LIMNOLOGICAL STUDIES OF RIVER KHARKAI AT RIVER'S MEET (DOMOHANI) AND ADITYAPUR, JAMSHEDPUR (JHARKHAND)

Anjali Srivastava, M.Sc

Enrollment No. PHD54393/2011

Thesis submitted for the Degree of

DOCTOR OF PHILOSOPHY

2016

P. G. DEPARTMENT OF ZOOLOGY

KOLHAN UNIVERSITY

CHAIBASA – 833201

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CERTIFICATE

This is to certify that the subject matter of the Thesis entitled " Limnological studies of River Kharkai at River's meet (Domohani) and Adityapur, Jamshedpur (Jharkhand)" ,is record of work done by Mrs Anjali Srivastava, H.O.D. of Zoology , Jamshedpur Women's College, Jamshedpur, by the Candidate herself under my guidance and that the contents of her thesis did not form a basis of the award of any previous degree to her and to the best of my knowledge, to anybody else and that the Thesis has not been submitted by the Candidate for any research degree in any other University.

Further, the Candidate in habit and character is a fit and proper person for the award of the Ph.D degree.

Signature of the Supervisor / Guide.

Ravinder Singh
HEAD OF THE DEPARTMENT OF
ZOOLOGY
KOLHAN UNIVERSITY
CHAIBASA .

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PREFACE

The thesis is an attempt to investigate the limnological studies of river Kharkai at rivers meet (Domohani) and Adityapur, Jamshedpur (Jharkhand). The studies on limnology of river Kharkai has undertaken to test and substantiate the prediction of abiotic and biotic factors, quantitative and qualitative analysis of phytoplankton and zooplankton at seasonal levels, benthic fauna such as insects, fishes, molluscs and macrophytes of the river water body and their systematic account.

The thesis has been completed in five chapters. Chapter 1 deals with the physiography of the study area while Chapter 2 describes materials and methods used in this investigation. Chapter 3 is divided into six parts : The first part deals with the seasonal trends in certain physic-chemical parameters, the second part accounts for the quantitative and qualitative analysis of Phytoplankton and Zooplankton. The third part accounts for the qualitative analysis of benthic macro invertebrates on the background of taxonomic foundation. The fourth part deals with the accounts of vulnerable, endangered, rare and endemic ichthyofauna species while fifth part deals with Macrophytes and the sixth part deals with temporal change in planktonic fauna.

Chapter 4 is divided into two parts. The first part discusses the seasonal trends of certain physic-chemical parameters and their roles and correlation. The second part discusses seasonal variations, periodicity and population dynamics of Zooplankton and Phytoplankton groups and other benthic forms in relation to the physico-chemical factors.

The present dissertation deals mainly with the following aspects of the River Kharkai at three research sites:-

1. Physiography of the study area
2. Physico-chemical parameters of the water
3. Quantitative and qualitative analysis of phytoplankton and zooplankton and their systematic account

4. Benthic Macro-invertebrates and their systematic account
5. Macrophytes of the river water
6. Qualitative analysis of vulnerable, endangered, rare and endemic Ichthyofauna of the river at three sites
7. Temporal change in planktonic fauna and their variational trends
8. Discussions done on the basis of observations and results are explained under two major headings-

   First – Physico-chemical parameters and their seasonal trends.

   Second – Study in relation to seasonal variations, periodicity and population density of planktonic and other benthic forms.

The thesis embodies 19 tables as well as 11 figures. There are 24 plates. The references contain 226 entries of papers including 6 research articles published which have been cited in the text.

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Last but not the least, Goddess Durga who always stands with me and my family may ever bless us.

Date

Place (Anjali Srivastava)

INTRODUCTION

INTRODUCTION

Water (in liquid state) covers about 3/4th of earth's surface, either as ocean or as freshwater and contains life in one form or other. Aquatic ecosystems are historically the source of life on the earth. The omnipresent environmental factor which sets the tone for all aquatic systems is **"water"**, which makes the aquatic system in many ways. It is the medium within which all aspects of the eco-system co - exist, it is the source of all nutrients for aquatic life including the gaseous nutrients such as O_2 and CO_2. Freshwater has always been of vital importance and early habitations of men were within easy reach of lakes and rivers. Primary concern for water for human being was primarily for drinking, food and as a means of cleaning. But with due course, the importance of water was more and more recognized by man. Further it explores much the mysteries of aquatic phenomenon and it was established that water is the basis for all life activities, be it lake or river.

India is a vast sub continent of contrasts with its varied physical and meteorological features. The freshwater habitats are a kaleidoscopic as the land itself, the hill streams with torrential falls, precipitous rocks, the broad and long placid rivers with their extensive deltaic and estuarine system and tanks, lakes, brackish waters and pools form the major inland aquatic media according diverse animal groups. The animals vary in size from minute microscopic to some of the large ones measuring several centimetres in length. Extensive comparable probes were felt to crack the mysteries of any freshwater habitat be it lake or river.

The atmosphere and the lithosphere are linked directly by the hydrosphere. The relationship between the terrestrial and aquatic ecosystem is a functional one and the ecological consequences of this linkage are profound in shaping the inhabitability of the biosphere. Aquatic ecosystems are of various types such as oceanic, riverine, lacustrine, marshy and swampy. Deep clear and larger freshwater ecosystem have attracted the attention of ecologists from the very beginning of 20th century and a no. of

works have been done by various workers on individual freshwater ecosystems. Freshwater comprises the lentic (stagnant) and lotic (flowing) water. Lentic environments are developed due to multiple effects of physical and biotic forces whereas lotic environments are formed only due to physical forces.

Lentic environments have been extensively investigated mostly due to the stability of their flora and fauna facilitating long time observations. Lakes and ponds besides swamps and impoundments are categorised under lentic environments.

Lotic water includes rivers and streams which are major features of most types of landscapes. Their total area is only about one thousandth of that of the land surfaces as compared by lakes. Rivers annually carry out 37,000 cu. km of water to the sea, which is equivalent to about 15 cm. of rainfall spread over the entire land surface (Schmitz, 1961).

Lotic water includes rivers and streams which are major features of most types of landscape. Their total area is only about $1/1000^{th}$ of that of the land surfaces as compared by lakes. Rivers and streams carry about 37,000 cu. km. of water to the sea, which is equivalent to about 25 cm. of rainfall spread over the entire land surface (Schmitz, 1961). This is a considerable proportion of the water present at any one time in all freshwater lakes, for which the Figures 200,000 cu. km. and 123,000 cu. km. (30,000 cu. miles) are variously quoted by Schmitz (1961) and Leopold *et.al.* (1964). An enormous volume of water is therefore involved, Schmitz has calculated that taking the mean height of the land surface as 825 m above sea level, the amount of energy expanded by running water in a year is 10^{14} kwh or about 100 times that produced by man from all sources in 1950.

Only 2.8% of world's total water occurs on the land and of this most (2.24%) is locked up in polar ice-caps and glaciers. Lakes account for only 0.009% of the total and at any given time only 0.0001% of water is in river channels. This is the only one tenth of the amount in the atmosphere and very much less than occurs in the ground water (0.61%).(Leopald *et.al* 1964). Despite their size and grandeur and their importance in erosion, even the

great rivers of the world are thus relatively insignificant features of our planet. In human terms, however their significance is enormous (Shadiv, 1956).

The water that flows in streams and rivers come of course, from precipitation, but only a fraction of rain which falls actually reaches the water courses. Some is immediately evaporated back into the atmosphere from rocks, soil or vegetation. Some enters the soil, where it is taken up by plants transpired, some is lost into the deep ground water, and only remainder enters the soil or as shallow seepage. Rainfall varies with season and from year to year, because most of the losses outlined above are to some extent, independent of rainfall. The quality which enters the stream is extremely variable. It is, as it were the remnant of a variable from which a more or less constant amount is deducted and it is thus even more irregular than the precipitation itself. For example, Leopold (1962) calculated that the average annual rainfall of 30 inches (76cm.) which falls on the United States only 9 inches. (23cm.) gets into the rivers, so that in a year in which precipitation varies only 1 inch, about 3% from the average, stream flow is likely to alter by about 10%.

In fact, much of the water which does ultimately reach the streams goes first into the shallow underground reservoir of the water table and is released more or less slowly into the channels and this smoothing out of variations in flow is much influenced by vegetation (Rutter, 1958). Forests increase the area from which evaporation can occur and they transpire enormous amount of water, reduce the total volume which find its way into the channels. They also, however cut down immediately, run off and tend to maintain moist soil, so that they usually result in more steady stream flows. The ways in which water flows and the fact that it actually forms the pattern of rivers and streams and their beds, are fundamental to most of the properties of biotic habitats in running water.

Running water provides an environment quite different from that in lakes and pond. The flow in one direction produces many effects which determine the kind of plants and animals that can live in such a habitat. As there are many types of ponds and lakes, there is a great diversity in running

water environments such as rusting mountain torrent, shallow streams, and wide sluggish river. All leave their characteristic flora and fauna. Oxygen supply is abundant in these habitats and the temperature remains almost constant.

In rapid streams all small particles from the stream bed are removed by the flowing water and the substratum is composed mainly of stones, rocks, gilders and large boulders. In low land streams as well as tidal reaches, the rate of flow is greatly reduced and large quantity of muddy debris gets deposited. Running waters are marked by the conspicuous absence of many rooted plants. Absence of higher vegetations as well as movement of water prevents the accumulation of humus. Running waters are colder than the stagnant water during the summer months. One of the major characteristics features of running water is relative absence of plankton.

In geographer's words an ideal river is that "which rises in the mountains,'to the foot hills, where it is still swift enough to carry sand and small stones along and so retain a gravel bed, when it reaches the plains, it tends to deposit silt and indulge the meander". But many rivers, indeed most, do not confirm in detail to this scheme, even if they happen to rise in mountains and flow through foot hills on to plains (Mecan and Worthington, 1951).

The natural characteristics of river are altered primarily by the nature of soils and other local climatic factors. Most typical rivers according to Hynes (1979) present to distinct zones in their bed-riffles, (errosion zone) and pools (deposition zone). On physical basis however, Illies (1961 b) divide the rivers into two groups: a) A swift, strong, upland rivers (Rhithron) and b) A lower sluggish reaches (Potamon). Many organisms of rivers and streams are regulated in the existence and densities by the nature of riverbeds than by general physical state of river. Thus the geographer's definition of an ideal river in most cases does not hold good because of local variation. Considering the work of Butcher (1993) and Ricker (1934), it can be concluded that rivers are strict individualists, each of which varies in its own way so as to make nonsense of anything but a very broad general division. Such a division may

be finally made at level of geography, but at a level of detail study of animals and the plants, it is the local conditions, some of which ecologists call microhabitat, that over side all other considerations.

A stream is defined as a water body with its load of dissolved and suspended inorganic and organic materials flowing towards a lower level following the line of least resistance. The volume of water of a stream as a whole, flows in one direction.

The running water ecosystem can be divided into two major zones namely **Rapid zone** and **Pool zone.**

Rapid zone is the shallow water zone where velocity of current is maximum and is occupied by the organisms living in sediments or attached to stems and leaves of roots, plants or other surfaces or by strong swimmers. It can be defined as "the portion of the stream in which the flow is both rapid and turbulent." Everything that is not attached or weighted is swept away by the current including organism as well as sediment particles. The substrate tends to be rock or gravel and the fragments are rounded and smoothed by the water. The habitat itself is an extremely diverse one. The majority of primary consumers of such a micro habitat are detritus-eaters.

"Pool zone" represents the deep water where velocity of current is reduced and silt and other materials tend to settle at the bottom. It provides a soft bottom for burrowing forms.

A wide variety of animals and plants occur on or in the bottom of streams, rivers, ponds, lakes and reservoirs. The name **benthos** is given to such "bottom dwelling organism" or are "organisms attached to, resting on or living in the bottom". The benthos can also be defined as "that assemblage of animals living in or on the sediments and dependent upon the decomposition cycle for most if not all of its basic food supply". Benthic macro invertebrates are defined as invertebrates that are retained by a net or sieve with an aperture of 0.6 mm (Elliot *et.al.* 1980).

Benthos occur virtually in all aquatic ecosystems. The benthos living above the sediment water interface are termed benthic-"epifauna" and those living in the sediment itself are termed "Infauna". The term Bottom includes

the substratum at the shore line as well as that at the greatest depth of any water body. Living conditions vary not only at different depths but also with physical nature of substratum.

The "community" is defined as an assemblage of a number of organisms usually of different species, which occupy the same habitat. Thus the "community" is essentially a biotic community since the plants, animals and micro organisms all interact with each other and can not be separated. The concept of community was first visualized by Farbes (1844) as "Regions distinguished from each other by association of species" and later recognized by Mobilus (1877) as "the biotic nature of the community" and considered it as a community of living beings "where the sum total of species and individuals mutually limited and selected have continued in possession of a certain definitic territory".

The community may be defined as a "Functioned system of interacting niche differentiated species populations that tend to complement one another rather than directly competing, in their utilization of the community's space, time resources and possible kind of interactions".

A "population" may be defined ecologically as a group of organisms of the same species occupying a particular space. Such a population is the basic unit of the community. Each species population is independent in its occurrence and can form a part of any community subject to its interactions with other species populations.

The density of a population is the number of individuals per unit area or volume. It is the quantitive characteristics of the community. It will be worth while to note that the "density of a population varies with time and space".

The population density may be expressed as "crude density" that is, the density measured at a place at a particular time.

However, the population may occupy only certain favourable parts of the total area. The density expressed on the basis of measurements in such area alone is called "specific or ecological density". The density is measured by actual count of organism in a known area or volume. In case of animals the actual count is usually difficult and hence it is determined by the capture and

recapture method involving marked individuals whose proportion in the total catch gives the estimate of the population density. This density is affected by a no. of environmental factors.

The physical and biological link between areas and land is "**Freshwater**". It is discussed earlier that it includes rivers and lakes etc. The study of organism in relation to fresh water habitat (e.g. ponds, lakes and streams) constitute freshwater ecology where as various physico chemical aspects of freshwater such as chemical, geological, physical and biological come under the term "Limnology". In other words Limnology embraces the bio - chemical and ecological characteristics of the fresh water organisms, while freshwater ecology emphasizes the interrelationship between organism and the immediate environment.

As discussed earlier, rivers are large water bodies constrained in a channel (Rao, 1979) whereas a stream is water mass with its load of dissolved and suspended organic and inorganic matters flowing towards a lower level adapting the lines of least resistance. Laminous flow may occur in shallow streams or in channels which have smooth sides. In such channels, water may move slowly in paths that are straight and and parallel to the sides of the channel. Turbulent flow of water occurs in mountain streams having irregular and rough beds and results in the formation of eddies and circular currents.

No doubt, rivers and streams are major features of most types of landscape, but their total area comprises only about 0.1% of the total land surface as compared to 1.8% of that area which is occupied by lakes.

A river system normally consists of a pattern of channels such as rivulets, streams and tributaries joining one another and coalescing to form the main stream. Most drainage systems have a definite type of morphological pattern. However drainage pattern of few stream system may differ the common morphological pattern, because they have imposed upon them all sorts of factors in the geological history of the area, which may have a marked influence. The idea of drainage was first proposed by Robert A.Harton and later adopted by Leopold *et.al.* (1964) with lit.tle modifications. It is the study

of the relationship of stream length to stream order. It is observed that there are usually some fairly clear relationships among orders, numbers, lengths and drainage areas of streams. It is usually found that there are between three and four times as many streams of order n-1 as there are of order n and that each is, on average rather less than half as long and drains rather more than one-fifth ($1/5^{th}$) of the area (Leopold *et.al.* 1964). According to scheme of drainage analysis "stream order is the measures of the position of stream in the hierarchy of tributaries". First-order streams have no tributaries and are perennial streams or those persist for at least long enough to develop bio-data. When two first order streams meet they become a second-order stream. Two second-order streams meet to form third-order stream and so on. However, acquisition of extra tributaries of an order lower than that of the receiving streams does not increase the order of that stream. A third order stream may receive several first or second order tributaries without becoming a fourth-order stream. The concept of stream order may prove of value to biologists in classifying water courses, in identifying zones of running water and in examining distribution of organisms in stream order (Kuchne, 1962).

Besides stream orders, rivers are classified on a number of ways depending on various criteria, such as reservoir rivers, flood rivers, tropical forest rivers, Savanna rivers, desert rivers and tundra rivers. **Reservoir rivers** have extreme lakes, swamps or flood plains near the head waters resulting in the gradual release of flood waters and sustained flow with only slight variations in flow rate. **Flood rivers** have extreme annual fluctuations in water level from flood to complete desication during dry season. **Tropical forest rivers** have evened out flow because retention of water in the flooded forests.The pH, alkalinity and silt load are low in such rivers. **Savanna rivers** may either be of sand bank type which frequently cease to flow or even dry out seasonally depending on the form of the basin. The pH of water rarely extreme but usually ranges between slightly acidic to alkaline, conductivity is reasonably high. **Desert rivers** have considerable high alkalinity and conductivity due to evaporation. Such rivers receive no tributaries, tend to resemble flood type and end up as salt marsh or lake. **Tundra rivers** drain

arctic and sub arctic zones, flow regimes depend on water freezing. The water has poor ionic contents as the land on which they flow are denned of top soil during glaciations. Streams and rivers change along their course in relation to various physic - chemical parameters such as substratum, temperature turbidity, depth, speed and nature of flow and load of suspended particles along their long stretch over varying edaphic and eco-climatic condition. These are the important factors that influence the distribution of biota at various sections of a river and as such running waters display longitudinal zonation. These phenomenon have been used as means of classifying water course by many limnologists (Illies, 1955; Cummino, 1974; Merritt and Cummino, 1978; Vannote *et.al.* 1980).

On the basis of formal differences and characteristics of physico chemical parameter (Illies, 1955) divided river stretches into two major zones- Rhithron and Potamon. Later in the year 1963, Illies and Botosamenn proposed to distinguish two more zones above the Rhithron. We have, therefore a series of zones, e.g. Encrenon, Hypo crenon, Rhithron and Potamon. Encrenon and Hypocrenon are spring region and spring brooth region and are present above the Rhithron. Rhithron is the region extending from the source of the point where the mean monthly temperature rises upto 20°C, oxygen concentration rises upto 20°C. Oxygen concentration is always high, flow is fast and turbulent and bed is composed of rocks, stones or gravels with occasional sandy and silty patches. The fauna is cold, stenothermic, characteristics of running water and true plankton are either very few or absent. **Rhithron** zone ranges from strong streams to small rivers and can often be faunistically divided into epi, meta and hyporhithron. **Potamon** region is characterised as a stretch of river where the monthly mean temperature rises to over 20°C, Oxygen deficits may occur at times, flow is slow with a tendency to become laminar and the riverbed is mainly sandy or muddy. The zone is often rich in plankton and has eurythermic or warm stenothermic fauna. On faunistic grounds, Potamon is also divisible into epi, meta and hypopotamon. The hypopotamon is the sea. The potamon stretch consists of braided and meanandric forms.

Since temperature is an important factor of such classification the point of change from Rhithron to Potamon tends to lie at higher altitude to lower altitude. At very high latitudes the water is always cold, so Potamon region may not occur at all. Similarly in tropics the water is always warm at low altitudes so a true Rhithron is absent.

Since the nature of substrate changes in different zones of river, it is possible to distinguish fairly definite benthic fauna associated with particular substrate type. As we pass from Crenon through Rhithron to Potamon, generally the individual units of the mosaic of substrata increase in area. Rocks, gravels, stones and sand occur in small patches epi, and metarhithron but in hyporhithron the rifle and pool structure tends to produce large area of gravel and silt and this increase in size of uniform areas becomes remarkable in epipotamon (Illies, 1958).

Rivers are viewed in terms of entire water shed rather than just the actual body of water flowing in the channel. Both rivers and the landscape upon which they flow have been considered as one system (Leopold and Maddole, 1953). The river stretch cannot be considered in isolation simply because the environmental change in catchment area due to such factor as deforestation, industrialization, cultivation and fertilization etc. exert influences on the physico chemical properties of water, organic load, sedimentation rate and ultimately on distribution of invertebrate communities. This river continuous concept emphasizes the need to treat river as a "continuum" from source to month including the catchment area, tributaries, main stream and distributaries. The physical variables within a river system present a continuous gradient and physical conditions. The river continuous concept provide framework for integrating predictable biological features of the system. Scraper dominance follows shifts in primary production being maximized in mid sized rivers. With increasing river size and general reduction in detrital particle size, collectors will increase in importance and dominate the large sized invertebrates assemblage of large rivers. Predators would be well represented throughout the course of river.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

At a time when limnology was emerging in United States, the science was well developed in Europe. As early as in 1850, F.Simony studied thermal stratification in Austrian lakes. Anton Fritisch began studied lakes in the Bophemian forests around 1888.. These studies through mainly concerned with physical limnological studies on temperature and water movement, but they soon established the worldwide similarity of a variety of lake phenomena. At about the same time Russian limnologists emphasized aquatic bacteriology and studies Vinogradskay, S.I.Kutznetsov, G.G.Linberg and V.I.Romanenko helped originate and sustain the interest in this often neglected area of microbial limnology.

Limnology grew steadily through the early part of the twentieth century. The four American investigators, C.A.Kofoid, James, G.Needhan, E.A.Brije and C.Juday dominated the American Limnology at the twentieth century. The Birje and Juday published their first joint paper in 1908 and both continued to make significant contribution to limnology for about 30 years.

Many valuable works in form of journal and text books have come out since then. However at Yale University, G.Evelyn Hutchinson began a comprehensive "Treatise on Limnology"(1957, 1967, 1975) which has become a standard reference work on the subject throughout the world.

On January 1, 1936 the Limnological society of America was formed. Twelve year later, in 1948 it was recognized as the American society of limnology and oceanography. This provided integration among limnologists , oceanographers, and marine biologists on the one hand, and paved a common outlet for the publication of scientific papers on all aspects like physical, chemical, geological and biological of phenomena exhibited by natural bodies of water. The year 1948 also marked the formation of the Freshwater Biological Association in Britain. In Italy the Institute Italiano di hydrobiologia, furthered the science through intensive study of Northern Italian lakes. The institution also become a Mecca for visiting scientists

throughout the world who utilized the intellectual climate and the excellent library.

The field of limnology has largely been developed through the study of physical, chemical, biological and evolutionary structure of lakes. However the idea of food chains or spatial heterogeneity, has been best understood through studies of rivers and estuaries. In recent years, new generation of scientist who hope to cure the pollution of the World's water bodies, especially lakes, streams and estuaries by applying basic limnological principles. Limnology have now achieved a youthful step and the experienced limnologists can in most cases accurately predict ecological problems in most areas of the world without even visiting the sight. Limnologists have been playing an increasing role in the decision-making.

Limnological research in India has a late start. Early investigations were mostly descriptive and observational. Many other studies subsequently related to listing of species both animals and plants phytoplankton's macrophytes, microflora, zooplankton, benthos and periphyton in aquatic habitats. This type of work is still going on to fulfil this objective, it is necessary to gather data collect information and investigative processes and interaction between different plants, animals, microorganism and biotic communities with one another and with the physical environment. Although much information is available on the biology of freshwater plankton, zooplankton occurring in different waterbodies occurring in many parts of the world. Our knowledge of the species occurring in different water bodies of freshwater system in India, the present study will on the one hand add information to the previous pool of knowledge in the country and on the other, it will also provide a complete picture of the physico-chemical characteristics of the River Kharkai at .

Purely, physico-chemical investigations in lotic waters in India have been done by a number of workers. Their studies include, diurnal, seasonal, horizontal and vertical variations, ranging from water bodies in plain to high altitude water bodies. To name some such investigators, Zafar (1964), Singh (1965), Aboo and Manuel (1967), Bhuyan (1970), Unni (1971), Mandal and Hakim (1975), Vyas (1978), Purohit and Singh (1981), Khanna and Badola

(1987), Shrivastava and Renu (1988) are Pioneers and path finders in the phyto and Zooplankton studies.

Besides the above general works there have been specific studies on taxonomy and biochemical aspects on various aquatic organisms (Michael, 1980), but general works on benthos are very limited (Srivastava, 1956, Hussain 1965. Bose *et.al.* 1978, Gupta 1979, Roy *et.al.* 1980, Mahato 1990).

The dominated physico-chemical factors like transparency, dissolved O_2, free CO_2 , alkalinity , pH and nutrients have been described as the trophic status indicators by Moyle (1946), Mendis (1956), Hutchisnson (1967), Sreenivasan (1969-1974), Jayaongaudar *et.al.* (1984), Singh *et.al.* (1986) and Arya *et.al.* (1987).

Seasonal variations in physico-chemical characters of water and their relationship to phytoplankton dynamics have been primarily investigated by Vyas (1968), Tandon (1977), Grover *et.al.* (1981), Dakshini and Gupta (1984), Prasad *et.al.* (1985) and many others too. Similarily, George (1966), Kant and Kanchroo (1977) Hasmani and Bharti (1980 and 1983), conducted valuable comparative studies between different water bodies for physical and physico - chemical properties.

Wrigh (1958) Richaman (1974) and Zaret *et.al.* (1976) have also observed the Symbiotic association of phytoplankton and zooplankton. Edmouson (1965) found the reproductive rate of the planktonic rotifers Kerfoot (1974) studied cyclomorphosis in egg size of Copepods, Allan investigated life history patterns in zooplankton.

The idea of the co-existence of Zonal distribution of animal in rivers has developed from some early studies (Steinmann, 1907; Selfold, 1911; Thienemann, 1912). The zonation of fish fauna or at least some indication that fish communities change along the length of rivers has been reported by several limnologists from continents like North America (Frunk and Campbell, 1953), Fair amount of information regarding zonal arrangement are available in groups like Amphipoda (Thienemann, 1950), Decapoda (Hynes *et.al.* 1961), Ephemeroptera (Mecan, 1957), Plecaptera (Hynes, 1941), Odonata (Zahner, 1959), Chironomidae (Thieneman, 1954).

In recent years species - species studies with regards to their distribution and abundance has been carried out in various lotic habitat. Geurold *et.al.* (1992) made an extensive study of physico-chemical characteristics and the macro invertebrate communities of six streams draining a small granite catchment exposed to acidic precipitation (Vosges Mountains, North Eastern France). Among the six streams, five were affected by acidification and characterized by low pH (x 5.4) low HCO_3 concentration and elevated aluminium concentrations. Only one stream was normal with almost neutral pH (x 6.90). They found that the macroinvertebrate communities of the acidified streams were strongly affected as compared to the non-acidified one. Species richness abundance and diversity were remarkably low when acidification occurred. All the major taxonomic groups were affected but molluscs and ephemeropterans were found to be most acid-sensative organisms while plecopteran and oligochaetes appeared to be resistant ones. However, they observed that recolonization of acidified streams was possible during summer.

Cerfolli and Rossi (1995) worked on the numerical variation in three coexisting macro-detrivore species (*Proacellus coxalis*, *Planorbarins corneus* and *Bithynia tentaculata*) under different levels of vertical forces in aquatic macrocosms and substantiated the Hrbacek *et.al.* (1961) hypothesis that in aquatic ecosystem the abundance and biomass size spectra of large trophic categories (eg : phyto-plankton, zooplankton, planktivores and piscivores) are controlled by vertical forces.

Then there has been an unnoticed drift from the individual micro herbivore study to the study related to population and of community structure of the zooplankton by yet another group of interested workers from the field of aquatic biology. Pennak (1957) investigated species composition of a zooplankton community, Weibe (1970) of Oceanic zooplankton, Likens and Gilbert (1970) of planktonic rotifers, Patalas (1971 and 1974) on crustacean plankton communities of 45 different lakes in North Western Ontario, Green (1972) on latitudinal variation in Rotifera, Rigleer (1974) on population statistics of Copepod, Rultner Kolisko (1974) on comparative study of four zoo

plankton communities, Lewis (1979) on zooplanktonic community dynamics and Fernando (1980) on fresh water zoo plankton structure.

No limnological studies have been carried out in detail on this economically important river of Jharkhand. Study of blood changes parameters in *Channa orientalis* after the infection of Genera-*Chopsis goppa* (Ozakil) studied by Dr. K.C.Bose, Ranchi University, Ranchi and Dr. A.K.Sinha, Jamshedpur.

David Turtan, project manager (Jamshedpur Operation) of Veolia, a multinational water management firm based in France worked on a contract to manage water operation for a number of industrial town in North East India.

Turtan said - Kharkai is more polluted river in comparison to Subernarekha as most of the untreated waste from industries and domestic use are dumped into it. Discharge from many small and medium scale industries of Jamshedpur are seen to flow in Kharkai which empties into Subernarekha at Domohani.

The present study was undertaken towards the fulfilment of the same project. The studies on limnology of river Kharkai at river's meet (Domohani) and Adityapur, Jamshedpur (Jharkhand) under taken to test and substantiate the prediction of abiotic and biotic factors, quantitative and qualitative analysis of phytoplankton and zooplankton at seasonal levels, heavy metals investigation and benthic fauna such as insects, fishes, molluscs and macrophytes of the river water body and their systematic account.

PHYSIOGRAPHY OF THE STUDY AREA


JHARKHAND
N
BIHAR
UTTAR PRADESH
CHHATTISGARH
ODISHA (ORISSA)
WEST BENGAL
Sahibganj
Godda
Pakaur
Deoghar
Dumka
Jamtara
Kodarma
Giridih
Chatra
Garhwa
Daltonganj
Hazaribag
Latehar
Bokaro
Dhanbad
Ramgarh
Lohardaga
RANCHI
Khunti
Gumla
Jamshedpur
Saraikela
Chaibasa
Simdega
Koel
Mayurakshi
Barakar
Ajay
Damodar
Sankh
South Koel
Map not to Scale
Copyright © 2012 www.mapsofindia.com
(Updated on 13th December 2012)
LEGEND
National Highway
Major Road
Railway
District Boundary
State Boundary
River
District HQ
State Capital

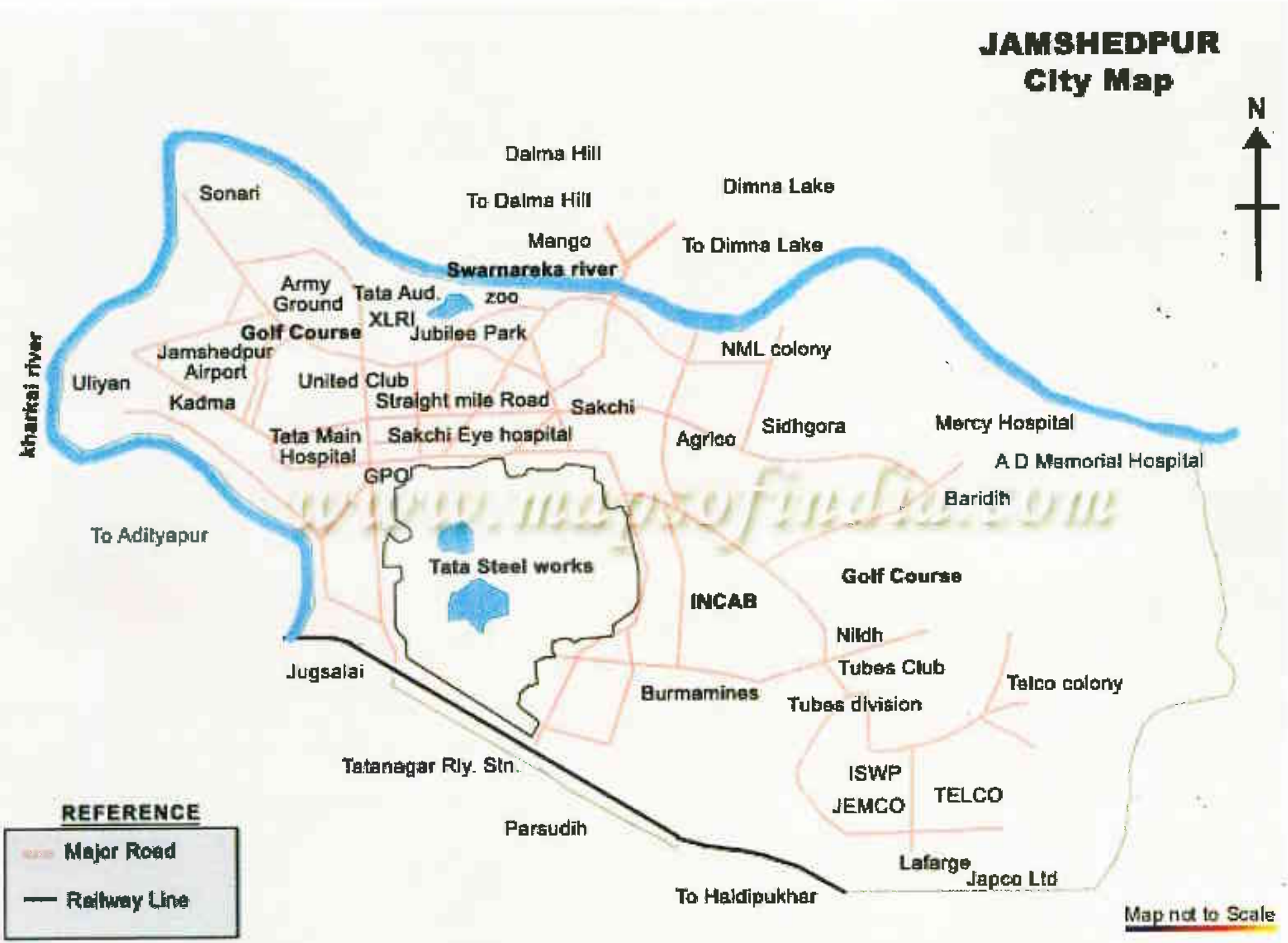
CHAPTER - 01

PHYSIOGRAPHY OF THE STUDY AREA

The state of Jharkhand lies on south-eastern part of India, extends from latitude 22° N to 25° N and longitude 83° 22' E to 87° 02' E and is divisible into North and South Chhotanagpur plateau (extends from latitude 21° 50' N to 24° 59' N and from longitude 83° 48' E to 86° 63' E). This plateau lies on basement of Archean rocks mainly granites and schists varying incomposition from place to place. The colour of the soil is red or rusty brown due to weathering of several types of rocks. The Chhotanagpur Plateau consists of four plateaus in which the lower part of Outer Lower Chhotanagpur (500 to 1000 m above the sea level) is one. Out of four drainage system in Lower Chhotanagpur- Subernarekha, Sank, South Koel river and Kharkai in south-east direction, the Subernarekha valley is located in the eastern part of Ranchi district and whole of Dalbhum subdivision (South eastern part of singhbhum district). The area of west singhbhum, east singhbhum saraikella-kharsawan district is directly drained to the Bay of Bengal through the Subernarekhaeast River. The considerable geolocical wealth of lower Subernarekha valley includes iron, copper, asbestos, kyanite, manganese, china clay and limestones. It is most importnat region with regards to industries. The chief tributary of the Subernarekha is the Kharkai river.

KHARKAI RIVER:

The Kharkai river arises in Mayurbhanj District, Odhisa, on the north slopes of Dasbarmela Parwat and the western slopes of Tungru Pahar. It flows past Rairangpur and hits north near Saraikela and then east, entering the Subernarekha in north western Jamshedpur. The geographic location of Jamshedpur is 86°04' to 86°54' East latitude and 22°12' to 23°01' North Longitude.



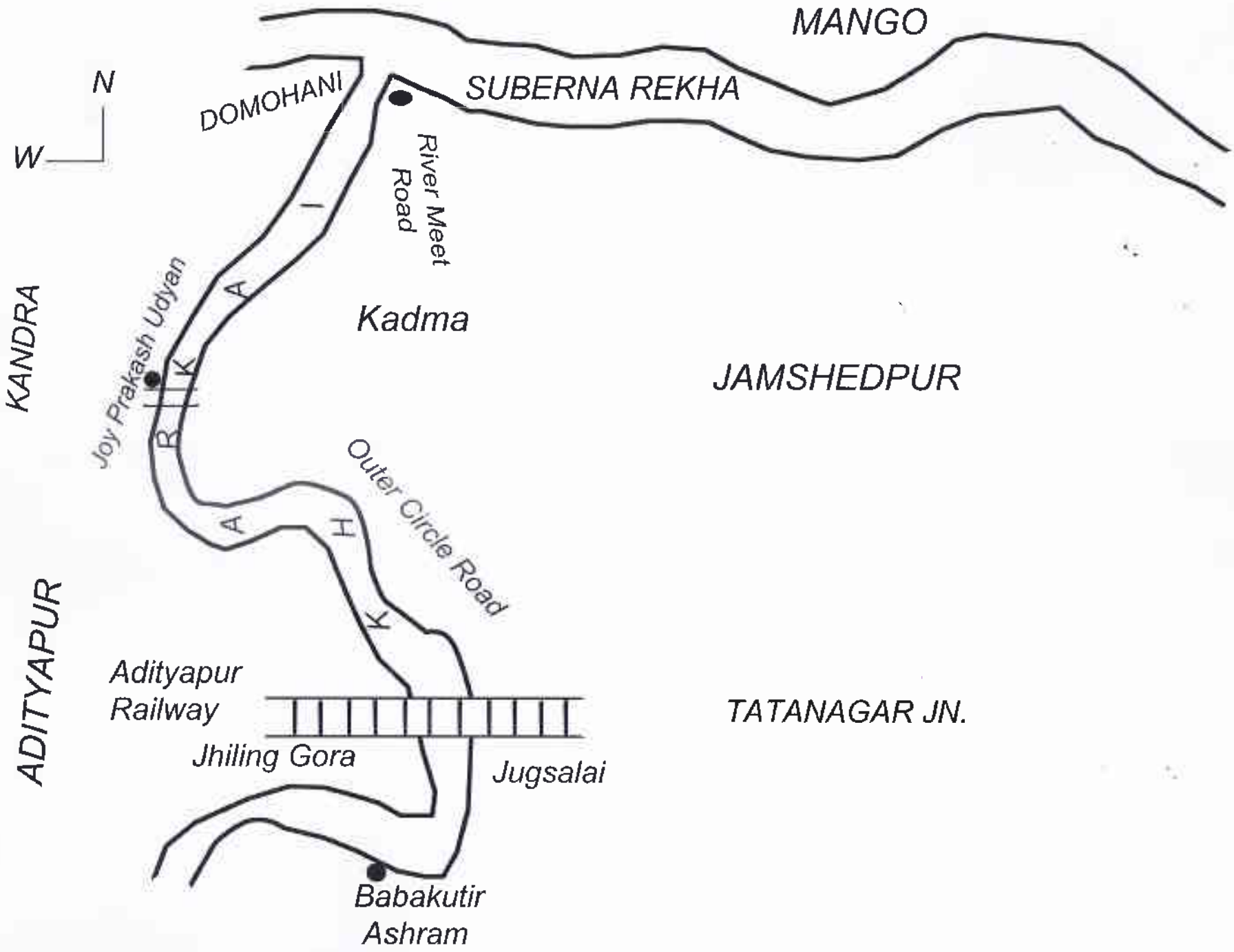
River Kharkai surrounds Adityapur from three sides (except west) and is connected with the well known cosmopolitan city of Jamshedpur (famous for TATA STEEL) through a bridge over the river of Kharkai (east of Adityapur) and recently formed Bridge with marine drive road.

The limnological work on river Kharkai was carried out for a period of two years, March 2012 to Feb 2014 on the different aspects at three different spots. The first spot was at **"Baba Kutir Ashram"**, Adityapur (District Seraikela-Kharsawan), the second spot be near the **"Jayprakash Udyan"** below the bridge and the third spot was at the River's meet, i.e **"Domohani"**.

So, three sampling station namely S-1, S-2 and S-3 were established along the 7.5 Km stretch of the river Kharkai.

River Kharkai

Country	-	India
States	-	Odhisa, Jharkhand
Source		
Location	-	Simlipal Massif, India
Elevation	-	928m (3,045 feet)
Coordination	-	22°04' N and 86°23' E
Mouth		
Location	-	Subernarekha river, India
Elevation	-	134m (440ft)
Coordination	-	22°50' N and 85°10' E


MANGO
N
W
DOMOHANI
SUBERNA REKHA
River Meet Road
KANDRA
Joy Prakash Udyan
Kadma
JAMSHEDPUR
Outer Circle Road
ADITYAPUR
Adityapur Railway
TATANAGAR JN.
Jhiling Gora
Jugsalai
Babakutir Ashram

STATION 1

BABA KUTIR ASHRAM

Baba Kutir Ashram (S-1)

Baba Kutir Ashram (22°46' N 85°05' E) is selected as the 1st study site. It is located 4 Km away from the main road of Adityapur towards Southern site of AIADA. Its western site is covered by Canopy of trees and it discharges water carrying heavy load of domestic sewage from Adityapur area. Bottom of the river is rocky and sandy. Banks are rocky with grasses and other aquatic vegetation. Village Jhilinggora is situated at its western site and Adityapur (densly populated) at the eastern side. The width of the river at this site is narrow. This site is always busy with the people for bathing. Speed of water currents not markable. So, it can be taken as area of stagnant water. Depth of water is too much. This site was the best for study of zoo plankton and phyto plankton.

S1 (BABA KUTIR ASHRAM)

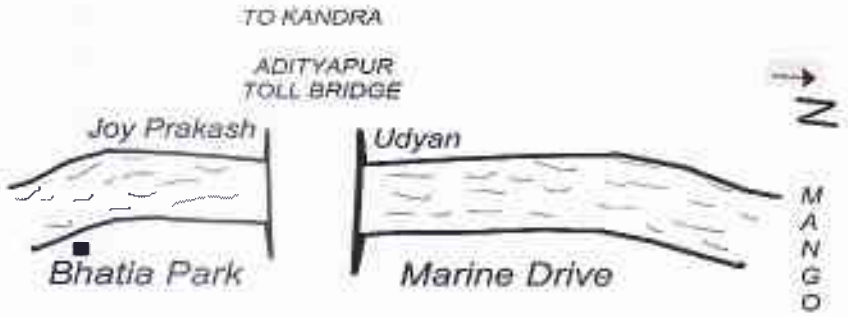

S1 (BABA KUTIR ASHRAM)


S1 (BABA KUTIR ASHRAM)

S1 (BABA KUTIR ASHRAM)

STATION 2

JAY PRAKASH UDYAN



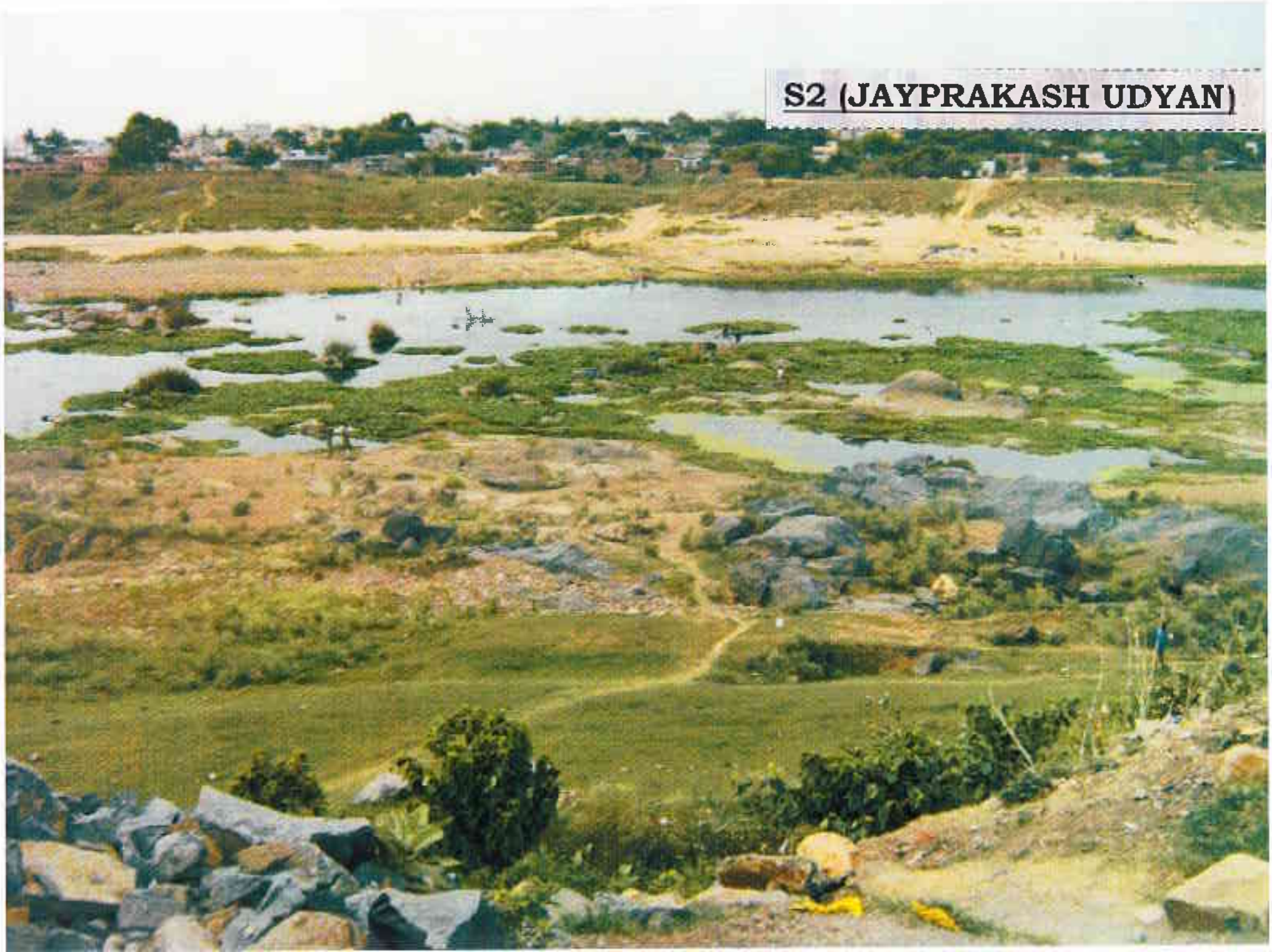
Length : 850 metres
Bredth : 429 metres

Sketch Map of Station-1

Jay Prakash Udyan (S-2)

Jayprakash Udyan (22°48' N 85°07' E) situated just below the Adityapur toll bridge. The altitude of this site is 182m. In the western side of this site is Kandra gowing road over Adityapur. The eastern side indicates Bhatia Basti, Bhatia Park, Marine Drive road, Kadma.The bottom of this river at this site is rocky and sandy. Both the sides of river banks are thickly rocky which remains under flooded during most part of the rainy season, thereby providing a suitable habitat for a temporary period of piscian, molluscan and crustacean species. In other season when the water level recedes, the rocky part becomes dried and does not provide as a habitat of the said species.


S2 (JAYPRAKASH UDYAN)

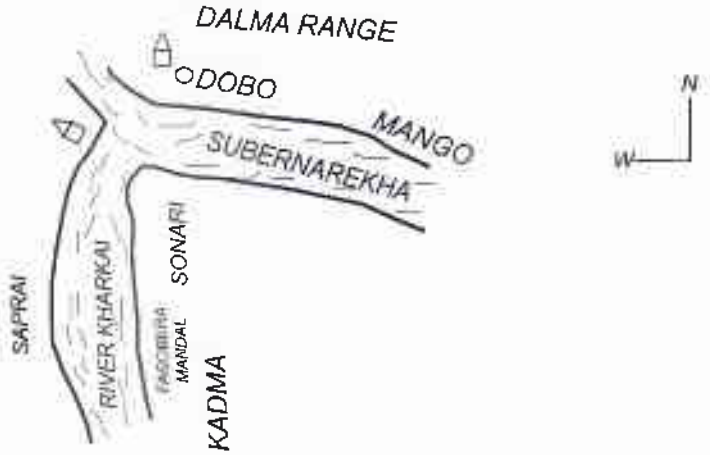

S2 (JAYPRAKASH UDYAN)


S2 (JAYPRAKASH UDYAN)


S2 (JAYPRAKASH UDYAN)

STATION 3

DOMOHANI



Domohani (S-3)

Domohani (Rivermeet 22°51' N 85°10' E) is the interesting site where both the river Subernarekha and Kharkai meet. Village Sapra (Dist-Saraikella-Kharsawan) is situated in its western side, Sonari in the eastern side and village Dobo is situated in the Northern Side facing towards Dalma Hill. At the western corner of meeting place the Temple of Lord Shiva is situated. In this station water level is too deep. The site is always busy with boating, fishing and bathing by the nearby people. The water of this site of the river is being polluted by the seawage carrying from Kadma-Sonari zone. Both site of the river banks are thickly rocky which remain flooded during most part of the rainy season; thereby providing a suitable habitat for a temporary period of some species. It not only forms a course of rain water drainage for the city but it also collects on what is realeased in it by dense human population.


S3 (DOMOHANI)


S3 (DOMOHANI)


S3 (DOMOHANI)


S3 (DOMOHANI)

MATERIALS AND METHODS

CHAPTER - 02

MATERIALS AND METHODS

Rivers are viewed in terms of entire watershed rather than just the actual body of water flowing in the channel. Both rivers and the landscape upon which they flow have been considered as one system (Leopold and Maddok, 1953). Rivers Kharkai is a tributary of the rivers Subarnarekha. It flows in eastward direction and drain Gamharia sub division of Seraikella-Kharsawan district. It enters the Subarnarekha in north western side of Jamshedpur (famous for TATA STEEL) though a bridge over the river (east of Adityapur). River Kharkai surrounds Adityapur from three sides except west.

In the present work three sampling station namely S_1, S_2 and S_3 were established along the proposed stretch of the river. Study sites are near the Baba Kutir Ashram, Adityapur (S_1), Jayprakash Udyan (S_2), the River's meet i.e Domohani (S_3). Regular measurements of certain physico -chemical parameters as well as sampling of waters and benthic fauna such as insects, fishes, molluscs of the water body and their systematic study were made at each sampling site in every calendar month for a period of two years (March 2012 to February 2014). So total 24 months collection were done. Sampling was done at each site at monthly interval between 8:30 AM to 10:30 AM for a period of two years.

Periodical surveys in two calendar years are conducted and the data collected are indicated in the sheets. These data are analyzed to identify the morpho-taxonomic account. The following tools were used while collecting water sample, aquatic, organisms and data.

Scoop Samplers:

Prepared of rigid metal sheet or cone like, the rim of which acts as a cutting edge is provided with a ring to which the hauling rope is attached. It is thrown into the water and dragged along the bottom and brought upto the surface. Large organisms should be hand picked after emptying the contents

into a shallow white enamelled tray. Smaller organisms are retrieved by passing the sample through a set of sieves. This scoop sampler is effective in shallow waters. The samples collected by this are identified by general survey.

Core Samplers:

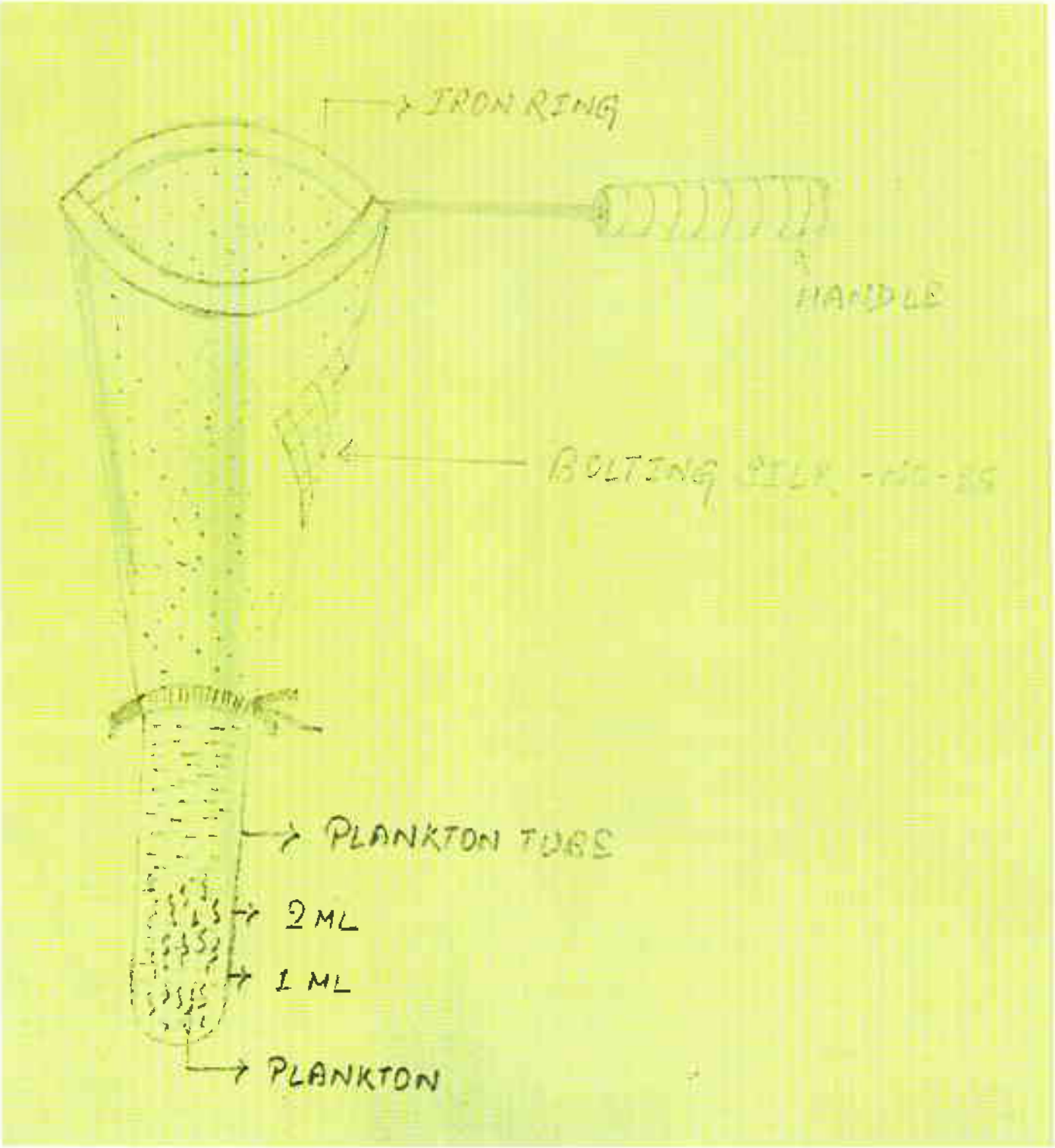
These are the ideal tools for bottom sampling. The corner penetrates deeper than any other sampler. Since the cover is open at ends there is no pressure built up. This is the ideal tool for study of bottom stratification if the bottom is soft, other suitable accessories are used to make the instrument operative is hand sand bottoms.

Ekman dredge:

This is widely used standard equipment for quantative studies of soft bottom. The body of the dredge is a square or rectangular box. The lower opening is closed by a pair of opposing scoop like jaws which are operated by spring. When shut the jaws close the box tightly and when pulled apart they leave the entire bottom of the box open. The dredge is sent down with the jaws held open. On reaching the bottom, a weight is sent down. This releases the spring which hold the jaws apart. The jaws close shut and during this process the bottom materials is scooped up by the jaws.

Plankton Net (Bolting Silk No-25):

It is made up of a circular iron rim attached to a handle. The rim is tied with bolting silk cloth of specified mess no.25. It's one square inch of blotting silk there is fixed no. of meshes in different types of blotting silk cloth. Muslin cloth may also be used in place of blotting silk. At the other end of blotting silk cloth a plankton collecting tube of desired capacity is tied. A thick band of rubber is used to tie the plankton collecting tube with the blotting silk tightly at their junction. The size of the tube should be 8 cm long and 2.5 cm wide. There is marking with ml. This help to know the volume of plankton. Plankton net is used for collecting plankton from the pond and river water.



PLANKTON NET

Methods--

Sieving:

The next step in the sampling procedure is the separation of the crustacean, molluscan, piscian and other species. This is the important part of the whole procedure which has been carried out in two steps-sieving and hand sorting. The sieved samplers were hand sorted in white enamelled tray before preservation.

Fixation and Preservation:

The aquatic species were fixed in alcohol formalin (5%) and arctic acid. After that the organisms are removed and thoroughly washed in running tap water. After proper washing they were kept in plastic bottle with source water in the field. They were then preserved with 4% formalin solution and brought to laboratory

Quantitative Studies:

The population density of aquatic species in collection site was studied by quadrate method. In it a metal square is dropped in the area of study and also the aquatic species found within that ring or square are collected and counted.

Identification:

Sampled were taken in the laboratory. The fauna were sorted out and identified with the help of the supervisor and other experts of our laboratory. Shorting samples were kept in plastic bottle.

Each bottle was provided with relevant data like station number, name of species type with classification.

Water sample were taken in plastic bottles to the laboratory from different collection sites for total alkalinity test.

Identification of the specimens were carried out using following taxonomical keys.

1. A guide to the study of fresh water biology Needham, J.4 and Needham P.R.(1972)
2. Fresh water invertebrates of United States. Pennak, R.W (1953).

3. Hand book – Freshwater Molluscs of India. ZSI Kolkata. Subba. Rao, N.V. (1989)
4. Fresh Water Biology – Needham and Needham.

Some of the identifications done were studied and further confirmed by the Zoological Survey of India, Kolkata (West Bengal).

Measurement of Physico-Chemical Parameters:

Physico-chemical character of water analysed by standard methods derived by "American Public Health Association" (1976), Trivedi and Goel (1984) and Adoni (1985). The methods followed during this study of analyse the chemical factors of water are as follows.

Samples were collected from all the three study sites at regular monthly intervals the collection time being 8:30 AM to 10:30 AM. For water sample collection used plastic bottles and stainless steel samplers were cleaned with detergent followed by rinsing with tap water and then distilled water.

The samples were analysed for their physico-chemical parameters as described below.

1. **Temperature:**

   The water temperature was measured with the centigrade mercury thermometer (graduated from 0°C to 110°C).

2. **Hydrogen-Ion-Concentration:**

   The hydrogen-ion-0concentration was measured by calorimetric method using a pH comparator and a comparator disc. Bromothymole blue was found to be a suitable indicator for the entire period of observation.

3. **Substrate Type:**

   Nature of substrate was examined visually during the period the station was visited for collection.

4. **Water depth:**

   Mean water depth at each station was calculated by measuring the water-depth at the middle and at the banks of the river with the help of a water scale.

SCHOLAR AT THE COLLECTION SITE

5. **Current Speed :**

The current speed was measured with the help of a stop watch and a float. The distance covered by the float in 20 seconds was measurement and converted into a measure of cm./sec.

6. **Transparency :**

Transparency was increased by Sacchi disc.

Sacchi Transparency

Sacchi (1865), an Italian scientist deviced a method for studying the transparency of aquatic bodies. The sacchi disc is a metallic plate of 20cm. diameter with four (alternate black and white) quadrants on the upper surface and a hook in the centre to tie a graduated rope.

Principle of Transparency: Transparency is inversely proportional to the turbidity of water, which in turn is directly proportional to the amount of suspended particles in organic matters. When the sacchi disc is lowered in water it remains visible in the euphoitc zone.

Method:

1. Lowered the disc in water and note the dept (in cm.) at which it disappears.
2. Now slowly raise the disc upward and note the depth at which it re appears.
3. Take the average value as sacchi disc depth (sdd) or transparency.

Calculation: Euphotic limits (cm..) = 2.5 x sdd.

7. **Dissolved Oxygen:**

Dissolved oxygen was measured by Winkler's method. Collect the sample in a 300 ml borosilicate bottle. Add 2 ml manganese sulphate followed by 2 ml alkali-iodide ozide Reagent. Mix well by inverting the bottle 2-3 times and allow the precipitate to settle down leaving 150 ml clear supernatant. Add 2 ml conc.H_2SO_4 mix well till precipitate goes into solution. Take 200 ml in a conical flask and titrate against standard sodium this sulphate till blue colour changes to colourless using starch as an indicators.

8. Free Carbon dioxide in water sample:

$C0_2$ in water samples are present as (HCo_3). So the $C0_2$ concentrations proportional to (HCo_3) alkalinity. 50mg per lit.re of (HCo_3) =mg/l bicarbonate alk x 1.22 where 1.2 is a conversion factor.

Free Co_2 in water (aq Co_2) is a source of carbon to the phyto and zooplankton. In the absence of free Co_2, plants utilize bicarbonates.

Dissolved Co_2 in natural waters actively participates in the carbonate system as:

$$Co_2\ (gas) = Co_2\ (aq)$$
$$Co_2 + H_2O = H_2Co_3$$
$$H_2Co_3 = H^+ + HCo_3^-$$

Free Co_2 in water samples in estimated by titrating the sample with standard alkalit.itrant to pH 8.3.

Requirement:

NaOH (0.0227 N), phenolphthalein indicator, burette, pipette, Erlenmeyer flask ,measuring cylinder, stand etc.

Method:

Take 50ml of sample and add 2 drops of phenophthelon, indicator. If slight pink colour develop then free Co_2 is absent.

If the solution is colourless, titrate with standard alkalit.itrant till slight pink colour develops then free Co_2 is present.

Calculation:

$$\text{Free } Co_2 \text{ in mg/l} = \frac{\text{ml of titrant x 1000}}{\text{ml of sample}}$$

9.Alkalinity:

The alkalinity of water is a measure of its capacity to neutralize acids. The alkalinity of natural water is due to the salts of carbonates, bicarbonates, borates, silicates and phosphates along with the hydroxyl ions in the free state. However the portion of the alkalinity in natural water is caused by hydroxide, carbonate and bicarbonates which may be ranked in order of their association with higher values. Alkalinity values provide guidance in applying proper doses of chemicals in water and wastewater treatment processes, particularly in coagulation, softening and operational control of anaerobic digestion.

Principle:

Alkalinity of sample can be estimated by titration with standard sulphuric acid. Tritation to pH 8.3 or decolourization of phenotpthalein indicator will indicate complete neutralization of OH and ½ of CO_3 while to pH 4.5 or sharp change from yellow to orange of methyl orange indicator will indicate total alkalinity, (Complete neutralization of OH^-, (CO_3), $(HCO^3)^{-1}$).

Inference: As indicated in acidity estimation.

Reagents:

1. Standard H_2SO_4 0.02N: Prepare 0.1 N H_2SO_4 diluting 3.0 ml conc. H_2SO_4 0.1 N. Dilute appropriate vol. of H_2SO_4 (approx 0.1) to 1000 ml to obtain standard 0.02 N H_2SO_4.

2. Phenolpthetein indicators: Dissolvé 0.5 g in 500 ml 95% ethylalcohol. Add 500 ml distilled water. Add dropwise 0.02N NaOH faint pink colour appears.

3. Methyl orange indicator: Dissolve 0.5g and dilute to 1000 ml with CO_2 free distilled water.

Procedure:

1. Take 25 or 50 ml sample in a conical flask and add 2-3 drop phenolphthalein indicator.

2. If pink colour develops titrate with 0.02 N H_2SO_4 till it disappear or pH is 8.3 Note the vol. of H_2SO_4 required.

3. Add 2-3 drop methyl orange , and continue till pH comes down to 4.5 or yellow changes to orange.

4. In case pink colour does not appear after addition of phenolphthalein continue as in 3 added.

5. Calculate Total (T), Phenopthalein (P) and methyl orange alkalinity as follows and express in angle as $CaCo_3$.

   P – Alkalinity, mg/l as$CaCo_3$ = A x1000/ml sample.
   T – Alkalinity, mg/l as$CaCo_3$ = B x1000 ml Sample.

In case H_2SO_4 is not 0.02 N applying the following formula:

$$\text{Alkalinity, mg/l as } CaCo_3 = \frac{A/B \times N \times 5000}{\text{Ml of Sample}}$$

Where, A= ml of H_2SO_4 required to bring the pH to 8.3
B= ml of H_2SO_4 required to bring the pH to 4.5
N= normalit.y of H_2SO_4 used.

Once the phenolphthalein and total alkalinities are determine then three types of alkalinities carbonate and bicarbonate are calculated.

Carbonate and bicarbonate alkalinities are known then their Conversation to milligrams per lit.re of Co_3^{2-} or HCo_3^{-1} are possible.

Mg/l Co_3^{-2} = mg/l Carbonate alk x 0.65

Mg/l HCo_3^{-1} = mg/l bicarbonate alk x 1.22

From above molar concentration may be obtained as follows:

$$(Co_3)^{-20} = \frac{\text{mg/l } Co_3^-}{\text{mg/l } HCo_3^-}$$

$$(HCo_3)^{-2} = \frac{\text{mg/l } HCo_3^-}{1000}$$

10.Chloride:

Chloride was measured by Argento metric method. Adjust sample pH to 7.0, if it is not in this range. Take 50 ml sample in a conical flask. Add 1 ml potassium chromate indicator solution. Titrate with standard silver nitrate titrant to a pinkish yellow end point. Standardize silver nitrate titrant and establish reagent blank value by the titrant method with distill water in place of sample.

$$\text{Chloride mg/l} = \frac{AxBx1000}{N \text{ ml of Sample}}$$

Where A= ml silver nitrate required for sample.

B= ml silver nitrate required for blank.

N= normalit.y of silver nitrate.

11.Phosphate

Phosphate reacts with ammonium molybdate to form phosphomolybdic acid which on being reduced by stannous chloride produces a blue colour. The intensity of colour is directly dependent on the amount of phosphate present. Phosphate was estimated by measuring the intensity of colour by spectrophotometer at 650 nm (M)

against a reagent blank. The spectrometer reading was converted into ppm on the basis of standard curve.

Take 50 ml of sample, add 2 ml ammonium molybdate and mix well. Add 0.5 ml stannous chloride and dilute to 100 ml. Prepare blank using distilled water in the sample way. Measure the intensity of blue coloured complex at 650 nm. Prepare a graph by suitable volume of standard phosphate solution. Calculate phosphate present present in sample.

12.Nitrate

It is measured by phenolodisulphonic acid method. Nitrates present in the water Sample reacts with 2dn Phenol disulphate and reagent when this is converted to alkaline salt, a yellow colour is produced. The intensity of yellow colour thus developed is directly proportional to the amount of nitrates present.

The amount of nitrates was estimated by measuring the intensity of colour in spectrophotometer at 410 nm against reagent blank. Prepare a calibration curve using standard nitrate solution. Calculate nitrate present in sample.

13.Estimation of Total Iron:-

Principle:

Total iron is the sum of both Ferric and Ferrous forms. The analysis of iron in water is usually done photo metrically.

Reagent:

1. Conc. HCl
2. Hydroxylamine Hydrochloride solution.
3. Ammonium acetate buffer solution.
4. Phenonthroline solution.

Procedure:

All the iron is converted into ferrous state by boiling with HCl and hydroxyl amine. 50 ml of water sample is heated with 2ml Conc. HCl and 1 ml of hydroxyl amine hydrochloride solution. Boil the contents to half of the volume for dissolution of all the iron, coal,

and add 10 ml ammonium acetate buffer and 2 ml phenonthroline solution. An orange red colour appears. The volume is made up to 100 ml and after 10 minutes the reading is taken at 510 nm on a spectrophotometer.

The concentration of Fe is calculated directly from the standard curve.

$$\text{Iron (as Fe) mg/l} = \frac{\text{matching std.} \times 0.01 \times 1000}{\text{ml sample taken for determination}}$$

14. **Heavy Metals:**

LEAD:

Lead is practically not occurring in any natural water. If lead is present in a water supply, it may be due to the corrosion reactions and wastes contamination. Water in contact with lead piping usually contains lead. Since lead is cumulative poison, its determination in water is important. It is done by Dithizone method which is applicable to raw water, polluted water.

Reagents:

1. Ammonia sol^{n} of 0.5 N.
2. Dithizone stock solution of 0.1%.
3. Sodium hexametaphosphate solution (10%)
4. 1% Hydroxylamine hydrochloride solution.
5. Alkaline cyanide sol^{n}
6. Lead working solution. (1 ml=10 µg Pb)

Procedure:

Add 1.0 ml sodium hexametaphosphate solution, 1.0 ml hydroxylamine hydrochloride solution, 30 ml alkaline cyanide solution, 0.5 ml dithizone working solution and 10 ml chloroform. It has done with shaking after each addition. The funnel was shaken vigorously and allow the layers to separate. Dry the stem of the funnel with filter paper strips. Draw the chloroform layer in

the optical cell. The optical density is measured using spectrophotometer.

NICKEL:

Nickel does not occur in natural water. Metal plating wastes when discharged into water courses contribute nickel. The presence of nickel indicates corrosion of nickel alloys. The dimethyl Glyoxime method is a best method for the determination of nickel. This method is applicable to all types of water and waste water.

Procedure:

Place appropriate volumes of nickel working solution 100 µg in a 50 ml volumetric flask. Then add 10 ml sodium citrate solution, 2 ml iodine solution, 4 ml dimethyl glyoxime solution. It is then made up to 50ml with distilled water and allow to stand for 20 minutes. The colour is compared photometrically using spectro photometer with a suitable blue filter taking water as the reference. Calibration curve is prepared and find out the mg nickel equivalent to the observed optical density.

Zinc:

Zinc is commonly found in small quantities in domestic water supplies and industrial water due to the corrosion of galvanized iron and in industrial effluents. Zinc is identified by Dithizone method. This method needs following reagents:

1. HCl (0.02 N)
2. Zinc stock solution (1.00 ml = 100 µg Zn)
3. Zinc working solution (1.0 ml = 0.001 µg Zn)
4. Dithizone Stock solution.
5. Dithizone working solution.
6. Acetate buffer solution.
7. Sodium thiosulphate solution.
8. Sodium citrate solution.

Procedure

Place an aliquot of the sample with a zinc content below 0.008 mg in a 50 ml beaker. Adjust the volume of the sample to 10 ml by dilution. It is transferred to a 100 ml separating funnel. In a series of 100 ml separating funnels, place 1.0, 2.0 ..... 8.0 ml of zinc working solution and dilute to 10 ml with zinc free distilled water. A separating funnel is included containing 10 ml zinc free distilled water as the blank. To the blank standard and sample add the following reagents in order with mixing after each addition-- 5.0 ml acetate buffer, 1.0 ml sodium thiosulphate solution, and 10.0 ml dithizone working solution. Allow the layer to separate and draw the CCl_4 layer into the absorption cell after drying the stem of the funnel with filter paper strips. The red colour of zinc dithizonate is measured at 535 nm, after setting the photometer at 100% transmittance with blank. The various colours obtained with zinc standards are follows:

Zinc in mg	Colour
0.001	Blue
0.002	Blue Violet
0.003	Violet
0.004	Red Violet
0.006	Red Violet
0.007	Violet

Plankton Counts:

Sample Collection: Water samples were collected with the helps of standard plankton net made up of silk. No. 14 (120mm) and 25 (65mm).

The water sample was passed carefully through the plankton net. The filtrate was transferred to marked glass stopper bottles. The samples were preserved with 5% HCHO and ethanol iodine solution.

Silk No. 14 net collects phytoplankton and silk no. 25 net collects zooplankton.

The samples were further concentrated to 5ml by centrifugation at 2500 round per minute (rpm). After Sedimentation of phytoplankton and zooplankton, the supernatant liquid was siphoned off and sedimented portion was preserved in 5% formaldehyde.

Phytoplankton counting

The phytoplankton were systematically identified up to group level by using compound microscope with the help of works of Fritsch (1935), Needham and Needham (1974), APHA (1989).

The organisms/ litre were calculated using formula:

$$\text{Organism/litre} = \frac{C \times 1000\ mm3 \times 1000}{L \times D \times W \times S}$$

Where C = The average number of organisms in the counting cell

S = Number of Strips counted

L, D and W = Length, Depth and Width of a strip

Zooplankton Counting Technique-

In the pipette method, adjust sample to a concentrated volume in a graduated cylinder concentrating the plankton by using a rubber bulb and clear acrylic plastic tube mesh netting fitted at the end. Zooplankton use sedimentation techniques as described for concentrating phytoplankton.

Gently stir sample completely and randomly with the pipette and quickly with land 1 to 5ml. Transfer to a suitable counting chamber.

Using a compound microscope enumerate small Zooplankton (protozoa, Copepods, Cladocerans, rotifers, etc.) in a 1 to 5 ml, clear acrylic plastic counting cell.

Report smaller zooplankton as number / litre and larger forms as per cubic meter. Quantitative analysis were done according to Lackey drop micro transect method.

$$\text{Number / } m^3 = \frac{C \times V^{I}}{V^{II} \times V^{III}}$$

C = Number of Organism Counted

V^{I} = Volume of Concentrated sample in ml

V^{II} = Volume counted/ ml

V^{III} = Volume of the grab sample/ m^3.

OBSERVATION

CHAPTER – 03

OBSERVATIONS

A. PHYSICO-CHEMICAL PARAMETER:

Physicochemical parameters like nature of substrate, current speed, pH, temperature, nutrients, etc, are well known to affect the aquatic organisms and are responsible for alternation in community structure of all ecological niches. India being a tropical country exhibit much variation in climatic condition and consequently, changes in physical parameters are evident. Each ecotype and even each ecological niche within the same ecotype shows variation in physical factors and may be, due to this fact no two biotype can be identical.

Nature of substrate, channel width and water depth at various sampling sites of the Kharkai River are shown in Table 1, Turbidity in Table 2 and Figure 1, Transparency in Table 3 and Figure 2, while Temperature, pH, current speed, PO_4, NO_3, in Table 4 and Figure 3 to Figure 7. In the legend for convenience, period from March, 2012 to February, 2013 is described as first year and that from March, 2013 to February, 2014 as second year.

Nature of Substrate:

Nature of substrate in stream is extremely important as it influences the distribution and abundance of benthic invertebrates in many ways. The nature of streambed influences the discharge, current speed and the nature of flow (Hynes, 1979).

Fairly distinct benthic fauna are associated with particular type of substrate. The large area of sand, mud, clay etc have their own characteristics fauna (Berg, *et.al*, 1948; Greeze, 1953; Shadin, 1956). Maitland (1968) has clearly forward that some species are limited by temperature while other by substratum.

Table: 1

Showing the nature of substrate, channel width and water depth act various sampling stations of the Kharkai River during March, 2012 to February, 2014

Station	Nature of Substrate	Width of river (metre)	Mean Water Depth (cm.)
S_1	Muddy with patches of coarse sand and sparsely scattered gravels (size 1.6 cm. to 3.4 cm.)	90 metre	9-85
S_2	Black waste muddy coarse sand and sparsely scattered gravels (size 1.6 cm. to 2.8 cm.)	100 metre	5-29
S_3	Sandy with this patches of silts, sparsely scattered gravels (0.4 cm. to 2.7 cm.), chips	120 metre	22-135

In the present investigation substrate was muddy with patches of coarse sand and sparsely scattered gravels (size 1.6 cm. to 3.4 cm.) at S1,gravels (size 1.5 cm. to 2.8 cm.) at S_2; sandy with this patches of silts sparely, scattered gravels (0.4 cm. to 2.7 cm.), chips at S_3.

Water Depth:

The mean water depth of the river around sampling stations ranged from 9 cm. to 85 cm. at S_1, from 5cm. to 29 cm. at S_2, and from 22 cm. to 135 cm. at S_3. Thus the mean water depth was highest at S_3.

Turbidity (NTU) Table 2:

Turbidity was found to range between 20.8 to 28.0 (NTU) for S_1, 42.0 to 62.0 (NTU) for S_2 and 51.0 to 76.0 (NTU) for S_3. Minimum turbidity was recorded in the month of November at site S_1, October at site S_2 and S_3 while maximum turbidity was recorded in the month of August for Site S_1, September for Site S_2 and S_3. On the annual average basis turbidity of site S_3 was maximum 61.91 (NTU) while it was minimum at site S_1 32.50 (NTU) as exhibited in Table 2.

The reduced turbidity in the other months indicated a reduced amount of suspended matter in the water. In the present study the turbidity values were always less at S_1, more at S_2 and maximum at S_3. The amount of turbidity at S_3 almost double to the site S_1 (Table 2). Further, the turbidity of water in rainy season was at its highest and in

winter months it was lowest. An identical trend was apparent in the mean values of turbidity of site S_1 and S_3 (Table 2).

Figure 1 further exhibits that turbidity was less in the water at S_1 and high at S_3.

Transparency (Table 3):

Transparency of river water ranged from 11.2 to 25.5 cm of length and 11.0 to 16.5 cm for sites S_1 to S_3 respectively. Minimum transparency was recorded in the month of July for S_1, July for Site S_2 and August for Site S_3. While maximum transparency was recorded in the month of October for Site S_1, October, January for the Site S_2 and January for Site S_3.

Table : 2

Variations in Turbidity (NTU) of the Kharkai river at Three Stations during March 2012 to February 2014

Months	Stations		
	S_1	S_2	S_3
Mar-12	31.00	48.00	62.00
Apr-12	33.00	51.00	65.00
May-12	34.00	54.00	67.00
Jun-12	35.00	58.00	64.00
Jul-12	37.00	49.00	61.00
Aug-12	38.00	60.00	73.00
Sep-12	35.00	62.00	76.00
Oct-12	28.00	42.00	51.00
Nov-12	29.00	45.00	58.00
Dec-12	29.00	44.00	52.00
Jan-13	31.00	47.00	29.00
Feb-13	32.00	46.00	58.00
Mar-13	30.00	49.00	61.00
Apr-13	32.00	50.00	65.00
May-13	33.00	55.00	67.00
Jun-13	35.00	58.00	64.00
Jul-13	37.00	49.00	60.00
Aug-13	38.00	60.00	72.00
Sep-13	36.00	62.00	76.00
Oct-13	29.00	42.00	51.00
Nov-13	28.00	45.00	58.00
Dec-13	29.00	44.00	52.00
Jan-14	31.00	47.00	29.00
Feb-14	32.00	46.00	58.00
Mean	**32.58**	**50.54**	**59.54**

Fig 1

Turbidity of water of Kharkai river at three station during March'2013 to February'2014

Table : 3

Variations in Transparency (NTU) of the Kharkai river at Three Stations during March 2012 to February 2014

Months	Stations		
	S_1	S_2	S_3
Mar-12	20.60	14.00	14.20
Apr-12	19.00	13.00	12.00
May-12	16.50	15.00	11.00
Jun-12	15.00	12.00	11.60
Jul-12	12.00	11.00	12.00
Aug-12	18.00	11.00	9.25
Sep-12	14.00	11.30	9.50
Oct-12	25.50	18.20	11.00
Nov-12	19.00	17.00	14.40
Dec-12	18.50	16.00	15.20
Jan-13	20.60	18.20	16.50
Feb-13	19.00	16.20	15.40
Mar-13	20.60	14.40	14.20
Apr-13	19.00	13.00	12.00
May-13	17.60	14.00	11.00
Jun-13	15.00	13.00	12.00
Jul-13	11.20	10.00	11.00
Aug-13	18.00	11.00	9.00
Sep-13	14.00	11.30	9.50
Oct-13	25.50	18.20	11.00
Nov-13	19.00	17.00	14.40
Dec-13	18.50	16.00	15.20
Jan-14	20.60	18.20	16.50
Feb-14	19.00	16.20	15.40
Mean	**18.15**	**14.38**	**12.64**

Fig 2

Transparency of water of Kharkai river at three station during March'2013 to February'2014

On the annual average basis transparency of site S_3 was minimum 12.7 cm and S_1 was maximum 16.6 cm.

Table (3) also exhibits that transparency of the river water was minimum during earlier half of rainy months, but it increased during later half of this season and remained high even during winter months. It may be stated that transparency showed inverse dependence on turbidity of the river water (Table 2 and 3). Thus as exhibited by (Fig. 2) maximum transparency was observed in the month of October, when the turbidity was recorded minimum (Table 2). Another maximum transparency was observed in January. In the remaining months the transparency of the river water was found to undergo depression (Fig. 2).

Current Speed:

The current speed of running water ecosystem is an important ecological factor as it influences the organisms either directly or indirectly by determining the nature of river bed and the amount of silt deposition.

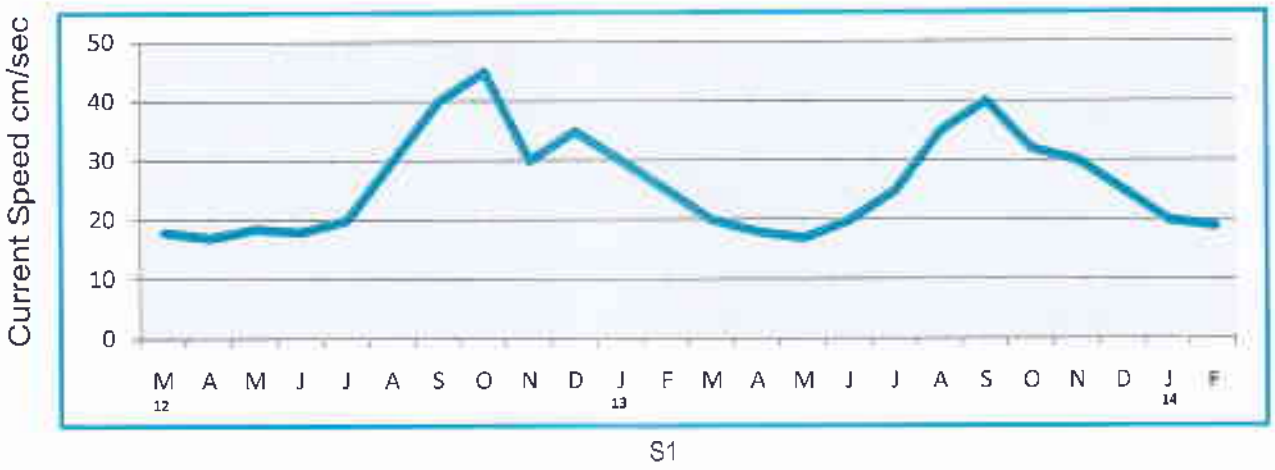
The stream flow is a complex process and is related to the discharge, width, depth, roughness of stream bed, Stream bank and also to some extent the water surface. The velocity of flow at any point in a channel is inversely proportional to the logarithmic depth (Hynes, 1979). The current speed is highest at the water surface, especially at the centre, and it decreases with the depth. In the present investigation, however, current speed occured at about ¾ th of the depth.

The current speed in the present study, ranged between 8cm./sec to 52 cm./sec at S_1, 13 cm./sec to 45 cm./sec at S_2, 6cm./sec to 37 cm./sec at S_3. The minimum current speed was recorded in´April 12 during first year of observations, whereas during second year the minimum current speed was recorded in the month of June' 13 at all stations, though at S_1, it was also recorded in the month of April' 13 and May' 13.

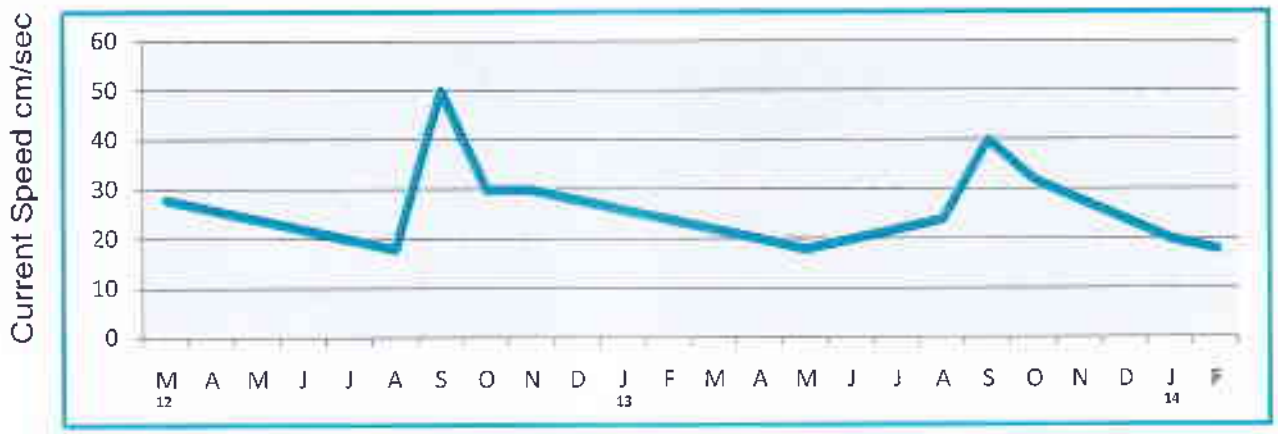
The data revealed that the current speed was lowest in summer months (March to June), moderate in winter months (Nov. to Feb.) and highest in monsoon months (July to Sept) (Fig.-3a).

Fig 3(a)

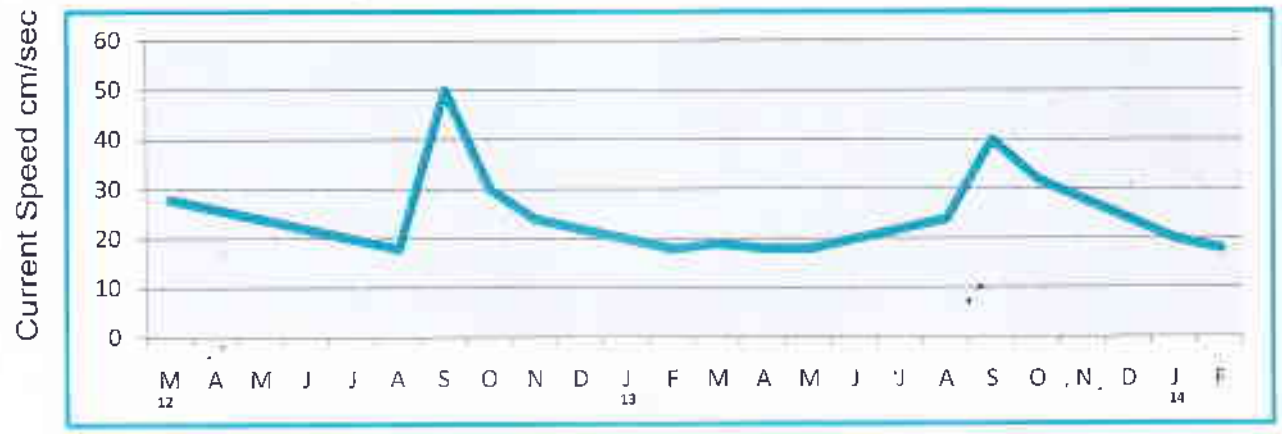
Current Speed at the three sampling station of the Kharkai River during March'12 to Feb'14



S1



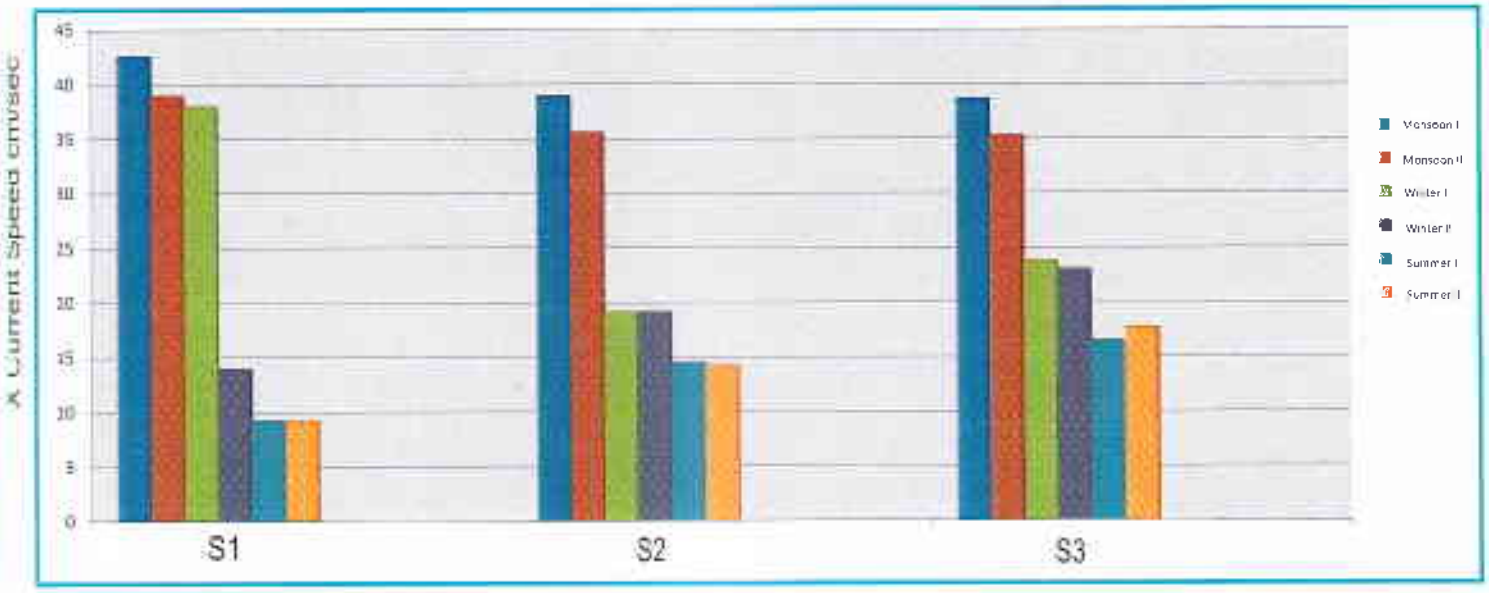
S2



S3

Fig 3(b)

Mean value of Current Speed at three Sampling Stations of Kharkai River during various season from March 2012 to February 2014



The mean current speeds during monsoon winter and summer months were 42.67 cm./sec, 19.25 cm./sec and 9.25 cm./sec at S_1; 39 cm./sec, 19.25 cm./sec and 14.50 cm./sec at S_2; 38.67 cm./sec, 23 cm./sec and 16.50 cm./sec at S_3 respectively during first year of observations. Similarly, during monsoon winter and summer months were 36.33 cm./sec, 14 cm./sec and 9.25 cm./sec at S_1; 35.67 cm./sec, 19.50 cm./sec and 14.25 cm./sec at S_2; 35.33 cm./sec, 23 cm./sec and 17.75 cm./sec at S_3 respectively (Fig. 3b).

Hydrogen ion concentration (pH):

In freshwater ecosystem pH is responsible for important biological consequences. The pH of natural water is an important environmental parameter. The variation of which along with other factors, determines the species composition and the processes of organisms. Though pH range is species specific, yet lower forms in general showed little reaction to change in pH, while higher aquatic forms responded quickly to variation in pH.

In the present investigation the water remained neutral to slightly alkaline at all sampling stations during the entire course of study except S_1 where acidic tendency was recorded (Fig. 4a).

The acidic pH value was 6.9 and was recorded in the months of July to September 2012 and May to August 2013 at S_1.

During first year of observation the value of pH varied from 6.9 to 7.0 at S_1, 7.0 to 7.1 at S_2, 7.0 to 7.2 at S_3 with mean value being 6.95, 7.04, 7.08 at corresponding stations similarly during second year it ranged from 6.9 to 7.2 at S_1, 7.0 to 7.2 at S_2, 7.0 to 7.2 at S_3 with mean value being 6.98, 7.11, 7.13 at corresponding stations (Fig. 4b).

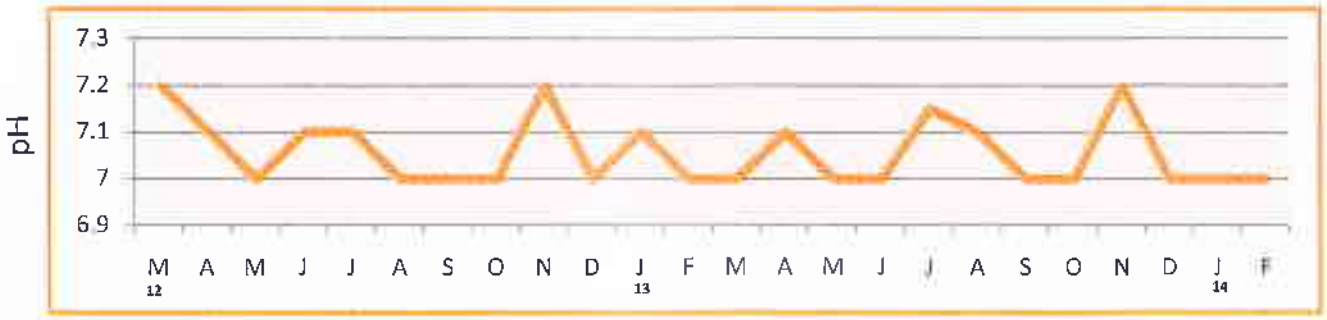
Temperature:

The variation in temperature in aquatic habitat has a great effect upon its productivity in general. All metabolic and physiological activities and life processes, such as feeding, reproduction and distribution of aquatic organism are greatly influenced by water temperature. This is because organism possess well defined limit of temperature tolerance with the optimum lying somewhere in between. High temperature is responsible for rapid decomposition of organic matter releasing nutrients into the water body.

Fig 4(a)

pH at the three Sampling Stations of the Kharkai River during March 2012 to February 2014

S1



S2

S3

Fig 4(b)

Mean value of pH at three Sampling Stations of the Kharkai River during March 2012 to February 2014

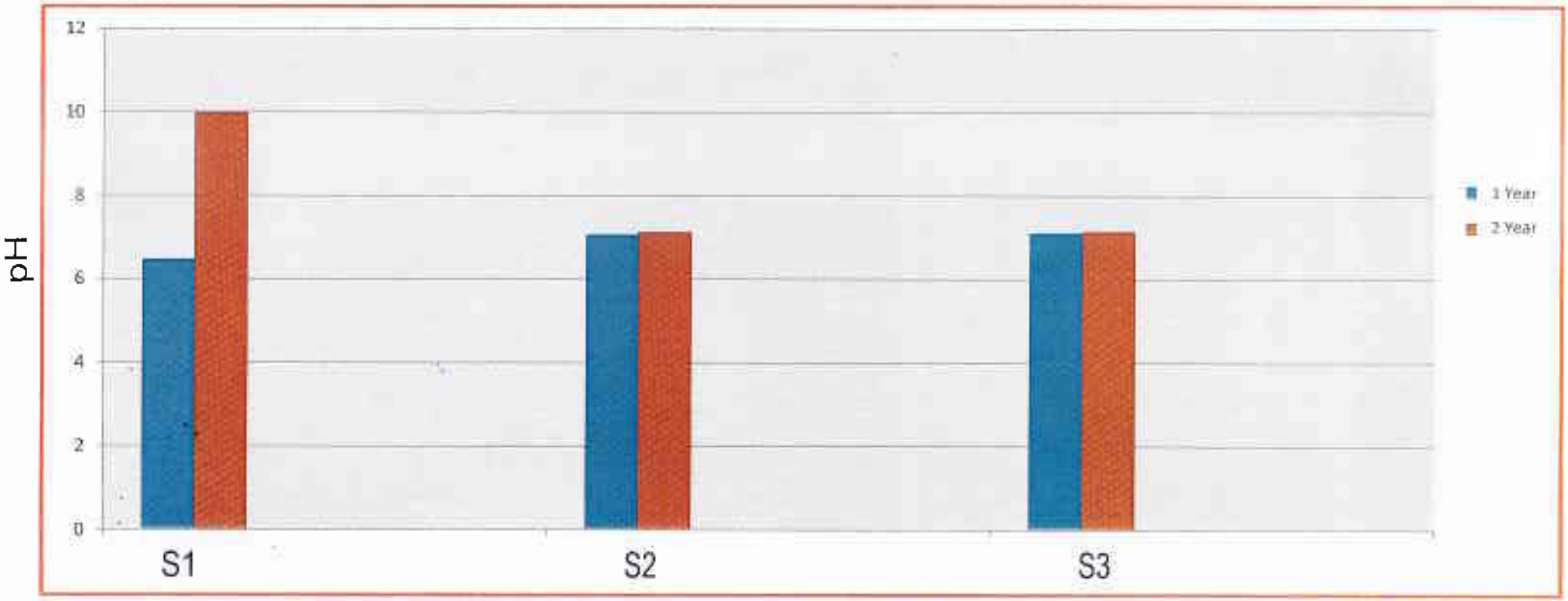
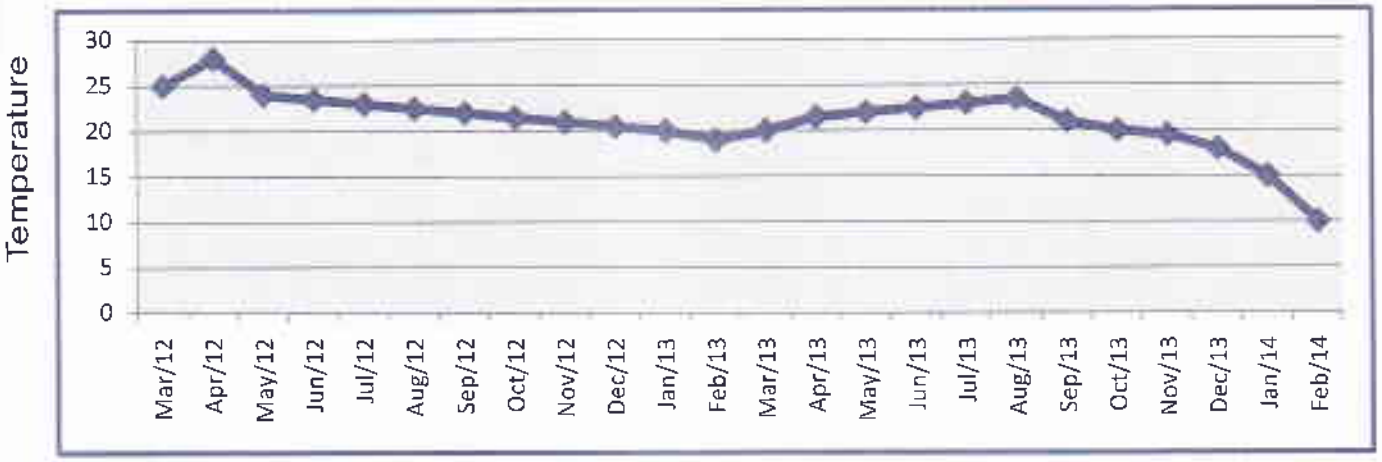
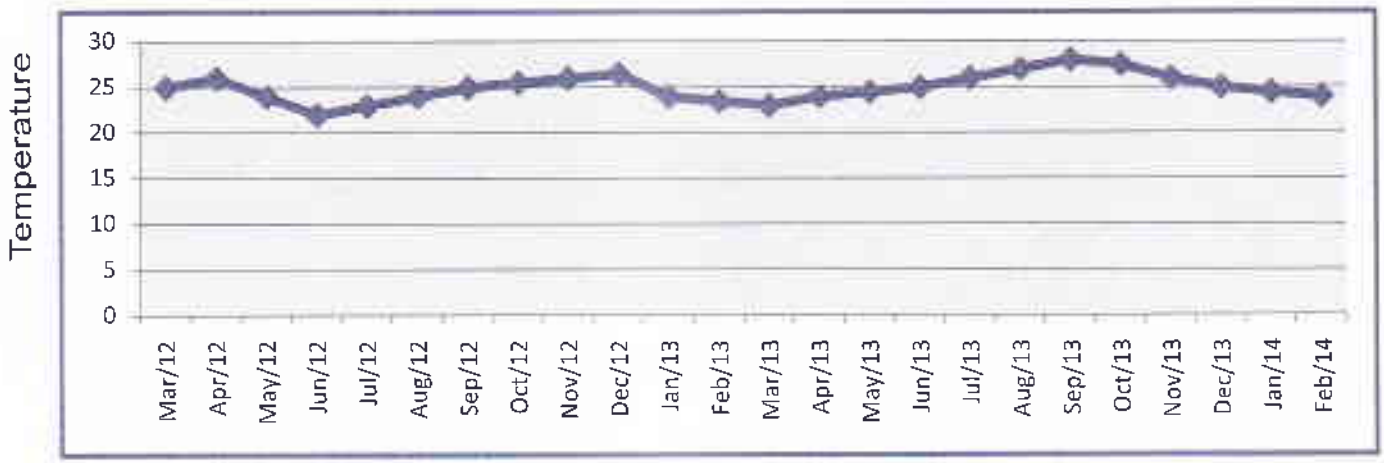


Fig 5(a)

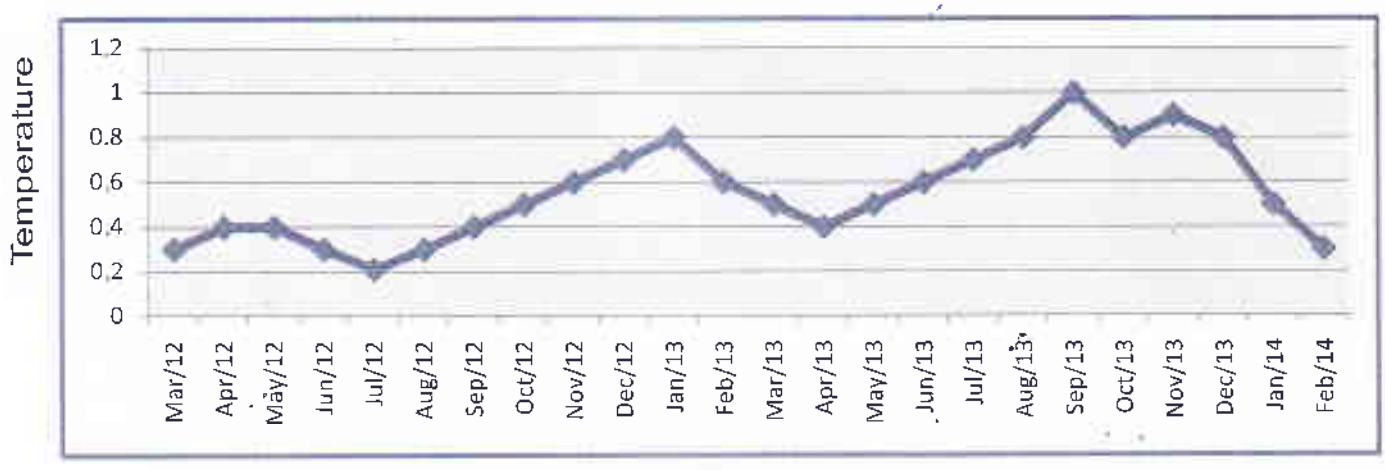
Fig 5(a) Temperature at the three Sampling Stations of the Kharkai River during March 2012 to February 2014



S1



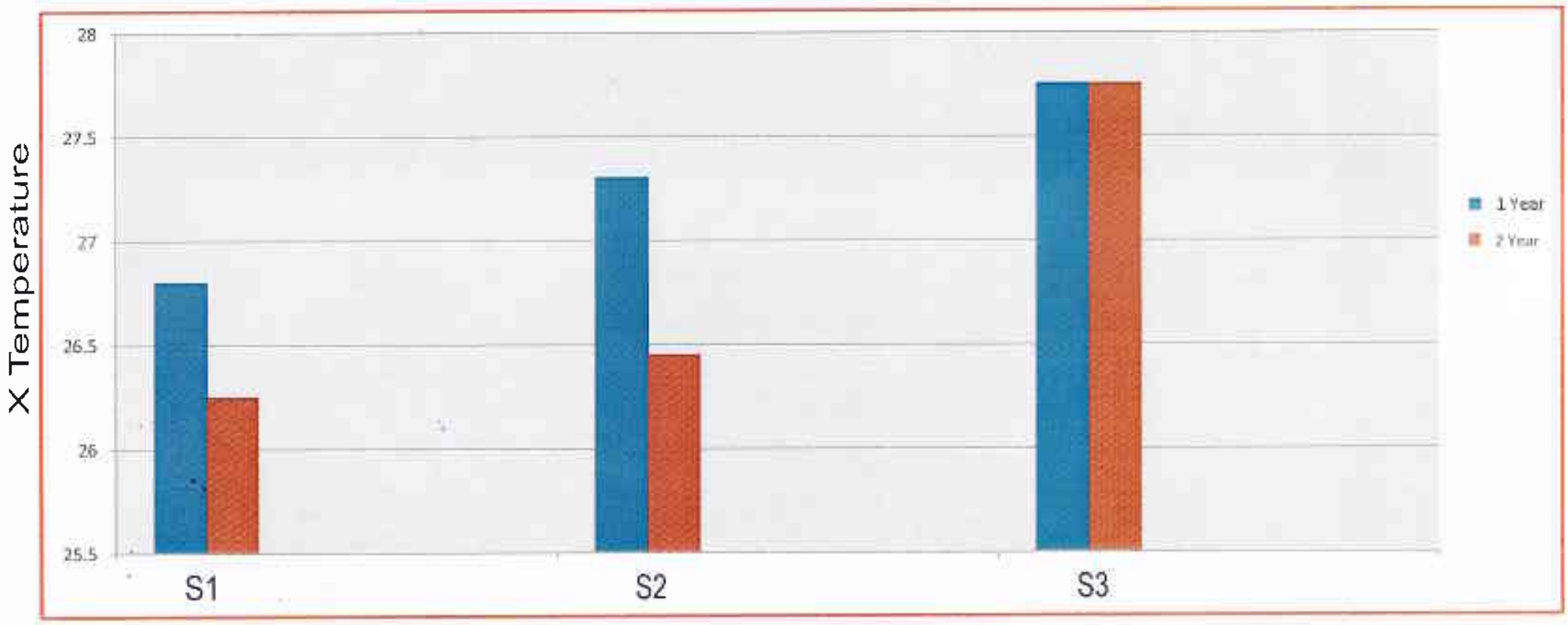
S2



S3

Fig 5(b)

Mean Value of Temperature at three Sampling Stations of the Kharkai river during March-12 to Feb-14



Another effect of temperature on water is to alter its viscosity, and this causes silts to sink twice as fast as at 23°C as it does at 0°C (Hynes, 1979).

In the present investigation the temperature revealed no significant variation along the course of the river; however it showed significant temporal variations (Fig. 5a).

The temperature ranged between 18.5°C to 35.2°C at S_1, 18.6°C to 36.0°C at S_2 and 19.0°C to 36.5°C at S_3, with mean value being 26.85°C, 27.30°C and 27.75°C at corresponding stations during first year of observations. During second year it ranged between 18.5°C to 34.0°C at S_1, 18.7°C to 35.2°C at S_2 and 18.6°C to 36.9°C at S_3, with mean value being 26.25°C, 26.25°C and 27.75°C at corresponding stations during second year of observations (Table 4, Fig. 5b).

During the first year of observation the minimum value of water temperature was recorded in the months of January'13 (S_1-18.5°C, S_2-18.6°C and S_3-19.0°C) and maximum value in the month of June'12 (S_1-35.2°C, S_2-36.0°C and S_3-36.5°C) at all sampling stations; similarly during second year of observations minimum value of water temperature was recorded in the month of January'14 (S_1-18.5°C, S_2-18.7°C and S_3-18.6°C) but the maximum value was recorded in the month of June'13 (S_1-34.0°C, S_2-35.2°C and S_3-36.9°C).

The water temperature remained fairly high during May to June ranging from 31.0°C to 35.2°C and 31.3°C to 34.0°C at S_1; from 30.8°C to 36.0°C and 29.2°C to 35.2°C at S_2 and from 30.5°C to 36.5°C and 30.9°C to 36.9°C at S_3, during first and second year of observation respectively (Fig. 5a).

Dissolved Oxygen (Table 5):

Dissolved oxygen was found below normal level for many months of the year at site S_1 and for the most of the months at sites S_2 and S_3. It was only in the months of July and August that water of all the three study stations contained dissolved oxygen. During these months the maximum amount (12.70 mg/l) at S_1 and minimum amount (7.00 mg/l) at S_2. The periodicity of dissolved oxygen showed a definite pattern during the course of study.

Dissolved oxygen concentration was below normal level during the summer and the highest during the rainy month but started declaiming at the

Table: 4 (A)

Showing certain physicochemical parameters at various sampling stations of the Kharkai river during March' 2012 to Feb' 2014

Current Speed (cm / sec)

Station	Months																						
	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14
S_1	9	8	8	12	42	52	34	22	47	15	12	12	10	9	9	9	32	48	29	20	16	12	10	9
S_2	14	14	13	17	40	45	32	25	23	18	18	19	15	16	14	12	30	45	32	23	22	19	21	15
S_3	16	16	14	20	40	46	30	24	22	24	23	23	21	18	17	15	32	44	30	25	24	26	23	19

pH

Station	Months																						
	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14
S_1	7.0	7.0	7.0	7.0	6.9	6.9	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.9	6.9	6.9	6.9	7.0	7.0	7.0	7.0	7.1	7.1
S_2	7.0	7.0	7.1	7.1	7.0	7.0	7.0	7.0	7.2	7.1	7.2	7.1	7.1	7.2	7.1	7.0	7.0	7.0	7.1	7.2	7.0	7.1	7.1	7.1
S_3	7.1	7.0	7.0	7.0	7.1	7.2	7.1	7.2	7.1	7.2	7.2	7.0	7.0	7.2	7.2	7.1	7.2	7.1	7.2	7.0	7.0	7.0	7.0	7.1

Water Temperature (C)

Station	Months																						
	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14
S_1	26.3	27.2	31.0	35.2	29.5	25.5	25.2	27.1	24.0	19.1	18.5	19.1	21.0	26.5	31.3	34.0	29.2	27.5	28.3	27.0	21.5	18.8	18.5	19.0
S_2	26.3	27.3	30.8	36.0	28.7	28.6	29.3	27.3	24.3	19.2	18.6	19.3	24.1	26.6	31.4	35.2	29.2	27.8	28.5	27.0	21.7	18.8	18.7	19.0
S_3	25.8	26.9	30.5	36.5	29.5	28.0	29.1	26.8	25.0	19.5	19.0	19.2	21.2	25.6	30.9	36.9	29.4	27.8	28.6	27.1	27.4	18.6	18.6	19.2

PO_4 (ppm)

Station	Months																						
	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14
S_1	0.03	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.05	0.04	0.05	0.04	0.05	0.05	0.02	0.02	0.10	0.08	0.03	0.03	0.03	0.03
S_2	0.21	0.23	0.21	0.21	0.20	0.16	0.18	0.25	0.25	0.28	0.28	0.25	0.29	0.28	0.28	0.25	0.23	0.23	0.27	0.28	0.17	0.19	0.17	0.19
S_3	1.23	1.25	1.05	0.89	1.05	0.84	0.42	0.64	0.85	1.50	1.42	1.50	1.90	1.86	1.88	0.50	0.48	0.50	0.62	1.05	0.90	0.95	1.17	1.15

NO_3 (ppm)

Station	Months																						
	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14
S_1	0.05	0.10	1.10	0.09	0.05	0.05	0.06	0.06	0.06	0.09	0.09	0.10	0.15	0.16	0.18	0.15	0.10	0.09	0.05	0.09	0.05	0.07	0.06	0.06
S_2	0.09	0.14	0.10	0.07	0.05	0.05	0.05	0.08	0.09	0.10	0.13	0.09	0.21	0.20	0.22	0.05	0.05	0.15	0.13	0.09	0.07	0.08	0.08	0.07
S_3	0.25	0.24	0.26	0.20	0.19	0.13	0.18	0.21	0.26	0.20	0.28	0.26	0.25	0.28	0.29	0.20	0.70	0.20	0.26	0.26	0.18	0.20	0.21	0.19

Table: 4 (B)

Showing certain physicochemical parameters at various sampling stations of the Kharkai river during March' 2012 to Feb' 2014

DO_2 (mg / l)																							
Station	Months																						
	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14
S_1	6.20	6.00	6.00	6.00	11.00	12.50	10.60	9.50	9.70	6.50	6.60	6.10	6.20	6.00	6.00	6.00	11.50	12.70	10.60	9.50	9.70	6.50	6.60	6.10
S_2	5.50	7.50	7.20	6.50	6.50	7.20	7.00	9.60	9.60	5.50	5.40	5.80	5.50	7.50	7.40	6.50	6.80	7.00	7.00	9.60	9.60	5.50	5.40	5.80
S_3	7.20	7.50	7.00	7.20	7.00	7.00	7.20	7.50	7.00	7.20	7.20	7.00	7.00	7.20	7.00	7.50	7.50	7.20	7.20	7.50	7.00	7.20	7.20	7.00

FCO_2 (mg / l)																							
Station	Months																						
	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14
S_1	0.04	0.04	0.04	0.06	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.06	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04
S_2	0.04	0.04	0.05	0.06	0.01	0.03	0.04	1.03	0.04	0.04	0.04	0.04	0.04	0.05	0.06	0.02	0.03	0.04	0.03	0.04	0.04	0.04	0.04	0.04
S_3	0.04	0.05	0.06	0.06	0.03	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.03	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.04

Chloride (mg / l)																							
Station	Months																						
	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14
S_1	92.00	130.00	80.00	50.00	40.00	90.00	86.00	116.00	68.00	85.00	105.00	90.00	92.00	130.00	80.00	50.00	70.00	90.00	86.00	116.00	68.00	85.00	106.00	92.00
S_2	70.00	90.00	120.00	32.00	75.00	80.00	92.00	84.00	44.00	69.00	95.00	70.00	70.00	90.00	120.00	32.00	75.00	80.00	92.00	84.00	44.00	70.00	95.00	70.00
S_3	69.00	114.00	90.00	52.00	15.00	110.00	118.00	101.00	68.00	90.00	80.00	99.00	69.00	114.00	90.00	52.00	65.00	110.00	118.00	100.00	69.00	92.00	80.00	99.00

Clacium (mg / l)																							
Station	Months																						
	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14
S_1	175.00	160.00	170.00	110.00	190.00	160.00	165.00	178.00	180.00	170.00	160.00	165.00	175.00	160.00	170.00	100.00	190.00	160.00	165.00	180.00	180.00	170.00	170.00	160.00
S_2	190.00	160.00	160.00	94.00	180.00	140.00	246.00	178.00	180.00	180.00	230.00	190.00	190.00	160.00	160.00	95.00	180.00	140.00	240.00	180.00	180.00	180.00	180.00	230.00
S_3	190.00	180.00	210.00	130.00	230.00	210.00	246.00	180.00	180.00	200.00	140.00	210.00	190.00	180.00	210.00	130.00	290.00	210.00	215.00	190.00	180.00	180.00	200.00	140.00

Table : 5

Variations in Dissolved Oxygen (mg/l) at three Stations of River Kharkai

During Mar-2012 to Feb-2014

Months	Stations		
	S_1	S_2	S_3
Mar-12	6.00	5.50	7.00
Apr-12	6.00	7.50	7.00
May-12	6.20	7.20	7.20
Jun-12	6.20	6.50	7.50
Jul-12	11.50	6.80	7.50
Aug-12	12.70	7.00	7.20
Sep-12	10.60	7.00	7.20
Oct-12	9.50	9.60	7.50
Nov-12	9.70	9.60	7.00
Dec-12	6.50	5.50	7.20
Jan-13	6.60	5.40	7.20
Feb-13	6.10	5.80	7.00
Mar-13	6.20	5.50	7.00
Apr-13	6.00	7.50	7.20
May-13	6.00	7.40	7.00
Jun-13	6.00	6.50	7.50
Jul-13	11.50	6.80	7.50
Aug-13	12.70	7.00	7.20
Sep-13	10.60	7.00	7.20
Oct-13	9.50	9.60	7.50
Nov-13	9.70	9.60	7.00
Dec-13	6.50	5.50	7.20
Jan-14	6.60	5.40	7.20
Feb-14	6.10	5.80	7.00

Fig 6(a)

Po_4 Concentration (ppm) at the three Sampling Stations of Kharkai River during – March 2012 to Feb 2014

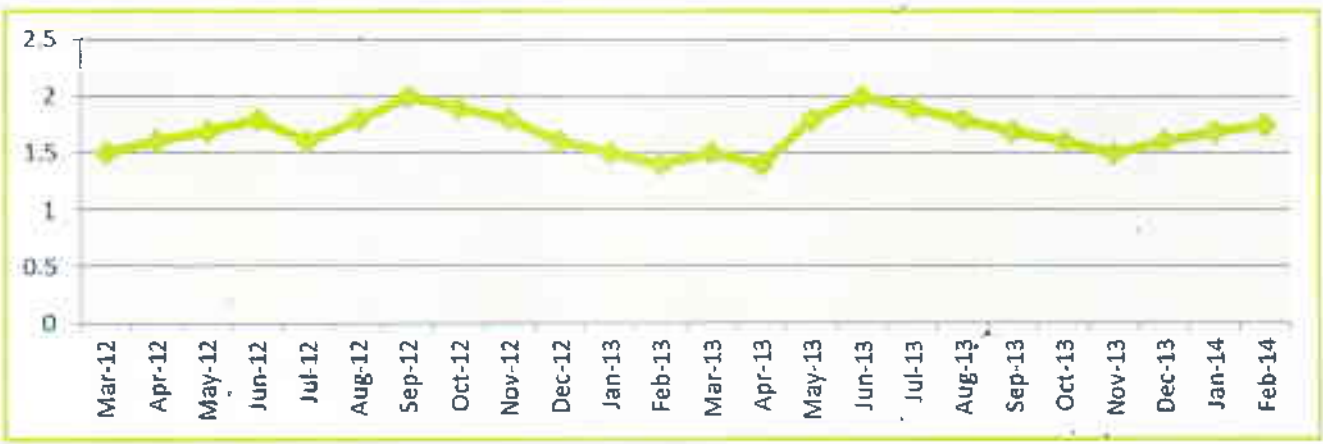


Fig 6(b)

Mean of Po_4 at the three Station of Kharkai river

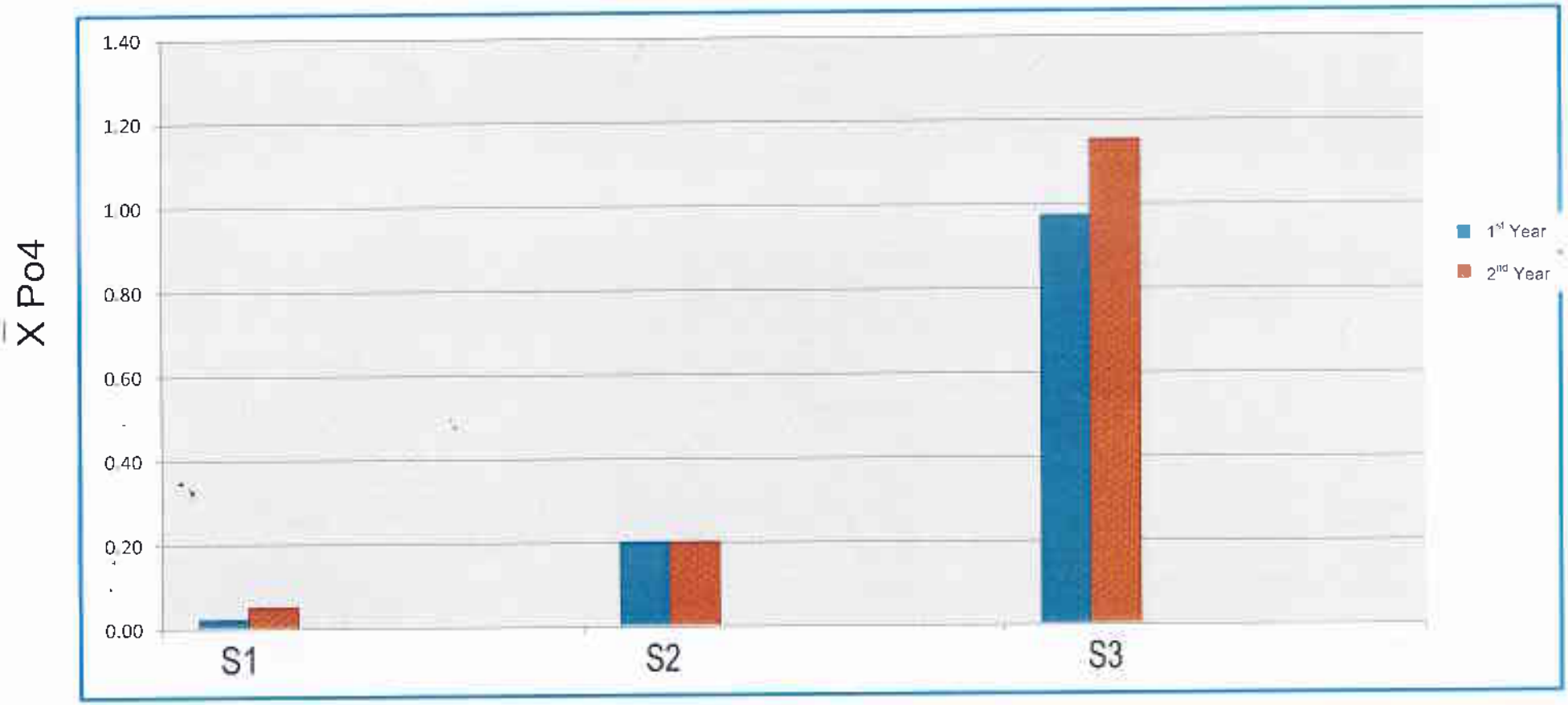


Fig 7(a)

No_3 Concentration (ppm) at three Sampling Stations of the Kharkai River during March-2012 to Feb-2014

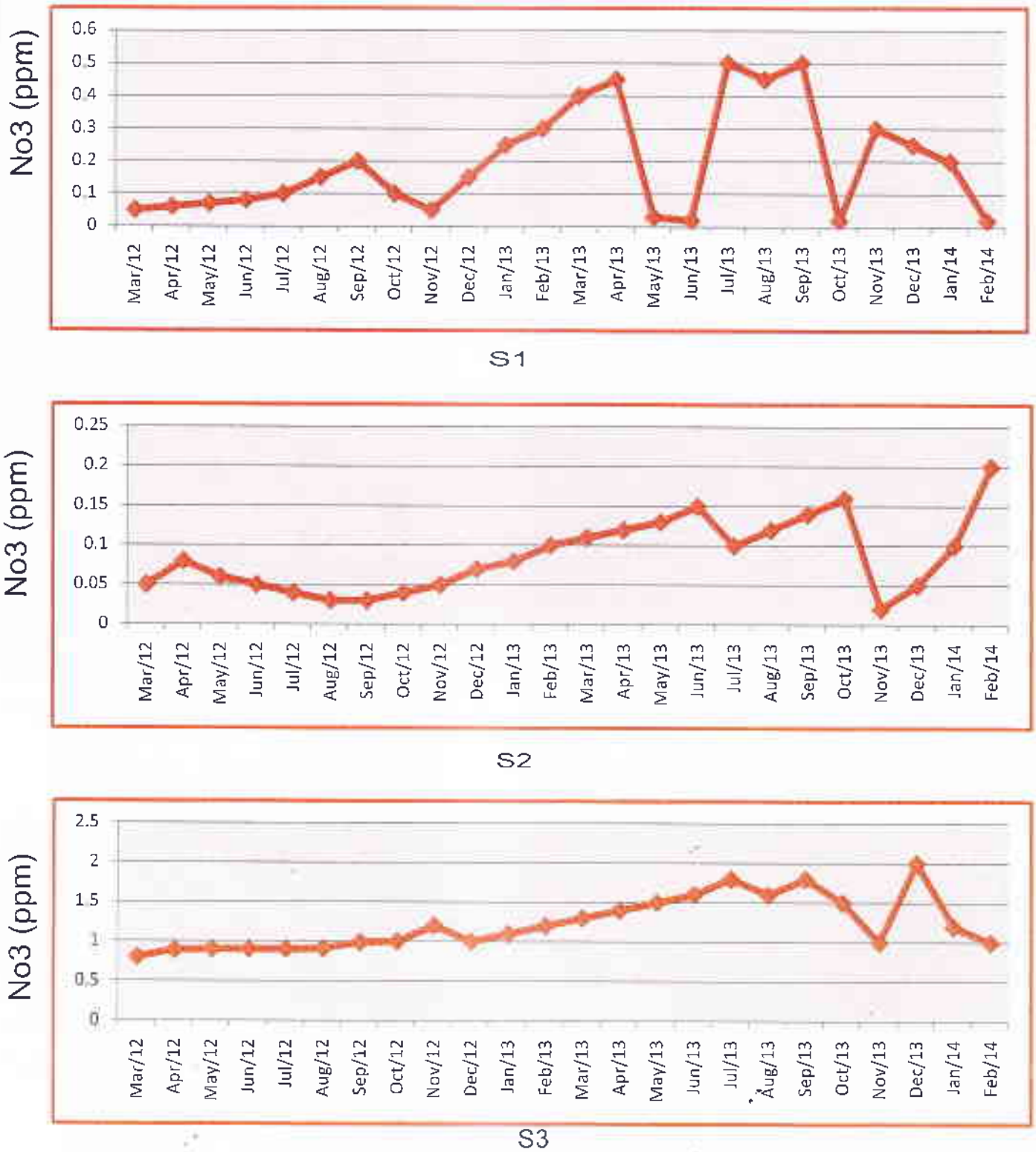


Fig 7(b)

Mean Value of No_3 Concentration (ppm) at three Sampling Stations of the Kharkai River during March-12 to february-14

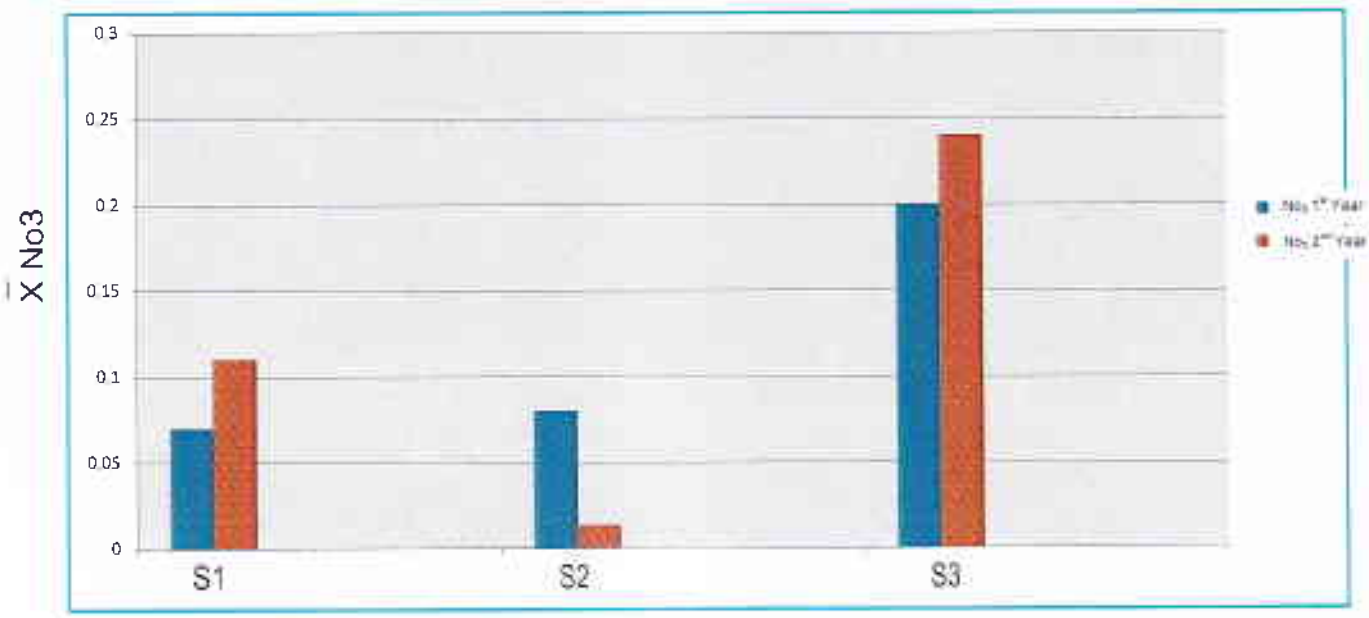
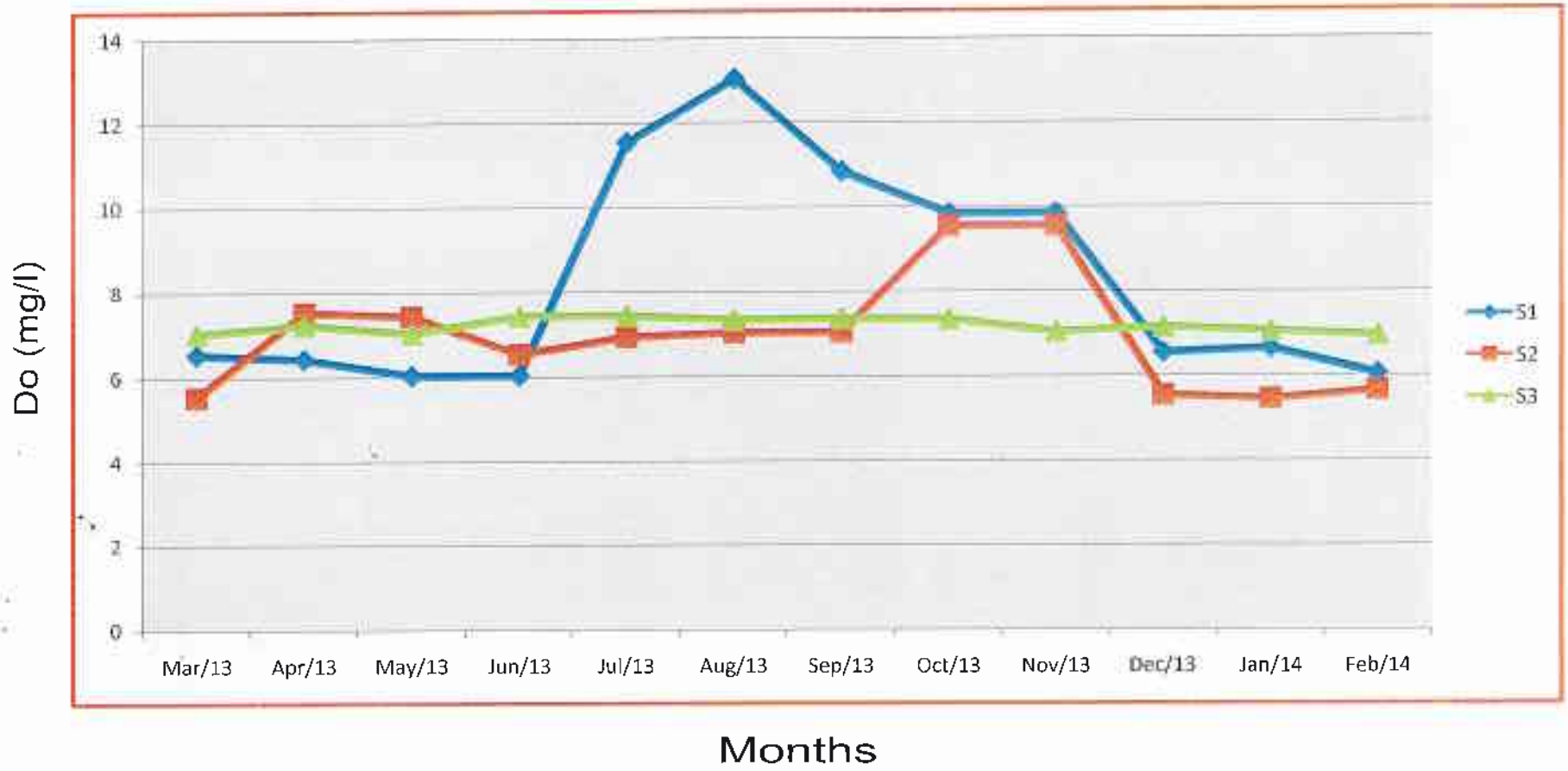


Fig 8

Graphical representation of Dissolve oxygen (mg/l) of Kharkai River at three Stations during March 2013 to February2014



advent of winter season. A similar pattern of dissolved oxygen has been reported by Prasad *et.al.* (1980). Fig. 8 shows the trend of dissolved oxygen during the study period. It is seen that the peak of the dissolved oxygen reached in the month of July-Aug in rainy season. In other months of rainy season the concentration of dissolved oxygen was remarkably low, it was totally absent during later three months of summer season. In fact oxygen is less freely soluble in water as compared to the solubility of some other gases like carbon dioxide, ammonia, etc. Several investigators have consequently reported values of 0.00 mg/l to a value of as high as 16 mg/l for water of Indian rivers (Bhatt *et.al.* 2004). Thus the current observation of oxygen concentration in Kharkai river water is in line with the previous records.

Free Carbon Dioxide:

Free of the water sample ranged between 0.03 to 0.06 for site S_1, S_2 and S_3 all maximum free CO_2 was recorded in the month of June for all the sites (S_1 to S_3) and minimum (0.03 mg/l) in many months of the study year for the water samples of all three sites.

The annual averages reveal that site S_3 had maximum values of 0.042 mg/l and S_1 had minimum average value of 0.036 mg/l. The values for river water of site S_2 was closer to each other and had more or less similar trend with lit.tle variation throughout the year.

Fig.9 suggests that free carbon dioxide value was lowest in October at all the three study sites. A gradual increase in the value was apparent in the subsequent months. The peak value was obtained in the month so May and June. Here after again a decrease in the value of free carbon dioxide because apparent in July and onwards months. A large number of earlier workers Chako *et.al.* (1959), Singh *et.al.* (1985), Shreenivasan (1965), Sugunam, V.V. (1999), Bhatt *et.al.* (2004), Sharma, L.L. *et.al.* (1995).

Total Alkalinity:

Alkalinity is considered to be an important basis for classifying water in the nutrient types. The rise and fall of total alkalinity probably corresponded with that of bicarbonates. Total Alkalinity has been estimated by titrating the sample.

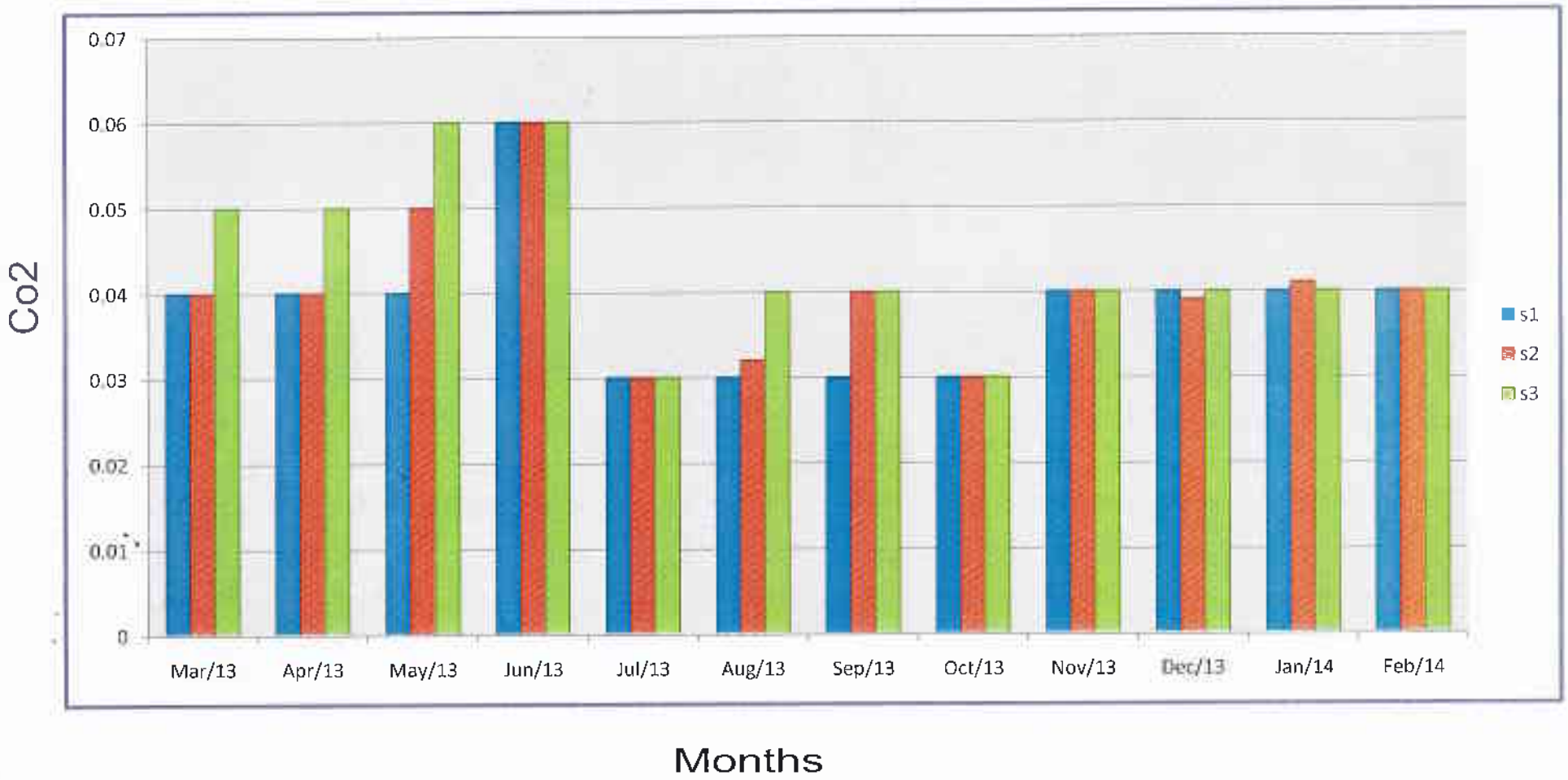
Table : 6

Variations in Carbon Dioxide (mg/l) at three Stations of the Kharkai river during Mar'12 to Feb'14

Months	Stations		
	S_1	S_2	S_3
Mar-12	0.04	0.04	0.05
Apr-12	0.04	0.04	0.05
May-12	0.03	0.05	0.06
Jun-12	0.06	0.04	0.05
Jul-12	0.04	0.01	0.04
Aug-12	0.03	0.03	0.05
Sep-12	0.03	0.04	0.04
Oct-12	0.03	0.03	0.03
Nov-12	0.04	0.04	0.04
Dec-12	0.04	0.04	0.04
Jan-13	0.04	0.04	0.04
Feb-13	0.04	0.04	0.04
Mar-13	0.04	0.04	0.05
Apr-13	0.04	0.04	0.05
May-13	0.04	0.05	0.06
Jun-13	0.06	0.06	0.06
Jul-13	0.03	0.00	0.03
Aug-13	0.03	0.03	0.04
Sep-13	0.03	0.04	0.04
Oct-13	0.03	0.03	0.03
Nov-13	0.04	0.04	0.04
Dec-13	0.04	0.04	0.04
Jan-14	0.04	0.04	0.04
Feb-14	0.04	0.04	0.04
Mean	**0.038**	**0.037**	**0.044**

Fig 9

Histogram of Co_2 of Kharkai River at Three Sampling Stations



Calcium:

Calcium hardness ranged from 110.00 to 190.00 mg/l and 94.00 to 246.00 mg/l and 130.00 to 230.00 mg/l for site S_1, S_2 and S_3 respectively (Table 8).

Lower values of calcium were recorded in the month of June for all the sites (S_1 to S_3). Maximum calcium hardness was observed in the month of July for site S_1 and S_3 and in September for Site S_2. Site S_2 maintained a distinctly higher values in calcium.

Hardness through out the year as compared to the values for site S_1 and S_3.

On the annual average maximum calcium in water (190.50 mg/l) was obtained at site S_3 and lowest value of calcium (165.00 mg/l) was recorded for site S_1 respectively. The monthly variation in the amount of calcium was more or less similar at all the three sites. The values of hardness although did not exhibit any seasonal pattern but were higher during the rainy months (July, August, September) and the slightly lower values were obtained in the winter months (October, November and December) in comparison to summer months.

Fig. 11 suggests that calcium was always in higher concentration in the water of all three study sites. Its low concentration in water was recorded only in the month of June, while the peak value was obtained in the month of September Munawar (1970) also noted higher values of calcium during winter and summer months.

Chloride:

Estimation of Chloride content as exhibited by Table 7, showed that it ranged between 40.0 to 130.0 mg/l, 32.0 to 120.0 mg/l and 52.0 to 118.0 mg/l for site S_1, S_2 and S_3 sample respectively.

Chloride was recorded in minimum quantity 40 mg/l at site S_1 in the month of July, while at sites S_2 and S_3 the respective minimum values of 32 mg/l and 52 mg/l were recorded in the month of June.

Computation of monthly average (Table 7) revealed that annual average of Chloride concentration was minimum at S_2 (76.75 mg/l). The

Table : 7

Variations in Chloride ion concentration in (mg/l) at three Stations of the Kharkai river water during Mar'12 to Feb'14

Months	Stations		
	S_1	S_2	S_3
Mar-12	93.00	72.00	69.00
Apr-12	130.00	90.00	113.00
May-12	80.00	120.00	90.00
Jun-12	50.00	33.00	53.00
Jul-12	40.00	75.00	65.00
Aug-12	90.00	80.00	110.00
Sep-12	86.00	92.00	118.00
Oct-12	116.00	84.00	102.00
Nov-12	68.00	44.00	68.00
Dec-12	85.00	69.00	90.00
Jan-13	105.00	95.00	80.00
Feb-13	90.00	70.00	99.00
Mar-13	92.00	70.00	69.00
Apr-13	130.00	90.00	114.00
May-13	80.00	120.00	90.00
Jun-13	50.00	32.00	52.00
Jul-13	40.00	75.00	65.00
Aug-13	90.00	80.00	110.00
Sep-13	86.00	92.00	118.00
Oct-13	116.00	84.00	101.00
Nov-13	68.00	44.00	68.00
Dec-13	85.00	69.00	90.00
Jan-14	105.00	95.00	80.00
Feb-14	90.00	70.00	99.00
Mean	**86.04**	**76.88**	**88.04**

Fig 10

Chloride of Kharkai River at Three Stations (March 2013 – Feb 2014)

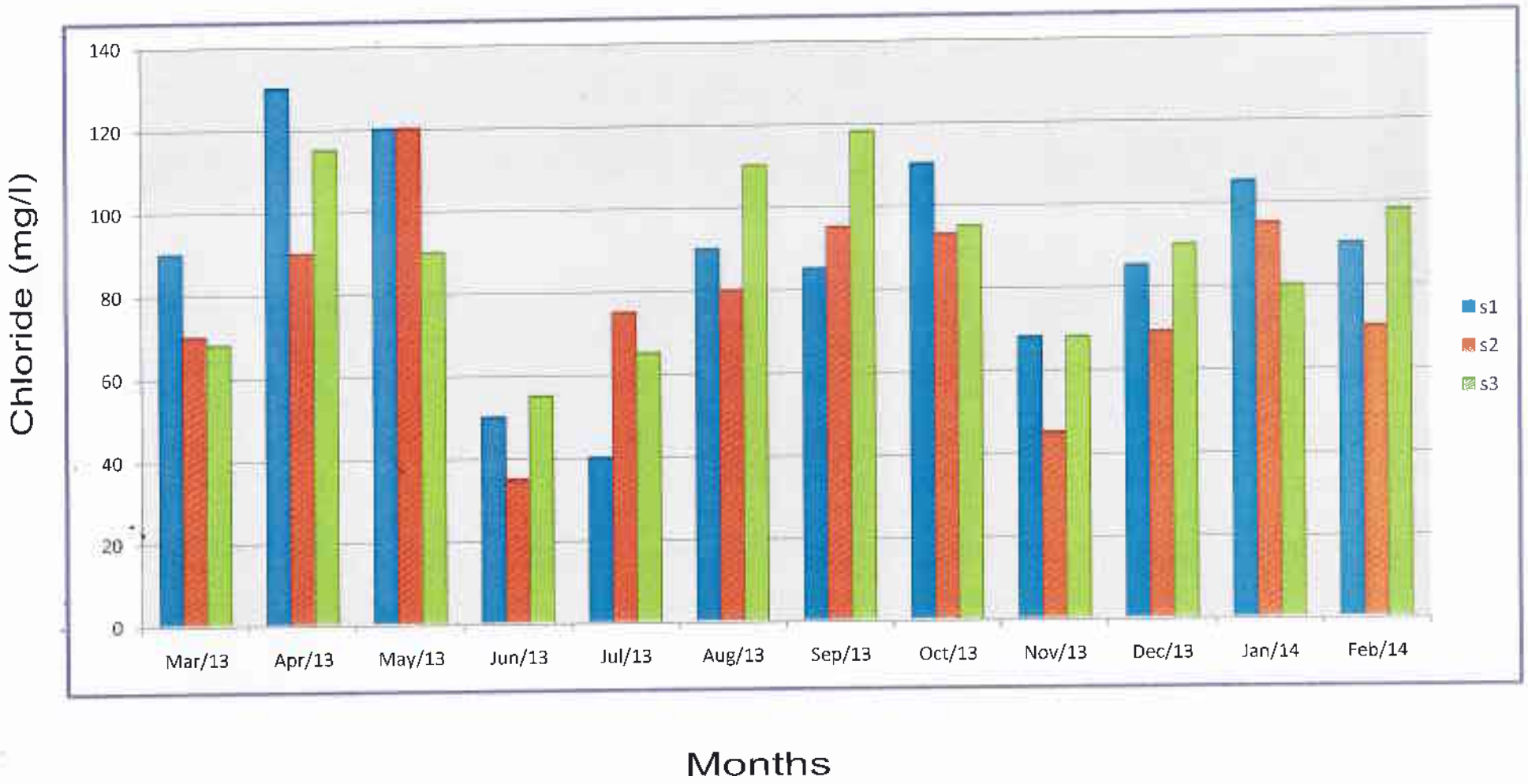


Table : 8

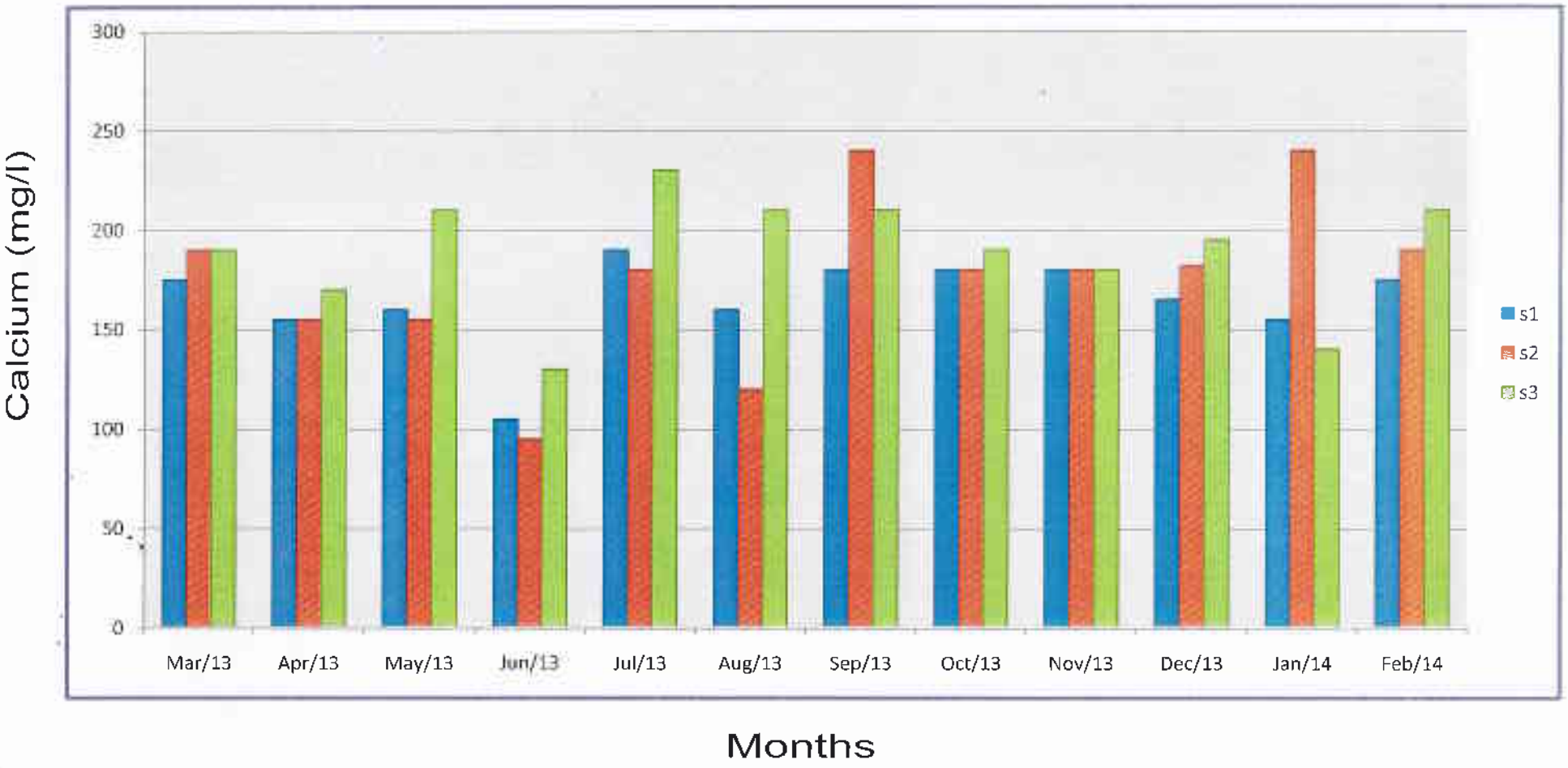
Variations in Calcium (mg/l) at three Stations

of the Kharkai river water during Mar'12 to Feb'14

Months	Stations		
	S_1	S_2	S_3
Mar-12	175.00	190.00	190.00
Apr-12	160.00	160.00	180.00
May-12	170.00	160.00	210.00
Jun-12	120.00	96.00	130.00
Jul-12	190.00	180.00	230.00
Aug-12	160.00	140.00	210.00
Sep-12	167.00	246.00	216.00
Oct-12	178.00	177.00	189.00
Nov-12	180.00	180.00	180.00
Dec-12	170.00	180.00	200.00
Jan-13	160.00	230.00	140.00
Feb-13	165.00	190.00	210.00
Mar-13	175.00	190.00	190.00
Apr-13	160.00	160.00	180.00
May-13	170.00	160.00	220.00
Jun-13	110.00	94.00	130.00
Jul-13	190.00	180.00	230.00
Aug-13	160.00	140.00	210.00
Sep-13	165.00	246.00	216.00
Oct-13	178.00	178.00	190.00
Nov-13	180.00	180.00	180.00
Dec-13	170.00	180.00	200.00
Jan-14	160.00	230.00	140.00
Feb-14	165.00	190.00	210.00
Mean	**165.75**	**177.38**	**190.88**

Fig 11

Calcium of Kharkai River at Three Stations (March 2013 – Feb 2014)



annual average of S_1 was 86.00 mg/l and S_3 was 88.41 mg/l. So average of S_1 was very close to that of S_3.

Gonzalves and Joshi (1946) took chloride into account in the tank water and according to them, the concentration of chloride increases in the summer when the water level is low. However in the present investigation too, the chloride concentration showed a regular periodicity, being higher in the warmer summer months (Fig. 10). When its peak values were recorded abruptly decreased in June. But steadily increased in rainy season. Its concentration in comparatively lower concentration except only one case in May during the study period.

Phosphates (PO_4):

It is a nutrient. It is needed for primary production in aquatic habitats. PO_4 is available in running water. Phosphorus occurs in two forms firstly as simple ionic orthophosphates and secondly as bound phosphates in soluble and particulate form. The bound phosphate is continuously released by bacterial activity.

During first year of observations the concentration of phosphates ranged between 0.2 ppm to 0.05 ppm at S_1, 0.16 ppm to 0.28 ppm at S_2 and 0.42 ppm to 1.50 ppm at S_3; whereas during second year of observation it ranged between 0.02 ppm to 0.10 ppm at S_1; 0.17 ppm to 0.29 ppm at S_2 and 0.48 ppm to 1.90 ppm at S_3.

In the present investigation phosphate concentration revealed lower values during monsoon months and higher values during dry months, especially in summer season (Fig. 6a).

The minimum value of phosphate concentration was recorded in the months of June, July, August, September and October 2012 at S_1 (0.02 ppm) in August'12 at S_2 (0.16 ppm), in May'13 at S_3 (0.48 ppm); whereas the maximum value was recorded in the month of July, April and May'12 at S_1 (0.04 ppm); in December'12 at S_2 (0.28 ppm) and the month of April at S_3 (1.25 ppm) during first year of observation. Similarly during second year the maximum value of phosphate concentration was recorded in the month of

September at 2013 at S_1 (0.10 ppm); in the month of March'13 at S_2 (0.29 ppm) and in the month of March'13 at S_3 (1.90 ppm) (Fig. 6b).

The phosphate concentration was low in the beginning but attained higher values in the later part of observation.

Compare to first year the phosphate concentration in second year at observation increased by 67% at S_1, 30% at S_2 and 22% at S_3.

Nitrate (NO_3):

From study point of view the nitrate concentration was low at upstream stations but attained higher volume at downstream stations (Table 4).

The nitrate concentration ranged between 0.05 ppm to 1 ppm at S_1, 0.05 ppm to 0.14 ppm at S_2 and 0.13 ppm to 26 ppm at S_3 during first year of observation, whereas during second year it ranged between 0.05 ppm to 18 ppm at S_1, 0.05 ppm to 0.22 ppm at S_2 and 0.17 ppm to 0.29 ppm at S_3.

In the present investigation nitrate concentration recorded lower values during monsoon months and higher values during dry months especially during summer months (Fig. 7a).

The minimum value of nitrate concentration was recorded in the month of July, August and September'13 at S_1 (0.05 ppm); in July, August and September'13 at S_2 (0.05 ppm) and in August'13 at S_3 (0.13 ppm); whereas the maximum value was recorded in the month of April and May'13 at S_1 (0.1 ppm); in April'13 at S_2 (0.14 ppm) and in May'13 at S_3 (0.26 ppm) during the first year of observations. Similarly during second year the minimum value of nitrate concentration was recorded in the month of September'13 at S_1 (0.05 ppm), in June and July'13 at S_2 (0.05 ppm) and in July'13 at S_3 (0.17 ppm); whereas the maximum value was recorded in the month of May'13 at S_1 (0.18 ppm), S_2 (0.22 ppm) and S_3 (0.29 ppm).

The data also revealed that the nitrate concentration was low in the beginning but attained higher values in the later part of investigation.

The mean values of nitrate concentration were 0.07 ppm and 0.11 ppm at S_1, 0.08 ppm and 0.13 ppm at S_2 and 0.20 ppm to 0.24 ppm at S_3 (Fig. 7b).

Iron:

Iron was found to range between 0.09 to 0.73 mg/l at S_1, 0.10 to 0.96 mg /l at S_2 and 0.09 to 0.86 mg/l at S_3 during the study year.

Maximum iron content in water was recorded in the month of November for all three sites S_1 (0.73 mg/l) in January for site S_2 (0.69 mg/l) and in November for site S_3 (0.86 mg/l). However the minimum iron content was recorded in the samples of May for all the three sites on the annual average basis site S_3 had minimum value of 0.50 mg/l, S_2 had minimum average value of 0.47 mg/l. The value for sewage water at site S_1 was 0.48 mg/l (Table 9).

Fig.12 exhibits that iron concentration in Kharkai River water was consistently moderate at all the three sites between October to March. Its amount suddenly dropped during the subsequently months of April and May, but increased after May. The upper values of iron concentration were always recorded at site S_3, Table 9.

Heavy Metal Estimation of Three Stations of Kharkai River:

Water plays several role in the ecological relation of the fauna and flora. Any deterioration in its quality can be of great harm to human being as well as to the environment. The continuous addition of treated and untreated wastes from various activities change the water quality. Analysis of water samples is done for water quality parameters like pH, total hardness, DO trace elements concentration like Zn and toxic elements concentration like Cd and Pb. In fishes- Their gills, muscles, fins, are analysed for Mo, Zn, Cd, Co and Pb; Table 11 (a, b and c). These elements ultimately reach the human body. Zoo plankton and other micro benthos serve as food source to fishes. Toxic metals influence the population of Zoo plankton and cause sharp decline in micro and macro zoobenthos colonies.

Important physical and chemical parameters of surface water at the sampling stations were analysed monthly, water and fish samples were analysed for trace elements like Zn and toxic elements like Cd and Pb. Fish organs and phyto plankton collectively were dried and ashed in the Muffle furnace at 450°C. Ash was dissolved in 10% HNo_3. Then metals in the ash

Table : 9

Variations in Iron (mg/l) at three Stations

of the Kharkai river water during Mar'12 to Feb'14

Months	Stations		
	S_1	S_2	S_3
Mar-12	0.64	0.68	0.70
Apr-12	0.15	0.12	0.14
May-12	0.09	0.10	0.09
Jun-12	0.62	0.62	0.50
Jul-12	0.18	0.17	0.19
Aug-12	0.50	0.46	0.43
Sep-12	0.48	0.42	0.46
Oct-12	0.56	0.50	0.52
Nov-12	0.73	0.64	0.86
Dec-12	0.60	0.67	0.68
Jan-13	0.70	0.69	0.72
Feb-13	0.60	0.68	0.72
Mar-13	0.64	0.68	0.70
Apr-13	0.15	0.12	0.14
May-13	0.09	0.10	0.09
Jun-13	0.62	0.62	0.50
Jul-13	0.17	0.17	0.19
Aug-13	0.52	0.46	0.42
Sep-13	0.48	0.40	0.46
Oct-13	0.56	0.50	0.52
Nov-13	0.73	0.64	0.86
Dec-13	0.60	0.67	0.68
Jan-14	0.70	0.69	0.72
Feb-14	0.60	0.68	0.72
Mean	**0.49**	**0.48**	**0.50**

Table : 10

Total Alkalinity (ppm) at three Stations

of the Kharkai river water during March'13 to Feb'14

Months	Stations		
	S1	S2	S3
Mar-12	140	134	124
Apr-12	123	123	115
May-12	109	126	140
Jun-12	114	122	131
Jul-12	104	109	123
Aug-12	122	138	124
Sep-12	141	124	138
Oct-12	124	122	136
Nov-12	122	134	123
Dec-12	133	122	141
Jan-13	107	138	124
Feb-13	123	139	138
Mar-13	140	134	124
Apr-13	123	123	115
May-13	109	126	140
Jun-13	114	122	131
Jul-13	104	109	123
Aug-13	122	138	124
Sep-13	141	124	138
Oct-13	124	122	136
Nov-13	122	134	123
Dec-13	133	122	141
Jan-14	107	138	124
Feb-14	123	139	138

were complexed with suitable reagent. Perkin Elmer model 4000 (Atomic absorption spectro photometer) was used for Zn, Cd and Pb estimations. Maximum absorption was obtained by adjusting the cathode lamps. Water quality parameters were determined as per the details mentioned in "Manual on water and waste analysis (pp.355 NEERI. (1986))". Proper authentic assurance help was taken from the renowned lab assistance of National Metallurgical laboratories, Burmamines, Jamshedpur (Jharkhand).

Table : 11 (a)

Result of Water Analysis

Parameter	Stations		
	S1	S2	S3
Total Hardness	550 mg/l	600 mg/l	500 mg/l
Sodium ion	175 mg/l	200 mg/l	180 mg/l
Zn ion	6 mg/l	5.5 mg/l	5 mg/l
Pb ion	0.07 mg/l	0.05 mg/l	0.06 mg/l
Cd ion	0.02 mg/l	0.03 mg/l	0.02 mg/l
Cl^- ion	130 mg/l	120 mg/l	114 mg/l

Table : 11 (b)

Lead Concentration (in ppm) in *Mystus vitatus*

Species organs / year	Stations		
	S1	S2	S3
Muscles 2013	0.27	0.28	0.28
Visceral organ 2013	0.28	0.27	0.25
gill 2013	0.17	0.19	0.22

Contd..

Table : 11 (c)

Cadmium concentration (in ppm) in *Mystus vitatus*

Parameter	Stations		
	S1	S2	S3
Gill (2013)	0.07	0.09	0.09
Muscle (2013)	0.06	0.08	0.08
Visceral organ (2013)	0.07	0.06	0.04

Blood parameters are affected by Pb pollution. Cd^{2++} and Pb^{+2} tend to accumulate in gill, fin and liver. Cd^{+2} and Pb^{2+} from phyto and zooplankton come to fishes via food chain. Lead is known to have multiple hematotoxic effects. Cd has toxic effects on renal function.

B. PLANKTON (PHYTOPLANKTON AND ZOOPLANKTON):

Chapter consists study of Plankton. The term "plankton was coined by an oceanographer Victor in 1887." It is heterogeneous assemblages of minute free floating organism of water (Welch, 1952). Since the phytoplankton are considered as "Biological Indicator of pollution" a number of workers have contributed to their knowledge in the study of phytoplankton. On the basis of nature it is divided into two major groups phytoplankton and Zooplankton.

Phyto and Zooplankton are the basis components of the aquatic ecosystem. Two important aspects of hydrobiology like drinking water quality and fishery are intimately connected with the quality and quantity of these two components of the aquatic ecosystem.

The basis sampling or collection techniques of fresh water benthos were described by Wetzei (1975), Lind (1938), Welch (1952), Hutchinson (1967), Brinkhurst (1964), Klein (1956) and other several keys for the identification of benthic macro invertebrates were provided by Pennak (1956), Edmondson (1971), Needham (1971), Prescott (1973) and others.

Plankton organisms play a vital role in aquatic environment; they form an important link in the food chain and are capable of affecting the entire aquatic life. Information with regard to the fresh water planktonic organisms is scanty in India. Even the basis aspects of the knowledge of fresh water plankton is very limited and detailed study on their biological and ecological relations are required. However, the prominent contributions to the fresh water plankton in India were made by Allikunhi (1952), Arora (1931, 1966), Bhowmic (1968), Chacko and Krishnamoorthy (1954), Chacko and Sreenivasan (1955), Chakraborthy *et.al.* (1959), Das *et.al.* (1956b, 1959), David (1963), Dals (1954), George *et.al.* (1966), Govindan and Sudersan (1979), Trivedi (1979), Verma *et.al.* (1982), Verma and Dalela (1975), Zafar (1964, 1966), Trisal (1977), Jana (1973, 74, 1980), Shashikant (1979), Billore (1981), Kulshrestha (1981), Dad (1981), Rao *et.al.* (1982), Agarwal Gautam (1985), Bhowmic and Singh (1985), Singh and Singh (1985), Kulshrestha *et.al.* (1987), Adholla (1988), Bhattarcharya and Saha (1988), Trivedi, Garud and Goyal (1985), Expendith and Premkishore (1989), Ghosh and George (1989), Bhardwaj

(2005), Naik *et.al.* (2007), Nair (2009), Kalam (2011), Bhuyan *et.al.* (2014), Singh *et.al.* (2013, 2015).

Plankton play several important role in the aquatic community. Direct correlation has been established between the planktonic crop and fish production, because planktonic biomass indirectly related to the fish production. Among the planktonic communities, the zooplankton are the main primary micro consumers and are found to be dominated by Protozoa, Copepoda and Cladocera and Ostracoda.

Materials and Methods:

a. Plankton Collection:

The plankton net is a device used for collection of plankton of bigger size. The size of plankton which can be filtered by a net depends on the mesh size used (mesh 25). The use of Plankton net involves filtering large quantity of water through the nets. The water is filtered through the sides and the plankton can be concentrated in a bottle or test tube connected at the lower end of the net. The net is taken to the bottom through a rope and from there it is gradually hauled upwards with a speed of 10 cm/sec. The phytoplankton sample should be immediately preserved in 4% formalin but a better method of preservation is to use Lugol's solution for quantitative sampling, the Zooplankton are fixed in 2 – 3% formalin. For identification purpose, however it is better to preserve the plankton in Lugol's solution or with 70% ethanol. Net samples are usually concentrated.

b. Enumeration (=counting) of plankton:

Sedgwick-Rafter Cell Method-

Counting of zooplankton can be done by using Sedgwick – Rafter cell and the density is represented in organism/l or org./100l. The Sedgwick – Rafter cell strip generally available in 50 mm long, 20 mm wide and 1mm deep. Plankton are counted by microscope. The process is repeated about 10 replicates.

$$\text{No. of plankton /ml} = \frac{\text{No. of organisms counted}}{\text{No of replicates taken}}$$

If each strip is counted separately then.

$$\text{No. of plankton /ml} = \frac{\text{No. of organisms counted in all the stripes x 1000}}{\text{lxbxd of each strip x no. of stripes counted}}$$

Lackey's drop method:

This is the simplest method for counting phytoplankton and is especially useful when no other equipments is available. The count is fairly reliable (Lackey, 1938, Vollenweider, 1969, Edmerson, 1971) specially when density of phytoplankton is high.

Put exactly 0.1 ml volume of the sample by using a calibrated medicinal dropper on to a glass slide. Place cover slip on known area, avoiding any air bubble. Put the slide in microscope and measure the width of the high power microscopic field. Suppose the area visible at one time as one microtransect. Now move the slide from one corner to another counting the plankton in each microscopic filed visible. Count several fields by moving the slide in horizontal and vertical directions. Counting must quick to avoid drying of the sample.

Calculation:

$$\text{No of individual / drop} = \frac{\text{Area of cover slip (22 x 22) A x No. of organism counted in all fields}}{\text{Area of focus x average no of individual per focus}}$$

Individual per litre = A x l/L x V/v

A = No. of individuals per drop.

v = Volume of 1 drop. (ml).

V = Total volume of concentrated sample (ml)

L = Volume of the original sample. (say 10 ml)

Phytoplankton:

Phytoplankton are Chlorophyll bearing suspended microscopic organisms consisting of algae belonging to Chlorophyceae, Cyanophyceae, Euglennophyceae and Bacillariophyceae. They consist of recycling elements such as carbon and sulphur. They have ability to convert light energy into chemical energy.

Although there are a number of major groups of phytoplankton, those relevant to the present study are Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae.

1. Bacillariophyceae (diatoms) : is one of the most important groups of phytoplanktonic algae. Most species are sessile and associated with littoral substrata. Their primary characteristic is siliceous cell and both unicellular and colonial forms are common.
2. The Chlorophyceae (green algea) : is extremely large and morphologically diverse group which is mostly fresh water in distribution.
3. The Cyanophyceae (also known as Myxophyceae or blue-green algea) : has been among the most studies of all the groups. It is a primitive group which has both prokaryotic and eukaryotic features in its cell structure and function.
4. The Euglenophyceae (euglenoid algae) : forms a relatively large and diverse group but few species are truly planktonic.

The details of the comparative qualitative and quantitative occurrence of phytoplankton and zooplankton diversity at the three study stations shown in the next page:

Table: 12

The details of the comparative qualitative occurrence of phytoplankton diversity (u/l) at three study stations during Mar-12 to Feb-14

Pyhtoplankton and Classificaton	Sampling Stations		
	S_1	S_2	S_3
Cyanophyceae	**u/l**	**u/l**	**u/l**
Oscillatoria chalybea	146	172	181
Oscillaria curiceps	179	180	182
Nostoc commune	178	192	190
Nostoc paluaosum	188	183	172
Anabaena sphaerica	146	180	178
Anabaena oryzae	146	190	184
Scytonema stuposum	183	192	192
Chlorophyceae			
Ulotrix zonata	223	225	224
Cladophora fracta	220	221	281
Pithophora varia	272	346	480
Chaetophora elegans	491	374	378
Coleochate irregularis	372	281	273

Contd....

Pyhtoplankton and Classificaton	Sampling Stations		
	S_1	S_2	S_3
Zygnema majus	480	281	223
Spirogyra brunea	286	370	380
Oedogomium pussilum	284	390	385
Spirogyra microspora	440	450	385
Spirogyra liylina	380	378	370
Closterium dianae	410	----	280
Closterium acerosum	280	292	327
Euglenophyceae			
Euglena acus	215	----	178
Euglena acus varrigida	280	223	229
Euglena virdis	266	72	115
Phacus curvicauda	210	178	120
Volvox globater	184	200	218
Bacillariophyceae			
Synedra capitata	539	541	530
Navicula viridula	392	390	348

Navicula pupula	280	290	380
Pyhtoplankton and Classificaton	**Sampling Stations** Contd....		
	S_1	**S_2**	**S_3**
Pinnularia braunil	272	305	280
Pinnularia tabellaria	272	283	260

Zooplankton:

Zooplankton are microscopic free swimming animal components of aquatic system. The members of the groups are belonging to protozoa, Rotifera, Cladocera, Copepoda and Mollusca.

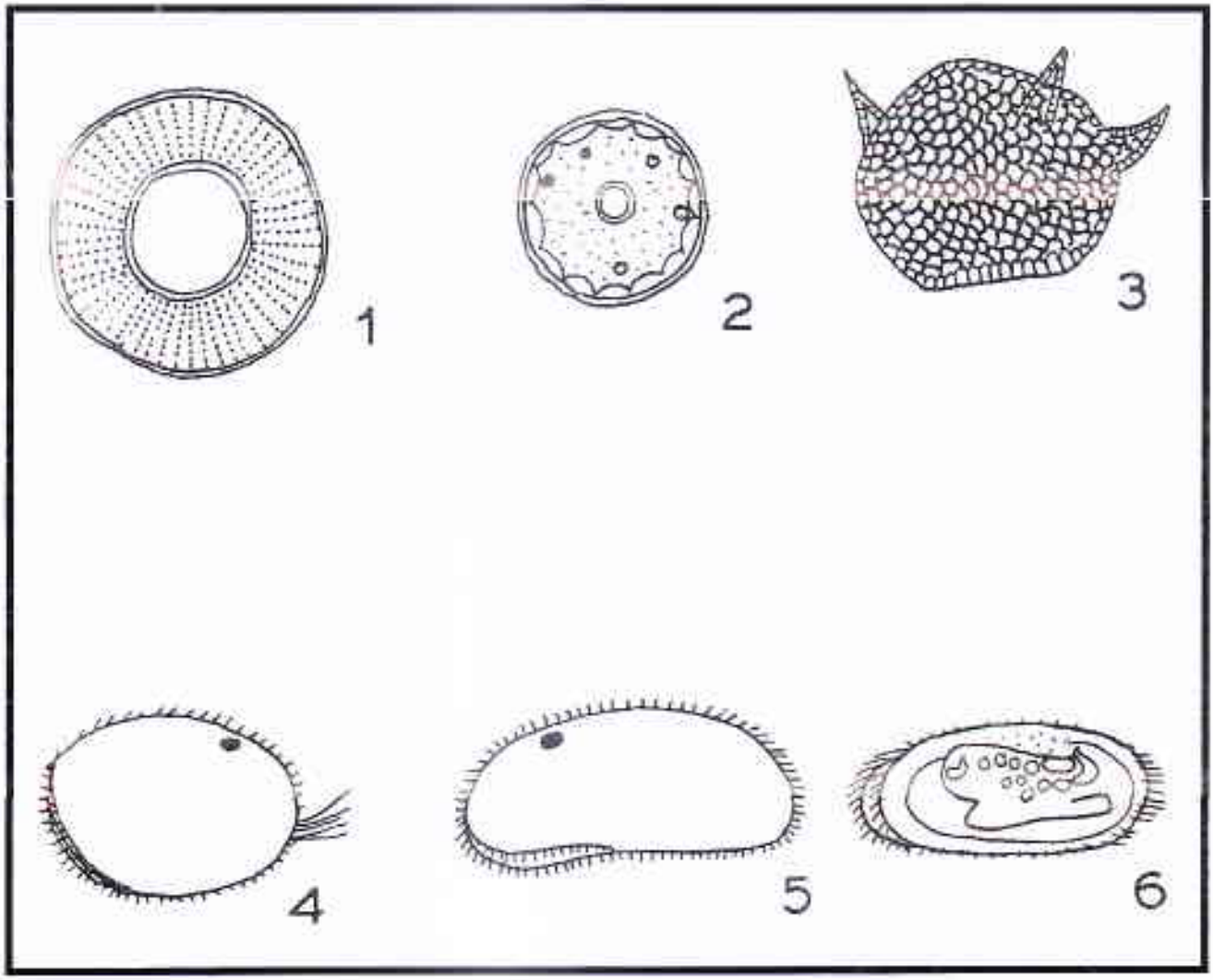
They dominate the entire consumer communities. The ability of movement not only provided them an effective defence measure but also enable them to show activity such as to feed upon the phytoplankton. They constitute an important link between primary producers and consumers in aquatic food ways.

The details of the comparative qualitative occurrence of Zooplankton diversity at the 3 study stations shown in the next page:

Among the protozoans only rhizopods were found represented by few species such as *Arcella, discoidea, centropyxis, echornia and diffugia, obleng.* They were found absent during October, November, April and May during the year 2012-13 and November, December and May during 2013-14. Maximum density was found in the month of August and minimum density in the month of January and February in 2012-13 and 2013-14 at all three sites.

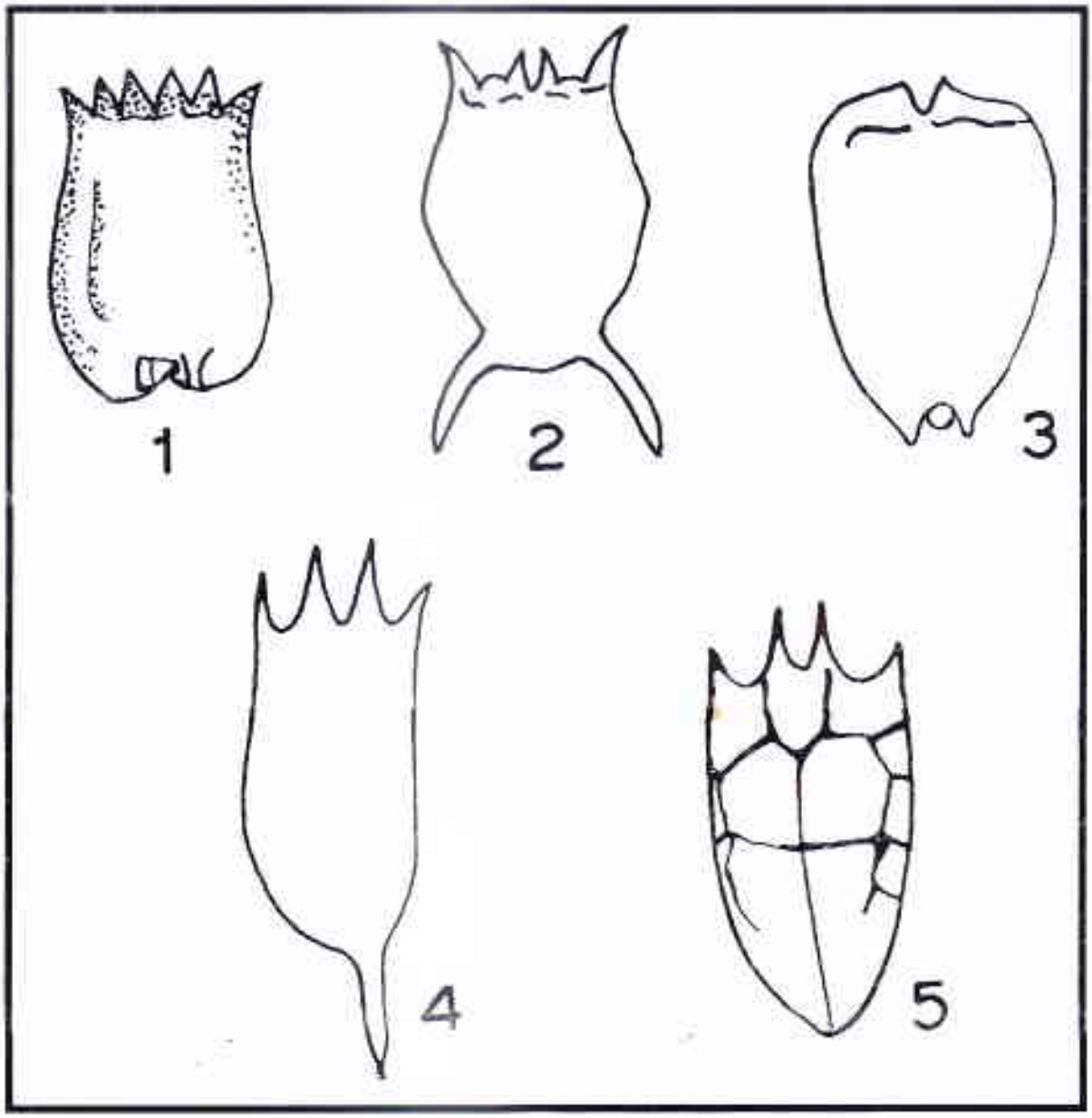
Protozoans were also absent from S_2 and S_3 during November, December, April, May and June.

PROTOZOA AND OSTRACODA



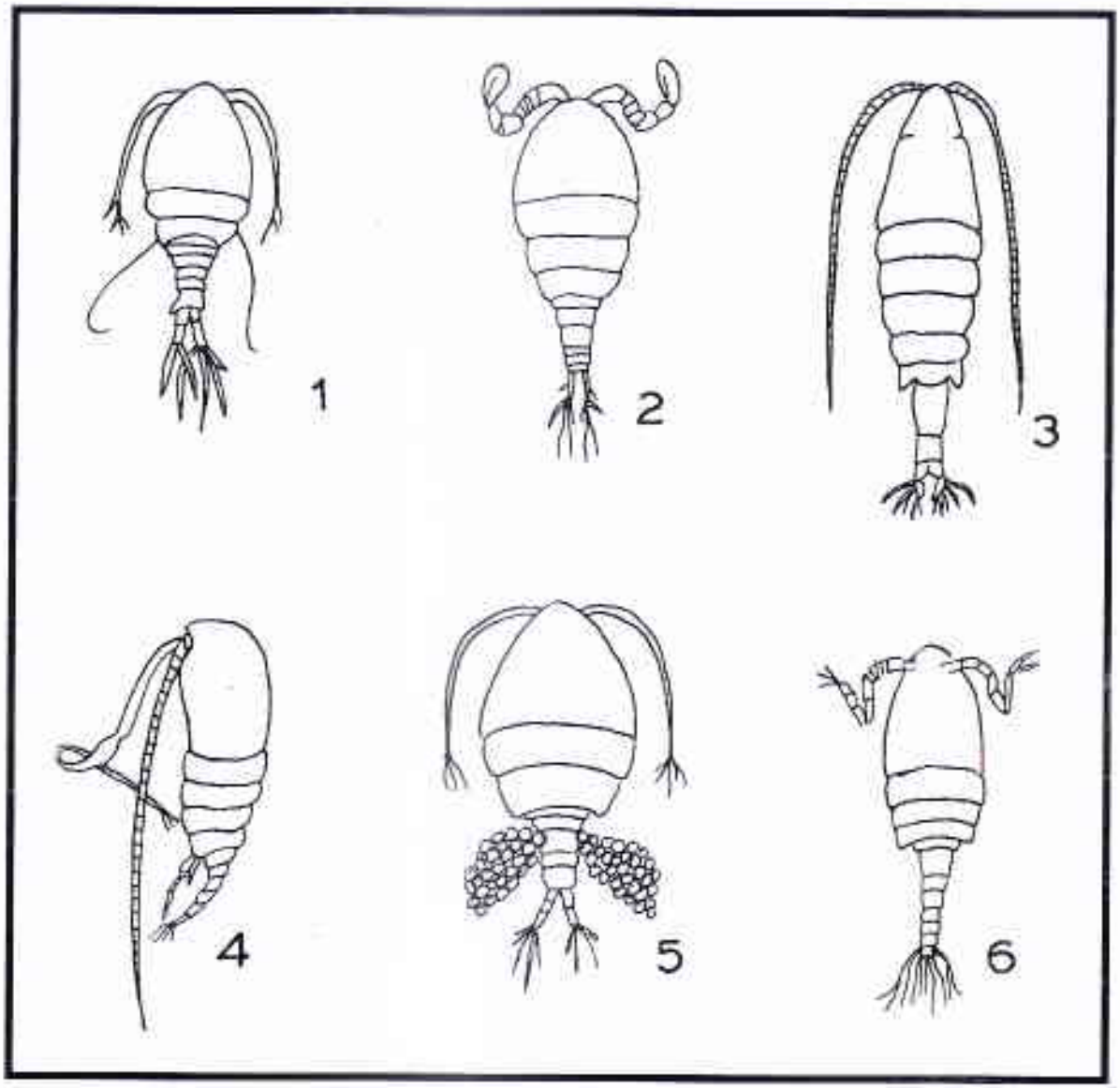
1. Arcella discoides
2. A. vulgaris
3. Difflugia corona
4. Cypris spp.
5. Heterocypris spp.
6. Stepnocypris malcomsoni

ROTIFERA



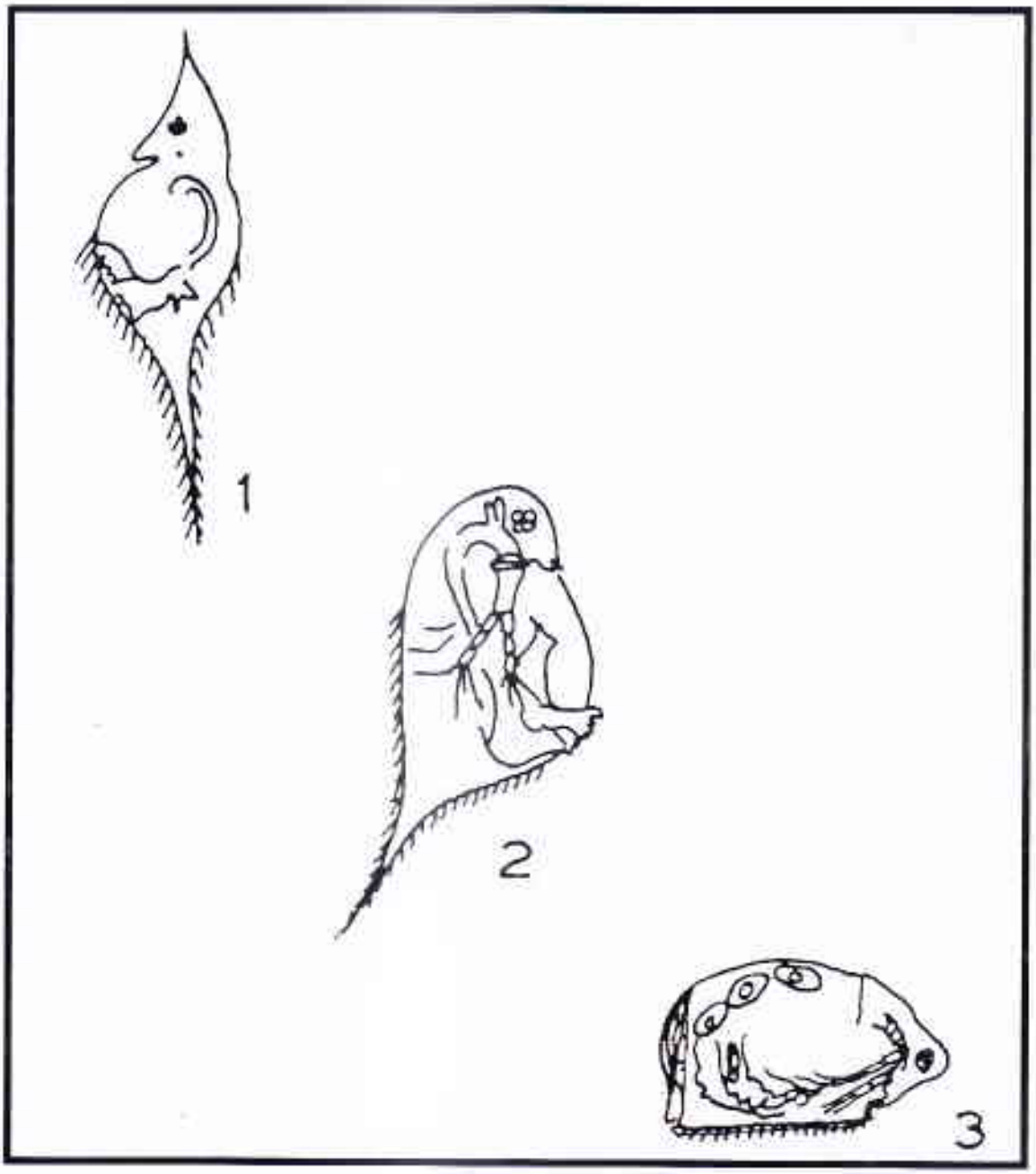
1. B. plicatilis
2. B. candatus
3. B. angularis
4. Keratella tripica
5. K. cochlearis

COPEPODA



1. Cyclops spp.
2. Mesocyclops leukart
3. Heliodiaptomus viduus
4. Neodiaptomus laudeli
5. Mesocyclops hyalinus
6. Mesocyclops spp.

CLADOCERA



1. Daphnia lumboltri
2. D. carinata
3. Scapholebris spp.

Table: 13

The details of the comparative qualitative occurrence of Zooplankton diversity (u/l) at three study stations during Mar-12 to Feb-14

Zooplankton and Classificaton	Sampling Stations		
	S_1	S_2	S_3
Rotifera	**u/l**	**u/l**	**u/l**
Asplanchnopus multiceps	200	248	251
Branchonus angularis	72	132	128
B. caudatus	85	136	243
Brachionus pilcatilis	152	178	241
Finilia longiseta	90	180	344
Hexarthra mira	244	314	344
K.kellicathia	85	122	210
Keratella cochlearis	90	184	222
K. tropica	215	98	136
Monostyla-bulla	105	108	95
Rotaria tridens	198	95	108
Rotaria vivipara	95	200	290
Polyarthra vulgaris	172	132	210

Contd....

Synchaeta pecinata	112	130	95
Ostracoda	**u/l**	**u/l**	**u/l**
Cypris sps.	94	88	98
Copepoda	**u/l**	**u/l**	**u/l**
Cyclops sps.	86	92	94
Heliodiaptomus viduus	72	65	45
Heliodiaptomus pulcher	78	82	90
Neodiaptomus strigilipes	84	80	94
Pseudodiaptomus lobipes	105	110	98
Eucyclops sp.	100	95	105
Paracyclops fimbriatus	94	98	86
Cladocera	**u/l**	**u/l**	**u/l**
Bunops sps.	13	38	40
Chydorus phaericus	32	28	40
Daphnia sps.	39	28	32
Hycryptus sordidus	38	40	18
Scapholeberis	13	30	19

The details of the comparative quantitative occurrence of Zooplankton and Phytoplankton at three sites are as follows:

Parameter	Stations		
	S1	S2	S3
Zooplankton	5500 / lit.	5600 / lit.	6000 / lit.
Phytoplankton	17000 / lit.	17500 / lit.	18000 / lit.

C. BENTHIC MACROINVERTEBRATES

Qualitative analysis on taxonomic foundation:

Altogether 33 benthic macro-invertebrates taxa were recorded from all the three sampling stations established along the 28.5 km. stretch of the Subarnarekha River during November 1996 to October 1988. Of the observed taxa, insects alone contributed 60.61% while the rest 24.24% and 15.15% were contributed by molluscs and oligochaetes respectively.

Among oligochaete taxa 60% was contributed by Tubificidae and rest 40% by Naididae. Another important group was Insecta, of which 20% taxa were contributed by ephemeropterans, 10% taxa by placopterans, 15% taxa by trichopterans, 20% taxa by coleopterans and 35% by dipterans. The last group encountered was Mollusca, of which 37.5% taxa belonged to order Mesogastropoda and rest 62.5% by order Basommatophora

Benthic macro-invertebrates recorded from Kharkai river during March, 2012 to Feb, 2014 are shown in Table 14:

Oligochaeta:

Oligochaetes are one of the important benthic macrofauna in almost all freshwater habitat. The group has 24 families (Brinkhurst 1972) of which only two families have been recorded from the proposed study area namely, Tubificidae and Naididae.

Altogether 5 taxa of oligochaetes were recorded from all the three sampling stations of the stream under investigation, of which three taxa

Table : 15

Part-A

Percentage of Total Phytoplankton at three sites during Mar-12 to Feb-13 in u/l

Sl. No.	Types	Months											
		Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13
		S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3
1	*Chalamydomanas reinhardi*	52-29-10	50-27-9	40-22-8	35-20-8	70-50-25	80-60-30	60-40-15	57-30-12	55-30-10	54-29-10	55-29-11	59-30-10
2	*Dunalellis bioculata*	62-34-10	58-32-9	50-30-7	50-27-6	72-53-30	85-65-40	65-30-14	71-34-13	69-32-12	67-35-11	65-36-10	63-35-11
3	*Platimonas - sub cordifermis*	39-31-9	37-29-8	35-26-7	34-25-6	47-31-19	50-40-30	60-30	45-29-14	43-27-15	44-30-12	42-31-11	40-30-10
4	*Chlorella pyrinoidosa*	37-26-8	35-25-7	33-25-6	30-21-7	75-50-40	80-50-40	70-50-40	72-45-30	65-45-31	62-42-30	40-30-10	39-28-9
5	*Ulothrix - sp.*	50-34-25	49-33-24	47-30-21	42-29-20	67-53-36	70-50-40	60-45-30	65-40-35	60-39-30	69-38-30	58-37-29	50-35-26
6	*Microspora. Sp.*	60-56-35	58-51-30	55-47-29	50-45-25	90-70-45	80-70-50	70-60-50	80-65-40	72-62-39	74-60-38	70-61-35	66-69-36

Site - 1	Baba Kutir Ashram
Site - 2	Jay Prakash Udyan
Site - 3	Domohani

Table : 15

Part-B

Percentage of Total Phytoplankton captured at three sites during Mar-13 to Feb-14 in u/l

Sl. No.	Types	Months											
		Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14
		S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3
1	*Chalamydomanas reinhardi*	52-29-10	50-27-9	40-22-8	35-20-8	70-50-25	80-60-30	60-40-15	57-30-12	55-30-10	54-29-10	55-29-11	59-30-10
2	*Dunalellis bioculata*	62-34-10	58-32-9	50-30-7	49-27-6	72-53-30	85-65-40	65-30-14	71-34-13	69-32-12	67-35-11	65-36-10	63-35-11
3	*Platimonas - sub cordifermis*	39-31-9	37-29-8	35-26-7	33-25-6	47-31-19	50-40-30	50-30	45-29-14	42-27-13	44-30-12	42-31-11	40-30-10
4	*Chlorella pyrinoidosa*	37-26-8	35-25-7	33-25-6	30-21-7	75-50-40	80-50-40	70-50-40	72-45-30	65-45-31	62-42-30	40-30-10	39-28-9
5	*Ulothrix - sp.*	50-34-25	49-33-24	47-30-21	42-29-20	67-53-36	70-50-40	60-45-30	65-40-35	60-39-30	69-38-30	58-37-29	50-35-26
6	*Microspora. Sp.*	60-56-35	58-51-30	55-47-29	50-45-25	90-70-45	80-70-50	70-60-50	80-65-40	72-62-39	74-60-38	70-61-35	66-69-36

Site - 1	Baba Kutir Ashram
Site - 2	Jay Prakash Udyan
Site - 3	Domohani

Table : 16

Percentage of Total Phytoplankton at three sites during 2012-14 in u/l

Months	*Chlorella pyrenoidosa*	*Chlanydamonas reinhardl*	*Dunalellis bioculata*	Total	% to Total	Captured - C Relnladi - D	Pyrenoidosa - C bioculata
	S1 S2 S3 (u/l)	S1 S2 S3 (u/l)	S1 S2 S3 (u/l)				
Mar-12	37-26-8	52-29-10	62-34-10	268	26.50	33.96	39.56
Apr-12	35-25-7	50-27-9	50-32-9	252	26.59	34.13	39.29
May-12	33-24-6	40-22-8	50-27-6	220	28.64	31.82	39.55
Jun-12	30-21-7	35-20-8	49-27-6	203	28.58	31.00	40.40
Jul-12	75-50-40	70-50-25	75-53-30	465	35.49	31.19	33.13
Aug-12	80-50-40	80-60-30	85-65-40	530	32.00	32.00	35.86
Sep-12	70-50-40	60-40-15	65-30-14	384	41.67	29.95	28.39
Oct-12	72-15-30	57-30-12	71-34-13	364	32.11	27.20	32.14
Nov-12	65-45-31	55-30-10	69-32-12	349	40.40	27.72	32.38
Dec-12	62-42-30	54-29-10	67-35-11	340	39.41	27.36	33.24
Jan-13	40-30-10	55-29-11	65-36-10	286	27.98	32.22	38.81
Feb-13	39-28-9	53-20-10	65-35-11	278	27.35	33.45	39.20
Mar-13	37-26-8	52-29-10	62-34-10	268	26.50	33.96	39.56
Apr-13	35-25-7	50-27-9	50-32-9	252	26.59	34.13	39.29
May-13	33-24-6	40-22-8	50-27-6	220	28.64	31.82	39.55
Jun-13	30-21-7	35-20-8	49-27-6	203	28.58	31.00	40.40
Jul-13	75-50-40	70-50-25	75-53-30	465	35.49	31.19	33.13
Aug-13	80-50-40	80-60-30	85-65-40	530	32.00	32.00	35.86
Sep-13	70-50-40	60-40-15	65-30-14	384	41.67	29.95	28.39
Oct-13	72-15-30	57-30-12	71-34-13	364	32.11	27.20	32.14
Nov-13	65-45-31	55-30-10	69-32-12	349	40.40	27.72	32.38
Dec-13	62-42-30	54-29-10	67-35-11	340	39.41	27.36	33.24
Jan-14	40-30-10	55-29-11	65-36-10	286	27.98	32.22	38.81
Feb-14	39-28-9	53-20-10	65-35-11	278	27.35	33.45	39.20

Table : 17

Total Zooplankton at Three Study sites and Their Relative Density During 2013-14 in u/l

Months	*Rotifers (u/l)*	*Copepods (u/l)*	*Cladocerans (u/l)*	Total	Rotifera	Copepoda	Cladocera
March	194	34	26	254	76.37%	13.98%	10.23%
April	206	29	38	273	75.45%	10.62%	13.92%
May	169	11	21	201	84.07%	5.47%	10.44%
June	89	7	9	105	84.76%	6.66%	8.57%
July	81	98	6	185	43.78%	52.97%	3.24%
August	18	163	12	193	9.32%	84.45%	6.21%
September	53	194	21	268	19.77%	72.38%	7.83%
October	106	121	39	266	39.84%	45.49%	14.66%
November	135	90	28	253	53.36%	35.57%	11.06%
December	111	63	14	188	59.04%	33.51%	7.44%
January	106	34	8	148	71.62%	22.97%	5.40%
February	172	38	11	221	77.83%	17.19%	4.97%
Mean With	120.00	73.50	19.41		57.93	33.38	8.66
S.D.	± 54.81	± 58.06	± 10.89		± 24.14	± 24.90	± 3.37

Table : 18

Number of Copepods at Three Sites of Kharkai River During 2013-14 in u/l

Sl. No.	Types	Months											
		March	April	May	June	July	August	September	October	November	December	January	February
		S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3	S1 S2 S3
1	***Neodiatomus strigillipes***	0-3-7	0-4-6	0-2-5	0-0-3	4-10-13	6-16-21	8-15-19	3-9-18	0-4-7	6-8-5	4-4-5	2-4-5
2	***Paracyclopes fimbriatus***	0-0-0	0-0-2	0-0-0	0-0-0	3-8-12	6-11-17	9-13-21	4-11-21	1-7-13	0-2-5	0-0-2	0-20-0
3	***Heliodiaptomus pulcher***	0-5-5	0-7-4	0-3-1	0-0-0-	2-3-6	5-8-12	7-9-13	0-3-8	0-2-5	0-0-4	0-0-3	0-3-4
4	***Pseudodiaptomus labipes***	0-0-0	0-0-0	0-0-0	0-0-2	2-5-6	5-8-11	4-14-10	2-5-7	0-6-9	0-5-7	0-3-5	0-3-2
5	***Eucyclops sp.***	0-2-0	0-1-0	0-0-0	0-0-0-	3-3-5	2-6-6	5-9-5	1-0-5	2-6-7	0-8-5	0-2-0	0-3-2
6	***Cyclops sp.***	27-7-0	0-5-0	0-0-0	0-2-2	6-5-5	5-10-8	8-12-14	5-11-8	4-10-7	3-5-0	2-4-0	3-5-0
	TOTAL	02-17-15	0-17-12	0-5-6	0-0-7	16-35-47	29-57-77	40-72-82	15-39-67	07-35-48	09-28-26	06-13-15	05-20-13

Table : 19

Number of Rotifera at Three Sites of Kharkai River during 2013-14 in u/l

Sl. No.	Types	Months											
		March	April	May	June	July	August	September	October	November	December	January	February
		S1 S2 S3 (u/l)	S1 S2 S3 (u/l)	S1 S2 S3 (u/l)	S1 S2 S3 (u/l)	S1 S2 S3 (u/l)	S1 S2 S3 (u/l)	S1 S2 S3 (u/l)	S1 S2 S3 (u/l)	S1 S2 S3 (u/l)	S1 S2 S3 (u/l)	S1 S2 S3 (u/l)	S1 S2 S3 (u/l)
1	*Branchonous*	13-18-31	15-17-32	18-19-24	10-12-14	07-14-17	01-03-00	02-03-05	03-08-10	03-05-08	04-00-08	08-14-11	12-17-29
2	*Keratella tropica*	00-03-03	00-02-01	00-02-02	00-01-00	00-00-00	00-00-00	00-01-00	00-02-30	00-01-01	00-01-03	00-02-02	00-02-03
3	*Kellicathia*	00-07-11	00-06-12	00-08-10	00-05-07	00-04-06	00-03-03	00-05-05	00-01-02	00-04-04	00-05-03	00-02-04	00-05-05
4	*Asplanchna Sp.*	15-09-11	04-10-10	05-12-14	00-06-06	04-10-13	00-03-03	00-05-00	02-06-08	03-10-14	00-09-11	00-04-03	03-08-11
5	*Polyarthra Sp.*	06-13-13	15-10-12	00-04-07	00-00-02	00-00-00	00-03-00	00-00-00	03-05-07	04-09-13	00-07-10	00-05-08	00-14-16
6	*Synchaeta Sp.*	00-08-00	00-04-00	00-00-00	00-00-00	00-00-00	00-00-00	00-02-00	00-03-07	00-06-00	00--04-00	00-02-00	00-00-03
7	*Fillinia longlseta*	00-03-07	00-11-07	00-08-05	00-03-02	00-00-00	00-00-00	00-03-03	00-05-06	00-09-07	00-06-02	00-02-00	00-00-03
8	*Hezarthra mira*	02-07-09	04-08-11	00-06-05	00-03-04	00-00-00	00-00-00	00-03-03	02-03-05	03-05-06	03-07-09	02-08-11	00-06-07
9	*Rotaria tridens*	00-00-14	00-00-16	00-00-10	00-00-06	00-00-03	00-00-05	00-00-05	00-00-09	00-00-13	00-00-10	00-00-07	00-00-11
10	*Rotaria vivipera*	00-21-00	00-24-00	00-13-00	00-08-00	00-00-00	00-00-00	00-04-00	00-04-00	00-07-00	00-09-00	00-11-00	00-17-00
	TOTAL	26-69-99	28-82-101	23-69-77	10-38-41	11-31-39	01-09-08	02-26-25	10-37-59	13-56-66	07-48-56	10-50-45	15-72-85

belonged to family Tubificidae and the rest two taxa belonged to the family Naididae

Tubificidae:

This family is not only common and the most widely distributed in aquatic ecosystem but also well suited for use in biological assessment of water quality, water pollution or other changes in aquatic habitat. Individuals of this family are restricted to aquatic environment throughout their life cycle and water quality requirement as well as pollution tolerance of many species have been documented in the literature (Hiltunen, 1980).

In the present investigation Tubificidae, the most dominant family of Oligochaeta, was found to be represented by 3 taxa, namely, *Branchiura sp., Limnodrilus udekemianus* and *Limnodrilus angustipenis.*

Naididae:

Like Tubificidae, Naidids also are used to investigate the effects of pollution of biological integrity of water and changes in biotic community resulting from destructive human interference. In few studies where Naidids have been identified to species level, a relationship between species assemblage and water quality is established (Hiltune 1980, Learner *et.al.* 1978).

In the present investigation family Naidide was found to be represented by only two taxa, namely *Dero sp.* and *Chaetogaster sp.*

Insecta:

Most of the insects are terrestrial, but insects belonging to eleven orders are aquatic. They fall into two major groups:

(i) insects having aquatic larval and pupal stages, such as Ephemeroptera, Trichoptera, Odonata, Diptera etc.; and (ii) those spending their entire life cycle in or near some waterbody, such as Coleoptera, Herniptera etc.

So far as the insect benthic macrofauna is concerned only larval and pupal stages are involved. Insects are important because of their significance as fish food and also as indicator organism for examining the water quality of freshwater habitat.

In the present investigation of the 11 orders of aquatic insects that inhabit in freshwater habitat, only five orders, namely, Ephemeroptera, Plecoptera, Trichoptera, Coleoptera and Diptera having 20 taxa had been recorded from the proposed study area.

The species composition of various insects belonging to the above mentioned orders are as follows:

Ephemeroptera:

This order was represented by three families namely Ephemeridae, Baetidae and Caenidae the former one having two taxa and the latter two having one taxon each i.e. *Ephemera* sp., *Ephemerella* sp., *Baetis* sp. And *Caenis* sp., respectively.

Plecoptera:

This order was represented by two families, namely Nemouridae and Peltoperlidae having one taxon each i.e *Amphinemura* sp. and *Brachyptera* sp., respectively.

Trichoptera:

Like *Plecoptera trichopteran* fauna was also represented by 2 families having three taxa, of which one *Rhyacophila* sp. belonging to family Rhyacophilidae and the rest two *Hydropsyche* sp. and *Cheumatopsyche* sp. to family Hydropsychidae.

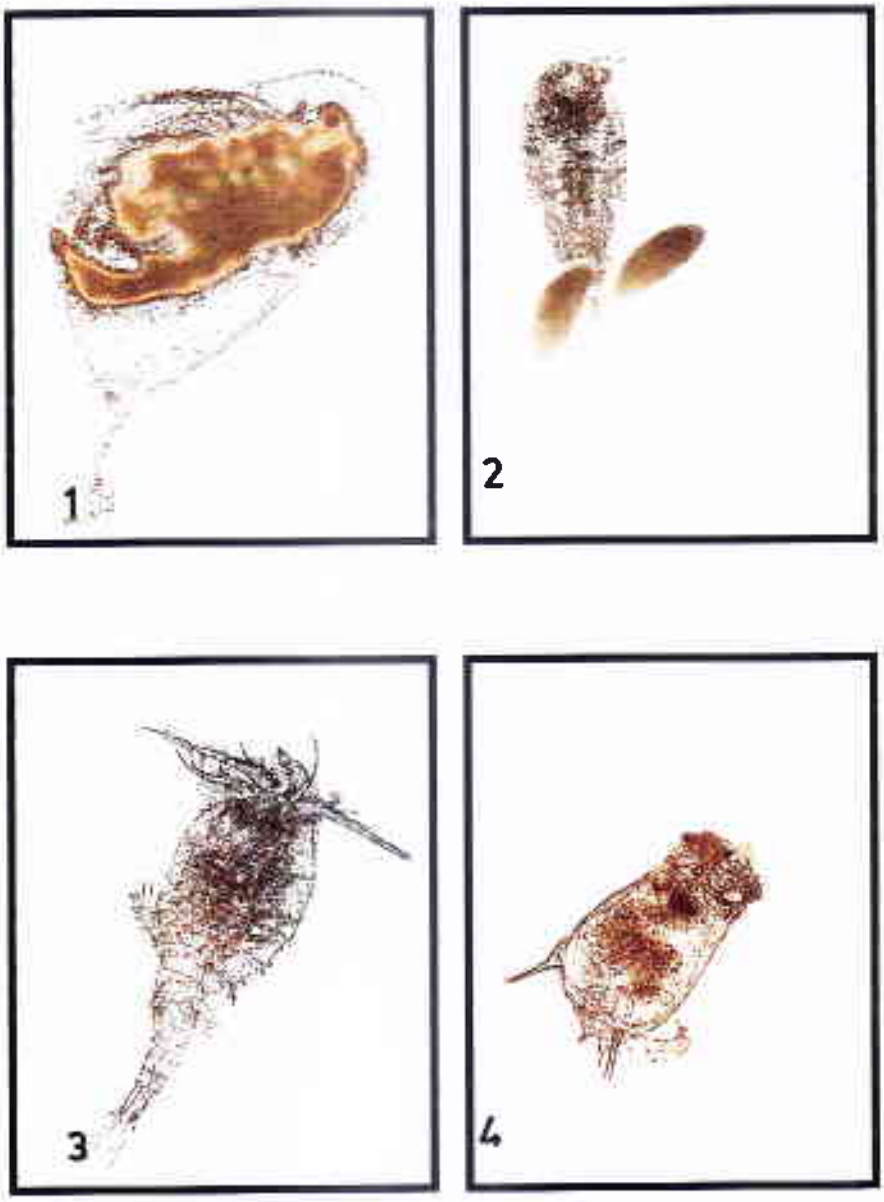
Coleoptera:

This order was represented by two families, namely Ptilodactylidae and Hydrophilidae, the former having one taxon and the later three taxa i.e *Stenocolus* sp., *Enochrus* sp., *Hydrophilidae* (unidentified) and *Berosus* sp., respectively.

Diptera:

This order was represented by 2 families, namely Chironomidae and Simulidae. Of these Chironomidae was found to be the most diverse family having altogether six taxa belonging to 2 sub families *Chiromous* sp., *Polypedilum* sp., and *Dicrotendips* sp. representing sub family Chironominae, while *Tanypus* sp., *Coelotancypus* sp. and *Procladius* sp. representing sub

CRUSTACEANS, CLADOCERONS, COPEPODS AND OSTRACODS



1. Daphnia carinata
2. Cyclops spp.
3. Mesocyclops spp.
4. Branchionus spp.

family Tanypodinae. Family simulidae was represented by single taxon i.e. *Simulium* sp.

Table: 14

Showing the benthic macroinvertebrates recorded from three sampling stations of the Kharkai river during March, 2012 to Feb, 2014

Class	:	**OLIGOCHAETA**
Family	:	**Tubificidae**
		Branchiura sp.
		Limnodrilus udekemianus
		Limnodrilus angustipenis
Family	:	**Naididae**
		Dero sp.
		Chaetogaster sp.
Class	:	**INSECTA**
Order	:	**Ephemeroptera**
Family	:	**Ephemeridae**
		Ephemera sp.
		Ephemerella sp.
Family	:	**Baetidae**
		Baetis sp.
Family	:	**Caenidae**
		Caenis sp.
Order	:	**Plecoptera**
Family	:	**Nemouridae**
		Amphinemura sp.
Family	:	**Peltoperlidae**
		Brachyptear sp.
Order	:	**Trichoptera**

Family	:	**Hydropsychidae**
		Hydropsyche sp.
		Cheumatopsyche sp.
Family	:	**Rhyacophilidae**
		Rhyacophila sp.
Order	:	**Coleptera**
Family	:	**Ptilodactylidae**
		Stenocolus sp.
Family	:	**Hydrophilidae**
		Enochrus sp.
		Hydrophilidae (unidentified)
		Berosus sp.
Order	:	**Diptera**
Family	:	**Chironomidae**
Subfamily	:	**Chironominae**
		Chironomus sp.
		Polypedilum sp.
		Dicrotendips sp.
Subfamily	:	**Tanypodinae**
		Tanypus sp.
		Coelotanypus sp.
		Procladius sp.
Family	:	**Simuliidae**
		Simulium sp.

D. MOLLUSCA

Mollusca is a large phylum, second only to Arthropod in the number of species. The Molluscs have colonised every possible habitat and are dominant in benthic communities of all aquatic ecosystems. The largest number of molluscs are found in the marine environment where forms support valuable shell and pearl fisheries in addition to the lime industry. Species inhabiting the freshwater ecosystem are few in number.

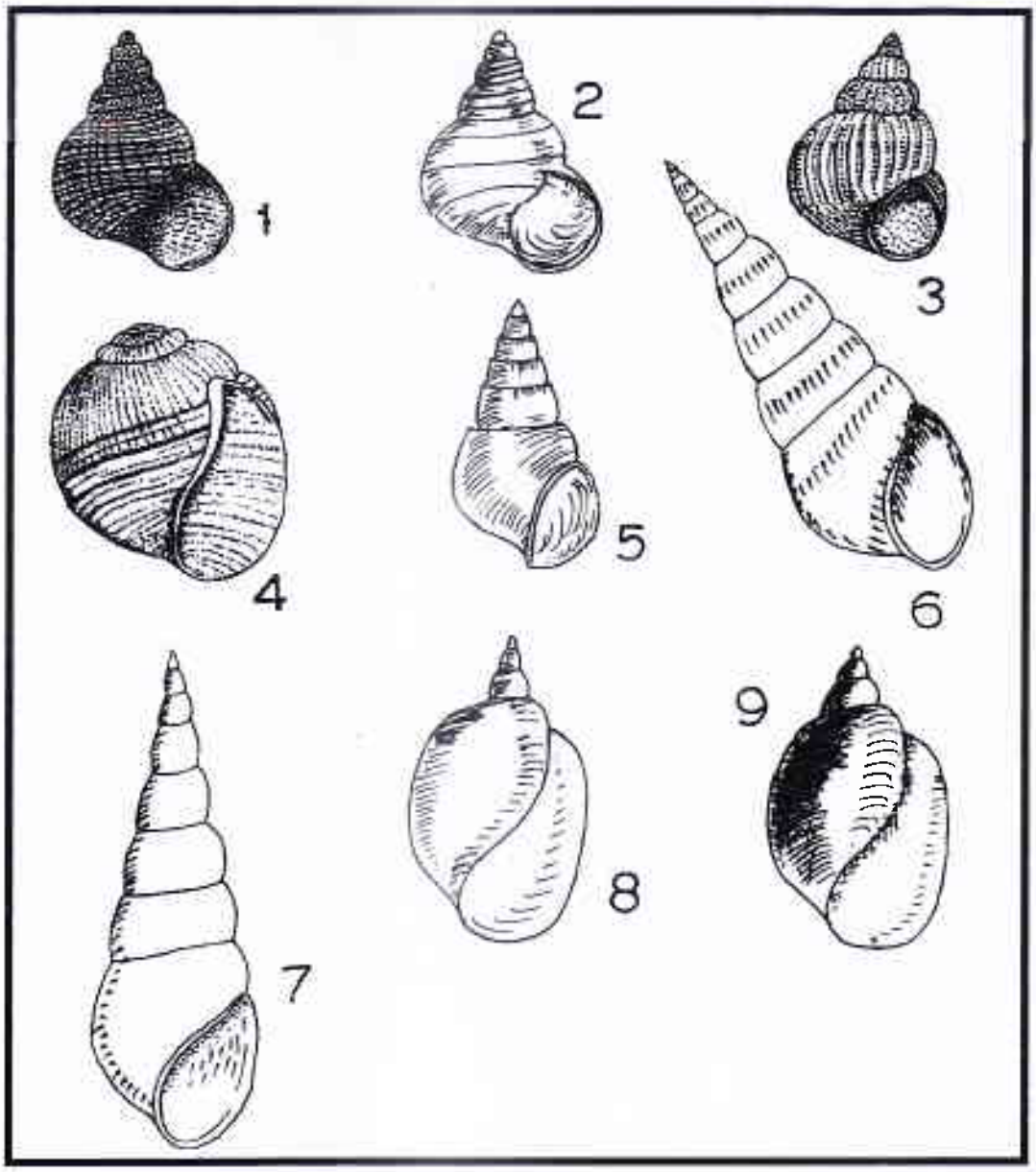
The fresh water mollusc one of the largest group of limnofauna constitute a weighty and important part of the benthic organism in almost all perennial fresh aquatic system play an important ecological role in the system. Since their evolution they are related with different benthic group of organisms as they act as scavenger well as good item of many aquatic and terrestrial animals. The participation of fresh water molluscs in the way of life of many organisms has made them significant partners in the ecological communities.

GASTROPODA:

Gastropods are available, most successful interesting and varied forms that have undergone extensive adaptive radiations and have invaded various kinds of habitat.

The group gastropoda was represented by 15 taxa belonging to 6 families of two orders namely Mesogastropoda and Basommatophora. The order Mesogastropoda was represented by 4 families, Viviparidae, Pilidae, Bithymidae and Thiaridae. Viviparidae having three taxa *Bellamya bengalensis* (form *typical, madiensis* and *eburnea*), *Bellamya dissimilis* and *Bellamya variata* ; *Pilidae* with single taxon *Pila globosa* ; *Bithyniidae* with two taxa *Digoniostoma pulchella, Gabbia orcula* and family *Thiaridae* naming five taxa namely *Thiara Scabra, Thiara tuberculata, Thiara lineate, Thiara requeti* and *Thiara paludomoidea.* Similarly the order *Basommatophora* was represented by two families *Lymnaeidae* and *Planorbidae.* Family

GASTROPODA



1. Bellamya bengalensis (Lamarck)
2. B. bengalensis f. typica (Lamarck)
3. B. dissimilis (Muller)
4. Pila globosa (Swainson)
5. Thiara scabra (Muller)
6. Thiara (Mclanoides) tuberculatus (Muller)
7. Thiara (Tarebia) lineata (Gray)
8. Lymnaea (Pseudosuccinea) acuminata f. typica (Lamarck)
9. L. (Pseudosuccinea) f. rufescens (Gray)

Lymnaeidae having three taxa *Lymnaea accuminata, L. luteola, L.ovalis* while the later having one genera *Indoplanorbis exustus*.

GASTROPODA:

Prosobranchia

Mesogastropoda

Viviparidae

1. *Bellamya bengalensis* Lamarck
   - *form typica* (Lamarck)
   - *form mandiensis* (Kobelt)
   - *form eburnea* (Lamarck)
2. *Bellamya dissimilis* (Mueller)
3. *Bellamya variata* (Frauenfeld)

Pilidae

4. *Pila globosa* (Swainson)

Bithyniidae

5. *Digoniostoma pulchella* (Benson)
6. *Gabbia orcula* (Frauenfeld)

Thiaridae

7. *Thiara scabra* (Mueller)
8. *Thiara tuberculata* (Mueller)
9. *Thiara lineata* (Gray)
10. *Thiara requeti* (Grateloup)
11. *Thiara paludomoidae* (Nevill)

Palmonata

Basommatophora

Lymnaeidae

12. *Lymnaea accuminata* (Lamarck)

13. Lymnaea luteola (Lamarck)

14. Lymnaea ovalis (Gray)

Planorbidae

15. *Indoplanordis exustus* (Deshayes)

BIVALVIA:

Bivalves (having two valves) are recorded in little number in the river Kharkai represented by 7 taxa belonging to 2 families of one order namely Unionoida. The order Unionoida was represented by two families Unionidae and Corbiculidae. Unionidae having five taxa and Corbiculidae with two taxa.

CLASS	:	**BIVALVIA**
Subclass	:	Eulamellibranchiata
Order	:	Unionoida
Family	:	Unionidae
		1. *Lamellidens marginalis* (Lamarck)
		2. *Lamellidens corrianus* (Lea)]
		3. *Perreysia corrugate* (Mueller)
		4. *Perreysia favidense* (Benson)
		5. *Indonaia coerulea* (Lea)
Family	:	Corbiculidae
		6. *Corbicula occidens* (Deshayes)
		7. *Corbicula striatella* (Deshayes)

TAXONOMIC ACCOUNT OF GASTROPODA :

The live shells of Bellamya *bengalensis* studies from the river Kharkai were thin shelled having variable and irregular dark bands. The species has three forms in the river form *typical*, form *mendiensis* and form *eburnea*. All the forms of *B.bengalensis* are edible in the form of cooked curry after the removal of the shell.

The shell of *B.dissmiles* was broad by ovate with ovate aperture and with five whorls. Its maximum population was encountered at S_2.

Bellamya variata had smaller shell in size in contrast to *form typical,* ovately shaped aperture, sutures with 5 whorls.

The *Pila globosa* of the river had 3 or 4 whorls. It was rarely and scarcely marked where temperature and pH was below 25°C and 7.5 respectively.

Digoniostoma pulchella had small thin shell with depressed sutures having whorls 3-4 in number, convex with spiral striae and weak growth of lines.

The *Gabbia orcula* had globesely concical shell with 4 whorls, the body whorl was considerably swollen, operculum shelly crecentic, concave with a central nucleus.

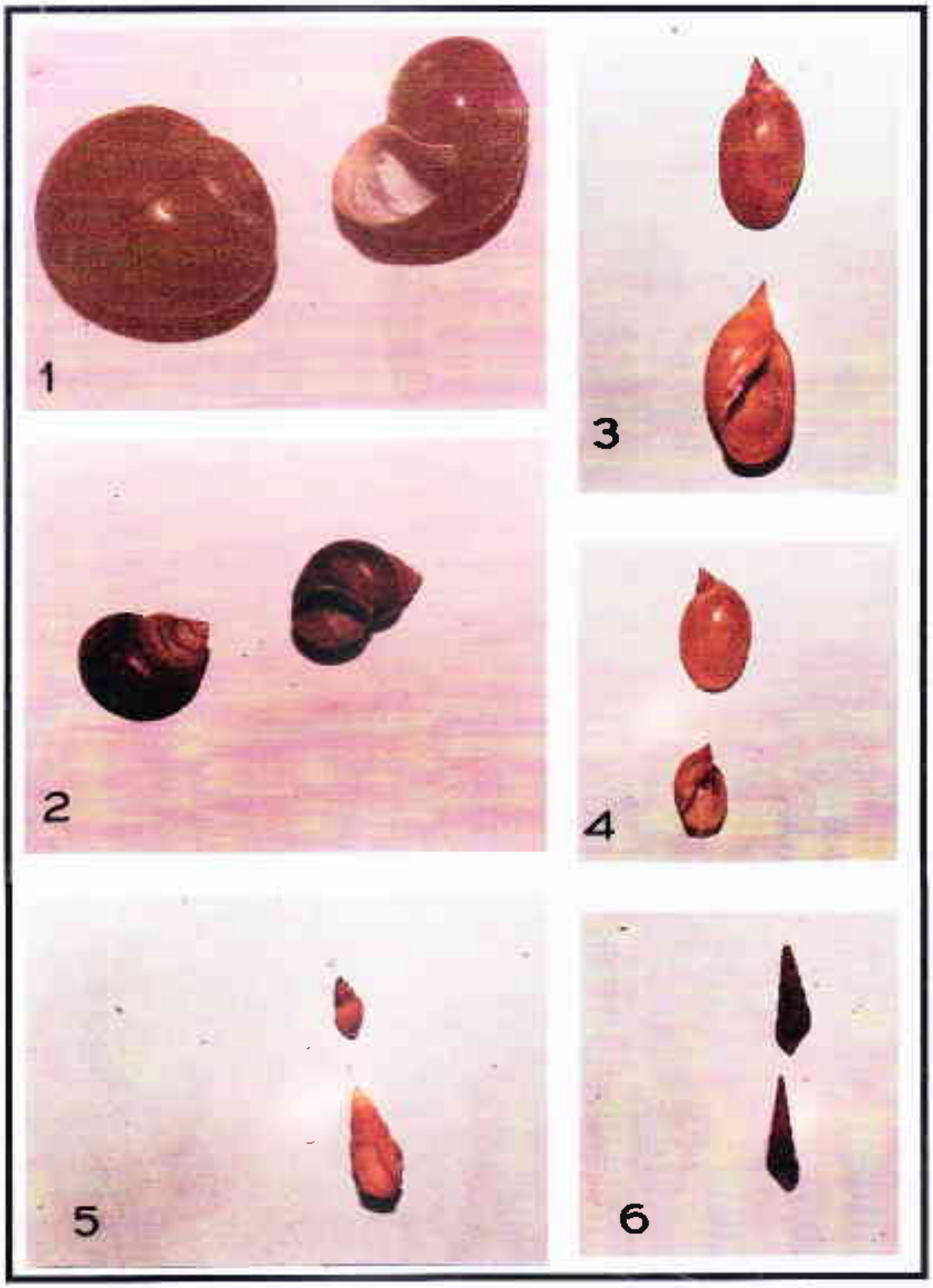
Thiara scabra from the river had elongated, ovate thin shell with 7-8 whorls. operculum ovately rounded and horny, small ovate aperture, pale blackish.

Thiara tuberculata had thin elongated shell with high spire and large body 8 - 9 whorls having dark red brown dots, ovate operculum.

Thiara lineata from the river have thin shell which was spirally ridged with 7-8 whorls, angularly round, operculum ovate, horny dark brown.

Thiara paludomoidae collected from river had conical shell with distinct suture including 9-10 whorls regularly arranged, operculum conical yellowish brown.

GASTROPODA



1. Pila globosa (Swainson)
2. Bellamya bengalensis (Lamarck)
3. Lymnaea (Pseudosuccinea) f.rufescens (Gray)
4. L. (Pseudosuccinea) acuminate patula Trosche
5. Thiara scabra (Muller)
6. Thiara (Melanoides) tuberculatus (Muller)

TAXONOMIC ACCOUNT OF BIVALVES :

Lamellidens marginalis of the river had in equilateral ovate shell, unbone swollen knob like structure in each shell and the nacreous pearly white, two large oval scars seen on the inner surface of the shell into which anterior and posterior adductor muscles remain attached.

Lamellidens corrianus having inequilateral shell, narrowly ovate with larger valves. The unbones are slightly elevated and the macreous is pearly white iridescent.

Perreysia corrugate had small shell scarcely inequilateral and smooth, oblique linear ridges, dorsal margin concave whereas the ventral margin is convex.

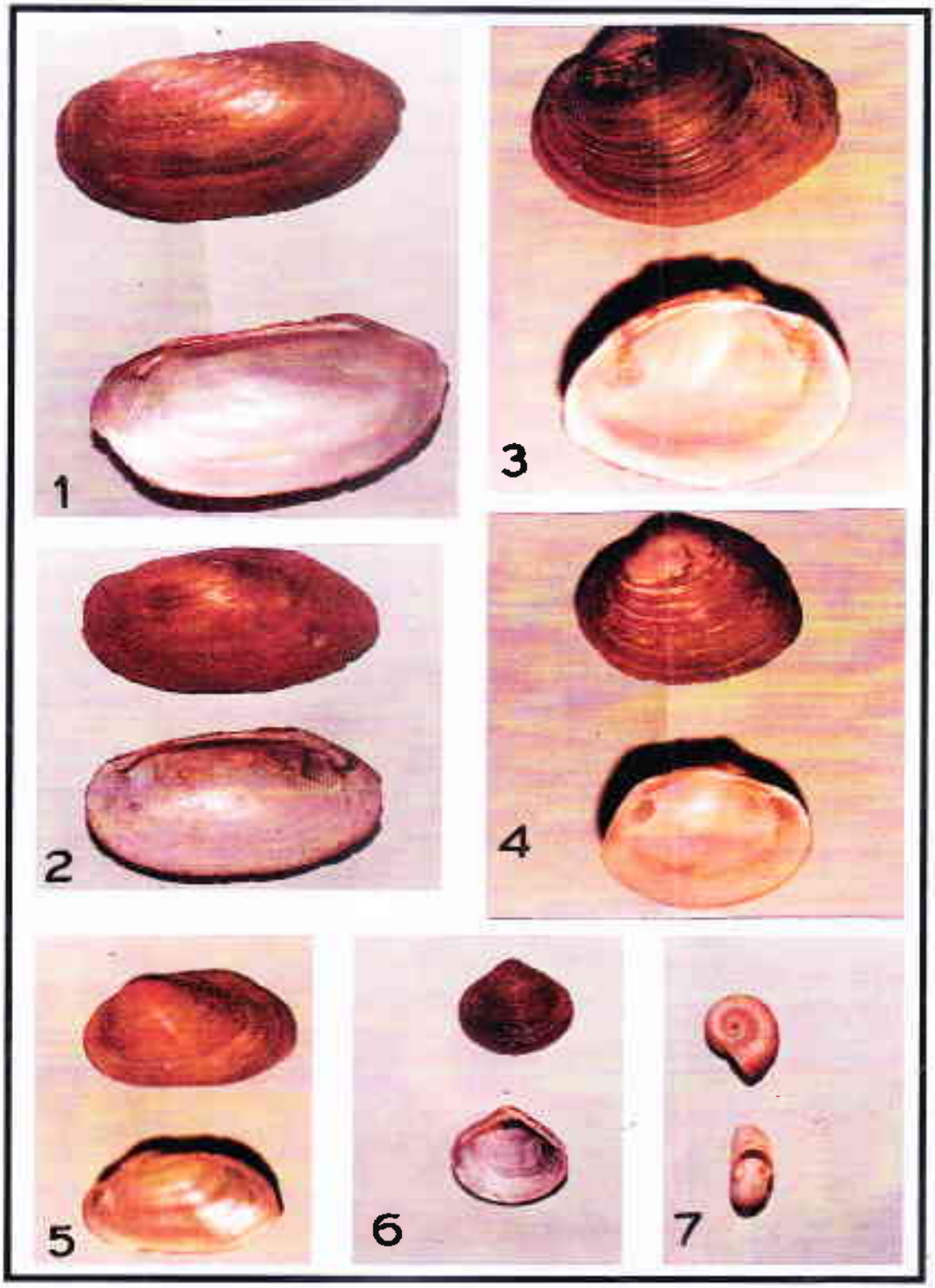
Perreysia favidense had thick shell, broad but short in contrast to lamellidens : shape elliptical to round, cardinal teeth narrow on the inner surface.

Indonaia courulea had shell elliptical, inequilateral short and rounded anteriorly, texture thin, irregularly striate, hinge narrow and straight.

Corbicula occidens had small triangular ovate shell with regularly striated surface. Anterior and posterior margin of the shell are always equally broad and rounded, ventral margin smoothly curved.

Corbicula striatella had triangular shell, ovate slightly inequilateral. The shell surface regularly and closely concentrically striated.

BIVALVIA



1. Lamellidens marginalis (Lamarck)
2. L. corriarus (Lea)
3. Parreysia (Parreysia) favidens (Benson)
4. Parreysia (Parreysia) Var pinax (Benson)
5. Parreysia (Parreysia) Var marcens (Benson)
6. Corbicula striatella Deshayes
7. Indoplanorbis exustus Deshayes (Castropoda)

E. ICHTHYOFAUNA OF THE RIVER KHARKAI AT THREE SAMPLING STATIONS:

Fishes are the important aquatic animals and have an important role in aquatic ecosystem and life in one or other ways. They form a rich source of food of man and many other animals. They serve as an important item of human diet from time immemorial and are primarily caught for this purpose. Fish diet provides proteins, fat, vitamin A and D as well as phosphorus and other elements. They have a good taste and are easily digestible. Many research works have been carried out on fishes of both the lentic and lotic water bodies of inland water of the Indian sub-continent by a lot of workers.

The freshwater fish fauna of Kharkai River (Jharkhand) has been represented in respect of the threatened and endemic freshwater fishes of our country. At present forty four species belonging to thirty six genera, fifteen families of freshwater fishes are known to occur in this river. It has been found that this river contains forty three threatened and one endemic freshwater fishes of India.

The available published literature on the fishes of river Kharkai and field study in different fishes resource places of the river are made during this investigation (March-2012 to February-2014) to prepare the list of vulnerable, endangered, rare and endemic species of fishes. In this regard opinions of the fisherman, fish catchers and other rural people who are fond of fishes are consulted for the present study.

The fish species found in river Kharkai which were recorded vulnerable, endangered, rare and endemic species are as listed below:-

A) Vulnerable Species :

Name of Species	**Family**
1. *Gudusa chopra* (Ham.)	Clupeidae
2. *Notopterus notopterus* (Pallas)	Clupeidae
3. *Oxygaster phulo* (Ham.)	Cyprinidae

4. *Barilius bola* (Ham.)
   Cyprinidae
5. *Barilivs bendelisis* (Ham.)
   Cyprinidae
6. *Danio acquipinnatus* (Mc.Clelland) Cyprinidae
7. *Chela laubuca* (Ham.) Cyprinidae
8. *Amblypharyngodon microlepis* (Bleeker) Cyprinidae
9. *Cirrhinus reba* (Ham.) Cyprinidae
10. *Garra gotyla gotyla* (Gray) Cyprinidae
11. *Garra mullya* (Sykes) Cyprinidae
12. *Labeo calbasu* (Ham.) Cyprinidae
13. *Labeo gonius* (Ham.) Cyprinidae
14. *Puntius chonchonius* (Ham.) Cyprinidae
15. *Puntius chola* (Ham.) Cyprinidae
16. *Lepidocephalichthyes guntia* (Ham.) Cyprinidae
17. *Noemacheilus rupicola* (Mc.Clelland) Cyprinidae
18. *Rita rita* (Hams.) Bagridae
19. *Mystus vittatus* (Bloch) Bagridae
20. *Mystuc Oar* (Ham.) Bagridae
21. *Mystus seenghala* (Sykes) Bagridae
22. *Alia coila* (Ham.) Schilbeidae
23. *Clupisoma garua* (Ham.) Schilbeidae
24. *Pangasius Pangasius* (Ham.) Pangasidae
25. *Bagarius bagarius* (Ham.) Sisoridae
26. *Clarias batrachus* (Linn) Claridae
27. *Heteropneustes fossilis* (Bloch) Heteropneustidae
28. *Channa orientalis* (Bloch) Channidae
29. *Rhinomugil corsula* (Ham.) Mugilidae
30. *Anabas testudineus* (Bloch) Anabantidae

B) Endangered Species:-

Name of Species	Family
1. *Anguila bengalensis* (Grey)	Anguilidae
2. *Amphipnous cuchia* (Ham.)	Amphipnoidae
3. *Notopterus chitala* (Ham.)	Notopteridae
4. *Barilius bola* (Ham.)	Cyprinidae
5. *Tor tor* (Ham.)	Cyprinidae
6. *Tor puntitora* (Ham.)	Cyprinidae
7. *Ompok bimaculatus* (Bloch)	Siluridae
8. *Ompak pabda* (Ham.)	Siluridae
9. *Glyptothorax nelsoni* (Ganguli *et.al.*)	Sisoridae

C) Rare Species

Name of Species	Family
1. *Barilius barna* (Ham.)	Cyprinidae
2. *Puntius clavatus*	Cyprinidae
3. *Mystus mukherjee* (Ganguly and Dutta)	Siluridae
4. *Glyptothorax coheni* (Ganguli *et al*)	Siluridae

D) Endemic Species

Name of Species	Family
1. *Garra satyendranathi* (Ganaguly and Dutta)	Cyprinidae

F. DESCRIPTION OF MACROPHYTES:

Macrophytes are rich in Kharkai river because of stony bottom of the river. The abundant macrophytes are *Eichhornia* (Water Hyacinth or Jalkumbhi), *Vallisneria, Potamogeton, Hydrilla,* etc.

Eichhornia – The free floating hydrophyte that grows in ponds, lakes and rivers containing fresh water. When the level of water is low, the plants get rooted in the soil. The stem is offset that grows prostrate below the surface of water. It is spongy and stores air. The leaves arise at the nodes in cluster. The petioles of the leaves are inflated that keep the leaves out of water. The nodes also bear clusters of brown adventitious roots in water. They act as balancers. The emerged leaves have water proof waxy and cuticular coating to prevent wetting.?

Vallisneria – It is submerged stoloniferous flowering plants which have seen mostly in S1 near Baba Kutir Ashram. The stem is reduced, the leaves are large and ribbon shaped. The leaves lack cuticle and stomata. They do not provide any resistance to the flow of water. The whole plant is covered with mucilage.

Pistia – This is a free floating hydrophyte found in both edge of S3, which were present as dense green belt having offset subaerial stems. The leaves arise at the node in cluster out of water. The nodes also bear cluster of brown adventitious roots in water.

Potamogeton – The submerged hydrophytes having spongy, slender, elongated, and delicate stem. It limps when taken out of water showing that it does not bear any mechanical tissue. The leaves lack cuticle and stomata.

Hydrilla – The submerged hydrophyte found in fresh water river or ponds. The stem is soft and slender and bears thin and membranous leaves in whorls of 3 - 8. The leaves are arranged in such a way to provide least resistance to the flow of water.

G. TEMPORAL CHANGE IN PLANKTONIC FAUNA:

In the present investigation water temperature at each station was measured once a day at the time the station was visited. Several workers after studying the temperature variation over a stretch of streams found that the diurnal cycles are superimposed upon seasonal change. So many discussion of temperature involve the method of measurement. Thus accurate comparison of temperature at different seasons and at different stations could not be made. From the observation it arises that the water temperature of the Kharkai river showed distinct seasonal variations and was recorded to be fairly low during December to February. With the onset of spring, March onward it tended to increase and attained appreciably high values during April to October.

The partial Correlation between temperature and Zooplankton density was found to be very less. It suggests that the number of Zooplankton has in inverse correlation with the increase in water temperature. In fact temperature is the main factor that regulates the seasonal pattern of development and densities of plankton. The three groups of Zoo-plankton showed their period of maximum density in different months which may be due to their different optimal thermal requirement.

Bottrel (1975) in the laboratory conditions has demonstrated the dependence of densities on temperature. This is a good support to our findings in the present work. Global rise in temperature is to create havoc in the days to come.

Higher temperature increased growth and multiplication of both phyto and zooplankton. Occurrence of rich micro fauna in a water body proved high polluted water and high temperature. So in stations-3 (S-3) no. of phytoplankton diversity is comparatively more than S-1 and S-2. Because this site got more polluted water from major parts of Jamshedpur and Adityapur town. (Table-12.). In this site shallow water reacts quickly to the change of atmospheric temperature.

Phytoplankton produce asexually and keep population number up. These are most abundant in areas with a high intensity of light and high range of temperature as they can convert Light energy into Chemical energy.

RESULT AND DISCUSSION

CHAPTER – 04

RESULTS AND DISCUSSION

A. PHYSICO-CHEMICAL PARAMETERS

NATURE OF SUBSTRATE:

From the foregoing observation it appeared that the river bed was basically muddy along the upper course of the river but sandy along the lower course. Substrate was muddy with patches of coarse sand and sparsely scattered gravels and thick layer of silts at S_3. Besides muddy area with silt was also present on the fine sandy bed of S_1 and S_2.

In the present investigation,sandy substrate of S_2 and S_3 was provided with boulders and chips. Rocks, boulders, pebbles and chips provide surface for the growth of algae and mosses (Hynes, 1979), which act as potential food base for the organisms. Hynes (1979) also proposes that mean particle size decreases in downstream direction and there is thus a correlation between the particle size and the slope. Many factors, such as composition of particles, its exposure to weathering, turbulence and current speed, combined together to make it probable that the further down a river, the smaller is the general size of particles on the river bed. Larger particles, pebbles, stones and chips, etc provide shelter to smaller ones and protect them from being entrained. Consequently a mixture of coarse and fine particles co- exists at certain areas of a river (Hynes, 1979).

Next important point arising from the observation is that the bottom of headwater stations (S_1 and S_2) were basically muddy and downstream station (S_3) was sandy. Besides this, the upstream sites were devoid of silts (S_1 and S_2) but the amount of silts gradually increased further downstream and there was a thick layer of silts at S_3. This may be attributed to the current speed, nature of flow and nature of substrate. According to Hynes (1979), fine materials like silts and mud would settle 20 cm/sec. The current speed of the

Kharkai river throughout the period of observations remained low enough to justify the sandy bed of the river. The mean current speed ranged between 9.25 cm/sec to 37 cm/sec during summer and rainy season respectively (Fig 16). The river bed is almost infinitely adjustable complex of inter-relation between discharge, width ,depth, rate of flow, bed resistance and sediment transport.

The nature of substrate in a stream influences the benthic fauna both directly and indirectly. Stream bed is the source of friction to the water and hence alter the current speed. Stream bed provided with obstruction cause turbulence which effect gaseous exchange, grinding of particles and erosion etc. It has long being known that habitat heterogeneity is responsible for the distribution and abundance of certain taxa. Different type of substratum harbour different communities or organisms. Varied nature of substratum contributes to river zonation. Fairly distinct benthic fauna are associated with particular type of substrate. The large area of sand, mud, clay, etc. each have their own characteristics fauna (Berg. *et.al.* 1948). In the present investigation as would be seen later, substrate played but little role in change community structure of benthic macro invertebrates along the proposed stretch of the Kharkai River.

Water Depth and Current Speed.

The water depth of the river at the three sampling stations varied with the seasons, being maximum in monsoon months and minimum in summer months. Similarly the current speed was found to be highest in monsoon months, lowest in summer months and moderate in winter months at all sampling stations. This fact is attributed to the ecoclimatic condition and geographical location of the study area. Next important point is that continuous flow of water is maintained in channel of Kharkai river even during summer months because the river is also fed with ground water, the amount of ground water is being minimum in summer, maximum in monsoon and in between in winter months.

Next important point arising from the observations is that the current speed at the sampling stations remained fairly low throughout the period of observations. The mean current speed during the seasons of highest flow (monsoon) ranged between 35.33 cm/sec to 45 cm/sec. while during the period of lowest flows (summer) ranged between 5.75 cm/sec to 20.75 cm/sec at the sampling sites. The observed current speed is suitable for settlement of fine suspended materials and for occurrence of sandy or muddy bed (Hynes, 1979). The observed current speed was not high enough to erode the river bed. According to Hynes (1979) current speed above 200 cm/sec begins to enlarge the river bed by erosion, unless they are harmed by rocks or mud made structure. Einsele (1960) suggests the mean rate of flow is, of course, related to discharge, width, depth and roughness of the stream bed but even at times of flood it rarely exceeds 300 cm/sec.

Water discharge is of little direct interest in most ecological studies. Usually, biologists are interested in most ecological studies. Usually, biologists are interested in current speed of water where the organisms actually live. The current speed has great effect on distribution and abundance of organisms as it influences many organisms directly. The current speed is inversely proportional to the logarithm of depth. The rate of flow decreases rapidly at the bottom and there is a boundry layer right on the bed in which it declines very rapidly to zero (Shukla, 1995).

pH:

In the present investigation the pH value revealed no significant temporal or longitudinal change and remained neutral to slightly alkaline in reaction with a range of 7.0 to 7.2 at all sampling stations throughout the course of study, where occasionally acidic tendency (pH 6.9) was observed (Table 4) in monsoon month. The acidic pH value of 6.9 was recorded in the months of July and Aug'12 and May to Aug'13 at S_1. This might be attributed to high temperature and heavy organic load at this station which has enhanced the rate of decomposition producing more Co_2 and consequently reducing the pH to acidic zone.

Temperature:

In the present investigation water temperature at each station measured once a day at the time the station was visited. From the observation it is observed that the water temperature of the Kharkai river showed distinct seasonal variation and was recorded to be fairly low during December to February (18.6°C to 19.5°C). With the onset of spring, March onward it tended to increase and attained appreciably high values during April to October. Temperature is of course intimately related to latitude, altitude and season (Hynes, 1979).

Next important point arising from the observation is that the range of annual variations in temperature was maximum at S_1 (18.5°C to 35.2°C) and S_2 (18.6°C to 36.0°C) and minimum at S_3 (18.5°C to 36.9°C). This fact may be attributed to the water depth which was very low at S_1 and S_2 but significantly high at S_3. It is well known that shallow water reacts quickly to the change of atmospheric temperature. Hynes (1979) also suggests that the temperature of streams and rivers vary much more rapidly than lakes but the variation is over a much wide range in shallow water than in deep water.

Temperature is a very important factor in stream ecology and this is shown particularly well where it changes suddenly along the course of a river (Dad, 1981). The seasonal fluctuation of temperature is reported to control the rhythm of life histories of many animals. Low water temperature may slow down growth rate.

It is well known that the number of Zooplankton has in inverse correlation with the increase in water temperature. In fact temperature is the main factor that regulates the seasonal pattern of development and densities of plankton. The three groups of zooplankton showed their period of maximum density in different months which may be due to their different optimal thermal requirement.

Bottrel (1975) in the laboratory conditions has demonstrated the dependence of densities to our findings in the present work. Global rise in temperature is to create a havoc in the days to come.

Free Carbon Dioxide:

Variation of free carbon dioxide in Kharkai river has been shown in the Table-6. The minimum value of free carbon dioxide was recorded as 0.036 mg/l at site S_1 and maximum value was 0.042 mg/l at site S_3.

Chloride:

The monthly variation of Chloride in the water of the river has been shown in Table-7. The minimum value was 40 mg/l at S_1 in the month of July and maximum 118 mg/l at S_3 in the month of September.

Calcium:

Calcium concentration of the river water has been shown in the Table-8. Calcium hardness varies from 94.00 to 246.00 mg/l. The minimum value was recorded at the site S_2 in the month of June and maximum value observed in the month of September.

Iron:

Monthly variation of iron in the river water has been shown in the Table-9. The minimum value of Iron is 0.10 mg/l in the month of May and maximum value 0.86 mg/l in the month of November. The low concentration of iron is not created health hazards. But high quantity creates digestive problems (Singh D.K and Singh A.K, 1985). WHO, 1971 suggested maximum permissible limited of iron as 1.0 mg/l for Drinking Water.

INTERRELATIONSHIP OF SOME PHYSICO-CHEMICAL FACTORS

In the case of transparency, it was seen that transparency of the water decreases as the concentration of solid particles in the water increase. Thus an inverse correlation was observed between these two parameters. In the rainy season naturally hardness of water washed away, which influences the zooplankton and phytoplankton density.

In the case of pH and Chloride of the water, it reveals that pH has a positive correlation with the Chloride. As per Zusti (1978), the pH of the water appears to be dependent much more on the relative quantities of Calcium carbonates and bicarbonates, but poorly dependent on Chlorides. The findings of the present work thus support the earlier Zusti (1978). The inconsistent increase in Chloride content during different periods particularly in summer season may be due to the incoming organic wastes of human activity with domestic water and low water level in the river. But the value increases in rainy season.

The interrelation of pH and alkalinity show positive correlation. This point should be noted that the monthly values of pH of the river water showed no significant difference during the study period. Values of alkalinity in the present study were much higher to the values reported for river water by Saxena (1997), Sharma (1986). The lower alkalinity values during rainy seasons months show a reduction in the degree of pollution of the river water at all the three sites.

The nearly constant concentration in Calcium and also magnesium during Winter and Summer may be attributed to the study state of hardening of water due to evaporation of the surface water and addition of Calcium and magnesium salts from detergents and soaps released from houses and workshop with washing water. Shukla (1995), Sharma *et.al.* (1995) have arrived at a similar conclusion.

B. PLANKTON

Plankton (Gr. Plankton Drifting), drift passively or swim so weakly that even modest current push them around. They are microscopic organisms that live suspended in the water environment and form a very important part of the fresh water community. They are small animals and plants less than 5 mm long.

Phytoplankton are microscopic plants which obtain their energy via photosynthesis. They require 400 x magnifications to see Bacteria Plankton, Proto Plankton and most phytoplankton.

Zooplankton are mainly crustaceans larva, Rotifiers and Copepods, Cladocerans. They are larger than phytoplankton.

PHYTOPLANKTON GROUP:

The main species found in the present work belongs to family Cyanophyceae, Chlorophyceae, Euglenoenophyceae and Bacillariophyceae. The phytoplankton occupies the first position in the aquatic food chain. The effect of some elements like Pb, Cd, etc show striking changes, even reduction of cell volume in phytoplankton. Quality parameters play very important role. The polluted water was found to have altered water quality like Co_2, pH, temperature alkalinity, nitrate, phosphate, food material, all collectively control phyto and zooplankton populations.

The main concern of the present work was to gain clear information about plankton. It is estimated that over 90% of the world oxygen is produced by four groups of plankton (Soil and water conservation society of Metro Halifa, 2006).

Phytoplankton are more abundant in areas with high intensity of light, as they convert this light energy into chemical energy. Higher temperature increase growth and multiplication of the both phytoplankton and zooplankton.

Phytoplankton species have mixed nutritional modes (some feed on other algae) in addition to synthesizing their food. When pollution increased as in the site S_3, their density decreased due to adverse situation to large

scale climatic periodicity. Ulothrix Sp. Were relatively tolerant to Pb. Oedogonium is sensitive to Pb. (Bryan. G.W.-1971).

The work of Adhikary.S (1996), shows that physical parameters interfere with the bloom forming – cyanobacteria (J.S.Industrial Research, 55 (8, 9) 732-732. According to Saxena.A (1997) seasonal variation of phytoplankton productivity of Sagar Lake, (Sagar, M.P.) suggests that summer is the most favourable seasons for phytoplankton productivity. Winter was unfavourable. Ahmad Shamim, Nayak.P. Hussain M.A. found diurnal variation of phytoplankton were influenced by pH, DO, Co_2, Co_3^{-2}, HCo_3^{-1} and temperature [Kef.J.Fresh water Biol.7 (1), (1995), 41 - 44].

Phytoplankton density depends upon transparency, temperature and sun shine as observed by Joshi, B.D (1995).

Phytoplankton of river Koshi was studies by Pandey B.N. *et.al.* (2005). Chlorophyceae and myxophyceae were abundant during summer, Bacillariophyceae and Euglenophyceae were abundant in winter. pH, hardness, Phophate concentration and toxixity due to Cd, Pb cause variable life histories [Cloern J.E. and Dufford R. (2005)]

In the light of above findings by different authors, the present work "Limnologistcal studies of river Kharkai at river's meet (Domohani) and Adityapur, Jamshedpur (Jharkhand)", has given important informations on Zooplankton and Phytoplankton.

ZOOPLANKTON GROUPS:

Investigation into the groups of Zooplankton and phytoplankton has been the theme of the present work. In the study of zooplankton we have centred the attention on only three prominent groups of micro invertebrates. These are Rotifera, Copepoda and Cladocera. Gupta (2005), stated that planktonic organisms very quantitatively with the depth site, time and the seasons of the collection. Since very little is known about the planktonic diversity, particularly the zooplankton of different fresh waters are assorted and incomplete, hence the present investigation was intended to understand the seasonal variation, periodicity and population dynamics of zooplankton groups in relation to the physic-chemical factors.

PROTOZOA

Among the protozoans, only rhizopods by few species such as *Arcella discoides, Centropyxis ecornis, Diffugia oblonga* were present in all the three sites. It formed only about 3.13 to 3.68% of the total zooplankton of the S_1 and S_2 and 2.3 to 2.95% of the site S_3 (Plate - 5). The S_1 site had its maximum density of rhizopods in the month of August as 21 U/L and minimum density of 2 U/L in the month of March / April 2012-13 and 27 U/L in September and 2 U/L in February / March during 2013-14. They were absent during October, November, April and May during 2012-13 and November, December during 2013-14. The S_3 site had its maximum density of 18 U/L and 30 U/L in September during 2012-13 and 2013-14 respectively and minimum value of 4 U/L in February 2012-13 and 2 U/L in December 2013-14.

ROTIFERA

Among the observed species of Rotifera *Branchionus plicatilis* was available not only in all sites throughout the year, but this species also available in minimum number, compared to the other species. The other two species occurring throughout the year were *Keratella kellicathia* and sp. *Keratell tropica* was captured in minimum number.

Quantitatively, only three species occurred throughout the year at all the three sites. *Synchacta pecitinate* could not be captured during later half of

the summer season and early half of the rainy season. Four species of Rotifera (*Keratella tropica,Polyarthra vulgaria, Filinia longiseta* and *Hexarthra mira*) could not be recorded during the months July and August. Moreover *Synchacta sp.* and *Rotifera vivipara* were available in the samples of site S_2, but these species could not be recorded at S_1 and S_2. Like wise *Rotaria tridens* was recorded only at Site S_3, but never found in water samples from site S_1 and S_2. Likewise *Keratella sp., Kellicathia sp., Synchacta sp., Fillinia longiseta, Rotaria tridens* and *R. vivipera* were not found in the samples of Site S_1 in any months during the study period.

Summing up the whole, it can hence be said that out of the 10 species of Rotifers in the present study, three were recorded at all the three study sites and in all the months, two species *Synchacta pecitinata* and *Roteria vivipera* were available only at site S_2, *Rotaria tridens* was recorded only at Site S_3.

Six species (*Keratella, kellicathia Synchacta, Rotaria tridens* and *R.vivipera*) were not recorded at Site S_1. Species of *Synchacta* was not recorded between later half of summer and early half of rainy seasons and four species (*K.tropica, Polyarthra vulgaria, Filinia longiseta* and *Hexarthra mira*) were not available in the early half of rainy season.

Previous Table No – 13 shows that Rotifers were available throughout the year. They were found in maximum numbers between February to May. There minimum numbers was recorded in month of August. Such a trend in the distribution of rotifers has been earlier reported by Goving (1963) and Gophen (1972) in their studies on river and lake system respectively.

COPEPODA

In the Kharkai river only five species from Copepod group were recorded during the study period. These were *Neodiatomus strigilipes, Paracyclops fimbriatus, Heliodioptomus viduus, Pseudodiaptomous lobipes* and *Encyclop sps.* It can be seen from the Table No – 13 that out of the five recorded species, *Neo*diaptomous strigilips was captured in maximum number in comparison to others. This species was also available throughout

the sampling period and at almost all the sites, except in the month of June. *Paracyclops timbriatus* and *Eucyclops sps.* were not found in the peak summer months such as May and June. *Psendodiaptomous lobipes* was not available almost the entire summer months.

In the present work Copepodes occured maximum during the months from July till October. They were recorded in peak number during September. Contrastingly, they were recorded in minimum numbers in the months of May and June which were also the hottest months of the year. Yusuf and Quadri (1985) have found a bimodal pattern of fluctuations in the Copepods number in their findings on Lake Manosbal, Kashmir. They have reported at peaks of modes in the month of late summer and early spring.

CLADOCERA

Present work exhibits the occurrence of Cladocera in the three stations of the Kharkai river. Only five species of this group of Cladocera were found in the samples. These were *Scapholeberis sp., Bunops sps. Daphnia sps., Chydorus phaericus* and *Hycryptus sordidus*. Out of them *Hycryptus sordidus* occurred in almost all the samples, at all the three sides throughout the greatest number amongst all the Cladocerans. Other four species were not available throughout the year. Thus, *Scapholeberis sp.* was not found in the months of January and August. *Bunops sps.* and *Chydorus sps.* were similarly not found in July. At site S_3 none of the above species could occur in the months January, February, June, July and August.

Cladocerans were maximally recorded in October and April. There minimum number was recorded in the months like other two groups of zooplankton. Cladocerans also occurred throughout the year at one or the other or at all the sites of study.

Data of table also lead us to say that among the three groups of zooplankton, Rotifers community comprised of the largest number of individuals, in general and in most of the months. The Copepods occurred at second position and the Cladocerans comprise of the minimum number of individuals amongst the entire zooplankton community, under investigation.

The consolidated and percentage of captured data given in the Table-17 further suggest that the population of Zooplankton comprised maximum number of individuals at study sites S_1, minimum number of individuals at site S_3. Number of Copepods captured are shown in the Table-17.

The concern over deterioration of water quality to pollution has attracted wider attention. This stimulated studies on limnology of the water bodies like lakes, rivers and oceans. Recently Winter (1954), Capland (1970) and Dickson (1971) reported the benthic macroinvertebrates, communities along with species diversity indices to compare changes in aquatic communities caused by environment stress in Europe. Important studies on the seasonal variations of zooplankton and phytoplankton from other parts of the world are those of Davis (1954), Cloem J.E. *et.al.* (2005), Hopkins W.A., *et.al.* (2004).

Cerlin 1943 correlated the seasonal changes of zooplankton with the changes in Calcium and pH values. Welch (1962) has mentioned light, food, factors for various patterns of distribution of zooplankton and phytoplankton.

Importance of studies of seasonal variations in fresh water of India was recognized by different workers systematic studies started only lately. Ganpati (1972) contributed much on the environmental factors as they effect the dynamics of a aquatic system. Michel (1980) Prasad and Singh (1980) reviewed the status of knowledge in Indian Hydrobiology.

In the light of above facts it was felt desirable to study the hydrobiology of polluted Kharkai river water and its principal effects on the zooplankton and phytoplankton density in water.

PHYSICO-CHEMICAL CHARACTERISTICS OF WATER AND ZOOPLANKTON DENSITY:

So far it is known, all natural bodies of water, irrespective of latitude, longitude, altitude and physic-chemical characters in the vast majority of localities support plankton, one of the main feature concerning horizontal

distribution of plankton is its irregularity, when any area of aquatic environment is considered.

Welch (1962) has mentioned light, food, dissolved gases, temperature, gravity and wind as possible factor for various patterns of zooplankton distribution.

Dorris (1978) stated that polluted waters have low diversity indices because of the fact that pollution sensitive species are eliminated and few pollution tolerant species flourish well in absence of competition.

Harrel and Doris (1978), Rao *et.al.* (1981) have inferred that macroinvertebrate diversity tend to increase with increasing self-purification on polluted rivers.

Coming to the reference of present study about the zooplankton structure and their dynamics in the Kharkai river water, basically as already reported (Chapter-3) investigation was limited to 3 taxanomic categories of zooplankton. viz. the Rotifers, the Copepods and Cladocera. Among the three taxonomic groups the Rotifer was represented by 14 species, the Copepod was represented by 7 species and the Cladocera by 5 species. Thus from species diversity point of view Rotifera constituted the most prevalent groups. Among the zooplankton, Copepods occupy second place and cladocera the third.

Pertaining occurrence of the zooplankton in the river water was found that almost all the three categories were available throughout the study period (March, 2012 to February, 2014). However further observation revaeled that not all the species from any taxonomic groups could always be available in the water. Thus only 3 species *Asplanchnopus multiceps,* were available at all the sides of the study period. Among Copepods, only species viz. *Neodiaptomus strigilipes* and *Heliodiaptomus viduus* could be captured in almost all the months and among Cladoceran only one species viz. *Hycryptus sordidus* was found to remain present in the three stations site of river water around the year.

The numerial dominance of Rotifers were found over Copepods and Cladoceran groups round the year. As exhibited by Table-17 the average

density of Rotifers as 120.00 ± 54.81, that of Copepods 73.50 ± 58.06, and Cladoceran 19.41 ± 10.89 of water. Percentage of the three groups further reveals that in the zooplankton community of river water rotifers population comprised 57.93 ± 24.14%, whereas Copepods comprised of 33.38 ± 24.90% and Cladoceran comprised of only 8.66 ± 3.37%. The main peak of rotifers as observed in April, that of Copepods in with two peaks in the study period. The first peak was recorded in the month of October and the second peak in April. Choubey (1990) has reported a single peak for rotifers in the month of March, for Copepods in the month of July and September. They too have stated that Cladoceran in zooplankton community was scanty, but had two peaks, a bigger peak in October and a smaller peak in July.

The concentration of zooplankton as seen in Table-13 suggested that from amongst three stations (study sites) the maximum number was always recorded at site S_3 and minimum number at site S_1.

Water temperature:- The number of zooplankton has in inverse co-relation with the increase in water temperature. In fact temperature is the main factor that regulates the seasonal pattern of development and densities of plankton. The three groups of zooplankton showed their period of maximum density in different months/season which may be due to their different optimal thermal requirement. The rich growth of zooplankton was noticed during the winter months with highest range and lowest range in monsoon months in respective years of the study. Rotifera was the most dominant group. The Copepods contributed the second position with the total density. The maximum density of Rotifers observed in summer months in both the years. The minimum density was observed in monsoon months. Highest density of Cladocerans was noticed in summer months and lowest density in the monsoon months. Among the Cladoceran group, *Dhapnia sps.* was dominated throughout the study period. The maximum density of Copepods was recorded in winter months and minimum density was recorded in monsoon months. Among the Copepods *Cyclops* was dominating during the study period. In Ostracods,

Cypris was the only species present in the water during post monsoon months.

Alkalinity:- Study indicates that growth, survival and increase in number of planktons is influence by the alkalinity of the water.

Nitrate and Phosphate:- The role of nitrate and phosphate in the metabolism of the river water and sewage water draw an unprecedented attention due to its importance in eutrophication. The increase in concentration of nitrate during summer season is due to evaporation of water in the river water and domestic sewage water, thereby increasing the concentration. Occurrence of fewer nutrients during the other seasons may be due to its utilization in macrophytic growth. Release of nutrients due to decomposition and rising summer temperature also increase the nitrate concentration of water. The increased nitrate concentration favoured the growth of Rotifer population in water during this period. The optimal nutrient requirement vary from species to species.

Turbidity:- Turbidity of water and zooplankton density was found to be weak and negative. It suggests that zooplankton are not affected by turbidity level of the water in the present findings. Trivedi and Goyal (1986) have reported that turbidity of a water body is associated with reduced microbial growth.

From the study it was found that Rotifers density was lowest in the rainy season, high in winter season and highest in summer season. The Copepod population was highest in summer season, high in winter season and lowest in rainy season. During early rainy season most of the Rotifers were not available. Likewise most of the Copepods were not available during late summer season; while Cladocerans showed a great irregularity in their distribution.

PHYSICO-CHEMICAL CHARACTERISTICS OF WATER AND PHYTOPLANKTON DENSITY:

A perusal of the data obtained on the density and composition of phytoplankton revealed that Bacillariophyceae and Cyanophyceae density were comparatively high during summer season and the density of Chlorophyceae was high during winter season but Roy (2007), Bhowmick and Singh (1985) reported that the density of these phytoplankton were always high during summer season. Singh and Srivastava (1988) have opined that Chlorophysean algae proliferate in moderate alkaline aquatic medium associated with low temperature while Munawar (1970) have suggested that water with high alkalinity support Volvocaceae. The present study showed that green algae form exhibited close affinity for high value of transparency, dissolved oxygen and alkalinity and was also indicative the fact that polluted water are unsuitable for multiplication of the green algal forms. The present study also revealed that the members of Cyanophyceae behave differently towards the phosphate and nitrate of the river. It is also suggested that silicate is always more where the growth and concentration of diatom is less in water and a temperature of 28-30°C to be the most suitable for Cyanophyceae growth.

The present work was consistent with the finding of Bilgrami and Dutta Munshi (1985), Singh and Srivastava (1988), Sinha (1992), Chakravarty and Moitra (1993), Das and Sinha (1994), Roy (2007).

Thus the year round study revealed density of phytoplankton during monsoon season in the river (Study Sites) was scanty and almost negligible because of very fast water current. Massive inflow of pollutant, less penetration of light, variation of physic-chemical properties in comparison to summer and winter season.

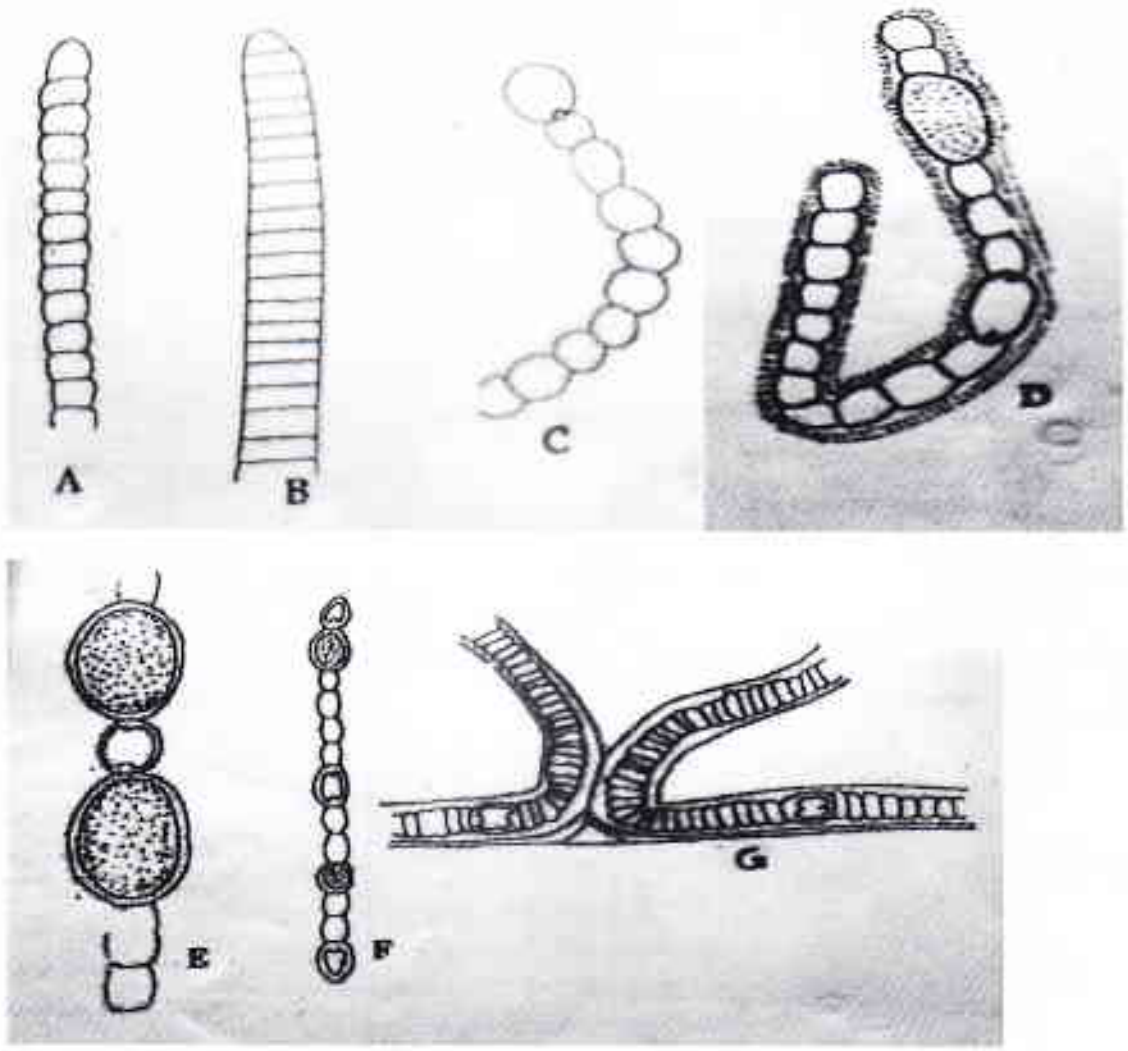
The physic-chemical characters showed that the river water always carried various physico-chemical substances in high concentration which suggest that the water is qualitatively impure. In the present study, it is observed that phytoplankton and zooplankton occurred throughout the year at

all the sites in water in fairly good numbers. It can be said that apart from the Rotifers, Copepods and Cladocerans, many more categories of micro and macro invertebrates thrive in the water. It therefore, leads the author to infer that the domestic sewage, in here contaminate the river water, which cannot be safe for health of those inhabiting on its banks.

It is said that the disorderness of the system (eutropy) of the universe is increasing. There are many contributory factors like global warming, depletion in ozone layer due to chlorofluorocarbans, oxide of nitrogen and other chemicals of the volatile nature. Anthropogenic activities contribute more to the global pollution. So river, rivulates and domestic sewage water show high degree of pollution. The net effect is depletion of the important zooplanktonic and phytoplanktonic species.

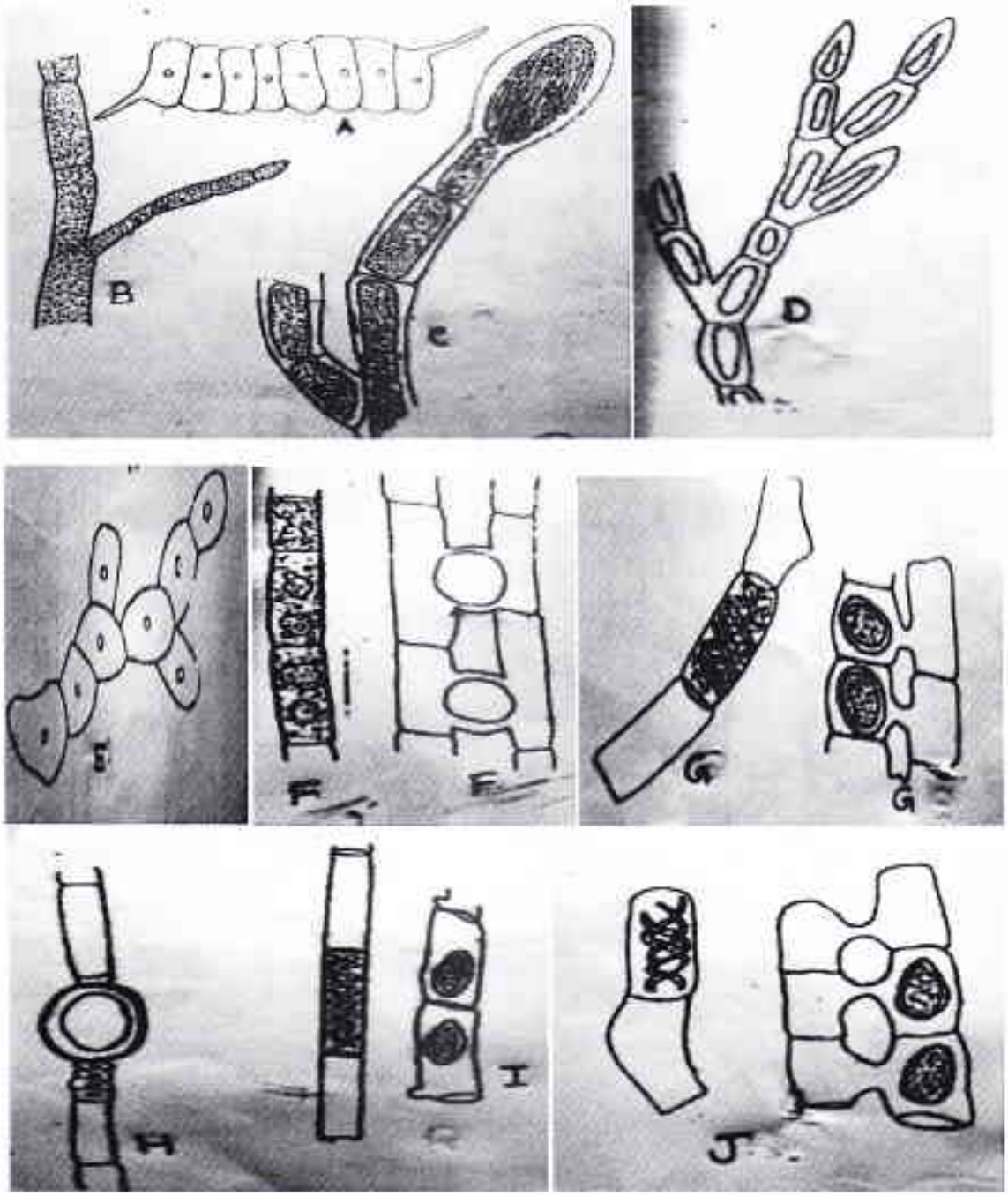
PLATES

PLATE - 1CYANOPHYCEAE



A. *Oscillatoriachalybea*
B. *O.curviceps*
C. *Nostoc commune*
D. *Nostoc paluasum*
E. *Anabaena sphaerica*
F. *Anabaena oryzae*
G. *Scytonema* stuposum

PLATE-2CHLOROPHYCEAE



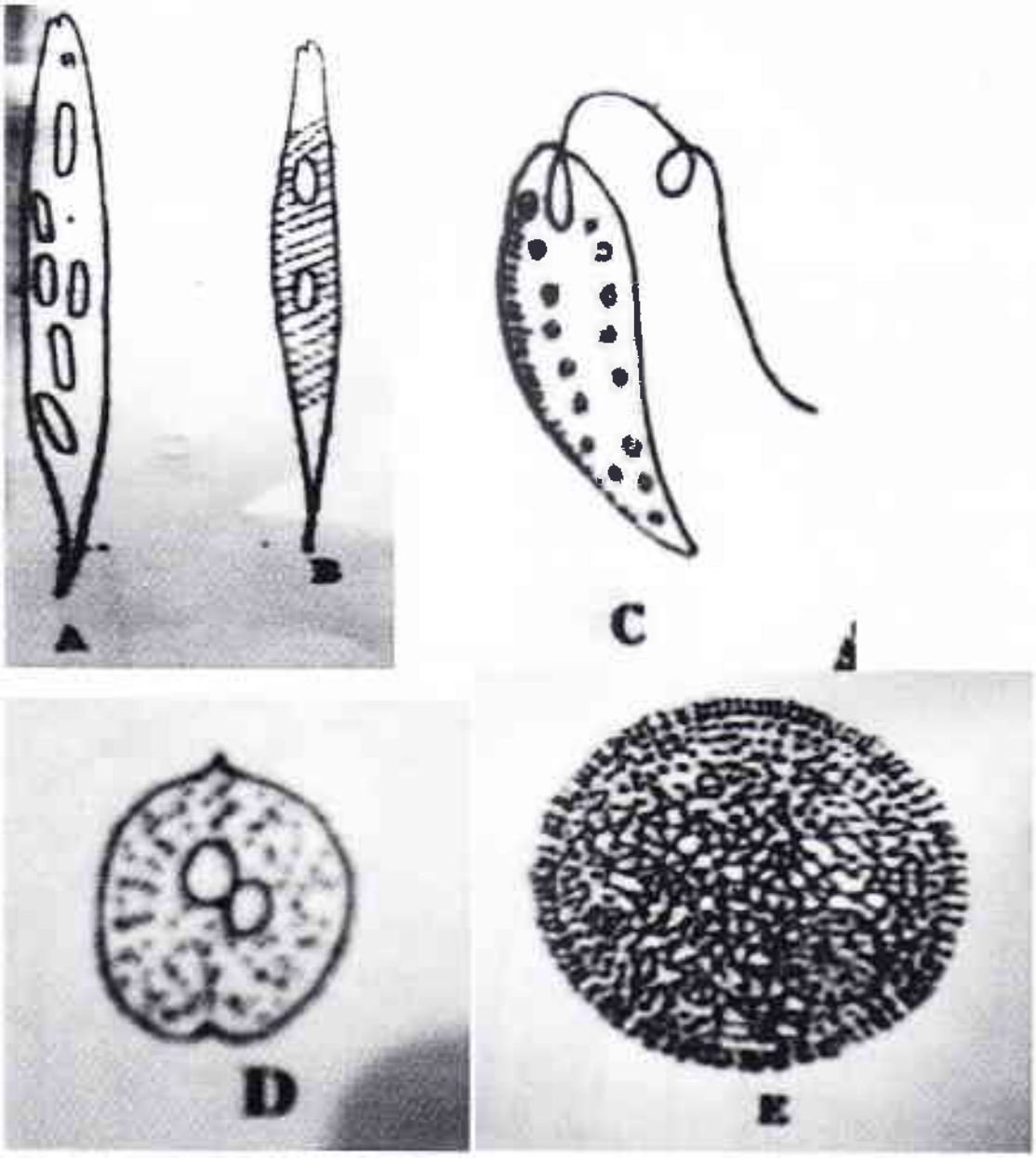
A.*Ulothrix zonata* B. *Cladophora fracta* C.*Pithophora varia*

D. *C.elegans* E. *Coleochate irregularis* F. *Zygnema majus*

G. *Spirogyra brunea* H. *Oedogonium pussilum*

I. *Spirogyra microspora* J.*Spirogyra lylina*

PLATE-3EUGLENOPHYCEAE



A.*Euglena acus*

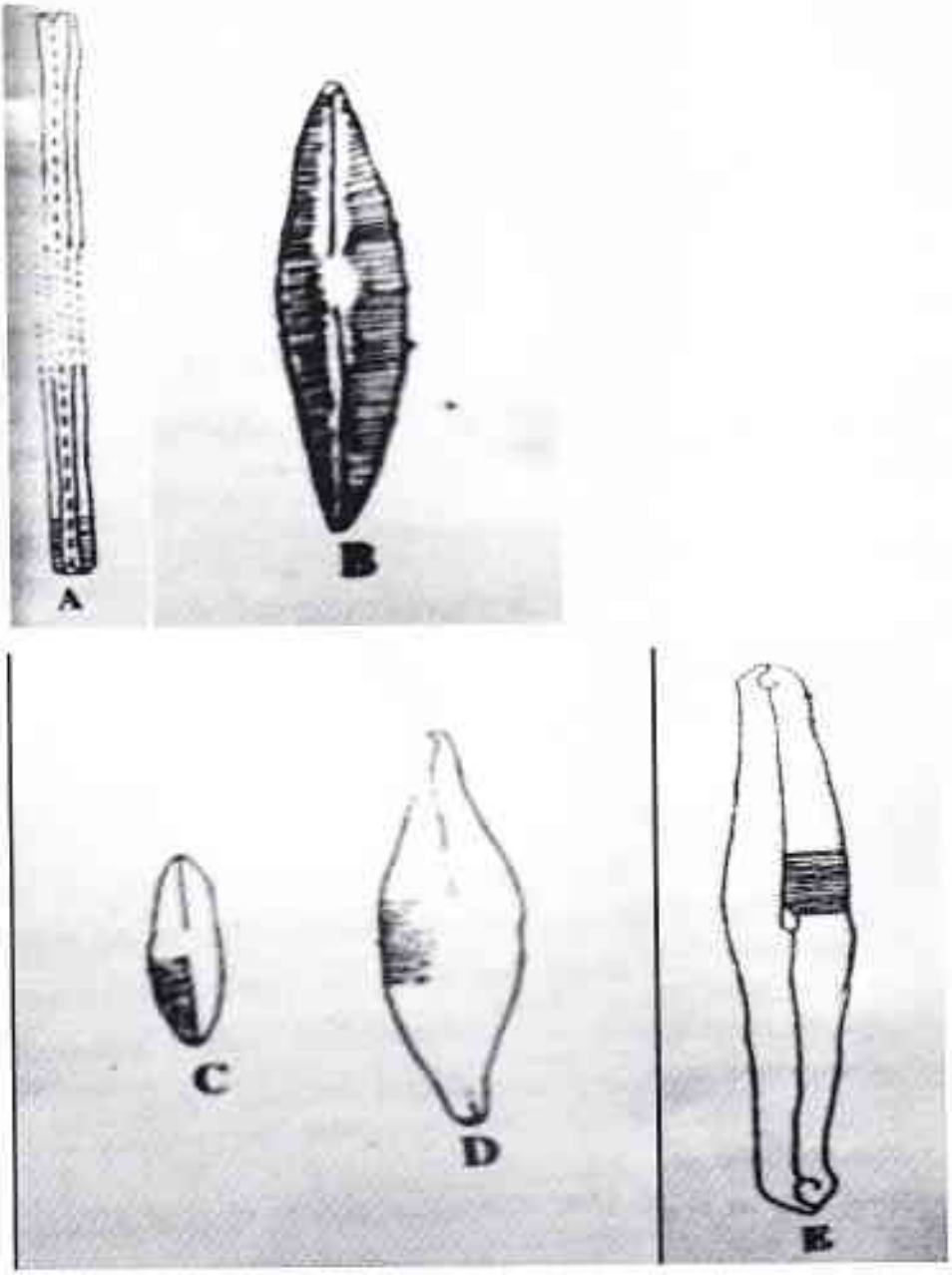
B.*Euglena acus varrigida*

C. *Euglena viridis*

D. *Phacuscurvicauda*

E. *Volvox globater*

PLATE-4BACILLARIOPHYCEAE



A.*Synedra capitata*

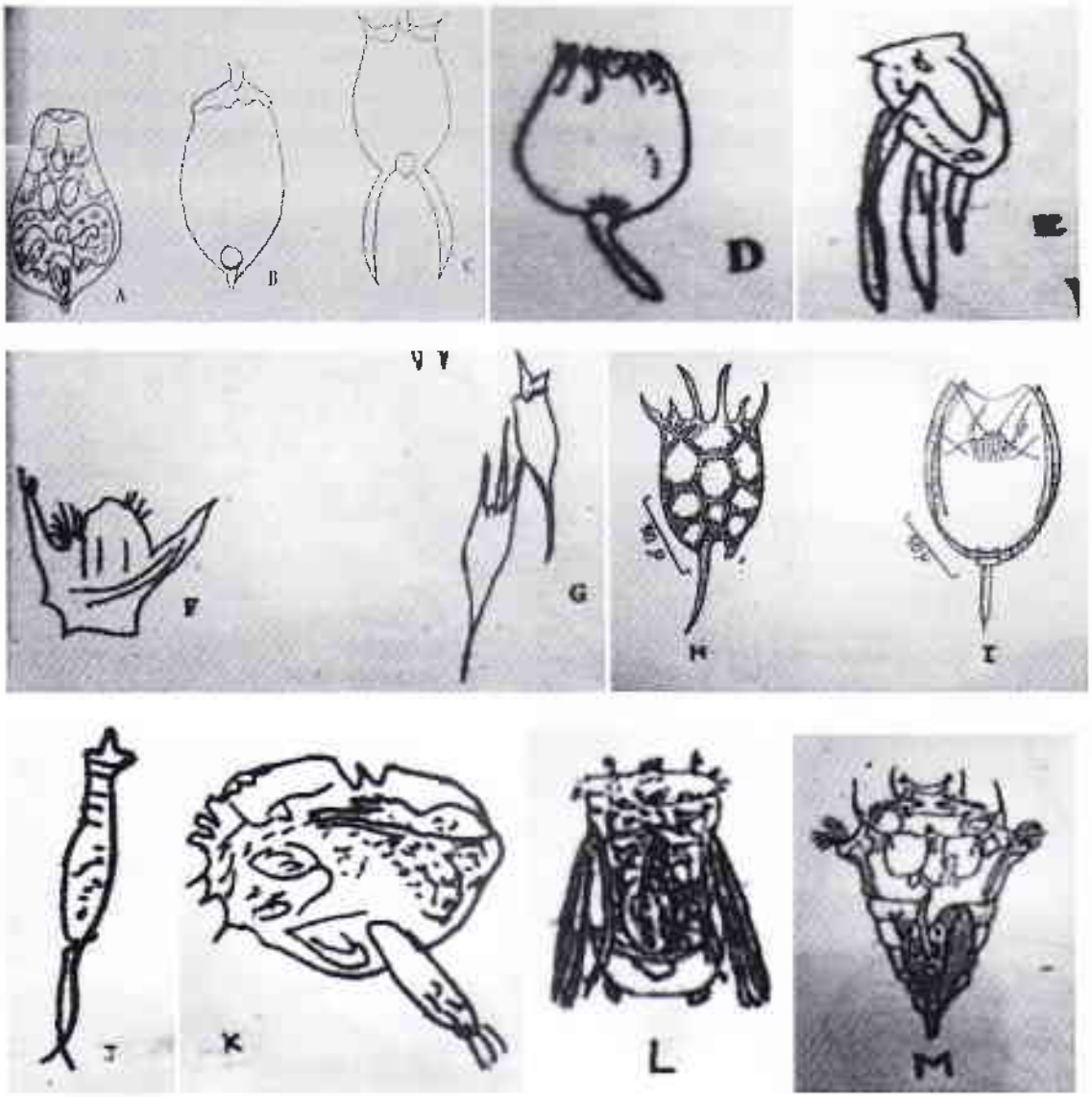
B. *Navicula viridula*

C. *Navicula pupula*

D.*Pinnularia braunii*

E.*Pinnularia tabellaria*

PLATE-5 **ROTIFERA**



A. *Asplanchnopus multiceps* B. *B.angularis* C. *B.caudatus*

D. *Brachionus sp.* E. *Filinia longiseta*

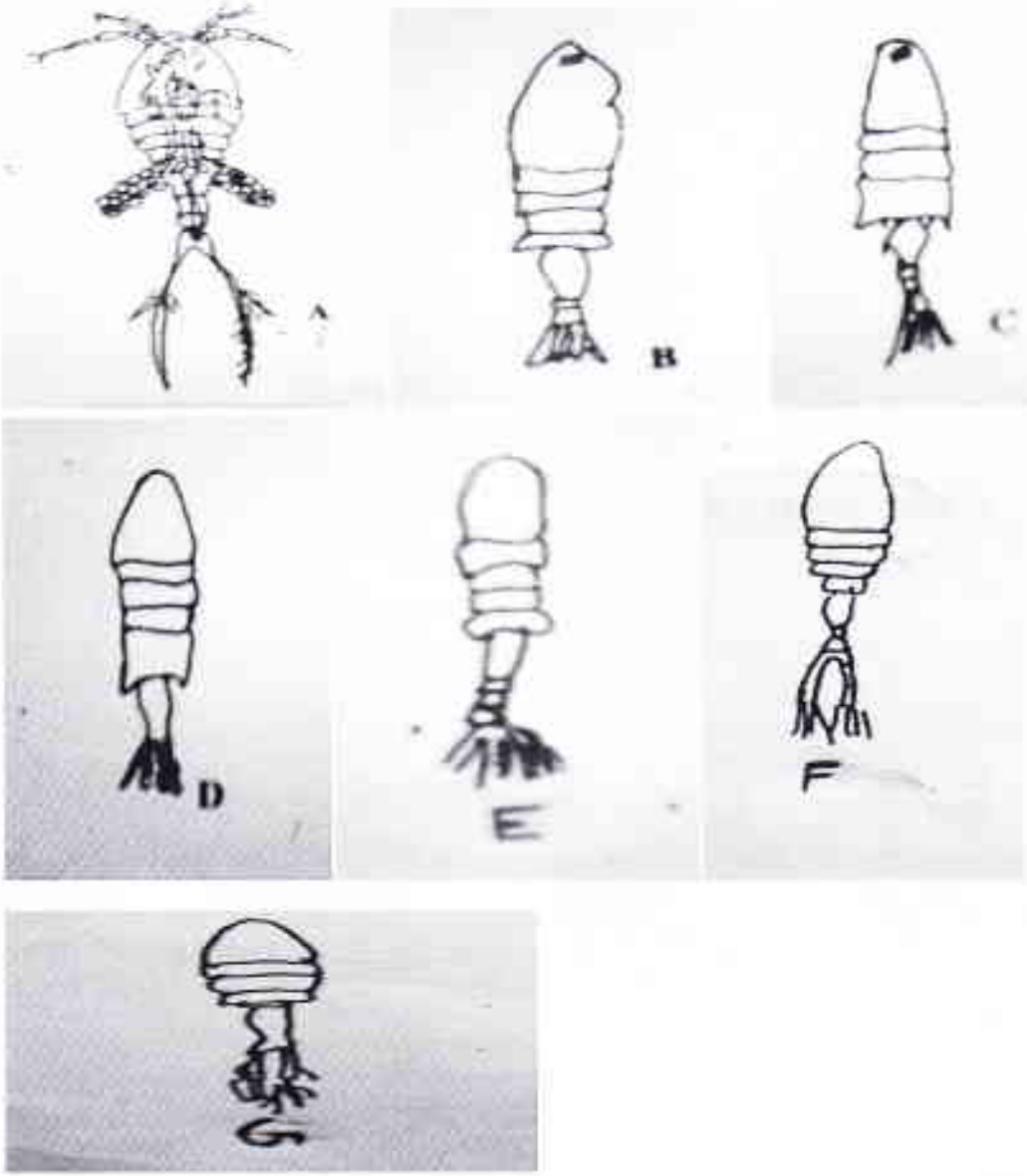
F. *Hexarthra mira* G. *Kellicathia* H. *K.tropica*

I. *Monostyla bulla* J. *Rotaria tridents*

K. *Rotaria vivipara* L. *Polyarthra vulgaris*

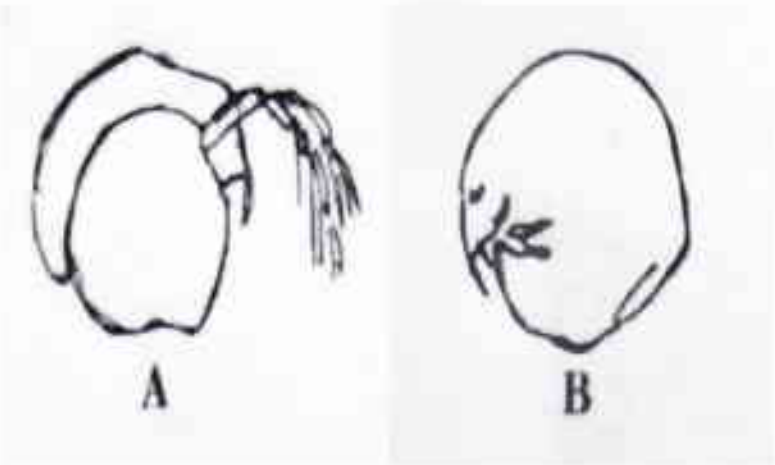
M. *Synohaeta pectinata*

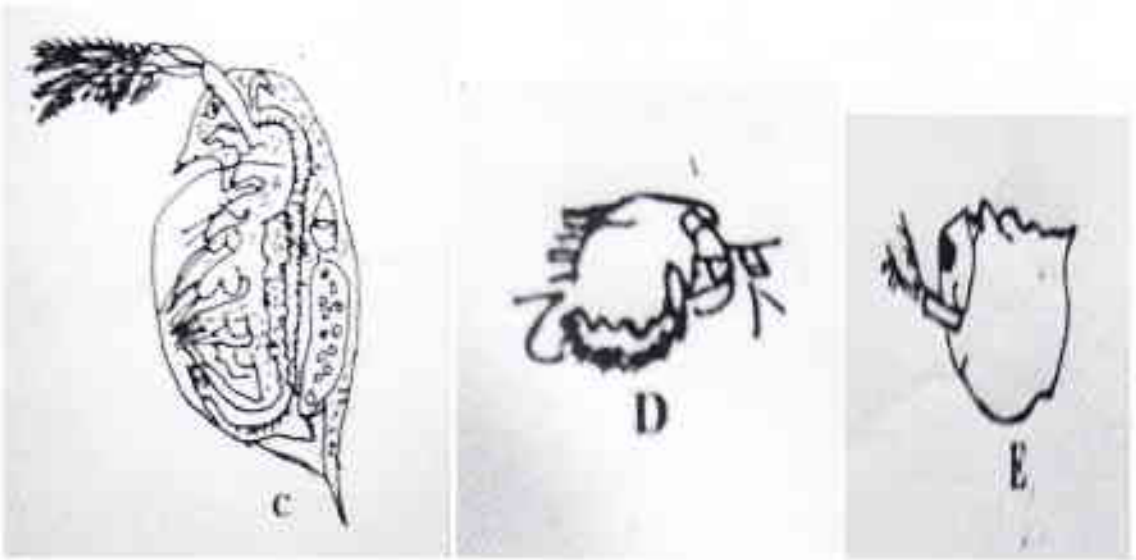
PLATE-6**COPEPODA**



A. *Cyclopes sp.*
B. *Heliodiaptomus viduus*
C. *Heliodiaptomus pulchur*
D. *Neodiaptomus strigilipes*
E. *Pseudodiaptomus lobipes*
F. *Eucyclops sp.*
G. *Paracyclops fimbriatus*

PLATE-7 **CLADOCERA**





A. *Bunops sp.*

B *Chydorus phaericus*

C *Daphnia sp.*

D. *Hycryptus sordidus*

E *Scapholeberis sp.*

PLATE-8 GASTROPODA

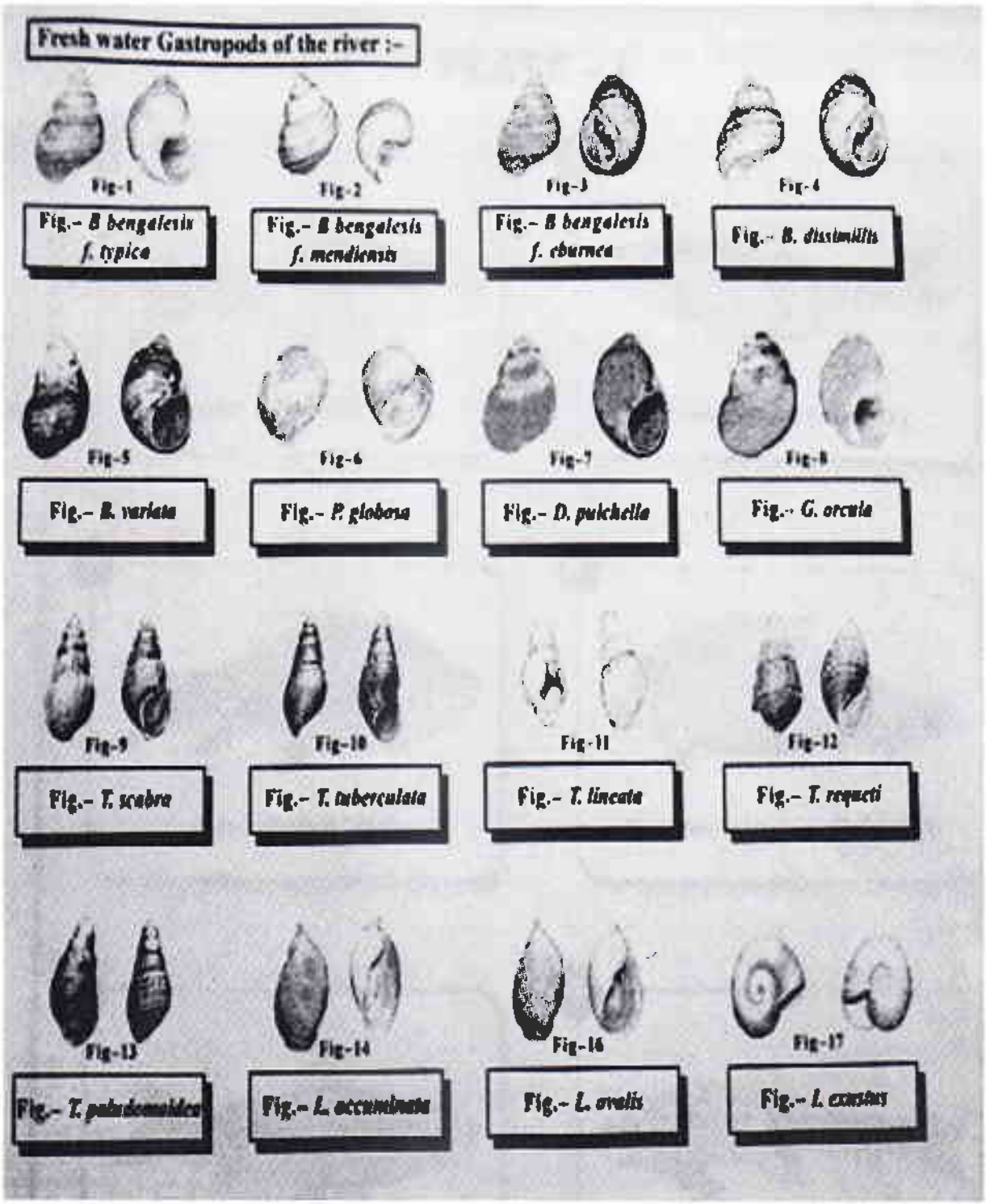


PLATE-9 ICHTHYOFAUNA

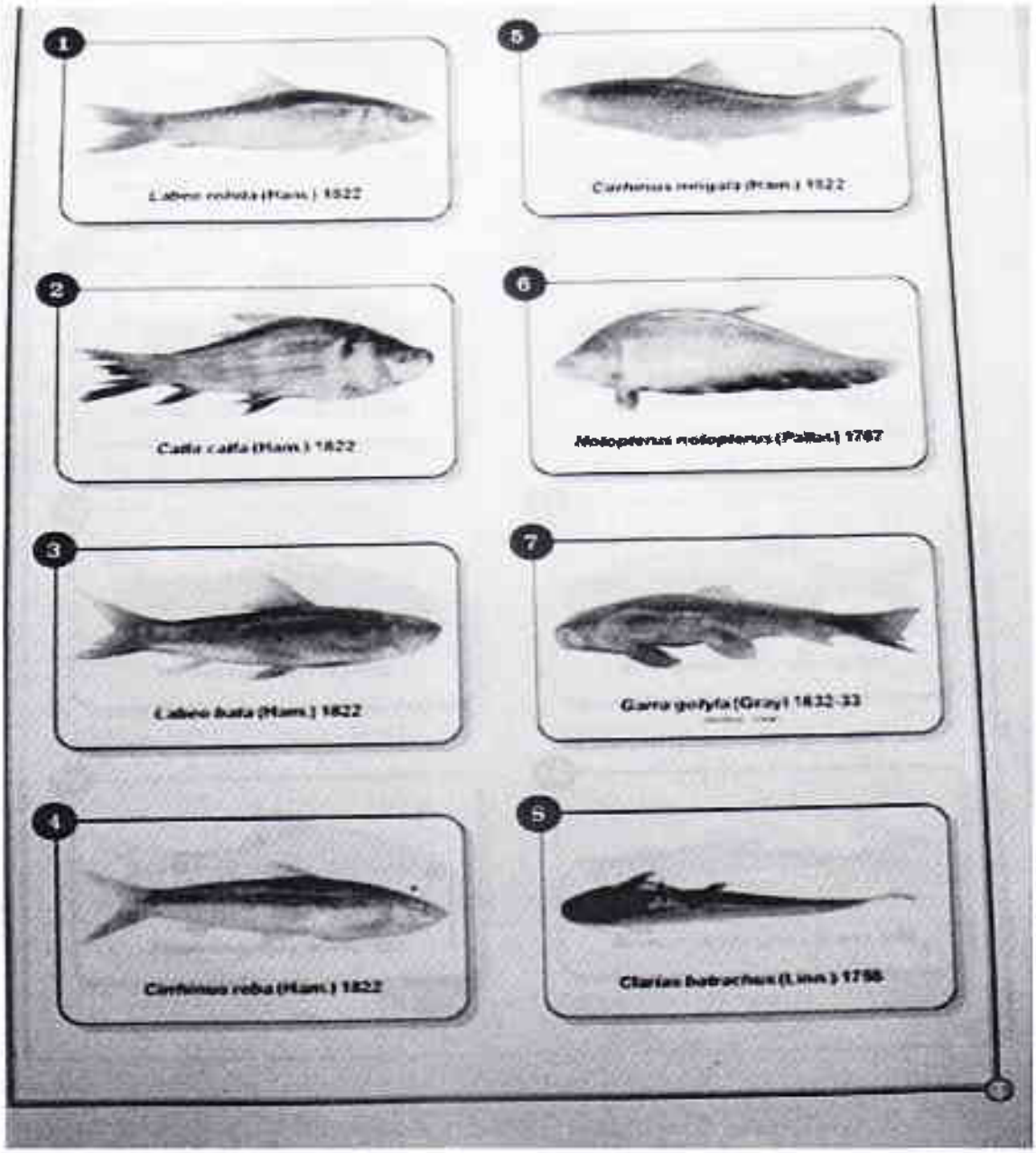


PLATE-10 ICHTHYOFAUNA

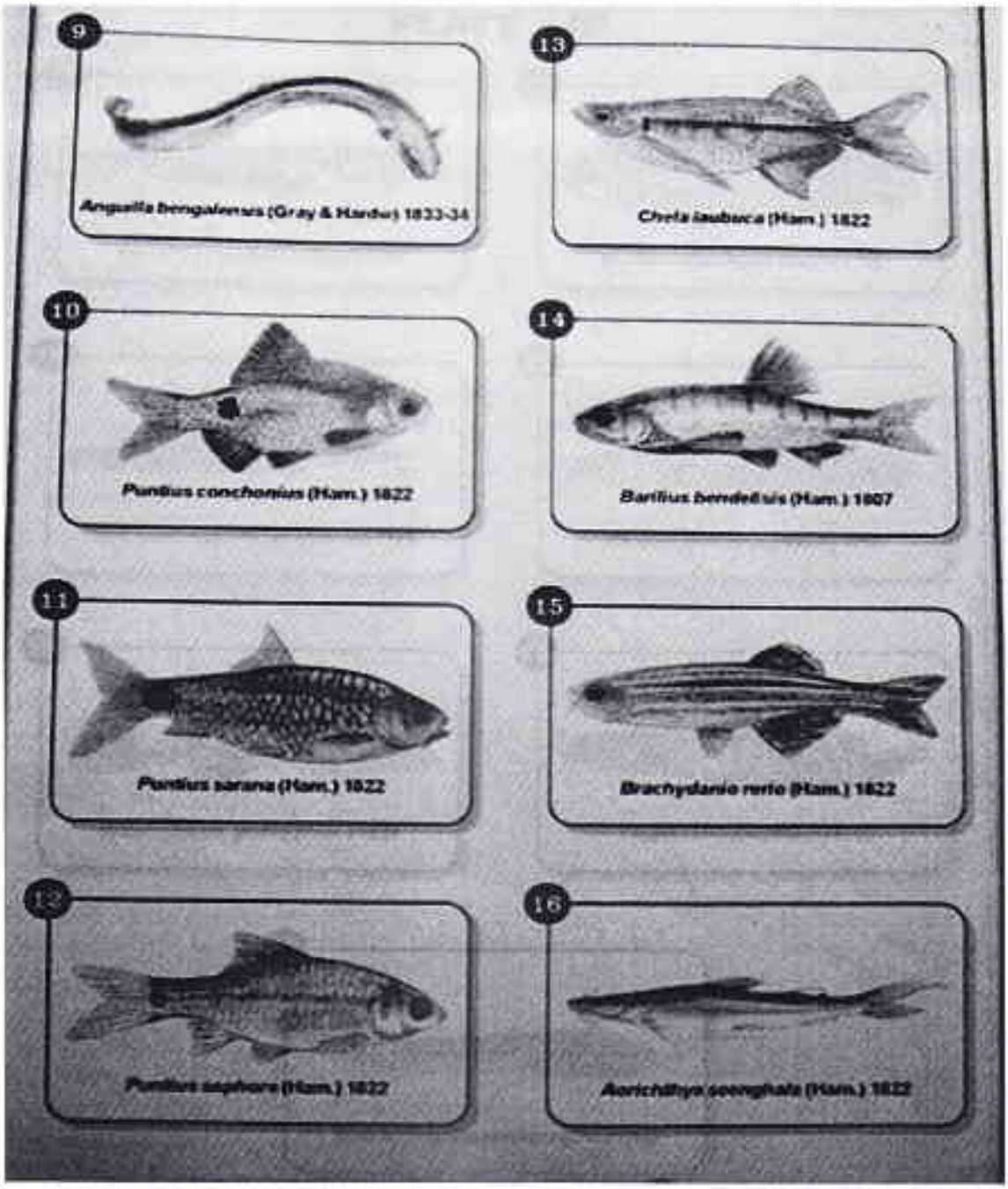


PLATE-11 ICHTHYOFAUNA

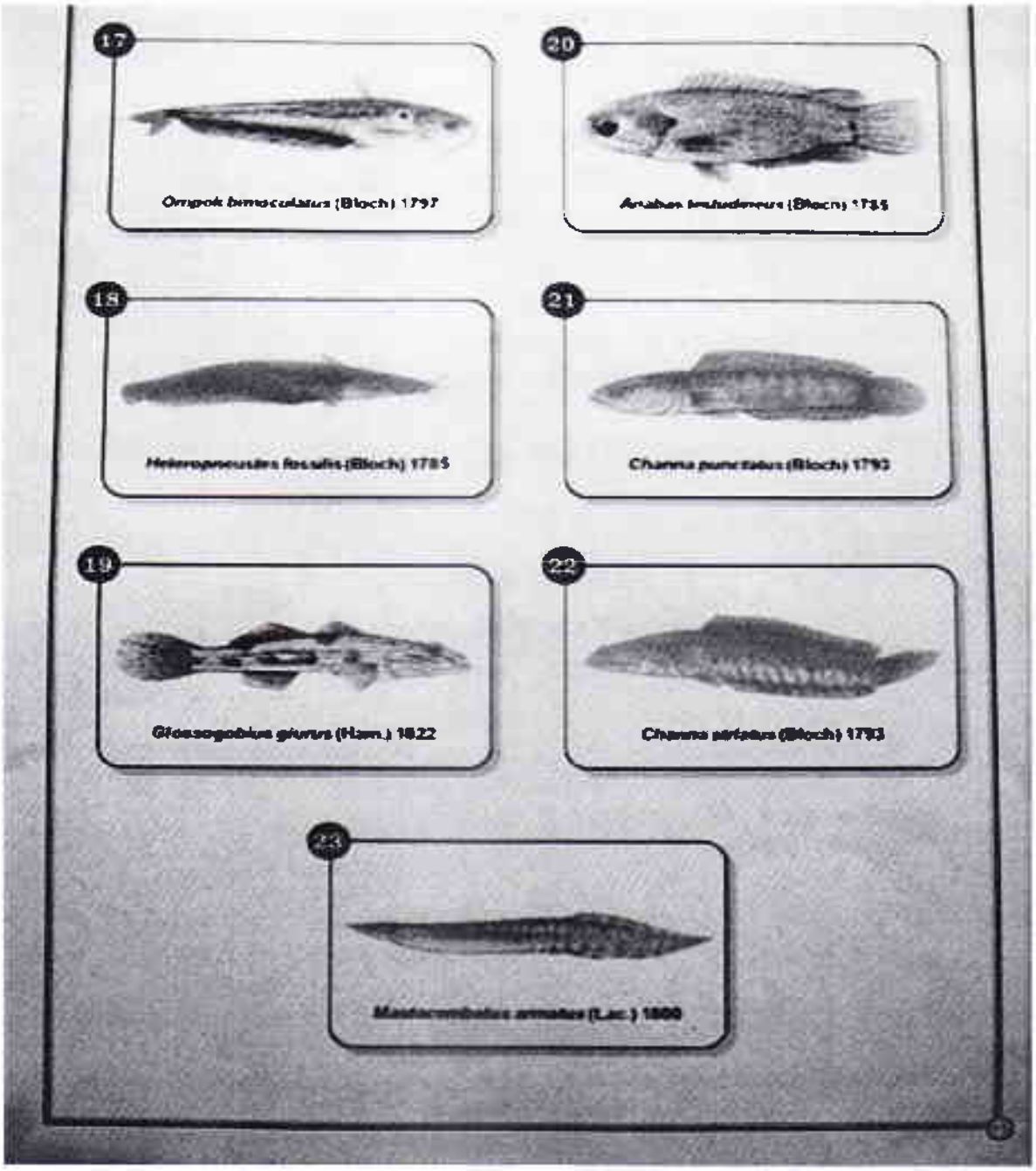


PLATE – 12 : CRUSTACEANS, CLADOCERONS, COPEPODS AND OSTRACODS

CYCLOPS SP

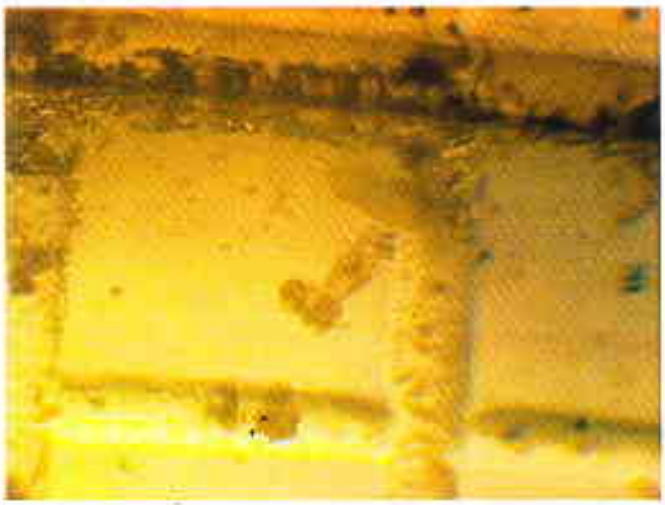


PLATE – 13 : CRUSTACEANS, CLADOCERONS, COPEPODS AND OSTRACODS






PLATE – 14 : CRUSTACEANS, CLADOCERONS, COPEPODS AND OSTRACODS

DAPHNIA

PLATE- 15

FISH FAUNA OF THE RIVER

PLATE- 16

MACROPHYTES OF THE RIVER

SUMMARY

CHAPTER – 05

SUMMARY

The Kharkai river arises in Mayurbhanj District, Odhisa on the north slope of Darbarmela Parwat and the Western slopes of Tungru Pahar flows touching Rairangpur, Saraikela zones and lastly enters the Subarnarekha river in North Western part of Jamshedpur. The present study was undertaken to test and substantiate the prediction of abiotic and biotic factors, quantitative and qualitative analysis of phytoplankton and zooplankton at seasonal levels, benthic fauna such as insects, fishes and molluscs of the river water and their systematic account. Three stations were opted for collection of water samples. The total distance of successive sites was about 7.5 km stretch of the river Kharkai. The three sites taken were Babakutir Ashram (S_1), near Jayprakash Udyan (S_2) and rivers' meet Domohani (S_3). Photographs are shown at the end of the first chapter.

Investigation was done for a period of two years (March, 2012 to February, 2014). The temperature of the water ranged between 18.5°C to 36.9°C at the three sites.

The turbidity value was found on the average to be lowest at site 1 and highest at site 3 due mixing of varieties of effluents from the houses and workshops on way. The transparency of the water naturally got affected and it was maximum of S_3 and less at S_1. Maximum transparency was observed in January. In the remaining months the transparency of the river water was found to undergo depression.

Little variation as observed in the value of pH in the water of the three study sites. Concentration of dissolved oxygen was less during the summer months and remarkably low at rainy season. Calcium, magnesium and iron all three contribute to the total hardness of any water body. The minimum value of free Co_2 was recorded as 0.036 mg/l and site S_1 and maximum value was

0.042 mg/l at site S_3.Heavy metals like Zinc, Cadmium, Nickel and Lead observed mainly at Site3,found in low amount at other two sites.

Continuous addition of treated and untreated wastes change the water quality. Analysis of water samples were also done for water quality parameters like to toxic heavy metals concentrations like Zn, Cd, Pb. Gills, muscles and fins of fishes are analysed for Mo, Zn, Cd, Co and Pb. These elements ultimately reach the human body. Zooplankton and other micro benthos serve as food source to fishes. Toxic metals or trace elements or heavy metals influence the population of zooplankton and cause sharp decline in the micro and macro zoo-benthos colonies.

Investigation into zooplankton was centered on only four taxonomic categories viz. Rotifera, Copepoda, Cladocera, Ostracoda and some Protozoa. Among the Rotifers, in all, fourteen different species were recorded in the river water. Copepods were represented by seven species. Among Cladocerans only five species were recorded in the water. Ostracoda was only one species that is *Cypris sp.* All the four categories of zooplankton were found at all three study sites. Rotifers were found in maximum numbers between February to May and minimum numbers was recorded in the month of August. Copepods occurred maximum during the months from July till October. Cladocerans were maximally recorded in October and April.

Phytoplankton are microscopic plants which obtain their energy via photosynthesis. They assist in recycling elements such as Carbon and Sulphur. They produce asexually and keep population number up. These are most abundant in areas with a high intensity of light as they can convert light energy to chemical energy.

During the course investigations four families of Phytoplankton were recorded for example Cyanophyceae, Chlorophyceae, Euglenophyceae and Bacillariophyceae. There was 7 species of Cyanophyceae, 12 species of Chlorophyceae, 5 species of Euglenophyceae and 5 species of Bacilariophyceae recorded in Table-12.

Higher temperature increased growth and multiplication of both phytoplankton and zooplankton. Phytoplankton density depends upon

transparency, temperature and sunshine as observed by Joshi, B.D (1995). Chlorophyceae was abundant during summer. In the rainy season naturally hardness of water washed away which influences the zooplankton and phytoplankton density.

The member of Cyanophyceae behave differently towards the phosphate and nitrate of the river water. Thus the year round study revealed that density of phytoplankton during monsoon season in Kharkai river was scanty because of very fast water current, massive inflow of pollutant, less penetration of light.

The group gastropoda was represented by 15 taxa belonging to six families of two orders namely Mesogastropoda and Basommatophora. Both orders include 15 species.

The fish species found in river Kharkai during March 2012 to February 2014 were recorded thirty species as vulnerable species, nine as endangered species four as rare species and one as Endemic species.

Macrophytes are rich in Kharkai river because of stony bottom of the river. The abundant macrophytes are *Eichhornia* (Water Hyacinth or Jalkumbhi), *Vallisneria*, *Potamogeton, Hydrilla,* etc.

Occurrence of microfauna in a water body is not the character of the good quality of water. The presence of poor number of zooplankton and phytoplankton in the water leads us to infer that the water of the river is qualitatively polluted. Poor number of zooplankton and phytoplankton show less dissolved O_2. Finally it is concluded that physico-chemical parameters of water of the river Kharkai as compared to a potable water is poor. Therefore conservation of all living species in the river Kharkai is very essential to maintain the eco balancing of the river. The conservation can be undertaken through stopping direct discharge of sewage and industrial effluents from the industries.

REFERENCES

REFERENCES

- Ahmad, E. (1965) : Bihar, a physical, economic and regional geography, R.L., Ranchi, pp 1-120.

- Ahmed, J.W. and Sarkar, A (1997) : Limnology and productivity of two reservoirs in North Eastern India, *J.Inland FishSoc.*India, **29** (2) : 1-10.

- Alam Aftab & Khan Asif, A. (1996) : Dynamics of Plankton Communities in four fresh water lentic ecosystems in relation to varying dominant biota. *Polln Res,* 15 (**3**), 287-291.

- Alikunhi, K.H.(1952) : On the food of young carp fry. *J.Zool. Soc.* India, **4**: 77-84.

- Alikunhi, K.H.1957 : Fish culture in India Farm Bull No. 20, ICAR, New Delhi.

- Anderson, M.M. 1989 : J. Assiotic Society Bengal, **58**: 345-358.

- APHA, (2005) : Standard Methods for the examination of water and waste water. American Public Health Association, New York, USA 112 pp.

- Ayyappan, S. and Chandrasekhara Gupta T.R. (1980) : Limnology of Ramasundra Tank, *J.Inland Fish Soc.*India vol.12 No.2.

- Abernethy, Charles L. (1997) "Water Management in the 21st Century : "Problems and Challenges" inDev and Cooperation No 2 pp 8-13

- A.Sharma, M.M.Ranga and P.C.Sharma (2009) : Water Quality status of historical Gundolav lake at Kishangarh as a Primary Data for sustainable Management 173-187.

- Baruah, A. (1993) : Plankton variability of a tropical wetland, Kawar Lake, Begusarai (Bihar), *J.FreshwaterBiol***5** (1) : 27-35.

- Baruah, A. *et.al.* (1994) : Diel variation of phytoplankton in a tropical wetland of North Bihar. *Env Eco,* 12 (1), 30-32.

- Banziger, R. 1995 : A comparative study of the zoo-benthos of eight land water interfaces. *Hydrobiologia* 300/301 :133-140.

- Banerjee, R.K; *et.al.* (1998) : River Damodar and its environment, Bull. No.-79 Central Inland Fish Res. Ins. Barrackpore, India.

- Battis, S.K. (1992) : Freshwater zooplankton of India. Oxford and IBM Publication. pp 178.

- Benzie, John A.H. (1984) : The colonization mechanism of stream Benthos in a tropical river (Menik Ganga; Sri Lanka) *Hydrobiological*111: 171-179.

- Berg, *et.al.* (1948) : Biological Studies on the river Susha. **Folial Limnol Scand 4** : 318 pp.

- Berg, L.S. (1940) : Classification of fishes both recent and fossils. Repoint 1957, Ann, Arbor Michigen, J.W. Edwards Brothers.

- Bhowmick, B.N. & Singhj A.K. (2005) : Phytoplankton in relation to physico-chemical factors of river Ganga at Patna. *Indian J. Ecol.* 12 (**2**) : 360-364.

- Bhowmik W.L. (1978) : Environmental factors affecting fish food in freshwater fisheries, Kalyani, West Bengal, pp1-238.

- Bhatia, V.S (1970) : Studies on the biology of some freshwater fishes part IV *Mystusseenghala*(Sykes) J. Bombay Nat. Hist. Soc. **67**(2) : 289-302

- Bhell, I.A. and Yousuf, A.R. (2004) : Limnological features of some lotic system of Kashmir in Bioresource, pp 57-70.

- Bhuyan *et. al.* (2014) : Water Quality Index in Subernarekha river *J.Env.Sc.* pp 39-45

- Bilgrami, K.S. and Dutta Munshi, J.S. (1985) : Ecology of river Ganga Impact of human activities and conservation of aquatic biota (Patna to Farakka) final technical report, Department of Environment, New Delhi 1-97.

- Bishop, J.E. (1973) : Observation on the vertical distribution of the benthos in a Malaysian Stream. *Fresh water Biol.* **3**: 147-156.

- Bose, K.C., Pandey, P.N and Mahata, M.C. (1978) :Environmental studies of three ponds of Ranchi (Bihar), Benthic macrofauna. *Comp. Physical.Ecol.***3**(2) 73-76.

- Boxter, R.M.(1977). Environmental effects of dams and impoundments. *Annu. Rev. Ecol. Syst.***8:** 255-283.

- Brinck, P. (1945) : Studies on Swedish stoneflies. *Opuse. Ent. Suppl.***11** : 250 pp.

- Brinkhurst, R.O. (1972) : The benthos of lakes. *The McMillan Press. Ltd. Lond.***190.** pp.

- Bronmark, C. *et.al.* 1984 : Animal community structure as a function of stream size. *Hydrobiologia***112;** 73-79.

- Bryan, G.W. (1971) : Ann.Inst. Oceanograph, **45,** 145-150.

- Chakroborty, N. *et.al.* (2002) : Spatiotemporal distribution pattern of certain plankton of river Hoogly. *J. Inland. Fish. Soc., India,***27** (1) 6-12.

- Chako *et.al* (1959) : A survey of the fisheries of the Cauvery river contr. Freshw. Fish Biol. Arch *Hydrobiol***46.** 128-141, 324-391.

- Chakrobarti, P.K. (1997) : Fish species diversity in the flood plain lakes and the need for its conservation, Central Inland Capture Fisheries Research Institute, Barrackpore –West Bangal. 217-231.

- Champman, D.W. and Demori, R. (1963) : Seasonal change in food ingested by aquatic insect larvae and nymphs in two Oregon streams. *Ecology* **44** 140-6, 192, 194, 229, 432.

- Choubey, U. (1990) ; Studies on Physico-Chemical and Biological parameters of GandhiSagar reservoir, Mandsaur, Dist (M.P) pp 1-229.

- Chowey, C.B. (1975) : Aspects of proteins utilization by fish. Proc. Nutr. Soc.; 34,57.

- Cowell, B.C. (1981) : Distribution and seasonal abundance of benthic macro invertebrates in a Subtropical Florida Lake. *Hydrobiologia***78;** 97-105

- Cummins, K.W. and Klug, M.J.(1979) : Feeding Ecology of stream invertebrates. *Ann. Rev. Ecol. Syst***10;** 147-172.

- Cummins, K.W. (1994) : Structure and Function of stream ecosystem *Bioscience* **24 :** 631-645.

- Cummins, K.W. &Lauff, G.H. (1969) : The influence of substrate particle size on the micro distribution of stream macrobenthos. *Hydrobiologia***34 :** 145-181.

- Darke, J.A. (1984) : Species Aggregation : The influence of detritus in a benthic invertebrate community, *Hydrobiologia*, **112;** 119-125.

- Das, Satyajit (2015) : Study of Fish Diversity and Physico-chemical parameter of river Singla, Assam, *Int.J.Env.Sci,* Vol 5 (**6**), pp 15-20

- Das, S.M. and Moitra, S.K. (1958) : The surface the mid and the bottom feeding fishes of U.P. *Proc. Ind. Sci. Cong*pt III **307**.

- Datta Munshi, J.S. & Srivastava M.P. : Natural History of fishes and systematic of fresh water fishes of India. 1-403.

- Day, F. (1878) : The fishes of India being a natural history of the fishes known to in habit the seas and fresh water of India, Burma and Ceylonvol I & II pp.778.

- Dhanpathi, **M.V.S.S.,** (2000) : Taxonomic notes on the Rotifers from India. Indian Association of Aquatic Biologists (IAAB), Hyderabad.

- Diamond, R.M. (1967) : Evidence thatdrift of stream benthos is density related. *Ecology* ;**48**: 855-857.

- Dikson, K.L. & J. Cairns, Jr. (1972) : The relationship of freshwater macroinvertebrates communities collected by floating artificial substrates to the Mac Arthur-Wilson equilibrium modal. *Atn. Midt. Nat.* **88** :68-75.

- Director, ZSI (1991) : Animal Resources of India, ZSI, Calcutta. 124 pp.

- Dubey, G.P. &Mehra, R.K.(1959) : Fish Fisheries of Chambal river, *Porc. All India Zool. Cong.* **1** (2) : 647-665.

- Dudgeon, D. (1984) : Longitudinal and temporal changes in functional organisation of macroinvertebrate communities in the Lam Tsuen River Honkong. **Hydrobiologia III** : 207-217.

- Dutta, S.P.S; Malhotra, Y.R. (1986) : Seasonal variations in the macrobenthic fauna of Gandhigarh Stream (Miran Sahib), Jammu *Ind. J. Ecol.* **12** (1), 138-145.

- DBL (1973) : A field guide of African Freshwater snails (1979). Introduction, 1-28.

- Edmondson, W.T. (1959) : Freshwater Biology, New York, Wiley, 1-1157.

- Egglishaw, H.G. (1968) : The quantative relationship between bottom fauna and plant detritus in streams of different calcium concentrations *J. Appl. Ecol.* **5 : 731-740.**

- Einsele,W.(1960) : Flussbiologie, Kraft werke and Fishcherei. **Schr. Err. Ost. Fischeirerb. 1** : 1-63, 447.

- Eisenberg, R.M. (1970) : The role of food in regulation of pond snail, *Lymnaeaelodes. Ecology* **51:** 680-684.

- Elliot, J.M.(1971) : Some methods for statistical analysis of Samples of benthic invertebrates. *Freshwater Biol. Assoc. Sc. Publ.***25** : 148 pp.

- Elliott, J.M. ,Darke, C.M. &Tullet, P.A. (1980) : The coice of suitable sampler for benthic macroinvertebrates is deep rivers, *Pollut. Rep. Environ*, No 8 : 36-44.

- Fisher, S.G. and Likens, G.E. (1973) : Energy flow in Bear Brook, New Hampshire; an integrative approach to stream ecosystem metabolism. *Ecol. Monogr.* **43**,421-439.

- Fox, L.R.(1977) : Species Richness in streams an alternative mechanism. *Amer. Nat.* **III** :1017-1021.

- Frutosis, S.M., ASG and Neiff.JJ (May 2010) : Zooplankton abundance and species diversity in two lakes with different trophic states. 138-148.

- Ganapathi, S.V.(1960) : Ecology of tropical waters. In *Proc. Sys. On Algology* 1959 ICAR New Delhi, 204-213.

- Gopa Kumar, K.*et.al.* (1999) : National Fresh water Aquaculture Development plan; **75**

- Gorai, B.K.; Jha, B.C. and Pandey, P.N.(2003) : Plankton ecology of a Wetland North Bihar, ISFP Newsletter, vol. **1&2**27-30.

- Gore, J.M.(1982) : Benthic Invertebrate Colonization source distance effects on community composition *Hydrobiologia***94;** 183-193.

- Gregg, W.W. & Rose, F.L. (1982) : The effects of aquatic macrophytes on the stream microenvironment. *Aquatic Botany.* ***14*** : 309-324

- Goving M.S. (1969) : Bottom fauna and macro vegetation in Tungabhadra reservoir and their role in the food chain of fish communities *Proc. Of seminar on the Ecology and fisheries of fresh water reservoirs* Barrackpore 99-123 pp.

- Gupta, D.R &Rao, K.S. (1978) Experimental studies or tagging as an effective technique in aging and fish growth on GandhiSagar reservoir. *Bio Research***2** (182): 15-18.

- Gupta, S.D. (2005) ; Macrobenthic fauna of Loni reservoir. J.Ind Fish.Soc. **8**,81.

- Haefner, J.D. & Wallace, J.B.(1981) : Shift in aquatic insect population in a first order southern Appalachian stream following a decade of old field succession *Can.J.Fish.Aquatic.sci***38;** 353-359.

- Hart, D.D. (1978) : Diversity of stream insects : Regulation by rock size microspatial complexity. *Intver Thor. Angew. Limnol. Verb.* **28** : 1376-1381.

- Haniffa, M.A.(1978) : Secondary productivity and energy flow in a tropical pond; *Hydrobiological***59;** 49-66.

- Hawkins, C.P. (1981) : Longitudinal and seasonal changes in functional organization of macroinvertebrate communities in four Oregon Streams *Ecology***62** : 387-397

- Hiltunen, J.K (1980) : Invertebrate macrobenthos of Western lake. Limnol. Oceanogr. **14** (2) : 260-264.

- Hota, S.S and Suresh Gouri (2010) : Physico-chemical properties of water of river Kharkai at Domohani, Jamshedpur, Jharkhand in relation to water pollution, Biospectra. 69-78.

- Hora, S.L. (1922) :Fish and Fisheries of Manipur with some observations on those of the Naga Hills, *Hydrobiologia*, XXII, pp. 169-214.

- Holden, M.J. and Green.J.(1960) : The hydrology of plankton of river Sokoto. *J. Anim. Ecol***29** :65-68.

- Hynes, H.B.N (1950) : The food of freshwater sticklebacks with a review of the food of fishes, *J.Anim Ecol*., **19** : 36-58.

- Hynes, H.B.N (1960) : The biology of polluted water. Liverpool University Press, Liverpool, 202 pp.

- Hynes, H.B.N (1979) : The ecology of running water. Liverpool University Press, pp 1-555.

- Holden, A.V. (1972) : The effects of pesticides on life in freshwater. *Proc. R. Soc. London*; **180** :383-394.

- Illies, J. (1964) : The invertebrate fauna of the Hvallaga, a Peruvian tributary of the Amazon River from the sources down to Tingo Maria *Verb. Int. Verein. Theor, AnjewLimnol***15**: 1077-1283.

- I.F.Pailwan; D.V.Muley & Suryakant Maske (2008) : Limnological feature plankton Diversity and Fishery status of Three fresh water perennial Tanks of Kolhapur District India.

- Jal Nigam (1993) : Report on pollution abatment of river Gomti.

- Jayaram, K.C. (1981) : The freshwater fishes of India, Zoological Survey of India, Calcutta.

- Jhingran, V.G. (1968) : Synopsis of biological data on *Catlacatla* (Ham.1822) : F.A.O. Fish Synopsis **32 (1).**

- Jhingran, V.G. (1982) : Fish and Fisheries of India 2nd.Edn.Hindustan Publishing Corp.(India) Ltd. Delhi. 1-954.

- Jordon, D.S. (1923) : A Classification of fishes including families and genera as far as known Stanford. Uni. Publ.(a) **3(2)**: 79-243.

- Joshi, B.D. (1995) : Proc. Symp. Sci. Technol. Ecosys. 56-66.

- Joshi, B.D. and Tandon, R.S. (1977) : Seasonal variation in haemotological values of freshwater fishes *(Heteropneustes fossils* and*Mystusvittatus)Comp. Physiol. Ecol*, **2** : 22-26.

- Kalam, Abdul (2011) : Limnological study of some freshwater ponds of Muzaffarpur, District in relation to fish production. Ph.D. Thesis, BRA Bihar University, Muzaffarpur.

- Kalff, J., (2002) Limnology : Inland water ecosystem, Prentice Hall Publication. New Jersey, U.S.A.

- Kartha K.N. and Rao, K.S. (1990) : Length-weight and length maximum girth relationship of *Catlacatla*(Ham.) in commercial 3rdedn. Hindustan Publishing Corp.(India) Ltd., Delhi.

- Kaushik, N.K and Hynes, H.B.N (1971) : The fate of dead leaves that fall into stream *Arch Hydrobiol* **68** : 465-515.

- Kazak, Z. (1963) : Analysis of quantitative benthick methods ***Ekol.pol.(A)*** **,II** 1-56

- Kazak, Z. and Warda, J. (1968) : Feeding of Benthic non-predatory Chironomedae in lakes *Anti.Zool.Fenn.* **5** :57-64.

- Kelkar, P.S. and Nanoti, M.V. (2005) : Impact assessment of Ganga Action Plan on river quality of Varanasi. *J.Indian Water Work Association* 37 (3), 225-234.

- Kendeih, S.C. (1980) : Ecology with special reference to animals and man. Prentice Hall of India Pvt. Ltd. N.Delhi, pp 1-474.

- Khatri T.C. (1987) :Nutrient level and its influence on Phytoplankton population in Lakhotia Lake of Pali (Raj) *J. InslandFish Soc.* India **19** (2) : 37-46.

- Khan, A. and Siddique, A.Q. (1980) : Seasonal changes in Limnology of a perennial fish pond at Aligarh *IndianJ.Fish***21** (2) : 463-478.
- Kotpal, R.L. (2003) : Modern text book of zoology "INVETEBRATE (Animal diversity-1)" Rastogi Pub; Meerut 1-864.
- Kuchne, R.A.(1962) : A classification of streams, illustrated by fish distribution in an eastern Kentucky creek. *Ecology***43** :608-614.
- Kumar, S.Gupta, R.K; and Gorai, A.C. (1998) : Species diversity of macrobenthos in polluted tank of PutkiBalihari Colliery area of Dhanbad district, Bihar, Environment and pollut, **5** (2): 111-116.
- Khanna, S.S. (1989) : Survey of Indian Agriculture. The Hindu Madras 28-39.
- Kulshreshtha, Surendra, N. (1998) : "A global outlook for water Resources to the year 2025" In: Water Resources Management Vol. 12 No.3 pp 167-184.
- Laglev, K.F.(1956) : Freshwater fishery biology W.M.C. Brown Company Dubuguelowa421 pp.
- Lakshmina, J.S.S. (1995) : Studies on the phytoplankton of River Gangas, Vanaras, India, the physicochemical characteristics of the river Gangas. Hydrobiologia **25**: 119-137
- Lavandier, P. and Cereghino, R. (1995) : Use and partition of space and resources by two co-existing *Rhyacophilasp*(Trichoptera) in a high mountain stream. *Hydrobiologia***300/301** : 157-162.

- Learner, M.A. *et.al.*(1978) : A review of the biology of Poritish Naididae (oligochaeta) with emphasis on the lotic environment. *Freshwater Biol***8** :357-375.

- Leopold, L.B. (1962) : Rivers *Am Scient*2511-632.

- Leopold, L.B. , Gordon, M.G. and Miller, J.P. (1964) : Fluvial processes is geomorphology W.H. Freeman and Co. San Fransisco522 pp.

- Lovel, R.T. (1980) : Progress and prospects of fish farming in New Protien Food **3:** 261-280.

- Lugthart, G.J. & Wallace, J.B. (1992) : Effects of disturbance on benthic functional structure and production in mountain streams *J.N. Am. Benthol. Soc.***11** :138-164.

- Lush, D.L. & Hynes, H.B.N (1973) : The formation of particles in freshwater leachate and dead leaves. *Limnol* Oceanogr. **18** :968-977.

- Maitland, P.S. (1978) : Biology of freshwater, Blackie & Glasgow, London 236 pp.

- Mandal, B.K. and Moitra, S.K. (1975) :*Trop. Ecol.***16 :** 43-48.

- Mansoori H.A., Lavania R.K. and Tiwary, R.K. (1995) :Hydrobiological study of Lake Jhansi special reference to plankton productivity, Flora & Fauna No.1 pp 39-42.

- Macan, T.T. (1963) : Freshwater ecology Longmens Green and Co. Ltd London, 232 pp.

- Macan, T.T. and Worthington, E.B.(1951) : Life in lakes and rivers. *New Nat* **15** London. 495 pp

- Macan, T.T. (1958) : Methods for Sampling the bottom fauna in stony streams*Met. Int. Ver. Limnol***8** :1-21.

- Mahata, M.C.(1988) : Preliminary report on the Benthic Invertebrate macrofauna of some aquatic environment of Chhotanagpur plateau (Bihar); Proc. 75th session of Ind. Sc. Cong. Part III (Section - Zool. Ento. & Fish) p 87-89

- Mahata, M.C.(1984) : Environment Studies of three ponds of Ranchi (Bihar) II plankton, Proc. 71st Session of Ind. Sc. Cong. Part-III

- Mahata,M.C.(1993) : The Invertebrate macrofauna in some rice field of Ranchi,Bihar,India; *Zoom Res***1**(i); 1-6

- Malhotra, S.K and Chauhan, R.S.(1984) : Bionomics of hill-streams cyprinda IV Length-Weight relationship of *Labeodero*(Ham.) from India Proc. *Indian Acad. Sci.* (AnimSci) **93**, 411-417.

- Mangalef, R. (1960) : Ideas for a Synthetic approach for ecology of running waters. *Int. Rev. Gesmaten. Hydrobiol.* **45** 133-153.

- Mangalef, D.R. (1958) : Information theory in ecology *Gen. Syst.***3**; 36-71.

- Manivasakam, N. : Physico Chemical Examination of Water Sewage and Industrial Effluents, Pragati Prakashan, Meerut, pp 1-268.

- Mason, C.I. (1981) : Biology of freshwater pollution. Longmann group Ltd. London, pp 250.

- Menon, M and P.I.Chacko (1956) : Food and Freshwater fishes of Madras State India Proc. Indo, Pacific Fish Coun. Sec II and III.

- Michael, R.G. (1964) :Limnological investigations on pond plankton, macrofauna and chemical constituents of water and their bearing on fish production. 203-230.

- Michael L.Pace[2] and John D.Orcutt, Jr. (1981) : The relative importance of protozoans, rotifers and crustaceans in fresh water zoo plankton community.

- Mishra, K.S. (1959) : A check list of fishes of India, Burma and Ceylon Part-II, Clupeiformes, Bathyclupeiformes. Ibid XLV : 377-431.

- Motwani*et.al.*(1962): Fish and Fishery of Brahmaputra river syst.in Assam Fish fauna with observation of their Zoo-geographical significance.*Trop. Ecol*; **3**(2) : 334-367.

- Munawar, M. (1970) : Limnological studies on freshwater ponds of Hyderabad, India. *Hydrobiologia***35,** 127-162.

- Nair, M.S. and Arvindin, M. (2009) : Abundance, diversity and seasonal fluctuation of Plankton in a Tropical Fresh water Lake. J.Inland Fish Soc., *India*, 41 (**1**) : 34-40.

- Nandan S.N. and Galankar V.S. (2000) :Limnological study of Unapdeo Thermal Spring of Maharastra Indian *J.Environ and Ecoplan*3(2) : 357-360.

- Natrajan, A and Jhingran, V.G.(1964) : On the biology of *Catlacatla* (Ham.) from the river Yamuna. Proc. Nat. Ins. Sc. India 27B: 198-225.

- Needham, J.G. and Needham, P.R.(1962) : A guide to study of freshwater biology. Haldan Bay San Francisco, U.S.A 1-107.

- Needham, J.C and Needham, P.R.(1972) : A guide to the study of freshwater biology. Holden Bay, Inc, San Francisco. 108pp.

- NEERI (1986) : Manual on water and Waste water analysis, pp 355 Nehru Marg, Nagpur. 498 pp

- Naik, P. K. *et. al.* (2007) : Conservation of Chilka Lake, Orrisa, India; Proc. of Taal. 88-94.

- Nelson, J.S.(1984) : Fishes of the world, 2nd Ed. John Willey and Sons. New York pp 523.

- Nicolski, G.V.(1969) : On the influence of the rate of flow on the fauna of the rivers of central Asia. *J. Anim. Ecol.*2 : 266-381.

- Nevil, G. (1877) : Catalogue of Mollusca in Indian Museum. Calcutta, Part-II, Fasciculata E.;306.

- Novotny, J.F. and Fuler, M.P. (1982) : Diurnal characteristics of zooplankton and macroinvertebrates in the water flood control reservoir, *J. Freshwat. Ecol.*1 :383-393.

- Odum, E.P. (1971) : Fundamentals of Ecology, W.B.Saundars, 574 pp.

- Odum, E.P.(1983) : Basic Ecology . Std. College Pub, New York pp.613.

- Pahwa, D.V. & Mehrotra,S.N.(1966) : Observations on Fluctuations in the abundance of plankton in relation to certain hydrological conditions of river Ganga. Proc. Nat. Acad. Sci. India **36** (2) : 157-189.

- Pal, S.R, Mahata, M.C. and Pandey, P.N. (2006) : Hill stream fish diversity in the river Subarnarekha, Jharkhand, India Proc. Zool.Soc. India ; **5** (1) , 83-91.

- Pal, S.R. (2005) :Molluscan Species Diversity in lower reaches of the river Subarnarekha. 92nd ISCA NirmaUniv, Ahmedabad. Proc. of Ani. Vet. Fishery Science. pp 20-29.

- Pandey, B.N.; Prasad, S.S.,Singh S.B. (2005) : Pollution research **14** (3) 243-293.

- Pandit, A.K.; Pandit, S.N. and Kaul, U.(1985) : Ecological relations between invertebrates and Submergedmacrophytes in two Himalaya lakes, Pol. Res. **4**(2) : 53-58.

- Patel, N.K. and Singh, V.K.(1998) : Study of the pollution load in the ponds of Burla area near Hirakund Dam Orissa, *J.Environ andpollut.***5**(2) : 157-160.

- Parker, N.C. (1984) : Technological Innovations for aquaculture. Fisheries (Bethesda) **9** (4) : 13-16.

- Pennak, R.W.(1978) : Freshwater Invertebrates of the united States. The Roland press, New York pp-769.

- Pillay, T.V.R.(1952) : A criric of the method of study of food of fishes. *J.Zool. Soc. India*, **4** :185-200.

- Philip K.P. and Mathew Kuruvila (1996) : Length-weight relationship and relative condition factor in Pricanthus-Fishery technology 1996 vol (**33**) 2 pp 78-83.

- Preston, H.B.(1915) : The fauna of British India, including Ceylon and Burma Mollusca (Freshwater, Gastropod and Pilecypoda) London Taylor and Frances. pp-1 – xi+1-244

- Prasad, B.N. and Saxena S. (1980) : Ecological study of Blue green algae in river Gamoti.*Environ.Hlth*; **22**(2) : 151-160.

- Purthi, H.S(1953) : Studies on the bionomics of freshwater ponds in India.Seasonal change in physicochemical condition of the water of tank in the Indian Museum compound.

- Qasim, S.Z.(1964) : Studies on the biology of some freshwater fishes, part I-III *J.Mumbai Nat. Hist. Soc.* **61**(3) : 627-650.

- Raberi, C.F. and Minshall, G.W. (1977) : Factors affecting Macro distribution of Stream benthic insects Gikos : **29** : 33-43.

- Raghvan, S.L. &Rahman, M.F.(1986) : Hydrobiological investigations in two parental ponds of AnekalTaluk, Karnataka *J.Inland Fish Soc. India***18**(2) : 52-59.

- Ramchandran *et.al.* (2006) : Zooplankton as Bioindicators : *Hydrobiological Investigations in selected Bangalore Lake. Technical Report:* 115:11-15.

- Ray, S.P. &DattaMunsi, J.S. (1983) : Seasonal variation in the calorific contents of certain freshwater insects *J.Singapore Nat. Acad. Sc.* 10-12 : 22-29.

- Rao, K.L. (1979) : India's water wealth. Orient Longmans Ltd. , New Delhi 267 pp.

- Rao, K.S.; Shrivastava, S. and Choubey, U.(1998) : Surface sediments of Gandhisagar reservoir.*Arch.Hydrobiol* : 147-160.

- Rao, P.R.N. (1998) : Studies on food and feeding of freshwater food fish *Mystusseenghala*(Sykes) in relation to growth rate from Kshipra river.

- Ray, P. Singh,, S.B. and Sehgal, K.L.(1966) : A study of some aspects of the rivers Ganga and Yamuna at Allahabad (U.P.) in 1958-1959. *Proc. Nat. Acad. Sc. India***36** (3) : 235-272.

- Regan C.T. (1997) : Fishes In : Encyclopedia Britanica. 14th Edition London and New York, **9**, 305-329.

- Reid, G.K. (1961) : Ecology of Inland waters and Estuaries. Reinhold, New York **VII2,** 23.

- Ricker, W.E. (1948) : Method of estimating vital statistics of fish populations. IInd Univ. Publ. Sci. 15-105.

- R. Bhardwaj. (2005) : Water Quality Monitoring in India ; Central Pollution Control Board, India. 20-22.

- Roy, S.P.; Rai D.N and Sharma, U.P. (1980) : Investigation on the seasonal changes in population of Chironomid larvae in a freshwater shallow tropical pond at Bhagalpur (Bihar) oriental insects **14** (1) : 1-9.

- Roy, S.P. (2007) : Status of Faunal Bio Diversity of the river Ganga from Barauni to Farakka. *The Bioscan* 2(3): 169-176.

- Rounsefall, G.A. (1953) : Growth of fishery science its methods and applications p. 445 John Willey and sons Inc. New York.

- Rutter, A.J.(1958) : The effect of afforestation on rainfall and run off. *J. Inst. Publ. Hlth. Engrs* 2,3,119-238.

- S.A. Manjare, S.A. Vhanalakar and D.V.Muley. (Dec 2010) : Analysis of water quality using physic-chemical parameters of Tandalage Tank in Kolhapur district Maharastra.

- Sarmah, P. and U.C.Goswami (2012) : Physico-chemical parameters of the Subansiri river, a North Eastern Himalayan tributary of the Bramhaputra river system following through Arunachal Pradesh and Assam, North East India. *Proc.Zool.Soc. India* 11 (2); 23-29.

- Sahib, S.S. (2004) : Physico-chemical of zooplankton of the Shendurni river, Kerala. *J.Ecobiol.* 16: 159-160.

- Sarkar, S.K. and B.Chowdhury (1999) : Limnological research in India. 1st edition, Daya Publishing hous. ISBNO – 08-09675795, pp., 108-130.

- Sanjer, L.R. and Sharma, U.P. (1995) : Community structure of Plankton and their periodicity in Kawar Lake Wetland, Begusarai, Bihar: Zooplankton .J. Freshwater Biol 7 (**3**) : 165-167.

- Satpathi, M and Singh Ravinder (2015) : Acute toxicity study of dioctyl phthalate on haematological parameter in freshwater fish, Clarias batrachus (Linn.), Proc.Zool.Soc.India. 14 (2) : 31-36.

- Saxena A. (1997) : Fishes and human population Ecoder& Environ. Ed. S.P.Singh and R. Prakash. Bindra Publication Jalgaon India p 79-84.

- Saxena B.S. (1990) : Potentialities production and problems of\ Indian Resevoir Fisheries in India Ed. p 39-44.

- Seldon, A.L. (1979) : Colonization Curves: application to stream insects on environmental substrates*Oikos***28** : 256-261.

- Seighal, S. (1956) : Non Parametric statistics for the Behavioural Science (McGraw Hill : Tokyo). 287 pp

- Seighal P. (1967) : Food Feeding habits of *M. seenghala* (Sykes) Research Bulletin of Punjab University **18** (I & II) : 149-155.

- Sharma, R.C. (1986) : Effect of Physico-chemical factors on benthic fauna of Bhagirathi river, Garwal Himalaya*Ind.J.Ecol.* **13** (1) : 133-137.

- Sharma,L.L. *et.al.*(1995) : The sewage water impoundment was found to have attended water quality where CO_2 ,NO_3,PO_4 and BOD were above the normal value.

- Shivani and Tripathi, A.K. (2003) : Longitudinal and Seasonal Variations of pH, O_2 and CO_2in river Ganga. Proc. Zool. Soc. India **2** (2) : 35-38.

- Srivastava, S. and Pandey, A.K. (1981) : Growth rate of different body parameter in *Catlacatla***8** 39-40.

- Shrivastava V.K. (1956) : Bottom organization of a freshwater fish tank. *Curr.Sei.***23** : 158-159.

- Shukla A.N. (1995) :Limnological studies on Gandhisagar Reservoir with special reference to Macro zoo – benthos p 131-174.

- Shukla, A.N., Shrivastava, S and Rao, K.S. (1997) : Observation on zooplankton community analysis trends in Gandhisagar reservoir with relation to its entrophicationEnv. Manage Int. **1** (1) : 23.

- Singh D.K. and Singh, A.K. (1985) : Zooplankton density inrelation to physic-chemical factors during diet cycle at Bhagalpur, Bihar. Env. Eco. **3** (2) : 231-234.

- Singh, B.B. (1995) : Pollution status of Raptiriver at Gorakhpur *J.of Env. And pollut* **2** (3) : 117-120.

- Singh, R.K. and Desai, V.R. (1982) :Limnological observations on Rihand reservoir III Primary productivity *J.Inland.Soc.* **12** (2) : 63-68.

- Singh, R. (1988): Assessment of drinking Water supplied to Jamalpur Town Monghyr (Bihar).

- Singh, R. (1988): Comparative limnological studies of the feeder tanks of Jamalpur water works and power house, Jamalpur, Monghyr (Bihar) – Ph.D. Thesis, Bhagalpur University, Bhagalpur.

- Singh, S.P. (1997) : Assessment of water quality by using bio indicator invertebrates. Ecodev, and Environ Vrina Publication, Jalgaon p. 187-192.

- Singh, T.K, *et.al.* (2013) : Fish Diversity in the river Mahanadi. *Res. J. Ani, Vet.,* and *Fishery Sc.* Vol. **1(3)**, 16-24.

- Sinha, Pramod Kumar, Satpathi Manisha and Singh, R (2015) : Seasonal phytoplankton diversity of perennial pond of Chaibasa, West Singhbhum at Jharkhand in India, Proc.Zool.Soc.India **14 (2)** 19-25.

- Srivastava U.K. and Vahsala, S. (1984) : Strategy for development Resources in India of Inland Fishery L.L.M. Ahmedabad p -630.

- SubbaRao, N.V. (1989) : A Handbook of Freshwater Molluscs of India Publ. Director Zool. Surv. of India p.283.

- Sugunam, V.V. (1999) : Ecological Significance of river continuum - Conceptual framework. Summer School on Ecology fisheries and Fish Stock Assessment in Indian rivers. CIFERI, Barrackpore, 14 July to 12Aug, 1999. pp 18-29.

- Sugunan, V.V. *et.al.* (2000) : Ecology and fishery of West Bengal CIFRI, Report (I.C.A.R). 189 pp.

- SWCSMH (2006) : Soil and Water Conservation society of Metro Halifa, July 26, 2006. 326 pp.

- Talwar, P.K.(1991) : Animal Resources of India. Protozoa to Mammalia Zoological Survey of India, Calcutta, pp. 577-630.

- Tewari, A.K. (1988) : Revival of water Harvesting Methods in the Indian Desert, office of Arid Land, University of Arizona. Arid lands Newsletter, vol. **26**: 3-8.

- Tilak, R. (1980) : Studies on the fish fauna of Uttar Pradesh. ZSI, Dehradun.

- Tiwary, R.K.; Rajak G.P. and Mandal M.R. (2005) : Water quality assessment of ganga river in Bihar region, India. *J.Env.Sc.Eng.* 47(4). 326-355.

- Tonapi, G.T. : "Fresh Water Animals of India" (An Ecological Approach) 341 pp. New Delhi; Oxford & IBH Pub. Co.

- Trivedi, R.K. and Goyal P.K. and Trisal C.L. (1986) : Chemical and biological Methods for water pollution studies environ. Publ. Karad, India.

- Unni, K.S.(1985) : Comparative limnology of several reservoirs of Central India *Int. Rev. Ges. Hydrobiol***70** (6) : 845-856.

- United Nations (1998) :Johad watershed in Alwar District Rajasthan, UN Inter Agency Group on water & sanitation 24 pp.

- Vannofe, R.L. *et.al.*(1960) : The river continuum Concept Can. *J. Fish. Aqut. Sci.* **37** :130-132.

- Varshney, P.K. (2006) : Biodiversity and Fisheries potential of river Gomti in relation to the prevailing environmental condition in Lucknow. Project report CIFE Lucknow Centre, Lucknow. 1-81.

- Venkateshwarlu V. (1986) : Ecological studies on rivers on Andhra Pradesh with special reference to water quality pollution *Proc.Indian Acad. Sci.* (Plant Sci.) **96** : 495-508.

- Vohra, B.B.(1982) : Land and Water Management Problems Ministry of Home Affairs, New Delhi, Jan 1982. 516 pp.

- Voigt, G.K. (1960) : Alteration of the composition of rain water by trees. Am Mudl. Nat. **63** : 321-406.

- Welch, P.S. (1952) : Limnology methods McGraw Hill Book Co. New York, P-538.

- W.H.O.(1971) : International standards for drinking water (3rd Edn.) World Health Organization, Geneva p. 240.

- "Water Consumption and Sustainable Water resources Management" (1998) OECD, Environment Directorate, FR, 64p.

- Yusuf Md., and Quadri (1985) : Study of Zoo Plankton in Manasbal Lake, Kashmir, pp 67-91.

• Zutsi, D.P. & K.K.Vass (1978) : Limnological studies on Dal Lake, Chemical features, Indian, J.Ecol.; **5** (I); 90-97.

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17

ZOOPLANKTON DIVERSITY IN CHANGING ENVIRONMENT OF RIVER KHARKAI, IN JAMSHEDPUR

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ABSTRACT

To evaluate the zooplankton diversity of river Kharkai (Jharkhand State) in relation to the prevailing environmental conditions three stations-Baba Kutir Ashram, Jayprakash Udyan and Domohani (River meet) were identified from upstream to downstream along the course of river in Jamshedpur. DO was low on many occasions at all the stations except Baba Kutir Ashram and COD values were high. There was a gradual increase in mean nitrite and phosphate values from up to downstream. Planktonic density was poor. Copepoda and Cladocera were the most pre-dominant groups followed by rotifers, planktonic oligochates, dipteral, ostracoda, protozoa and Hydra at all stations. Relatively low density of zooplankton in spite of high nutrients budget may be a function of great infestation of water quality. Seasonally high density was reported during monsoon while low in post-monsoon. Increasing number of rotifers next to copepods and cladocerans indicate an aquatic regime with substantial load of organic matter. Planktonic diversity was poor. Abundance of a particular group of organism in a deteriorated and polluted environment may not eliminate the energy at higher tropic level. Filthy condition with foul smell through the length of the river coupled with poor water quality and appearance of indicator organism was marked.

Key words: *Environmental condition, Planktonic Density*

INTRODUCTION:

The disposal of wastes into the aquatic environment has long been an accepted fact but it is being done without considering the possible consequences it may pose. The aquatic environment has a good deal of assimilation capacity but when the waste load exceed absorbing capacity pollution becomes a serious problem. Today aquatic pollution assumes a major challenge to man because the living resources form an essential source of animal protein. The rivers have become seriously vulnerable to pollution in industrialized cities leading to serious limitations to our harvesting the food from the polluted environments. Jamshedpur city is an example of the conditions posed by increasing urbanization and industrialization. The quality of domestic sewage and industrial waste produced in Jamshedpur Town is about 325mld (Jal Nigam, 1993). At present there is only one treatment plant of 42 mld capacity located at Bistupur to treat the sewage from Jugsalai, Bistupur, C.H.Area, Bhatia Park and TISCO. Therefore a major portion of the sewage is discharged untreated at various places in the river Kharkai. Usefulness of Zooplankton in pollution monitoring programme to ascertain the river health environment is well established.

MATERIALS AND METHODS

Three sampling stations were identified along the course of river in Jamshedpur. The selection of two sampling stations was made in specific discharge dominated areas while one station (Baba-Kutir Ashram) in upstream presuming a stress free unpolluted environment.

Baba Kutir Ashram (22°46'N 85°05'E) is selected as the first study site. Bottom of the river in this site is rocky and sandy. This station is situated in the upstream of river Kharkai besides Baba Ashram. On this side the width of the river is less and comparatively the depth is more. The site is the best for study of zooplankton and phytoplankton.

Jayprakash Udyan (22°48'N 85°07'E) is a spot on the river Kharkai in downstream in the out skirt of the city Jamshedpur. A Toll Bridge is constructed on the river. It gives a beautiful architectural view. Both the side of the river banks are thickly rocky.

The 3rd station is Domohani (22°51'N 85°10'E) the interesting site, because both the river Subernarekha and Kharkai meet in this place. This part is always busy with boating and fishing. This site gives beautiful architectural view. On the side of the riverbank, there is Shiva Temple, Marine Drive Road with beautiful lookout. This station has been identified as a recovery zone in downstream.

Samples were collected monthly for assessment of environmental parameters (water and soil) and biological parameters. Water sample include temperature (air and water), pH, DO_2, CO_2, alkalinity hardness and nutrients (NO_2, NO_3 & PO_4). Temperature pH, CO_2 and DO_2 were analyzed immediate in the field itself, while for rest of the parameter the water samples were collected in half litre narrow mouth polythene bottle and were analyzed following the standard methods (APHA, 1998).

Zooplankton, the microscopic free floating animal component of aquatic system are endowed with many remarkable features and are often armored with species, which hamper their predation by higher organisms. The ability of movement not only provide them an effective defense measure but also enable them to actively search and feed upon the phytoplankton. Their high and rapid rate of parthenogenetic reproduction usually overcomes the predation losses and enables them to exploit algal blooms. These constitute an important link between primary producers and consumers of higher order in aquatic food web.

The zooplankton samples collected following the standard methods (APHA, 1998). The samples thus collected were preserved in 5% formaline. Identification of the zooplankton in the sample were done in laboratory using keys & monographs and then proceeded for qualitative and quantitative analysis (APHA, 1998: Edmondson, 1959; Needham & Needham, 1962).

RESULTS AND DISCUSSION

The mean pH shows a gradual decrease from upstream to downstream stations except Baba Kutir Ashram with exceptionally low value (7.20). DO were low at both sewage dominated (Jayprakash Udyan) and industrial waste dominated (Domohani) stations. Perhaps the high organic load might have causes the depletion of oxygen. There was a gradual increase of CO_2 from upstream to downstream. High mean alkalinity (266.96 mg/l) at Jayprakash Udyan and hardness (288.96 mg/l) at Domohani were observed. Mean values of phosphate and nitrate show increasing trend from upstream to downstream. Higher mean nitrate was noticed at Jayprakash Udyan and Domohani may be because of high organic load. Increasing trend of CO_2, Po_4 and No_3 from upstream to downstream as well as poor Do values represents the poor river condition due to influx of sewage and industrial effluents. The water quality of the river indicates that the

river is under severe pollution stress both but sewage as well as industrial wastes.

At Baba Kutir Ashram protozoa was represented by only one genus i.e. *Polytoma*. The two genera *Cypris* and *Cyprinotus* belong to order *Ostracoda*. Order Rotifer has *Branchionus* and *Keratella*. The genera belong to the order *Cladocera* were *Daphnia*, *Monodaphnia* and some unidentified forms. The genera *Cyclops* and *Diaptomus* represent the *Copepoda*. *Dioptram* insects were also reported.

In Jayprakash Udyan Ostracoda were represented by two genera *Cypris* and *Cyprinotus*. The genera belongs to Rotifer were *Testudinella*, *Brachionus*, *Monostyla*, *Trichocera*. The Cladocerans were *Dhapnia*, *Monodaphnia*, *Ceridodaphnia* and some unidentified forms. The genera *Cyclops* and *Diaptomus* belong to Copepoda. Worms were *Tubifex* and *Chironomus* larvae. Maximum population density was observed in April'13 and July'13. Seasonally higher values for density were noticed during monsoon followed by pre-monsoon & post monsoon.

In Domohani protozoa represented by three genera *Euglena*, *Vorticella* and *Polytoma*. The *Cypris* and *Cyprinotus* were the candidate genera belong to *Ostracoda*. The genera belong to Rotifer were *Filinia*, *Testudinella*, *Branchionus*, *Trichocera*, *Monostyla*. The order *Cladocera* has *Daphnia*, *Monodaphnia*, *Ceridodaphnia*, *Moina* and some unidentified forms. The copepod was *Cyclops*, *Mesocyclops*, *Paracyclops*. The dominant and common genera encountered at this station were *Daphnia*, *Monodaphnia*, *Cyclops*. Maximum population density was noticed in July'13 and August'13.

Highest number of rotifer genera were encountered at Jayprakash Udyan while lower in Baba Kutir Ashram. The population of zooplankton is comparatively low as compared to phytoplankton. Increasing number of rotifer next to *Copepods* and *Cladocerans* indicates an aquatic regime with substantial load of organic matters (Baruah, 1993). Relatively low abundance of zooplankton could be attributed to less availability of energy for their growth probably in a populated environment. Higher values of nutrients coincide with high population density of phytoplankton and benthos during pre-monsoon (Varshney, 2006). Relatively low abundance of plankton population and biomass inspite of high nutrient budget of the system was a function of great infestation of water quality by pollutants which indicate extreme state of deterioration of water quality leading to un-conductive ecological regime for fisheries development.

Mean maxima for zooplankton at all the three stations was observed during monsoon while minimum density was recorded during post-monsoon.

REFERENCES

APHA, 1998. Standard methods for the examination of water and waste water, American Public Health Association, Washington D.C.

Baruah, A., 1993. Plankton variability of a tropical method, Kanwar Lake Begusarai (Bihar), *J. Freshwater Biol.* **5**(1), 27-32.

Banerjee, R.K. *et.al.* 1998. River Damodar and its environment, Bull. No. 79, Central Inland Fish. Res. Ins., Barrackpore, India.

Chakraborty, N. *et.al.* 2002. Spatiotemporal distribution pattern of certain plankton of river Hoogly, *J. Inland Fish. Soc.*, India, **27**(1) 6-12.

Edmondson, W.T 1959. Freshwater biology, New York, Wiley, 1.....1157.

Gorai, B.K Jha, B.C.; and Pandey, P.N. 2003. Plankton ecology of a wetland, North Bihar, ISFP News

letter, Vol. **1 & 2** 27....30

Jal Nigam, 1993. Report on pollution a treatment of river Gomti

Needham, J.G. and Needham, P.R. 1962. A guide to study of freshwater biology Holden Bay, San Francisco, U.S.A, 1-107

Varshney, P.K.; 2006. Biodiversity and Fisheries polluntial of river Gomti in relation to the prevailing environment condition in Lucknow. Project report CIFE, Lucknow Centre, Lucknow 1-81

National Seminar "Encroachment of Water bodies challenges and Remedies" Proc. Society for Environment & Social Awareness (SESA), Daltonganj, Palamau (Jharkhand) held on 08-09-2014, RANCHI

WATER MANAGEMENT - A REQUIREMENT FOR SUSTAINABLE LIVELIHOOD

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ABSTRACT : Water is a prerequisite for the existence of life. Water bodies are important ecological habitats, high in productivity as well as biodiversity. Water has become an issue of a major concern and countries, states, regions; groups are locked in conflict over access to water. Water is the most critical limiting factor for many aspects of life, such as economic growth, environmental stability, biodiversity conversation, food security and health care. The main thrust is not a sacred reverence for water but a material interest in the water as a source and requirement for livelihood, not so much a concern with the rights of other species and of further generation. As a consequence to these problems the biodiversity and the livelihood will be affected severely. These may in near future extends to a war. Even though there are legal protections, they are violated by a great extent. This paper is an attempt to protect the grave problems with existing legal aspects and the problem suggestion.

Key words: Water Management, Biodiversity, sustainable, livelihood.

INTRODUCTION

Water is perceived by different people in different contexts in different ways; as a commodity, as common as a basic right and as a sacred resource of divinity. Now it can be termed as an environmental issue. The main thrust is not a sacred reverence for water but a material interest in the water as a source and requirement for livelihood, not so much a concern with the rights of other species and of future generations. All these perceptions are valid and they are partial. What is true of one of the multiple dimensions or aspects of water may not hold for another.

Perceptions of water:

Water as commodity: Let us see some contexts where water is treated as a commodity: Use of water for irrigation in commercial agriculture, Use of water for cooling or steam generation or industrial processes, Luxury uses by the affluent like in saunas, swimming pools, gardening and so on, Use of water in hotels for keeping its operations like kitchen,

bathrooms, toilets, laundry, swimming pools, gardening and other recreational facilities. For all these uses they may enter into contracts with supplying agencies for bulk water supplies for a regular basis. To many of us the notion of water as a commodity seems unacceptable.

Water as commons: This view of water as commons or as a common pool resource is strongly advocated. Here two points are to be noted on the notion of commons. The first is that in the context of a small lake or pond or tank or other water body on common land, water can be treated as owned by community and its application is easy.Its application is difficult in larger water bodies, streams and rivers, urban water supply systems where an agency, that may be public or private, supplies water to citizens by a network of pipelines from its storages. Second point is that the community is collectivity and the idea of community management of common pool resource does not imply any individual rights to water. The rights of individuals will be that are agreed upon by the community or conferred by civil society institutions instead of being granted by the state or arising from contacts.

Water as a basic right: Water sustains life and it is a basic need and a right. The fundamental right to live is held to include the right to drinking water. We need to go beyond human beings and recognize the rights of other species, whether livestock or wildlife, to water.

Water as a sacred resource: Water supports life and it is a part of the natural environment, sustaining it, and in turn being sustained by it, leads to its being regarded as sacred. In Indian tradition rivers have always been regarded as divinities.

Water as an economic good: It argues that it is best left to market forces. If property rights in water were defined and trading allowed, water markets would emerge, prices would be established, resource conservation would take place, sustainability would be taken care of, equity would be ensured and conflicts would automatically resolved by market forces. When it is used for industry or agriculture, it becomes an economic good. When water it is used for sanitation or in hospitals or for firefighting, it becomes social good.

Water as on environmental issue: This perspective emerges from a concern to protect the natural environment from human depredations in pursuit of what goes by the name of

development. That concern give assertion of the rights of aquatic life, the rights of the river and-the rights of the natural environment. These issues may be mainly on dams and privatization of water services. All these are partial perspectives. That does not imply a questioning of their validity or relevance. All are required also. The assignment of centrality to some perspectives is problematic.

Problems of water:

Undoubtedly we can state that the projects and schemes undertaken in the past have contributed to an increase in food production, added to Hydropower capacity, provided water for domestic, municipal and industrial uses and helped in flood moderation. There are some negative aspects which affect the eco systems and human beings are:

Drinking water: scarcity of water in rural areas is a burden of fetching water from distant sources falls on women including girl children and yet women who are providers and managers of water in the households have little voice in water resource planning in our country. Most of the large cities are chronically short of water. Some states like Tamil Nadu, Karnataka, and Delhi have to depend on neighboring states for water.

Drought- prone areas: There are many arid zones and drought-prone areas in the country like; Rajasthan, Gujarat, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. Droughts are recurring features in these a areas. This causes much misery to human beings and the eco-system. They may often result in large scale migration.

Floods: The initial response to flood damage was to try to control floods by structural means such as dams or embankments which found ineffective or even harmful. Large dams are not often planned with the primary aim to flood moderation. Dams may moderate flood flows to some extent under normal conditions. They may aggravate the position if water has to be suddenly released in the interest of the safety of structures. For embankments they have to be repeatedly rebuilt at great cost and may fail in major flood.

Irrigation: The benefits of irrigation are evident but the channels used for irrigation are not effective. Injudicious canal-irrigation regardless to soil conditions, over-application of water, the failure to take the ground water table into account and inadequate attention to drainage

have led to the emergence of conditions of water logging and salinity in many areas. This will result in valuable agricultural land going out of use. The reclamation of land thus lost is possible only with large investments.

Conflicts: Disputes over river waters are becoming intractable and the constitutional conflict resolution mechanisms do not seem to be working well. Conflicts could also arise between users, between areas and between classes. There is also possibility of conflicts between the people and the state.

Groundwater: There has been over extraction (mining) of ground water leading to depletion in several areas and salinity ingress in some coastal zones. There are serious equity issues in the context of power- driven extraction of ground water through tube wells and bore wells and sand mining. There are also serious problems of pollution and contamination of ground water and there are no such mechanism to regulate or enforce the law and order.

Water pollution: It can be defined as the concentrations of particular pollutants in water for sufficient periods of time to cause certain effects. If the effects are health related, caused by pathogenic bacterial intrusion, the term contamination is appropriate. Effects of limitations on water availability due certain water quality requirements related to usage can serve as basis for defining a condition of water pollution. Nuisance refers to displeasing effects created by oils, or other floating materials.

Large Dams and its impacts:

Dams have two main functions; the first is to store water to compensate for fluctuations in river flow or in demand for water and energy. The impacts can be classified into two; environmental and human impact.

Environmental Impact: can again be grouped under **(i) Impacts due to existence of dams and reservoir**. Upstream change from river valley to reservoir. Change in downstream morphology of river bed and banks, delta, estuary and coast line due to altered sediment load. Change in downstream water quality, temperature, nutrients, turbidity, dissolved gases, heavy metals and minerals. Reduction of bio-diversity due to the blocking of the movement of

organisms. ***(ii) Impacts due to pattern of dam operation include:*** Change in downstream hydrology, Change in total flows., Change in seasonal timing of flows., Short-term fluctuations in flows, Change in extreme high and low flows, Change in downstream morphology caused by altered flow pattern, Change in downstream water quality caused by altered flow pattern, Reduction in riparian / flood, plain habitat diversity, especially because of elimination of floods.

Human impacts: In most cases there are varying degrees of displacement of human settlement with the attendant problems of resettlement and rehabilitation. This impact often falls on poor and disadvantaged sections, particularly tribal communities. There are inherent difficulties in it like - Lack of knowledge of the numbers and categories of people likely to be affected, Separation of communities from the natural resource base on which they are dependant, Inadequacy of land for land based rehabilitation, Scattering of well-knit communities, Resettlement in distant and unfamiliar areas, Difficulties with the host communities in the resettlement areas, Major transformation in ways of living, Loss of old coping capabilities and the need to learn new skills and ways of living. As a consequence to these problems the bio-diversity and the livelihood will be affected severely.

Laws relating to the water include :-

Constitutional provisions: Under the Indian Constitution water is a State subject. There-is a tendency to take this proposition to proceed to further propositions and arguments. This can be in two directions: one is to assert that water is rightly a State subject, this must be accepted and the Centre must refrain from encroaching into this area. The other is to deplore that water is a State subject, and to argue that the Centre needs to play an important role in regard to this precious resource. In order to facilitate this water should be transferred to the Concurrent list. Article 262 of the Constitution provides for parliamentary legislation for the adjudication of inter- state river water disputes, and for barring the jurisdiction of the courts including the Supreme Court in such cases.

The Water (prevention and Control of Pollution) Act, 1974- 73rd &74th Amendments: The Eleventh and Twelfth Schedules to the Constitution lay down lists of

subjects to be devolved to the Panchayaths and Nagarpalikas. The lists include, inter alia, drinking water, water management, watershed development and sanitation

Inter- State Water Dispute Act 1956, Amendment to ISWD Act 2002 and Recommendations of Sarkaria Commission National Water Policy 1987 and 2002: This does not talk about the environment, ecology, sustainability, equity, social justice, conservation, participation, role of women, involvement of stakeholders and so on. Even though above these acts and policies are in application we do not have proper safeguards to protect water and there by sustainable livelihood.

Suggestions for Improvement:

Ensure access to safe drinking water for all, Availability of water for agriculture, industry and urban centers with due regard for efficiency, economy and equity, Appropriate control and management measures to drought-prone areas, Creation of consciousness on water scarcity, Promotion of conservation and minimizing waste, Improvement of water quality, Control of pollution, Protection of water resources, Proper water recharge measures, Protection and preservation of eco-systems, Rain water harvesting, Preservation of integrity of rivers, Ensuring equity-between groups, generations and species, Reduction in women's burden , Giving voice to women in water planning and management, Minimizing conflicts and hardships, Provision for resolution and redress, Development of coping strategies in floods, Minimizing damage in flood, Proper implementation of law and order', Formulation and effective implementation of state water policy. By carrying out these in a proper way will ensure a sustainable livelihood in future'

REFERENCES

Biswas, J. 1993. Water for Sustainable Development in the 21't Century, Oxford University Press, Delhi.

Farrington,Turton Cathryn & James, A Participatory Watershed Development Challenges for the Twenty First Century,Oxford University Press, New Delhi

Mandal, S; Mehta, S 1997.Controlling Pollution Incentives and Regulations, Sage Publications, New Delhi

McCully, Patrick 1996" Silenced Rivers The Ecology and Politics of Large Dams, Orient Longman Limited, New Delhi

Ramaswamy R 2003, Water Perspectives,Issues,concerns, Sage Publications, New Delhi

Trivedi, R. P. & Gurdeep Raj.1992. Environmental Problems. Impact Assessment, Akashdeep Publishing House, New Delhi

STATUS OF WATER QUALITY OF SUBARNAREKHA RIVER AT JAMSHEDPUR (JHARKHAND)

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Abstract

Key Words: *Indiscriminate disposal, urbanization, biological population.*

Water is one of the most unusual natural compounds found on our earth and it is also one of the most and main component for the survival of any living being since life on earth was began in the seas. Rivers are the most important resources in the world and in India in particular. The rivers are being polluted by indiscriminate disposal of sewage and many other wastes of human activities. All water bodies are normally populated by organism and it is almost impossible to find a body of water that is entirely free of life. Any undesirable change in the physico-chemical characteristics of water brings about water pollution. This change is mainly due to human activity such as rapid urbanization and industrialization coupled with injudicious exploitations of natural resources. The discharge of domestic sewage and industrial effluents into natural water resources results primarily in alternation of their physical and chemical properties which in turn influence adversely the biological population. The Subarnarekha River originates from South of the village Nagri (23°13' N and 85°2' E) 15 Kms away on South West Corner of Ranchi Town (capital of Jharkhand). The data revealed that 17 parameters of Subarnarekha River water at Jamshedpur. The results indicated that the analysis of physico-chemical parameters of the Subarnarekha River at Jamshedpur (Jharkhand) during the Summer (April 2012 & 2013), Monsoon (July 2012 & 2013), Post Monsoon (Oct. 2012 & 2013) and Winter (Jan. 2012 & 2013). In the present study of the Subarnarekha River its physico-chemical characteristics *viz* temperature, transparency, pH, dissolved oxygen, biological oxygen demand, conductivity, total dissolved solids, turbidity, chloride, hardness, free-CO_2, alkalinity, nitrite, nitrate, phosphate, iron and sulphate.

Introduction:

In the lotic system, the significance of physical and chemical data for the assessment of water quality has been recognized. The Studies consider water quality usually involve physical, chemical and biological variables. The Subarnarekha River originates from South of the village Nagri (23°13' N and 85°2' E) 15 Kms away on South West Corner of Ranchi Town (capital of Jharkhand). In its 476 Km. long journey before joining the Bay of Bengal. The Subarnarekha flows through the three states Jharkhand, W.B and Oddisha. Directions of the flow of river is from West to East.

Jamshedpur is a town in East Singhbhum district of Jharkhand. The Jamshedpur town lies on Northern and Southern bank of the Subarnarekha River. There are several bathing ghats and domestic sewage drains from where waste water reaches the river. The Tata Iron and Steel Company and their other industries area situated at the bank of the river.

Numbers of workers have carried out their work on water quality of different rivers. Khanna D.R. (1993), Dhindsa and Bhargava (1982) studied the physico-chemical characteristics of river Chambal. But no study has been conducted to assess the water quality of river Subarnarekha at Jamshedpur.

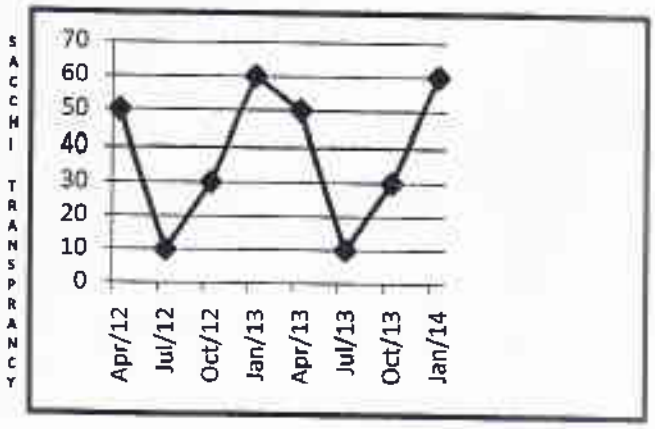
Materials and Methods:

In this study, limnological status of river Subarnarekha at Jamshedpur was observed for a period of two successive years. During the study period a particular month of the season was selected for sampling. The study period was from April, 2012 to January, 2014. Physico-chemical characteristics of the water samples were determined following APHA (1998), Adoni, (1985) and Golterman (1969).

Table & Graph:

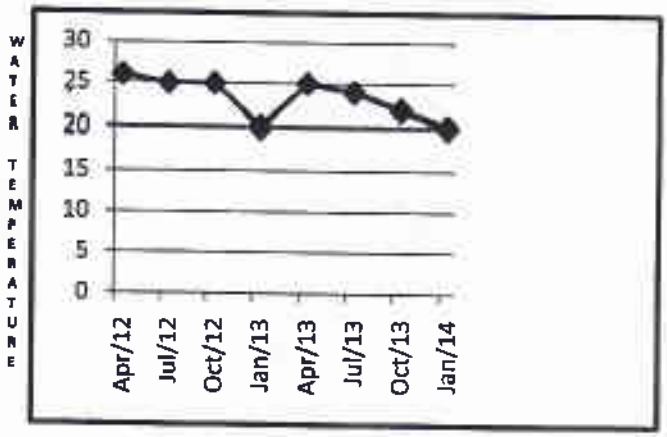
SEASONAL VARIATION IN PHYSICO-CHEMICAL PAAMETERS AT JAMSHEDPUR											
Sl. No	Parameters	Summer	Monsoon	Post Monsoon	Winter	Summer	Monsoon	Post Monsoon	Winter	Max	Min
		Apr, 12	Jul, 12	Oct, 12	Jan, 13	Apr, 13	Jul, 13	Oct, 13	Jan, 14		
(A)	**Physical Parameters**										
1	Water Temperature (°c)	26	25	26	22	27	26	22	22	27	22
2	Sacchi Trans-parency (cm)	51.2	10.8	32.5	58.5	52.9	10.8	35.2	60.0	60.0	10.0
(B)	**Chemical Parameters**										
3	pH	8.5	7.64	8.31	8.25	8.18	8.14	8.21	8.43	8.5	7.64
4	DO (mg/l)	12.2	8.4	8.2	9.6	14.2	6.2	8.2	8.4	14.4	6.2
5	BOD (mg/l)	6.8	3.6	3.8	4.5	7.6	13.8	4.9	4.5	7.6	3.6
6	Conductivity (ms/cm)	0.236	0.294	0.285	0.257	0.228	0.346	0.289	0.229	0.346	0.228
7	TDS (mg/l)	143.96	179.34	173.85	156.77	139.08	211.06	176.29	139.69	211.6	139.08
8	Turbidity (mg/l)	118	4200	1550	78	104	4500	3000	84	4500	78
9	Chloride (mg/l)	46	54	48	41	39	66	43	32	66	32
10	Total Hardness (mg/l)	168	218	188	152	166	224	208	178	224	152
11	Free – Co_2 (mg/l)	4.8	2.2	14	1.2	14.4	7.2	13	3.6	14.4	1.2
12	Alkalinity (mg/l)	120	138	122	114	130	110	124	92	138	92
13	Nitrite (mg/l)	0.016	0.014	0.008	0.005	0.007	0.009	0.007	0.005	0.016	5.005
14	Nitrate (mg/l)	2.519	5.742	6.348	2.636	3.541	4.246	3.874	2.754	6.348	2.519
15	Phosphate (mg/l)	1.174	1.248	1.664	1.246	1.947	2.842	1.994	1.678	2.842	1.174
16	Sulphate (mg/l)	46	52	38	60	48	52	40	46	60	38
17	Iron (mg/l)	0.024	0.032	0.041	0.013	0.015	0.008	0.011	0.013	0.041	0.000

Sacchi Transparency



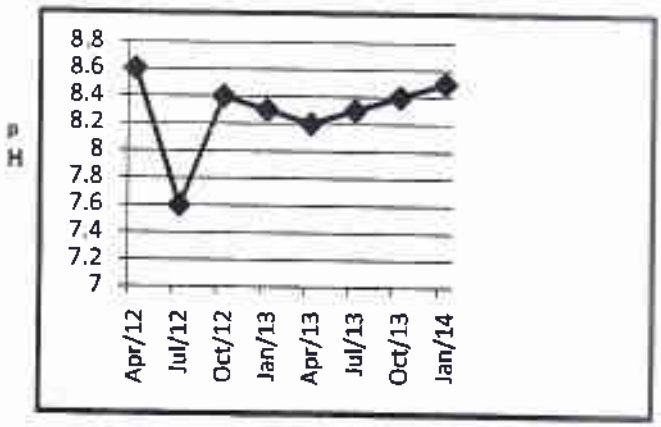
Months

Water Temperature



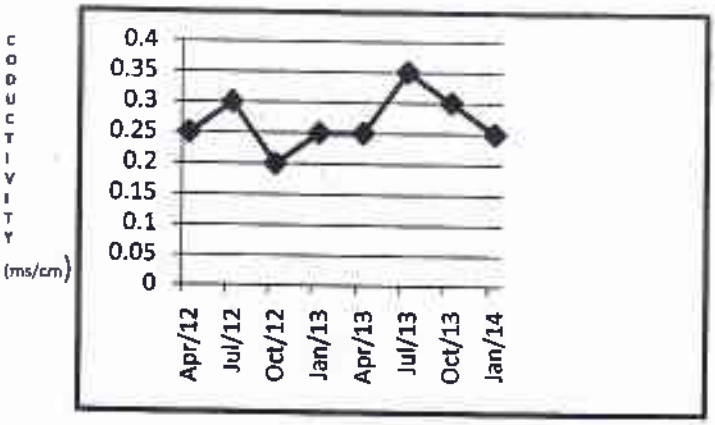
Months

pH



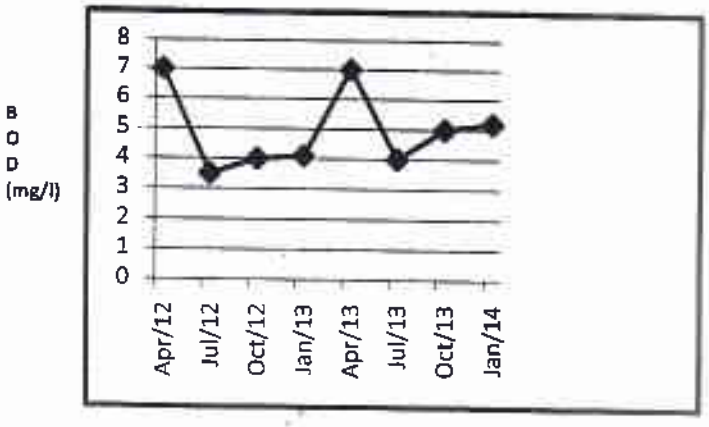
Months

Conductivity (ms/cm)



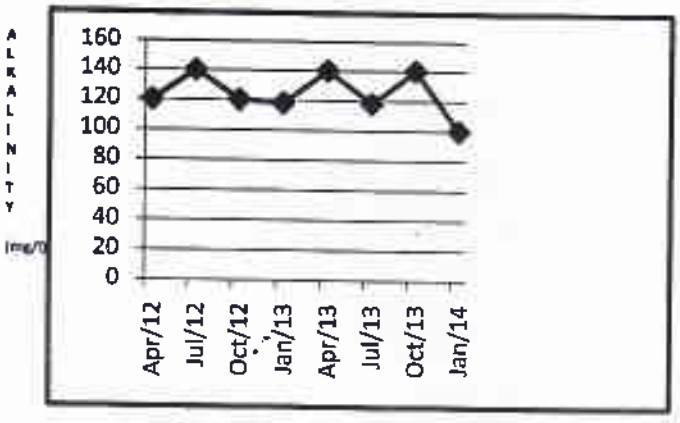
Months

BOD (mg/l)



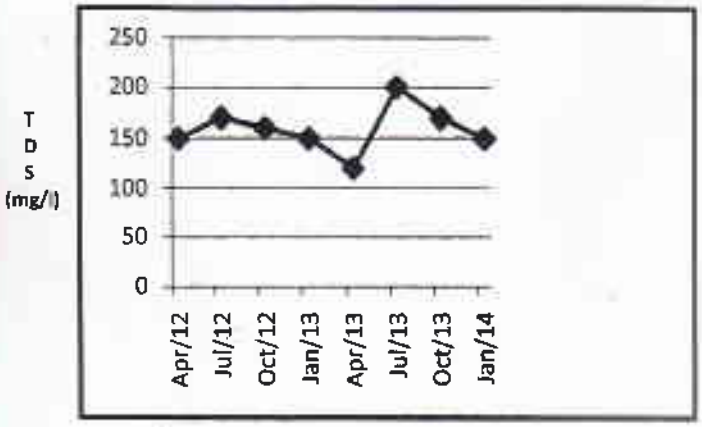
Months

Alkalinity (mg/l)

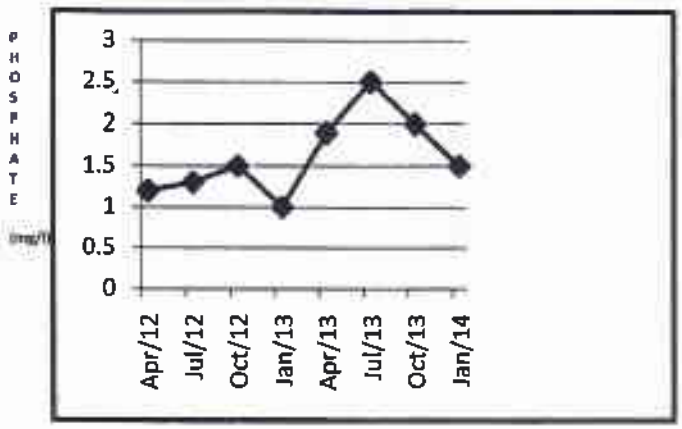


Months

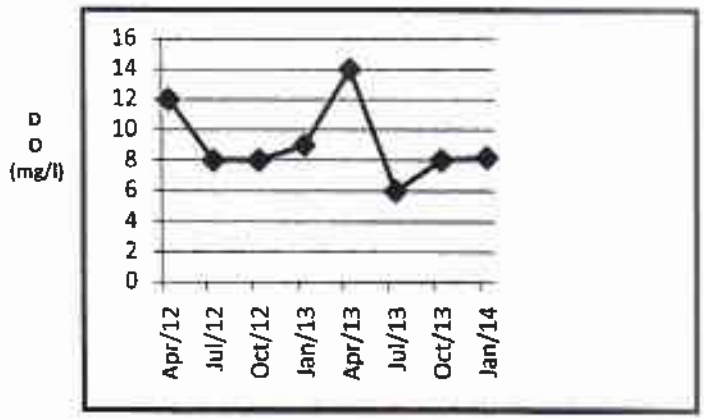
TDS (mg/l)



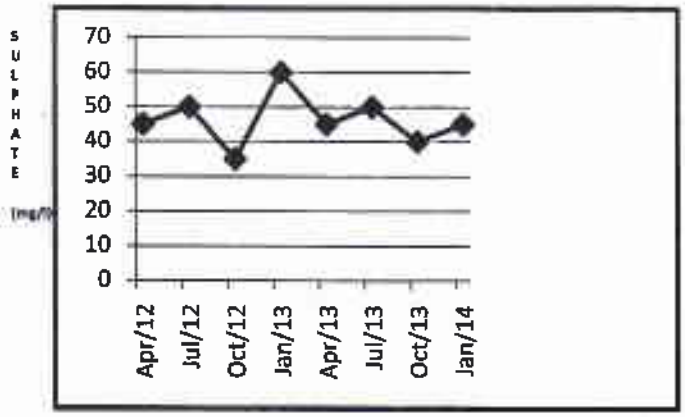
Phosphate (mg/l)



DO (mg/l)



Sulphate (mg/l)



Result & Discussion:

The water samples were collected seasonally from the bathing ghats of Jamshedpur. The water receives discharge from several drainages of Jamshedpur Town.

This investigation was done during the period from April, 2012 to January, 2014. In this connection various parameters of water quality were analyzed following the method suggested by APHA (1998). This study indicated that the temperature range of river water is 22-27°C, transparency 10.8 – 60.0 cm, pH 7.64 – 8.5, dissolved oxygen 6.2 – 14.4 mg/l, biological oxygen demand 3.6 – 7.6 mg/l, conductivity 0.22 – 0.346 ms/cm, total dissolved solids 139.8 – 211.06 mg/l, turbidity 78 – 4500 mg/l, chloride 32 – 66 mg/l, total hardness 152 – 224 mg/l, free CO_2 1.2 – 13 mg/l, alkalinity 92 – 138 mg/l, nitrite 0.005 – 0.016 mg/l, nitrate 2.519 – 6.348 mg/l, phosphate 1.174 – 2.842 mg/l, sulphate 38 – 60 mg/l and iron 0.008 – 0.041 mg/l at sampling point.

The fluctuation in water temperature has relationship with the air temperature. Similar fluctuations are reported by Khanna D.R. (1993). Maximum values of the studied parameters were observed during summer season and shock load of first rain in rainy season except DO and maximum values of these parameters obtained during winter, while higher values of dissolved oxygen were observed during rainy period at sampling point which may be due to dilution in rainy period and super saturation of oxygen at lower ambient temperature and less human activities like bathing / washing etc, in winter. After winter period as temperature of the environment rises bathing, washing and other human activities are also increased which gradually deteriorates the water quality of Subarnarekha River (Jamshedpur).

During the study period we found that pH variation lies mostly within the alkaline range and conductivity values support the fact river is very productive (Rao 1993). Turbidity and transparency are also quite favorable of water ranged between 10.8 and 60.0 cm during the course of study and had a negative correlation with turbidity. Similar results are reported by Dagaonkar and Saxena (1992).

The dissolved oxygen ranged from 6.2 to 14.2 mg/l having moderate fluctuation. The presence of free CO_2 is due to incomplete utilization in photosynthesis and respiratory activity. Free CO_2 and dissolved oxygen showed inverse relationship to one another as similar to Welch 1952, Hutchinson 1857 and Hynes 1970. Chloride was low indicating no organic pollution in river. Chloride concentration was recorded from 32 to 66 mg/l showed a decreasing trend during the study but in the month July it increased up to a comparatively higher level.

Chloride and hardness showed a positive relationship. Hardness and alkalinity showed negative relationship to one another and their range are quite favorable for fish life as indicated by Trivedi *et.al.* (1986).

Conclusion:

It is the duties of concerned authorities as well as people of the area to protect such contaminations and bathing / washing by soaps because Subarnarekha River is the most important river of this Industrial build of Jamshedpur. Public awareness is most essential especially for those who are responsible to pollute the natural water quality of river Subarnarekha.

The values of various parameters obtained in the present study is found to be higher than the normal permissible limit. Hence the water is gradually becoming polluted and it is not advisable to use for drinking purpose unless it is well treated.

References:

- Adoni, A.D., (1985) Work book on Limnology, Pratibha Publishers, Sagar (MP).
- APHA (1998) "Standard methods for the examination of water and wastes water," American Public Health Association, Washington D.C.
- Dagaonkar, A., Saxena D.N., (1992) Physico-chemical and biological characterization of a temple tank, Kaila Sagar, Gwalior, MP. *J.Hydrobiol* VIII (1), 1-19.
- Dhindsa, S.S. and Bhargava, N., (1982) Periodic variation in the physico-chemical characteristics of the river Chambal at Kota Acta Ecol.,4(2) 21-23.
- Golterman, H.L. and Clymo R.S., (1969) Methods for the chemical Analysis of Fresh water. B.P.Handbook No.8 Blackwell Sci Pub.Oxford.pp 166.
- Hutchinson, G.E., (1975) A Treatise on Limnology vol.I John Wiley and sons, New York, London 1050 pp.
- Hynes, H.B.N.,(1970) Ecology of Running water. Liverpool University Press. Liverpool IV impression 1-555.
- Khanna, D.R., (1993) ecology and Pollution of Ganga river. Ashish Publishing House, New Delhi. pp 1-241.
- Rao M.Babu, (1993) Studies on the Ecology and Fish fauna of an oligotrophic lake HimayatSagar, Hydrabad (A.P.). In K.S.Rao (ed) Recent Advances of Fresh Water Biology. Vol – II. 73-98.
- Trivedi, R.K., and Goel, P.K., (1986) Chemical and Biological Methods for water pollution studies Environment Publication Karad.
- Welch, P.S., (1952) Limnology. McGraw Hill Book Co., New York, pp 593.

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Threatened and endemic ichthyofauna of the river Kharkai, Jharkhand with suggestion for their conservation

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Abstract : The freshwater fish fauna of Kharkai River (Jharkhand) has been reviewed in respect of the threatened and endemic freshwater fishes of our country. At present forty four species belonging to thirty six genera, fifteen families of freshwater fishes are known to occur in this river. It has been found that his river contains forty three threatened and one endemic freshwater fishes of India. Since for several reasons a large number of freshwater fishes of our country has been designated as the threatened species , it is therefore, their conservation measures should be immediately adopted to protect them. A number of factors are responsible for the present position of the freshwater fishes, of our country causing concern for their existence and survival. Some of the factor are like overfishing , pollution , deforestation , habitat alternation primarily due to construction of dam across rivers, intensive aquaculture, competition from the exotic species etc. Some conservation measures have been described in this paper.

Key words: Freshwater , Fish, Threatened , Endemic , Conservation

INTRODUCTION

The river Kharkai originates from Mayurbhanj district of Orissa near Badampahar region. It comes from plateau land as small narrow canals, then take wide shape gradually and meet the Subarnarekha river at Domahani (River Meet) near Sonari, Jamshedpur river tributary Kharkai is the main tributary of the river Subarnarekha. Discharge from many small and medium scale industries of Jamshedpur are seen to flow into Kharkai which empties into Subarnrekha at Domahani. The river spate during rainy season. It houses many kinds of limnofauna. One of the most important group of these limnofauna is the fishes. The account is of the fishes of the river are found in the work of Bose *et al* it at (1974-76) Mahata & Gorai (1976-77) Mishra (1978). The detail account of fishes found in river , is still wanting and therefore a through investigation in this aspect is required . However in the present paper the works of the above workers have been reviewed as well as also studied fish resource places like fish markets of nearby places of the river. A list of vulnerable , endangered , rare and endemic species of India found in the river Kharkai is prepared for information and knowledge of all concerned.

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MATERIALS AND METHODS

The available published literature on the fishes of river Kharkai and field study in different fishes resource places of the river are made during this investigation (February 2011-January 2012) to prepare the list of vulnerable, endangered, rare and endemic species of fishes. In this regard opinions of the fisherman, fish catchers and other rural people who are fond of fishes are consulted for the present study.

OBSERVATION

The fish species found in river Kharkai which were

recorded vulnerable, endangered , rare and endemic species are as listed below:-

Table 1: The fish species found in river Kharkai

A) Vulnerable Species :	
Name of Species	**Family**
1. *Gudusa chopra* (Ham.)	Clupeidae
2. *Notopterus notopterus* (Pallas)	Clupeidae
3. *Oxygaster phulo* (Ham.)	Cyprinidae
4. *Barilius bola* (Ham.)	Cyprinidae
5. *Barilius bendelisis* (Ham.)	Cyprinidae
6. *Danio acquipinnatus* (Mc Clelland)	Cyprinidae
7. *Chela laubuca* (Ham.)	Cyprinidae
8. *Amblypharyngodon microlepis* (Bleeker)	Cyprinidae
9. *Cirrhinus reba* (Ham.)	Cyprinidae
10. *Garra gotyla gotyla* (Gray)	Cyprinidae
11. *Garra mullya* (Sykes)	Cyprinidae
12. *Labeo calbasu* (Ham.)	Cyprinidae
13. *Labeo gonius* (Ham.)	Cyprinidae
14. *Puntius chonchonius* (Ham.)	Cyprinidae
15. *Puntius chola* (Ham.)	Cyprinidae
16. *Lepidocephalichthyes guntia* (Ham.)	Cyprinidae
17. *Noemacheilus rupicola* (Mc Clelland)	Cyprinidae
18. *Rita rita* (Hams.)	Bagridae
19. *Mystus vittatus* (Bloch)	Bagridae
20. *Mystuc Oar* (Ham.)	Bagridae
21. *Mysrus seenghala* (Sykes)	Bagridae
22. *Alia coila* (Ham.)	Schilbeidae
23. *Clupisoma garua* (Ham.)	Schilbeidae
24. *Pangasius Pangasius* (Ham.)	Pangasidae
25. *Bagarius bagarius* (Ham.)	Sisoridae
26. *Clarias batrachus* (Linn)	Claridae
27. *Heteropneustes fossilis* (Bloch)	Heteropneustidae
28. *Channa orientalis* (Bloch)	Channidae
29. *Rhinomugil corsula* (Ham.)	Mugilidae
30. *Anabas testudineus* (Bloch)	Anabantidae
A) Endangered Species:-	
Name of Species	**Family**
1. *Anguila bengalensis* (Grey)	Anguilidae
2. *Amphipnous cuchia* (Ham.)	Amphipnoidae
3. *Notopterus chitala* (Ham.)	Notopteridae
4. *Barilius bola* (Ham.)	Cyprinidae
5. *Tor tor* (Ham.)	Cyprinidae
6. *Tor puntitora* (Ham.)	Cyprinidae
7. *Ompok bimaculatus* (Bloch)	Siluridae
8. *Ompak pabda* (Ham.)	Siluridae
9. *Glyptothorax nelsoni* (Ganguli *et al*)	Sisoridae

CONSERVATION STATEGIES

The problems of protection and conservation of the fishes of river Kharkai are very similar to that of other rivers of the state Jharkhand as well as of the country. The fish population of this river and flowing water level of it is day by day decreasing on. Indiscriminate fishing in the river, deforestation of forest on the banks of both side of the river and discharge of effluents from various sources has decreased the fish population of the river. Considering these factors some suggestion for protection and conservations of the fishes are furnished below :-

1) Deforestation along the course of the river should further be avoided because it causes soil instability that increases turbidity of the water bodies. It also increases the temperature of the breeding ground as well as also increases the food availability of the fishes. Replantation is needed on both sides of the bank of the river, where vegetation has been destroyed, to avoid the soil erosion, to maintain the clear water and to maintain the required temperature of the spawning ground of the fishes as well as sufficient availability of food to fishes.
2) Pesticides and agricultural fertilizers along the water courses should be used very carefully. The fisherman and local people employed in fishing should be advised to use only rapidly degradable types of pesticides.
3) Effluents from industries should be released into the river systems after proper treatment to remove toxic materials. It is necessary for flourishing growth of planktons and to increase oxygen content of the river's water which are very essential for fish population and many other limno fauna.
4) Indiscriminate harvesting of fishes is another meanse to the whole fish population. This should be controlled or monitored during the spawning period. Immature species should be protected by banning the use of very small mesh sized nets so that juveniles are not captured.
5) The vulnerable, endangered, rare and endemic fishes should not be captured while fishing the fishes the river for food purposes. The knowledge on the aspects should be conveyed to the fishermen and local people who usually capture fishes from the river for food and commercial purposes and this could be done through public awareness programme by the state fishery development concerned

REFERENCE

1. **Bose , K.C; Mahata, M.C.: & Gorai A.C. 1976-77.** Poikilothermous Vertebrate of Chotanagpur plateau , Bihar **Res.Jour**.R.U;12&13;301-306.
2. **Bose , K.C., Firoz, M. 1974-75.** Fishes of Jamshedpur, **Res. Jour.** R.U.; 10&11;296-304.
3. **Day, F. 1978**. The Fauna of British India Including Ceylon and Burma **Fish I & II** . Today and Tomorrow's book agency, New Delhi.
4. **Gorai, A.C.; & Mahata , M.C. 1974-75.** Ichthyofauna of Purulia, **Res.Jour** R.U 10 & 11; 314-320.
5. **Jayaram K.C. 1981.** The fresh water fishes of India, A hand book . Zoolsurv of India, Govt. of India XXII + 475.
6. **Mishra, K.C. 1959**. An aid to the identification of the common commercial fishes of India and Pakistan; Rec. Ind. Mus.; 57÷XXVi + 318.
7. **Talwar , P.K and Jhingran , A.G. 1991.** Inland fisheries of India and adjacent countries Oxford & IBH Publishig Company Pvt Ltd , New Delhi , I & II, 1158 P.

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