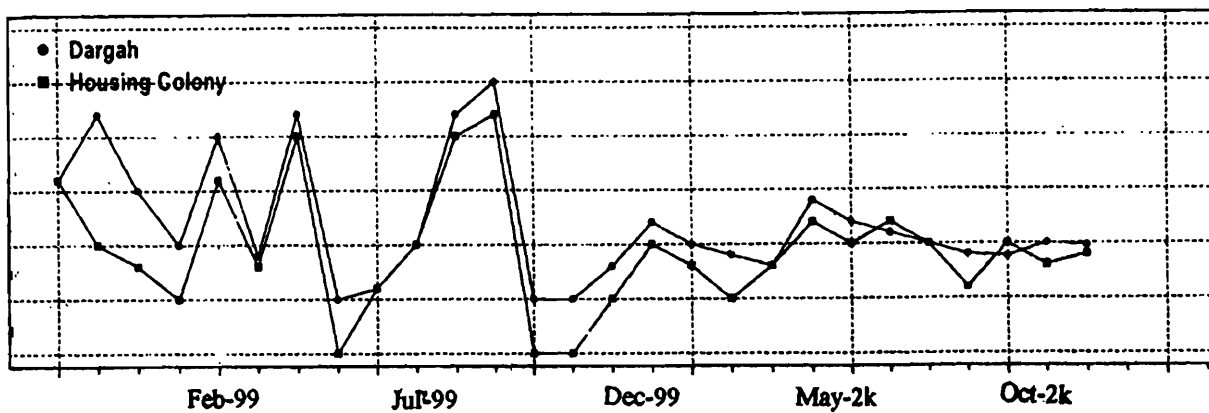
Year	Species	Individual	Swinder	Himax	Diver- gence (D1)	D1 %	Even- ness	Simpson Diversity Index	Equita- bility Index	Rich ness ($\alpha 1$)	Mantini $\alpha 2$
1998			(H1)								
Oct.	<i>Faunus ater</i>	124.00	3.1451	4.0000	0.8549	21.3728	78.6272	5.0347	0.3147	3.1119	1.4368
Nov.	<i>Gyraulus convexiscullus</i>	142.00	2.3711	3.7004	1.3293	35.9229	64.0771	2.6771	0.2059	2.4214	1.0909
Dec.	<i>Cremno. conicus</i>	139.00	2.6180	3.9069	1.2889	32.9892	67.0808	3.1421	0.2095	2.8372	1.2723
1999											
Jan.	<i>Cremno. conicus</i>	147.00	3.3031	3.9069	0.6038	15.4542	84.5458	6.1025	0.4068	2.8054	1.2372
Feb.	<i>Faunus ater</i>	140.00	3.1239	4.0000	0.8761	21.9031	78.0969	4.5645	0.2853	3.0354	1.3522
Mar.	<i>Faunus ater</i>	155.00	3.1977	4.0000	0.8023	20.0584	79.9416	5.1567	0.3223	2.9742	1.2852
Apr.	<i>Gabbia stenothyroide</i>	181.00	3.0667	4.0875	1.0208	24.9731	75.0269	4.4688	0.2629	3.0778	1.2636
May.	<i>Faunus ater</i>	168.00	3.6833	4.0000	0.3167	7.9164	92.0836	10.5708	0.6607	2.9274	1.2344
Jun.	<i>Cremno. conicus</i>	110.00	3.5928	3.9069	0.3141	8.0400	91.9600	10.0666	0.6711	2.9784	1.4302
Jul.	<i>Indoplanorbis exutus</i>	69.00	3.6615	3.8074	0.1458	30.8299	96.1701	11.6978	0.8356	3.0703	1.6854
Aug.	<i>Gabbia stenothyroide</i>	96.00	3.9221	4.0875	0.1653	4.0449	95.9551	13.6331	0.8019	3.5054	1.7351
Sep.	<i>Indoplanorbis exutus</i>	146.00	2.7984	3.8074	1.0090	26.5001	73.4999	3.6764	0.2626	2.6086	1.1586
Oct.	<i>Cremno. conicus</i>	178.00	2.5378	3.9069	1.3691	35.0438	64.9562	2.9063	0.1938	2.7018	1.1243
Nov.	<i>Faunus ater</i>	192.00	2.7950	4.0000	1.2050	30.1254	69.8746	3.4510	0.2157	2.8531	1.1547
Dec.	<i>Cremno. conicus</i>	169.00	2.8601	3.9069	1.0468	26.7931	73.2069	3.8570	0.2571	2.7291	1.1538

TABLE - 52 : DIVERSITY INDICES OF BENTHIC ORGANISMS FOR THE YEAR 1998 ~ 2000 : SITE II

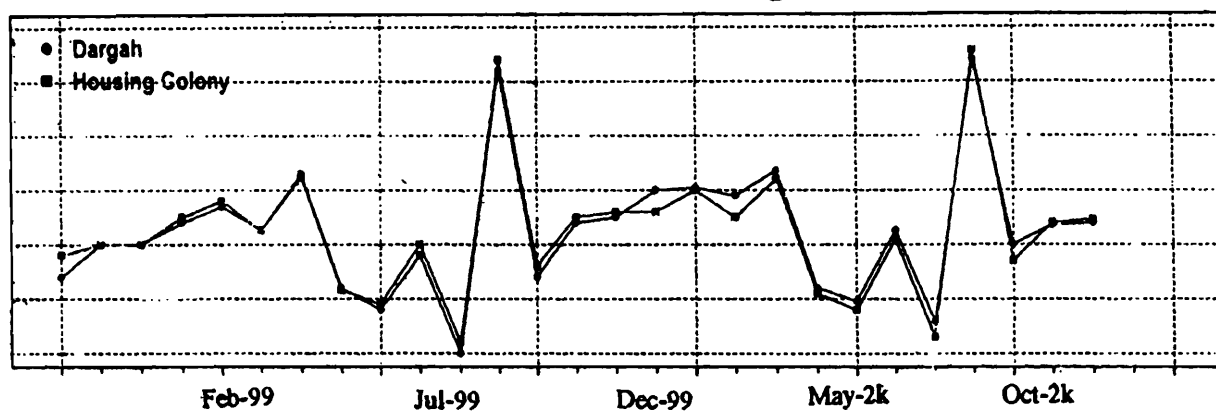
Year	Species	Individual	Swinder	Himax	Diver- gence (D1)	D1 %	Even- ness	Simpson Diversity Index	Equita- bility Index	Rich ness ($\alpha 1$)	Mantini $\alpha 2$
2000			(H1)								
Jan.	<i>Faunus ater</i>	131.00	2.7623	4.0000	1.2377	30.9416	69.0584	3.4453	0.2153	3.0768	1.3979
Feb.	<i>Cremno. conicus</i>	156.00	2.7219	3.9069	1.1850	30.3304	69.6696	3.3791	0.2253	2.7724	1.2010
Mar.	<i>Cremno. conicus</i>	137.00	2.7808	3.9069	1.1261	28.8243	71.1757	3.5433	0.2362	2.8455	1.2815
Apr.	<i>Faunus ater</i>	227.00	3.0796	4.0000	0.9204	23.0106	76.9894	4.4349	0.2772	2.7650	1.0620
May.	<i>Gabbia stenothyroide</i>	166.00	3.5657	3.9069	0.3412	8.7330	91.2670	9.8064	0.6538	2.7387	1.1642
Jun.	<i>Faunus ater</i>	129.00	3.8130	4.0000	0.1870	4.6761	95.3240	12.6740	0.7921	3.0865	1.4087
Jul.	<i>Faunus ater</i>	96.00	3.8561	4.0000	0.1439	3.5969	96.4031	13.5929	0.8496	3.2863	1.6330
Aug.	<i>Gabbia stenothyroide</i>	141.00	3.8954	4.0875	0.1921	4.6994	95.3006	12.9886	0.7639	3.2331	1.4317
Sep.	<i>Faunus ater</i>	166.00	3.0345	4.0000	0.9655	24.1379	75.8621	4.1450	0.2591	2.9343	1.2418
Oct.	<i>Gabbia stenothyroide</i>	218.00	2.8511	4.0875	1.2363	30.2467	69.7533	3.4063	0.2004	2.6715	1.1514
Nov.	<i>Gabbia stenothyroide</i>	235.00	2.6112	4.0875	1.4763	36.1170	63.8830	2.8395	0.1670	2.9306	1.1090
Dec.	<i>Gabbia stenothyroide</i>	159.00	3.2238	4.0875	0.8636	21.1285	78.8715	4.8571	0.2857	3.1565	1.3482



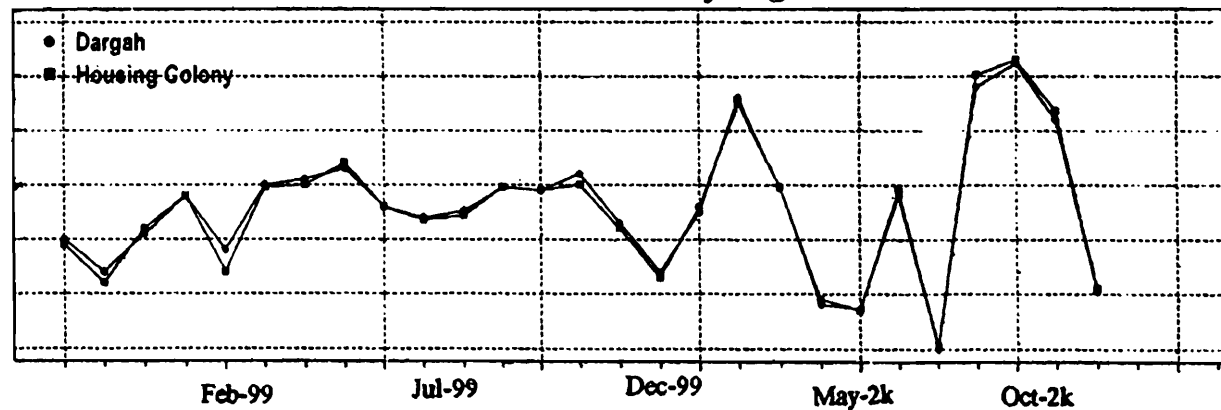
5a - D.O. mg/lit



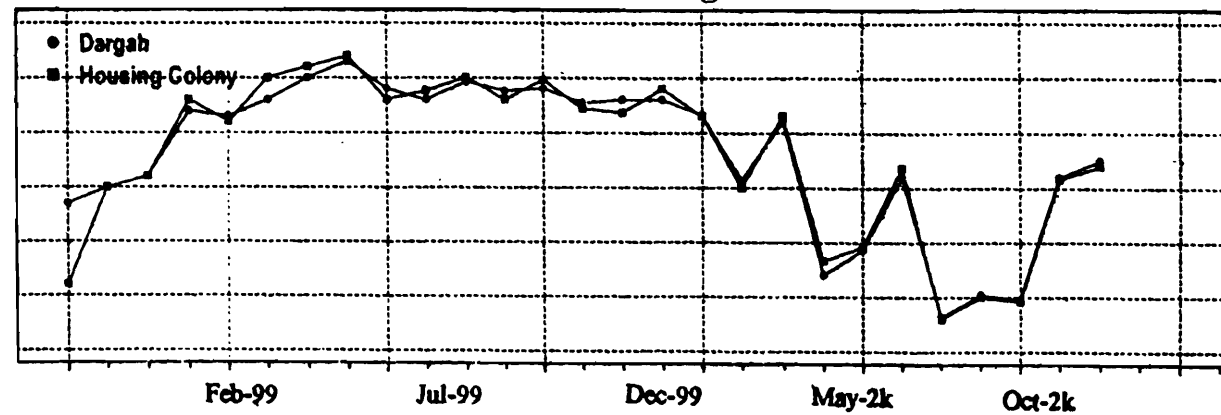
5b - Total Hardness mg/lit

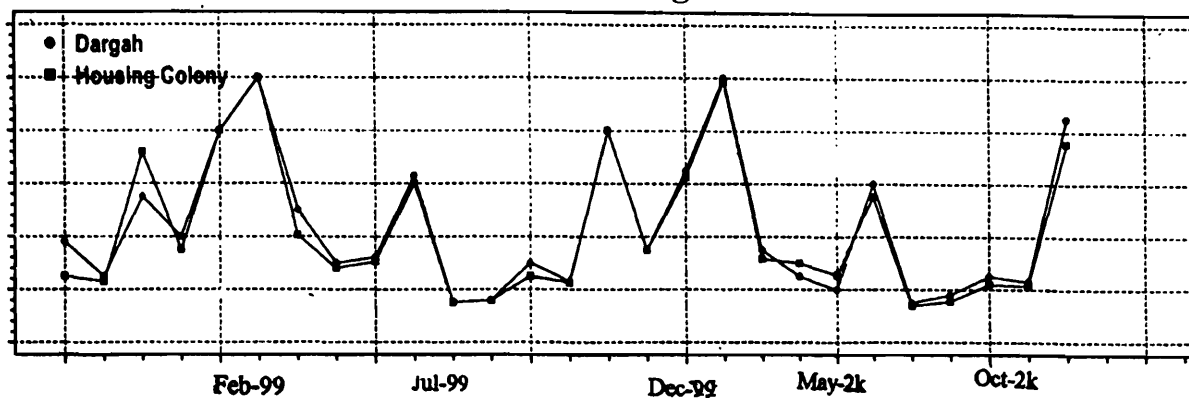
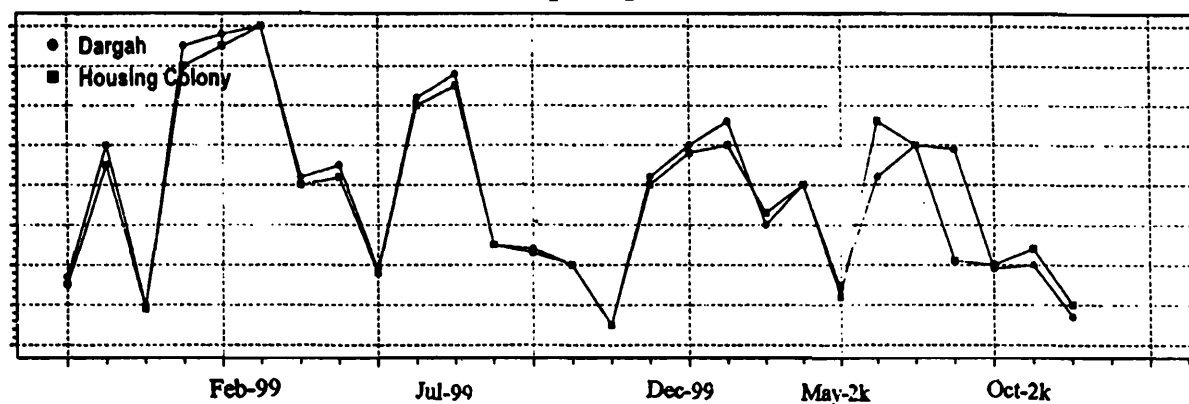
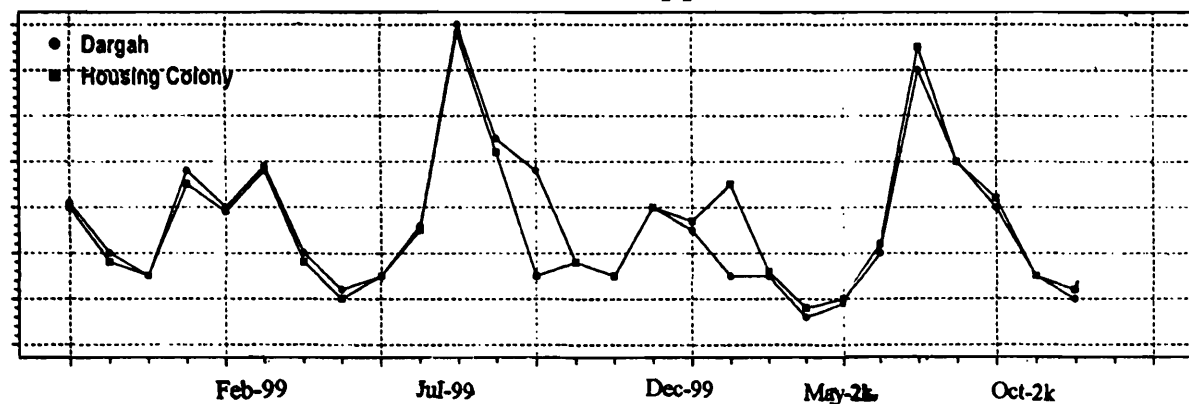
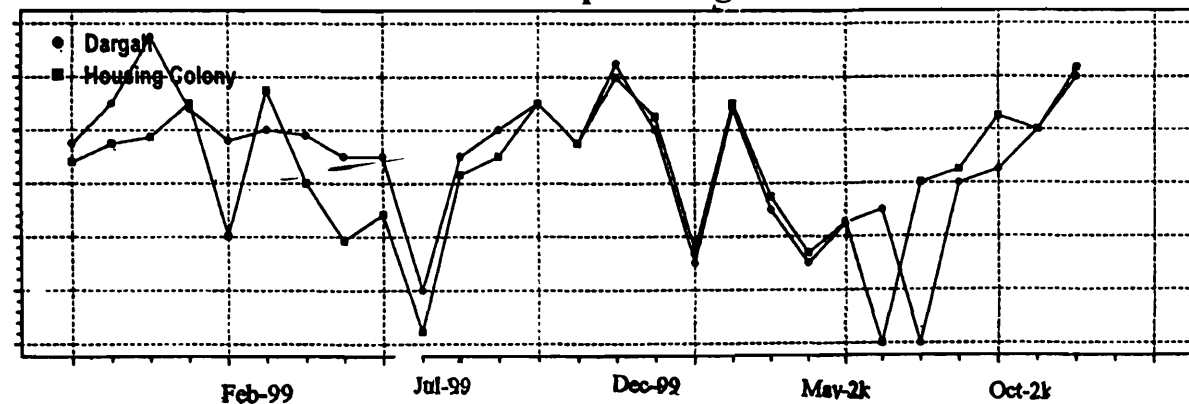


5c - Total Alkalinity mg/lit

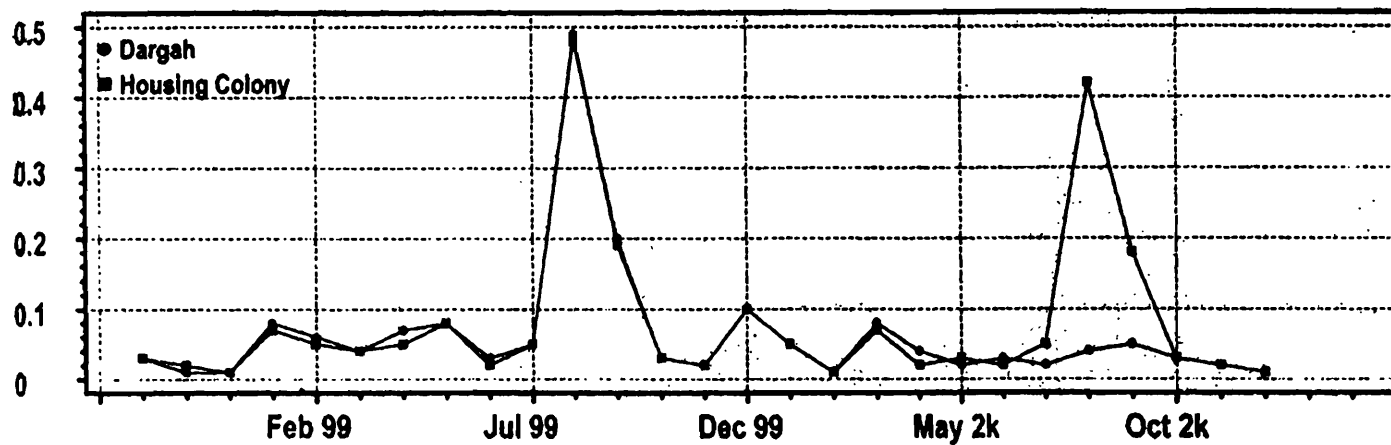


5d - Chloride mg/lit

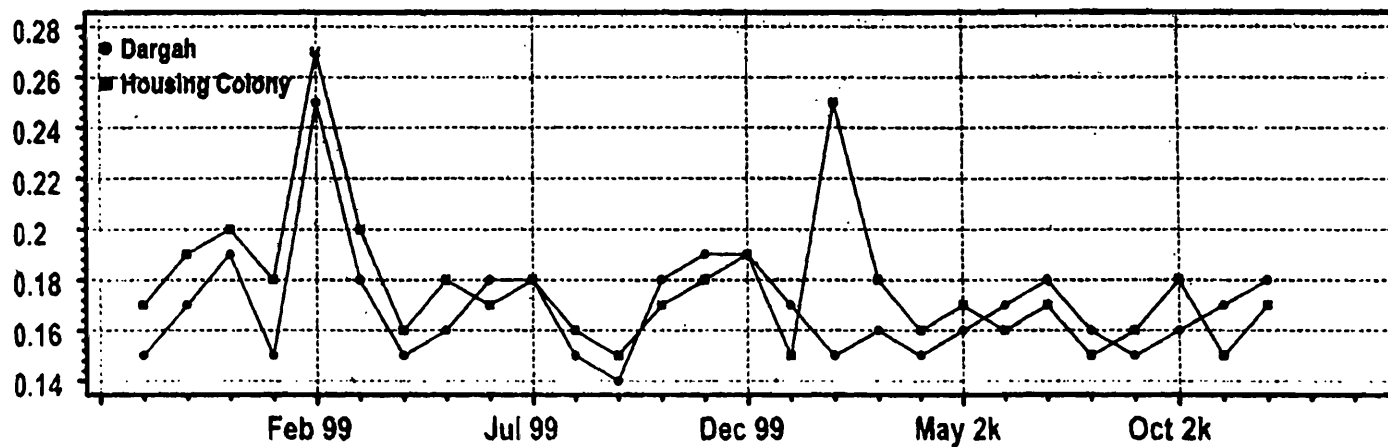


6a - Calcium mg/lit**6b - Orthophosphate ppm****6c - Nitrates ppm****6 d - Sulphate mg/lit**

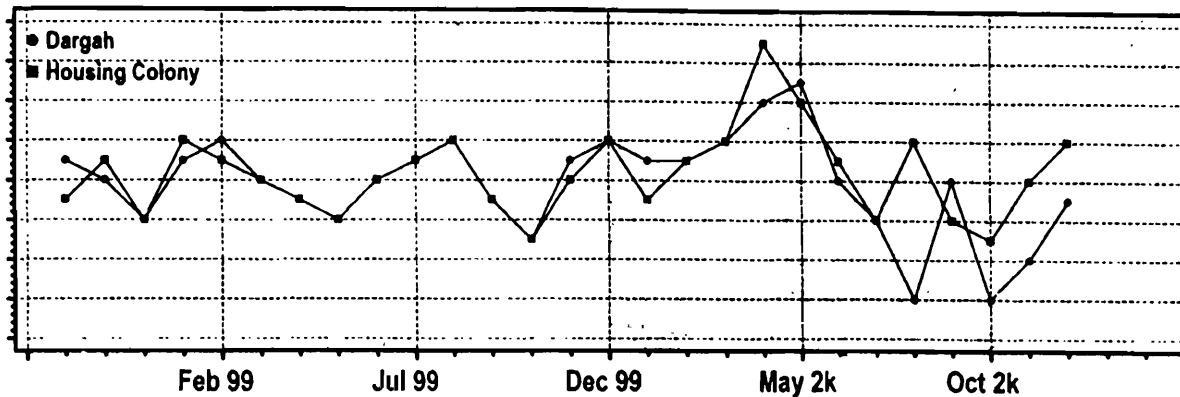
7a - Lead ppm



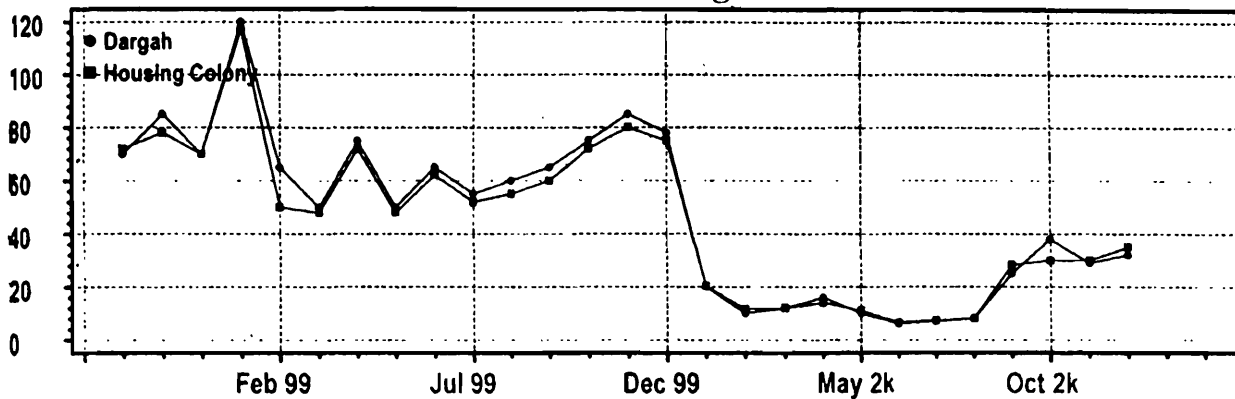
7b - Iron ppm



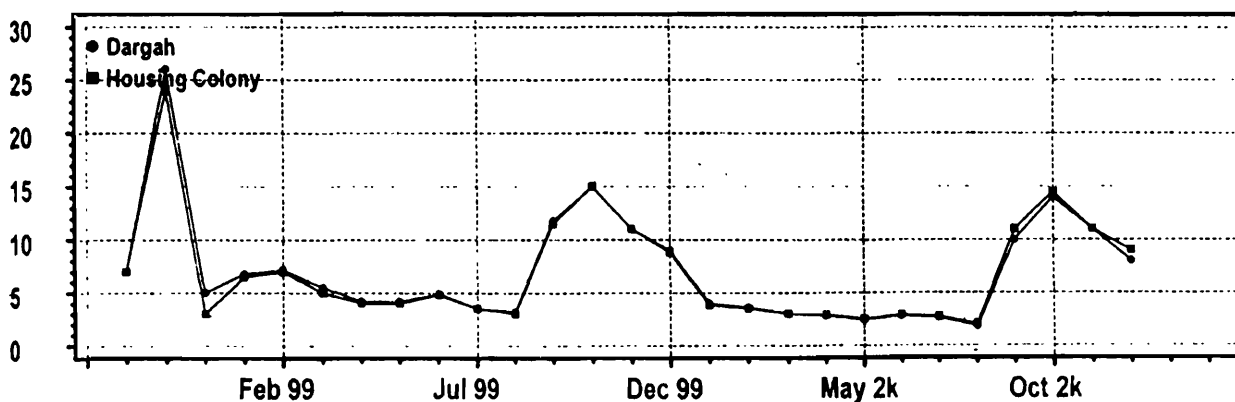
8a - Sacch. Disc cm



8b - CoD mg/lit



8c - BoD mg/lit



8d - Magnesium mg/lit

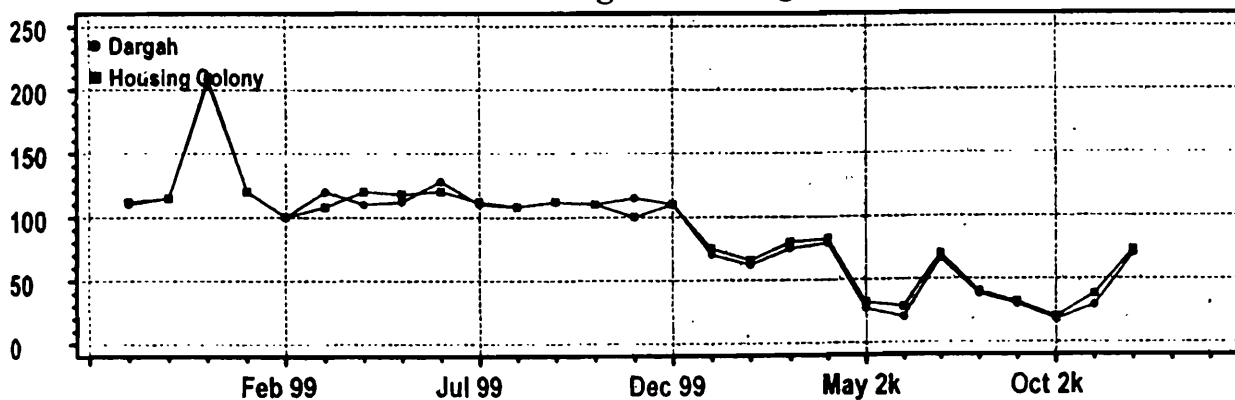
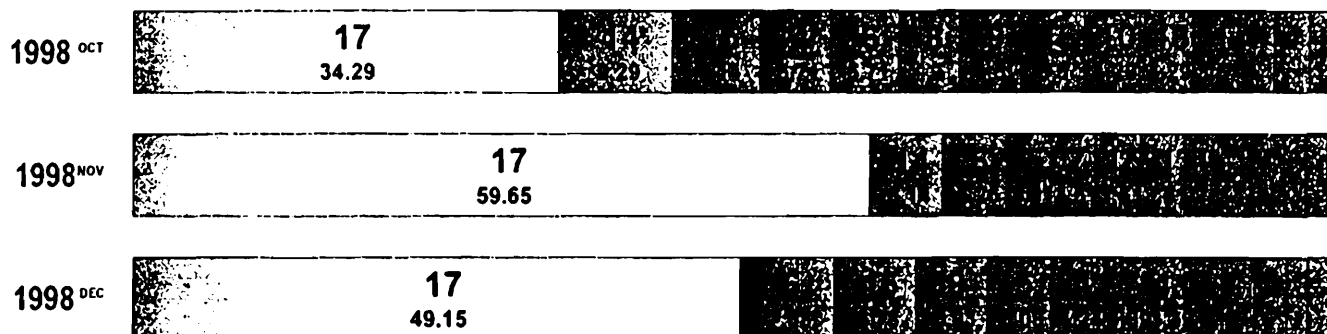
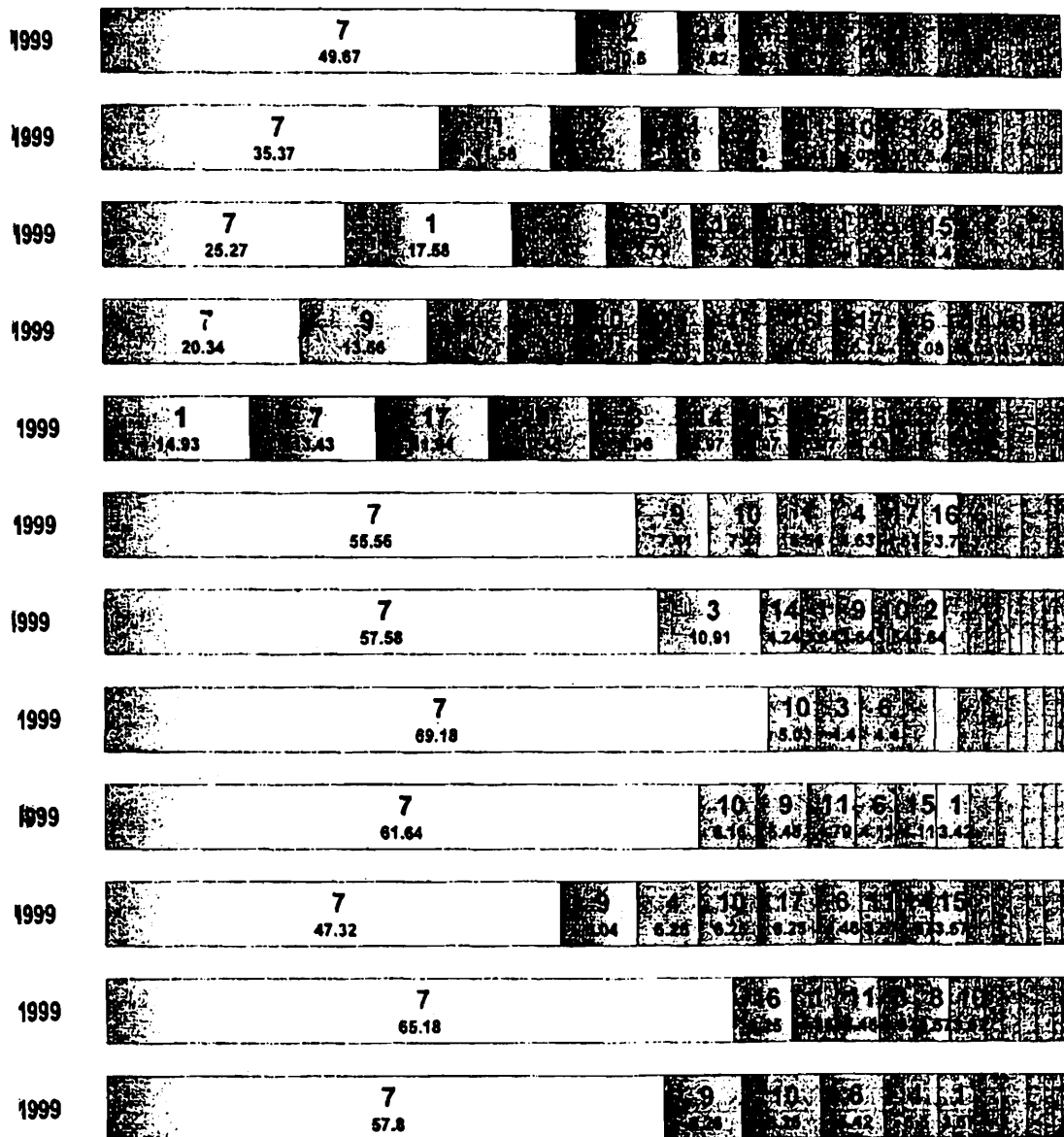


Fig. 9 : Month wise Percentage Composition of Benthic Macro Invertibrates from Mir - Alam Lake Site - I, 1998

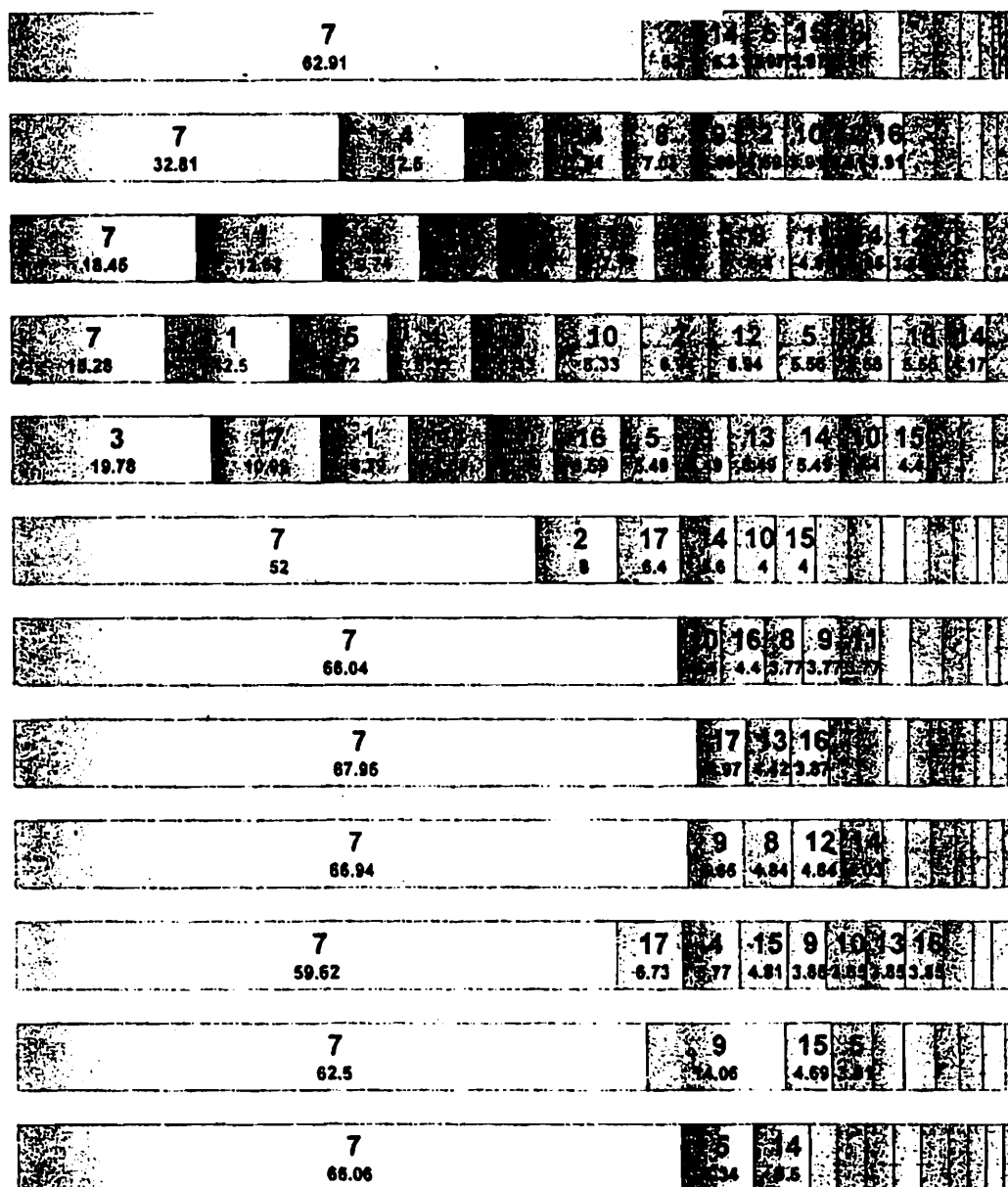


1. *Limnodrilus hoffmeisteri*
2. *Pristina aquiseta*
3. *Lumbricidae*
4. *Chironomus circumdatus*
5. *Chironomus plumosus*
6. *Notonecta glauca*
7. *Mosquito larvae*
8. *Lymnaea accuminata*
9. *Bellamya dissimilis*
10. *Bellamya bengalensis*
11. *Thiara tuberculata*
12. *Gyraulus convexus*
13. *Cremnoconchus conicus*
14. *Indoplanorbis exustus*
15. *Cremnoconchus conicus*
16. *Faunus ater*
17. *Gabbia stenothyroide*

Fig. 9A : Month wise Percentage Composition of Benthic Macro Invertibrates from Mir - Alam Lake Site - I, 1999

- | | |
|------------------------------------|----------------------------------|
| 1. <i>Limnodrilus hoffmeisteri</i> | 10. <i>Bellamya bengalensis</i> |
| 2. <i>Pristina aquiseta</i> | 11. <i>Thiara tuberculata</i> |
| 3. <i>Lumbricidae</i> | 12. <i>Gyraulus</i> |
| 4. <i>Chironomus circumdatus</i> | <i>convesuiusculus</i> |
| 5. <i>Chironomus plumosus</i> | 13. <i>Cremnoconchus conicus</i> |
| 6. <i>Notonecta glauca</i> | 14. <i>Indoplanorbis exustus</i> |
| 7. <i>Mosquito larvae</i> | 15. <i>Cremnoconchus conicus</i> |
| 8. <i>Lymnaea accuminata</i> | 16. <i>Faunus ater</i> |
| 9. <i>Bellamya dissimilis</i> | 17. <i>Gabbia stenothyroide</i> |

Fig. 10 : Month wise Percentage Composition of Benthic Macro Invertebrates from Mir - Alam Lake Site - I, 2000



- | | |
|------------------------------------|----------------------------------|
| 1. <i>Limnodrilus hoffmeisteri</i> | 10. <i>Bellamya bengalensis</i> |
| 2. <i>Pristina acquisetia</i> | 11. <i>Thiara tuberculata</i> |
| 3. <i>Lumbricidae</i> | 12. <i>Gyraulus</i> |
| 4. <i>Chironomus circumdatus</i> | <i>convesuiusculus</i> |
| 5. <i>Chironomus plumosus</i> | 13. <i>Cremnoconchus conicus</i> |
| 6. <i>Notonecta glauca</i> | 14. <i>Indoplanorbis exustus</i> |
| 7. <i>Mosquito larvae</i> | 15. <i>Cremnoconchus conicus</i> |
| 8. <i>Lymnaea accuminata</i> | 16. <i>Faunus ater</i> |
| 9. <i>Bellamya dissimilis</i> | 17. <i>Gabbia stenothyroide</i> |

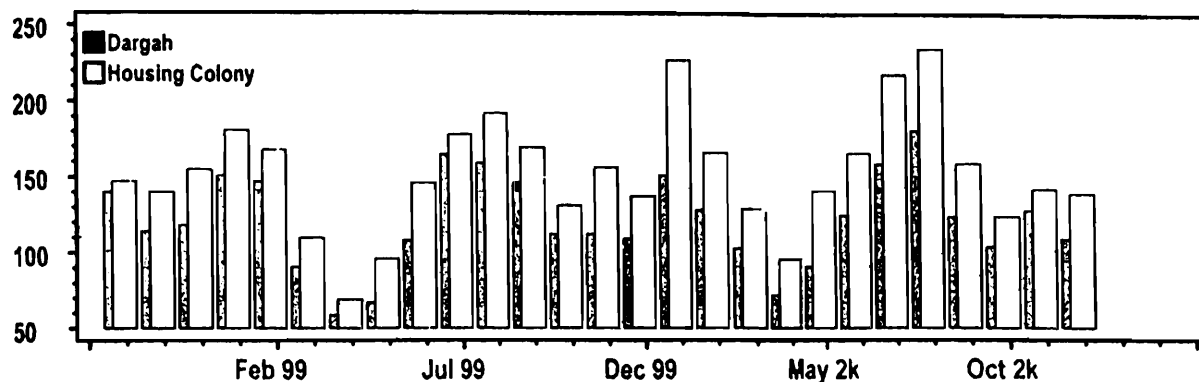
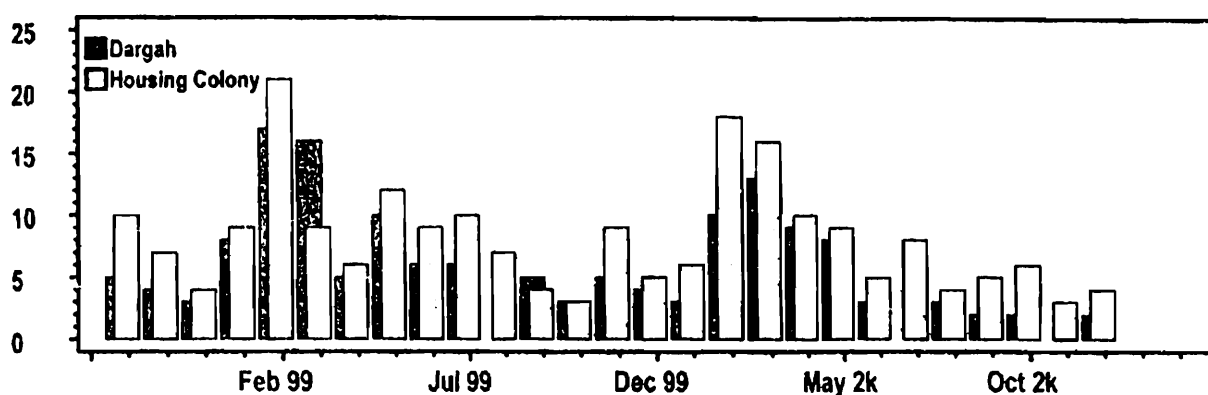
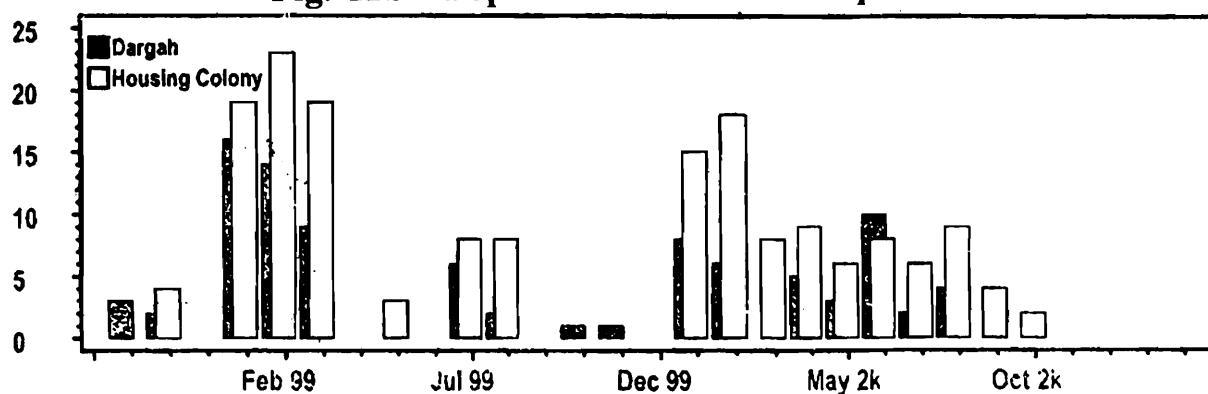
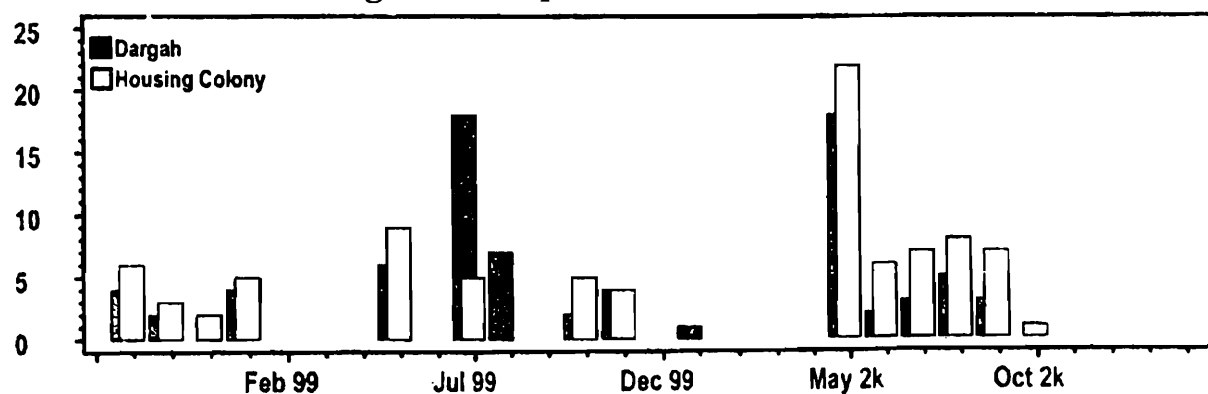
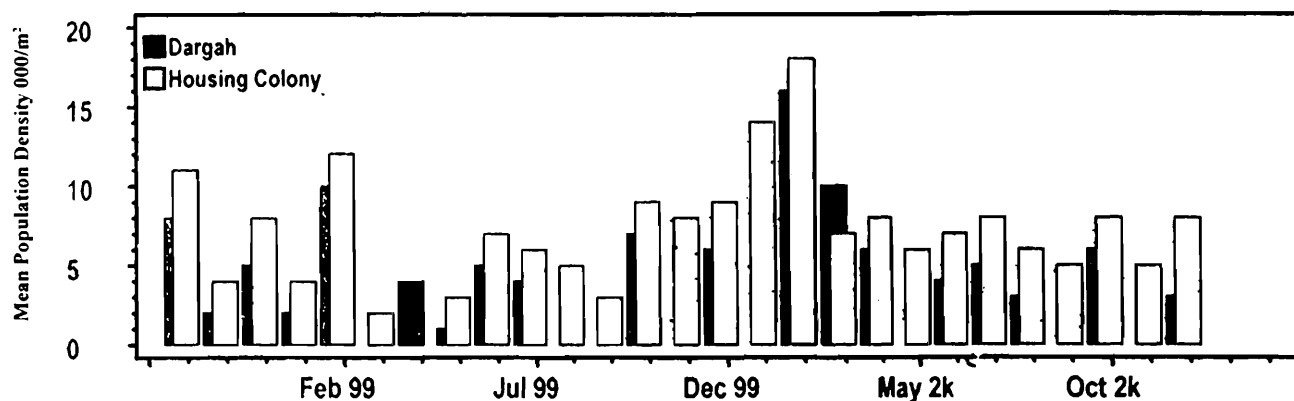
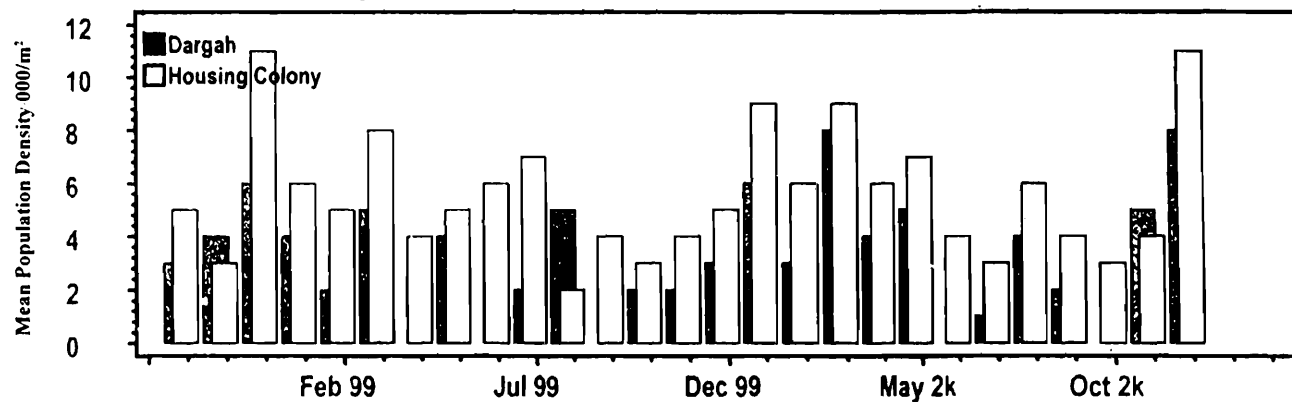
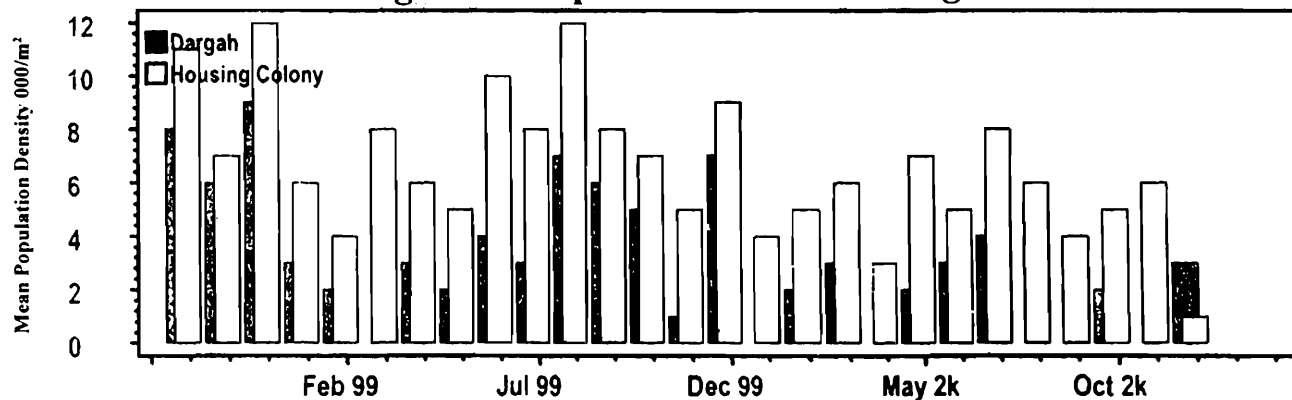
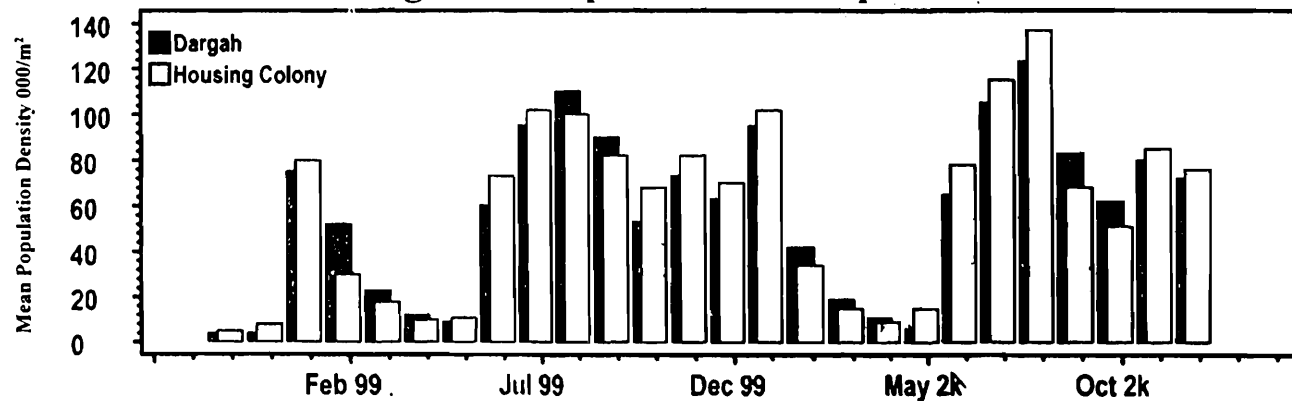
Fig. 11 - Population of Total Benthic Organisms**Fig. 12a - Population of *Limnodrilus hottmeisteri*****Fig. 12b - Population of *Pristina acquiseti*****Fig. 12c - Population of Limbricidae**

Fig. 13a - Population of *Chironomus circumdatus***Fig. 13b - Population of *Chironomus plumosus*****Fig. 13c - Population of *Notonecta glauca*****Fig. 13d - Population of Mosquito larvae**

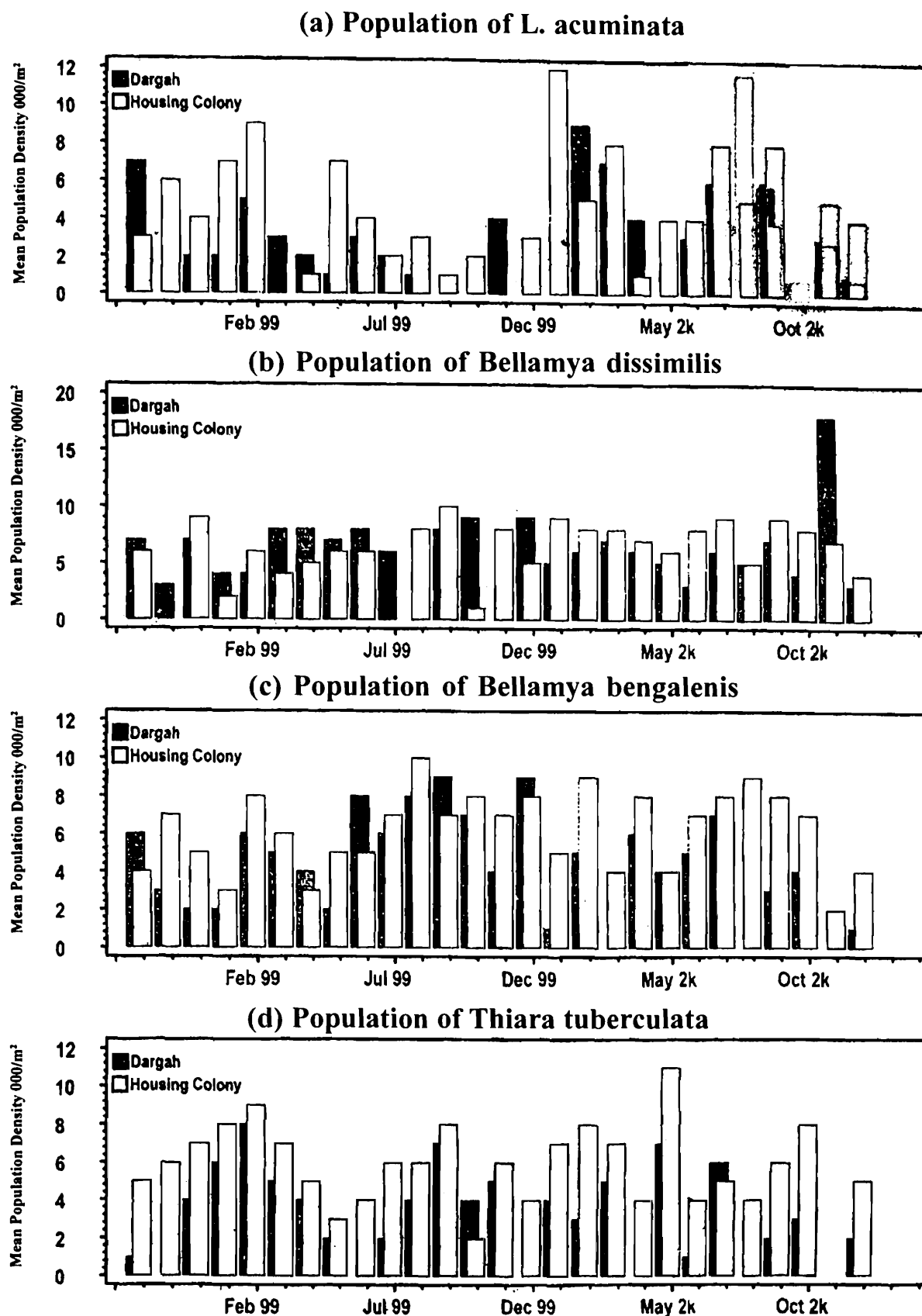


Fig. 14 : Monthly abundance of (a) *Lymnaea accuminata* (Lamarck); (b) *Bellamya dissimilis* (Muller); (c) *Bellamya bengalensis* and (d) *Thiara tuberculata* (Miller) at Site-I and Site-II of the Littoral zone of Mir-Alam Lake

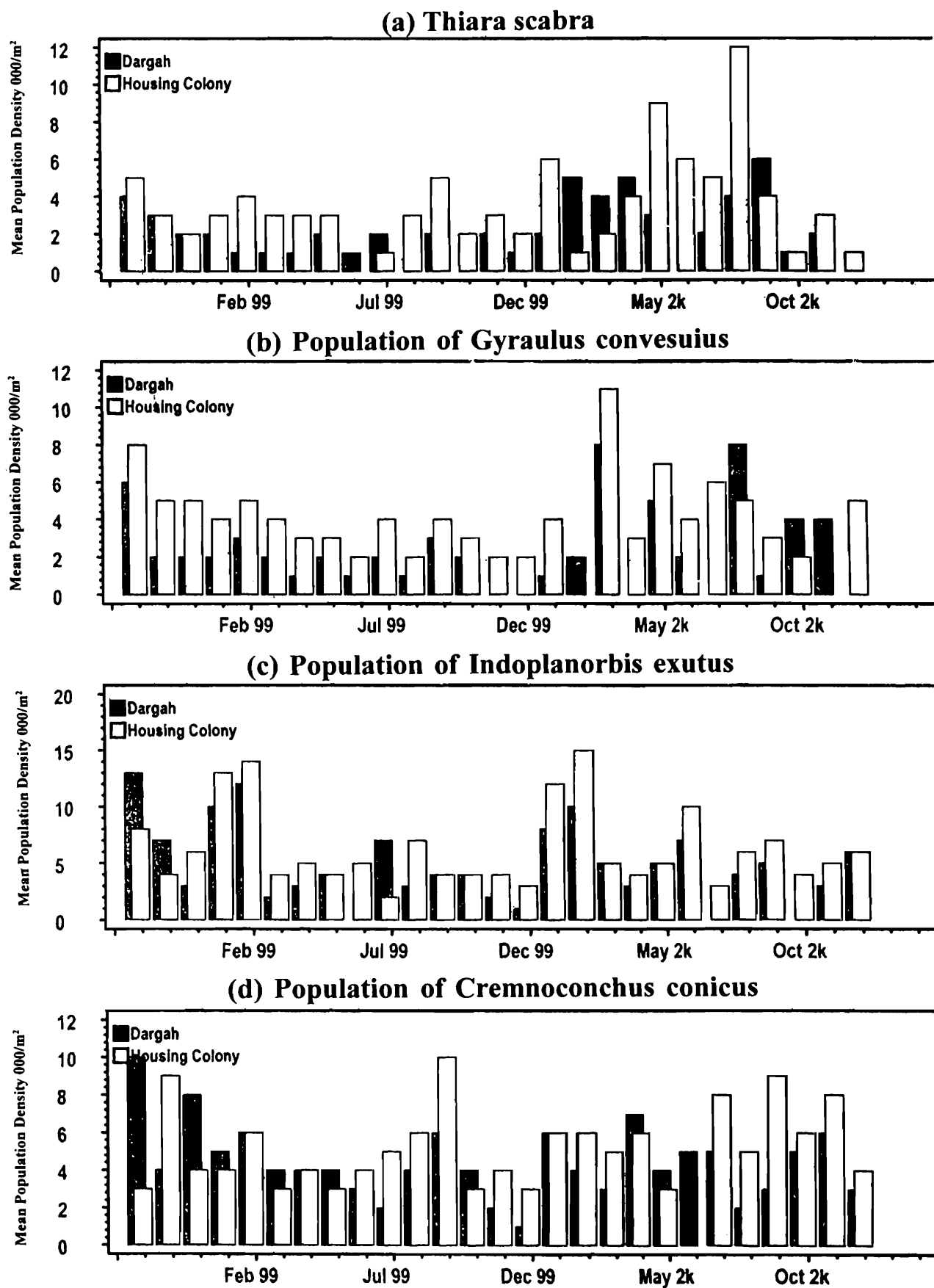
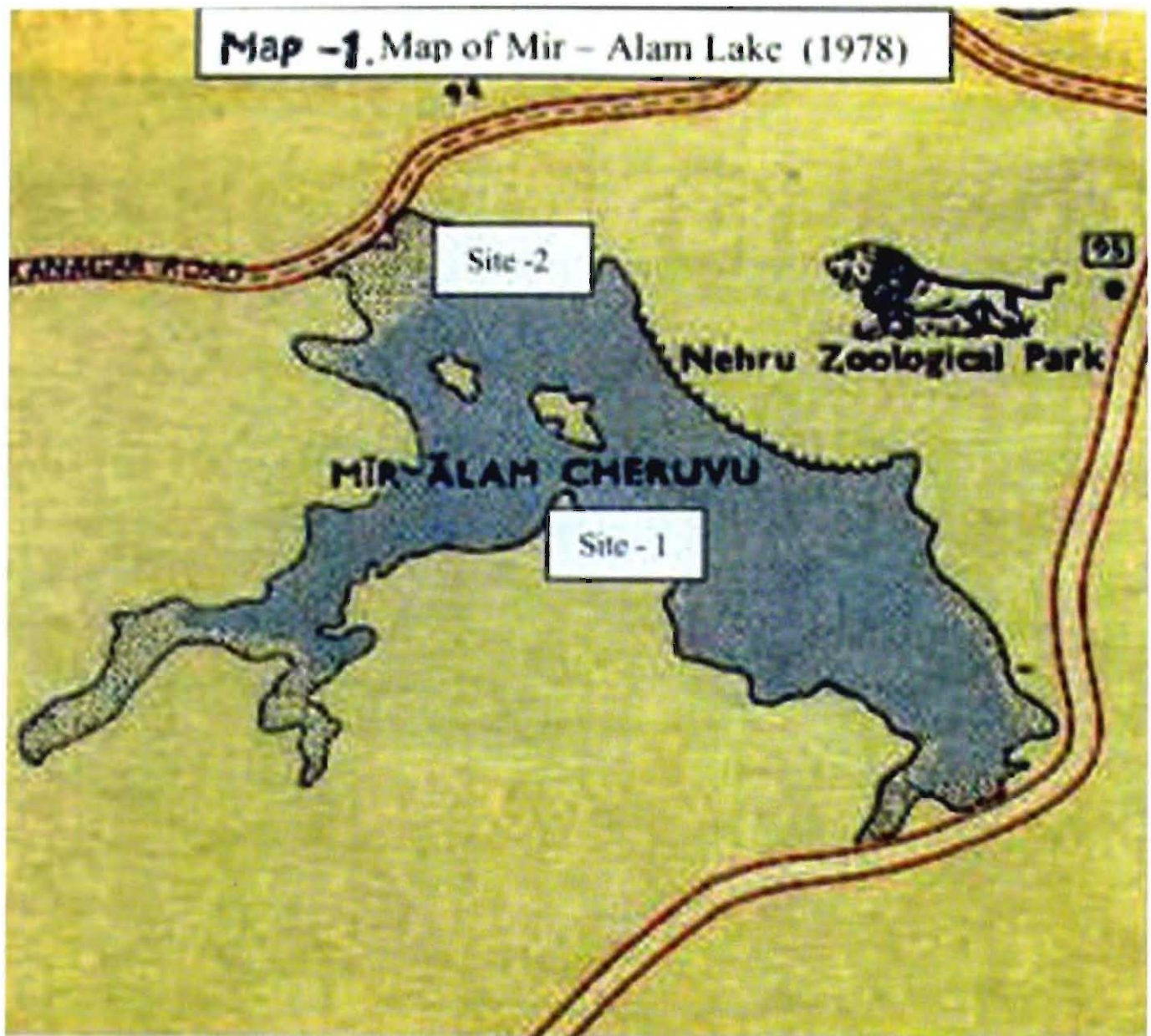
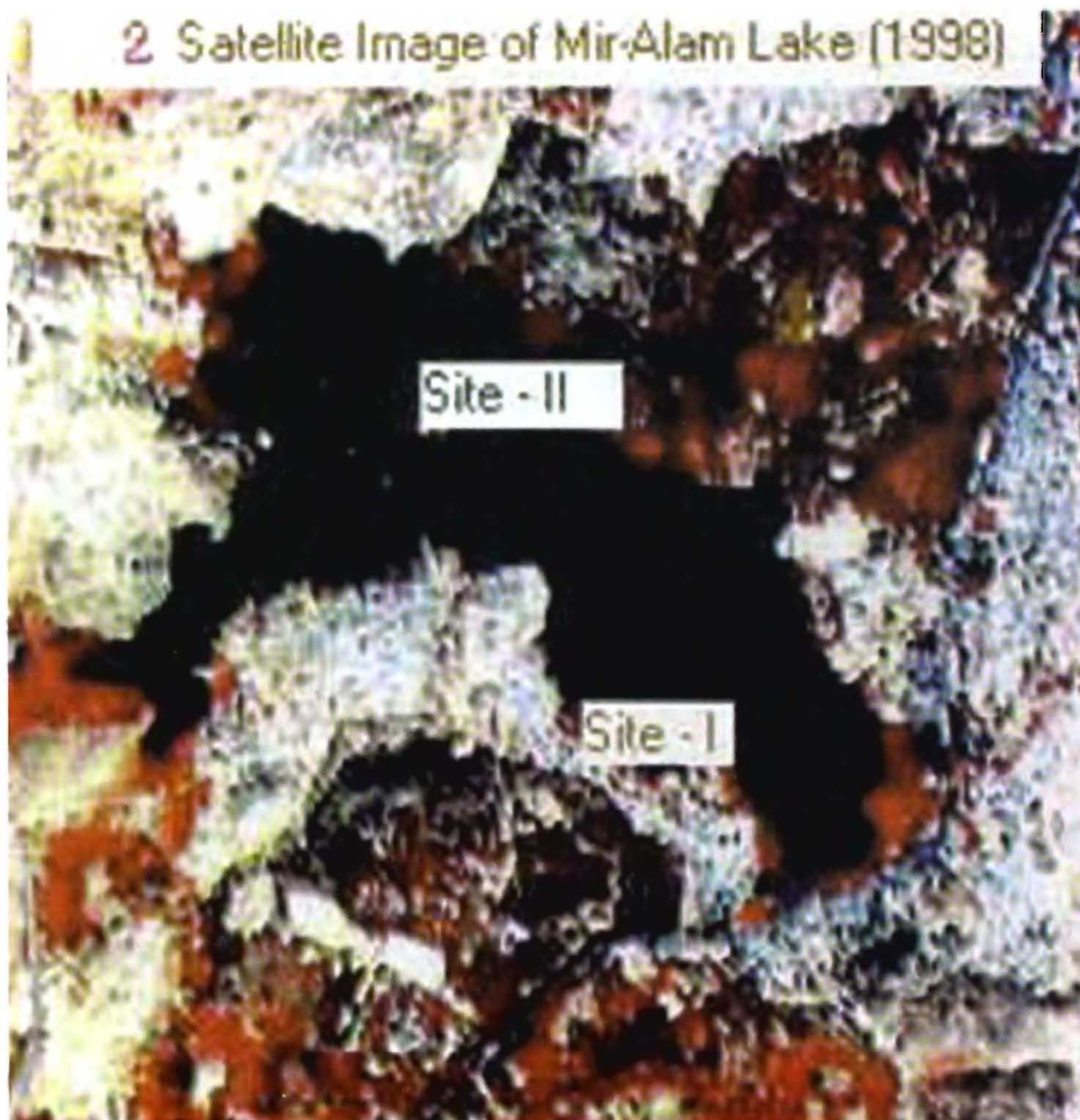


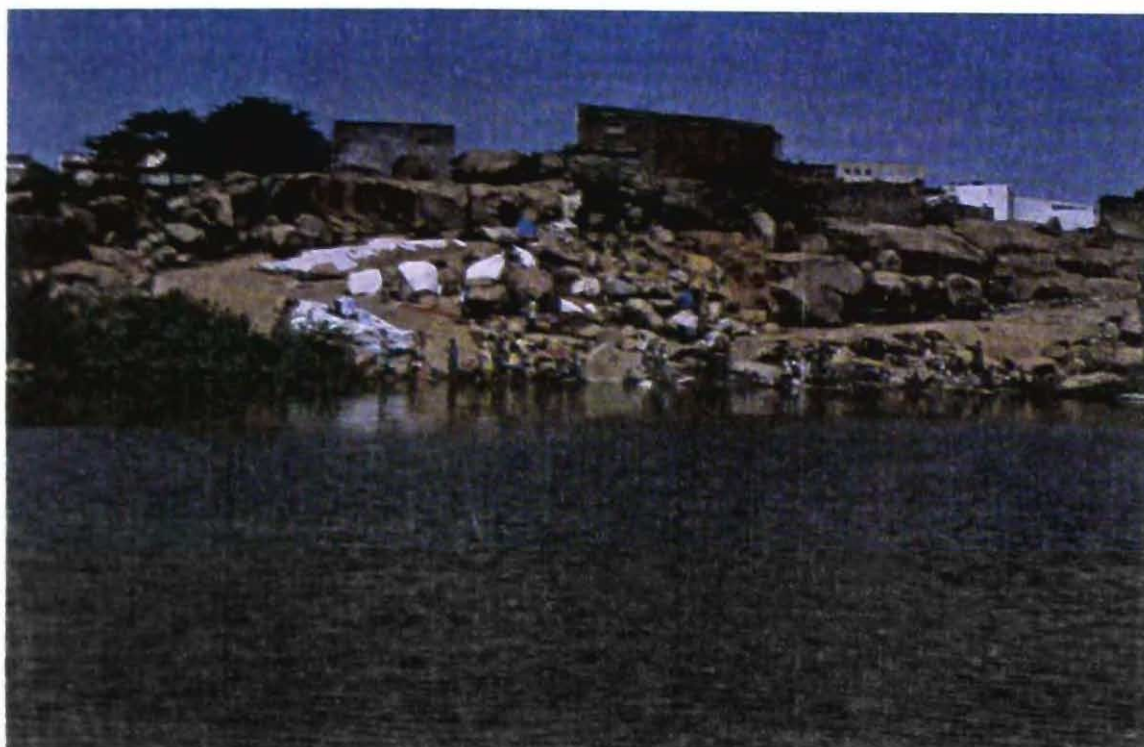
Fig. 15 : Monthly abundance of (a) *Thiara scabra*; (b) *Gyraulus convexus*; (c) *Indoplanorbis exustus* and (d) *Cremnoconchus conicus* at Site-I and Site-II of the Littoral zone of Mir-Alam Lake



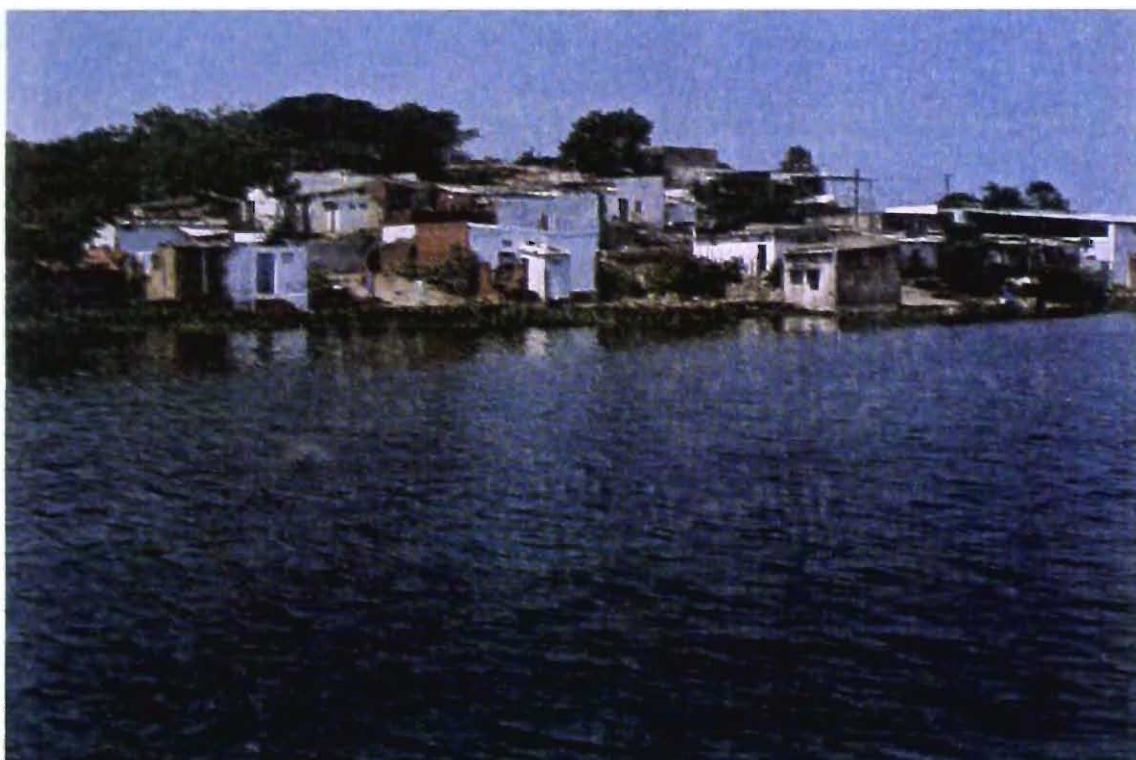
1. Map of Mir Alam Lake of site 1 & 2



2. Satellite Image (1998) of site I & II of Mir Alam Lake



3. Site I, A view of the lake where swimming taking place

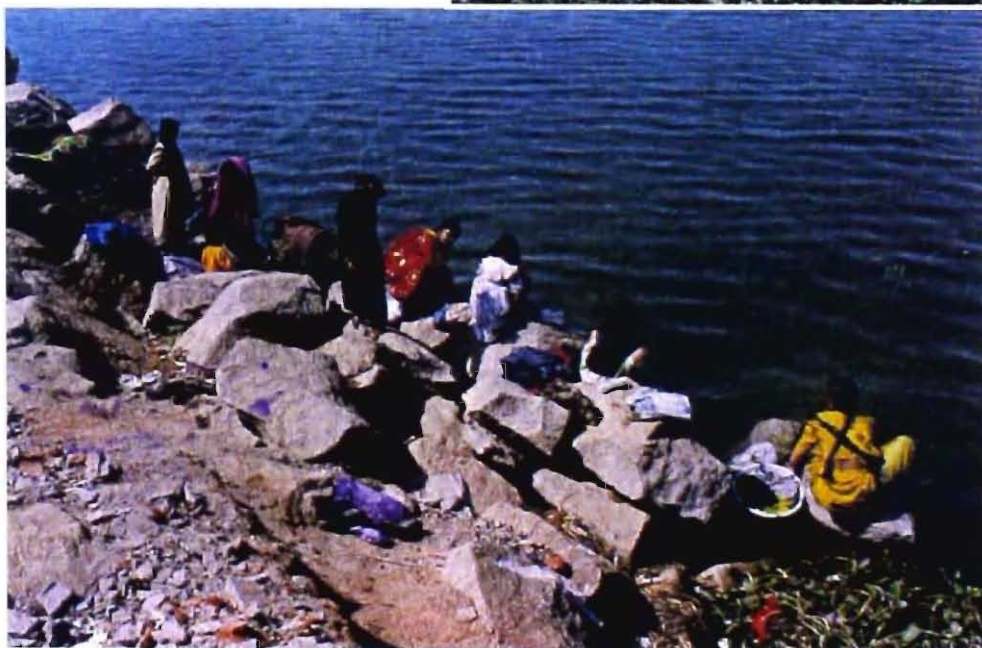
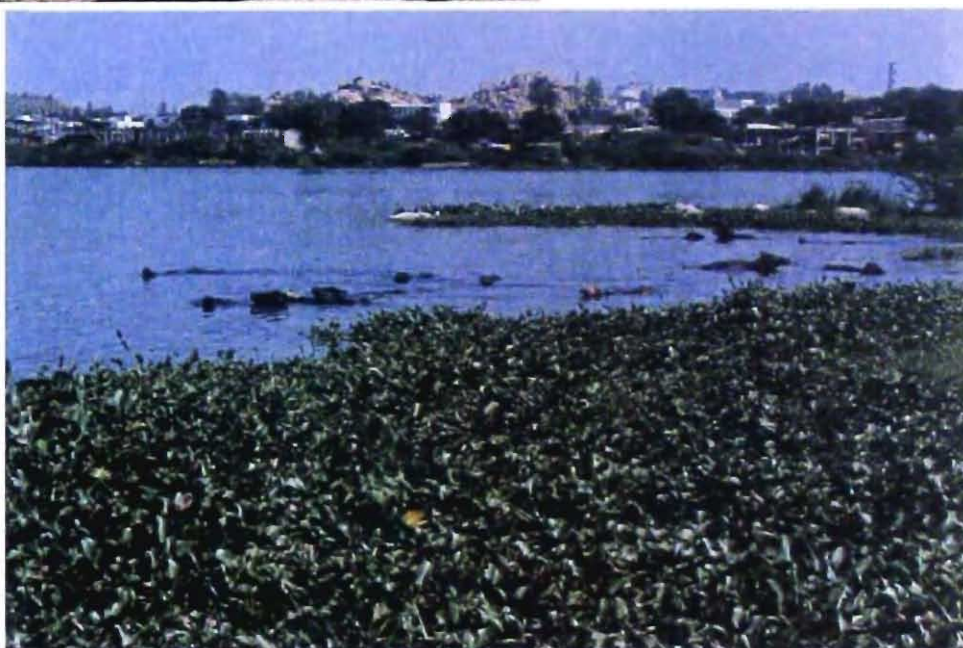


4. Site II, A view of the lake showing the entry of detergents into the lake.



5. Site I, A view of the lake showing washing buffaloes and *Echornia*.

6. Site I, littoral zone near the high way is covered with Water Hyacinth



7. The inlets of the sanitary pipes are introduced into the lake



8. *Pristina aequisetata*



9. *Bellamya bengalensis*



10. *Indoplanorbis exustus*