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**RESOURCE POTENTIAL OF SASTHAMKOTTA LAKE
WITH SPECIAL REFERENCE TO FISH FAUNA
AND THEIR SUSTAINABILITY**

*Thesis submitted to the Mahatma Gandhi University, Kottayam
in partial fulfillment of the requirements for the degree of
DOCTOR OF PHILOSOPHY
in ZOOLOGY*

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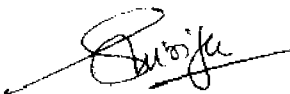
April 2007

...dedicated to my husband and kids

DECLARATION

I hereby declare that this thesis entitled '*Resource Potential of Sasthamkotta Lake with Special Reference to Fish Fauna and Their Sustainability*' is a bonafied record of research carried out by me under the supervision and guidance of Dr. Nelson P. Abraham M.Sc. PhD, Sel. Grade Lecturer, Department of Zoology, St. Thomas College, Kozhencherry in partial fulfillment of the requirements for the degree of **Doctor of Philosophy** of the Mahatma Gandhi University and that no part of this has been presented for any degree, diploma or any other similar title of any University.

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CERTIFICATE

This is to certify that this thesis entitled '*Resource Potential of Sasthamkotta Lake with Special Reference to Fish Fauna and Their Sustainability*' is an authentic record of research carried out by Smt. S. Girijakumari M.sc, M.Phil, B.Ed. under my supervision and guidance in partial fulfillment of the requirement for the degree of Doctor of Philosophy of the Mahatma Gandhi University and that no part of this has been presented for any degree, diploma.

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ABSTRACT

The present study was to assess the Resource Potential of Sasthamkotta Lake with Special Reference to Fish Fauna and Their Sustainability. 26 species of fishes belonging to 7 orders, 14 families and 16 genera were reported. Out of this 6 species were newly reported during the study. The lake supports a negligible fishery potential when compared to its area. *Horabagrus brachysoma* and *Etroplus suratensis* were observed only rarely which were common fish in the past. The diversity indices, abundance and lake potential were assessed based on the data obtained during the study period. Ecological parameters relating to hydrography, sedimentology, primary productivity and plankton composition were also studied. The nutrient status of the lake was negligible but the potassium content of the lake water increased when compared with the previous studies. This shows the silting and land erosion from the catchment area since the lake is an enclosed water body. The lake has only a thin film of plankton and low rate of productivity. As the lake is a drinking water source to lakhs of people in Kollam District, the microbiological parameters were also studied. The results showed that the drinking and bathing standards of the lake water are beyond the ISI limits. Conservation strategies were also suggested to prevent the lake from further deterioration and finally the death of the lake.

Key words: - Sasthamkotta lake, hydrography, resource potential, abundance, microbiology, ISI standards, sediment analysis, plankton, productivity, diversity indices.

PREFACE

Sasthamkotta lake is the largest fresh water lake of Kerala, is one among the nineteen wetlands identified for intensive conservation and management by the Ministry of Environment and Forests under the national wetland programme. This wetland was declared as Ramsar site since 2002. This is the main source of drinking water to the lakhs of people at Kollam District. This wetland system is subjected to considerable pressure, especially due to biotic disturbances in the catchment. The changes in land use and subsequent soil erosion have been a threat to this wetland ecosystem. The catchment area, being urban, is thickly populated; hence domestic or community waste water is indiscriminately discharged into the lake. Several house holds near the lake do not have proper sanitation facilities; local inhabitants in the catchment bathe and wash clothes and domestic animals in the lake using soaps and detergents. Human faeces in the catchment area make the water highly unfit for human use. All these activities continue to exert their impact on this fresh water lake. Hence the study was designed to assess the total ecological aspect of the lake especially with reference to the fishery potential and drinking water standards of the lake water.

Fresh water fishes form an important component of fish resources in India. The fresh water ecosystems provide suitable conditions for the growth of a number of indigenous species of fresh water fishes and are one of the most significant inland water resources of the state. No authentic information regarding the fish diversity and resource potential of the lake is available except a few studies about the ecology of the lake. Hence the study was meant to assess the fishery potential of the lake.

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CHAPTER I
GENERAL INTRODUCTION

CHAPTER I

GENERAL INTRODUCTION

Fishes have great significance in the life of mankind, being an important natural source of protein and providing certain other useful products. As a part of the Indian culture, they have appeared in mythology also. One of the incarnations of Vishnu was in the form of a fish (Matsyavatara) to rescue the Vedas from the Asuras. A lot of references and information are available from the epics and classics of India regarding the ecology and biology of the fishes. In Kerala, there are ponds to protect the fishes and there is a religious fete called 'Meenuttu' (feast for the fish). The ancient Hindus knew greatly about the variety of freshwater fishes especially of the Indo-Gangetic plain and fishes appeared in Ramayana (Hora, 1935; 1950a; 1952).

Recent investigations on world human population have revealed that the population has increased manifold, which, in turn, has necessitated a high yield of food. This can be achieved only through blue revolution by the developing world (Dadzie and Wangila, 1980). One of the ways of achieving this goal is the culturing of aquatic organisms especially fishes. A major part of the world's fish catch is from inland waters, which comprise 0.5% of the total water bodies (Srivastava, 1985). These inland water bodies consist of streams, rivers, irrigation channels, reservoirs, ponds, backwaters and freshwater lakes. These aquatic ecosystems form the main and important breeding, nursery and growth ground for commercially important species of fishes.

The aim of any good fishery management is always to obtain the maximum sustained yield of fishes from a water body. Tremendous progress has been made in the past few decades in tackling the problems of fishery science and also in the fishery industry. It is a well known fact that the existing natural resources of fish are very much limited and, for that matter, they are getting depleted at an alarming

rate, because of the commercial exploitation of these resources to cater to the increasing demand for fish, the world over.

India is endowed with a vast expanse of open inland waters in the form of rivers, canals, estuaries, natural and manmade ponds, fresh water lakes, backwaters, brackish water impoundments and mangrove wetlands (Munshi and Hughes, 1991). Fresh water fishes form an important component of fish resources in India. This field offers great scope for future and further development of fish production. Research efforts have been directed towards assessment of fresh water fish stocks and their yield rates in relation to production potential of the system so that fishery can be exploited to near optimum level through regulation of fishing efforts and ecosystem management (Munshi and Hughes, 1991).

Kerala is a small state at the southwest coast of the Indian peninsula, lying between north latitudes $8^{\circ} 17'30''$ and $12^{\circ} 47'40''$ and between east longitudes $74^{\circ} 51'57''$ and $77^{\circ} 24'27''$. It has an area of 38,863 sq. km. It is a very narrow strip of land wedged between the Western Ghats on the east and the Arabian Sea on the west. Its breadth varies from 32 to 120 km and it has a coastline of 590 km (Nair and Tranter, 1971). This state is rich in water resources, having 44 rivers (41 flowing towards west and 3 flowing towards east) originating from the Western Ghats, cut across the state with their innumerable tributaries and ending in lakes. The major freshwater lakes of Kerala include the Sasthamkotta lake (Kollam District), Vellayani lake (Trivandrum District) and Pookot lake (Wynad District). The fresh water ecosystems provide suitable conditions for the growth of a number of indigenous species of fresh water fishes and are one of the most significant inland water resources of the state.

The lakes of Kerala are peculiar in a sense that a number of rivers open into them. Sasthamkotta lake is an exception. It has no inlets or outlets. Sasthamkotta lake, the largest fresh water lake of Kerala, is one among the nineteen wetlands identified for intensive conservation and management by the Ministry of Environment and Forests under the National Wetland Conservation Programme. This wetland was declared as a Ramsar site in November 2002.

The major values /attributes of the lake include: source of drinking water in Kollam Corporation and suburbs, groundwater recharge, receptacle for flood waters, sink for pollutants and an ideal habitat for freshwater flora and fauna. The available studies on tropical freshwater bodies mostly dealt with only the physico-chemical parameters. The same is the condition of Sasthamkotta lake. Considering the importance of the wetland as a biodiversity site, the present study aims to make a documentation of fishes in Sasthamkotta Lake and to assess the fishery potential of the lake. Along with this the hydro biological characteristics, sedimentological parameters as well as the productivity that influence the resources of the lake were also subjected to study.

Review of Literature

The science of Ichthyology dates back to the time of Aristotle (BC-384-322). His knowledge on the habit, habitat, propagation, migration and utility of fishes was proved to be correct. In 'Manasollasa', King Someswara (1127 AD) classified fishes as scaled, scale less, ascending rivers, marine and freshwater inhabitants (Jayaram, 1981). He also suggested methods of fishing and suitable baits. The traditional uses of fishes were briefly narrated by Day (1865). Belone in 16th century wrote '*De aquatilibus libri duo*' which was an important progress in Ichthyology. The successor of Belone, Randelt's (1507-1557) work in '*Libri de piscibus marinus*' reveals his knowledge regarding the anatomy of fishes. Ray and Willughby (1635-72) contributed much to the taxonomy of fishes. The book entitled "*Historia piscium*" describes the fishes collected during their journeys in Great Britain (Day, 1875-1878).

Peter Artedi is considered as the father of Ichthyology. He described forty-five genera and seventy-two species. Linnaeus (1766-1768), father of taxonomy contributed much to the taxonomy of fishes also. Bloch's (1785-1795, 1797) work was unique with great number of illustrations. Lacepede's (1798-1803) "Histoire des poissons" and Cuvier and Valenciennes's "Histoire Naturelle des poissons" are indispensable for any fisheries related studies. Nelson (1984) presented a modern

introductory systematic treatment, diversity, and zoogeography of all major fish group in the world.

The fish fauna of the world is diminishing at a rapid rate due to habitat destruction (Maitland, 1987; Burton, 1995), pollution (Moyle and Leidy, 1992; Kimmel *et al.* 1996; Bonetto, 1998; Hudd and Kalax, 1998), unscientific fishing methods, overexploitation and introduction of exotic species, and fragmentation. The assemblage of fishes in tropical rivers has attracted considerable scientific attention. Welcomme (1979) studied the fisheries ecology of flood plain rivers. Moyle and Senanayaka (1984) studied the fishes of rain forest streams in Sri Lanka with reference to resource partitioning. The diversity, density, and standing crop of fishes in the Ancora river, North Portugal, were examined by Formigo *et al.* (1998). Smith (1998) reported 38 species of fishes from 14 rivers in eastern Sabah, Malaysia. Hsiung *et al.* (1999) studied the effects of dams on fish assemblage of the Tachia River, Taiwan.

Study of Indian fish fauna

Study of fish fauna in India is as old as Vedic times. They classified fish based on shape and structure as seen from Kautilya's Arthasasthra, King Someswara's Manasollasa etc. The first Indian wrote on the Indian fishes is Bloch whose work entitled *Auslandische Fische* was published in 1785. This was continued by Lacepedes (1798-1803). In Russel's *Fishes of Vizagapatnam*, 200 forms are delineated and described. Bleeker's (1853) *Ichthyologische fauna van Bengalen* included all the fishes known from India (Day, 1875-78). Blyth (1858-1860) gave several interesting articles on the Indian fishes in their proceedings on the fishes of India during 1858-60. Gunther (1859-1870) of British museum made a compilation of the fishes in the museum and published as catalogue of the fishes which deals with 6843 well established species and 1682 doubtful species.

The more scientific and systematic study on the Indian freshwater fish fauna started with Hamilton-Buchanan's account of the fishes found in the river Ganges. Beavan (1877) published a book on the freshwater fishes of India in which he gives a clue on the distribution pattern of some Malayan species found in

Peninsular India. Information on the fish fauna of Malabar region was made by Hamilton (1877) during his journey through south India. All these pioneer researchers laid a solid foundation for Indian systematic Ichthyology. Nevertheless, a comprehensive and authoritative account on the fishes of Indian region was published during 1875-78 by Francis Day.

Day included 1418 species of fishes found in the territories of present Republic of India, Pakistan, Bangladesh, Myanmar and Srilanka. Hora published over 440 papers, and established three families, 28 genera, and 139 species (Jayaram, 1976). The survey and documentation as "Notes on the fishes in Indian Museum" carried out during 1920-1955 by Hora brought out information on the freshwater fishes of various river systems of India. Misra published a series of checklists and aids for the identification of the fauna of India and adjacent countries (Misra 1947, 1952, 1953, 1976a, b). These studies were continued by the publication of Tilak (1987), Menon (1987, 1992) and Talwar (1995). Datta Munshi and Srivasthava (1988), Jayaram (1976, 1981) and Jhingran (1982) supplemented information on the inland fish fauna of India.

Hora's (1949; 1950 b, 1953c) "Satpura hypothesis" generated interest on the freshwater fishes in the rivers of the Western Ghats. Besides these, Molesworth and Bryant (1921), Hora (1936), Hora and Misra (1942), Silas (1951), Rajan (1955), Jayaram (1976, 1981), Johnsingh and Vikram (1986), Ilango (1990), Indra (1991, 1992), Remadevi (1992), Remadevi and Ilango (1993) Menon *et al.* (1993), Singh (1994), Remadevi and Menon (1994), Remadevi *et al.* (1996), Arunachalam *et al.* (1997), Manimekalan and Singh (1997) and Arunachalam and Sankaranarayanan, (1998) also made some studies in peninsular India. Martin *et al.* (2000) recorded 36 species of fishes from Tamaraparani river. Arunachalam *et al.* (2001) recorded 25 species belonging to eighteen genera from Ramanadhi river in Kalakkad Mundanthurai Tiger Reserve in Tamil Nadu.

Studies on the freshwater fish fauna of Kerala

Fish fauna of Kerala starts with Jerdon's (1849) and Hamilton's (1877) journey through South India. A systematic account of the fishes is available from

Day's (1865) "Fishes of Malabar" –this book is considered as germ for the publications of "Fishes of India." After Day's monumental work, the next fish fauna study of Kerala was by Pillai (1929), in which he listed 369 species from Travancore region. John (1936) published a book on fresh water fish and fisheries of Travancore. Based on the above studies Hora and Law (1941) published a comprehensive list of 76 species of typical freshwater fishes of Travancore.

Chacko (1948) listed indigenous fishes from the Periyar lake. Later Silas (1949, 1951, 1952, and 1954) documented fishes of the Travancore region. Freshwater fishes in the headwaters of Bhavani river was studied by Rajan (1955). Remadevi and Indra (1986) reported fish fauna of Silent Valley. In 1994 Pethiagoda and Kottelat described three new species from the Chalakudy river in central Kerala. Easa and Bhasha (1995) conducted a survey on the habitat and distribution of stream fishes in Kerala part of the Nilgiri Biosphere Reserve and recorded 92 species. Fishes from Periyar Tiger Reserve was documented by Arun *et al.* (1996) and Zacharias *et al.* (1996). Fish diversity in Wyanadu District (Shaji and Easa, 1995), Aralam wild life sanctuary (Shaji *et al.*, 1995) and Pampara river and Chinnar wild life sanctuary (Easa and Shaji, 1996) has also been studied. Zacharias *et al.* (1996) recorded 35 fish species from the Periyar river and reservoir within Periyar Tiger Reserve. Arunachalam *et al.* (1997) studied the fish diversity in Chittar river of Western Ghats. Thomas *et al.* (1998) and Ajith Kumar *et al.* (1999) studied the fish fauna of Chalakkudy river and Biju *et al.* (1999) of Parambikulam wild life sanctuary. Ajith Kumar *et al.* (2001) recorded 34 species of fishes belonging to 7 families in Puyamkutty river and its tributaries. Thomas *et al.* (2002) studied the fish fauna of streams south of Palghat gap in Kerala and reported 117 species. They also reported the distribution of endemic and endangered species. Cherian *et al.* (2002) studied the ichthyofauna of Thiruvananthapuram District. Sandhya (2003) reported thirty six species of fishes from Vellayani lake. Sushama (2003) and Sushama *et al.* (2004) recorded 150 species of fishes in Nila river. Manojkumar and Kurup (2005) studied the degradation of fish habitat in Kerala. Bindu and Harikumar (2007) studied the physicochemical factors influencing the fishery of Vembanad lake.

Over exploitation and alternate use of water has affected the fish fauna of most of the inland water bodies. The conservation of living resources has become a world wide concern. This has led to the International Convention on Biodiversity at Rio in 1992, to formulate policies for the conservation of biodiversity and its sustainable use.

In aquatic ecosystems understanding of species diversity is complicated due to existence of several factors and their combinations. Factors like the quality of fish resources, abundance of predators, emigration, reproductive potential, physical and chemical characteristics of the environment, etc are responsible for the diversity and richness of species in aquatic systems. In fact the well being of an aquatic ecosystem is assessed by its biodiversity. For this species richness, species diversity etc have been evaluated and related to the environment. Many ecologists used these diversity measurements for the monitoring and conservation of the environment. According to Tonn (1990) number of species and their abundance are governed by several environmental processes. In a continental scale fish assemblages are believed to have attained the present status through selective extinction, speciation, refuges and routes of disposal. Within the continents or geographic regions, types of habitats available, diversity of habitats and the occurrence of disturbances within the habitats shape the structure of fish assemblages (Arun, 1997). However, within these habitats, fluctuations in the environmental factors during seasons and at different regions influence their diversity. These short term fluctuations in diversity have not been understood in many water bodies of the world especially in the tropics. In addition, greater predation pressure and competition existing in tropical areas affect the species assemblages and diversity in a particular area (Schoener, 1986). In tropical areas the high species diversity is attributed to the rapid change within the limits of tolerance in an ecosystem (Lovelock, 1992). Due to the low capacity of smaller fishes to tolerate low temperature, they have gradually disappeared from temperate regions and confined themselves to the more tolerable climatic regions, resulting in high species diversity in tropics (Mina, 1991). Similarly within the

tropical aquatic habitats high velocity results in higher species diversity in streams compared to lakes.

Within each system, fish assemblages show dynamics due to several factors. The abundance, diversity of species and the pattern of distribution of fish assemblages in an aquatic ecosystem depend on the interaction of several factors and their spatial and temporal changes. The physical and chemical changes within the ecosystem and other characteristics of the habitat are of great use in predicting the dynamics of fish assemblages to a great extent. In small water bodies like shallow lakes, fish assemblages show noticeable spatial and temporal variations due to their geomorphology, hydrological patterns, water budget etc. This means that the physical factors are the most influential factors that affect the dynamics of fish assemblages (Leveque and Quensiere, 1988). Hence knowledge of the pattern of environmental variables will help in determining the dynamics of the assemblages, but these need not help in predicting them.

In spite of the importance of studies involving the dynamics of fish assemblages in small water bodies especially with regard to their potential effect on the fisheries, no serious attempts have been made to study diversity and assemblages of fishes in freshwater lakes of Kerala. The little available information is from tropical fluvial systems (Moyle and Senanayake, 1984; Ross, 1986; Wikramanayake and Moyle, 1989; Gregor and Deacon, 1988; Flecker, 1992; May and Brown, 2002). Some of the lacustrine fish assemblage studies include the works of Barbour and Brown (1974) Tonn and Magnuson (1982), Gido and Mathews (2000) and Amarasinge and Welcomme (2002). In Kerala the assemblage structure of fishes in Periyar Lake Valley system was studied by Arun (1997) and by Sandhya (2003) in Vellayani lake.

For improving the fishery potential of lakes, we must have a sound knowledge about their ecology and the diversity of fishes. A satisfactory understanding of aquatic life requires knowledge not only of the organisms themselves, but also of those external influences which directly or indirectly affect them. A thorough knowledge of the physico-chemical parameters is essential to understand the occurrence, growth, breeding and abundance of the fish fauna of an aquatic system during different seasons

of the year. The hydrographical features of the extensive water bodies of the world have been investigated by a number of investigators (Reid and Wood, 1976; Cummins, 1979; Holdon, 1979; Stalnaker, 1979; Winterbourn and Townsend, 1991; Berg, 1993; Smith, 1997). Armantrout (1994) systematically documented the condition of world's aquatic habitat.

In India, many investigators conducted studies in relation with physico-chemical properties of water include those by Dwivedi *et al.* (1986) in Kulgari reservoir, Madhya Pradesh; Mishra and Singh (1989) in some ponds of Sitamarhi district; Rao and Durve (1989) in Rangasagar lake, Udaipur; Yadava *et al.* (1987) in Dighali beel lake, Assam; Ahmad and Singh (1990) in Kanwar lake, Bihar; Gupta (1991) in Sagas lake; Desai (1991) in Kodaikanal lake and Rao *et al.* (2006) studied the ecology of Kolleru lake in Andhra Pradesh. The fish production in inland water bodies in relation to ecological factors were done by Nair and Prabhoo (1980), Chandrasekhara (1992), Nair and Balachand, (1992), Abraham and Balakrishnan (1993), Padmalal and Seralathan (1994), Joseph (1994), Kumar and Chattopadhyay (1995). Abbasi *et al.* (1997) studied the physico-chemical parameters of water in Pookot lake and also conducted detailed studies on Punnurpuzha in Kerala. Sareena (1998) and Sandhya (2003) studied the water quality parameters that influence fishery potential in Vellayani lake and Bindu and Harikumar (2007) at Vembanad lake.

The physico-chemical characters are very important in determining the biological productivity of aquatic ecosystem. The limnological studies in relation to the seasonal fluctuation of water characteristics and biological conditions of lakes, reservoirs, tanks and ponds are scanty in comparison to the vast area of inland fresh water available.

Lake pollution is a serious water pollution problem and has become universal. Waterborne diseases are the major causes of morbidity and mortality in developing countries (Morris and Levin, 1995). The presence of coliforms in water is indicative of the water being contaminated with faecal matter (Edward, 1999). The coliforms are seen in water, soil vegetation, fish, insect, farm products and raw food material. It is well known that the non-faecal coliform bacteria can grow in

water even with very small amounts of organics (Raghuvachari and Iyer, 1939). Sasthamkotta Lake is a drinking water source to lakhs of people in Kollam District. Hence the study was carried out to assess the faecal indicating bacteria of the lake.

Morphometry is the major element of a lake structure. Once the lake basin is formed, physical, chemical and biological factors interact to produce a discernible structure within the water. The topography of the surrounding area may provide a clue to the morphometry of the lake basin. A severe condition is the sedimentation in lakes. Sediments are derived from allochthonous or autochthonous sources and are regarded as the storehouses of essential elements in productivity in overlying water and even pollutants (Wetzel, 1975). Sedimentology components have a vital role in regulating the characteristics of the aquatic ecosystem. A comprehensive idea of the bottom sediment is thus a prerequisite in any water quality management procedures.

Different lakes at different stages exhibit various degrees of trophic status under natural conditions and equilibrium. The basis for nearly all life in the aquatic system is the photosynthetic activity of the aquatic plants and plankton. So in any aquatic system, primary productivity has a significant role and is the pulse of the aquatic ecosystem. In an aquatic ecosystem, plankton community plays a significant role in the productivity and trophic balance of the system. Plankton is considered as an index of fertility (Prasad, 1969). Knowledge of their abundance and composition is one of the essential prerequisites for successful fishery management of lakes (Pandey and Sony, 1993). The concentrations of fish fauna are directly proportional to the quantity of plankton (Chidambaram and Menon, 1945). Living organisms can influence the composition of sediment significantly. Phytoplankton production is in relation with the percentage of organic matter in the sediment (Prakasam and Joseph, 1991). Chlorophyll 'a' is an indicator of phytoplankton abundance, which directly influences the abundance of fishes. In studies related to aquatic food chains or tropho-dynamics, estimate of the standing crop of phytoplankton becomes a necessary prerequisite and chlorophyll 'a' indicates the total plant material available in the water at the primary stages of food chain (Quasim, 1970).

In Kerala only few fresh water lakes exist, out of which Sasthamkotta lake is the largest freshwater lake. During recent times, the lake is exposed to several anthropogenic activities. This wetland is subjected to considerable pressure, especially due to biotic disturbances in the catchment. The changes in land use and subsequent soil erosion, lack of proper sanitation facilities for the local inhabitants of the catchment area and indiscriminate use of soaps and detergents, pollute the lake to a great extent. Part of the agrochemicals used in the catchment also finds their way to the lake. Due to the unscientific land use pattern in the catchment, sediment load entering into the lake has considerably increased, thereby contributing to the reduction in the capacity of the water body. If these activities continue without a check, eutrophication of the lake is the result which ultimately affects the fishery potential of the lake. However no authentic information regarding the diversity pattern of fish fauna of the lake and their fluctuations are available, except a few studies about the physicochemical parameters of the lake (Thomas *et al.*, 1980; Pillai, 1981; Nair, 1988; Prakasam and Joseph, 1989, 1991, 1992; Joseph, 1994) and CWRDM (2001). Nair and Girija (2003) suggested the significance of a holistic approach to Sasthamkotta lake. Considering the paucity of information regarding the resource potential of the lake, the present study was conducted in Sasthamkotta lake. The study encompasses the following aspects,

1. Physical and Chemical parameters of the lake water that influences the fishery potential.
2. Since the lake is a drinking water source, microbiological studies were undertaken.
3. Geochemical study regarding the texture and nutrients of the lake.
4. Density of planktons along with the productivity of the lake
5. Estimation of chlorophyll 'a' as an indicator of productivity.
6. Biodiversity of fishes.
7. Composition and assemblage of fish fauna collected using different nets.
8. Fishery potential of the lake.
9. Suggestions regarding the conservation of fish fauna and the lake as whole.

CHAPTER II
DESCRIPTION OF THE LAKE

CHAPTER II

DESCRIPTION OF THE LAKE

Sasthamkotta lake, the largest fresh water lake of Kerala, is one among the nineteen wetlands identified for intensive conservation and management, lies between latitude $9^{\circ} 00'$ - $9^{\circ} 05'$ North and longitude $76^{\circ} 35'$ - $76^{\circ} 46'$ East. It is spread out in the adjacent villages of Sasthamkotta, Mynagappally and West Kallada of Kunnathur Taluk, Kollam District.

Shape

This wetland has an inverted F shape with a number of small and large creeks, thereby drawing an irregular contour (Fig. 2.1). It is surrounded by hills of compact clay on all sides except the South-eastern region where, in 1956, a concrete bund has been constructed separating the lake from the nearby paddy fields. The lake is thus a completely isolated water body.

Area

Literature shows that the area of the lake was about 3.75 sq. km (Nair, 1958; Anon, 1983, 1991-1992). Data on area of the lake, as given by various authors, are inconsistent (Prakasam, 1991). The average depth of the lake was calculated as 6.79 m with a maximum of 13.9 m during summer and likely further increase by 1.5 m during monsoon rains (Prakasam and Joseph, 1991). The maximum breadth of the lake was reported to be about 500 m (Thomas *et al.*, 1980).

Lake capacity

Sasthamkotta lake is a rain fed lake depending on seasonal rains for its yearly replenishment. It was established that from its catchment area, million liters of water flows into the lake every year. The water holding capacity of the lake was worked out to be 22390 liters (Anon, 1991-92, Joseph, 1994).

Catchment area

Sasthamkotta lake has an effective catchment area of 934.56 ha. draining into the wetland. The major causes of degradation in the catchment are changes in agricultural practices in the watershed, urbanization in the watershed and pollution due to lack of sanitation and drainage facilities (CWRDM, 2001). Most of the catchment area is residential and is under private ownership. There are 1616 holdings with a population of 9487 numbers (Anon, 1991-92). The major problems/threats faced by the wetland are due to the developmental activities in the catchment area.

The use of fertilizers and pesticides for agriculture purposes in the surrounding areas and the land usage pattern in the catchment areas are the major threats to the water quality of the lake. In addition to this, human excreta which are the source of coliforms are another major problem facing the lake. This makes the water polluted and unfit for human use.

Only very few reports exist on the fishery resource of the lake other than the scanty references on the ecology of the lake and the survey of fishes (Thomas *et al.*, 1980; Prakasam, 1991; Joseph, 1994). Information regarding the fishery resource and potential of the lake are meager.

STUDY SITES

Five stations were selected for the study (Fig. 2.1), based on the shape of the lake, difference in habitat type and the existing fishing activity (Plate I, Figs. S-I to S-V).

Station-I (Vallakadavu)

This station is having comparatively high anthropogenic activities. Bathing, washing of clothes, cattle and vehicles causes the increased deposition of soaps and detergents into the ecosystem. The adjoining lands of this station are steep which enhances agricultural run off. The catchment area of the lake is used indiscriminately for insanitary purposes and is used for dumping domestic refuse. Being the conventional temple bath place (Kulakadavu) and the only country boat jetty, possibility for human intervention become high in the station. Another significance

is related to forest cover near the station. It existed in early forties, but had almost disappeared with only a little remaining undisturbed within the surroundings of the sacred temple. In the eastern side of the station, Acacia plantation can be seen and the pollen of which are commonly seen floating on the lake water surface.

Station-II (Near Market)

It is surrounded by hills of compact clay on all sides and the market refuses are dumped into the lake in this part of the lake. Market is situated at the eastern side of Sasthamkotta junction and households are there at the valley of the lake in this station. This station of the lake is significant due to the presence of market.

Station-III (Near Concrete Bund)

This site is in the South-eastern region where, in 1956, a concrete bund was constructed separating the lake from the nearby paddy fields. This concrete bund separates the lake from Cheloor puncha, the buffer water storage site. Rubber plantation occupies the elevated regions on the northern side of the bund. Due to the unscientific agricultural practices, fertilizers and pesticides are continuously entering into the lake in this station.

Station-IV (Near Filter House)

This area is protected by the Water Authority Department of the Government of Kerala and hence anthropogenic activities except fishing are comparatively less. According to survey among the fishermen, this area is commonly used for fishing. Waste water after purification from the filter house and other domestic sewage are continuously discharged into the lake at this area. This station is significant due to the presence of the pumping station providing water for lakhs of people.

Station-V (Rajagiri Side)

This station is comparatively low populated area and hence human intervention is low. The use of fertilizers and pesticides for agriculture purposes in the surrounding areas and the land usage pattern in the catchment areas are the major threats to the water quality at this area. Fish catching is regular at this area.

Fig. 2.1 Map

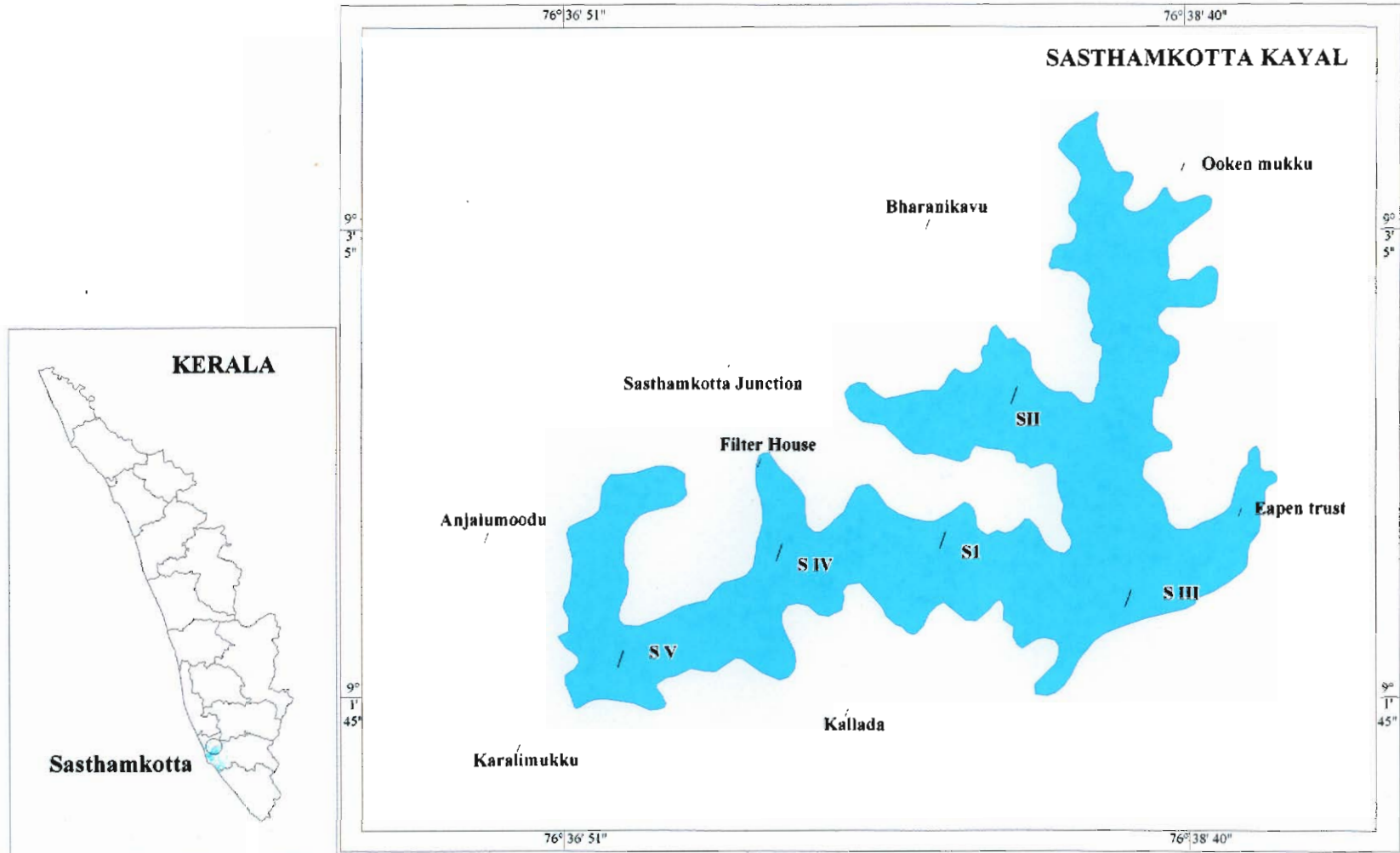


PLATE I



- S I - Vallakkadavu
- S II - Market (North-west side of BB College)
- S III - Near Concrete Bund
- S IV - Near Filter House
- S V - Near Rajagiri

(S - Station)

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CHAPTER III
LIMNOLOGY OF LAKE
1. HYDROGRAPHY
2. MICROBIOLOGY

CHAPTER III - 1

HYDROGRAPHY

INTRODUCTION

Limnology has contributed to the understanding of fresh water masses of our planet and has helped in improving water resources management, wastewater treatment, and hydraulic engineering. The physical and chemical features prevalent in the aquatic system govern the diversity, abundance and behavior of organisms in the same.

A satisfactory understanding of aquatic life requires knowledge not only of the organisms themselves, but also of those external influences, which directly or indirectly affect them. A thorough knowledge of the physico-chemical parameters acting directly or indirectly on aquatic life is essential to understand the occurrence, growth, breeding and abundance of the fish fauna of an aquatic system during different seasons of the year.

The hydrographical features of the extensive water bodies of the world have been investigated by a number of investigators (Reid and Wood, 1976; Cummins, 1979; Holdon, 1979; Stalnaker, 1979; Winterbourn and Townsend, 1991; Berg, 1993; Smith, 1997, Stalnacker *et al.*, 1999; Kamal *et al.*, 1999; and Nair Achuthan *et al.*, 2005).

In India, many investigators conducted studies in relation with physico-chemical properties of water include those by Ahmad and Singh (1990) in Kanwar lake, Bihar, Unni (1993) in central Indian lakes, Sagar lake by Joshi and Adoni (1993), Kaushik and Saxena (1999) in some of the water bodies of central India, Rao *et al.*, 2002 in the reservoirs of Karnataka, Sunitha *et al.*, (2005) in ground water of Gooty area in Andhra Pradesh and Rao *et al.*, (2006) in Kolleru lake.

The fish production in inland water bodies in relation to ecological factors in Kerala were studied by Dwivedi *et al.* (1986), Nair and Prabhoo (1980),

Mishra and Singh (1989), Rao and Durve (1989), Gupta (1991), Chandrasekhara (1992), Nair and Balachand (1992), Abraham and Balakrishnan (1993), Padmalal and Seralathan (1994), Kumar and Chattopadhyay (1995). Abbasi *et al.*, (1997) studied the physico-chemical parameters of water in Pookot lake and also conducted detailed studies on Punnurpuzha in Kerala. Vellayani lake was studied by Sareena (1998) and the hydrochemistry and drinking water potential of the Vellayani lake have been investigated by Krishnakumar (1999). Ecology of the Nila River was studied by Sushama (2003) and water quality and fish assemblages of Vellayani lake by Sandhya (2003).

The physicochemical characters are very important in determining the biological productivity of a water body. Fluctuation in various physicochemical parameters creates variation in abundance, pattern of distribution, and species composition of a given biotope. Quantification, evaluation, and study of interrelations between various physicochemical aspects are a prerequisite for understanding the health status of lakes. The limnological studies in relation to the seasonal fluctuation of water characteristics and biological conditions of lakes, reservoirs, tanks and ponds are scanty in comparison to the vast area of inland freshwater available. The living aquatic resources in general and those of India in particular are under constant pressure due to alternate water use, increased demand for food and environmental modifications. This has resulted in consistent changes in our aquatic heritage. The need for more food and drinking water has created tremendous impacts on the animal and plants chiefly due to overexploitation. This is especially evident in the inland water bodies in many ways which prompted the present study.

The present study was conducted to relate the physicochemical factors that influence the productivity and diversity of the biotic community in the Sasthamkotta lake. The parameters studied were rainfall, air temperature, water temperature, Hydrogen ion concentration, conductivity, transparency, turbidity, hardness, total suspended solids, salinity, alkalinity, dissolved oxygen, carbon dioxide, total organic carbon, biological oxygen demand and chemical oxygen

demand, nutrients such as silicate, phosphate, nitrate, nitrite and potassium and productivity such as gross primary productivity and net primary productivity.

METHODOLOGY

Regular monthly collection of surface water for hydrographic study was made from the five stations in Sasthamkotta lake (as mentioned in Chapter II). The study was conducted for a period of one year from November 2004 to October 2005. The stations were visited once in every month as far as possible on the same date. For collection of samples the area was visited in the early morning and proceeded to the collection sites in a small country craft.

Meteorological Characters

The rainfall data of Kollam District were collected from the Indian Meteorological Department, Thiruvananthapuram.

Air temperature was recorded at all the five stations. The measurements were made in the morning by using a centigrade thermometer having $\pm 0.1^{\circ}\text{C}$ accuracy.

Hydrological Parameters

Standard methods were employed to estimate the hydrological parameters with slight modification wherever necessary. Estimations were carried out as soon as possible to minimise errors due to chemical and microbial action. The parameters analysed were water temperature, pH, conductivity, transparency, turbidity, hardness, total suspended solids, salinity, alkalinity, dissolved oxygen, carbon dioxide, total organic carbon, biological oxygen demand and chemical oxygen demand, nutrients such as silicate, phosphate, nitrate, nitrite and potassium and productivity such as gross primary productivity and net primary productivity (APHA,1985; BIS,1991;Trivedi and Goel,1986).

Water Temperature

The temperature of water was recorded at the site itself by using a high quality centigrade thermometer ($\pm 0.1^{\circ}\text{C}$ accuracy).

Hydrogen ion Concentration (pH)

The pH of water samples were measured in the laboratory using a digital pH meter (Elico, Model No. LI – 10, India).

Conductivity

Conductivity was measured with the help of Conductivity meter (Systronix, India).

Transparency

Transparency was measured with the help of a Secchi disc (Golterman, 1969)

Turbidity

The turbidity of water sample was measured by using a Nepheloturbidity meter (Systronix digital Nepheloturbidity meter 132).

Total hardness

Hardness of the water sample was estimated by EDTA method (Golterman, 1969). The results were expressed in mg l^{-1} .

Total Suspended Solids

Total Suspended Solids was measured with the help of an instrument UV Pastel Water Analysing Kit.

Total alkalinity

Alkalinity of the water sample was estimated according to the method suggested by Grasshoff *et al.*, (1983) by titration. The results were expressed in mg l^{-1} .

Salinity

Salinity was estimated titrimetrically by the chlorosity method (Grasshoff *et al.*, 1983).

Free carbon dioxide

Dissolved free CO₂ was estimated immediately after reaching the laboratory by titration method (Trivedi and Goel, 1986). The results were represented in mg l⁻¹.

Dissolved oxygen

The dissolved oxygen content of each water sample was fixed *in situ* using Winkler's reagents and analysed by the classic Winkler's titration method (APHA, 1985). The results were presented in mg l⁻¹.

Total Organic Carbon

Total Organic Carbon was measured with the help of an instrument UV Pastel Water Analysing Kit.

Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD)

BOD and COD were measured according to APHA (1985).

Nutrients

The concentrations of five nutrients were determined during the present investigation. They were inorganic phosphate, silicate, nitrite, nitrate, and potassium. The water samples collected for the estimation of nutrients were preserved by adding a few drops of chloroform. Particulate matter in the water sample was separated by filtration through a uniform millipore Whatman GF/C filter paper (0.5 µm porosity) in the laboratory. The concentration of nutrients was recorded by spectrophotometer by using a UNICAM UV-VIS Spectrophotometer, (Model UV-2, UNICAM, UK). Analysis of nutrients like phosphate, silicate, nitrite and nitrate were made in the laboratory based on the methods by Parsons *et al.*, (1984). Potassium was determined by using the flame photometer (Systronix.128) based on the procedure described in APHA (1995). The results were expressed in µg l⁻¹.

RESULTS

1. Rainfall

Based on the pattern of rainfall in Kerala, three seasons are recognized, Monsoon (June-September) when the south-west monsoon is active, Post monsoon (October-January) when the north-east monsoon become active and Pre monsoon (February-May). The data on the monthly and seasonal variations in rainfall in Sasthamkotta were given in Fig. 3.1.1. During the monsoon season the highest rainfall was recorded in June (321mm) and July (242.7mm). Rainfall was lowest in December (4mm).

Seasonal mean of the rainfall data were given in Table 3.1.1 indicate that the highest rainfall was during monsoon (213.23 mm), followed by pre- and post monsoons registering 144.25 mm and 83.5 mm, respectively. Seasonal variation was found to be significant (Table 3.1.1a).

2. Atmospheric temperature

The results of the monthly variations in atmospheric temperature at the five stations were given in Fig.3.1.2. Temperature ranged from 27.0°C (during June) to 33.5°C (during March) with a difference of 6.5°C.

The mean seasonal atmospheric temperature registered the maximum during pre monsoon period (32°C) followed by postmonsoon (30°C) and monsoon (29°C) at all stations (Table 3.1.2). A slight difference in the atmospheric temperature was noted in the various stations. The results of ANOVA showed that the observed difference in atmospheric temperature between seasons was significant ($P < 0.001$) (Tables 3.1.2a). Atmospheric temperature was negatively correlated with rainfall.

3. Water Temperature

Surface water temperature measured in the Sasthamkotta lake during the period of study was given in Fig. 3.1.3. The highest water temperature was observed in March (34.0°C) at Station IV, while the lowest temperature was in July (26.0°C) at Station II with a difference of 8°C.

Seasonal trend in water temperature was given in Table 3.1.3. The mean seasonal water temperature registered the maximum during pre monsoon period (31.5°C) followed by postmonsoon period ((30°C) and minimum during monsoon period (28°C). The observed difference in water temperature between seasons was statistically significant ($P < 0.001$) (Table 3.1.3a).

4. Hydrogen ion concentration (pH)

The results of the monthly variations in water pH at the five stations were presented in Fig.3.1.4. The values of pH ranged between 6.08 at station III in December to 7.9 at station I in April and Station II in February.

Seasonal trend in pH was given in Table 3.1.4. At all stations except station IV, water pH was higher during pre monsoon than during monsoon and post monsoon seasons. Except in pre monsoon, when pH registered slightly high value (7.36) at station I, on the whole, seasonal variation in water pH in any of the stations was not great. The results indicate that the water of Sasthamkotta lake was almost acidic or neutral during the period of study. The difference in water pH between stations was statistically not significant but seasonal variation was found to be significant (Table 3.1.4a).

5. Conductivity

Figure 3.1.5 gives the conductivity values of water in different stations of lake Sasthamkotta during the period of study. Conductivity fluctuated between a minimum of 33.9mmho/cm at Station V in November to a maximum of 65.2mmho/cm in October at Station I. Seasonal variation in conductivity values was given in Table 3.1.5. The value was high during pre monsoon period (62.025mmho/cm at Station I) and low during monsoon except Station IV and V where the lowest value recorded was during post monsoon (42.05mmho/cm) at Station IV). Significant variation in conductivity values was observed between stations and seasons (Table 3.1.5a).

6. Transparency

Monthly variations in light penetration at the five stations were given in Fig. 3.1.6. The values ranged from 120 cm in July at Station V to 150 cm in February (at station I and II).

The mean seasonal transparency values registered the maximum during pre monsoon period (143.25 cm) followed by postmonsoon (137.5 cm) and monsoon (131.25 cm) at all stations (Table 3.1.6). Significant variation in transparency values was observed between stations and seasons (Table 3.1.6a).

7. Turbidity

The observed variations in turbidity values were illustrated in Fig. 3.1.7. The turbidity values ranged between 1.5 NTU in April to 9.8 NTU in July at Station II.

The seasonal mean values (Table 3.1.7) of turbidity showed that minimum was observed during pre monsoon and maximum during monsoon. The lowest turbidity values obtained during pre monsoon was 1.825 NTU at Station II and during monsoon the maximum value was 5.75 NTU at the same station. Post monsoon registered the highest turbidity value 4.975 NTU at Station I and V. The difference in water turbidity between stations was statistically not significant but seasonal variation was found to be significant (Table 3.1.7a).

8. Hardness

The results of the monthly variations in water hardness at the five stations were given in Fig. 3.1.8. Hardness varied between 4.1 mg l⁻¹ at station III and 14 mg l⁻¹ at station III and IV. The lowest value was recorded in December and the highest value in February at station III and in October at station IV.

Seasonal mean for hardness was the highest during monsoon and the lowest during post monsoon except at station IV during the study period (Table 3.1.8). The results of ANOVA showed that the observed difference in hardness between the seasons was statistically significant ($P < 0.01$) (Table 3.1.8a).

9. Total Suspended Solids (TSS)

The observed variations of total suspended solid values were illustrated in Fig. 3.1.9. The minimum TSS was recorded from Station III (5.6 mg l^{-1}) in May and the maximum from Station IV (26.6 mg l^{-1}) in March.

Seasonally the highest TSS value was recorded during pre monsoon followed by monsoon. Post monsoon season recorded the minimum TSS at all the stations. The highest value during pre monsoon was at Station IV (20.325 mg l^{-1}). The highest value noted at post monsoon was at Station III (15.025 mg l^{-1}) (Table 3.1.9). Annual mean indicated high value at Station IV (17.97 mg l^{-1}) and low value at Station V (15.17 mg l^{-1}). The variation was significant among seasons ($P < 0.05$) (Table 3.1.9a).

10. Alkalinity

Monthly fluctuations in alkalinity of water in the five stations at Sasthamkotta lake were presented in Fig. 3.1.10. The mean alkalinity ranged from 8.4 mg l^{-1} at station V at February to 16.8 mg l^{-1} at September at station IV. At all stations alkalinity registered a decreasing trend from monsoon to pre monsoon. Seasonal mean values showed that alkalinity was highest at station IV during monsoon (15.1 mg l^{-1}) followed by pre monsoon (13.025 mg l^{-1}) in the same station and post monsoon (11.9 mg l^{-1}) at station IV (Table 3.1.10). The observed difference in alkalinity between stations was statistically significant ($P < 0.05$) and seasonally also significant ($P < 0.001$) (Table 3.1.10a).

11. Salinity

Monthly fluctuations in salinity of water in the different stations at Sasthamkotta lake were presented in Fig. 3.1.11. The salinity ranged from 2.51 ‰ at station V at July to 12.3 ‰ in the same month at station IV. At all months salinity registered maximum values at station IV irrespective of seasons. Seasonal mean values showed that salinity was highest at station IV during monsoon (9.775 ‰) followed by post monsoon (9.675 ‰) and pre monsoon (9.55 ‰) in the same station (Table 3.1.11). The observed difference in salinity between stations was statistically significant ($P < 0.001$) (Table 3.1.11a).

12. Carbon dioxide

The results of the monthly variations in the carbon dioxide content of water at the different stations were given in Fig. 3.1.12. The lowest CO₂ value (1.8 mg l⁻¹) was noted at station II and IV during November and the highest value (7.7 mg l⁻¹) was in the same stations during May.

Carbon dioxide content registered an apparent increasing trend from pre monsoon to monsoon at all stations. At stations III, IV and V the CO₂ value was the highest during pre monsoon than post monsoon. Annual mean indicated a high value at Station V and low value at Station III (Table 3.1.12). The observed difference in CO₂ content between seasons was statistically significant ($P < 0.01$) (Table 3.1.12a).

13. Dissolved Oxygen

Variations in the concentration of dissolved oxygen at the five stations were presented in Fig. 3.1.13. Dissolved oxygen content ranged from 4.45 mg l⁻¹ in May at Station III to 8.918 mg l⁻¹ in June at Station III.

Seasonal mean showed that dissolved oxygen was high (> 5.0 mg l⁻¹) at all stations and highest during postmonsoon except Stations III and V. At these stations dissolved oxygen was high during monsoon. Dissolved oxygen registered minimum values during pre monsoon at all Stations during the study period (Table 3.1.13). There was significant seasonal variation (Table 3.1.13a).

14. Biological Oxygen Demand (BOD)

The observed variations of biological oxygen demand values were illustrated in Fig. 3.1.14. The minimum BOD was recorded from Station V (3.7 mg l⁻¹) in December and the maximum from Station II (8.5 mg l⁻¹) in May.

Seasonally the highest BOD was recorded during pre monsoon followed by postmonsoon. Monsoon season recorded the minimum BOD at all the stations. Annual mean indicated high value at Station II (4.79 mg l⁻¹) and low value at Station V (4.48 mg l⁻¹) (Table 3.1.14). The variation was significant among seasons ($P < 0.01$) (Table 3.1.14a).

15. Chemical Oxygen Demand (COD)

The results of the monthly variations in chemical oxygen demand at the five stations were presented in Fig. 3.1.15. The values of COD ranged from 5.1 mg l⁻¹ at station V in October to 10.1 mg l⁻¹ at all stations except IV.

Seasonal trend in COD is given in Table 3.1.15. At all stations station COD was higher during pre monsoon followed by monsoon and postmonsoon seasons. The seasonal variation in COD was found to be significant ($P < 0.001$) (Table 3.1.15a).

16. Total Organic Carbon (TOC)

The observed variations in total organic carbon values were illustrated in Fig. 3.1.16. The TOC values ranged between 2.3 mg l⁻¹ in November (Station V) to 5.8 mg l⁻¹ in May at Station II.

The seasonal mean values (Table 3.1.16) of TOC showed that maximum was observed during pre monsoon and minimum during post monsoon. The highest TOC values obtained during pre monsoon was 3.8 mg l⁻¹ at Station II and during monsoon the maximum value was 3.1 mg l⁻¹ at station V. Post monsoon registered the lowest TOC value 2.75 mg l⁻¹ at Station I and V. Seasonal variation in TOC was found to be significant (Table 3.1.16a).

17. Nitrite

The results of the monthly variations in nitrite content of water at the five stations were presented in Fig. 3.1.17. The nitrite content of water varied between nil value at station III at August and 0.09191 mg l⁻¹ at station IV in July. Nitrite content was the highest during monsoon season at stations III and IV (Table 3.1.17). The difference in nitrite values between stations and seasons was statistically not significant (Table 3.1.17a).

18. Nitrate

Monthly fluctuations in nitrate content of water at the different stations were presented in Fig. 3.1.18. The average nitrate content of the water of Sasthamkotta ranged from 0.00389 mg l⁻¹ at November (Station III) to 1.6759 mg l⁻¹ at the same station during April.

Nitrate content was lowest during post monsoon except at stations I and III where the lowest nitrate content was during monsoon. At all stations it was the highest during pre monsoon (Table 3.1.18). Nitrate content showed an apparently decreasing trend from pre monsoon to monsoon. The observed difference in nitrate content was statistically significant seasonally (Table 3.1.18a).

19. Phosphate

The results of the monthly fluctuations in phosphate content of water at the five stations were presented in Fig. 3.1.19.

Phosphate concentration ranged between $0.00022 \text{ mg l}^{-1}$ at station I (March) and III (May) and 0.2196 mg l^{-1} at station I (September). Annual mean indicated high value at Station I (0.0194 mg l^{-1}) and low value at Station II (0.0016 mg l^{-1}) (Table 3.1.19). The variation was not significant among stations and seasons (Table 3.1.19a).

20. Silicate

Monthly variations in silicate content of water are presented in Fig. 3.1.20. The silicate concentration registered considerable monthly variations (29.276 mg l^{-1} in November 2004 at station II to $151.802 \text{ mg l}^{-1}$ in October 2005 at station V), the mean annual silicate concentrations at the five stations showed not much variation. The highest concentration was noted at station I (127.58 mg l^{-1}) and the lowest at station IV (120.29 mg l^{-1}). Silicate content was the highest during pre monsoon and the lowest during postmonsoon (Table 3.1.20). The observed difference in silicate content of water was seasonally significant ($P < 0.01$) (Table 3.1.20a).

21. Potassium

The results of the monthly variations in potassium content of water at the five stations were given in Fig. 3.1.21. Potassium concentration varied between 0.7 mg l^{-1} in June to 3.2 mg l^{-1} in May and both at the same stations.

Potassium content was comparatively high during monsoon at all stations except stations I where its concentration was high during pre monsoon. Pre

monsoon registered higher potassium values than postmonsoon at all stations (Table 3.1.21). The results of ANOVA showed that the observed difference in potassium content between stations and seasons was statistically significant ($P < 0.001$) (Table 3.1.21a).

CORRELATION

Results of correlation analysis between various physicochemical parameters were presented in Tables 3.1.22 to 3.1.26. Several significant positive and negative relationships between climatic, physical, and chemical characteristics of the different stations of the lake can be delineated from the present investigation. A negative relation between air temperature and rainfall was observed at all the stations, which is statistically significant at Station I and V.

A negative relation between water temperature and rainfall was observed at all the stations, which is statistically significant at Station I, II and V. But water temperature is positively correlated with air temperature at all the stations.

The results revealed that transparency and rainfall was negatively related at all the five stations under study but is statistically significant at Station II and V. Conductivity showed a positive relationship with rainfall at all the stations except IV. Conductivity was positively related with air temperature, water temperature, transparency and pH but exhibited positive correlation with air temperature and transparency at stations II and IV.

Turbidity was positively related with rainfall at all the five stations selected for study but that was statistically significant at Station IV. Turbidity was highly negatively correlated with conductivity at station I; with air temperature, water temperature and conductivity at station II and for air temperature and transparency at station IV.

Salinity results were positively related with rainfall, transparency and conductivity at station I; with all factors except turbidity at station II; with air temperature, water temperature, transparency and conductivity at station III; with rainfall and pH at station IV and positive with all factors except rainfall and turbidity at station V. Salinity is highly positively correlated with conductivity at

station II, with water temperature at station III and air and water temperature at station V. Salinity showed high negative correlation with turbidity at Station III and with rainfall and turbidity at station V.

Alkalinity values were having positive relation with rainfall at all stations and showed positive correlation at stations I, IV, and V but negatively correlated with air temperature and water temperature at station I and V.

At station I, hardness showed negative correlation with transparency and with water temperature at Station V. Hardness showed positive correlation with alkalinity at station I and with pH at Station III. Total organic carbon is positively correlated with conductivity at Station I and IV; with salinity at station II; with hardness at station III and with pH at station V. Chemical oxygen demand values of Sasthamkotta lake water showed positive correlation with conductivity at all the station except station III. TOC showed positive correlation with COD at Station I only. At the same time biological oxygen demand showed positive correlation with salinity, total organic carbon and negative correlation with total suspended solids at station II. At station III BOD is positively correlated with water temperature and transparency at station III. At station IV BOD showed positive correlation with air temperature.

Dissolved oxygen showed a negative correlation with air temperature and water temperature at station V. At station I and II DO was negatively correlated with TOC and COD but at station II in addition to this DO is negatively correlated with air temperature and salinity. At station III, DO was negatively correlated with salinity and at station IV with COD.

Regarding the nutrients at station I, silicate and potassium showed a positive correlation with conductivity. At station II, III, IV and V potassium showed a positive correlation with rainfall. Potassium showed positive correlation with turbidity at station IV. Potassium showed a positive correlation with carbon dioxide at station III.

Silicate was positively correlated with hardness and carbon dioxide at station II and V. Silicate showed a positive correlation with conductivity and TOC

at station III. At station V positive correlation was noted between silicate and conductivity and at station IV with TOC.

Phosphate showed a positive correlation with NPP at station II and III. GPP was positively correlated with phosphate at station III. Phosphate was positively correlated with turbidity at station II. Nitrate was positively correlated with NPP at station IV and with TSS at station V. Nitrite was positively correlated with salinity at station IV and with pH and phosphate at station V.

Fig. 3.1.1. Monthly variations of Rainfall at Sasthamkotta lake during the study period

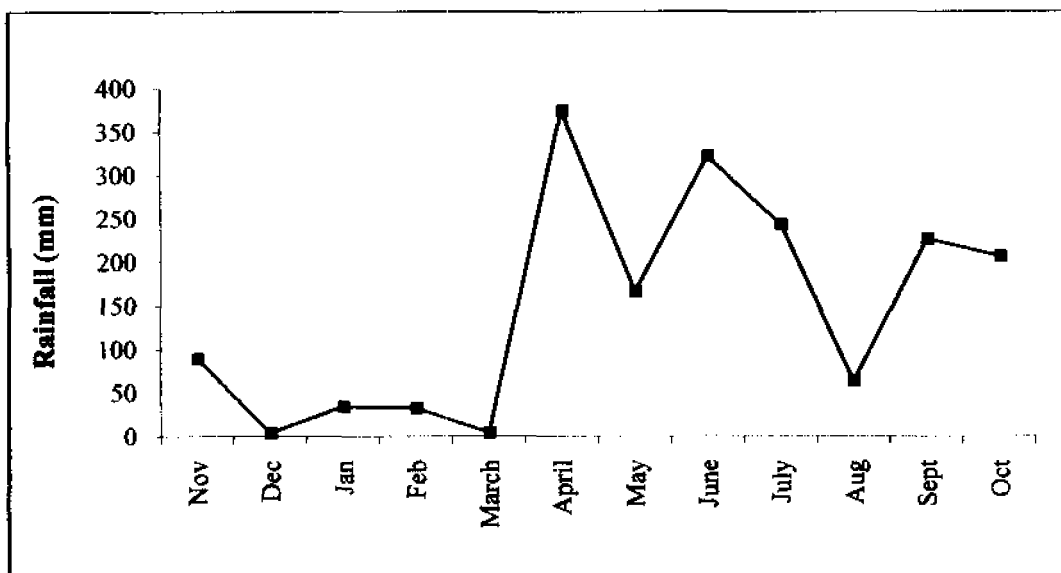


Table 3.1.1. Mean Rainfall (cm) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	144.25	144.25	144.25	144.25	144.25
+ SD	118.69	118.69	118.69	118.69	118.69
Monsoon	213.23	213.23	213.23	213.23	213.23
+ SD	108.35	108.35	108.35	108.35	108.35
Postmonsoon	83.50	83.50	83.50	83.50	83.50
+ SD	69.28	69.28	69.28	69.28	69.28
Annual mean	146.99	146.99	146.99	146.99	146.99
+ SD	107.28	107.28	107.28	107.28	107.28

Table 3.1.1a. Analysis of Variance (Two-way ANOVA) comparing rainfall at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	168511.26	14	12036.52	0.75
Intercept	1296393.00	1	1296393.00	80.741***
STATION	0	4	0	
SEASON	168511.26	2	84255.63	5.248**
STATION * SEASON	0	8	0	
Error	722527.89	45	16056.18	
Total	2187432.15	60		
Corrected Total	891039.15	59		

P < 0.01; *P < 0.001

Fig. 3.1.2. Monthly variations of Air temperature at Sasthamkotta lake during the study period

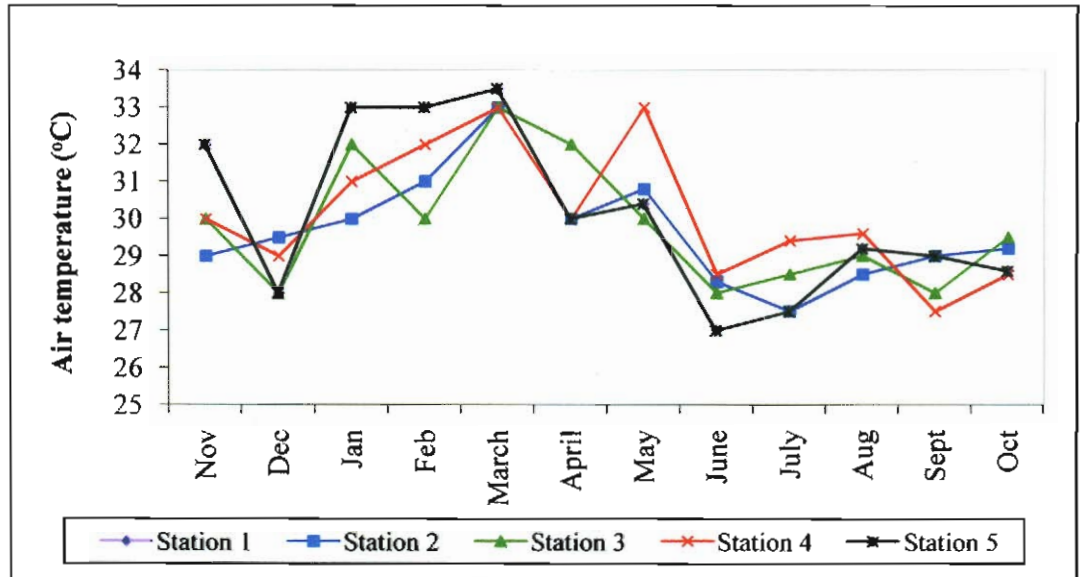


Table 3.1.2. Mean Air temperature (°C) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	31.73	31.20	31.25	32.00	31.73
+ SD	1.78	1.28	1.50	1.41	1.78
Monsoon	28.18	28.33	28.38	28.75	28.18
+ SD	1.09	0.62	0.48	0.96	1.09
Postmonsoon	30.40	29.43	29.88	29.63	30.40
+ SD	2.47	0.43	1.65	1.11	2.47
Annual mean	30.10	29.65	29.83	30.13	30.10
+ SD	2.28	1.46	1.71	1.79	2.28

Table 3.1.2a. Analysis of Variance (Two-way ANOVA) comparing air temperature at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	109.63	14	7.83	3.615**
Intercept	53862.09	1	53862.09	24862.613***
STATION	2.14	4	0.54	0.247
SEASON	103.69	2	51.85	23.932***
STATION * SEASON	3.80	8	0.48	0.219
Error	97.49	45	2.17	
Total	54069.21	60		
Corrected Total	207.12	59		

P < 0.01; *P < 0.001

Fig. 3.1.3. Monthly variations of Water temperature at different stations during the study period

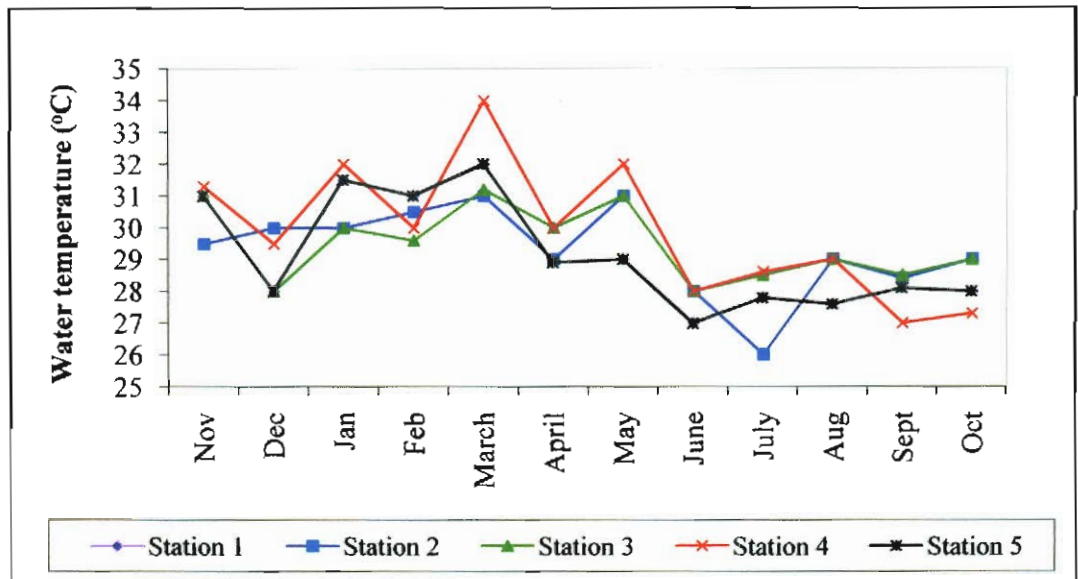


Table 3.1.3. Mean Water temperature (°C) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	30.23	30.38	30.45	31.50	30.23
+ SD	1.53	0.95	0.77	1.91	1.53
Monsoon	27.63	27.85	28.50	28.15	27.63
+ SD	0.46	1.30	0.41	0.87	0.46
Postmonsoon	29.63	29.63	29.50	30.03	29.63
+ SD	1.89	0.48	1.29	2.10	1.89
Annual mean	29.16	29.28	29.48	29.89	29.16
+ SD	1.74	1.41	1.16	2.11	1.74

Table 3.1.3a. Analysis of Variance (Two-way ANOVA) comparing water temperature at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	77.81	14	5.56	3.169**
Intercept	51843.96	1	51843.96	29562.242** *
STATION	4.55	4	1.14	0.648
SEASON	70.30	2	35.15	20.042***
STATION * SEASON	2.97	8	0.37	0.211
Error	78.92	45	1.75	
Total	52000.69	60		
Corrected Total	156.73	59		

P < 0.01; *P < 0.001

Fig. 3.1.4. Monthly variations of pH at different stations during the study period

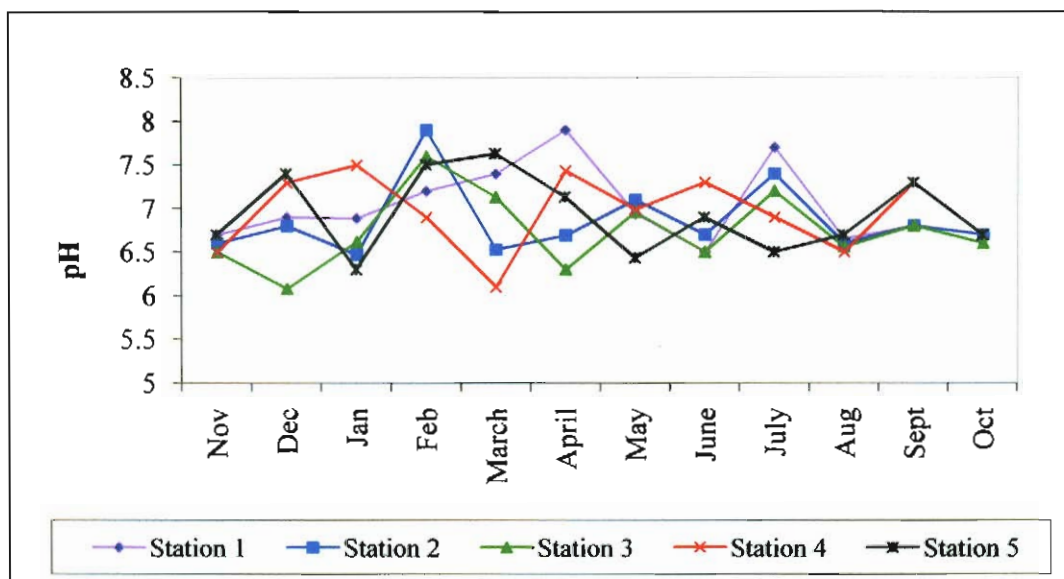


Table 3.1.4. Mean pH at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	7.36	7.06	7.00	6.86	7.17
+ SD	0.41	0.61	0.54	0.55	0.54
Monsoon	6.91	6.88	6.77	7.00	6.85
+ SD	0.54	0.36	0.32	0.38	0.34
Postmonsoon	6.80	6.64	6.45	7.00	6.78
+ SD	0.11	0.14	0.25	0.48	0.46
Annual mean	7.02	6.86	6.74	6.95	6.93
+ SD	0.44	0.42	0.42	0.44	0.45

Table 3.1.4a. Analysis of Variance (Two-way ANOVA) comparing pH of different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	2.63	14	0.19	1.028
Intercept	2857.01	1	2857.01	15626.757***
STATION	0.57	4	0.14	0.774
SEASON	1.27	2	0.64	3.479*
STATION * SEASON	0.79	8	0.10	0.542
Error	8.23	45	0.18	
Total	2867.87	60		
Corrected Total	10.86	59		

*P < 0.05; ***P < .001

Fig. 3.1.5. Monthly variations of Conductivity at different stations during the study period

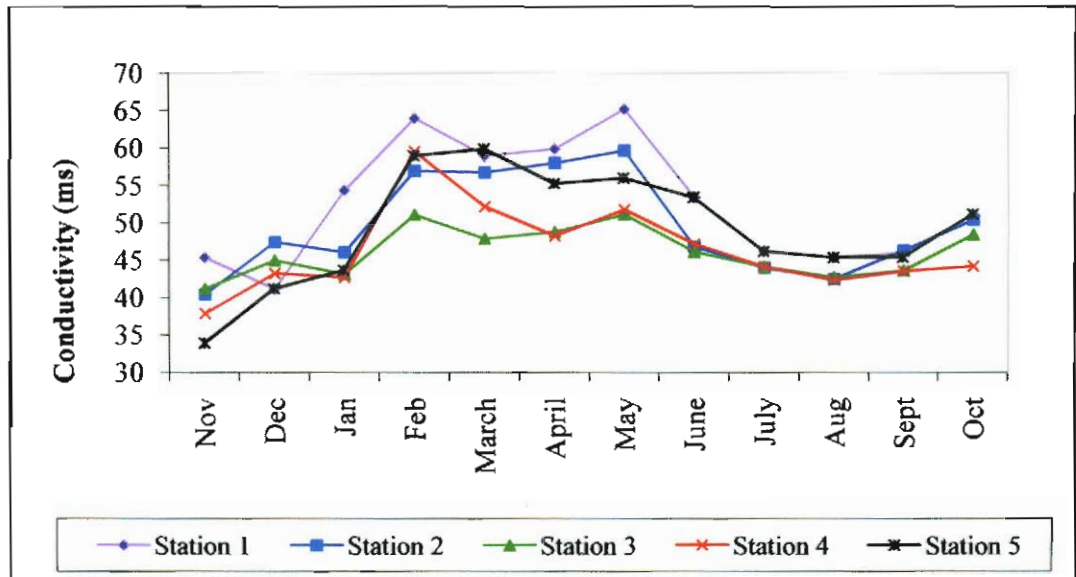


Table 3.1.5. Mean Conductivity (ms) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	62.03	57.88	49.73	52.98	57.55
+ SD	3.04	1.33	1.63	4.75	2.24
Monsoon	47.75	44.90	44.13	44.28	47.60
+ SD	3.78	2.01	1.44	2.09	3.89
Postmonsoon	48.00	46.13	44.45	42.05	42.50
+ SD	5.86	4.16	3.06	2.83	7.14
Annual mean	52.59	49.63	46.10	46.43	49.22
+ SD	8.02	6.60	3.32	5.81	7.87

Table 3.1.5a. Analysis of Variance (Two-way ANOVA) comparing conductivity of different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	2096.64	14	149.76	11.178***
Intercept	142857.12	1	142857.12	10663.234***
STATION	337.63	4	84.41	6.300***
SEASON	1582.57	2	791.28	59.063***
STATION * SEASON	176.44	8	22.06	1.646
Error	602.87	45	13.40	
Total	145556.63	60		
Corrected Total	2699.51	59		

***P < 0.001

Fig. 3.1.6. Monthly variations of Transparency at different stations during the study period

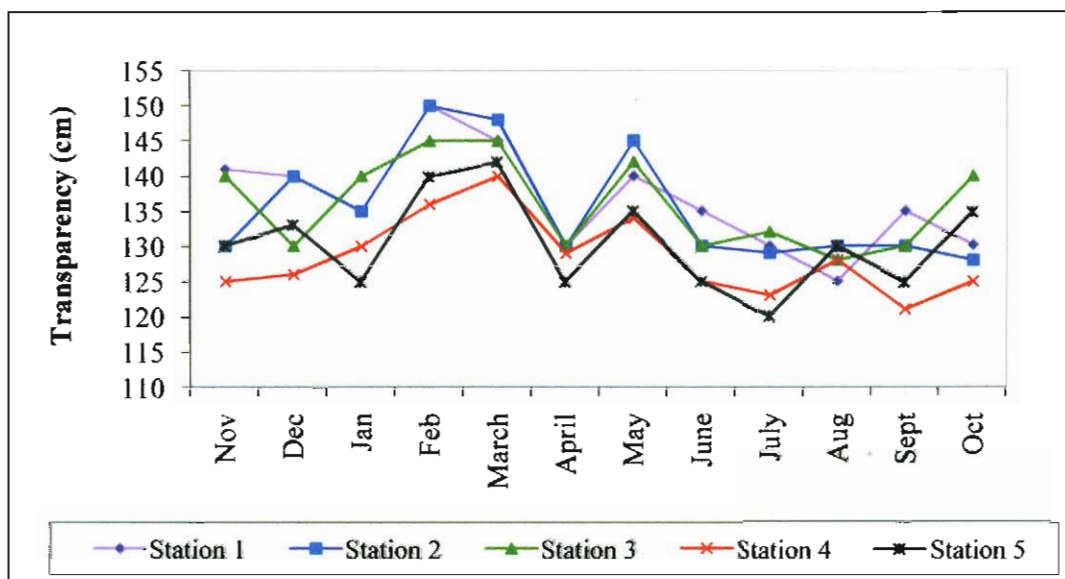


Table 3.1.6. Mean Transparency (cm) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	141.25	143.25	140.50	134.75	135.50
+ SD	8.54	9.07	7.14	4.57	7.59
Monsoon	131.25	129.75	130.00	124.25	125.00
+ SD	4.79	0.50	1.63	2.99	4.08
Postmonsoon	136.55	133.25	137.50	126.50	130.75
+ SD	4.98	5.38	5.00	2.38	4.35
Annual mean	136.35	135.42	136.00	128.50	130.42
+ SD	7.15	8.13	6.54	5.65	6.75

Table 3.1.6a. Analysis of Variance (Two-way ANOVA) comparing transparency of different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	1921.61	14	137.26	4.685***
Intercept	1066720.00	1	1066720.00	36408.759***
STATION	629.04	4	157.26	5.367**
SEASON	1215.46	2	607.73	20.743***
STATION * SEASON	77.11	8	9.64	0.329
Error	1318.43	45	29.30	
Total	1069960.04	60		
Corrected Total	3240.04	59		

P < 0.01; *P < 0.001

Fig. 3.1.7. Monthly variations of Turbidity at different stations during the study period

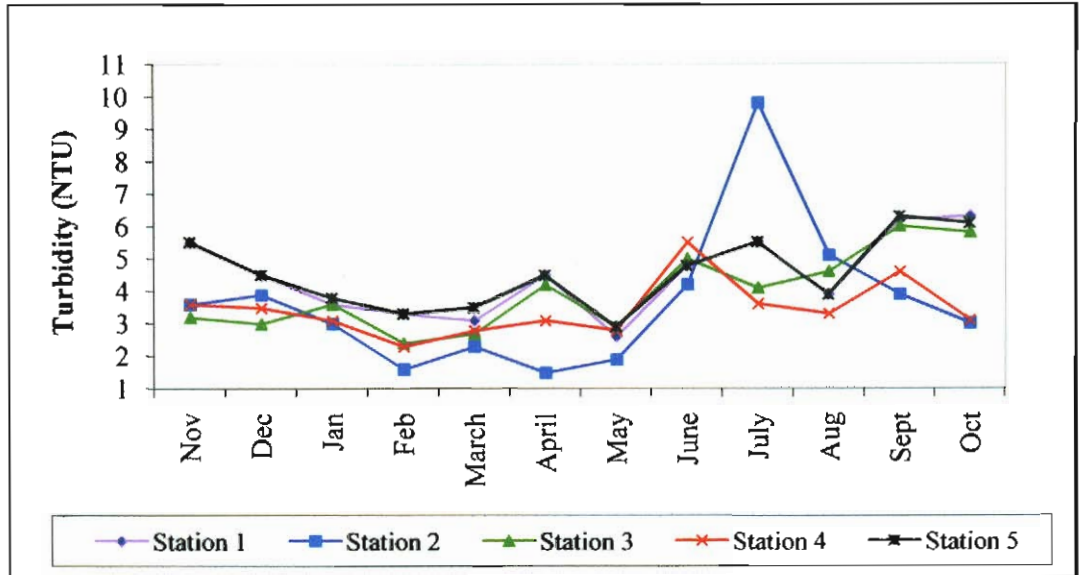


Table 3.1.7. Mean Turbidity (NTU) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	3.38	1.83	3.05	2.75	3.55
+ SD	0.81	0.36	0.79	0.33	0.68
Monsoon	5.10	5.75	4.93	4.25	5.13
+ SD	0.98	2.75	0.81	1.00	1.02
Postmonsoon	4.98	3.38	3.90	3.33	4.98
+ SD	1.18	0.45	1.29	0.26	1.02
Annual mean	4.48	3.65	3.96	3.44	4.55
+ SD	1.22	2.23	1.20	0.86	1.12

Table 3.1.7a. Analysis of Variance (Two-way ANOVA) comparing turbidity at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	67.99	14	4.86	4.148***
Intercept	968.02	1	968.02	826.737***
STATION	11.65	4	2.91	2.487
SEASON	45.21	2	22.60	19.304***
STATION * SEASON	11.14	8	1.39	1.189
Error	52.69	45	1.17	
Total	1088.70	60		
Corrected Total	120.68	59		

***P < 0.001

Fig. 3.1.8. Monthly variations of Hardness at different stations during the study period

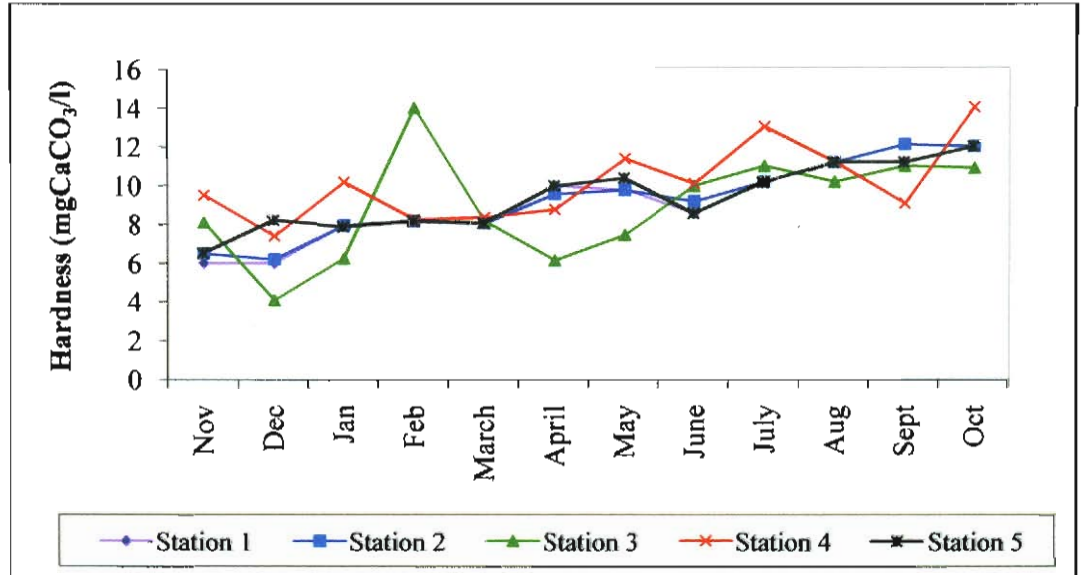


Table 3.1.8. Mean Hardness (mgCaCO₃/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	9.03	8.93	8.98	9.23	9.18
+ SD	1.01	0.90	3.45	1.47	1.20
Monsoon	10.30	10.68	10.55	10.85	10.30
+ SD	1.23	1.25	0.53	1.67	1.23
Postmonsoon	8.00	8.18	7.35	10.28	8.65
+ SD	2.83	2.67	2.88	2.75	2.35
Annual mean	9.11	9.26	8.96	10.12	9.38
+ SD	1.96	1.95	2.73	1.98	1.68

Table 3.1.8a. Analysis of Variance (Two-way ANOVA) comparing Hardness at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	65.08	14	4.65	1.134
Intercept	5260.32	1	5260.32	1283.144***
STATION	9.69	4	2.42	0.591
SEASON	44.49	2	22.25	5.426**
STATION * SEASON	10.90	8	1.36	0.332
Error	184.48	45	4.10	
Total	5509.88	60		
Corrected Total	249.56	59		

P < 0.01; *P < 0.001

Fig. 3.1.9. Monthly variations of TSS at different stations during the study period

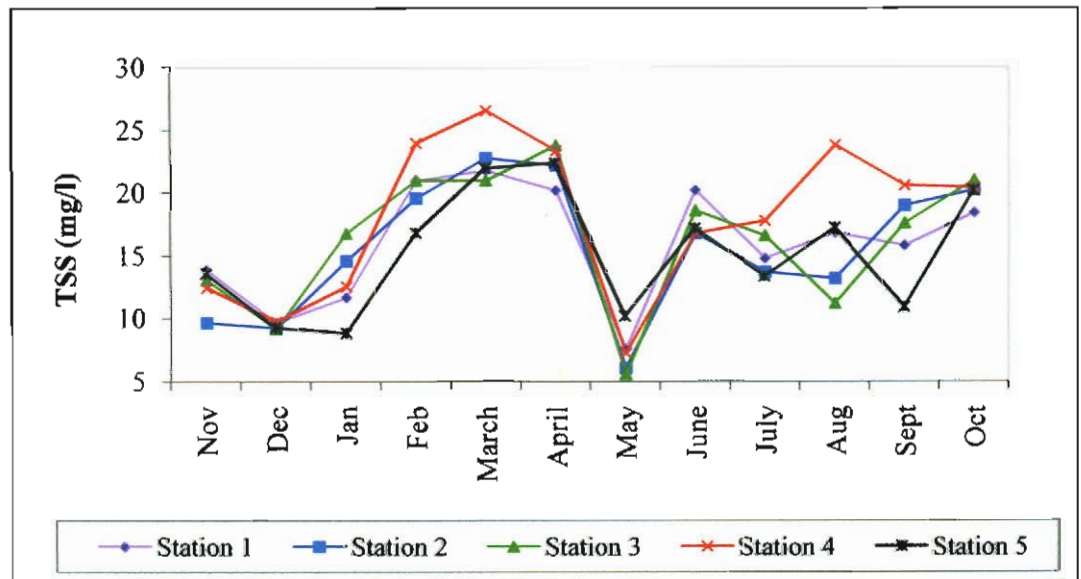


Table 3.1.9. Mean TSS (mg/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	17.65	17.68	17.85	20.33	17.85
+ SD	6.73	7.84	8.27	8.79	5.70
Monsoon	16.90	15.68	16.00	19.75	14.68
+ SD	2.35	2.73	3.30	3.14	3.09
Postmonsoon	13.43	13.45	15.03	13.83	12.98
+ SD	3.73	5.10	5.05	4.57	5.28
Annual mean	15.99	15.60	16.29	17.97	15.17
+ SD	4.62	5.40	5.49	6.24	4.85

Table 3.1.9a. Analysis of Variance (Two-way ANOVA) comparing TSS at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	300.63	14	21.47	0.728
Intercept	15752.88	1	15752.88	533.887***
STATION	55.21	4	13.80	0.468
SEASON	209.93	2	104.97	3.557*
STATION * SEASON	35.49	8	4.44	0.15
Error	1327.77	45	29.51	
Total	17381.28	60		
Corrected Total	1628.40	59		

*P < 0.05; ***P < .001

Fig. 3.1.10. Monthly variations of Alkalinity at different stations during the study period

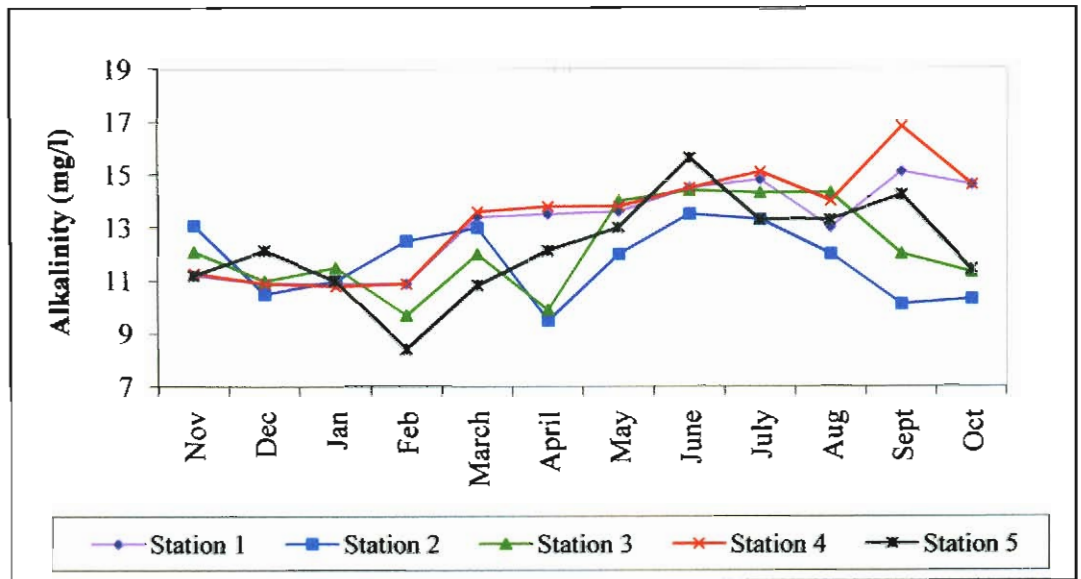


Table 3.1.10. Mean Alkalinity (mg/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	12.85	11.75	11.40	13.03	11.08
+ SD	1.30	1.55	2.02	1.42	2.00
Monsoon	14.35	12.23	13.75	15.10	14.10
+ SD	0.93	1.57	1.17	1.22	1.09
Postmonsoon	11.90	11.23	11.48	11.90	11.43
+ SD	1.81	1.28	0.46	1.81	0.48
Annual mean	13.03	11.73	12.21	13.34	12.20
+ SD	1.64	1.40	1.69	1.94	1.86

Table 3.1.10a. Analysis of Variance (Two-way ANOVA) comparing alkalinity at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	92.53	14	6.61	3.283**
Intercept	9380.00	1	9380.00	4658.684***
STATION	21.07	4	5.27	2.616*
SEASON	60.83	2	30.42	15.107***
STATION * SEASON	10.63	8	1.33	0.66
Error	90.61	45	2.01	
Total	9563.14	60		
Corrected Total	183.14	59		

*P < 0.05; **P < 0.01; ***P < 0.001

Fig. 3.1.11. Monthly variations of Salinity at different stations during the study period

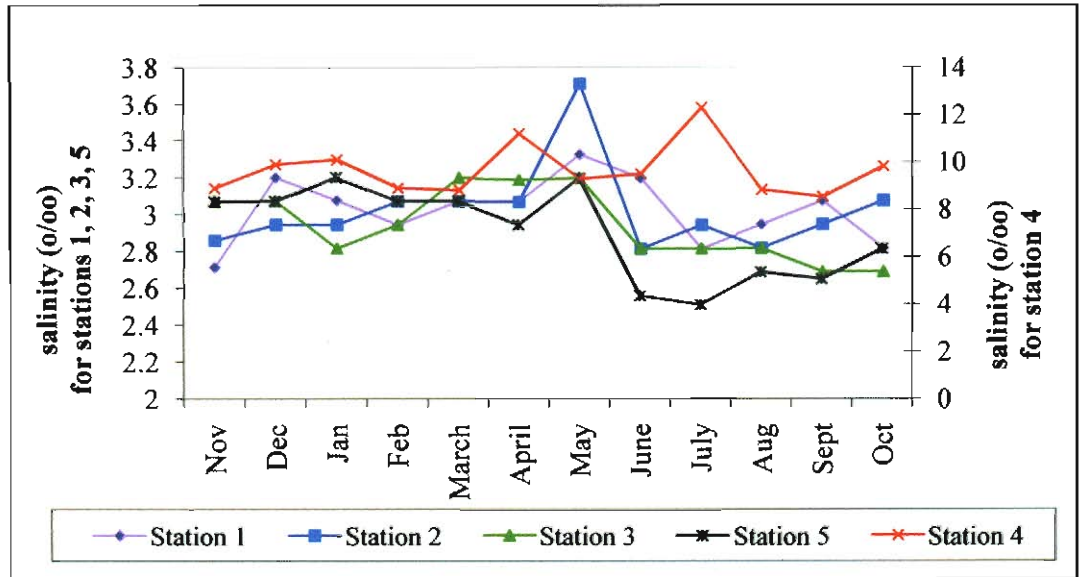


Table 3.1.11. Mean Salinity (o/oo) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	3.10	3.23	3.13	9.55	3.07
+ SD	0.16	0.32	0.13	1.12	0.10
Monsoon	3.01	2.88	2.78	9.78	2.60
+ SD	0.16	0.07	0.06	1.73	0.08
Postmonsoon	2.95	2.96	2.91	9.68	3.04
+ SD	0.23	0.09	0.19	0.53	0.16
Annual mean	3.02	3.02	2.94	9.67	2.90
+ SD	0.18	0.24	0.20	1.12	0.25

Table 3.1.11a. Analysis of Variance (Two-way ANOVA) comparing salinity at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	431.54	14	30.82	94.974***
Intercept	1115.28	1	1115.28	3436.398***
STATION	430.31	4	107.58	331.467***
SEASON	0.44	2	0.22	0.67
STATION * SEASON	0.79	8	0.10	0.30
Error	14.61	45	0.33	
Total	1561.42	60		
Corrected Total	446.14	59		

***P < 0.001

Fig. 3.1.12. Monthly variations of Carbon dioxide at different stations during the study period

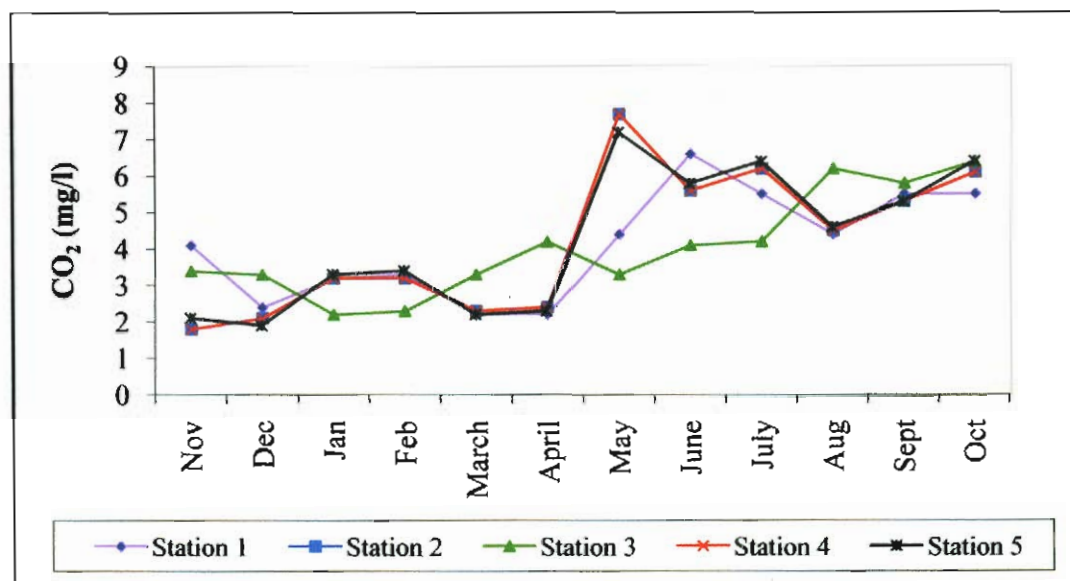


Table 3.1.12. Mean Carbon dioxide (mg/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	3.03	3.90	3.28	3.90	3.78
+ SD	1.05	2.57	0.78	2.57	2.35
Monsoon	5.50	5.40	5.08	5.40	5.53
+ SD	0.90	0.71	1.08	0.71	0.76
Postmonsoon	3.80	3.30	3.83	3.30	3.43
+ SD	1.33	1.96	1.80	1.96	2.08
Annual mean	4.11	4.20	4.06	4.20	4.24
+ SD	1.47	1.96	1.41	1.96	1.94

Table 3.1.12a. Analysis of Variance (Two-way ANOVA) comparing carbon dioxide at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	48.75	14	3.48	1.275
Intercept	1039.17	1	1039.17	380.578***
STATION	0.27	4	0.07	0.025
SEASON	44.55	2	22.28	8.158**
STATION * SEASON	3.93	8	0.49	0.18
Error	122.87	45	2.73	
Total	1210.79	60		
Corrected Total	171.62	59		

P < 0.01; *P < 0.001

Fig. 3.1.13. Monthly variations of DO at different stations during the study period

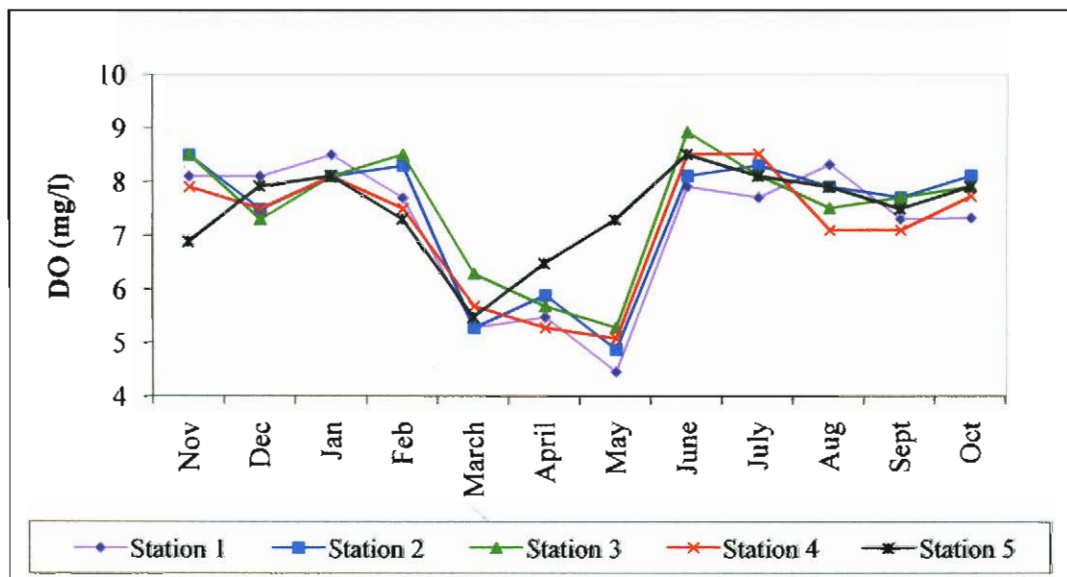


Table 3.1.13. Mean Dissolved oxygen (mg/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	5.72	6.08	6.43	5.88	6.64
+ SD	1.39	1.54	1.45	1.11	0.87
Monsoon	7.80	8.00	8.06	7.80	8.00
+ SD	0.42	0.26	0.63	0.82	0.42
Postmonsoon	8.00	8.05	7.95	7.81	7.70
+ SD	0.50	0.42	0.50	0.26	0.55
Annual mean	7.18	7.38	7.48	7.16	7.45
+ SD	1.34	1.28	1.16	1.20	0.84

Table 3.1.13a. Analysis of Variance (Two-way ANOVA) comparing DO at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	44.53	14	3.18	4.372***
Intercept	3221.62	1	3221.62	4428.569***
STATION	1.08	4	0.27	0.37
SEASON	41.64	2	20.82	28.619***
STATION * SEASON	1.81	8	0.23	0.311
Error	32.74	45	0.73	
Total	3298.88	60		
Corrected Total	77.26	59		

***P < 0.001

Fig. 3.1.14. Monthly variations of BOD at different stations during the study period

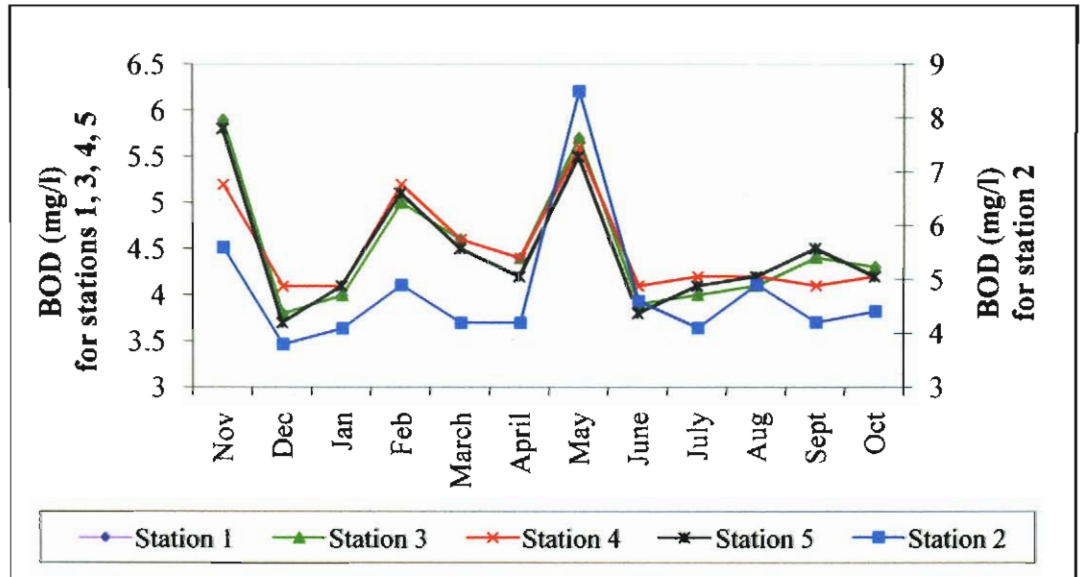


Table 3.1.14. Mean BOD (mg/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	4.93	5.45	4.93	4.95	4.83
+ SD	0.57	2.06	0.57	0.55	0.59
Monsoon	4.10	4.45	4.10	4.15	4.15
+ SD	0.22	0.37	0.22	0.06	0.29
Postmonsoon	4.50	4.48	4.50	4.40	4.45
+ SD	0.96	0.79	0.96	0.54	0.93
Annual mean	4.51	4.79	4.51	4.50	4.48
+ SD	0.69	1.27	0.69	0.53	0.66

Table 3.1.14a. Analysis of Variance (Two-way ANOVA) comparing BOD at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	8.42	14	0.60	0.954
Intercept	1245.79	1	1245.79	1976.055***
STATION	0.84	4	0.21	0.332
SEASON	7.06	2	3.53	5.598**
STATION * SEASON	0.52	8	0.07	0.103
Error	28.37	45	0.63	
Total	1282.58	60		
Corrected Total	36.79	59		

P < 0.01; *P < 0.001

Fig. 3.1.15. Monthly variations of COD at different stations during the study period

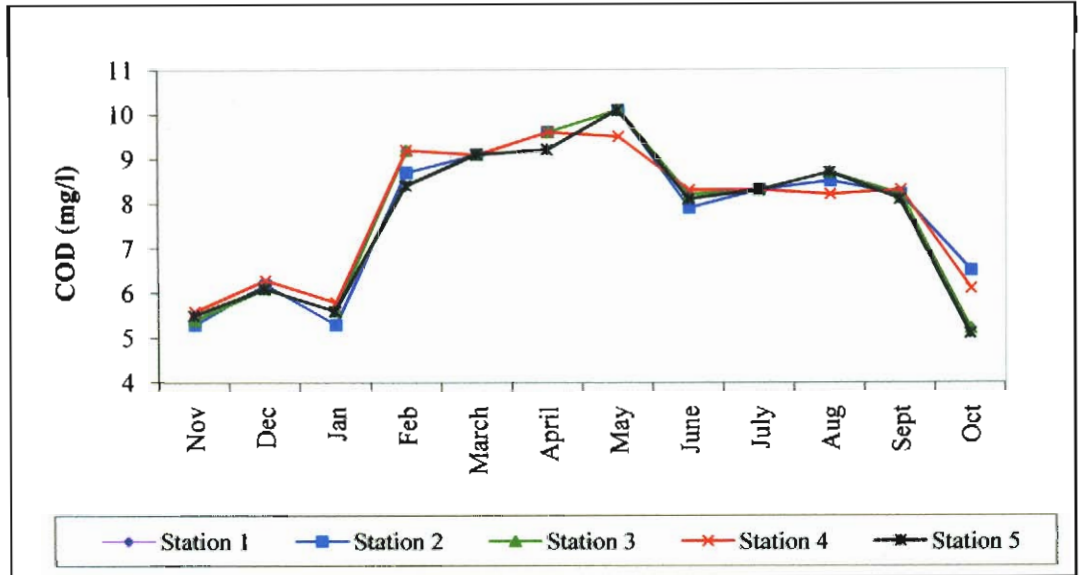


Table 3.1.15. Mean COD (mg/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	9.50	9.38	9.50	9.35	9.20
+ SD	0.45	0.61	0.45	0.24	0.70
Monsoon	8.35	8.23	8.35	8.28	8.30
+ SD	0.24	0.25	0.24	0.05	0.28
Postmonsoon	5.58	5.83	5.58	5.95	5.58
+ SD	0.39	0.62	0.39	0.31	0.41
Annual mean	7.81	7.81	7.81	7.86	7.69
+ SD	1.75	1.62	1.75	1.50	1.67

Table 3.1.15a. Analysis of Variance (Two-way ANOVA) comparing COD at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	144.24	14	10.30	61.062***
Intercept	3645.72	1	3645.72	21607.832***
STATION	0.18	4	0.05	0.271
SEASON	143.44	2	71.72	425.086***
STATION * SEASON	0.61	8	0.08	0.452
Error	7.59	45	0.17	
Total	3797.55	60		
Corrected Total	151.83	59		

***P < 0.001

Fig. 3.1.16. Monthly variations of TOC at different stations during the study period

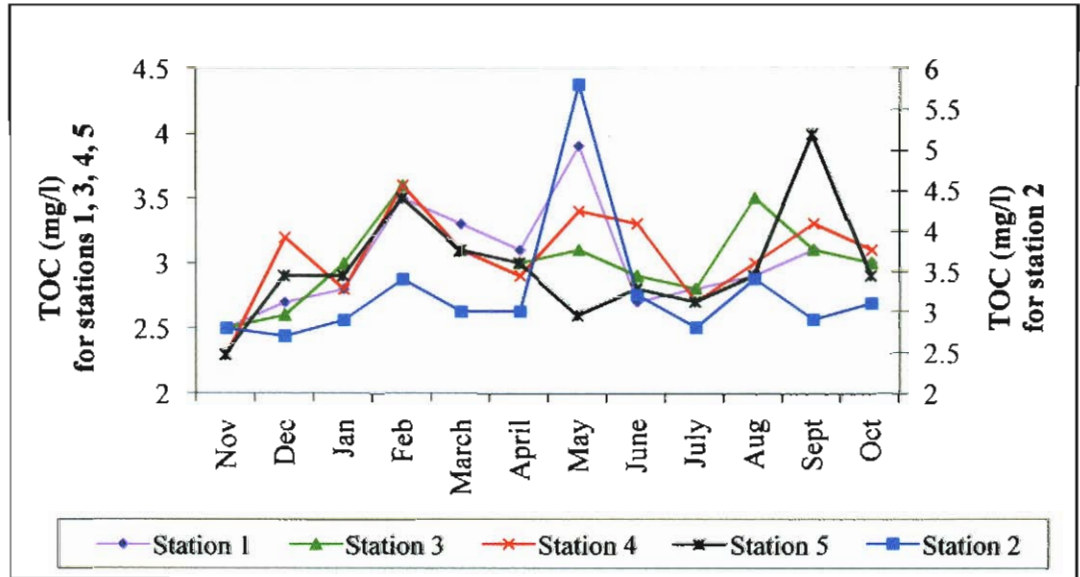


Table 3.1.16. Mean TOC (mg/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	3.45	3.80	3.20	3.25	3.05
+ SD	0.34	1.35	0.27	0.31	0.37
Monsoon	2.88	3.08	3.08	3.08	3.10
+ SD	0.17	0.28	0.31	0.29	0.61
Postmonsoon	2.75	2.88	2.78	2.85	2.75
+ SD	0.21	0.17	0.26	0.40	0.30
Annual mean	3.03	3.25	3.02	3.06	2.97
+ SD	0.39	0.83	0.32	0.35	0.43

Table 3.1.16a. Analysis of Variance (Two-way ANOVA) comparing TOC at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	4.57	14	0.33	1.493
Intercept	563.04	1	563.04	2573.573***
STATION	0.57	4	0.14	0.656
SEASON	3.04	2	1.52	6.951**
STATION * SEASON	0.96	8	0.12	0.548
Error	9.85	45	0.22	
Total	577.46	60		
Corrected Total	14.42	59		

P < 0.01; *P < 0.001

Fig. 3.1.17. Monthly variations of Nitrite at different stations during the study period

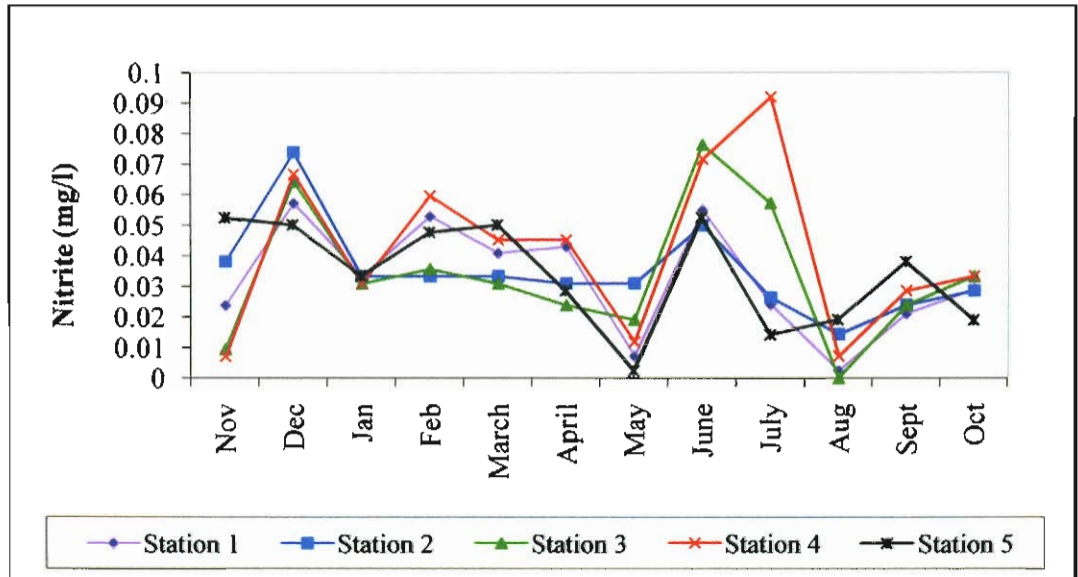


Table 3.1.17. Mean Nitrite (mg/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	0.04	0.03	0.03	0.04	0.03
+ SD	0.02	0.00	0.01	0.02	0.02
Monsoon	0.03	0.03	0.05	0.05	0.03
+ SD	0.02	0.02	0.03	0.04	0.02
Postmonsoon	0.04	0.04	0.03	0.03	0.04
+ SD	0.01	0.02	0.02	0.02	0.02
Annual mean	0.03	0.03	0.04	0.04	0.03
+ SD	0.02	0.01	0.02	0.03	0.02

Table 3.1.17a. Analysis of Variance (Two-way ANOVA) comparing nitrite at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	0.003	14	0.000	0.512
Intercept	0.077	1	0.077	178.111***
STATION	0.001	4	0.000	0.374
SEASON	0.000	2	0.000	0.221
STATION * SEASON	0.002	8	0.000	0.674
Error	0.019	44	0.000	
Total	0.098	59		
Corrected Total	0.022	58		

***P < 0.001

Fig. 3.1.18. Monthly variations of Nitrate at different stations during the study period

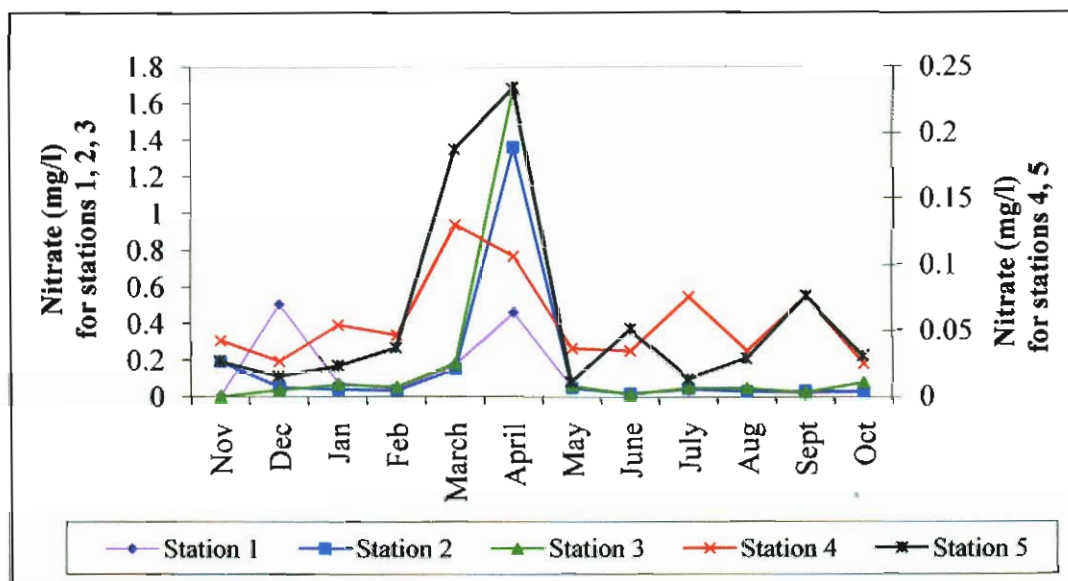


Table 3.1.18. Mean Nitrate (mg/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	0.18	0.40	0.49	0.08	0.12
+ SD	0.20	0.64	0.79	0.05	0.11
Monsoon	0.03	0.03	0.04	0.06	0.04
+ SD	0.01	0.01	0.02	0.02	0.03
Postmonsoon	0.15	0.08	0.05	0.04	0.02
+ SD	0.24	0.08	0.03	0.01	0.01
Annual mean	0.12	0.17	0.19	0.06	0.06
+ SD	0.18	0.38	0.47	0.03	0.07

Table 3.1.18a. Analysis of Variance (Two-way ANOVA) comparing nitrate at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	1.13	14	0.08	1.044
Intercept	0.88	1	0.88	11.375**
STATION	0.18	4	0.05	0.586
SEASON	0.55	2	0.28	3.570*
STATION * SEASON	0.40	8	0.05	0.641
Error	3.47	45	0.08	
Total	5.47	60		
Corrected Total	4.60	59		

*P < 0.05; **P < 0.01

Fig. 3.1.19. Monthly variations of Phosphate at different stations during the study period

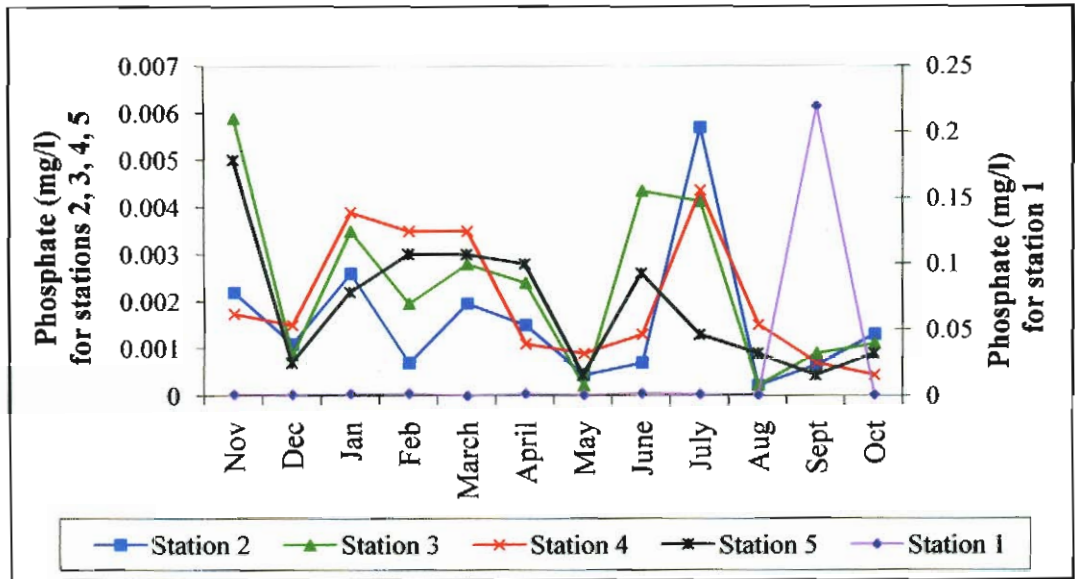


Table 3.1.19. Mean Phosphate (mg/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	0.0012	0.0012	0.0018	0.0023	0.0023
+ SD	0.0008	0.0007	0.0011	0.0014	0.0013
Monsoon	0.0559	0.0018	0.0024	0.0020	0.0013
+ SD	0.1091	0.0026	0.0021	0.0016	0.0009
Postmonsoon	0.0013	0.0018	0.0028	0.0019	0.0022
+ SD	0.0004	0.0007	0.0024	0.0015	0.0020
Annual mean	0.0194	0.0016	0.0024	0.0020	0.0019
+ SD	0.0630	0.0015	0.0018	0.0014	0.0014

Table 3.1.19a. Analysis of Variance (Two-way ANOVA) comparing phosphate at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	0.0109	14	0.0008	0.978
Intercept	0.0018	1	0.0018	2.256
STATION	0.0029	4	0.0007	0.919
SEASON	0.0016	2	0.0008	0.977
STATION * SEASON	0.0064	8	0.0008	1.007
Error	0.0358	45	0.0008	
Total	0.0485	60		
Corrected Total	0.0467	59		

Fig. 3.1.20. Monthly variations of Silicate at different stations during the study period

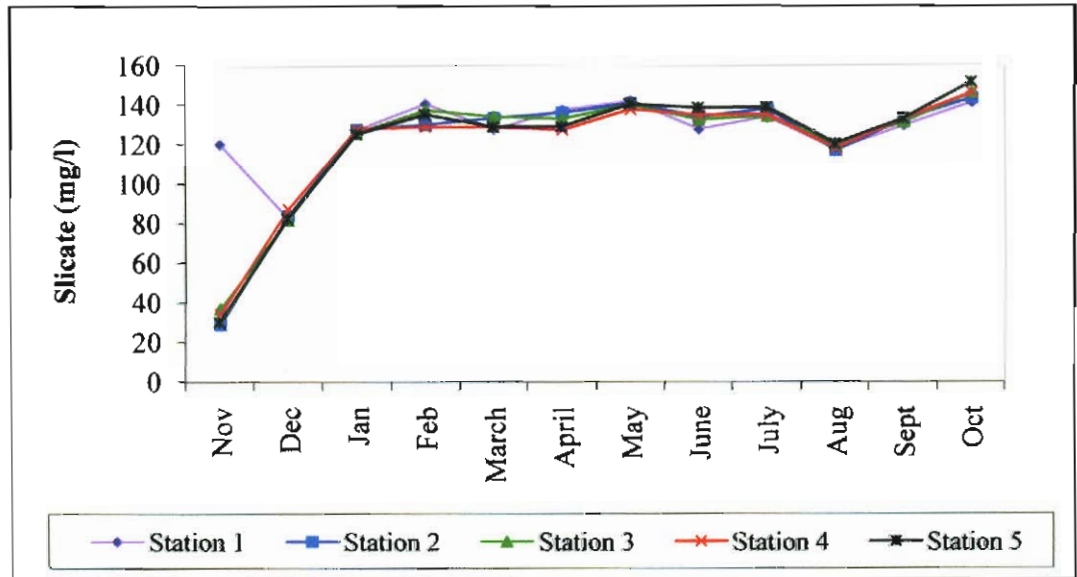


Table 3.1.20. Mean Silicate (mg/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	137.28	135.43	136.46	131.06	133.74
+ SD	6.40	4.49	3.21	4.75	5.60
Monsoon	127.36	130.68	129.84	130.50	133.06
+ SD	6.95	9.25	6.44	8.20	8.65
Postmonsoon	118.11	96.26	98.11	99.31	97.57
+ SD	25.08	51.21	48.49	49.46	53.09
Annual mean	127.58	120.79	121.47	120.29	121.46
+ SD	16.21	32.81	31.00	30.52	33.30

Table 3.20a. Analysis of Variance (Two-way ANOVA) comparing silicate at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	14245.88	14	1017.56	1.35
Intercept	897681.80	1	897681.80	1190.574***
STATION	427.50	4	106.88	0.142
SEASON	12744.12	2	6372.06	8.451**
STATION * SEASON	1074.26	8	134.28	0.178
Error	33929.59	45	753.99	
Total	945857.27	60		
Corrected Total	48175.47	59		

P < 0.01; *P < 0.001

Fig. 3.1.21. Monthly variations of Pottasium at different stations during the study period

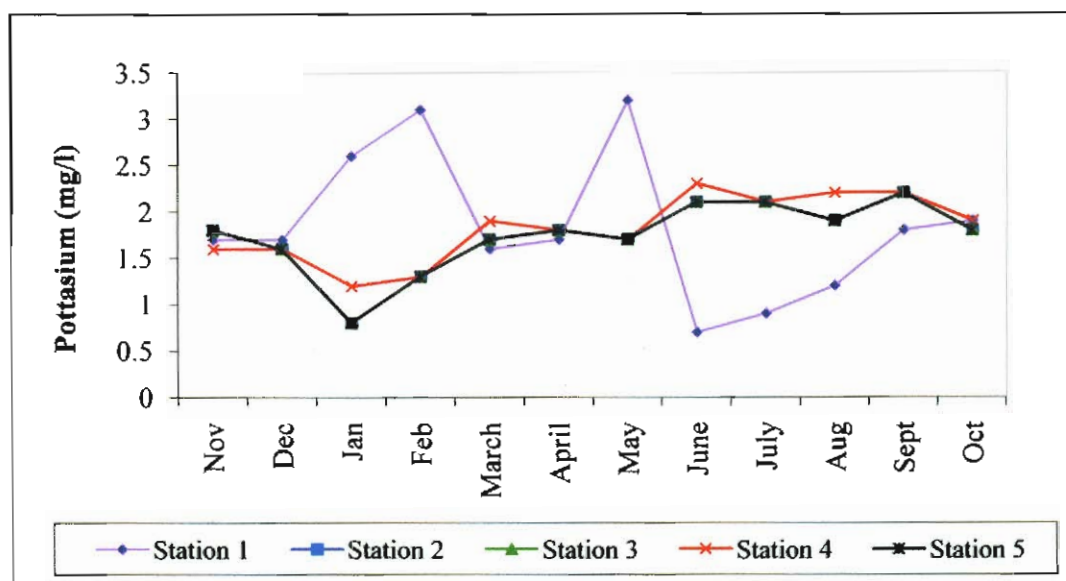


Table 3.1.21. Mean Pottasium (mg/l) at different seasons and stations

Seasons	Stations				
	1	2	3	4	5
Premonsoon	2.40	1.63	1.63	1.68	1.63
+ SD	0.87	0.22	0.22	0.26	0.22
Monsoon	1.15	2.08	2.08	2.20	2.08
+ SD	0.48	0.13	0.13	0.08	0.13
Postmonsoon	1.98	1.50	1.50	1.58	1.50
+ SD	0.43	0.48	0.48	0.29	0.48
Annual mean	1.84	1.73	1.73	1.82	1.73
+ SD	0.78	0.38	0.38	0.35	0.38

Table 3.1.21a. Analysis of Variance (Two-way ANOVA) comparing pottasium at different stations and seasons

Source	Sum of Squares	df	Mean Square	F value
Corrected Model	6.46	14	0.46	3.149**
Intercept	188.33	1	188.33	1284.542***
STATION	0.14	4	0.03	0.232
SEASON	0.94	2	0.47	3.207
STATION * SEASON	5.39	8	0.67	4.594***
Error	6.60	45	0.15	
Total	201.39	60		
Corrected Total	13.06	59		

P < 0.01; *P < 0.001

Table 3.1.22 Correlation between different water quality parameters at station I

	Rainfall	Air Temp.	Water Temp.	Transparency	pH	Conductivity	Turbidity	Salinity	Alkalinity	Hardness	TOC	TSS	COD	BOD	CO	DO	GPP	NPP	Silicate	Phosphate	Nitrate	Nitrite	Potassium	
Rainfall	1																							
Air Temp.	-0.583*	1																						
Water Temp.	-0.580*	0.970**	1																					
Transparency	-0.516	0.612*	0.657*	1																				
pH	0.233	0.17	0.218	0.028	1																			
Conductivity	0.092	0.515	0.434	0.433	0.341	1																		
Turbidity	0.459	-0.558	-0.476	-0.447	-0.17	-0.662*	1																	
Salinity	0.058	-0.101	-0.146	0.173	-0.061	0.375	-0.539	1																
Alkalinity	0.715**	-0.576*	-0.590*	-0.507	0.093	-0.026	0.436	0.04	1															
Hardness	0.507	-0.373	-0.502	-0.644*	0.057	0.077	0.286	-0.088	0.764**	1														
TOC	-0.038	0.332	0.205	0.377	0.253	0.796**	-0.591*	0.447	0.141	0.308	1													
TSS	0.243	0.121	0.091	0.034	0.244	0.247	0.115	-0.298	0.269	0.233	-0.011	1												
COD	0.267	0.039	-0.075	0.105	0.467	0.590*	-0.519	0.437	0.333	0.3	0.692*	0.263	1											
BOD	-0.138	0.507	0.47	0.502	-0.045	0.4	-0.231	-0.14	-0.215	-0.222	0.427	-0.185	0.148	1										
CO ₂	0.495	-0.618*	-0.620*	-0.392	-0.487	-0.263	0.542	-0.162	0.641*	0.482	-0.177	0.016	-0.09	-0.102	1									
DO	-0.247	-0.206	-0.163	-0.197	-0.464	-0.674*	0.414	-0.448	-0.339	-0.205	-0.755**	-0.037	-0.639*	-0.416	0.281	1								
GPP	0.086	-0.008	-0.002	-0.193	-0.366	-0.006	-0.232	0.284	-0.027	-0.214	-0.356	0.058	-0.018	-0.197	0.179	0.188	1							
NPP	0.565	-0.285	-0.17	-0.325	0.537	0.077	0.145	-0.136	0.315	0.095	-0.236	0.139	0.133	-0.307	0.239	0.021	0.211	1						
Silicate	0.453	0.229	0.155	-0.03	0.268	0.679*	-0.051	-0.153	0.449	0.568	0.543	0.367	0.396	0.343	0.3	-0.437	-0.111	0.32	1					
Phosphate	0.199	-0.153	-0.192	-0.059	-0.16	-0.258	0.444	0.089	0.394	0.334	0.058	-0.012	0.07	-0.051	0.298	0.032	-0.21	-0.276	0.044	1				
Nitrate	0.011	-0.091	-0.045	0.023	0.462	-0.043	-0.135	0.359	-0.27	-0.325	-0.073	-0.072	0.053	-0.291	-0.700*	-0.229	-0.181	-0.017	-0.518	-0.182	1			
Nitrite	-0.012	0.025	0.136	0.456	0.175	0.124	-0.031	0.194	-0.306	-0.527	-0.199	0.373	-0.118	-0.334	-0.304	0.141	0.036	0.156	-0.268	-0.197	0.498	1		
Potassium	-0.372	0.612*	0.525	0.541	0.012	0.620*	-0.518	0.249	-0.455	-0.104	0.689*	-0.332	0.103	0.535	-0.367	-0.315	-0.366	-0.388	0.311	-0.016	-0.051	-0.076	1	

*P < 0.05; **P < 0.01

Table 3.1.23 Correlation between different water quality parameters at station II

	Rainfall	Air Temp.	Water Temp.	Transparency	pH	Conductivity	Turbidity	Salinity	Alkalinity	Hardness	TOC	TSS	COD	BOD	CO	DO	GPP	NPP	Silicate	Phosphate	Nitrate	Nitrite	Potassium	
Rainfall	1																							
Air Temp.	-0.457	1																						
Water Temp.	-0.614*	0.842**	1																					
Transparency	-0.596*	0.826**	0.758**	1																				
pH	-0.012	0.003	-0.095	0.425	1																			
Conductivity	0.087	0.749**	0.556	0.665*	0.314	1																		
Turbidity	0.157	-0.719**	-0.832**	-0.486	0.142	-0.653*	1																	
Salinity	0.036	0.484	0.489	0.519	0.285	0.741**	-0.409	1																
Alkalinity	-0.188	-0.023	-0.118	0.219	0.257	-0.196	0.368	-0.104	1															
Hardness	0.52	-0.32	-0.43	-0.444	0.017	0.014	0.204	0.102	-0.289	1														
TOC	0.046	0.27	0.41	0.406	0.248	0.529	-0.31	0.880**	0.108	0.182	1													
TSS	0.258	0.303	-0.076	-0.017	-0.034	0.327	-0.247	-0.268	-0.22	0.321	-0.445	1												
COD	0.345	0.314	0.053	0.339	0.368	0.672*	-0.127	0.524	0.067	0.397	0.542	0.242	1											
BOD	0.002	0.186	0.394	0.311	0.197	0.342	-0.276	0.787**	0.237	0.032	0.930**	-0.583*	0.359	1										
CO₂	0.44	-0.347	-0.351	-0.191	0.254	0.067	0.315	0.452	0.099	0.705*	0.595*	-0.213	0.363	0.473	1									
DO	-0.065	-0.674*	-0.512	-0.479	0.143	-0.762**	0.463	-0.729**	0.146	-0.001	-0.580*	-0.043	-0.666*	-0.45	-0.071	1								
GPP	0.025	-0.209	-0.036	-0.377	-0.164	-0.244	-0.05	-0.028	-0.089	0.176	-0.074	-0.038	-0.491	0.105	0.114	0.345	1							
NPP	0.275	-0.489	-0.762**	-0.244	0.49	-0.259	0.850**	-0.177	0.408	0.143	-0.205	-0.044	0.143	-0.204	0.282	0.292	-0.131	1						
Silicate	0.376	0.158	-0.132	0.116	0.232	0.526	-0.022	0.347	-0.185	0.643*	0.293	0.484	0.605*	-0.032	0.576*	-0.326	-0.303	0.164	1					
Phosphate	0.091	-0.276	-0.56	-0.238	0.145	-0.298	0.696*	-0.195	0.298	-0.119	-0.376	-0.025	-0.203	-0.308	-0.004	0.225	0.019	0.817**	-0.024	1				
Nitrate	0.51	0.128	-0.018	-0.184	-0.167	0.386	-0.322	0.059	-0.45	-0.024	-0.117	0.37	0.316	-0.131	-0.367	-0.393	-0.14	-0.064	0.053	0.011	1			
Nitrite	-0.186	0.043	0.189	0.221	-0.058	-0.016	-0.115	-0.106	-0.014	-0.700*	-0.193	-0.284	-0.375	-0.176	-0.363	0.041	-0.148	-0.181	-0.382	-0.087	-0.066	1		
Potassium	0.589*	-0.468	-0.601*	-0.476	-0.027	-0.217	0.446	-0.142	0.139	0.496	-0.034	0.062	0.357	0.006	0.395	-0.013	0.055	0.332	0.043	0.01	0.052	-0.153	1	

*P < 0.05; **P < 0.01

Table 3.1.24 Correlation between different water quality parameters at station III

	Rainfall	Air Temp.	Water Temp.	Transparency	pH	Conductivity	Turbidity	Salinity	Alkalinity	Hardness	TOC	TSS	COD	BOD	CO	DO	GPP	NPP	Silicate	Phosphate	Nitrate	Nitrite	Potassium	
Rainfall	1																							
Air Temp.	-0.213	1																						
Water Temp.	-0.284	0.791**	1																					
Transparency	-0.478	0.577*	0.719**	1																				
pH	-0.193	0.162	0.264	0.587	1																			
Conductivity	0.146	0.279	0.243	0.46	0.413	1																		
Turbidity	0.609*	-0.444	-0.561	-0.564	-0.313	-0.278	1																	
Salinity	-0.167	0.533	0.657*	0.313	-0.041	0.385	-0.748**	1																
Alkalinity	0.179	-0.409	-0.164	-0.301	0.032	-0.311	0.226	-0.214	1															
Hardness	0.123	-0.289	-0.198	0.166	0.708**	0.175	0.281	-0.547	0.12	1														
TOC	-0.149	0.157	0.058	0.181	0.551	0.435	-0.003	-0.17	-0.072	0.579*	1													
TSS	0.347	0.382	-0.037	0.112	0.217	0.225	0.268	-0.192	-0.494	0.361	0.207	1												
COD	0.267	0.138	0.174	-0.042	0.46	0.541	-0.194	0.385	0.189	0.233	0.563	0.047	1											
BOD	-0.138	0.244	0.756**	0.597*	0.303	0.235	-0.432	0.492	-0.066	0.085	-0.017	-0.267	0.148	1										
CO ₂	0.406	-0.426	-0.416	-0.519	-0.261	-0.207	0.844**	-0.541	0.289	0.3	0.13	0.075	-0.05	-0.275	1									
DO	-0.094	-0.463	-0.488	-0.086	0.078	-0.483	0.248	-0.688*	0.076	0.481	-0.1	0.189	-0.54	-0.239	0.021	1								
GPP	0.153	-0.189	0.057	-0.03	0.101	-0.485	-0.071	-0.026	0.38	0.118	-0.575	-0.078	-0.238	0.243	-0.095	0.404	1							
NPP	0.205	0.096	0.269	0.073	-0.03	-0.303	-0.207	0.224	-0.02	0.027	-0.469	0.178	-0.171	0.417	-0.299	0.352	0.786**	1						
Silicate	0.342	0.132	-0.149	0.068	0.444	0.602*	0.293	-0.259	0.072	0.396	0.625*	0.396	0.521	-0.343	0.21	-0.255	-0.497	-0.597*	1					
Phosphate	0.132	0.167	0.173	0.128	0.017	-0.396	-0.153	0.047	0.078	-0.01	-0.531	0.286	-0.31	0.136	-0.392	0.492	0.780**	0.877**	-0.438	1				
Nitrate	0.527	0.463	0.183	-0.238	-0.29	0.294	0.035	0.429	-0.444	-0.323	0.01	0.459	0.344	-0.055	0.02	-0.534	-0.197	0.162	0.161	-0.011	1			
Nitrite	0.132	-0.528	-0.778**	-0.496	-0.141	-0.053	0.127	-0.289	0.332	0.027	-0.163	0.011	-0.032	-0.738**	-0.001	0.389	0.047	-0.148	0.165	0.08	-0.223	1		
Potassium	0.589*	-0.554	-0.365	-0.546	-0.095	-0.143	0.554	-0.172	0.488	0.279	-0.171	-0.002	0.272	-0.049	0.676*	-0.01	0.324	0.117	0.023	-0.018	0.032	0.197	1	

*P < 0.05; **P < 0.01

Table 3.1.25 Correlation between different water quality parameters at station IV

	Rainfall	Air Temp.	Water Temp.	Transparency	pH	Conductivity	Turbidity	Salinity	Alkalinity	Hardness	TOC	TSS	COD	BOD	CO	DO	GPP	NPP	Silicate	Phosphate	Nitrate	Nitrite	Potassium	
Rainfall	1																							
Air Temp.	-0.456	1																						
Water Temp.	-0.527	0.879**	1																					
Transparency	-0.479	0.926**	0.791**	1																				
pH	0.421	-0.367	-0.348	-0.392	1																			
Conductivity	-0.069	0.629*	0.279	0.747**	-0.069	1																		
Turbidity	0.507	-0.713**	-0.556	-0.680*	0.349	-0.436	1																	
Salinity	0.464	-0.15	-0.146	-0.279	0.358	-0.133	-0.03	1																
Alkalinity	0.652*	-0.431	-0.527	-0.394	-0.03	-0.096	0.475	0.087	1															
Hardness	0.334	-0.195	-0.351	-0.327	-0.171	-0.26	0.015	0.355	0.445	1														
TOC	-0.022	0.152	-0.182	0.342	0.194	0.730**	-0.036	-0.354	0.151	-0.201	1													
TSS	0.096	-0.016	-0.126	0.242	-0.385	0.341	-0.135	-0.104	0.332	-0.065	0.153	1												
COD	0.335	0.385	0.102	0.448	-0.043	0.722**	-0.119	0.026	0.409	-0.152	0.529	0.44	1											
BOD	-0.21	0.703*	0.521	0.532	-0.334	0.462	-0.496	-0.308	-0.317	-0.105	0.102	-0.236	0.285	1										
CO ₂	0.44	-0.133	-0.418	-0.245	0.096	0.077	0.235	0.126	0.642*	0.737**	0.343	-0.198	0.261	0.038	1									
DO	-0.057	-0.549	-0.477	-0.572	0.144	-0.425	0.45	0.161	-0.134	0.249	-0.26	-0.141	-0.614*	-0.438	0.026	1								
GPP	0.169	-0.085	0.039	-0.329	-0.371	-0.488	0.043	0.413	0.042	0.52	-0.81**	-0.169	-0.346	0.143	0.066	0.345	1							
NPP	0.236	0.142	0.287	0.205	-0.256	-0.008	-0.255	0.35	0.084	-0.169	-0.405	0.478	0.297	-0.064	-0.463	-0.499	0.206	1						
Silicate	0.355	0.061	-0.234	0.18	0.212	0.497	-0.031	0.211	0.53	0.381	0.602*	0.352	0.527	-0.262	0.613*	-0.185	-0.415	-0.111	1					
Phosphate	-0.409	0.442	0.446	0.373	-0.158	0.239	-0.334	0.328	-0.364	-0.077	-0.205	0.153	0.03	0.006	-0.257	0.287	0.223	0.036	0.049	1				
Nitrate	0.139	0.3	0.407	0.365	-0.177	0.255	-0.156	0.189	0.26	-0.306	-0.138	0.551	0.494	-0.063	-0.321	-0.478	-0.008	0.704*	0.192	0.359	1			
Nitrite	0.229	-0.178	-0.251	-0.107	0.277	0.269	0.222	0.598*	0.045	-0.071	0.186	0.119	0.178	-0.373	0.012	0.382	-0.001	0.029	0.289	0.447	0.172	1		
Potassium	0.542	-0.527	-0.539	-0.446	-0.164	-0.239	0.652*	0.02	0.861**	0.325	0.05	0.324	0.305	-0.42	0.461	0.041	0.103	0.136	0.272	-0.374	0.115	0.122	1	

*P < 0.05; **P < 0.01

Table 3.1.26 Correlation between different water quality parameters at station V

	Rainfall	Air Temp.	Water Temp.	Transparency	pH	Conductivity	Turbidity	Salinity	Alkalinity	Hardness	TOC	TSS	COD	BOD	CO ₂	DO	GPP	NPP	Silicate	Phosphate	Nitrate	Nitrite	Potassium	
Rainfall	1																							
Air Temp.	-0.583*	1																						
Water Temp.	-0.580*	0.970**	1																					
Transparency	-0.602*	0.535	0.479	1																				
pH	-0.197	0.175	0.176	0.5	1																			
Conductivity	0.19	0.189	0.111	0.464	0.369	1																		
Turbidity	0.452	-0.531	-0.442	-0.498	-0.069	-0.495	1																	
Salinity	-0.575*	0.747**	0.741**	0.567	0.068	0.07	-0.61*	1																
Alkalinity	0.595*	-0.773**	-0.769**	-0.627*	-0.276	-0.168	0.363	-0.678*	1															
Hardness	0.454	-0.524	-0.646*	-0.173	-0.192	0.225	0.3	-0.51	0.395	1														
TOC	0.008	0.074	-0.01	0.095	0.602*	0.313	0.126	-0.183	-0.064	0.304	1													
TSS	0.296	0.084	0.042	0.293	0.367	0.566	0.001	-0.203	-0.161	0.175	0.041	1												
COD	0.265	0.005	-0.102	0.089	0.219	0.654*	-0.493	-0.13	0.235	0.259	0.218	0.256	1											
BOD	-0.201	0.545	0.499	0.373	-0.095	-0.029	-0.202	0.466	-0.379	-0.263	-0.185	-0.108	0.131	1										
CO ₂	0.452	-0.522	-0.573*	-0.24	-0.519	0.202	0.193	-0.498	0.518	0.684*	-0.014	-0.141	0.232	-0.015	1									
DO	0.176	-0.632*	-0.628*	-0.524	-0.521	-0.368	0.278	-0.447	0.438	0.247	-0.097	-0.49	-0.353	-0.422	0.52	1								
GPP	-0.214	0.326	0.369	0.201	-0.128	-0.438	0.057	0.335	-0.217	-0.489	-0.569	-0.008	-0.229	0.74**	-0.315	-0.363	1							
NPP	0.006	0.068	0.212	-0.375	-0.452	-0.606*	0.366	-0.083	0.005	-0.347	-0.472	-0.326	-0.259	0.468	-0.003	-0.026	0.660*	1						
Silicate	0.371	-0.199	-0.281	-0.007	-0.03	0.74**	-0.137	-0.323	0.173	0.652*	0.425	0.273	0.451	-0.38	0.620*	0.166	-0.81**	-0.556	1					
Phosphate	-0.089	0.545	0.619*	0.115	0.145	-0.077	-0.072	0.275	-0.413	-0.76**	-0.306	0.335	-0.173	0.412	-0.59*	-0.441	0.637*	0.41	-0.543	1				
Nitrate	0.311	0.253	0.241	0.095	0.516	0.481	-0.087	0.065	-0.085	-0.007	0.259	0.688*	0.409	-0.121	-0.441	-0.75**	-0.093	-0.284	0.151	0.305	1			
Nitrite	-0.289	0.255	0.347	0.203	0.634*	-0.135	0.073	0.126	-0.209	-0.73**	0.194	0.087	-0.303	-0.052	-0.68*	-0.213	0.221	-0.02	-0.486	0.605*	0.198	1		
Potassium	0.589*	-0.683*	-0.676*	-0.298	0.117	-0.033	0.565	-0.77**	0.695*	0.46	0.062	0.251	0.319	-0.08	0.407	0.032	0.062	0.273	0.067	-0.204	0.121	-0.112	1	

*P < 0.05; **P < 0.01

DISCUSSION

Sasthamkotta lake is the largest fresh water lake of Kerala. This lake is a rain fed one depending on seasonal rains for its yearly replenishment. Lakes are reported to have extreme variations in environmental parameters due to their closed conditions and the resultant sensitivity to changes. In closed lakes heavy rain changes their depth (Carmouse *et al.*, 1983). Such lakes usually provide extreme environment to fish also. In Sasthamkotta lake the inlet source is water availability through rainfall at catchment areas. Since there is no outlet, there exist extreme environmental conditions.

Abundance and diversity of biotic communities are influenced by various physicochemical parameters of the environment. Biological and physicochemical methods are complementary, as they provide different sorts of information, both are needed for a full assessment of an ecosystem. The potentialities of an aquatic ecosystem such as nutrient dynamics, productivity, standing stock, and energy transfer are vast and for their assessment the study of physicochemical characteristics is inevitable. The physicochemical parameters are interdependent and they vary with seasons. Being in the tropical climatic region, the diurnal and seasonal fluctuations in atmospheric temperature significantly affect the water temperature of the lake. This temperature fluctuation directly affects the surface water temperature and the lake as a whole. The major parameter which influences the water quality of Sasthamkotta lake is the monsoon. As in the case of many lakes the nutrient rich flood water changes the ionic content, water temperature and water level of the lake. Results of the present study revealed a monsoon related variations in air temperature, water temperature, transparency, salinity, alkalinity turbidity and nutrients.

In the present study, the seasonal mean of rainfall was maximum during the monsoon period (June-Sept.) (213.23 mm) followed by pre monsoon (Feb.-May) (144.25 mm) and post monsoon (Oct.-Jan.) (83.5 mm). Similar observation was made by Madhusoodhanan Nair (1992) in Kallada and Neyyar river.

Temperature of both air and water play a major role in the life of organisms. No other factor has such profound direct or indirect influence on the aquatic habitat than temperature; temperature represents one of the most important physical characteristics of water body. It affects other physical properties of and influences the chemical and biochemical reactions which take place in the system (Walling and Webb, 1996).

According to Goldman and Horne (1983), in tropical regions temperature variations are much less than in temperate regions. During the present study the maximum atmospheric temperature recorded was 33.5°C (station V) during pre monsoon and the minimum, 27°C (station V) at monsoon. The annual difference between the highest and lowest air temperature was only 5.5. This was in agreement with the findings of Harikrishnan and Aziz (1989) in Neyyar reservoir of South Kerala and in Pookot lake of North Kerala (Anon, 1989). Joseph (1994) recorded a difference of 6°C in atmospheric temperature in Sasthamkotta lake and 5.8°C in Vellayani lake (Sandhya, 2003) 5.6°C in Kolleru lake (Rao *et al.*, 2006)

Water temperature has tremendous effects on the biogeochemical reactions and also in the self purification efficiency of aquatic systems. Self purification (breakdown of organic matter) is more rapid during summer than during other seasons (Binoda and Nayar, 1995). As per the present study, water temperature ranged from 26°C to 34°C. Water temperature was positively correlated with atmospheric temperature at all stations. Water temperature variation is reported to be directly related to variation in atmospheric temperature (Rangarajan, 1958; Chandramohan and Satyanarayana Rao, 1972; Sundararaj and Krishnamoorthy, 1981; Mishra *et al.*, 1993). Variations in the water temperature of several rivers in Kerala have been reported. In Vamanapuram river the water temperature is reported to vary between 25.2 to 32.0°C (Kingston, 1992). In Kallada river the variation is between 23.5°C and 33.0°C, in Neyyar between 24.5°C and 32.0°C (Madhusoodanan Nair, 1992) and in the Kodungalloor backwater system, it is between 26.5°C and 32.5°C (Mukundan and Thomas, 2004).

The mean seasonal water temperature was maximum during the pre monsoon period at all stations and lower during post monsoon and lowest in

monsoon periods. Similar trends have been reported in Kallada and Neyyar river (Madhusoodhanan Nair, 1992), Kallada river (Sahib, 1992) and Karamana river (Krishnakumar, 2002). The relatively low temperature recorded during the postmonsoon and monsoon months may be due to the cold climate conditions prevailing at that time. This is in conformity with the earlier observations of Nair *et al* in many estuaries in India (1983b; 1984c), Shibu in Paravur estuary (1991) and Sushama in Nila River (2003). The studies of Misra *et al.* (1975), Qadri and Yousuf (1978), Yadava *et al* (1987) and Ayyappan *et al* (1991) showed that surface water temperature of inland water bodies followed the changes in air temperature and the present findings are in agreement with this.

One of the important parameters for determining the quality of water in an aquatic environment is the pH of water. The principal component regulating pH in natural water is carbonate, which comprises CO_2 , H_2CO_3 , HCO_3^- and CO_3^{2-} (Stumm and Morgan, 1970). It is an important factor affecting the chemical and biological characteristics of natural waters. pH maintenance or buffering capacity of aquatic systems is very important because all biochemical activities depend on pH of the surrounding water. In addition to being an important means in understanding the chemical conditions of water bodies, analysis of water pH yields indirect information on free CO_2 content, alkalinity, dissolved oxygen and residual pH and thus may serve as a test of several environmental conditions (Wetzel, 1975). The alteration of pH of water was accompanied by variations in the other physicochemical properties of the medium.

The pH ranged between 6.08 at station III during December and 7.9 at station II in February and station I in April in the lake water. During August, October and November all the stations were acidic and stations IV and V shifted to slightly alkaline range during September and December. During January and June all other stations are acidic except station IV. But in February and March station IV only was acidic (also station II in March). During May stations III, IV and V are acidic. Previous studies had shown that water showed alkaline pH during June, July and August (Joseph, 1994). But in the present study all the stations and seasons showed varying results The annual mean of pH showed slightly acidic

range (except station I where pH was 7.02). Acidic nature of the lake was reported by Sreenivasan (1970, 1971b) in reservoirs like Pechparai, perinchaini and in Ooty lake; Yadava *et al.* (1987) in Dighali beel and Desai (1991) in Mayem lake and Sandhya (2003) in Vellayani lake whereas an extensive study by Unni (1985) exposed the alkaline nature of all the central Indian reservoirs and also by Biswas and Konar (2002), in Hussain Sagar lake of Hyderabad revealed the alkaline nature

In the present study, annual mean showed that the pH of Sasthamkotta lake was almost neutral (6.74-7.02). The pH levels of the lake is within the limits set for protection of aquatic life, (6.5 to 9.0) (USEPA, 1975), irrigation (5.5 to 9.0), domestic use (7 to 9) (ICMR, 1975), and drinking (6.5 to 8.6) (BIS, 1991). According to Bridge and Juday (1911), pH of water depends largely on the amount of free CO₂; thus, pH reading may indicate a measure of carbon dioxide content indirectly. Brock (1970) reported that pH of a neutral or alkaline stream is controlled by bicarbonate buffer system and varied with partial pressure of carbon dioxide gas. In the present study, a positive relationship was noted between pH and CO₂ at stations II and IV.

Structure of aquatic ecosystem is directly related to the solar radiation which heats and lights the water (Goldman and Horne, 1983). Sasthamkotta lake expressed high transparency values ranging from 120 to 150 cm during the period of study. Higher transparency value was reported by Sreenivasan (1971b) in Kodaikanal lake and Mathew (1975) in Govindgarh lake. Comparatively high transparency values in Sasthamkotta lake may be due to low level of total suspended solids, acidic pH and absence of thick growth of algae. Bright sunlight might be the reasons for slightly increased transparency values recorded during the pre monsoon periods. Lowest transparency values recorded during monsoon and post monsoon months are due to the influx of surface run off from the catchments area into the lake. Similar observations were made by Nair and Prabhoo (1980), Harikrishnan and Aziz (1989), Joseph (1994) and Sandhya (2003).

Water conductivity is the direct measurement of electrolytes like acids, bases and salts in the aquatic medium. If the conductivity is more, the concentration of dissolved salts will be higher (APHA, 1985). Low conductivity

values ranging from 33.9 mmhos to 65.2 mmhos were recorded in Sasthamkotta lake water during the present study. Low conductivity values ranging from 26.7 mhos to 63.7 mhos/cm were reported in Pookot lake (Anon, 1989). Majority of the Indian lakes and reservoirs possessed higher range of conductivity than lake Sasthamkotta (Sreenivasan, 1971a, Zutshi *et al*, 1980; Unni, 1985). However lower values were reported in Kolleru lake, the largest fresh water lake in South India (Rao *et al.*, 2006).

The conductivity values were slightly higher during the entire summer period owing to low water level and increased rate of evaporation. Rao *et al.*, (2006) in Kolleru lake noted increased conductivity values during summer months. Trivedi and Goel (1986) opined that fresh water lakes in their natural state have low conductivity values. The conductivity values recorded in Sasthamkotta lake agrees with this and the earlier findings of Joseph (1994).

Water alkalinity is a measure of acid present in water and of the cations balanced against them (Yogesh Shastri and Pendse, 2001). A low range of alkalinity was recorded in Sasthamkotta lake. Slight increase in alkalinity was found associated with the south west monsoon showing a peak value in June and also in September. Rainfall and the subsequent surface run off and leaching were the major factors responsible for increase in total alkalinity. A low range of alkalinity values has been reported by Sreenivasan (1971b) in Kodaikanal lake and Yadava *et al* (1987) in Dighali. In Pookot lake (Anon, 1989) low alkalinity values ranging between 10.7 to 29.5 ppm was recorded. Joseph (1994) also registered low alkalinity values in Sasthamkotta lake. As the alkalinity range of Sasthamkotta lake stood far below 40 ppm, the lake can be termed as soft water lake (Moyle, 1946). The annual mean of alkalinity values are below 15 ppm and hence the lake can be considered as nutrient poor (Spence, 1964).

Turbidity of water is another physical factor of importance because it restricts light penetration into the lake water. Penetration of light into water is determined by various factors such as wind, current and turbidity. Biological phenomenon such as plankton bloom also checks penetration of light. Monthly variation showed that maximum turbidity value was noted during July.

Season wise analysis showed that maximum turbidity values were during monsoon followed by post monsoon months. This may be due to the influx of surface run off from the catchment area into the lake. Such low turbidity values were recorded by (Ibrahim *et al.*, 2006). The ISI standards recommendation for the turbidity is 5.0 NTU. The annual mean value of lake water of Sasthamkotta is below this limit and hence this fresh water source is not turbid and is appreciable as a drinking water source.

Salinity has an important effect on the living components of an ecosystem. As Sasthamkotta is a fresh water lake low salinity values were recorded in all the stations except Station IV throughout the year. Minimum salinity value noted was 2.51 ‰ in July (Station V) and the maximum 3.712 ‰ in May (station II) except station IV. Low salinity values are reported by Khan *et al* (2005) in drinking water. Station IV recorded comparatively high salinity values. The minimum value noted at station IV was 8.8 ‰ in September and the maximum 12.3 ‰ in July. This may be due to the deposition of residual chlorine in water bodies (Royee and Prakasam, 2003). State Water Authority discharges the waste water into the lake at station IV after purification may attribute for the greater salinity values.

The respiration of aquatic biota, decaying organic matter, ground water, and bicarbonate salts are the major sources of carbon dioxide in aquatic systems. It may occur in the free state and it tends to vary inversely with oxygen. The presence of carbon dioxide was noted throughout the period of study. Similar observations were reported by Kannan and Job (1980), Joseph (1994) and Sareena (1998). In the present study, the carbon dioxide content of Sasthamkotta lake ranged from 1.8 mg l⁻¹ (station IV) to 7.7 mg l⁻¹ in the same station. Comparatively low values of CO₂ are reported which agrees with the findings of Shamsunder (1988) for River Jhelum (3.2 to 3.6 mg l⁻¹). In water bodies around Jaipur the carbon dioxide concentration varies from 6.05 to 12.65 mg l⁻¹ (Neera Srivastava *et al.*, 2003). An increase in carbon dioxide indicates an increase in pollution load (Chandraprakash *et al.*, 1978; Shah, 1988). Generally low but steady pulse of carbon dioxide during most of the time showed that the rate of photosynthesis may be too poor to exhaust the free carbon dioxide content completely.

Comparatively higher CO₂ concentration was observed in the months of monsoon. Similar findings were reported by Mathew (1975), Joseph (1994) and Sareena (1998). During monsoon the lake received more organic matter through surface run off and drainage and its decomposition might have resulted in the liberation of more amounts of CO₂ in the water column. A study by Prakasam and Joseph (1991) in the same water body revealed comparatively higher concentration of CO₂ indicating its release from the microbial decomposition. The relationship between pH and CO₂ was found to be negative at station I, III and V. Similar observations had been made by Harikrishnan (1993). CO₂ is positively correlated with alkalinity at station I and IV and with hardness at stations II, IV, and V.

The distribution of oxygen in the aquatic medium is governed by diffusion from air, photosynthesis of micro- and macrophytes, loss due to respiration, and chemical and biotic oxidation. Water temperature, water current, and turbidity also affect dissolved oxygen (Dobriyal and Singh, 1988; Singh, 1988). The oxygen regime exhibits both diurnal and seasonal variations. Many environmental parameters also influence the concentration of the oxygen content in an aquatic environment (Mishra and Yadav, 1978; Verma *et al.*, 1978; Bass and Harlet, 1981; Mitra, 1982). Dissolved oxygen content of Sasthamkotta lake water varied between 4.45 mg l⁻¹ (station I) and 8.918 mg l⁻¹ (station III). The major source of oxygen in this water body might be direct transfer from atmosphere to water. The annual difference between the highest and the lowest DO values were less which could be compared with the previous studies (Joseph, 1994).

High oxygen content during monsoon period with a peak in June was found to be in accordance with the amount of rainfall and fall in water temperature. Seasonal showers and influx of atmospheric oxygen through rain water and wind work in the lake water facilitate more dissolution of oxygen from the air column to surface water. An inverse relationship between DO and temperature was observed by Quasim and Gopinathan (1969), Sankaranarayanan and Quasim (1969), and Saraladevi *et al.* (1979) in Cochin backwater. Shibu (1991), Unni (1985), Geetha Bhadran (1997), Singh (1997), and Sushama (2003) have also reported low dissolved oxygen at high temperature. Present results at sasthamkotta lake are in

agreement with this. According to Robert *et al.* (1982), a minimum of 4 mg l^{-1} of DO should be maintained in water for healthy growth of fish and planktonic population. It is thus obvious that the water in this lake is of suitable not only for sustenance of aquatic biota but also for human use.

In the present study, hardness varied between 4.1 mg l^{-1} (station III) and 14 mg l^{-1} (station III and IV) and hardness was higher during monsoon. This may be because of low rate of evaporation, increased rate of run off from the catchments and its sedimentation. Hardness was low during post monsoon season (except station IV). Such low hardness was reported by Sreenivasan (1971 a,b) in Kodaikanal lake (12 ppm) and was ranked the lowest in productivity. Trivedi and Goel (1986) and Singh and Mahajen (1987) are of the view that the high hardness is suggestive of pollution due to domestic waste and industrial effluents. The present results suggest water pollution is well below the desirable limit (BIS, 1991).

The dynamics and seasonal cycles of the nutrients-nitrite, nitrate, phosphate, silicate and potassium- control most of the biological activities in an aquatic ecosystem as they are essential for the growth of phytoplankton and, in turn, for the survival and population fluctuation of other biota.

Silicate is universally present in all natural waters both in the ionic and colloidal forms. Ionic form of silicate is of much value for the development of diatoms. Whenever the available supply of the ionic form is exhausted, it is recouped to some extent by conversion of colloidal form into the ionic form. Diatoms use silicon for building of their shell wall (Frustule); they take up silicon largely as orthosilicic acid (Si(OH)_4). Availability of silica can have a strong influence on succession and productivity. In the present study, silicate was present in moderately high concentration in Sasthamkotta lake water; ranged between 30.36 mg l^{-1} and 151.8 mg l^{-1} . One of the reasons for this high silicate content might be soil erosion from the catchment area. Mathew (1975), Satya Mohan (1987), Joseph (1994) and Sulabha and Prakasam, (2004) have also reported higher silicate content in different water bodies. Since this lake has no inlets and outlets, the silica content might also be related to the soil characteristics of the lake basin.

Silicate content was highest during pre monsoon and the lowest during post monsoon. This observation is in accordance with the findings of Madhusoodhanan Nair (1992) and Sushama (2003). A general decrease in silicate concentration was noted during the post monsoon season. Similar observations were made by Harikrishnan and Aziz (1989) in Neyyar reservoir and Reddy and Prasad (1989) in Banjara Lake.

Phosphorus is one of the most important nutrients of living organisms. It is scarce than other principal elements of living biota such as carbon, hydrogen, nitrogen and sulphur. Its abundance at the surface of earth is about one tenth of one percent by weight (Cole, 1979). It is a nutrient of major importance in production process (Vollenweider, 1968) and it is taken up rapidly and concentrated by living organisms. Total phosphate concentration in non-polluted natural waters may range widely (Kennish, 1999). Water receiving raw or treated sewage, agricultural drainage, and industrial waste usually contain high concentration of phosphate. Inorganic phosphate concentration is a useful index of eutrophication of water bodies (Ketchum, 1967). In the present study, the phosphate concentration of Sasthamkotta lake ranged between $0.00022 \text{ mg l}^{-1}$ and 0.2196 mg l^{-1} . This is much lower than that reported (0.65 mg l^{-1}) in the same lake by Joseph (1994), Udaisagar fresh water lake (Pandey *et al.*, 2000), at Kathalnala (Gupta and Raghubanshi, 2002) and in Hussain Sagar lake (Nagaprapurna and Shashikanth, 2002). The findings are in agreement with the observations in Kodungallur backwater system (Mukundan and Thomas, 2004). According to Desai (1995), phosphate concentration above 2 mg l^{-1} can be considered as indication of high pollution. Venkateswaralu (1969) and Lerman (1979) reported that phosphate concentration will be high in polluted waters. Irrespective of the seasons, Station I is the site having high phosphate concentration in the present study. This is attributable possibly to the laundry activities, which uses considerable quantities of detergents. According to Golterman (1973), increased application of fertilizers, use of detergents and dumping of domestic sewage contribute to heavy loading of phosphate in water bodies. The results suggest that the lake becomes more and more polluted at station I and this is attributable to the increased rate of surface run off, human interference such as laundry activities,

dumping of domestic sewage and market wastes. Banerjea (1967) opined that ponds should have phosphorus concentration above 0.2 mg/l for high fish production.

Nitrogen in the form of nitrate is more significant than nitrite in fresh water. It is the highly oxidized form of nitrogen and it is essential for plankton growth. Nitrate is the end product of aerobic stabilization of organic nitrogen. It occurs in trace quantities in surface water. The concentration of nitrate depends on the activity of nitrifying bacteria, which in turn is influenced by the presence of dissolved oxygen. Discharge of sewage, natural runoff and agricultural wastes contribute to nitrate content of fresh water. In the present study, nitrate content of Sasthamkotta lake ranged from 0.00389 mg/l to 1.675 mg/l. This is higher than that reported by Joseph (1994) in the same lake. Wani *et al.*, (2002); Bhaskar Bhadra *et al.*, (2003); Sushama, (2003); Kadeeja Beevi *et al.*, (2004) noted higher nitrate concentration in many fresh water systems of India.

According to Kapoor (1993) and Kodarkar (1995), high nitrate content represents high organic pollution. In the present study, nitrate content was comparatively high at stations I, II and III and hence more polluted in relation to other stations. The increase in nitrate content during pre monsoon season may be due to the decaying of organic materials. Bacterial decomposition of concentrated organic matter during the dry pre monsoon period tends to increase the concentration of nitrates. Such increase in nitrate due to decomposition of organic material has been reported by Zafar (1964), Krishna Swarup and Singh (1969) and Aravindkumar and Gupta (2002). Wetzel (1975) opined that the concentration of nitrate ranged from 0 to 1 mg/l in unpolluted water, but was highly variable seasonally and spatially. Considering this view, nitrate concentration in the lake was not indicative of pollution. As in the case of phosphate, nitrate concentration was also high during pre monsoon period.

Nitrite is the partially oxidised form of nitrogen and it occurs in lower concentrations than nitrate in natural waters. The nitrite regimen of aquatic ecosystems is important because of the role of nitrite as an intermediary in the inter conversion of nitrate and ammonia. Nitrite is formed by bacterial action either

through the heterotrophic oxidation of ammonia to nitrite or by the reduction of nitrate (Carlucci and Shubert, 1969; Wade and Hattori, 1972). In the present study, the average nitrite content ranged from nil to 0.09191 mg/l. This is higher than that reported by Joseph (1994) in the same lake. Nitrite content was the highest during monsoon season at stations III and IV. Annual mean showed no significant variation in the nitrite concentration with regard to seasons. Nitrogen compounds in fresh water owe their origin to rainwater, soil organic matter, and other organic substances (Visser, 1974) and might be the reason for the increasing trend of nitrite values during monsoon.

Many factors of aquatic habitat are interrelated and interdependent and variation of any one influences the other. In the present study several significant positive and negative relationships between climatic and different physicochemical characteristics were observed. There was a negative relation between air temperature and rainfall and between water temperature and rainfall. In the present study water temperature was positively correlated with air temperature at all the stations (ChandraMohan and Satyanarayana Rao, 1972; Sundarraj and Krishnamoorthy, 1981 and Mishra *et al*, 1993). Many authors observed an inverse relationship of dissolved oxygen with temperature (Agarwal *et al.*, 1976; Gupta and Mehrotra, 1986; Singh and Mahajen, 1987; Yadava *et al*, 1987; Shastree *et al*, 1991 and Aneja and Singh, 1992). Correlation analysis showed an inverse relationship between dissolved oxygen and water temperature in the present study. The positive relationship shown by conductivity, turbidity and alkalinity with rainfall in the present study might be due to the high deposition of organic matter into the lake from the catchment area during rainfall. This may also be the reason for the positive correlation of total organic carbon with conductivity.

In Sasthamkotta lake turbidity showed a negative relationship with transparency at all the stations and significant at station IV. This might be due to the low level of suspended organic materials in the lake. Kramer (1978), Schindler (1980) and Yan (1983) reported that increase in transparency is apparently accompanied by acidification of freshwater. The enhanced transparency values in Sasthamkotta lake and its slightly acidic nature also support this observation.

At all the stations potassium showed a positive correlation with rainfall. This might be due to the leaching of loosened surface soil of the surrounding agricultural fields along with the fertilizers which is continuously entering into the lake. Phosphate and nitrate showed a positive correlation with gross primary productivity and net primary productivity at station IV, II and III respectively establishing the direct influence of phosphate in productivity. Silicate was negatively related with gross primary productivity significant at station V and net primary productivity at station III. Diatoms contain silica in their cells up to an extent of 25 to 60% of their dry weight (Goldman and Horne, 1983). Since diatoms constitute a major fraction of the phytoplankton community, fluctuation in their abundance and the decline of silica has certain relationship. Thus the correlation analysis established a well defined relationship among the different physicochemical parameters of Sasthamkotta lake.

CHAPTER III - 2

MICROBIOLOGY

INTRODUCTION

In India, where sanitary and hygienic conditions are poor, public health in terms of bacterial infection are in a greater risk due to lack of efficient sewage disposal systems and monitoring (Rashid Umar *et al.*, 2001). A large number of microbial pathogens, which include several viruses, bacteria and some protozoa are of faecal origin and are transmissible via faecal-oral route of exposure (Herwaldt *et al.*, 1992; Kramer *et al.*, 1996). The primary concerns are concentrated point sources such as failed septic systems, leaking sewer lines and cesspools. Thus waterborne diseases are a serious health hazard in many parts of the world (Cairncross and Feacham, 1983, Morris and Levin, 1995).

In India, a few workers have paid attention to the bacterial quality of water. Venkateswaran and Natarajan (1987), Baveja *et al.* (1989), Shah and Patel (1989), Narain and Sharma (1995) and Fokmare and Kulkarni (1999) investigated on the bacteriological status of drinking water. Vaidya *et al.* (2001) studied the bacterial indicators of faecal pollution Bhavnagar coast. Bacteriological status of drinking water in Aakola city of Maharashtra was studied by Anil *et al.* (2002). A total of 56 coli strains were isolated from different drinking water sources of greater Guwahali area by Begum *et al.* (2003). Damodaran and Suresh (2005) assessed the seasonal variation of water quality along with Coliform bacteria for surface and subsurface water in Tirupati.

In Kerala, pollution at Cochin backwater with reference to indicator bacteria was studied by Gore *et al.* (1978). Lakshmanaperumaladasamy *et al.* (1981) studied the microbial indicators and pathogens near the mouth region of Vembanad lake. Physicochemical as well as microbial quality of drinking water in school wells of Trivandrum District was analysed by Pillai and Ouseph (2000). Bacteriological quality of well water samples of Ponnani was studied by Mujeeb

Rahiman *et al.* (2003). Water related parameters of water supply of Kollam Municipality was studied by Royee and Prakasam (2003). Girija *et al.* (2006) reported alarming number of coliforms in Sasthamkotta lake.

The 'coliform bacteria' though represents a vaguely defined group of organisms, has universally been used as the prime indicator to assess biological contamination of water (Barabas, 1986). The coliform group is defined as aerobic gram negative rods, which ferment lactose with gas production within 48 hours at 35° C (APHA, 1989). Badge and Varma (1991) studied the interaction between coliform bacteria and its aquatic environment. According to them, the population of bacteria influences the physical and chemical conditions of water. Generally coliforms occur abundantly in faeces and sewage but are also found in the environment in the absence of faecal contamination. Hence faecal coliform count is necessary to state whether the water body is contaminated with faecal matter.

Escherichia coli is found in the intestine of all warm blooded animals including man; in fact human faeces may contain as much as 5-50% *E.coli* (Escherich, 1885). Certain serotypes of *E.coli* (enteropathogenic *E.coli*) are pathogenic in the sense that they may cause diarrhea and a common cause of gastroenteritis (Geldreich, 1972; ICMSF, 1978; Rao and Gupta, 1978). About 14 antigenic types of *E.coli* have been reported to cause gastroenteritis (Dart and Sretton, 1980)

Faecal streptococci are members of the genus 'streptococcus' which was first coined by Billroth and Ehrlich (1877). These organisms are found in the stools of man and many other warm blooded animals (Bartley and Slanetz, 1960). In addition to their presence in faecal matter FS also exist in plants, birds and insects and in soil (Mundt, 1961, 1963). Because of their close association with the alimentary tract of man and animals, their presence is generally accepted as an indication of faecal contamination in water (Geldreich, 1974; Gore *et al.*, 1978). The overall impact of anthropogenic activities in the lake has resulted in the deterioration of the water quality. Human excreta have posed great threat to the potability of Sasthamkotta lake water. According to Nair (1988) during rainy season large quantities of faecal mater were drained into the lake. Prakasam (1991)

revealed alarming number of faecal coliforms in the surface waters of this lake. Scientific studies are meager in this area though this is the main drinking water source for lakhs of people. Therefore an attempt was carried out to assess the faecal indicating bacteria of the lake (Girija *et al.*, 2006).

METHODOLOGY

Water samples were collected from five different stations in Sasthamkotta Lake during November 2004 to October 2005. The sites selected are Vallakadavu (site 1), Bharanikkav (site 2), Near Concrete Bund (site 3), Manakara (near filter house, site 4), Rajagiri (site 5). Samples were collected in sterilized bottles and brought to the laboratory in iceboxes and examined within 4 hours after collection. The analysis was mostly confined to the essential characteristics of drinking water, as specified by BIS (1991). MPN (Most Probable Number) tube test is the technique (APHA, 1995) used for total coliforms (TC), faecal coliforms (FC), *Escherichia coli* (*E.coli*) and faecal streptococci (FS). Monthly data were pooled into seasonal data and statistical analysis was conducted.

RESULTS

Total coliforms (TC)

The results of the monthly variations of total coliforms of the water of Sasthamkotta Lake were presented in Fig. 3.2.1.

At station I, the highest count of total coliforms was 1747 MPN/100 ml in August and lowest was 1171 MPN/100 ml in February. At station II, maximum count was during July and August (2509 MPN/100 ml) and minimum during June (277 MPN/100 ml). Station III registered highest TC count 1327 MPN/100 ml in July and lowest 1033 MPN/100 ml in May. At station IV, 532 MPN/100 ml was reported during April and 224 MPN/100 ml in September. A maximum of 912 MPN/100 ml TC was observed during March and minimum of 439 MPN/100 ml in January at station V. TC count was comparatively very high at stations I, II and III.

The mean seasonal TC registered the maximum during post monsoon period except station IV and V and the minimum count during pre monsoon period was at stations I, IV, V. The results of ANOVA showed that the observed difference in TC count between stations and seasons was statistically significant ($P < 0.01$) (Table 3.2.1).

Faecal coliforms (FC)

The results of the monthly fluctuations in faecal coliforms of the water of Sasthamkotta Lake were given in Fig 3.2.2.

At station I, the highest count of faecal coliforms was 1491 MPN/100 ml in April and lowest was 699 MPN/100 ml in February. At station II, maximum count was during August (1233 MPN/100 ml) and minimum during May (166 MPN/100 ml). Station III registered highest FC count 304 MPN/100 ml in August and lowest 186 MPN/100 ml in February. At station IV, 64 MPN/100 ml was reported during March and 39 MPN/100 ml in September. A maximum of 292 MPN/100 ml FC was observed during April and minimum of 141 MPN/100 ml in February at station V. FC count was comparatively very high at stations I and II.

The FC count was high during monsoon period at stations I, IV, and V and during post monsoon at stations II and III and low during pre monsoon period except stations II and IV. The result of ANOVA showed that the observed difference in FC count between stations and seasons was statistically significant ($P < 0.01$) (Table 3.2.2).

Escherichia coli

The results of the monthly fluctuations in E.coli of the water of Sasthamkotta Lake were given in Fig 3.2.3.

At station I, the highest count of E.coli was 954 MPN/100 ml in March and lowest was 127 MPN/100 ml in January. At station II, maximum count was during November (167 MPN/100 ml) and minimum during April and June (22 MPN/100 ml). Station III registered highest E.coli count 144 MPN/100 ml in

July and August and lowest 48 MPN/100 ml in January and February. At station IV, 27 MPN/100 ml was reported during July, August, October and 7 MPN/100 ml in June. A maximum of 180 MPN/100 ml E.coli was observed during April and minimum of 8 MPN/100 ml in November, January and February at station V. E.coli count was comparatively high at stations I, II and III.

The E.coli count was high during post monsoon period at stations III and IV and during monsoon at station I and V and in pre monsoon at station II. The result of ANOVA showed that the observed difference in FC count between stations and seasons was statistically significant ($P < 0.01$) (Table 3.2.3).

Faecal streptococci (FS)

The results of the monthly fluctuation in count of faecal streptococci of the water of Sasthamkotta Lake were presented in Fig. 3.2.4.

At station I, the highest count of faecal streptococci was 83 MPN/100 ml in August and lowest was 48 MPN/100 ml in January. At station II, maximum count was during August (144 MPN/100 ml) and minimum during March, May and June (11 MPN/100 ml). Station III registered highest FS count 147 MPN/100 ml in July and lowest 57 MPN/100 ml in February. At station IV and V one to four MPN/100 ml FS was reported. FS count was comparatively high at stations I, II and III.

The mean seasonal FS registered the maximum during post monsoon period at all stations and the minimum during pre monsoon period except at stations II. The results of ANOVA showed that the observed difference in FS count between stations and seasons was statistically significant ($P < 0.01$) (Table 3.2.4). Correlation between the water quality parameters and bacterial indicators was given in Table 3.2.5.

Fig. 3.2.1. Spatial and temporal variation of *Total coliforms* at Sasthamkotta Lake

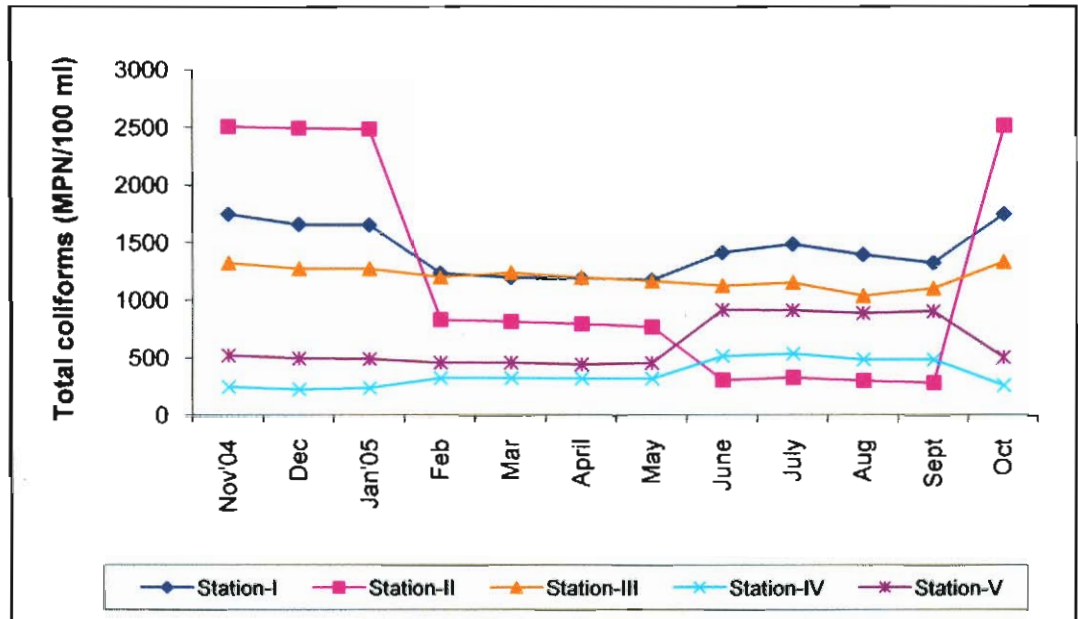


Fig. 3.2.2. Spatial and temporal variation of *Faecal coliforms* at Sasthamkotta Lake

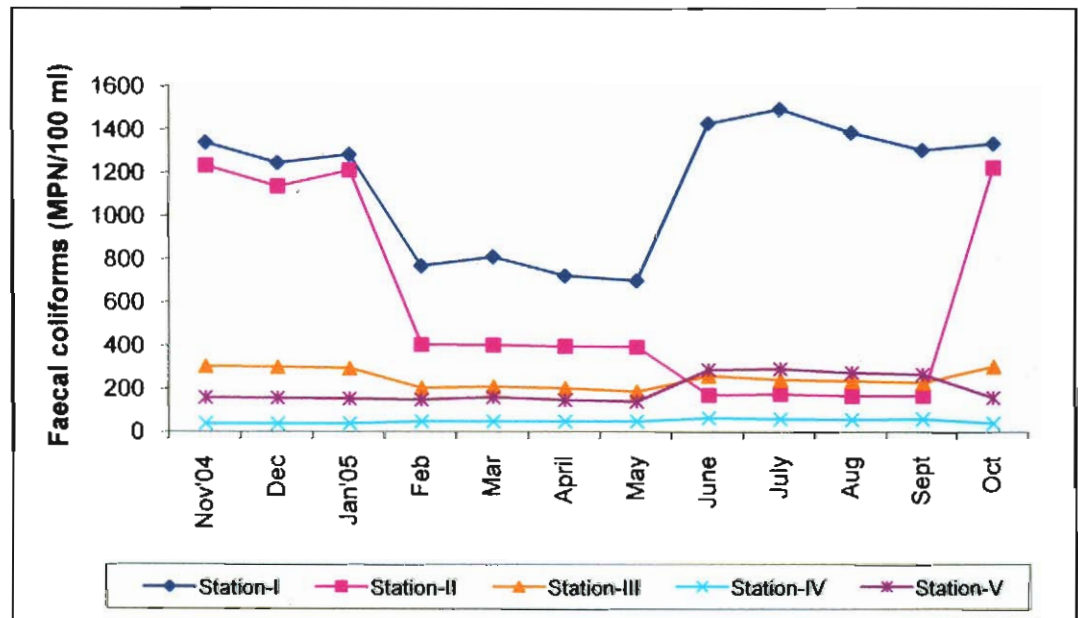


Table 3.2.1. Comparison of mean *Total coliforms* (MPN/100 ml) at different stations in different season (with ANOVA)

Station	Season	Mean	SD	F
I	Pre Monsoon	1200	24.8	95.9**
	Monsoon	1400	67.1	
	Post Monsoon	1700.5	53.2	
II	Pre Monsoon	800.5	29.1	11986**
	Monsoon	300	19.4	
	Post Monsoon	2500.5	10.3	
III	Pre Monsoon	1200.3	31.2	27.9**
	Monsoon	1100	49.3	
	Post Monsoon	1299.5	29.5	
IV	Pre Monsoon	320.3	3.4	250.8**
	Monsoon	500.3	26	
	Post Monsoon	240	12.7	
V	Pre Monsoon	450.3	8	1669.15**
	Monsoon	899.8	13.2	
	Post Monsoon	499.8	14.1	

**p < 0.01

Table 3.2.2. Comparison of mean *Faecal coliforms* (MPN/100 ml) at different stations in different seasons (with ANOVA)

Station	Season	Mean	SD	F
I	Pre Monsoon	749.8	49.4	137.58**
	Monsoon	1400.3	79.2	
	Post Monsoon	1299.5	44.6	
II	Pre Monsoon	399.5	5.5	1831.7**
	Monsoon	169.8	3.9	
	Post Monsoon	1200.5	43.3	
III	Pre Monsoon	200.5	10.2	102.83**
	Monsoon	239.8	13.3	
	Post Monsoon	300.5	3.9	
IV	Pre Monsoon	49.8	0.5	144.11**
	Monsoon	60.3	2.9	
	Post Monsoon	39.8	0.5	
V	Pre Monsoon	150	8.3	306.41**
	Monsoon	280	11.5	
	Post Monsoon	157.8	2.6	

**p < 0.01

Fig. 3.2.3. Spatial and temporal variation of *E. coli* at Sasthamkotta Lake

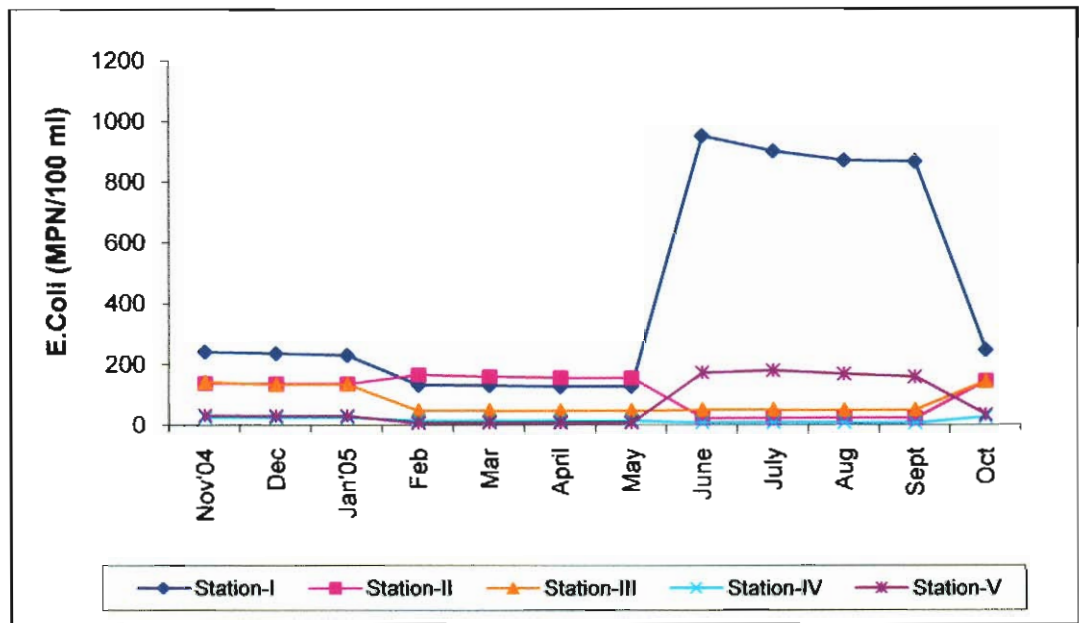


Fig. 3.2.4. Spatial and temporal variation of *Faecal streptococci* at Sasthamkotta Lake

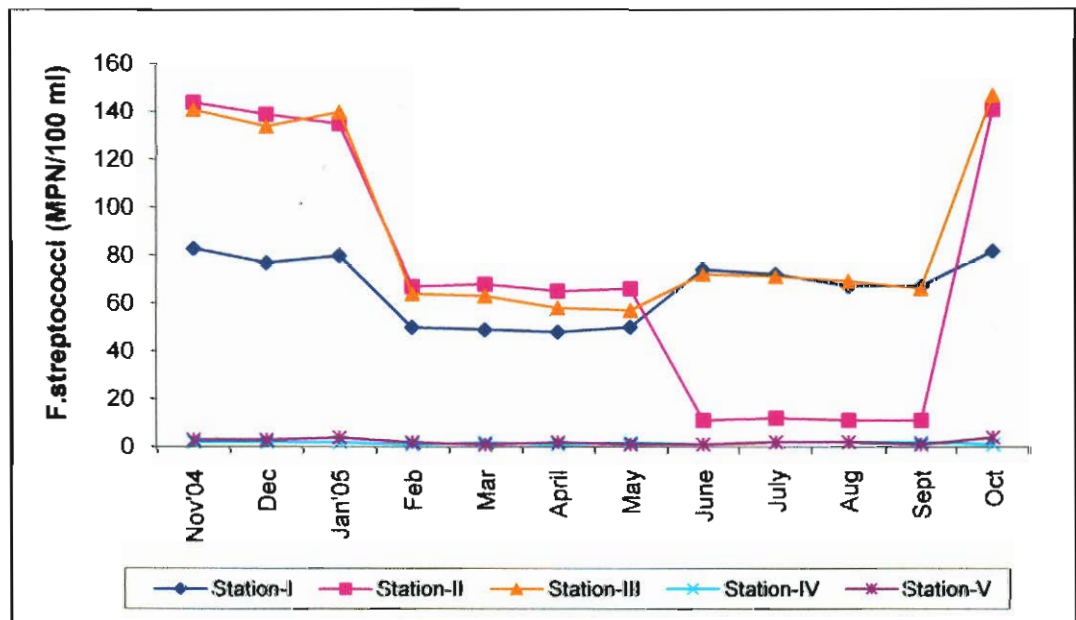


Table 3.2.3. Comparison of mean *Escherichia coli* (MPN/100 ml) at different stations in different seasons (with ANOVA)

Station	Season	Mean	SD	F
I	Pre Monsoon	129.8	2.8	1306.12**
	Monsoon	899.8	39.2	
	Post Monsoon	239.8	6.9	
II	Pre Monsoon	159.8	5.5	1501.44**
	Monsoon	22.8	1	
	Post Monsoon	140	3.6	
III	Pre Monsoon	48.5	0.6	1323.07**
	Monsoon	49.8	0.5	
	Post Monsoon	139.8	4.9	
IV	Pre Monsoon	16	0.8	933.64**
	Monsoon	7.8	0.5	
	Post Monsoon	26.8	0.5	
V	Pre Monsoon	8.3	0.5	1144.58**
	Monsoon	170	8.8	
	Post Monsoon	33	1.2	

**p < 0.01

Table 3.2. 4. Comparison of mean *Faecal Streptococci* (MPN/100 ml) at different stations in different seasons (with ANOVA)

Station	Season	Mean	SD	F
I	Pre Monsoon	49.3	1	147.44**
	Monsoon	70	3.6	
	Post Monsoon	80.5	2.6	
II	Pre Monsoon	66.5	1.3	3084.17**
	Monsoon	11.3	0.5	
	Post Monsoon	139.8	3.8	
III	Pre Monsoon	60.5	3.5	483.44**
	Monsoon	69.5	2.6	
	Post Monsoon	140.5	5.3	
IV	Pre Monsoon	1.5	0.6	0.3**
	Monsoon	1.8	0.5	
	Post Monsoon	1.8	0.5	
V	Pre Monsoon	1.5	0.6	16**
	Monsoon	1.5	0.6	
	Post Monsoon	3.5	0.6	

**p < 0.01

Table 3.2.5. Correlation between bacterial indicators with water quality parameters at different stations

Station-I

Parameters	Total Coliforms	Faecal Coliforms	E. Coli	Faecal Streptococci
Temperature	-.563	-.450	-.021	-.527
pH	.142	.297	.302	.181
DO	-.087	-.616*	-.793**	-.291
Nitrite	-.603*	-.335	.097	-.486
Nitrate	-.244	.023	.205	-.211
Phosphate	.316	.094	-.166	.234
Silicate	.271	.375	.326	.363
Potassium	-.462	-.402	-.108	-.484

Station-II

	Total Coliforms	Faecal Coliforms	E. Coli	Faecal Streptococci
Temperature	-.590*	-.593*	-.182	-.532
pH	.063	.069	.183	.111
DO	.499	.503	.775**	.621*
Nitrite	-.502	-.505	.012	-.411
Nitrate	-.327	-.330	-.427	-.387
Phosphate	.220	.227	.229	.231
Silicate	.135	.142	-.451	-.005
Potassium	.399	.391	-.245	.259

Station-III

	Total Coliforms	Faecal Coliforms	E. Coli	Faecal Streptococci
Temperature	-.523	-.309	-.465	-.426
pH	.134	-.265	-.214	-.228
DO	.422	-.109	.199	.124
Nitrite	-.092	-.176	-.168	-.162
Nitrate	-.198	-.034	-.214	-.164
Phosphate	-.088	-.336	-.301	-.296
Silicate	-.136	.390	.275	.297
Potassium	.229	.655*	.523	.574

Station-IV

	Total Coliforms	Faecal Coliforms	E. Coli	Faecal Streptococci
Temperature	.560	.649*	-.601*	-.554
pH	.044	.009	-.145	.341
DO	-.615*	-.503	.480	-.238
Nitrite	.075	.087	-.079	-.060
Nitrate	.448	.406	-.280	-.403
Phosphate	-.046	.053	-.012	-.718**
Silicate	.099	-.024	.022	.324
Potassium	-.044	-.179	.266	.244

Station-V

	Total Coliforms	Faecal Coliforms	E. Coli	Faecal Streptococci
Temperature	-.031	.005	-.040	-.423
pH	.154	.177	.137	-.527
DO	-.446	-.491	-.456	.322
Nitrite	-.064	-.051	-.119	-.683*
Nitrate	.629*	.667*	.646*	-.246
Phosphate	.102	.107	.067	-.434
Silicate	.325	.280	.359	.262
Potassium	.256	.216	.264	.370

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

DISCUSSION

In the present study, among the faecal indicating bacteria in water TC, FC dominated over E.coli and FS. FC count was usually higher because FC originates from non-faecal sources also (Geldreich, 1974). Similar higher FC counts have been reported by Rittenberg *et al.*, (1958) in the estuaries of Scotland, by Lakshmanaperumal Swami *et al.* (1981) in the mouth region of Vembanad Lake, by Abhaykumar (1990) in the tropical muddy coast of Bhavnagar, in Sasthamkotta lake by Prakasam (1991) and by Mathew (2001) in Pampa river.

According to Valecha *et al.* (1988), total coliforms indicate the degree of pollution which has been further supported by the observation of Trivedy *et al.* (1988).

Mujeeb Rahman *et al.* (2003) conducted studies on well waters from Ponnani and reported that TC ranged between 40 and 11,000 per 100 ml. The mean values reported for FC and FS were 3,640 and 1,714 per 100 ml, respectively. Vaidya *et al.* (2001) reported that the range of FC and FS in Bhavnagar coast was very high. In River Nunia, Chinmoy Chatterjee and Riaziuddin (2002) reported TC at the range of 94 to 1,600 MPN/100 ml and FC at the range of 6 to 170 MPN/100 ml. Comparable to these values higher bacterial counts were obtained in the present study. The acceptable limit of MPN/100 ml prescribed for drinking purpose by Indian standard Limit is < 10 total coliforms per 100 ml and 0 for faecal coliforms. For bathing the acceptable limit is 500 MPN/100 ml for total coliforms and 100 MPN/100 ml for faecal coliforms (Singh and Singh, 1995). The sample values observed in the present study in Sasthamkotta lake water exceeded the prescribed limit.

In the present study, maximum numbers of pathogenic organisms were noted in post monsoon and monsoon seasons. Lowest population was in the pre monsoon period. Nair (1988) revealed that during rainy season large quantities of faecal matter were drained into the lake. This is the reason for the increased bacterial count during monsoon and post monsoon months. Monsoon abundance was attributed to the addition of higher levels of suspended matter and nutrients

by the influx of rain water. Similar observations were made by Ward *et al.* (1985), Venkateswaralu (1986), Prajapathi and Mathur (2002) and Damodaran and Suresh (2005).

The present study showed that Vallakadavu station (SI) of the lake was the most contaminated site for all the four bacteria studied. This might be due to the increased anthropogenic intervention in the station. Bathing and washing of human and cattle is a usual seen here. Joseph (1994) reported that human excreta were the main source of faecal pollution in the lake. Station IV near the filter house was comparatively less polluted since this area is protected by the Government of Kerala and anthropogenic intervention was low. Another reason for the low bacteria was due to the increased chlorine content in the water which was entering as a result of the waste water discharge after the water treatment. Royee *et al.* (2003) reported that higher residual chlorine reduces the number of faecal coliforms in water.

It was evident from the present study that the lake water was getting polluted. This increase in the load of bacterial pathogens might be due to the frequent discharge of city drainage, domestic sewage, agricultural run off, leakage of septic tank, open toilet system, and non availability of sanitary latrine facilities. Since the lake is surrounded by small sloppy hills which hasten the process of seepage of these from the catchment area into the lake.

CHAPTER IV
SEDIMENTOLOGY

CHAPTER IV

SEDIMENTOLOGY

INTRODUCTION

Sediments are regarded as the storehouse of essential elements of productivity in overlying water and even pollutants. Sedimentology components have a vital role in regulating the characteristics of the aquatic ecosystem. A comprehensive idea of the bottom sediment is thus a prerequisite in water quality management procedures.

Sediment analysis of aquatic environment has greater attention in the world's scientific scenario due to growing awareness of environmental pollution and its impact on ecosystem. Sediments act as the ultimate recipient of all pollutants entering into aquatic systems. The nature and extent of pollution can be understood by sediment analysis. It directly affects the quality and composition of water. The sediments may govern the nutrient economy of the aquatic ecosystem and knowledge on the role of sediment nutrients is useful to determine the sediment water interactions, which eventually affect the productivity (Nair *et al.* 1984 d).

Quantitative analysis of the size distribution of particles is important in sediment transport studies, stratigraphic correlations, mapping, assessing modern and post-geological environments, geo-technical studies, and surface reactions (Lewis, 1984; McCave and Syvitski, 1991). Particle size distribution can, particularly in glaciated terrains, reflect mineralogical partitioning and this is an indicator of variations in the physical and chemical properties of sediments. (DiLabio, 1995; Shilts, 1995). In addition, spatial and temporal variability of trace element concentrations in sediments have been attributed, in the past, to particle size (Jones and Bowser, 1978; Jenne *et al.* 1980; Forstner and Wittmann, 1981; DeGroot *et al.* 1982; Barbanti and Bothner, 1993).

A strong correlation between concentrations of contaminants and fine-grained particle size of sediments has been observed in many studies

(Ackermann, 1980; Forstner, 1982; Mudroch, 1984). Further, concentration of organic carbon, which is known to bind different contaminants, is inversely related to the proportions of sand-sized and directly to the silt and clay-sized sediment particles (Damiani and Thomas, 1974). Barbanti and Bothner (1993) suggested that texture (i.e., grain size) may control trace metal contaminant concentration in marine sediments. It is well known that fine-grained sediments are more 'reactive' because of their higher surface area and adsorption capacity, than coarse-grained sediments (Forstner and Salomons, 1980). The clay-sized fraction preferentially adsorbs contaminants due to its high cation exchange capacity. Besides, it is the first to yield anthropogenically derived or naturally occurring trace elements as a result of sediment disturbance (Shilts, 1995).

Extensive work has been done on the geochemistry of several aquatic systems of the world: the Mackenzie river (Reeder *et al.*, 1972) the Mississippi (Trefrey and Presley, 1976; Moody *et al.* 2000; Soong Ta Wei and Ettinger, 2000), the Rhine (Duinker and Notling, 1976), the Amazon and Yacon (Gibbs, 1977), the Zaire (Meybeck, 1978) and the Chang Jiyang and Don Jaing rivers (Qu and Yan, 1990).

In India, Pillai and Sreenivasn (1975) worked on sediments on inland water bodies of Tamil Nadu. Banerjee (1967), Mollah *et al.* (1979) and Raghavan *et al.* (1986) studied the sediments of many fresh water bodies. Das (1989) studied the Dal lake in Kashmir. Dwivedi *et al.* (1986) in Kulgarhi reservoir, Goel and Chavan (1991) in a polluted fresh water tank, Ayyappan *et al.* (1991), studied the sediment water interactions. Sedimentological analysis of the Kali estuary was made by Bhat and Neelakantan (1988). According to Palmer *et al.* (1997) fresh water sediments contain an enormous variety of species, which involve in processing of organic carbon, recycling of nitrogen and breaking down of contaminants. Physical stability and substratum parameters like channel dynamics, bed form and sediment size were important in sustaining the ecological integrity of running waters (Geoffrey, 2000).

In aquatic ecosystems, anthropogenic interference can change the physical and chemical characters of the sediment (Ansari *et al.* 1994). Sediments are

indicators of the overlying water column and sedimentological study is useful in assessing environmental pollution. Sediments absorb organic and inorganic compounds and also release these to the overlying water column. Sedimentary organic matter is an important source of nutrients to water. The release of nutrients to water can promote algal growth and thus primary productivity is enhanced (Suess, 1976).

Organic carbon content of the sediment indicates a definite relationship with the texture and depth. Organic carbon content in the sediment is mainly responsible for the rate of primary production, dissolved oxygen content, water depth, sedimentation rate, biological activity and sediment stability. The Organic carbon content of the sediments can be a sensitive indicator of the nature of the sources, areas about the environment of deposition (Emerson and Hedges, 1988). Organic carbon plays a major role in controlling the redox potential of the sediment, thereby regulating the behaviour of the other chemical species.

Nitrogen is one of the important nutrients for phytoplankton growth in the marine environment (Ryther and Dunston, 1971; Thayer, 1974). Seasonal changes in the concentration of nitrogen changes the phytoplankton biomass and regulates primary productivity.

Phosphorus is a major component of living things. The main source of phosphorus in the aquatic system sediments are from commercial fertilizers, animal manures, plant residues including green manures (organic and inorganic) and withering of rocks. Aquatic sediments act as a reservoir for phosphorus, by retaining it by absorption and releasing it into the overlying water. The phosphorus content of the sediment is closely related to the organic content of the sediment (Murty and Veerayya, 1972). They also pointed out the close relationship between the phosphorus content of the sediment and its textural characteristics. Phosphorus occurs in the sediment as phosphate in both organic and inorganic forms, and is an indication of pollution. Phosphorus being an important constituent of biological systems, act as a growth limiting factor and regulating the production and biomass of an ecosystem (Righler, 1973; Nair and Balchand, 1992). When the bottom water

becomes anoxic, there is a major release of phosphate from the sediment to the overlying water (Mortimer, 1971).

Potassium is a naturally occurring element and the concentration remains quite low. The major source of potassium in natural waters is the weathering of rocks and disposal of wastewater.

Living organisms can influence the composition of sediment significantly. The dominant factor in sediment transport is the motion of water itself. Sedimentology materials may be transported in a number of ways depending upon the water velocity. The studies on the chemical characteristics of the sediments are useful in assessing the water quality and management of the ecosystem. The present investigation includes a study of textural characteristics of sediments, monthly and seasonal variation of Soil pH, Soil conductivity, organic carbon, total nitrogen, total phosphorus and potassium of Sasthamkotta fresh water lake.

METHODOLOGY

Sediment samples for sedimentological analysis were collected from five stations using a PVC corer (35 cm length and 8 cm diameter). The sampling was made monthly from November 2004 to October 2005 for textural analysis, pH, conductivity measurements and nutrient estimation.

Texture

Textural analysis of the sediment was carried out by the 'Pipette method' described by Carver (1971). This analysis is based on the calculation of the settling velocity of particles of different 'size' (Stroke's law) assuming that all particles are of the same shape and density. The various size fractions of the sediment are then computed from their respective settling velocities.

Hydrogen ion concentration (pH)

The pH of the sediment sample was measured using 1:5 sediment suspensions in distilled water with the help of Elico digital pH meter (Elico, Model No. LI – 10 pH meter, India).

Conductivity

Conductivity was measured using conductivity meter (Systronix, India).

Organic carbon

Sediment organic carbon was determined by chromic acid oxidation method (Wakeel and Riley, 1957).

Nutrients

Total Phosphorus content of sediment sample was measured by the modified method of Murphy and Riley (1962). Total nitrogen is measured by Kjeldhal method described by Barnes (1959). Potassium ions were determined using flame photometer based on the procedure described in APHA (1995).

RESULTS

Sediment texture

The results of sediment texture analysis of the lake are presented in Fig. 4.1. The sediment of Sasthamkotta lake was composed of sand, silt and clay. Clay constituted the major component of the sediment at all stations followed by silt and sand. The highest clay content noted at these stations was 72.3% at station IV and the lowest at station I (47%). Silt concentration was maximum at station I (52%) and lowest at station IV (26.2%). Sand content was highest at station II (3%) and lowest at station I (0.9%) (Table 4.1).

Hydrogen ion concentration (pH)

The results of the monthly variations of sediment pH at the five stations along Sasthamkotta lake are given in Fig. 4.2. The sediment pH ranged between four at station IV and 7.06 at station III. The mean seasonal sediment pH registered the maximum during monsoon and post monsoon at all stations, except stations IV and the minimum during the pre monsoon period except at stations I and IV (Table 4.2).

Conductivity

The monthly variations of sediment conductivity at the five stations along the lake water are given in Fig. 4.3. The conductivity ranged between 4.4 mmhos/cm at station IV and 27.2 mmhos/cm at station III. The mean seasonal sediment conductivity registered the maximum during monsoon at all stations, except stations II and the minimum during the pre monsoon period except stations II and III, where it was the lowest during post monsoon (Table 4.2).

Organic carbon

The monthly variations of sediment organic carbon at the five stations were given in Fig. 4.4. The sediment organic carbon content ranged from 0.034 mg g⁻¹ at station V to 2.642 mg g⁻¹ at station III. Sediment organic carbon was the maximum during post monsoon period at all stations except stations II and III where it is maximum during pre monsoon and the minimum during monsoon at all stations (Table 4.2).

Total nitrogen

Monthly variation of the total nitrogen content at different stations was illustrated in Fig. 4.5. Total nitrogen content varied from 0.081 mg g⁻¹ at station V to 2.52 mg g⁻¹ at station III. The mean seasonal total nitrogen registered the maximum during the pre monsoon period at stations III, during monsoon at station II and IV and during post monsoon at stations I and V (Table 4.2).

Total Phosphorus

The monthly variations of total phosphorus at the five stations along the lake water are given in Fig. 4.6. The total phosphorus ranged between 0.005 mg g⁻¹ at station V and 0.204 mg g⁻¹ at station II. The mean seasonal total phosphorus registered the maximum during post monsoon at stations II, III and V; during monsoon at station IV and during pre monsoon at station I (Table 4.2).

Potassium

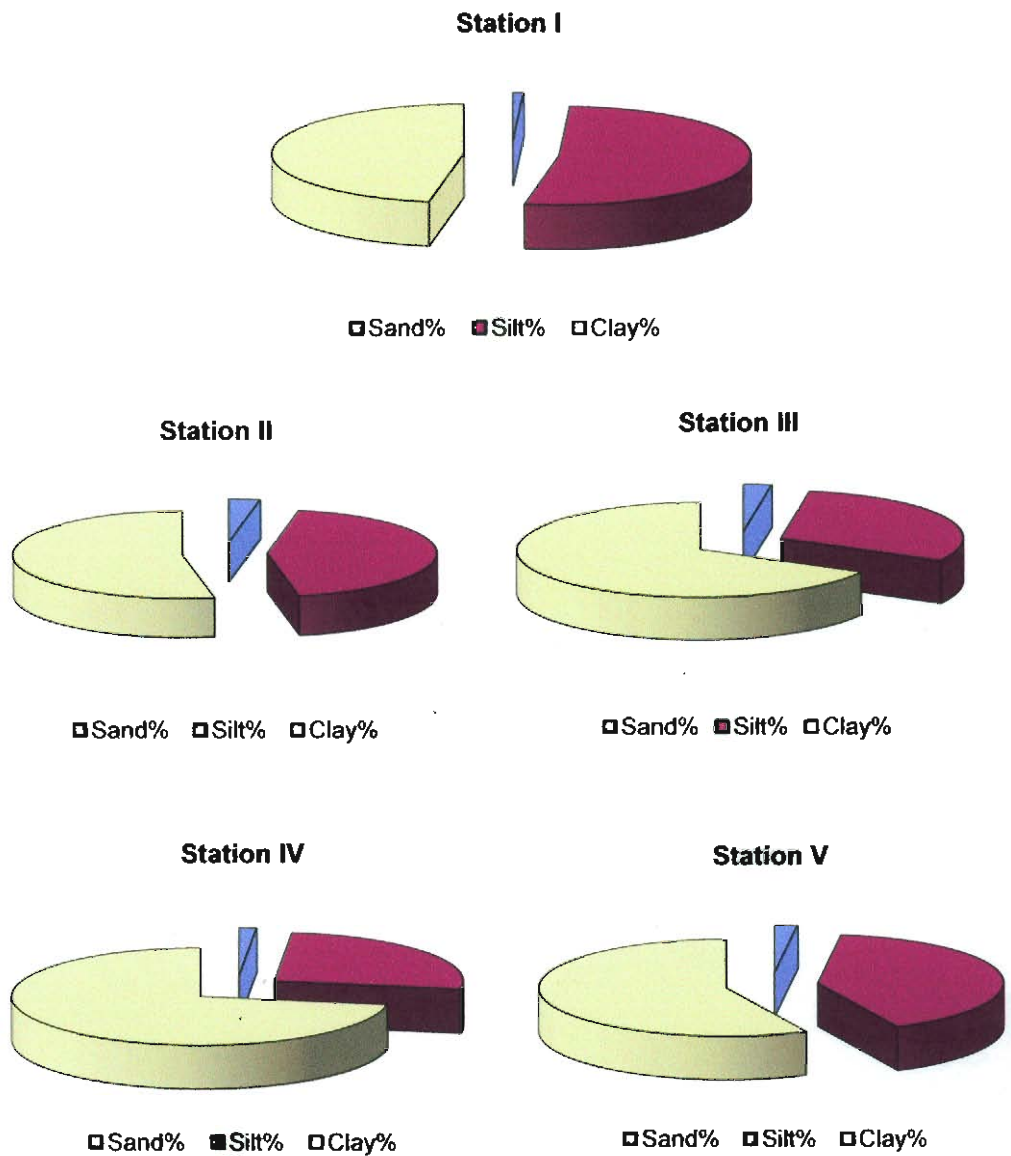
The monthly variations of potassium at the five stations along the lake sediment were given in Fig. 4.7. Potassium ranged between 0.007 mg g^{-1} at station V and 0.26 mg g^{-1} at station I. The mean seasonal potassium registered the maximum during the monsoon period at stations I, IV and V and during pre-monsoon at stations II and during post monsoon at station III (Table 4.2).

CORRELATION

At station I, organic carbon was positively correlated with conductivity total nitrogen and potassium. Total phosphorus was negatively correlated with pH, organic carbon and Total nitrogen. Potassium is positively correlated with pH, conductivity (Table 4.3). At station II, Total nitrogen was positively correlated with pH and negatively with potassium and total phosphorus. Total phosphorus was negatively correlated with pH. Potassium is negatively correlated with pH, conductivity and total nitrogen and positively with organic carbon.

At station III total nitrogen is negatively correlated with conductivity and potassium whereas positively correlated with pH and organic carbon. Total phosphorus and potassium are negatively correlated with pH and positively correlated with conductivity. Total phosphorus and potassium are positively correlated. At station IV, organic carbon was positively correlated with pH. Total nitrogen and potassium are positively correlated with conductivity. Total phosphorus and pH were positively correlated. Potassium was negatively correlated with organic carbon and positively correlated with total nitrogen. At station V, conductivity and organic carbon were positively correlated with pH and negatively correlated with total phosphorus. Total phosphorus was negatively correlated with conductivity and total nitrogen. Potassium was positively correlated with total nitrogen.

Fig 4.1. Spatial distribution of Sand, Silt and Clay at different Stations of Sasthamkotta Lake



TEXTURAL ANALYSIS			
Stations	Sand%	Silt%	Clay%
I	0.9	52	47.1
II	3	44	53
III	2.5	30.5	67
IV	1.5	26.2	72.3
V	2	41	57

Table 4.1 Seasonal mean (\pm) of various geochemical parameters of different stations at Sasthamkotta Lake.

Parameters	Stations	Premonsoon	Monsoon	Postmonsoon
pH	I	5.58 \pm 0.41	6.03 \pm 0.132	5.55 \pm 0.31
	II	5.68 \pm 0.78	5.33 \pm 0.14	5.83 \pm 0.103
	III	5.67 \pm 0.35	6.29 \pm 0.40	5.89 \pm 0.164
	IV	5.43 \pm 0.48	5.40 \pm 0.262	5.23 \pm 0.625
	V	4.94 \pm 0.26	5.30 \pm 0.21	4.95 \pm 0.34
Conductivity	I	10.31 \pm 1.05	18.85 \pm 3.48	15.475 \pm 1.38
	II	13.10 \pm 2.56	10.28 \pm 0.18	7.912 \pm 0.685
	III	19.53 \pm 4.15	21.333 \pm 1.14	13.98 \pm 1.32
	IV	6.08 \pm 1.04	18.13 \pm 0.64	15.15 \pm 1.77
	V	7.58 \pm 0.46	11.33 \pm 1.41	10.73 \pm 1.34
Organic carbon	I	0.216 \pm 0.016	1.53 \pm 0.166	1.98 \pm 0.181
	II	1.479 \pm 0.174	0.833 \pm 0.162	1.45 \pm 0.693
	III	2.299 \pm 0.842	1.63 \pm 0.221	2.29 \pm 0.254
	IV	0.789 \pm 0.215	1.438 \pm 0.20	15.15 \pm 1.77
	V	0.505 \pm 0.064	1.27 \pm 0.023	1.65 \pm 0.14
Total Nitrogen	I	0.418 \pm 0.16	0.723 \pm 0.05	1.27 \pm 0.19
	II	1.136 \pm 0.052	1.23 \pm 0.524	0.531 \pm 0.699
	III	2.32 \pm 0.96	1.59 \pm 0.22	1.69 \pm 0.97
	IV	0.789 \pm 0.331	1.119 \pm 0.124	0.655 \pm 0.639
	V	0.588 \pm 0.26	0.446 \pm 0.126	0.977 \pm 0.474
Total Phosphorous	I	0.129 \pm 0.012	0.40 \pm 0.036	0.41 \pm 0.05
	II	0.253 \pm 0.047	0.255 \pm 0.033	0.124 \pm 0.27
	III	0.55 \pm 0.074	0.59 \pm 0.029	0.144 \pm 0.024
	IV	0.158 \pm 0.0333	0.1385 \pm 0.189	0.136 \pm 0.228
	V	0.763 \pm 0.084	0.0805 \pm 0.014	0.252 \pm 0.025
Potassium	I	3.13 \pm 0.043	0.246 \pm 0.027	0.15 \pm 0.022
	II	0.1008 \pm 0.057	0.1005 \pm 0.0606	0.630 \pm 0.0414
	III	0.63 \pm 0.0414	0.685 \pm 0.036	0.913 \pm 0.068
	IV	0.155 \pm 0.136	0.182 \pm 0.28	0.925 \pm 0.303
	V	0.18 \pm 0.0414	0.188 \pm 0.059	0.945 \pm 0.052

Fig. 4.2. Spatial and temporal variation of Hydrogen ion concentration

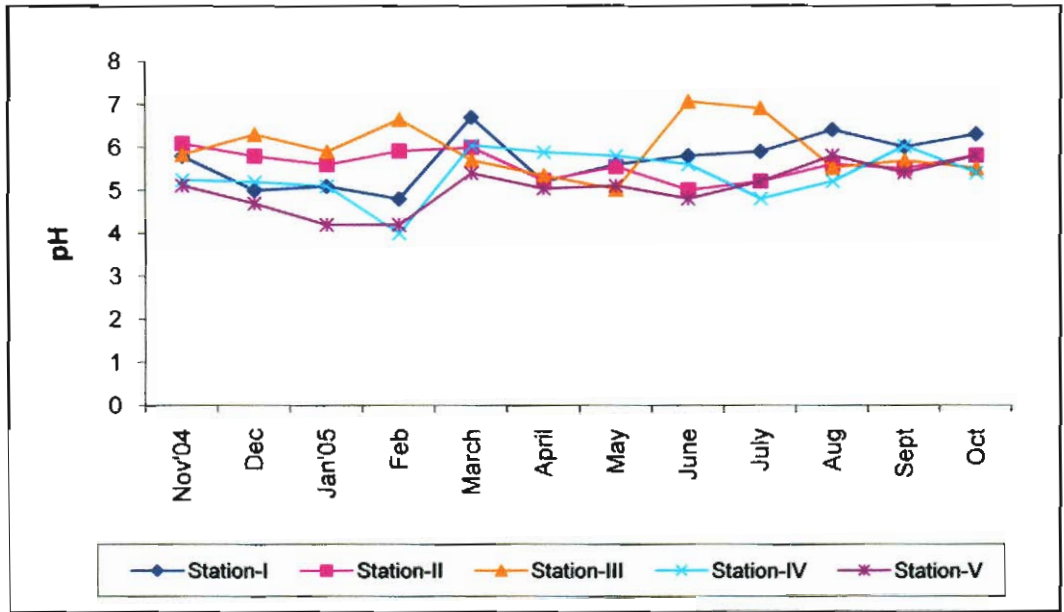


Fig. 4.3. Spatial and temporal variation of Conductivity

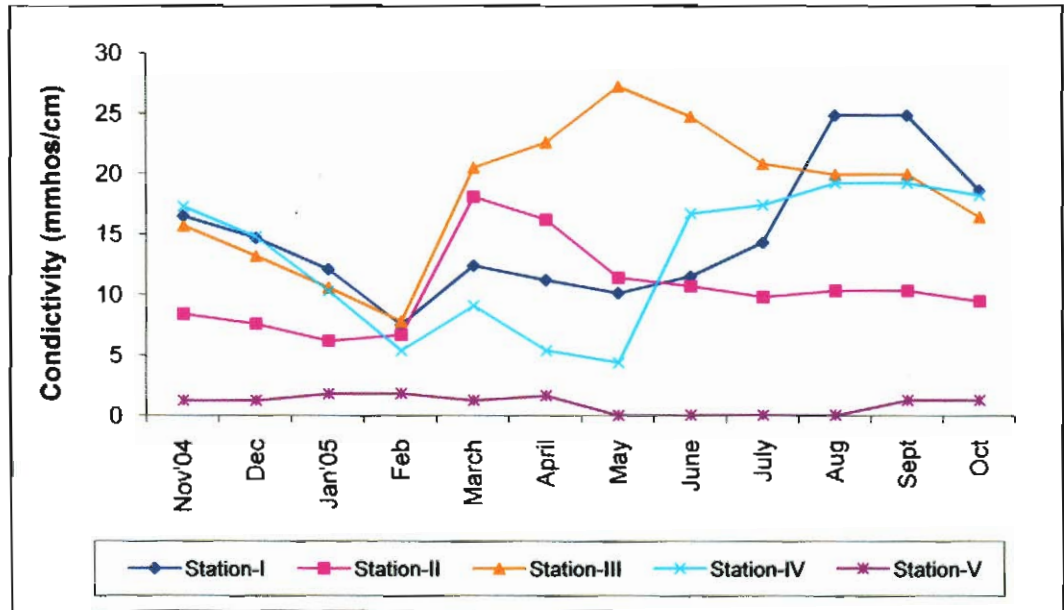


Fig. 4.4. Spatial and temporal variation of Organic Carbon

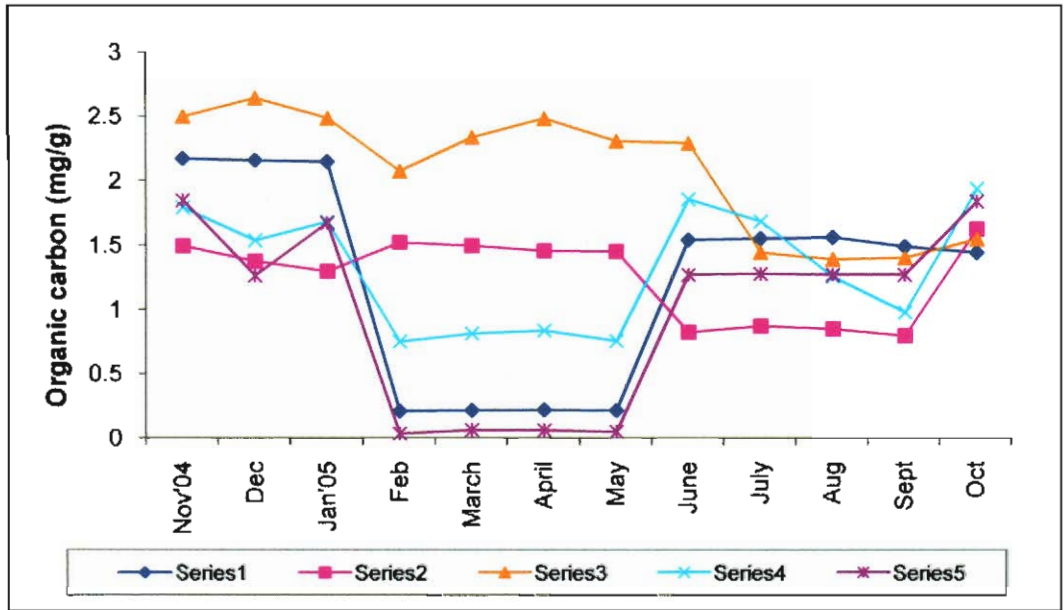


Fig. 4.5. Spatial and temporal variation of Total Nitrogen

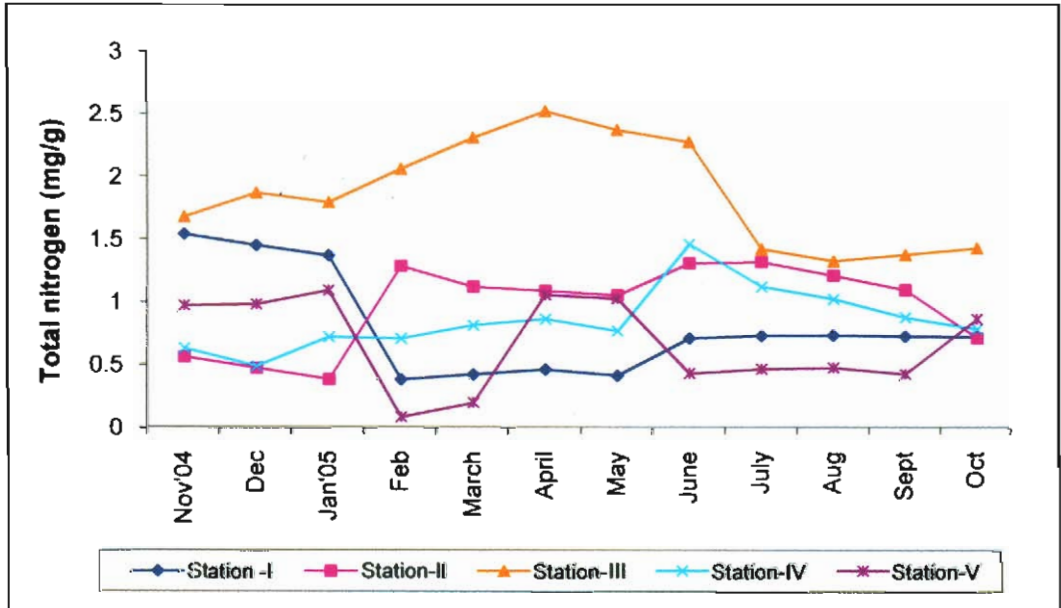


Fig. 4.6. Spatial and temporal variation of Total Phosphorous

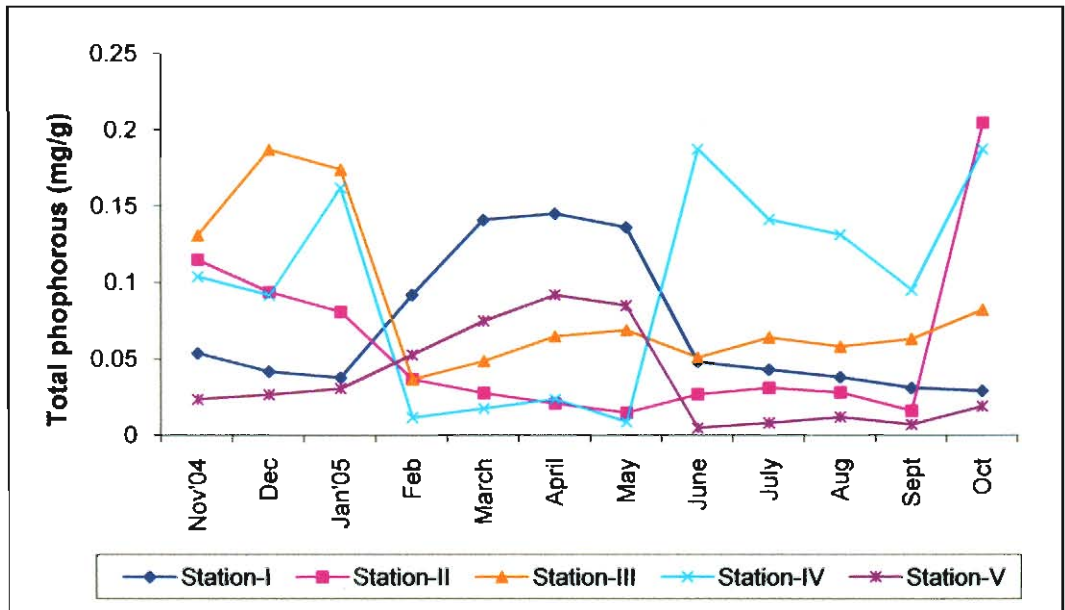


Fig. 4.7. Spatial and temporal variation of Potassium

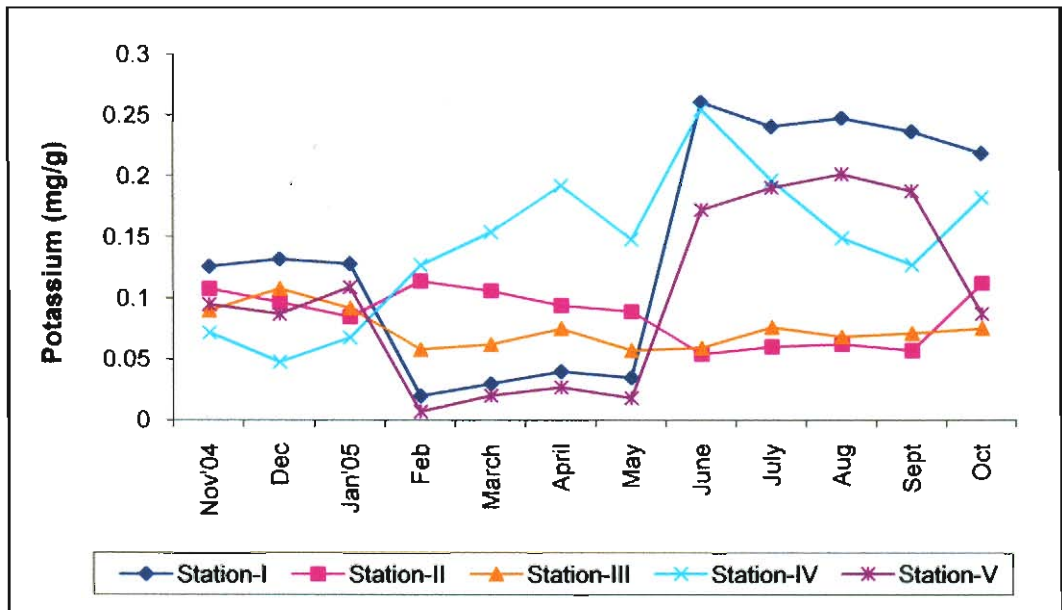


Table 4.2 Correlation between various geochemical parameters at different stations of Sasthamkotta Lake

Station-I

Parameters	pH	Conductivity	O. Carbon	T. Nitrogen	T. Phosphorus	Potassium
pH	1					
Conductivity	.535	1				
Organic Carbon	.596	.695*	1			
Total Nitrogen	.178	.305	.896**	1		
T. Phosphorus	-.872*	-.928	-.913**	-.637*	1	
Potassium	.999*	.996*	.628*	.218	-.891**	1

Station-II

Parameters	pH	Conductivity	O. Carbon	T. Nitrogen	T. Phosphorus	Potassium
pH	1					
Conductivity	.100	1				
Organic Carbon	-.637*	-.912**	1			
Total Nitrogen	.996*	.346	-.700*	1		
T. Phosphorus	-.981*	-.074	.477	-.961**	1	
Potassium	-.665*	-.896**	.999**	-.726*	.509	1

Station-III

Parameters	pH	Conductivity	O. Carbon	T. Nitrogen	T. Phosphorus	Potassium
pH	1					
Conductivity	-.212	1				
Organic Carbon	-.048	-.033	1			
Total Nitrogen	.743*	-.795*	.633*	1		
T. Phosphorus	-.902**	.864**	.474	-.381	1	
Potassium	-.995**	.984**	.143	-.676*	.939**	1

Station-IV

Parameters	pH	Conductivity	O. Carbon	T. Nitrogen	T. Phosphorus	Potassium
pH	1					
Conductivity	.196	1				
Organic Carbon	.701*	-.354	1			
Total Nitrogen	.250	.984**	-.516	1		
T. Phosphorus	.983**	.579	.557	.424	1	
Potassium	-.072	.875*	-.762*	.948**	.113	1

Station-V

Parameters	pH	Conductivity	O. Carbon	T. Nitrogen	T. Phosphorus	Potassium
pH	1					
Conductivity	.732*	1				
Organic Carbon	.958**	.812*	1			
Total Nitrogen	.443	.125	.680	1		
T. Phosphorus	-.962**	-.819*	-1.000	-.672*	1	
Potassium	.159	-.173	.434	.956**	-.424	1

* Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level

DISCUSSION

Texture, which deals with size, shape and mutual relationship among the particles constituting the sediments, is a basic descriptive measure of sediments and it is an important abiotic measure determining the living conditions of the aquatic biota.

The sediment collected from Sasthamkotta lake was sticky and smooth when moist and it formed hard clodes when dry as reported by Joseph (1994). In the present study clay constituted the major component of the sediment (range = 47% to 72%) followed by silt (range = 26% to 52%) and sand (range = 0.9% to 3%). According to the classification of USDA (1960), silty clay is one which contains 0 - 20% sand; 40 - 60% silt and 40 - 60% clay. Clay contains 0 - 45% sand, 0 - 40% silt and 40-100% clay. Thus it can be inferred that the sediment composition of the present lake was clay or silty clay which is in agreement with the observation of Joseph (1994).

The sediments of aquatic system are very important, as they influence the type of organisms living there, especially the plants and the benthic animals. The chemical composition of the soil is the major factor affecting the plant growth, besides water quality and climatic features. As the infiltrating waste water migrates to the soil media, it is attenuated by ion exchange, dilution, dispersion, complexing and filtration. Measurement of pH provides a good indication of the chemical nature of sediment. Assessment of soil's fertility status involves an estimation of its available nutrient status (Murali and Swaruprani, 2005). Sediments also influence the exchange of nutrients between the sediment and water (Petr, 1976; Bostrom *et al.*, 1982)

In Sasthamkotta lake, pH of the surface sediment ranged from 4 to 7, showing its acidic or neutral character. Similar acidic nature of the sediment was recorded by Dwivedi *et al.* (1986) in Kulgarhi reservoir and by Goel and Chavan (1991) in a fresh water tank. In poorly oxygenated mud layers the decomposition of organic matter was slow and the products of decomposition were mainly reduced or partially oxidised to compounds like Hydrogen sulphide, methane and

short chain fatty acids. Production of these compounds made the soil strongly acidic and reduced the rate of bacterial decomposition, ultimately leading to less productivity (Banerjea, 1967).

Since ions are the carriers of electricity, the electrical conductivity of the sediment water system rises according to the content of soluble salt concentration of the soil at any particular temperature (Murali and Swaruprani, 2005). Here the conductivity ranged between 4.4 mmhos/cm to 27.2 mmhos/cm. Monsoon season registered a maximum conductivity at all stations in the present study. The high electrical conductivity reported in this lake during monsoon may be due to the influx of rain water and land run off from the catchment area of the lake.

Organic carbon in sediments is regarded as the residue of organic life, and this becomes more abundant with the development and diversification of life. Organic carbon is important as an energy source for organisms in aquatic systems. The organic carbon content of sediments depends on the supply of organic matter to the environment, the rate of deposition of organic and inorganic constituents, the rate of decomposition and the texture of the sediment (Stewart, 1958). The organic content of the sediments can serve as a sensitive indicator of the nature, source, areas and environment of the deposition (Emerson and Hedges 1988).

The amount of organic material within the sediments influences to a considerable extent the physical and chemical properties of sediment such as water retention capacity, porosity and compressibility. In the present study the organic carbon of the sediment varied between 0.034 mg g⁻¹ at station V to 2.642 mg g⁻¹ at station III. Low organic carbon content was reported in Mandovi estuary, Goa (between 0.10 and 3.0 mg g⁻¹) (Alagara Samy, 1991), in Pampa river (between 0.6 and 1.39 mg g⁻¹) (Mathew Koshy, 2001). Higher organic content in Sasthamkotta lake sediment was reported by Prakasam and Joseph (1992). But comparatively low organic carbon was reported in the present study.

The sediment organic carbon content registered the maximum during post monsoon and minimum during monsoon season. The reduced flow of surface water after monsoon might have led to an increased load of waste in the water column. Decomposition and decay of plant materials from the surrounding area,

grain size of the sediment and the poor water flow might have contributed to the high concentration of organic matter during this period. A similar situation was noted by Mathew Koshy (2001) in Pampa river and by Krishna Kumar (2002) in Neyyar and Karamana rivers.

In Sasthamkotta lake, the sediment nitrate values ranged between 0.081 mg g^{-1} to 2.52 mg g^{-1} . This is higher than the value observed by Joseph (1994) in the same lake. Das (1989) reported similar observations in Hazrat Bal of Dal lake. No specific seasonal trend was observed in the distribution of sediment nitrogen which can be due to the homogeneity of the lake sediment. The high nitrogen content reported at station III was due to the influx of agricultural fertilizers from the catchment area.

Sedimentation of organic and inorganic allochthonous matter, organic autochthonous material, and uptake by sediment biota, adsorption to sediment particles and fixation to inorganic compounds in lake water are the several mechanisms for phosphorus deposition in lakes (Bostrum *et al.*, 1988). In Sasthamkotta lake, the sediment phosphorus ranged from 0.005 mg g^{-1} to 0.204 mg g^{-1} . Specific seasonal trend was not observed in the case of total phosphorus in the lake. According to OECD, 2006 eutrophication is controlled by phosphorus concentration. Present study showed that the phosphorus content of the lake sediment is within the limited range and that was the reason why macrophytes were absent in the lake except in certain pockets. Bindu and Harikumar (2007) reported that phosphorus concentration was directly proportional to eutrophication.

Potassium is a naturally occurring element and needed by plants. However in aquatic habitats, plants are less influenced by the variations in the concentration of this element when compared to terrestrial conditions (Jhingran, 1982). The range of available potassium in the present lake was between 0.007 mg g^{-1} at station V to 0.26 mg g^{-1} at station I. The distribution of available potassium in the sediment of Sasthamkotta lake was not uniform. Considerably higher values were recorded from Vallakadavu station (station D). Concentration of potassium may increase due to the disposal of waste (Trivedi and Goel, 1986; Prasanthan, 1999).

The basic reason for the discrepancy from station to station can be due to the influx of allochthonous sources as there are differences in local land use pattern. In certain parts of the catchments, farmers are using potash fertilizers for cultivation also reaches ultimately into the lake.

The low concentration of potassium might be due to the presence of heavy sand deposition and diminished organic detritus. Nair *et al.* (1983a) suggested that the organic detritus associated with potassium entered the system mainly by leaching and Serruya (1971) stated that potassium is generally associated with detritic silicates and their paucity in lake sediment may indicate the predominance of leaching over erosion.

Sediment consists of several factors which interact with each other. In the present study in Sasthamkotta, strong positive correlation was noted between total nitrogen and organic carbon at station I and III. Pillai and Sreenivasan (1975) noted a direct relationship between organic carbon and available nitrogen in the sediments of certain fresh water bodies in Tamil Nadu. Comparatively higher values for nitrogen and organic carbon were obtained from station near concrete bund (SIII). Joseph (1994) also reported similar observations and positive correlation of these parameters in Sasthamkotta lake.

Total nitrogen and total phosphorus in Sasthamkotta lake at station I, II and V are negatively correlated. Similar relationship was noted by Vijayaraghavan (1973) in fresh water systems. Organic carbon and pH were positively correlated at stations IV and V. Such correlation was reported by Ali *et al.* (1988) and Rameshan (1990). The relationship between conductivity and sediment nutrients were not consistent. Positive correlation of organic carbon and conductivity at station I, IV, and V establishes the direct influence of organic matter with pH.

CHAPTER V
PRODUCTIVITY OF THE LAKE
1. PLANKTON
2. PRIMARY PRODUCTIVITY

CHAPTER V - 1

PLANKTON

INTRODUCTION

Among the biotic components of the aquatic ecosystem, plankton communities play a significant role in the productivity and trophic balance of the system. Phytoplankton is microscopic, single celled aquatic plants that form the basic food in the aquatic ecosystems for all consumers in the higher trophic tiers. Hence knowledge of their abundance and composition is one of the essential prerequisites for successful fishery management of lakes (Pandey and Soni 1993). Generally plankton is considered as an index of the fertility of any water body (Prasad, 1969).

Plankton is the decisive factor for primary production on our planet (Nielson, 1964). The biotic community of a given system exhibits temporal variations; it also varies widely among different water bodies, depending upon the physicochemical characteristics of the water body. Phytoplankton serves as an indicator of the extent of environmental pollution (Lowe 1974). The numerical abundance and biomass of organisms affect the functioning of an ecosystem. In clean water, community diversity is higher than in contaminated waters (Archibald, 1972). Thus the community characteristics of an aquatic ecosystem are a reliable icon of cleanliness (Descy and Coste, 1991; Kelly and Whitton, 1995; Kelly, 1998; Wu, 1999). The changes in the population dynamics of phytoplankton are, therefore, useful for evaluating the status of water pollution; it can also be used as technology for bio- monitoring.

In India, considerable work has been done on the ecology of phytoplankton in fresh waters (Govind, 1963; Lakshminarayana, 1965 a,b; Venkateshwarlu, 1969; Munawar, 1970b; Khatri, 1987; Adholia *et al.*, 1991; Pandey and Soni, 1993; Rao *et al.*, 1999). Kumar (1998b, 1999a) made bio-monitoring of pollution by phytoplankton in freshwater systems. Kumar (1999a) made comparative studies of

phytoplankton in two ecologically different lentic freshwater systems in South Bihar. Saha *et al.* (2000) studied the diversity of phytoplankton of sewage polluted water systems in Bihar. Nutrient status of phytoplankton in Udai Sagar lake, Rajasthan, was analysed by Pandey *et al.* (2000). Ecological investigation on phytoplankton was carried out in Ushuwa lake by Kumar and Bohra (2001). The phytoplankton diversity and seasonal oscillations were reported by Kavitha *et al.* (2005) in temple ponds of Tamil Nadu.

In Kerala, the majority of studies on phytoplankton in inland waters are concentrated on their ecology, diversity, and distribution: Cochin backwaters (Pillai *et al.*, 1975; Madhupratap and Rao, 1979; Pillai, 1971; Qasim *et al.*, 1974; Qasim 1980), Vembanad Lake (Pillai *et al.*, 1975), Paravur-Edava-Nadayara backwaters (Abdul Azis, 1978) Ashtamudy lake (George Thomas and Fernandez, 1993), Neyyar Reservoir (Harikrishnan and Abdul Azis, 1989); Sasthamkottah freshwater lake (Mini Chandran, 1988; Joseph, 1994), Kadinamkulam backwater (Nandan, 1991), Paravoor lake (Shibu *et al.*, 1991), Vellayani lake (Sareena, 1998), Ithikara river (Sheeba and Ramanujan, 2005).

Zooplankton forms a major link in the energy transfer at the secondary level in the aquatic biosphere and their ecology is of considerable interest in assessing the production potential of the water bodies. In natural lakes and ponds of the tropics as in the other aquatic ecosystems, zooplankton occupies a central position between the autotrophs and other heterotrophs and forms an important link in aquatic food webs (Payne, 1986; Wanganeo and Wanganeo, 2006).

Species interactions are a key factor in determining the food web structure of a pelagic community, and changes in composition and biomass at a particular trophic level can cause marked changes at other levels, namely the metazoan plankton (Carpenter *et al.*, 1987; Vanni, 1988). Zooplankton is utilized as a food item by most of the fishes at least during the initial phases of development (Barbosa and Tundisi, 1984) and plays an important role in the natural purification of polluted waters (Batish, 1982). Zooplankton shows marked seasonal variation in occurrence and abundance.

Extensive studies on zooplankton have been made in Kerala: zooplankton ecology of zooplankton diversity of Vembanad lake (Pillai *et al.*, 1975); sediment and zooplankton relation in Veli lake, Thiruvananthapuram District (Arunachalam *et al.*, 1982); zooplankton diversity of Paravoor-Edava lake (Azis 1978) and of Sasthamkotta lake (Mini Chandran 1988); monthly difference of zooplankton in Kadinamkulam backwater (Nandan, 1991); biological productivity in relation to zooplankton abundance in Sasthamkottah lake (Prakasam and Joseph, 1992, Joseph, 1994) zooplankton in Paravoor lake (Shibu, 1991); diversity of zooplankton in Kallada river basin and Parappan reservoir (Sahib, 1992) and Vellayani lake (Sareena, 1998).

Sasthamkotta lake possesses a varied fishery resource which depends mainly on the primary and secondary production. No serious attempts have so far been made to assess the abundance of plankton population in relation with the fishery potential of the lake. An understanding of their seasonal abundance will help in the proper assessment of population structure, abundance, growth and spawning of many food fishes of the lake. With these views in mind, a study regarding the species composition, abundance and seasonal variation of plankton communities of the lake was attempted.

METHODOLOGY

Plankton samples were collected monthly from five stations during the period from November 2004 to October 2005. 100 liters of water was allowed to filter through a standard plankton net made of #21 bolting silk having a mesh size of 60 microns during the early hours of the day. Samples were preserved in 4% buffered formalin and allowed to stand in a 100 ml measuring cylinder for about 24 hours so as to allow time for the organic element to settle. Numerical estimation of plankton was made by Sedgwick-Rafter cell method (Trivedi and Goel, 1986). The identification of different plankton groups and species were done with the help of standard references and keys (Pennak, 1953; Davies, 1955; Edmondson, 1959; Kasturirangan, 1963; Batish, 1982; Santhanam *et al.*, 1989).

The plankton was subjected to the analysis of diversity using different diversity indices. Species diversity index was calculated using the Shannon-Wiener function (1963). Species richness was calculated by Margalef (1968); Index of Dominance by Simpson (1949) and Evenness was calculated by using the formula of Pielou (1966).

SHANNON-WIENER DIVERSITY INDEX (\bar{H})

Diversity index was found out using the formula given by Shannon-Wiener Index (Shannon and Wiener, 1963).

$$\bar{H} = -\sum [ni/N] l_n [ni/N] \text{ or } \bar{H} = -\sum [P_i] l_n [P_i]$$

INDEX OF DOMINANCE (C)

Index of Dominance was calculated using the formula by Simpson (1949)

$$C = \sum [ni/N]^2$$

RICHNESS INDEX (D)

Species richness was calculated using the standard formula by Margalef (1966)

$$d = \frac{s-1}{\log N}$$

EVENNESS INDEX (E)

Evenness index was calculated using the formula given by Pielou (1966)

$$e = \frac{\bar{H}}{\bar{H}_{\max}} \text{ or } e = \frac{\bar{H}}{\log S}$$

where

ni = importance value of each species

N = total importance value

P_i = importance probability for each species (ni/N)

$\bar{H}_{\max} = l_n S$

For every formula the logarithm is the natural logarithm (Odum, 1971).

Correlation coefficients were calculated on the numerical density of plankton with that of the physico-chemical parameters.

RESULTS

In the present study, 30 genera of phytoplankton belonging to four families were obtained from Sasthamkotta lake: Chlorophyceae (10 genera), Cyanophyceae (3 genera), and Dianoflagellata (one genus). Bacillariophyceae was the most abundant group (16 genera) at all stations and Dianoflagellata was generally, the least represented. The results of the analysis of the community characteristics of phytoplankton in Sasthamkotta lake are presented in Table 5.1.1. Altogether 36 species of phytoplankton were met with in Sasthamkotta lake; station I had the highest number of species (26) and station V had the lowest number of species (19). The phytoplankton was not evenly distributed in all stations (Table 5.1.1).

In the present study, six groups of Zooplankton were obtained from Sasthamkotta lake. Crustacea, Ostracods, Rotifera, Nematodes, Halobates and Cladocera. Crustacea were the most abundant group at all stations (Table. 5.1.2).

Results of the percentage composition of phytoplankton at the five stations are given in Table; 5.1.3 and Fig. 5.1.1 to 5.1.5. Monthly variations of the percentage composition of phytoplankton at the five stations showed that the peak of abundance of phytoplankton was in November at all the stations. The highest percentage was observed at station I (21.46%) and the lowest percentage was at station V (0.99%) in June.

Phytoplankton was most abundant during post monsoon at all the stations and the least during pre monsoon except stations III and V (Table 5.1.4).

The annual fluctuations of the percentage composition of the four major groups of phytoplankton at the five stations are given in Table 5.1.5. Among the four major phytoplankton groups, Bacillariophyceae constituted the major portion. Chlorophyceae was the second dominant group except at station II and here Cyanophyceae constituted the second position.

The annual variations and the seasonal values of various diversity indices of phytoplankton populations for the study period at all the stations are depicted in Table 5.1.6.

The Shannon Diversity (H), obtained high value at monsoon (2.01) and low at (1.893) pre monsoon. The Evenness index also showed the same trend, obtained high value at monsoon (0.671) and low at pre monsoon (0.632). The Dominance index showed high value at pre monsoon (0.21) and low value at monsoon (0.169). Regarding the Richness index, value was high at monsoon (1.399) and low at pre monsoon (1.358).

Monthly variations of the percentage composition of Zooplankton of the five stations during the study period are presented in Table 5.1.3. Highest percentage of zooplankton observed was in December at Station I (16.29%), and the lowest percentage of zooplankton observed was in April (4.83%), at the same station.

Zooplankton was most abundant during post monsoon at all stations and lowest during pre monsoon at stations I, III and IV (Table 5.1.4).

The annual fluctuations of the percentage composition of the four major groups of zooplankton at the five stations are given in Table 5.1.5. Among the six major zooplankton groups, crustacean constituted the major portion.

The results of the analysis of the diversity characteristics of Zooplankton in Sasthamkotta lake are presented in Table 5.1.7. The results showed that there was high diversity of zooplankton at all the five stations. Altogether 6 groups of Zooplankton could be collected from Sasthamkotta lake.

Table 5.1.1. List of phytoplankton present in Sasthamkotta Lake at different stations

Phytoplankton Species	I	II	III	IV	V
Chlorophyceae			+		-
<i>Cosmarium orthostuchuno</i>	+	+	-	-	+
<i>Staurastrum sp.</i>	+	+	+	+	+
<i>Pediastrum simplex</i>	+	+	+	+	-
<i>Closterium dianai</i>	-	+	+	-	-
<i>Ulothrix sp.</i>	+	+	+	+	-
<i>Desmidium sp.</i>	+	+	+	+	-
<i>Oedogonium sp.</i>	+	+	+	+	-
<i>Closterium asiculare</i>	+	+	+	+	-
<i>Scenedesmus quadricauda</i>	-	+	+	-	+
<i>Spirogyra sp</i>	+	-	-	-	-
Bacillariophyceae	-	-	+	-	+
<i>Grammatophora</i>	-	+	+	+	+
<i>Navicula cuspidate</i>	+	+	+	+	+
<i>Navicula radiosa</i>	+	+	+	+	+
<i>Navicula rectangularis</i>	+	-	+	-	-
<i>Navicula tenalla</i>	+	+	+	+	+
<i>Nitzschia acicularis</i>	+	-	+	-	+
<i>Nitzschia major</i>	-	+	+	-	-
<i>Pinnularia biceps</i>	+	+	+	-	+
<i>Thalassiosira</i>	+	-	+	-	-
<i>Cymbella ventricosa</i>	-	+	+	+	+
<i>Asterionella formosa</i>	+	-	+	+	+
<i>Eunotia formica</i>	+	-	-	+	-
<i>Melosira granulate</i>	-	+	+	+	+
<i>Synedra acusa</i>	+	-	+	+	+
<i>Synedra formosa</i>	+	+	+	-	+
<i>Suriella sp</i>	-	-	-	+	-
<i>Stauroneis acuta</i>	-	-	+	+	+
<i>Fragilaria rumpens</i>	-	+	+	-	-
<i>Mastogloia excilis</i>	+	-	-	-	-
<i>Diplonies puella</i>	+	+	-	+	-
<i>Coconies pedicularis</i>	+	-	+	+	-
<i>Coconies</i>	-	-	-	+	-
<i>Coscinodiscus granii</i>	-	-	+	-	+
Cyanophyceae		+			
<i>Oscillatoria prolifica</i>	+	+	+	-	+
<i>Microcystis</i>	+	+	+	+	-
<i>Anabaena</i>	+	-	+	+	-
Dianoflagellata		+			
<i>Peridinium</i>	+	-	-	+	+

Table 5.1.2. List of Zooplankton groups present in Sasthamkotta Lake at different stations

Zooplankton(Groups)	SI	SII	SIII	SIV	SV
Crustacea	+	+	+	+	+
Ostracods	+	+	+	+	+
Rotifera	+	+	+	+	+
Nematodes	+	+	+	+	+
Halobates	+	+	+	+	+
Cladocera	+	+	+	+	+

Table 5.1.3. Monthly percentage composition of the total phyto and zooplankton at the five stations of Sasthamkotta Lake

Month	Station-I		Station-II		Station-III		Station-IV		Station-V	
	Phyto (%)	Zoo (%)	Phyto (%)	Zoo (%)	Phyto (%)	Zoo (%)	Phyto (%)	Zoo (%)	Phyto (%)	Zoo (%)
Nov.	21.456	12.87	21.22762	10.19	15.437	11.23	11.50442	9.83	17.763	11.48
Dec.	7.6628	16.29	12.27621	10.07	10.21566	8.22	9.380531	7.27	9.8684	8.8
Jan	12.261	9.5	9.71867	9.26	8.399546	7.12	4.955752	11.04	6.9079	11.25
Feb	3.8314	5.32	2.046036	6.95	7.718502	6.85	7.964602	6.19	9.2105	5.99
March	7.2797	5.54	3.069054	9.36	14.75596	7.67	9.911504	7.0	20.066	11.25
April	4.9808	4.83	3.580563	7.86	8.967083	6.85	7.787611	6.19	12.5	11.56
May	3.0651	6.68	2.046036	6.95	5.902384	8.22	5.486726	7.27	5.2632	8.19
June	7.66284	6.95	5.11509	6.95	4.76731	6.85	7.256637	7.6	0.9868	5.99
July	14.559	8.9	16.11253	8.4	6.92395	12.05	12.38938	8.88	3.2895	8.9
Aug.	9.1954	7.87	5.370844	6.95	4.540295	6.85	8.672566	8.61	1.6447	5.77
Sept.	1.9157	6.35	7.672634	8.48	4.199773	7.95	7.787611	10.83	2.6316	5
Oct.	6.1303	8.9	11.76471	8.57	8.172531	10.14	6.902655	9.29	9.8684	5.82

Table 5.1.4. Seasonal mean values of phyto and zooplanktons at the five stations of Sasthamkotta Lake

Stations	Phytoplankton(%)					Zooplankton(%)				
	I	II	III	IV	V	I	II	III	IV	V
Monsoons	33.33	34.27	20.43	36.1	8.55	30.37	30.79	33.7	35.92	25.66
Postmonsoon	47.51	54.99	42.23	32.75	44.41	47.56	38.09	36.71	37.43	37.35
Premonsoon	19.16	10.74	37.34	31.15	47.04	22.37	31.12	29.59	26.65	36.99

Fig. 5.1.1. Monthly distribution (%) of the groups of phytoplankton at station I of Sasthamkotta lake

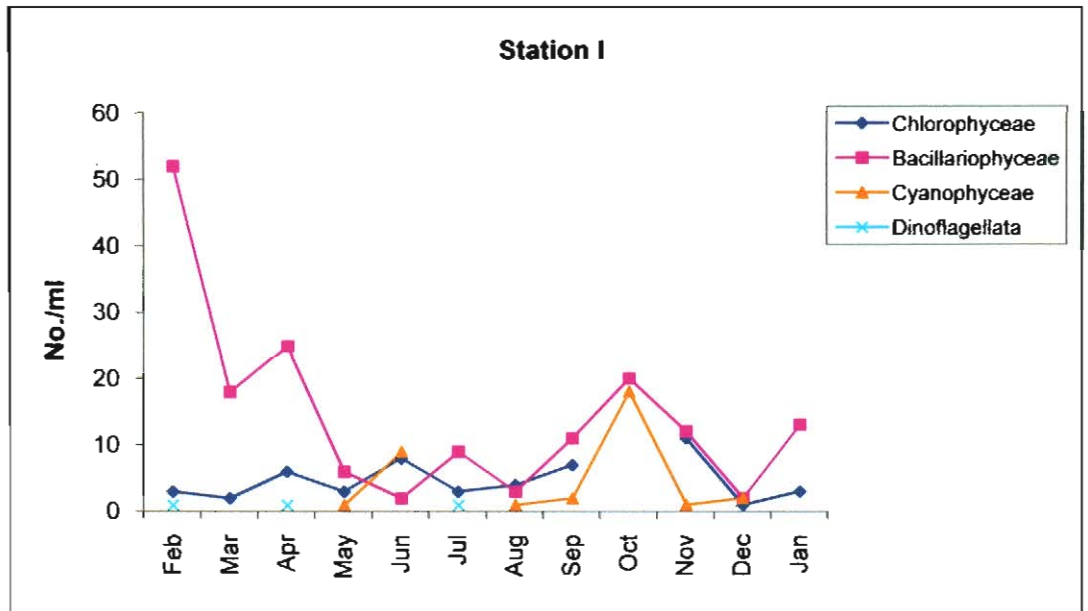


Fig. 5.1.2. Monthly distribution (%) of the groups of phytoplankton at station II of Sasthamkotta lake

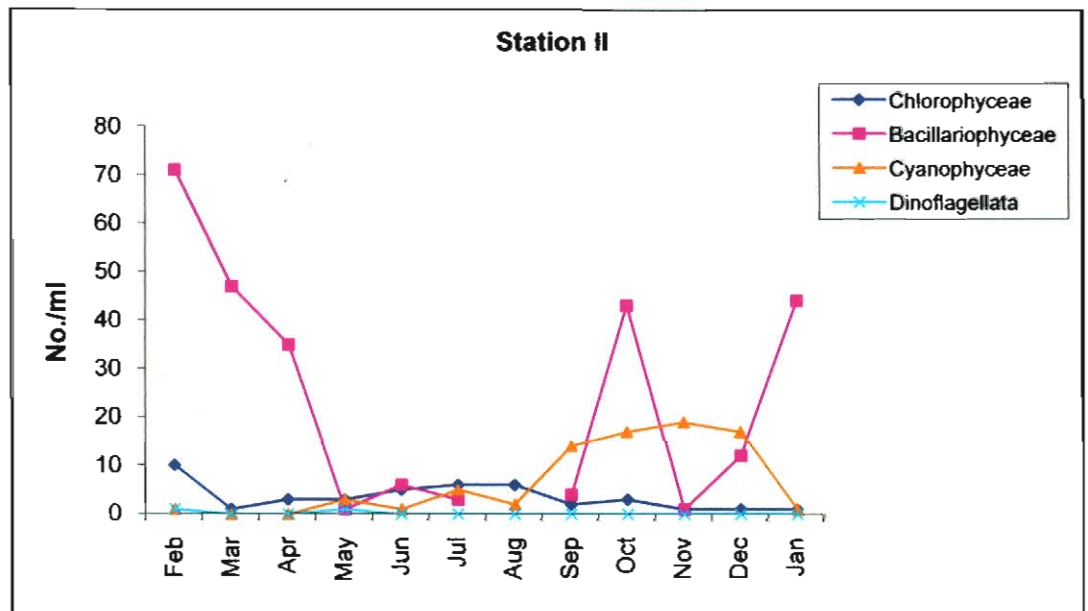


Fig. 5.1.3. Monthly distribution (%) of the groups of phytoplankton at station III of Sasthamkotta lake

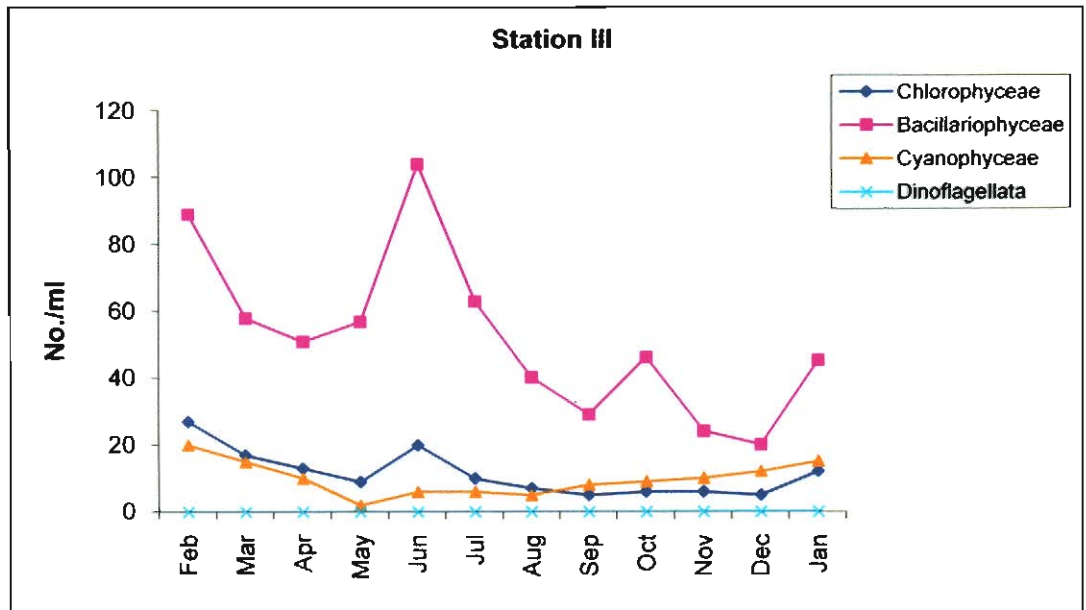


Fig. 5.1.4. Monthly distribution (%) of the groups of phytoplankton at station IV of asthamkotta lake

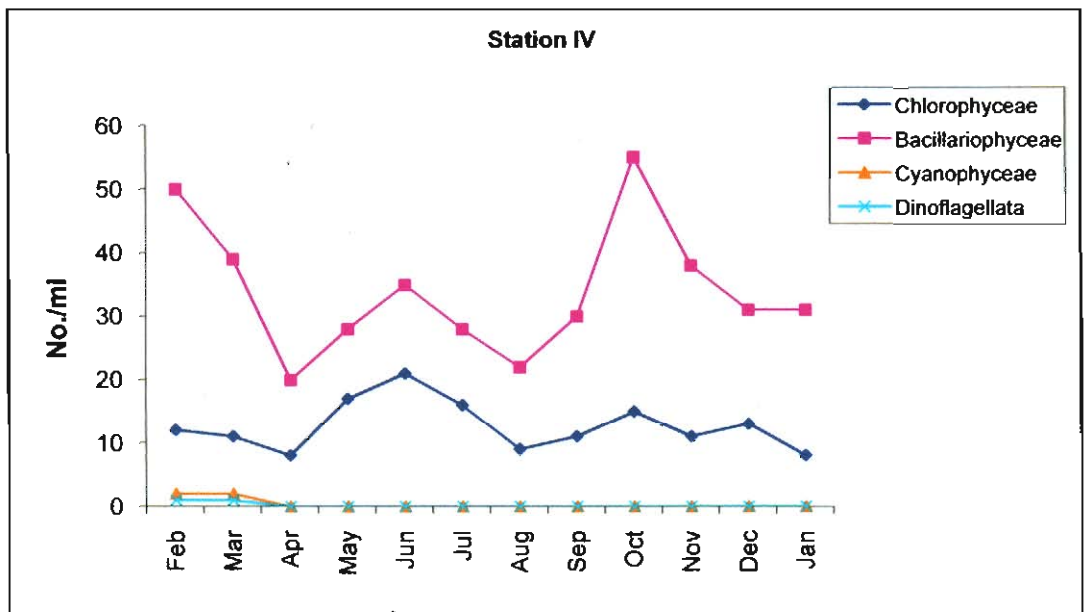


Fig. 5.1.5. Monthly distribution (%) of the groups of phytoplankton at station V of Sasthamkotta lake

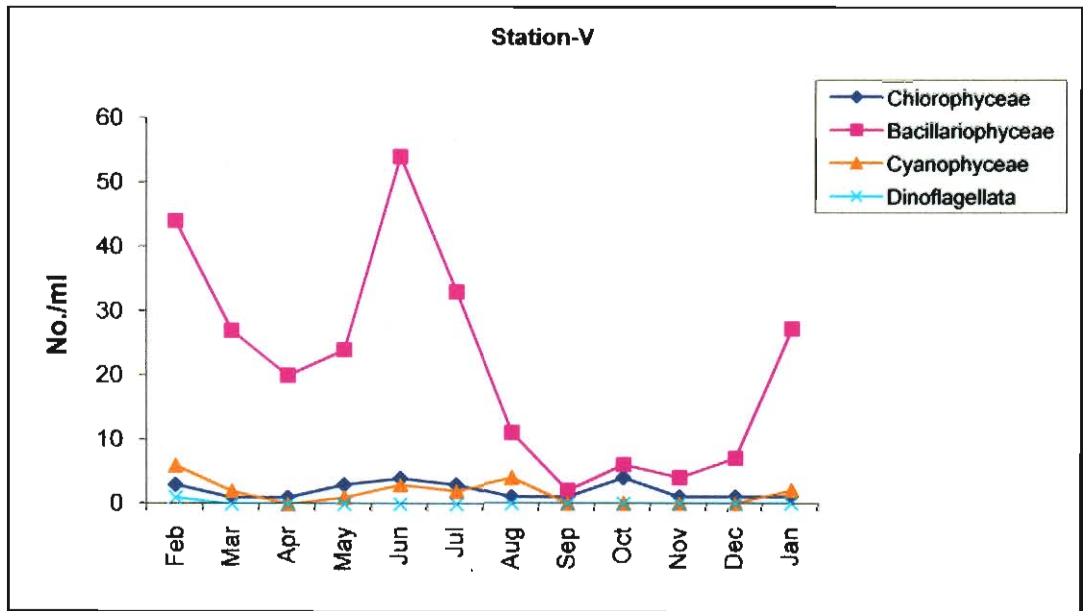


Table 5.1.5. Annual percentage composition of the phyto and zooplankton groups at the five stations of Sasthamkotta Lake

Phytoplankton (Groups)	SI	SII	SIII	SIV	SV
Chlorophyceae	19.54	10.74	15.55	26.9	7.89
Bacillariophyceae	66.28	68.29	71.05	72.04	85.2
Cyanophyceae	13.03	20.46	13.4	0.71	6.58
Dinoflagellata	1.15	0.512	0	0.35	0.33
Zooplankton (Groups)					
Crustacea	72.47	96.5	41.65	90.65	95.934
Ostracods	4.83	0.074	18.9	1.28	1.36
Rotifera	2.66	0.09	26.3	1.48	0.113
Nematodes	3.69	0.37	7.12	1.08	0.09
Halobates	6.8	0.212	3.84	1.95	0.023
Cladocera	9.55	2.76	2.19	3.57	2.48

Table 5.1.6. Different diversity indices of phytoplankton at Sasthamkotta lake

Month/season	Richness	Dominance	Diversity	Evenness
Feb	1.752	0.295	1.4112	0.457
Mar	1.672	0.299	1.4668	0.475
April	1.729	0.281	1.4228	0.46
May	1.801	0.3	1.4272	0.462
Premonsoon	1.386	0.21	1.8926	0.632
June	1.786	0.262	1.4776	0.478
July	1.69	0.228	1.6272	0.526
Aug	1.773	0.259	1.4567	0.471
Sept	1.789	0.274	1.4433	0.467
Monsoon	1.399	0.169	2.0103	0.671
Oct	1.717	0.239	1.5519	0.502
Nov	1.628	0.222	1.6418	0.531
Dec	1.694	0.249	1.5019	0.486
Jan	1.725	0.243	1.5509	0.502
Postmonsoon	1.358	0.182	1.9421	0.648

Table 5.1.7. Different diversity indices of Zooplankton at Sasthamkotta lake

Month/season	Richness	Dominance	Diversity	Evenness
Feb	2.543	0.169833	2.165	0.701
Mar	2.265	0.107097	2.376	0.769
April	2.539	0.376927	1.39	0.45
May	2.521	0.210277	2.055	0.665
Premonsoon	1.577	0.185645	1.924	0.642
June	2.558	0.159416	2.218	0.718
July	2.278	0.10021	2.419	0.783
Aug	2.673	0.274252	1.741	0.563
Sept	2.577	0.172421	2.212	0.716
Monsoon	1.579	0.190734	1.901	0.634
Oct	2.56	0.157411	2.22	0.718
Nov	2.264	0.10579	2.395	0.775
Dec	2.588	0.310897	1.596	0.516
Jan	2.504	0.254693	1.947	0.63
Postmonsoon	1.577	0.186469	1.923	0.642

DISCUSSION

All natural waters harbour a variety of plants and animals, which constitute the flora and fauna of these ecosystems. Biological components have great importance from the ecological point of view, especially in an aquatic ecosystem, in understanding its health status. Analysis of the biotic components helps in finding out bio-indicators of water pollution and in understanding the ecological disturbances caused by pollution. For example, information on plankton diversity gives clues to the factors influencing changes in algal population and to the impact of anthropogenic interferences on aquatic habitats (Round, 1981; Goldman and Horne, 1983; Kumar, 1990).

Phytoplankton stands at the lowest rung of the nutritional ladder of an aquatic ecosystem. They are the major food for zooplankton, fishes, and other aquatic organisms. They have a key role in maintaining proper equilibrium between abiotic and biotic components and the biodiversity of the aquatic ecosystem. The phytoplankton community in a water body reflects its average ecological condition; phytoplankton may be used as indicators of water quality (Bhatt *et al.*, 1999; Harikrishnan *et al.*, 1999; Saha *et al.*, 2000).

The present study showed that lake Sasthamkotta possessed a thin standing crop of phytoplankton belongs to 36 species coming under 30 genera was observed. Bacillariophyceae (16 genera), Chlorophyceae (10 genera), Cyanophyceae (3 genera), and Dianoflagellata (one genera). Bacillariophyceae was the most abundant group at all stations. Gopinathan (1985) in the Veli lake and Shibu (1991) in the Paravur lake found that Bacillariophyceae was the dominant phytoplankter in the freshwater zones of these water bodies. Phytoplankton concentration was high during post monsoon season. Joseph (1994) observed a peak Phytoplankton concentration in December-January. Abundance of phytoplankton during post monsoon may be because of the abundant nutrient dump during this period. Except stations III and V phytoplankton concentration was low during pre monsoon.

Cocconeis sp., *Fragilaria* sp., *Melosira* sp., *Nitzschia* sp., *Navicula* sp. and *Synedra* species were more abundant among the Bacillariophyceae in the lake. According to Blum (1960) and Harrison *et al.* (1969), *Nitzschia* sp. is the most resistant and tolerant form of diatom that sustain well even in polluted waters. This view has been further supported by Palmer (1980) and Paramasivam and Sreenivasan (1982). *Navicula* sp. and *Nitzschia* sp. are well represented in polluted waters (Nirmalkumar, 1989; Natherkhan, 1990; Gomez, 1998; Kelly, 1998). The present results are in conformity with the foregoing observations.

In the present study, Chlorophyceae stands second in the rate of abundance in the group of phytoplankton. *Pediastrum* sp., *Staurastrum* sp. and *Closterium* sp. were dominant and incidentally these genera are known to be pollution-tolerant (Palmer, 1980). The presence of low number of Cyanophyceae might be due to low content of nutrients (Singh, 1955; Vyas and Kumar, 1968). Schelske (1979) and Smith (1983) have discussed the role of phosphate in the formation of Cyanophyceae bloom. Dianoflagellata was represented by only one genera similar to the observation of Joseph (1994) in the same lake.

The slightly acidic nature of the water, scarcity of nutrients and the dominance of Zooplankton might be the reason for the low productivity and low Phytoplankton concentration in the lake. Similar low Phytoplankton concentration have been reported by Sreenivasan (1976) in reservoirs like Pechiparai, Perinchani and Hope lake; Dwivedi *et al.* (1986) in Kulgharhi reservoir. Factors like scarcity of nutrients and the grazing of Zooplankton can reduce the Phytoplankton production was noted by Goldman and Horne (1983). The present results are in agreement with those of other workers in other similar aquatic ecosystem.

The population density of Zooplankton in the present observation showed seasonal variations. The diversity of Zooplankton was found to be high during the post monsoon season at all stations. In agreement with the observation of Nandan (1991) post monsoon season recorded high Zooplankton population at Sasthamkotta lake. Copepods were the main crustacean group reported in the lake during the present study. Joseph (1994) also reported presence of copepods in the same lake. The concentrations of copepods were maximum in all seasons and stations.

In Sasthamkotta lake, the peaks of zooplanktonic and phytoplanktonic abundance were observed during the same periods. It indicated a direct dependence of zooplankton growth on the abundance of phytoplankton. The same results were reported by Ghosh *et al.* (1974) and Sharma and Sahai, (1988).

However the density of phytoplankton and zooplankton was very low in the present study. Previous studies in Sasthamkotta lake have reported the dominance of Chlorophyceae group which was indicative of the good quality of water (Joseph, 1994). In the present study Bacillariophyceae were the prominent group with 16 genera. Some species of Bacillariophyceae are indicators of pollution (Harrison *et al.*, 1969). Hence the present results have shown that the lake water is getting polluted.

CHAPTER V - 2

PRIMARY PRODUCTIVITY

INTRODUCTION

The basis for nearly all life in the aquatic system is the photosynthetic activity of the aquatic plants and plankton. So in an aquatic system, primary productivity has a significant role and is considered as the pulse of the aquatic ecosystem. The amount of primary production is the most significant factor, which determines whether or not a particular body of water is important from the fisheries angle (Prasad, 1969). Despite its growing importance, studies on the primary productivity of the fresh waters of India are few. The abundance of phytoplankton will reflect the primary production of the particular ecosystem. It nourishes the other microorganisms present in that aquatic ecosystem. This will increase the fish production of the aquatic system directly or indirectly.

The magnitude and dynamics of primary production has become an essential parameter to assess the state of pollution in aquatic systems and is an indication of the ecological stress to which an ecosystem is exposed to. All biotic components of an ecosystem are interdependent and interrelated with each other through various kinds of trophic and non-trophic links. These close interactions with the environment constitute a balanced ecosystem.

Primary productivity can be evaluated using chlorophyll pigments, plankton biomass and by direct productivity measurements. One of the most widely accepted methods of expressing biomass of phytoplankton in the aquatic habitats is the chlorophyll 'a' concentration. In studies related to aquatic food chains or trophodynamics, estimate of the standing crop of phytoplankton becomes a necessary prerequisite and chlorophyll indicates the total plant material available in the water at the primary stages of the food chain (Quasim, 1970). Thus, simultaneous study of phytoplankton, primary production and chlorophyll in various aquatic biotopes was interesting, as they throw light on the relative fertility and potentiality of waters.

Primary production studies are concerned with the evaluation of the capacity of an ecosystem to build up, at the expense of external energy, both radiant and chemical, primary organic compounds of high chemical potentials for further transformation and flow to higher system levels (Vollenweider, 1968). Accurate estimates of primary productivity are essential considerations for the proper exploitation and conservation of all natural habitats. It provides us with a means of assessing whether an ecosystem is being under-exploited or over-exploited or the yield is as great it could be (Clarke, 1954).

There are a number of factors which control the primary production in an aquatic ecosystem. The changes in water quality drastically affect the primary productivity, thereby bringing about major ecological changes. Regular measurements of primary productivity help to understand the problem of ecology and fishery management in aquatic ecosystems.

Primary productivity of fresh water habitat had been estimated by many workers (Moyle, 1946; Rodhe, 1958; Williams, 1966). In India Sreenivasan (1963) and Hussainy (1967) in certain reservoirs and Karunakaran *et al.* (1971) in shallow ponds studied the primary production. Vass and Langher (1990) observed the changes in primary production and trophic status of Oxbow lake, Kashmir. Phytoplankton productivity of few tropical ponds are investigated by Bhaskaran *et al.* (1991). Gupta *et al.* (1992) studied primary productivity and zooplankton of a shallow pond in Rajasthan. Thomas *et al.* (1980) and Prakasam and Joseph (1989) in Sasthamkotta lake; Sareena (1998) in Vellayani lake, Mathew Koshy (2001) in Pampa river and Sobha *et al.* (2003) in Paravur canal studied the primary productivity in Kerala.

To exploit aquatic ecosystem, information on phytoplankton productivity is essential especially for the estimation of level of fish production. Lake Sasthamkotta has not yet been subjected to detailed phytoplankton productivity and fish production related investigations. Hence the study was initiated.

METHODOLOGY

Gross Primary Productivity (GPP) and Net Primary Productivity (NPP)

Gross and Net primary productivity in the surface water were estimated by the methods described by Strickland and Parsons, (1968) by dark and light bottle technique

Chlorophyll 'a'

Chlorophyll 'a' was estimated by Trivedi and Goel (1986).

RESULTS

Data of monthly variation in surface water gross primary productivity of the five stations is illustrated in Fig. 5.2.1. The general distribution of gross primary productivity for the whole region fluctuated from 0.072 mg C/m³/day at station I in May to 4.5 mg C/m³/day at station III during February and October.

Data of monthly variation in surface water net primary productivity of the five stations is illustrated in Fig. 5.2.2. The general distribution of net primary productivity for the whole region fluctuated from 0.0756 mg C/m³/day to 0.375 mg C/m³/day in varying months.

The season wise gross primary productivity values recorded a minimum of 0.15 mg C/m³/day at Station IV during monsoon to a maximum of 1.26 mg C/m³/day at station III during post monsoon. The maximum value of gross primary productivity was observed during post monsoon season except station I and V. The values remained minimum during monsoon season except in stations I and V (Table 5.2.1).

The season wise net primary productivity values recorded a minimum of 0.132 mg C/m³/day at Station IV to a maximum of 0.263 mg C/m³/day at station III and V during pre monsoon. During monsoon the net productivity values ranged between 0.132 mg C/m³/day at Station V and 0.264 mg C/m³/day at station IV. During post monsoon the net productivity values showed a minimum of 0.132 mg C/m³/day at station III to a maximum of 0.714 mg C/m³/day at station II. Season wise distribution of net primary productivity (Table 5.2.1) showed that

maximum value of net primary productivity was observed during post monsoon season at station II.

In all seasons station III near the concrete bund showed the highest values of gross primary productivity. Analysis of variance (Table. 5.2.1.a) revealed that the variation in the GPP between three seasons were significant at 5% level.

Analysis of variance (Table 5.2.1.b) revealed that the variation in the GPP between three seasons were significant at 5% level.

NPP showed a positive correlation with Phosphate at station III and V but negatively with silicate at station V (Table 5.2.2).

The pattern of monthly distribution of Chlorophyll 'a' in the five stations is illustrated in Fig 5.2.3. In general the Chlorophyll 'a' values showed wide fluctuations, and it ranged from 16.42 mg/m³ to 136.25 mg/m³.

A distinct seasonal variation was observed in the fluctuation of the Chlorophyll 'a' (Table 5.2.1). Chlorophyll 'a' value varied from 20.37 mg/m³ during pre monsoon to 112.36 mg/m³ during post monsoon. Chlorophyll 'a' value, showed an increase during post monsoon season, with the highest values being recorded in November. During pre monsoon a steady decline was observed. During monsoon the values increased and the concentration was highest during post monsoon in all the five stations. Analysis of variance (Table 5.2.1.c) of Chlorophyll 'a' revealed that the variations between seasons and between months were not significant.

The simple correlation coefficients between gross and net primary productivity and Chlorophyll 'a' with the different physico-chemical parameters of water are shown in the Table 5.2.2. In station II, NPP showed a positive correlation with phosphate and negative correlation with pH, while chlorophyll showed a negative correlation with pH, nitrite, nitrate and potassium and positively correlated with dissolved oxygen, phosphate and silicate. In station III, GPP and NPP showed a positive correlation with phosphate and NPP negatively with silicate. In station IV NPP showed a positive correlation with nitrate. In station V, chlorophyll showed a positive correlation with silicate and GPP negative correlation with silicate and positive correlation with phosphate.

Table 5.2.1 Seasonal mean (\pm) of productivity and Chlorophyll 'a' of different stations at Sasthamkotta Lake

Seasons	Stations	Gross Primary Productivity	Net Primary Productivity	Chlorophyll 'a'
Premonsoon	I	0.24 \pm 0.167	0.17 \pm 0.09	20.37 \pm 2.76
	II	0.58 \pm 0.67	0.23 \pm 0.16	95.48 \pm 6.56
	III	1.24 \pm 2.18	0.26 \pm 0.23	44.93 \pm 5.43
	IV	0.17 \pm 0.15	0.13 \pm 0.07	57.22 \pm 9.69
	V	0.47 \pm 0.59	0.26 \pm 0.43	26.00 \pm 5.79
Monsoon	I	0.34 \pm 0.18	0.26 \pm 0.13	70.39 \pm 12.66
	II	0.19 \pm 0.13	0.23 \pm 0.14	72.5 0 \pm 10.34
	III	0.6 \pm 0.62	0.22 \pm 0.11	73.13 \pm 8.52
	IV	0.15 \pm 0.00	0.26 \pm 0.23	75.42 \pm 13.64
	V	0.30 \pm 0.13	0.13 \pm 0.07	75.37 \pm 11.26
Postmonsoon	I	0.19 \pm 0.13	0.23 \pm 0.25	112.36 \pm 26.29
	II	0.79 \pm 0.98	0.71 \pm 1.03	99.5 \pm 19.26
	III	1.26 \pm 2.16	0.13 \pm 0.11	83.51 \pm 7.39
	IV	0.21 \pm 0.13	0.17 \pm 0.72	98.22 \pm 6.47
	V	0.19 \pm 0.097	0.28 \pm 0.32	102.66 \pm 20.18

Fig. 5.2.1. Spatial and temporal variation of Gross primary productivity (GPP) at different stations

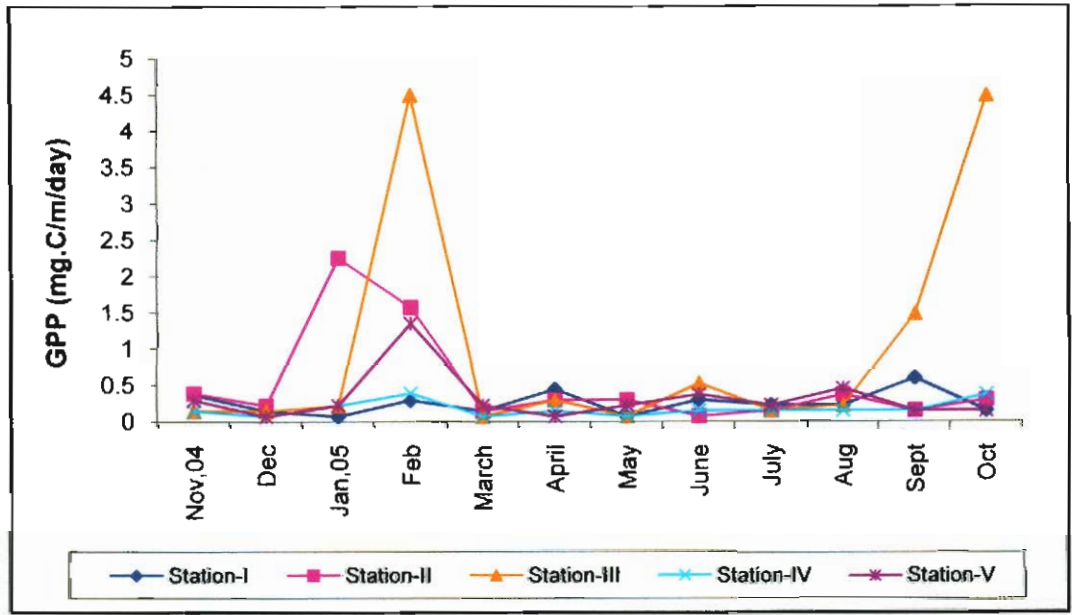


Table 5.2.1a One way ANOVA of GPP

Source of Variation	SS	df	MS	F	P-value	F crit
Stations	11.51721	11	1.04702	1.79185*	0.084789	2.014046
Seasons	5.66218	4	1.415545	2.422538*	0.062329	2.583667
Error	25.71022	44	0.584323			
Total	42.88961	59				

* P < 0.05

Fig. 5.2.2. Spatial and temporal variation of Net primary productivity (NPP) at different stations

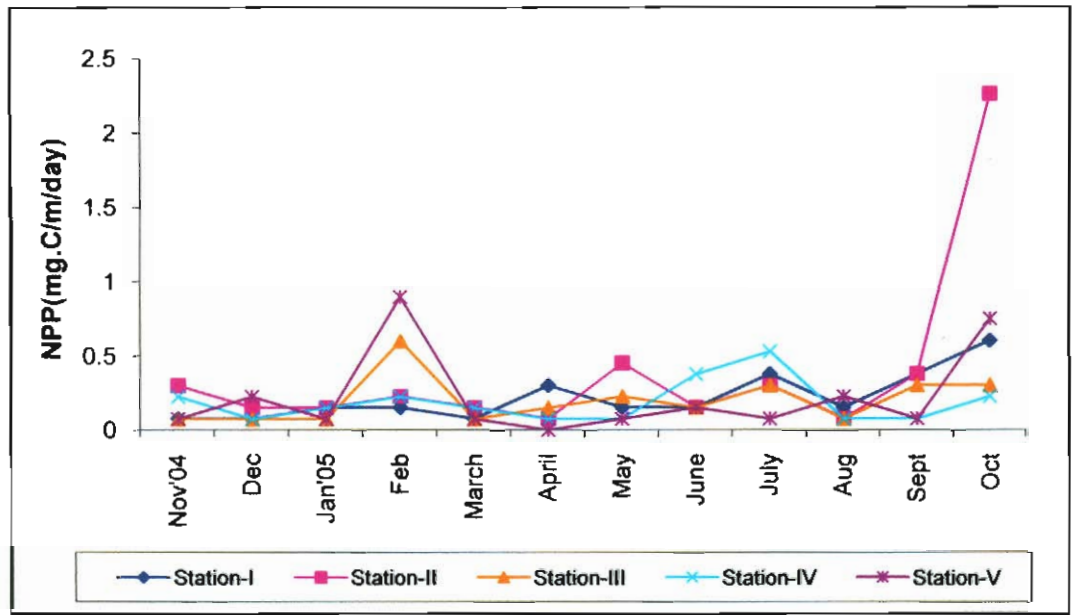


Table 5.2.1b One way ANOVA of NPP

Source of Variation	SS	df	MS	F	P-value	F crit
Stations	2.345215	11	0.213201	2.830687	0.006966	2.014046
Seasons	0.321601	4	0.0804	1.06748*	0.383992	2.583667
Error	3.313987	44	0.075318			
Total	5.980803	59				

* P < 0.05

Fig. 5.2.3. Spatial and temporal variation of Chlorophyll 'a' at different stations

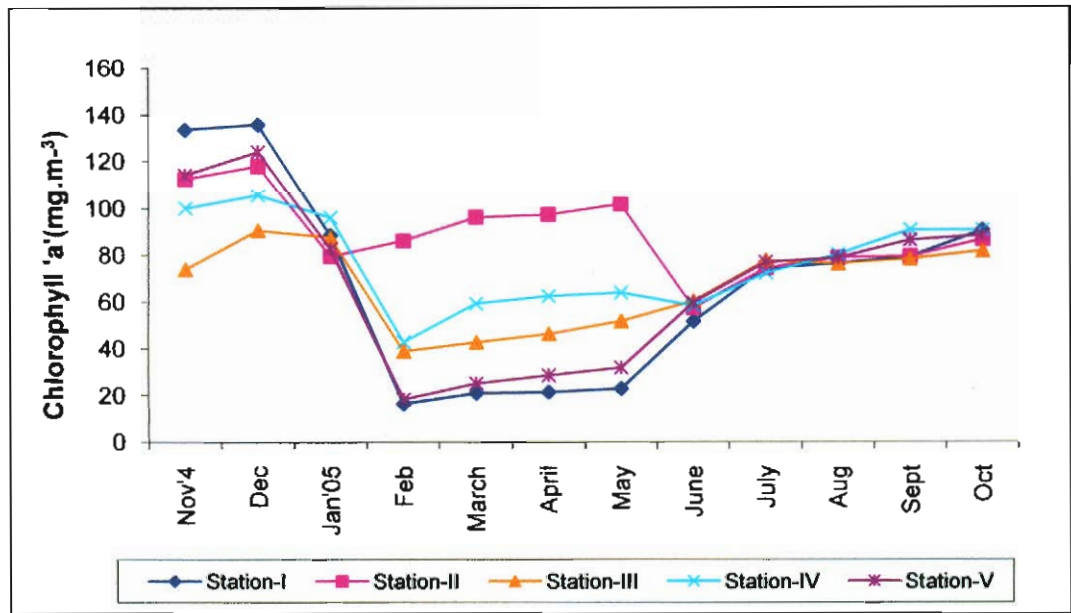


Table 5. 2.1c One way ANOVA of Chlorophyll 'a'

Source of Variation	SS	df	MS	F	P-value	F crit
Stations	30849.95	11	2804.541	8.976673	4.21E-08	2.014046
seasons	4325.109	4	1081.277	3.460914	0.01525	2.583667
Error	13746.72	44	312.4254			
Total	48921.77	59				

* P < 0.05

Table 5.2.2. Correlation between biological productivity and water quality parameters at different stations of Sasthamkotta Lake

Station-I

Parameters	Chlorophyll	Gross p. productivity	Net p. productivity
Temperature	-.758	-.002	-.170
pH	-.091	-.366	.537
Dissolved oxygen	.093	.188	.021
Nitrite	-.582	.036	.156
Nitrate	.099	-.181	-.017
Phosphate	-.572	-.210	-.276
Silicate	-.288	-.111	.320
Potassium	-.955	-.366	-.388

Station-II

Parameters	Chlorophyll	Gross p. productivity	Net p. productivity
Temperature	1.000	-.036	-.762**
pH	-1.000**	-.164	.490
Dissolved oxygen	1.000**	.345	.292
Nitrite	-1.000**	-.148	-.181
Nitrate	-1.000**	-.140	-.064
Phosphate	1.000***	.019	.817**
Silicate	1.000**	-.303	.164
Potassium	-1.000**	.055	.332

Station-III

Parameters	Chlorophyll	Gross p. productivity	Net p. productivity
Temperature	-.815	.057	.269
pH	.580	-.181	-.251
Dissolved oxygen	-.818	.404	.352
Nitrite	.851	.120	-.007
Nitrate	.854	-.197	.162
Phosphate	-.898	.780**	.877**
Silicate	.817	-.497	-.597*
Potassium	-.580	.324	.117

Station-IV

Parameters	Chlorophyll	Gross p. productivity	Net p. productivity
Temperature	-.815	.057	.269
pH	.856	-.371	-.256
Dissolved oxygen	.508	.345	-.499
Nitrite	.198	-.001	.029
Nitrate	.606	-.008	.704*
Phosphate	.919	.223	.036
Silicate	.959	-.415	-.111
Potassium	-.951	.103	.136

Station-V

Parameters	Chlorophyll	Gross p. productivity	Net p. productivity
Temperature	.043	.369	.082
pH	-.274	-.128	-.283
Dissolved oxygen	.959	-.363	-.085
Nitrite	-.879	.221	-.016
Nitrate	-.411	-.093	-.231
Phosphate	-.708	.637*	.382
Silicate	1.000*	-.810**	-.548
Potassium	-.912	.062	.358

* Correlation is significant at the 0.05 level (1-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

Generally the primary productivity of an aquatic habitat refers to phytoplankton production except where dominant producers are various types of macrophytes (Vass, 1980). In Sasthamkotta lake, macrophytes were comparatively sparse and hence the chief producers were only phytoplankton. In agreement with the findings of Thomas *et al.* (1980) and Joseph (1994) the gross primary productivity exhibited a low rate in this lake. Sreenivasan (1968 a, 1971 b) in Sathanur and Krishnagiri reservoirs and Kodaikanal lake and Yadava *et al.* (1987) in Dighali beel, had also recorded similar low productivity values. The high values observed in post monsoon season might be the result of nutrient addition through runoff from the catchment. Influence of nutrients in productivity was reported by Edmondson (1972) and Wetzel (1975). This might be the reason for the enhanced productivity values in the region near the concrete bund throughout the year. There is no relationship between the rate of net production and seasonal fluctuation. The highest value was reported in the post monsoon season. This increase might be due to the nutrient addition through runoff from the catchment and the increased phytoplankton production which occupies the first level in trophic level. Watson and Wilson (1978) also observed a similar trend and related higher Zooplankton number to higher content of chlorophyll 'a'. Chlorophyll 'a' is an indicator of phytoplankton abundance and a wide fluctuation in Chlorophyll 'a' was observed in the present study. During pre monsoon a steady decline in Chlorophyll 'a' concentration was observed which increased at monsoon and the concentration became highest during post monsoon. The high Chlorophyll 'a' concentration during post monsoon might be due to the increased phytoplankton population. Anuradha (1995) observed that silicate and Chlorophyll 'a' concentration have a direct relationship. This was also observed in the present study except station I and this relationship was significant at station V. In agreement with the observation of Anuradha (1995) potassium

exhibited an inverse relationship with chlorophyll 'a' which limits the growth of plankton. The positive relationship shown by Chlorophyll 'a' concentration and nitrate at three stations agrees with the report of Desai *et al.* (1984). Anuradha (1995) observed that nutrients seem to be a limiting factor in the synthesis and production of Chlorophyll 'a'.

Comparatively low production was observed in Sasthamkotta lake in the present study. The existing low rate of production in spite of leaching from the hills around may be due to complete isolation of the lake, totally preventing the inflow of nutrients from other areas and the very low fertility of the soil and the unscientific agricultural practices followed in the catchment area.

CHAPTER VI
ABUNDANCE AND DYNAMICS
OF FISH FAUNA

CHAPTER VI

ABUNDANCE AND DYNAMICS OF FISH FAUNA

INTRODUCTION

The information about the abundance and distribution of fishes of the aquatic biotope forms the basic step in assessing the fishery resources and their management. The fish fauna of the fresh water environment shows considerable variations in genera and species when compared to marine and estuarine environment. Monitoring the occurrence of species and their population has been the basis for assessing the effects of environment impacts (Spellerberg, 1993). Fish fauna of an aquatic habitat may disappear for reasons such as habitat alteration, population, overfishing, disturbances, changes in land use etc. to have an insight into the various threats that contributed to the decline of a species or an assemblage of species, there has to be first of all basic data of the distribution of the past, present or future changes in the species composition and abundance of the fish fauna.

It is very essential to follow an efficient sampling strategy to get a clear and accurate picture of the fish fauna of any water body. Gears like cast nets, seine nets, gillnets, electrofishing, ichthyotoxins etc are usually used for such studies [however, due to severe constraints electrofishing and ichthyotoxins are not in common use now]. These sampling techniques will help not only in assessing the efficiency of the commonly used gears but also in making a quantitative assessment of the fish resources of the lake. The assessment of the nature of the indigenous fish fauna that occur in the different types of water bodies is the primary requisite for using them as potential areas for fish culture.

India is rich in fish fauna, representing 11.72% species, 23.96% genera, 57% of families and 80% of orders of the world (Barman, 1998). Some of the important ichthyological studies in India in general and Kerala in particular include

the works of Day (1875-1878), Menon (1997), Rema Devi and Indira (1986), Rema Devi (1992) and Rema Devi *et al.* (1996).

Most of the recent studies on the assemblage structure of fishes have concentrated on rivers (Easa and Bhasha 1995; Shaji and Easa 1996; Biju *et al.*, 1999; Thomas *et al.*, 2002). The habitat associations, usage and requirements of fish species could reveal delicate relations with their environment. There are extensive studies on community level in temperate systems (Ross, 1986), while fish communities especially of South Asia, are totally under-investigated (Moyle and Senanayake, 1984; Wikramanayake and Moyle, 1989; Arun, 1992 and Sandhya, 2003). In Kerala, the distribution of fishes in the Western Ghats have been investigated by Chhapgar and Ranjit (2000). A detailed study of the patterns and processes of fish assemblages in Periyar lake valley system was undertaken by Arun (1997) and in Vellayani lake by Sandhya, 2003. The only Scientific data available on Sasthamkotta lake have been collected from the catches of fishermen who were operating nets there (Thomas *et al.*, 1980; Prakasam, 1991; Joseph, 1994; CWRDM, 2001). Hence it was felt highly necessary to undertake a detailed study on the fish diversity, their assemblages and their dynamics in lake Sasthamkotta.

METHODOLOGY

Samples of fish were collected from the selected five stations using different types of fishing gear. The selection of these gears was based on the survey among the fisherman who is engaged in fishing in Sasthamkotta lake. The three different nets used were cast net, encircling net and gillnets of different mesh sizes.

Encircling Net

Encircling nets are used for collecting fishes in open, still or slow flowing water bodies. The net is operated by two fishermen wading through the water. One fisherman keeps one end of the net stationary and the other fisherman brings the net in circle and joins the first fisherman and this results in encircling and

trapping of all the fishes in that area inside the net (Plate II Fig. I &2). Encircling net used in the present study had a mesh size of 20 mm.

Gill Net

Of the three nets, gill nets are more commonly used in all parts of the lake for getting large fishes of commercial importance. It is a passive method. One end of the net is anchored to a pole while the next is being set, the anchor is lowered after which the fishermen move slowly in the boat with the wind, shooting the rope, the fleet of net and buoy tied to the free end of the fleet. When the net is hauled, the anchor is pulled out. The net is held by cork and ground lines and lifted out of the water. (Plate II Fig. 3 & 4).

Three types of gillnets with three mesh sizes were used for the present study. They are named as Gill net-I with mesh size 4 cm; Gill net-II with mesh size 3 cm and Gill net-III with mesh size 1.5 cm. All the gill nets are having approximately a length of 12 metres and a breadth of 3 metres.

Cast net

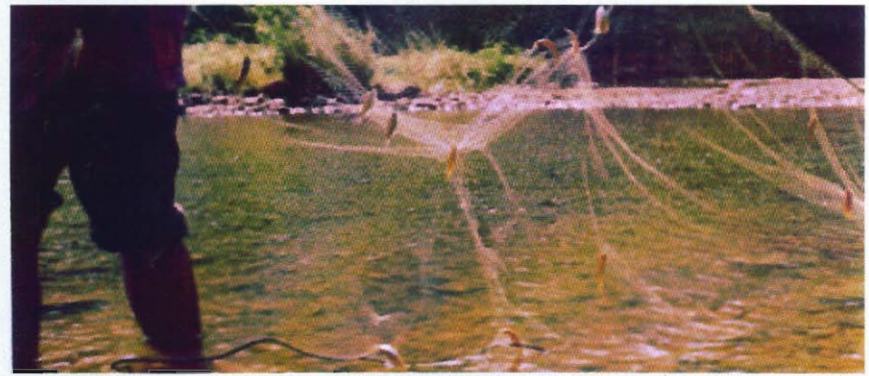
Fish in shallow water or on surface, in still or low flowing water can be caught by this method. Cast nets are circular in shape with weights around the perimeter. They usually have a central line, which is retained in the hands of the operator for hauling the net after it has been cast. (Plate II. Fig. 5 & 6)

At all the stations fishes were caught using encircling nets. Gill nets and cast nets are for the estimation of various parameters of biodiversity and conducted at station IV near the filter house where most of the fishermen do fishing. After fishing nets were brought to the shore, fishes were taken and preserved in 10% formalin and kept separately. Fishes were identified using relevant keys available for fish identification (Day, 1875-1878; Munro, 1955; Talwar and Jhingran, 1991 and Jayaram, 1999).

Encircling net operation



Gill net operation



Cast net operation



RESULTS

A total of 10810 fishes belonging to 7 orders 14 families 16 genera and 26 species were obtained during the period of study from November 2004 to October 2005 using the different types of nets from Sasthamkotta lake. Their taxonomic status along with their IUCN classification, availability in the lake from the present study and common names are given in Table 6.1. The pictorial evidences of all the fish obtained are provided in Plate III, IV and V.

Of the 14 families, Cyprinidae dominated with 7 species represented by *Puntius filamentosus*, *Puntius sarana*, *Puntius amphibius*, *Puntius dorsalis*, *Puntius vittatus* and *Puntius ticto*. This was followed by the family Siluridae and Bagridae represented by three species. Siluridae has *Ompok bimaculatus*, *Ompok malabaricus* and *Wallago attu*. Bagridae has *Mystus bleekeri*, *Mystus oculatus* and *Horabagrus brachyosoma*. Family Aplocheilidae, Cichlidae and Channidae were represented by two species each. The other eight families had only one species each (Table 6.1).

Temporal variation in the species composition using all the nets

Since the three types of nets used for sampling show some degree of selectivity, data obtained from all the three nets was pooled together so as to estimate the temporal variation in species composition and abundance. The results are presented in Figure 6.1. The number of species varied from 14 to 25 with the maximum number of species caught in June and the minimum number of species in February. The data for the different months of the three seasons, the monsoon, the postmonsoon and the premonsoon was pooled together and the seasonal value of the number of species is also provided in the figure. The maximum number of species was obtained during the post monsoon (26) and 25 species each was collected during the monsoon and pre monsoon season.

Abundance of fish fauna

For estimating the abundance of fishes belonging to each species during the different months, pooled data from all the nets was used and the abundance is given as percentage of the total number of fishes belonging to each species. The

data was estimated for all the months and the three seasons and the variations are given in Tables 6.2 and 6.3.

The overall abundance of fishes varied considerably from species to species. Of the 26 species collected the highest abundance was shown by *Dayella malabaricus* (36.85%) followed by *Puntius filamentosus* (20.05%), *Parambassis dayi* (13.01%) and *Etroplus maculatus* (12.43%) and the lowest abundance by the *Ompok malabaricus* (.03%). The most abundant species in the lake were considerably smaller in size and does not contribute significantly to the commercial fishery. Commercially important fishes like *wallago attu*, *Channa sp.*, *Ompok sp.* *Heteropneusteus fossilis* were obtained in fewer numbers. Neither the adult nor the larvae of any species of prawns were obtained during the present study.

On the basis of the abundance of fishes caught by different nets during the one year study, the fishes were categorized into the following 6 groups., as very rare (fishes obtained below 5 numbers) rare (>5 and < 20) not common (>20 and <100) common (>100 and <500) very common (>500 <1000) and abundant (>1000). This categorization is presented in Table 6.1. *Ompok malabaricus* (which comes under the very rare group (Vr) and was first reported in the lake) and *Channa micropeltus* are critically endangered. *Ompok bimaculatus*, *wallago attu*, *Channa marulius*, *Channa micropeltus*, *Glossogobius giuris* and *Aplocheilus lineatus*, *Aplocheilus panchax*, *Channa marulius*, *Channa micropeltus*, *Ompok bimaculatus*, *Wallago attu*, *Heteropneusteus fossilis* and *Glossogobius giuris* are the rarest fishes (R) in the lake. Here *wallago attu* is in the low risk category. *Aplocheilus sp.* and *Glossogobius giuris* comes under low risk least concern (LRlc) category and *Ompok bimaculatus* and *Heteropneusteus fossilis* in the vulnerable (Vu) group. *Channa marulius* comes under the low risk not threatened (LRnt) category. *Horabagrus brachysoma* and *Puntius dorsalis* are endangered (En) and not common (NC) now in the lake. *Dayella malabaricus* (CR), *Puntius filamentosus* (LRlc), *Etroplus maculatus* (LRlc) and *Parambassis dayi* (VU), are in the abundant (A) category. *Xenentodon cancilla* (LRnt), *Macragnathus guentheri* (VU), *Hyporhamphus limbatus* (LRnt), *Puntius sarana* (LRnt) and *Puntius amphibius* (LRlc) are in the common (C) category. *Mystus oculatus* is in

the very common (VC) group and *Puntius vittatus* (VU), *Puntius ticto* (LR1c), *Etroplus suratensis* (LR1c), *Mystus bleekeri* (LRnt) and *Macropodus cupanus* (LR1c) were included in the not common (NC) group.

Monthly and seasonal variations in fish abundance

The abundance of each species of fish during each month of collection and also during the three seasons was estimated from the pooled data. The overall abundance was the highest during June (12.35%) and the lowest during February (6.44%). Moderate values were found in the months of July, August and September.

Considerable variations were observed in the monthly abundance of each species. *Dayella*, which was the most abundant fish in the lake, had its highest abundance in July and the lowest abundance in October. *Etroplus maculatus* was also abundant in July; the lowest abundance of this fish was recorded in May. The highest abundance of *Parambassis dayi* was noticed in November and lowest in April. *Etroplus suratensis* were abundant in May and *Horabagrus brachysoma* in July. *Mystus oculatus* was abundant in August, *Puntius amphibius* in January, *Puntius filamentosus* in October, *Puntius ticto* in January and June, *Puntius vittatus* in June, *Puntius dorsalis* in August and *Xenentodon cancila* in November.

Seasonally the highest abundance was noted during the monsoon season and the pre monsoon season showed the lowest abundance. *Puntius filamentosus* was the most abundant fish in all the seasons. Most of the species were abundant during the monsoon months (Table 6.3 and Fig. 6.2). Variation in the abundance was not significant among seasons (Table 6.3a).

Spatial and temporal variation of species composition

Monthly sampling was carried out from the five selected localities for one year using encircling net in order to find out whether there is any difference in species composition in different parts of the lake. According to Sandhya (2003) encircling net is the most efficient gear. Spatial and temporal variation was studied using encircling whereas cast net and gillnets were operated for temporal studies. Using encircling net 16 species was obtained and their distribution in different

stations is given in Table 6.4. Thirteen species each from station I and IV, eleven species from Station II, twelve species from station III and six species from Station V (Fig. 6.3) were collected using encircling net. Total fish catch collected from different stations using encircling nets is given in Fig. 6.4. Since encircling net is selective the difference in species composition is only comparative. The absence of certain species from certain localities does not really mean that they are not present in that area. The species composition and abundance was lower in Station V.

The monthly variation in species composition in the five selected stations is given in Table 6.5. The maximum number of ten species was recorded at Station IV in December and the minimum of two in August at Station I and II. The maximum number of species at Station I was nine, found, during June. From Station II, a maximum number of six species was recorded in July. At station III the maximum number of nine species was found during January. The minimum number of species at Station IV was three during July and November. The maximum number of species at Station V was five and minimum was three in different months. By using encircling net the maximum number of 16 species was collected during the monsoon period and the minimum of 13 during the pre monsoon period (Table 6.6 to 6.16).

Net wise fish abundance

Different types of nets (encircling net, cast net, gill net I, II, III) were used during the study period for experimental fishing. Percentage abundance of fishes caught by each type of net is presented in Tables 6.6 to 6.28. The maximum abundance of fish was from the catches by cast net followed by gill net and encircling net (Fig 6.6).

1. Fish Abundance by Encircling Net

Station wise variation in the percentage abundance of fishes caught by encircling net is given in Table 6.4 and Figs. 6.4 and 6.5. The abundance was high in Station I followed by Station IV, Station III, station II and Station V. In all the stations *Puntius filamentosus* were found to be abundant. At station I,

Puntius filamentosus was followed by *Mystus oculatus*, *Puntius amphibius*, and *Etroplus maculatus*. At station II, *Puntius filamentosus* was followed by *Etroplus maculatus*, *Xenentodon cancilla* and *Puntius amphibius*. At station III, *Puntius filamentosus* was followed by *Etroplus maculatus*, *Mystus oculatus* and *Puntius dorsalis*. At station IV, *Etroplus maculatus*, *Mystus oculatus* and *Parambassis dayi* was abundant. At station V, *Puntius filamentosus* was followed by *Etroplus maculatus*, *Mystus oculatus* and *Puntius amphibius*.

Of the 16 species, five species were obtained from all the stations (*Parambassis dayi*, *Puntius filamentosus*, *Puntius amphibius*, *Mystus oculatus* and *Etroplus maculatus* were the most species present in all the stations. *Etroplus suratensis*, *Heteropnusteus fossilis*, *Wallago attu*, *Ompok bimaculatus*, *ompok malabaricus*, *Channa marulius*, *Channa micropeltus*, *Dayella malabaricus*, *Aplocheilus lineatus* and *Aplocheilus panchax* were not reported in the present study by using the encircling net.

Monthly variation in the percentage abundance and seasonal fluctuation in the number of fishes caught by encircling net is given in Tables 6.6 to 6.17.

In station I, maximum abundance value was noted in October and the minimum in August. However the maximum number of species was observed in June (Table 6.6). The seasonal maximum was noted during the post monsoon period and the minimum during monsoon season (Table 6.7). *Puntius filamentosus* was the most abundant species. This station had the maximum abundance compared to other stations using the encircling net.

The monthly and seasonal fluctuations in the abundance of fishes at station II are given in Tables 6.8 and 6.9. Abundance was high in March and minimum in April. Here also *Puntius filamentosus* was the most abundant species. In station III, maximum abundance value was noted in august and the minimum in February (Tables 6.10 and 6.11). In station IV, abundance was high in March and minimum in May (Tables 6.12 and 6.13). Fish abundance value was high in April and low in February, March and December at station V (Tables 6.14 and 6.15). In all these stations *Puntius filamentosus* dominated. At station I, II and V fish

abundance was maximum during post monsoon season whereas at stations III and IV during monsoon and pre monsoon respectively.

Data obtained from all the stations using encircling net was pooled together and the percentage was calculated and presented in Table 6.16. Of the 16 species *Puntius filamentosus* was the most dominating one followed by *Etroplus maculatus* and *Mystus oculatus*. The lowest abundance was *Horabagrus brachysoma*. The highest abundance value was noted in July and December. The lowest abundance was in November.

Seasonal fluctuation in the abundance by fish catch from all the stations is given in Table 6.17. Seasonal analysis showed that the highest abundance was during post monsoon and lowest during pre monsoon season. Significant season wise and station wise variation was observed (Table 6. 17a).

2. Fish Abundance by Gill Net

Out of the total number of 26 species of fishes obtained from the lake, 22 species were collected by the three gill nets. The availability of fishes in the different gill net is presented in Table 6.18. Station IV was selected as a study site for all gillnets and cast net. Only three species were collected in common by all the three types of gill nets. They were *Puntius filamentosus*, *Parambassis dayi*, *Etroplus maculatus* and *Mystus oculatus*. *Heteropnusteus fossilis*, *Wallago attu*, *Ompok bimaculatus*, *ompok malabaricus*, *Channa marulius*, *Channa micropeltus*, were caught in GN-I. *Etroplus suratensis* was obtained in GN-I and II. *Horabagrus brachysoma* was obtained in both GN-I and III but the adults were obtained only in GN-I. *Glossogobius giuris*, *Macropodus cupanus*, *Aplocheilus lineatus* and *Aplocheilus panchax* were not obtained in any of the gill nets.

Etroplus maculatus (28.24%) showed dominance in gill net collections. *Parambassis dayi* (27.58%), *Puntius filamentosus* (15.06%), and *Mystus oculatus* (11.95%) were the other fishes in abundance in all the three gill nets. Variations in the number of species collected by different gill nets and their abundance are given in Figs. 6.7 and 6.8. 15 species from GN- I, 6 species from GN-II and 13 species

from GN-III were obtained. Percentage abundance was found to be highest from GN-III. GN-II had the lowest abundance.

Month wise species composition, abundance and seasonal fluctuation in the number of fishes caught by the different gill nets are presented in Tables 6.19 to 6.26. Majority of the fishes collected by GN-I were large sized because of the large mesh size of the net. *Etroplus maculatus* (29.48%) was the dominant fish in this net and they were caught in large numbers during February. *Mystus oculatus* (17.94%) and *Parambassis dayi* (15.26%), were the other fishes in abundance by GN-I. Considering all the fish, the highest catch was in February followed by June. The seasonal trend showed a high abundance during the pre monsoon and low during post monsoon (Table 6.19 and 6.20).

Monthly species composition, abundance and seasonal fluctuation in the number of fishes caught by the GN-II are presented in tables 6.21 and 6.22. *Etroplus maculatus* (49.16%) was the dominant fish in this net and they were caught in large numbers during January. *Puntius filamentosus* (20.67%), and *Parambassis dayi* (11.17%), were the other fishes in abundance by GN-II. Considering all the fish the highest catch was in January. The seasonal trend showed a high abundance during post monsoon and low during monsoon.

Monthly species composition, abundance and seasonal fluctuation in the number of fishes caught by the GN-III are presented in Tables 6.23 and 6.24. *Parambassis dayi* (35.84%) was the dominant fish in this net and they were caught in large numbers during November. *Etroplus maculatus* (22.59%) and *Puntius filamentosus* (20.67%) were the other fish in abundance by GN-III. Considering all the fish the highest catch was in November. The seasonal trend showed a high abundance during postmonsoon and lowest during premonsoon.

Seasonal abundance from the fish catches using all the gill nets is shown in Table 6.25 and 6.26. The seasonal trend showed a high abundance during post monsoon and lowest during pre monsoon. The number of species was also high during post monsoon and monsoon. Season wise variation was found to be significant (Table 6.26 a).

3. Fish Abundance by cast Net

Monthly and seasonal fluctuations in the abundance of fishes caught by cast net are given in Tables 6.27 and 6.28. Compared to the other two nets the abundance of fish from this net was found to be higher. Season wise variation was found to be significant (Table 6.28 a).

Eighteen species were obtained from cast net. *Dayella malabaricus* was collected in large numbers, the highest of which was found in June. *Parambassis dayi*, *Puntius filamentosus*, *Etroplus maculatus* and *Mystus oculatus* were also present in fairly large numbers. The highest number of species was in July and abundance was recorded in June. Seasonal analysis showed the highest abundance was in monsoon period. *Dayella malabaricus* was the most abundant fish in all the three seasons (Fig. 6.10).

Table 6.1 Systematic position, vernacular name, conservation status and relative abundance of Ichthyofauna

Sl. No	Piscine Taxonomy	Vernacular Name	Conservation Status	Relative Abundance
I	Order: CLUPEIFORMES <i>Family: CLUPEIDAE</i> Subfamily: <i>PELLONULINAE</i>			
1	<i>Dayella malabaricus</i> (Day, 1873)	Netholi	CR	A
II	Order: CYPRINIFORMES <i>Family: CYPRINIDAE</i> Subfamily: <i>CYPRININAE</i>			
2	<i>Puntius sarana</i> (Hamilton, 1822)	Kuruva Paral	LRnt	C
3	<i>Puntius filamentosus</i> (Valenciennes, 1844)	Poovaliparal	LRlc	A
4	<i>Puntius ampibius</i> (Valenciennes, 1842)	Paral	LRlc	C
5	<i>Puntius dorsalis</i> (Jerdon, 1849)	Paral	En	Nc
6	<i>Puntius vittatus</i> (Day, 1865)	Paral	Vu	Nc
7	<i>Puntius ticto</i> (Hamilton, 1822)	Paral	LRlc	NC
III	Order: SILURIFORMES <i>Family: SILURIDAE</i>			
8	<i>Ompok bimaculatus</i> * (Bloch, 1794)	Manklan	VU	R
9	<i>Ompok malabaricus</i> * (Valenciennes)	Manklan	CR	Vr
10	<i>Wallago attu</i> * (Bloch & Schneider, 1801)	Attu Vaala	LR	R
	<i>Family: HETEROPNEUSTIDAE</i>			
11	<i>Heteropneustes fossilis</i> * (Bloch)	Kari	Vu	Vr
	<i>Family: BAGRIDAE</i> Subfamily: <i>BAGRINAE</i>			
12	<i>Mystus bleekeri</i> * (Day, 1877)	Chillan Koori	LRnt	NC
13	<i>Mystus oculatus</i> * (Valenciennes, 1840)	Koori	LRlc	VC
14	<i>Horabagrus brachyosoma</i> * (Gunther, 1864)	Manjetta	En	NC
IV	Order: BELONIFORMES <i>Family: BELONIDAE</i>			
15	<i>Xenentodon cancilla</i> * (Hamilton, 1822)	Kolan	LRnt	C
	<i>Family: HEMIRHAMPHIDAE</i>			
16	<i>Hyporhamphus limbatus</i> * (Valenciennes, 1847)	Koralan	LRnt	C

Systematic position, vernacular name, conservation status and relative abundance of ichthyofauna

Sl. No	Piscine Taxonomy	Vernacular Name	Conservation Status	Relative Abundance
V	Order: CYPRINODONTIFORMES <i>Family: APLOCHEILIDAE</i> <i>Subfamily: APLOCHEILINAE</i>			
17	<i>Aplocheilus lineatus</i> (Valenciennes, 1846)	Manathukanni	LRlc	R
18	<i>Aplocheilus panchax</i> (Hamilton, 1822)	Manathukanni	LRlc	R
VI	Order: PERCIFORMES <i>Family: CHANDIDAE</i>			
19	<i>Parambassis day</i> * (Bleeker, 1874) <i>Family: CICHLIDAE</i>	Mully	Vu	A
20	<i>Etroplus maculatus</i> * (Bloch, 1795)	Pallathi	LRlc	A
21	<i>Etroplus suratensis</i> * (Bloch, 1790) <i>Family: BELONTIDAE</i> <i>Subfamily: MACROPODUSINAE</i>	Karimeen	LRlc	NC
22	<i>Macropodus cupanus</i> (Old name) <i>Pseudosphromenus cupanus</i> (Cuvier, 1831) <i>Family: GOBIDAE</i> <i>Subfamily: GOBIINAE</i>	Karinkana	LRlc	NC
23	<i>Glossogobius giuris</i> * (Hamilton, 1822) <i>Family: CHANNIDAE</i>	Poonthi	LRlc	R
24	<i>Channa marulius</i> * (Hamilton, 1822)	Vaaka	LRnt	R
25	<i>Channa micropeltus</i> * (Cuvier, 1831)	Pulivaaka	CR	R
Vii	Order: SYNBRANCHIFORMES <i>Family: MASTACEMBELIDAE</i>			
26	<i>Macrognathus guentheri</i> (Day, 1865)	Arakan	Vu	C

*Commercially important (Jjingran, 1975)

En-Endangered; CR- Critically endangered; Vu- Vulnerable; LR-Low Risk; LRlc-Low Risk least concern; LRnt- Low Risk not threatened;

Vernacular Name-Malayalam

Availability: A-Abundant; C-Common; Vc-Very common; Vr-Very Rare; R-Rare

NC-not common

PLATE III



Puntius amphibius



Puntius sarana sarana



Puntius ticto



Puntius vittatus



Puntius filamentosus (female)



Puntius filamentosus (male)



Puntius dorsalis



Macropodus cupanus

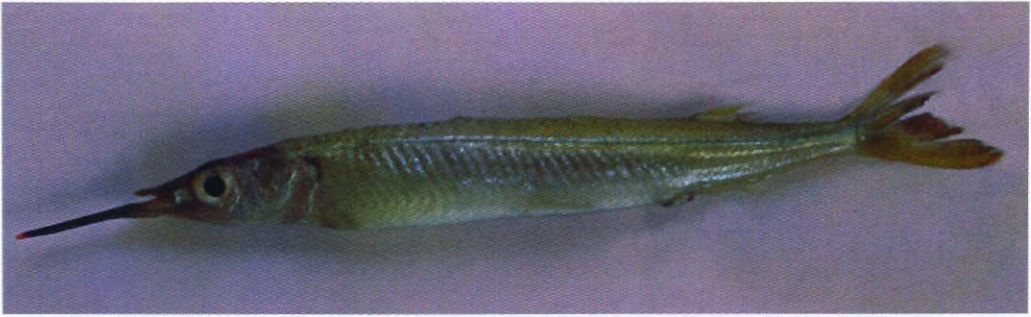


Etroplus maculatus



Etroplus suratensis

PLATE IV



Hyporhamphus limbatus



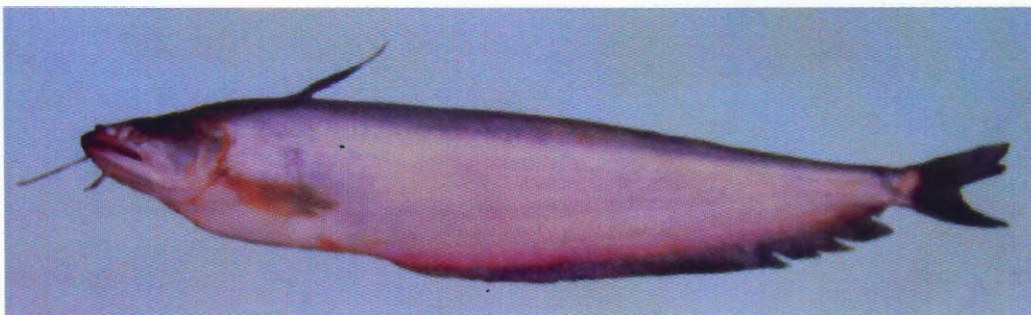
Xenentodon cancila



Ompok malabaricus



Ompok bimaculatus



Wallago attu

T1455

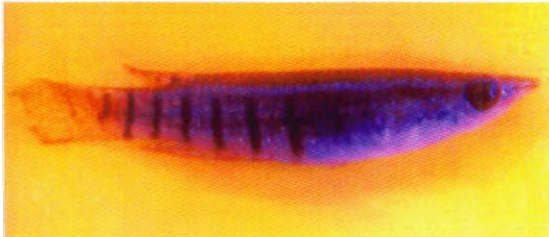
PLATE V



Mystus oculatus



Mystus bleekeri



Apolcheilus lineatus



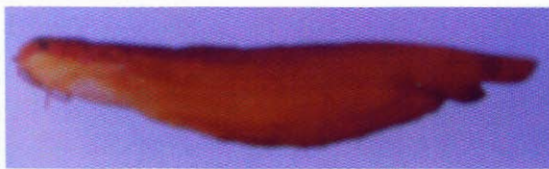
Aplocheilus panchax



Channa marulius



Channa micropeltes



Heteropneustes fossilis



Macrogathus guentheri



Parambassis dayi



Glossogobius giuris



Horabagrus brachysoma

Table 6.2 Gross monthly percentage catch using all types of gears from Sasthamkotta lake

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>		0.14	0.05	0.14	0.11	0.01	0.05	0.08	0.24	0.15	0.11	0.06	1.13
<i>P. filamentosus</i>	0.63	1.72	1.31	1.07	2.27	1.21	1.61	1.32	3.11	2.23	1.96	1.61	20.05
<i>P. amphibiis</i>		0.18	0.49	0.03	0.14	0.02	0.11	0.06	0.04	0.10	0.03	0.54	1.72
<i>P. dorsalis</i>		0.01	0.01	0.03	0.06	0.01	0.27	0.01	0.04	0.04	0.07	0.07	0.61
<i>P. vittatus</i>	0.03	0.04	0.04	0.04	0.07	0.00	0.04	0.06	0.04	0.06	0.04	0.06	0.50
<i>Puntius ticto</i>		0.02		0.02	0.08	0.00	0.03	0.02	0.04	0.06	0.05	0.08	0.39
<i>X. cancella</i>	0.18	0.19	0.06	0.05	0.06	0.00	0.12	0.06	0.08	0.23	0.14	0.09	1.25
<i>H. limbatus</i>	0.13	0.06	0.02	0.06	0.07	0.01	0.06	0.10	0.07	0.36	0.10	0.06	1.10
<i>P. dayi</i>	0.72	0.70	0.39	0.61	1.72	1.19	0.99	1.64	1.08	1.78	1.14	1.04	13.01
<i>E. maculatus</i>	0.97	0.47	0.93	0.18	0.99	1.96	0.82	0.89	1.15	1.31	1.10	1.66	12.43
<i>E. suratensis</i>	0.07	0.06	0.08	0.12	0.03	0.01	0.02	0.08	0.03	0.04	0.03	0.04	0.61
<i>M. guentheri</i>		0.01		0.01	0.02	0.06	0.06	0.01	0.01	0.01	0.02	0.03	0.23
<i>A. lineatus</i>		0.01	0.01		0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.13
<i>A. panchax</i>	0.01				0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.10
<i>H. fossilis</i>			0.02		0.02	0.03	0.01		0.01	0.01		0.01	0.10
<i>Wallago attu</i>		0.01		0.01	0.01	0.01		0.01		0.01	0.02	0.01	0.08
<i>O. bimaculatus</i>		0.01	0.01		0.02	0.01	0.01	0.02		0.01	0.01		0.09
<i>O. malabaricus</i>					0.01			0.01		0.01			0.03
<i>M. bleekeri</i>	0.02		0.02	0.01	0.02	0.03	0.07		0.05		0.01		0.22
<i>Mystus oculatus</i>	0.89	0.43	0.75	0.53	0.47	0.43	1.22	0.54	0.65	0.62	0.83	1.05	8.41
<i>H. brachyosoma</i>		0.02	0.03	0.02	0.10	0.11	0.05	0.01	0.03	0.01	0.05	0.01	0.42
<i>C. marulius</i>	0.01			0.01	0.01	0.01		0.01	0.01	0.01			0.06
<i>C. micropeltus</i>	0.01			0.01	0.01	0.01		0.01	0.01	0.01			0.06
<i>D. malabaricus</i>	2.77	2.87	3.23	2.05	5.95	6.37	4.93	4.84	0.63	1.01	1.46	0.74	36.85
<i>M. cupanus</i>	0.00	0.02	0.04	0.02	0.08	0.02	0.02	0.04	0.05		0.04		0.31
<i>G. giuris</i>	0.02	0.03		0.02							0.02		0.08
Total	6.43	6.97	7.46	5.01	12.4	11.5	10.5	9.85	7.38	8.08	7.23	7.19	100.00
Number	14	20	18	21	25	21	21	23	22	23	22	19	26

Table 6.3 Gross seasonal catch (No./Haul) from all types of gears from Sasthamkotta lake

Types of fish	PREMONSOON			MONSOON			POST MONSOON			TOTAL
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD	Total
<i>Puntius sarana</i>	35	8.75	7.5	27	6.75	4.79	60	15	8.406	122
<i>P. filamentosus</i>	513	128.3	49.7	694	173.5	51.6	967	241.8	69.17	2174
<i>P. amphibius</i>	75	18.75	25.5	36	9	5.72	76	19	26.24	187
<i>P. dorsalis</i>	5	1.25	1.15	37	9.25	13.4	24	6	2.309	66
<i>P. vittatus</i>	15	3.75	0.5	18	4.5	2	21	5.25	1.5	54
<i>Puntius ticto</i>	4	1	1.15	14	3.5	3.79	24	6	2.16	42
<i>X. cancella</i>	51	12.75	8.42	26	6.5	3.79	59	14.75	7.32	136
<i>H. limbatus</i>	28	7	5.03	26	6.5	4.2	65	16.25	15.26	119
<i>P. dayi</i>	262	65.5	16.5	601	150.3	38.5	547	136.8	37.77	1410
<i>E. maculatus</i>	277	69.25	41	505	126.3	58.3	566	141.5	27.45	1348
<i>E. suratensis</i>	37	9.25	2.63	15	3.75	3.59	14	3.5	0.577	66
<i>M. guentheri</i>	2	0.5	0	16	4	2.94	7	1.75	0.957	25
<i>A. lineatus</i>	2	0.5	0.58	6	1.5	0.58	6	1.5	0.577	14
<i>A. panchax</i>	1	0.25	0.5	6	1.5	0.58	4	1	0	11
<i>H. fossilis</i>	2	0.5	1	6	1.5	1.29	3	0.75	0.5	11
<i>Wallago attu</i>	2	0.5	0.58	3	0.75	0.5	4	1	0.816	9
<i>O. bimaculatus</i>	2	0.5	0.58	6	1.5	0.58	2	0.5	0.577	10
<i>O. malabaricus</i>				2	0.5	0.58	1	0.25	0.5	3
<i>M. bleekeri</i>	5	1.25	0.58	13	3.25	3.21	6	1.5	2.828	24
<i>Mystus oculatus</i>	281	70.25	22.3	289	72.25	40.1	342	85.5	21.49	912
<i>H. brachyosoma</i>	7	1.75	0.58	29	7.25	5.19	10	2.5	1.915	46
<i>C. marulius</i>	2	0.5	0.58	3	0.75	0.5	2	0.5	0.577	7
<i>C. micropeltus</i>	2	0.5	0.58	3	0.75	0.5	2	0.5	0.577	7
<i>D. malabaricus</i>	1183	295.8	53.6	2396	599	82	416	104	40.1	3995
<i>M. cupanus</i>	8	2	1.15	17	4.25	3.3	9	2.25	0.707	34
<i>G. giuris</i>	7	1.75	0.58				2	0.5	-	9
Total/mean catch	2777	694.3	113	4794	1199	120	3239	809.8	45.07	10810
No. of species	25			25			26			26

Fig. 6.1. Temporal variation of fish species using all nets collected from Sasthamkotta Lake

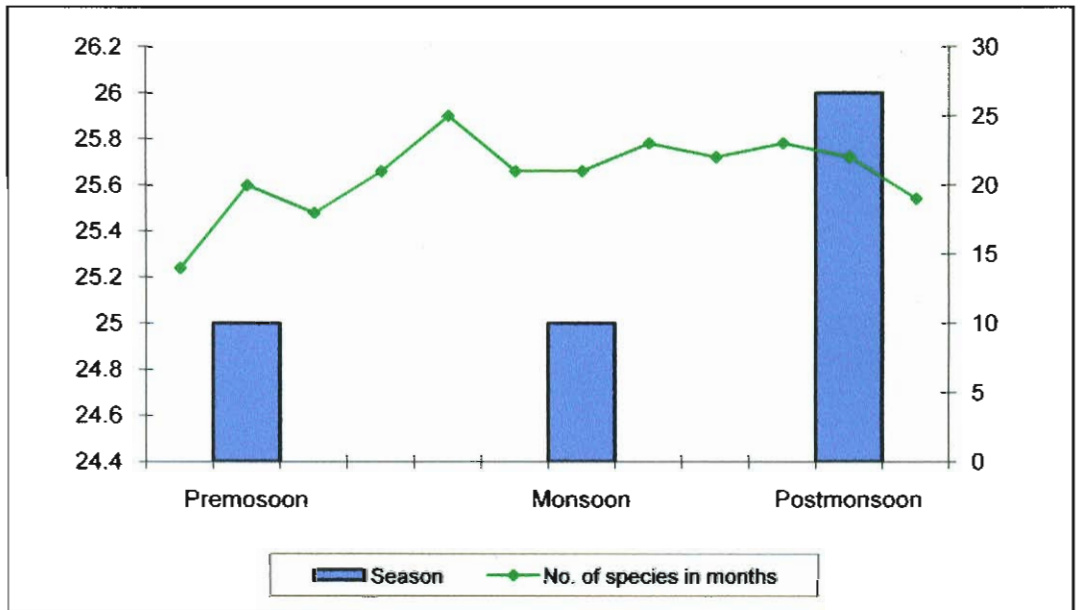


Fig. 6.2. Seasonal gross catch (No./Haul) and total species collected from Sasthamkotta Lake

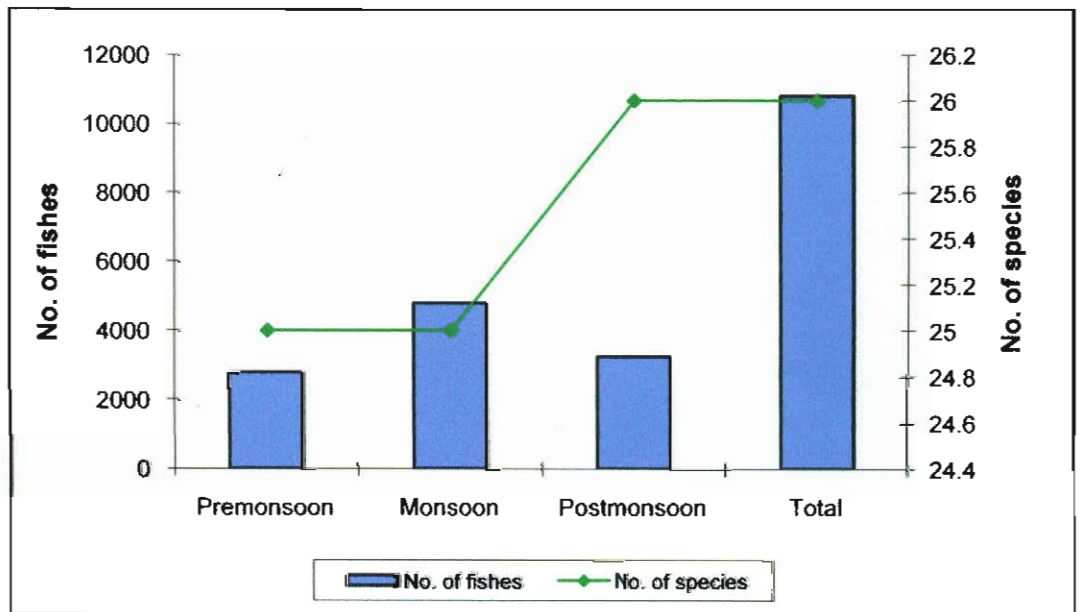


Table 6.4 Distribution of fish species in different stations using encircling net

Sl. No	Types of fish	STATIONS					TOTAL
		S I	S II	S III	S IV	S V	
1	<i>Puntius sarana</i>	38		10	33		81
2	<i>Puntius filamentosus</i>	368	390	252	283	176	1469
3	<i>Puntius amphibius</i>	104	16	5	18	11	154
4	<i>Puntius dorsalis</i>	2		39	2	4	47
5	<i>Puntius vittatus</i>	7	14	5			26
6	<i>Puntius ticto</i>	4	2	5	1		12
7	<i>Xenentodon cancilla</i>	25	23	14	57		119
8	<i>H. limbatus</i>	26		4	15		45
9	<i>Parambassis dayi</i>	20	5	16	69	10	120
10	<i>Etroplus maculatus</i>	70	45	115	197	49	476
11	<i>Etroplus suratensis</i>						
12	<i>M guentheri</i>		3		3		6
13	<i>Aplocheilus lineatus</i>						
14	<i>Aplocheilus panchax</i>						
15	<i>H. fossilis</i>						
16	<i>Wallago attu</i>						
17	<i>Ompok bimaculatus</i>						
18	<i>Ompok malabaricus</i>						
19	<i>Mystus bleekeri</i>	6					6
20	<i>Mystus oculatus</i>	171	1	115	76	86	449
21	<i>H. brachyosoma</i>		1				1
22	<i>C. marulius</i>						
23	<i>C. micropeltus</i>						
24	<i>Dayella malabaricus</i>						
25	<i>Macropodus cupanus</i>	11			9		20
26	<i>Glossogobius giuris</i>		2	4	4		10
	Total	852	502	584	767	336	3041

Table 6.5 Spatial and temporal variation in species composition by Encircling net

Month/ season	stations					
	SI	SII	SIII	SIV	SV	total
February	4	4	5	6	3	8
March	6	5	6	8	3	12
April	6	4	5	6	4	10
May	7	5	5	4	5	11
Premonsoon	10	5	7	9	6	13
June	9	5	7	4	4	12
July	4	6	4	3	4	8
August	2	2	4	4	4	7
September	6	4	5	5	4	9
Monsoon	12	10	9	6	6	16
October	8	5	5	7	4	12
November	4	5	6	3	4	11
December	8	5	7	10	5	15
January	6	3	9	9	4	10
Postmonsoon	11	7	11	13	6	15

Fig. 6.3. Number of species collected from different stations by encircling net

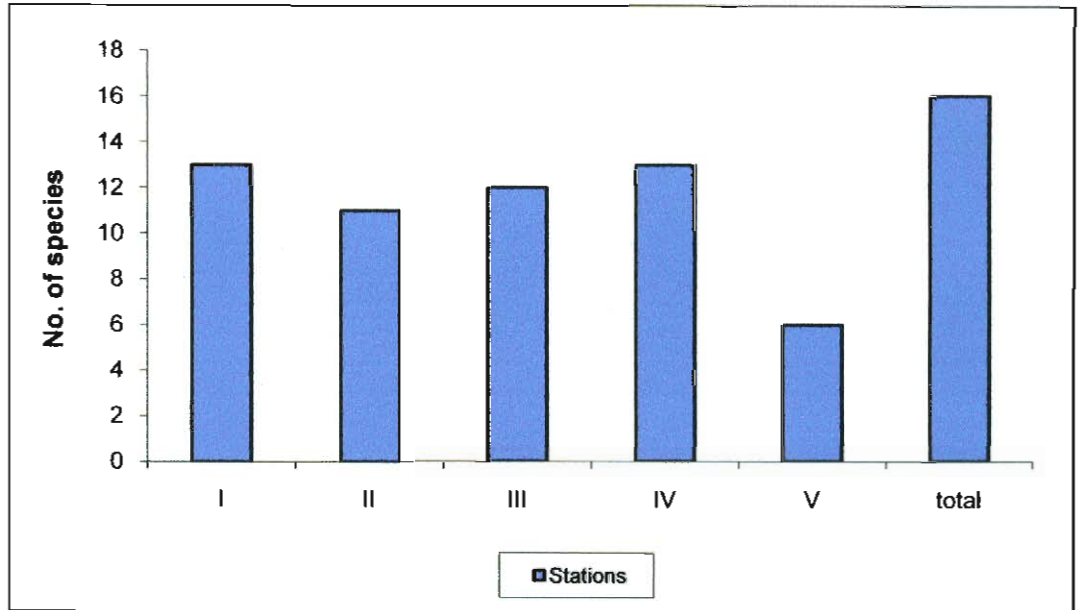


Fig. 6.4. Total fish catch (No./Haul) collected from different stations by encircling net

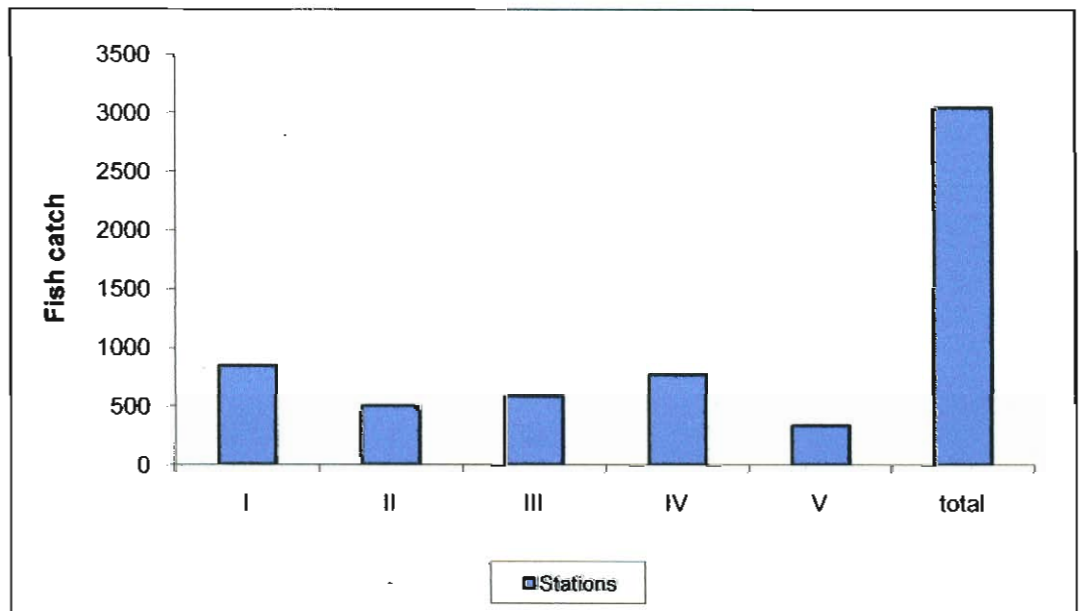


Fig. 6.5. Seasonal catch (No./Haul) and species collected by encircling net

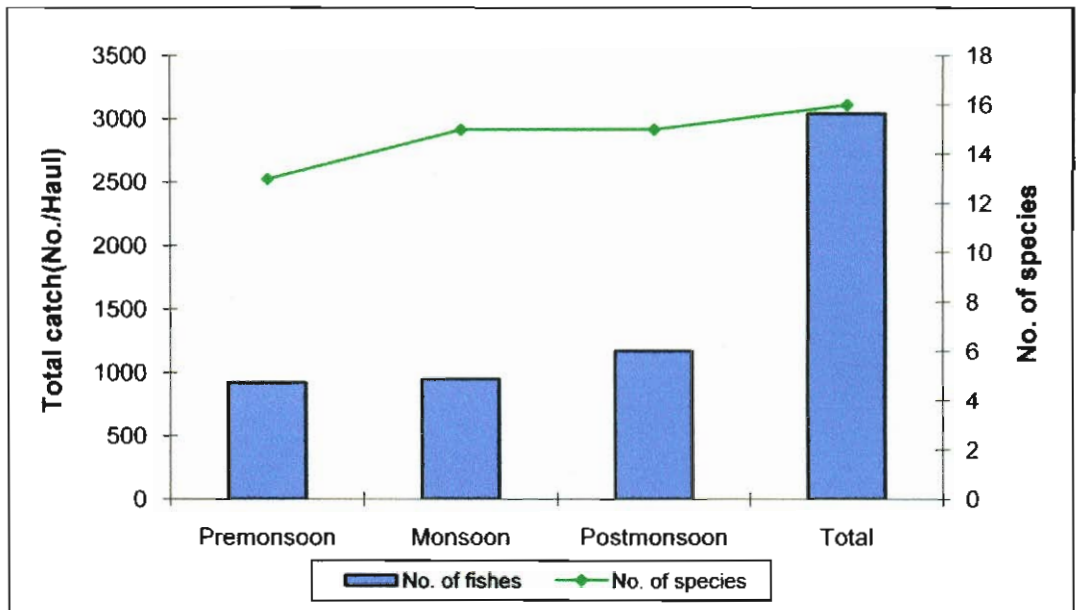


Fig. 6.6. Netwise gross catch (No./Haul) and total species collected from Sasthamkotta Lake

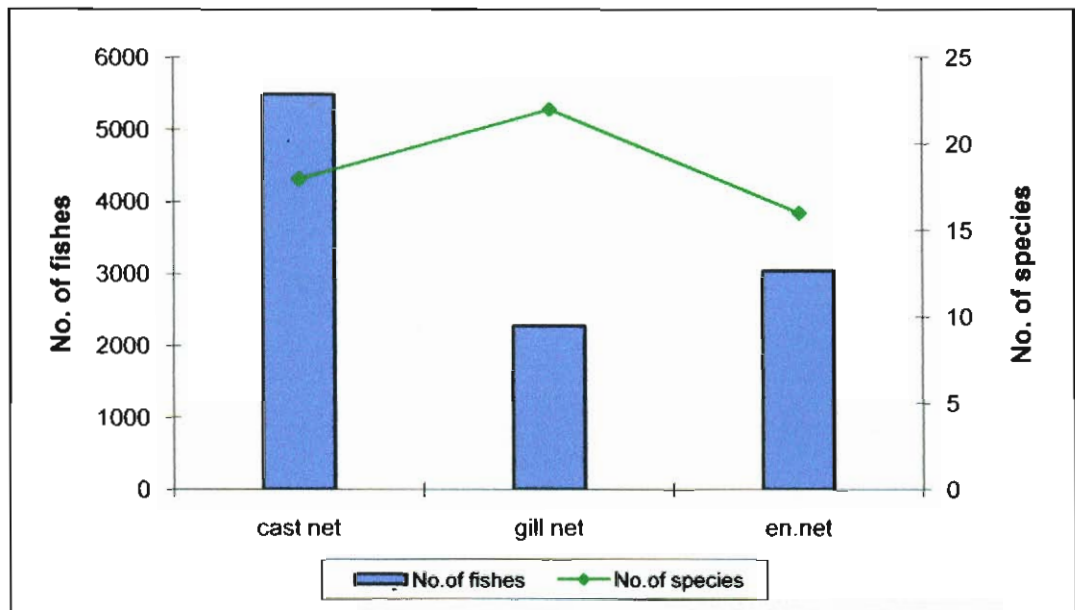


Table 6.6 Monthly percentage catch using encircling net at Station I

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>				1.53	0.59				1.17		1.17		4.46
<i>P. filamentosus</i>	1.29	3.29	3.05	3.17	3.40		2.70	2.46	12.91	1.29	7.04	2.58	43.19
<i>P. amphibius</i>			5.99					0.23				5.99	12.21
<i>P. dorsalis</i>					0.12	0.12						0.00	0.23
<i>P. vittatus</i>	0.12		0.23		0.12					0.12		0.23	0.82
<i>Puntius ticto</i>					0.47								0.47
<i>X. cancella</i>	0.94	0.23		0.35	0.23				0.12	0.94	0.12		2.93
<i>H. limbatus</i>	1.17	0.23			0.23				0.12	1.17	0.12		3.05
<i>P. dayi</i>		0.94	0.35			0.12		0.59				0.35	2.35
<i>E. maculatus</i>		0.94	0.12	0.12	0.35	2.58	0.23	0.94	1.41		1.41	0.12	8.22
<i>E. suratensis</i>													
<i>M. guentheri</i>													
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>				0.12		0.35			0.12		0.12		0.70
<i>Mystus oculatus</i>		1.41	4.93	1.76				1.17	2.93		2.93	4.93	20.07
<i>H. brachyosoma</i>													
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>													
<i>M. cupanus</i>				0.23	0.47			0.12	0.23		0.23		1.29
<i>G. giuris</i>													
Total	3.52	7.04	14.6	7.29	5.99	3.18	2.94	5.52	19.0	3.52	13.2	14.2	100
Number	4	6	6	7	9	4	2	6	8	4	8	6	

Table 6.7 Seasonal Catch (No/haul) from Station I of Sasthamkotta lake

Types of fish	PREMONSOON			MONSOON			POST MONSOON			TOTAL		
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD
<i>Puntius sarana</i>	13	3.25		5	2.88		20	5		38	3.17	3.32
<i>P. filamentosus</i>	92	23	8.04	73	18.25	12.6	203	50.75	44.7	368	30.7	28.8
<i>P. amphibius</i>	51	12.75		2	0.5		51	12.75		104	8.67	28.3
<i>P. dorsalis</i>				2	0.5					2	0.17	0
<i>P. vittatus</i>	3	0.75	0.71	1	0.25		3	0.75	0.71	7	0.58	0.55
<i>Puntius ticto</i>		0		4	1					4	0.33	-
<i>X. cancella</i>	13	3.25	3.21	2	0.5		10	2.5	4.04	25	2.08	3.1
<i>H. limbatus</i>	12	3	5.66	2	0.5		12	3	5.2	26	2.17	4.41
<i>P. dayi</i>	11	2.75	3.54	6	1.5	2.83	3	0.75		20	1.67	2.65
<i>E. maculatus</i>	10	2.5	4.04	35	8.75	9.22	25	6.25	6.35	70	5.83	6.88
<i>E. suratensis</i>												
<i>M. guentheri</i>												
<i>A. lineatus</i>												
<i>A. panchax</i>												
<i>H. fossilis</i>												
<i>Wallago attu</i>												
<i>O. bimaculatus</i>												
<i>O. malabaricus</i>												
<i>M. bleekeri</i>	1	0.25		3	0.75		2	0.5	0	6	0.5	1
<i>Mystus oculatus</i>	69	17.25	16.5	10	2.5		92	23	9.82	171	14.3	13.4
<i>H. brachyoxoma</i>												
<i>C. marulius</i>												
<i>C. micropeltus</i>												
<i>D. malabaricus</i>												
<i>M. cupanus</i>	2	0.5		5	1.25	2.12	4	1		11	0.92	1.1
<i>G. giuris</i>												
Total/mean catch	277	5.771		150	2.88	26.8	425	9.66		852	71	-
No. of species	11			13			11			13		

Table 6.8 Monthly percentage catch using encircling net at Station II

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>													
<i>P. filamentosus</i>	2.59	17.5	1.99	2.59	14.1	0.40	6.18	2.59	4.98	14.1	4.98	5.58	77.69
<i>P. amphibius</i>					1.59					1.59			3.19
<i>P. dorsalis</i>													
<i>P. vittatus</i>	0.40	0.40	0.40	0.40	0.20			0.40	0.20	0.20	0.20		2.79
<i>Puntius ticto</i>					0.20					0.20			0.40
<i>X. cancilla</i>	0.20	0.20	0.20	0.20			1.00	0.20	1.00		1.00	0.60	4.58
<i>H. limbatus</i>													
<i>P. dayi</i>						0.60			0.20		0.20		1.00
<i>E. maculatus</i>	0.20	0.20	0.20	0.20	0.60	4.38		0.20	0.40	0.60	0.40	1.59	8.96
<i>E. suratensis</i>													
<i>M. guentheri</i>						0.60							0.60
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>													
<i>Mystus oculatus</i>						0.20							0.20
<i>H. brachyosoma</i>						0.20							0.20
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>													
<i>M. cupanus</i>													
<i>G. giuris</i>		0.20		0.20									0.40
Total	3.39	18.6	2.79	3.59	16.7	6.37	7.17	3.39	6.77	16.7	6.77	7.76	100.0
Number	4	5	4	5	5	6	2	4	5	5	5	3	

Table 6.9 Seasonal Catch (No/haul) from Station II of Sasthamkotta lake

Types of fish	PREMONSOON			MONSOON			POST MONSOON			TOTAL		
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD
<i>Puntius sarana</i>												
<i>P. filamentosus</i>	124	7.1	38	117	29.25	30.3	149	37.25	22.5	390	32.5	28.2
<i>P. amphibius</i>				8	2		8	2		16	1.33	
<i>P. dorsalis</i>												
<i>P. vittatus</i>	8	2		3	0.75	0.71	3	0.75		14	1.17	0.53
<i>Puntius ticto</i>				1	0.25		1	0.25		2	0.17	0
<i>X. cancilla</i>	4	1		6	1.5	2.83	13	3.25	1.16	23	1.92	1.94
<i>H. limbatus</i>												
<i>P. dayi</i>				3	0.75		2	0.5	0	5	0.42	1.15
<i>E. maculatus</i>	4	1		26	6.5	11.6	15	3.75	2.87	45	3.75	6.28
<i>E. suratensis</i>												
<i>M. guentheri</i>				3	0.75					3	0.25	
<i>A. lineatus</i>												
<i>A. panchax</i>												
<i>H. fossilis</i>												
<i>Wallago attu</i>												
<i>O. bimaculatus</i>												
<i>O. malabaricus</i>												
<i>M. bleekeri</i>												
<i>Mystus oculatus</i>				1	0.25					1	0.08	
<i>H. brachyosoma</i>				1	0.25					1	0.08	
<i>C. marulius</i>												
<i>C. micropeltus</i>												
<i>D. malabaricus</i>												
<i>M. cupanus</i>												
<i>G. giuris</i>	2	0.5								2	0.17	
Total/mean catch	142	7.1		169	4.23		191	6.82		502		
No. of species	5			10			7			11		

Table 6.10 Monthly percentage catch using encircling net at Station III

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>										1.71			1.71
<i>P. filamentosus</i>	1.03	0.51	0.51	7.02	7.19		2.91	2.57	5.82	5.82	7.19	2.57	43.15
<i>P. amphibius</i>					0.17	0.34					0.17	0.17	0.86
<i>P. dorsalis</i>		0.17	0.17	0.17	0.34		4.28		0.17	0.17	0.34	0.86	6.68
<i>P. vittatus</i>					0.34			0.34				0.17	0.86
<i>Puntius ticto</i>					0.17						0.17	0.51	0.86
<i>X. cancella</i>	0.17			0.17	0.68				0.17	0.17	0.68	0.34	2.40
<i>H. limbatus</i>												0.68	0.68
<i>P. dayi</i>		0.86	0.86			0.17	0.17	0.68					2.74
<i>E. maculatus</i>	0.17	2.23	2.23	0.51		12.8		0.51	0.51	0.51		0.17	19.69
<i>E. suratensis</i>													
<i>M. guentheri</i>													
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>													
<i>Mystus oculatus</i>	0.68	0.17	0.17		0.17	0.68	11.3	2.05	0.68	2.57	0.17	1.03	19.69
<i>H. brachyosoma</i>													
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>													
<i>M. cupanus</i>													
<i>G. giuris</i>	0.17	0.17		0.17							0.17		0.68
Total	2.23	4.11	3.95	8.05	9.08	14.04	18.7	6.2	7.36	10.9	8.9	6.51	100.00
Number	5	6	5	5	7	4	4	5	5	6	7	9	12

Table 6.11. Seasonal Catch (No/haul) from Station III of Sasthamkotta lake

Types of fish	PREMONSOON			MONSOON			POST MONSOON			TOTAL		
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD
<i>Puntius sarana</i>							10	2.5	-	10	0.83	
<i>P. filamentosus</i>	53	13.25	18.6	74	18.5	17.4	125	31.25	11.5	252	21	16.6
<i>P. amphibius</i>				3	0.75	0.71	2	0.5		5	0.42	0.5
<i>P. dorsalis</i>	3	0.75		27	6.75	16.3	9	2.25	1.89	39	3.25	7.86
<i>P. vittatus</i>				4	1		1	0.25	-	5	0.42	0.58
<i>Puntius ticto</i>				1	0.25		4	1	1.41	5	0.42	1.15
<i>X. cancilla</i>	2	0.5		4	1		8	2	1.41	14	1.17	1.41
<i>H. limbatus</i>							4	1	-	4	0.33	
<i>P. dayi</i>	10	2.5		6	1.5	1.73				16	1.33	2.05
<i>E. maculatus</i>	30	7.5	6.4	78	19.5	50.9	7	1.75	1.16	115	9.58	23.8
<i>E. suratensis</i>												
<i>M. guentheri</i>												
<i>A. lineatus</i>												
<i>A. panchax</i>												
<i>H. fossilis</i>												
<i>Wallago attu</i>												
<i>O. bimaculatus</i>												
<i>O. malabaricus</i>												
<i>M. bleekeri</i>												
<i>Mystus oculatus</i>	6	1.5	1.73	83	20.75	30.5	26	6.5	6.03	115	9.58	19
<i>H. brachyosoma</i>												
<i>C. marulius</i>												
<i>C. micropeltus</i>												
<i>D. malabaricus</i>												
<i>M. cupanus</i>												
<i>G. giuris</i>	3	0.75					1	0.25	-	4	0.33	
Total/mean catch	107	3.821		280	7.778		197		2.12	584	4.06	
No. of species	7			9			11			12		

Table 6.12 Monthly percentage catch using encircling net at Station IV

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>		1.69	0.65					0.65	1.30				4.30
<i>P. filamentosus</i>	1.96	6.39	3.91	1.30	2.74	0.91	1.96	3.91	6.13	1.43	2.87	3.39	36.90
<i>P. amphibius</i>		2.09										0.26	2.35
<i>P. dorsalis</i>											0.26		0.26
<i>P. vittatus</i>													
<i>Puntius ticto</i>												0.13	0.13
<i>X. cancella</i>	1.04	2.35	0.65				1.04	0.65	0.26	1.04	0.26	0.13	7.43
<i>H. limbatus</i>					0.13				0.26	1.17	0.26	0.13	1.96
<i>P. dayi</i>	0.78	4.17	0.13	0.65	0.26	0.39	0.78	0.13	0.78		0.65	0.26	9.00
<i>E. maculatus</i>	4.17		1.83	0.65	0.78	6.78	4.17	1.83	3.65		1.30	0.52	25.68
<i>E. suratensis</i>													
<i>M. guentheri</i>											0.13	0.26	0.39
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>													
<i>Mystus oculatus</i>	5.74	1.56									1.56	1.04	9.91
<i>H. brachyosoma</i>													
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>													
<i>M. cupanus</i>		0.26	0.52						0.26		0.13		1.17
<i>G. giuris</i>	0.13	0.13		0.13							0.13	0.00	0.52
Total	13.82	18.6	7.69	2.74	3.91	8.08	7.95	7.17	12.7	3.65	7.56	6.13	100.0
Number	6	8	6	4	4	3	4	5	7	3	10	9	13

Table 6.13. Seasonal Catch (No/haul) from Station IV of Sasthamkotta lake

Types of fish	PREMONSOON			MONSOON			POST MONSOON			TOTAL		
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD
<i>Puntius sarana</i>	18	4.5	5.66	5	1.25		10	2.5	-	33	2.75	3.95
<i>P. filamentosus</i>	104	26	17.5	73	18.25	9.71	106	26.5	15.1	283	23.6	13.7
<i>P. amphibius</i>	16	4					2	0.5	-	18	1.5	9.9
<i>P. dorsalis</i>							2	0.5	-	2	0.17	
<i>P. vittatus</i>												
<i>Puntius ticto</i>							1	0.25	-	1	0.08	
<i>X. cancella</i>	31	7.75	6.81	13	3.25	2.12	13	3.25	3.20	57	4.75	5.17
<i>H. limbatus</i>				1	0.25		14	3.5	3.69	15	1.25	3.39
<i>P. dayi</i>	44	11	14.2	12	3	2.16	13	3.25	2.08	69	5.75	8.76
<i>E. maculatus</i>	51	12.75	13.7	104	26	20.5	42	10.5	12.5	197	16.4	15.7
<i>E. suratensis</i>												
<i>M. guentheri</i>							3	0.75	0.71	3	0.25	0.71
<i>A. lineatus</i>												
<i>A. panchax</i>												
<i>H. fossilis</i>												
<i>Wallago attu</i>												
<i>O. bimaculatus</i>												
<i>O. malabaricus</i>												
<i>M. bleekeri</i>												
<i>Mystus oculatus</i>	56	14	22.6				20	5	2.83	76	6.33	16.8
<i>H. brachyosoma</i>												
<i>C. marulius</i>												
<i>C. micropeltus</i>												
<i>D. malabaricus</i>												
<i>M. cupanus</i>	6	1.5	1.41				3	0.75	0.71	9	0.75	1.26
<i>G. giuris</i>	3	0.75	0				1	0.25	-	4	0.33	
Total/mean catch	329	9.139		208	8.667		230	4.423		767	4.92	
No. of species	9			6			13			13		

Table 6.14 Monthly percentage catch using encircling net at Station V

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>													
<i>P. filamentosus</i>	2.38	2.38	14.3	3.27	1.79	1.79	0.89	1.79	14.3	2.38	1.19	5.95	52.38
<i>P. amphibius</i>			0.60				1.79		0.60			0.30	3.27
<i>P. dorsalis</i>				0.60			0.30				0.30		1.19
<i>P. vittatus</i>													
<i>Puntius ticto</i>													
<i>X. cancilla</i>													
<i>H. limbatus</i>													
<i>P. dayi</i>	0.30	0.30		0.89	0.30	0.30		0.30		0.30	0.30		2.98
<i>E. maculatus</i>	0.30	0.30	2.38	1.19	1.19	1.19		1.19	2.38	0.30	0.60	3.57	14.58
<i>E. suratensis</i>													
<i>M. guentheri</i>													
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>													
<i>Mystus oculatus</i>			0.30	6.55	2.08	2.08	7.14	2.08	0.30	2.98	0.60	1.49	25.60
<i>H. brachyosoma</i>													
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>													
<i>M. cupanus</i>													
<i>G. giuris</i>													
Total	2.99	2.98	17.58	12.5	5.36	5.36	10.12	5.36	17.58	5.96	2.9	11.31	100.0
Number	3	3	4	5	4	4	4	4	4	4	5	4	48.00

Table 6.15. Seasonal Catch (No/haul) from Station V of Sasthamkotta lake

Types of fish	PREMONSOON			MONSOON			POST MONSOON			TOTAL		
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD
<i>Puntius sarana</i>												
<i>P. filamentosus</i>	75	18.75	19.6	21	5.25	1.5	80	20	19.9	176	14.7	16.2
<i>P. amphibius</i>	2	0.5		6	1.5		3	0.75	0.71	11	0.92	2.22
<i>P. dorsalis</i>	2	0.5		1	0.25		1	0.25	-	4	0.33	0.58
<i>P. vittatus</i>												
<i>Puntius ticto</i>												
<i>X. cancella</i>												
<i>H. limbatus</i>												
<i>P. dayi</i>	5	1.25	1.15	3	0.75		2	0.5		10	0.83	0.71
<i>E. maculatus</i>	14	3.5	3.32	12	3		23	5.75	5.19	49	4.08	3.53
<i>E. suratensis</i>												
<i>M. guentheri</i>												
<i>A. lineatus</i>												
<i>A. panchax</i>												
<i>H. fossilis</i>												
<i>Wallago attu</i>												
<i>O. bimaculatus</i>												
<i>O. malabaricus</i>												
<i>M. bleekeri</i>												
<i>Mystus oculatus</i>	23	5.75	14.8	45	11.25	8.5	18	4.5	4.04	86	7.17	8.15
<i>H. brachyosoma</i>												
<i>C. marulius</i>												
<i>C. micropeltus</i>												
<i>D. malabaricus</i>												
<i>M. cupanus</i>												
<i>G. giuris</i>												
Total/mean catch	121	5.042		88	3.667		127	5.292		336	4.67	
No. of species	6			6			6			6		

Table 6.16. Monthly percentage catch using encircling net at all Stations

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>		0.42	0.16	0.42	0.16			0.16	0.65	0.32	0.32		2.62
<i>P. filamentosus</i>	1.71	5.69	3.78	3.30	5.46	2.23	2.88	2.75	8.53	4.36	4.95	3.59	49.22
<i>P. amphibius</i>		0.52	1.71		0.29	0.06	0.19	0.06	0.06	0.26	0.03	1.78	4.98
<i>P. dorsalis</i>		0.03	0.03	0.10	0.10	0.03	0.84		0.03	0.03	0.16	0.16	1.52
<i>P. vittatus</i>	0.10	0.06	0.13	0.06	0.13			0.13	0.03	0.06	0.03	0.10	0.84
<i>Puntius ticto</i>					0.19					0.03	0.03	0.13	0.39
<i>X. cancella</i>	0.58	0.68	0.19	0.16	0.19		0.42	0.19	0.29	0.55	0.39	0.19	3.85
<i>H. limbatus</i>	0.32	0.06			0.10				0.10	0.61	0.10	0.16	1.45
<i>P. dayi</i>	0.23	1.49	0.29	0.26	0.10	0.29	0.23	0.36	0.23	0.03	0.23	0.16	3.88
<i>E. maculatus</i>	1.13	0.74	1.20	0.45	0.52	5.66	1.10	0.97	1.71	0.23	0.84	0.84	15.38
<i>E. suratensis</i>													
<i>M. guentheri</i>						0.10					0.03	0.06	0.19
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>				0.03		0.10			0.03		0.03		0.19
<i>Mystus oculatus</i>	1.55	0.81	1.42	1.20	0.26	0.39	2.91	0.94	0.97	0.81	1.29	1.97	14.51
<i>H. brachyosoma</i>						0.03							0.03
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>													
<i>M. cupanus</i>		0.06	0.13	0.06	0.13			0.03	0.13		0.10		0.65
<i>G. giuris</i>	0.06	0.10		0.06							0.06		0.29
Total	5.68	10.68	9.05	6.11	7.63	8.88	8.56	5.56	12.8	7.3	8.6	9.15	100.00
Number	8	11	9	10	11	9	7	8	11	10	14	11	

Table 6.17. Seasonal Catch (No/haul) from all Stations of Sasthamkotta lake

Types of fish	PREMONSOON			MONSOON			POST MONSOON			TOTAL		
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD
<i>Puntius sarana</i>	31	7.75	4.62	10	2.5		40	10	5.77	81	6.75	5.25
<i>P. filamentosus</i>	448	112	50.7	412	103	44.8	663	165.8	67.7	1523	127	57.8
<i>P. amphibius</i>	69	17.25	26.2	19	4.75	3.4	66	16.5	25.9	154	12.8	20.8
<i>P. dorsalis</i>	5	1.25	1.15	30	7.5	13.9	12	3	2.31	47	3.92	7.66
<i>P. vittatus</i>	11	2.75	0.96	8	2		7	1.75	0.96	26	2.17	1.17
<i>Puntius ticto</i>				6	1.5		6	1.5	1.73	12	1	2.45
<i>X. cancella</i>	50	12.5	8.19	25	6.25	4.04	44	11	4.69	119	9.92	5.74
<i>H. limbatus</i>	12	3	5.66	3	0.75		30	7.5	7.72	45	3.75	6.16
<i>P. dayi</i>	70	17.5	19	30	7.5	3.42	20	5	2.83	120	10	11.7
<i>E. maculatus</i>	109	27.25	10.8	255	63.75	74.6	112	28	18.9	476	39.7	44.3
<i>E. suratensis</i>												
<i>M. guentheri</i>				3	0.75		3	0.75	0.71	6	0.5	1
<i>A. lineatus</i>												
<i>A. panchax</i>												
<i>H. fossilis</i>												
<i>Wallago attu</i>												
<i>O. bimaculatus</i>												
<i>O. malabaricus</i>												
<i>M. bleekeri</i>	1	0.25		3	0.75		2	0.5	0	6	0.5	1
<i>Mystus oculatus</i>	101	38.5	10.1	139	34.75	37.9	156	39	15.9	449	37.4	22.2
<i>H. brachyosoma</i>				1	0.25					1	0.08	
<i>C. marulius</i>												
<i>C. micropeltus</i>												
<i>D. malabaricus</i>												
<i>M. cupanus</i>	8	2	1.15	5	1.25	2.12	7	1.75	0.71	20	1.67	1.21
<i>G. giuris</i>	7	1.75	0.58				2	0.5	1	9	0.75	0.5
Total/mean catch	922	18.75		949	15.82		1170	19.5		3041	16.1	
No. of species	13			15			15			16		

Table 6.17a. One way ANOVA of total catch by at different stations comparing seasons

Station I

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Pre monsoon	11	277	24.36	991.45
monsoon	13	150	10.84	429.47
post monsoon	11	425	19.81	808.56

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	1146.8	2	573.43	0.79*	0.461	3.294
Within Groups	23153.8	32	723.55			
Total	24300.7	34				

Station II

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Pre monsoon	5	142	28.4	2860.8
monsoon	10	169	16.9	1293.211
post monsoon	7	191	27.28571	2910.238

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	645.7442	2	322.8721	0.15*	0.86	3.521893
Within Groups	40543.53	19	2133.87			
Total	41189.27	21				

Station III

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Pre monsoon	7	107	10.14	359.47
monsoon	9	280	31.1	1318.1
post monsoon	11	197	17.09	1332.1

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	1884.308	2	942.15	0.868*	0.432	3.402
Within Groups	26022.66	24	1084.27			
Total	27906.96	26				

Station IV

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Pre monsoon	9	329	26.55	388.52
monsoon	6	208	19.66	708.66
post monsoon	13	230	8.692	133.73

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	1760.389	2	880.19	2.66*	0.08	3.38
Within Groups	8256.325	25	330.25			
Total	10016.71	27				

Station V

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Pre monsoon	6	121	20.16	788.56
monsoon	6	88	14.66	273.06
post monsoon	6	127	9.16	85.36

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	363	2	181.5	0.47*	0.63	3.68
Within Groups	5735	15	382.33			
Total	6098	17				

Using all encircling net

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
premonsoon	13	922	59.76	15378.36
monsoon	15	949	59.06	14493.92
post monsson	15	1170	72.6	28857.4

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	1707.159	2	853.57	0.04*	0.95	3.23
Within Groups	791458.8	40	19786.47			
Total	793166	42				

*P < 0.05

Table 6.18 Total fish catch (No/haul) using different gill nets from Sasthamkotta lake

Types of fish	GN I	GN II	GN III	TOTAL
<i>Puntius sarana</i>			30	30
<i>P. filamentosus</i>	39	74	230	343
<i>P. amphibius</i>			31	31
<i>P. dorsalis</i>			15	15
<i>P. vittatus</i>			24	24
<i>Puntius ticto</i>			28	28
<i>X. cancella</i>	1			1
<i>H. limbatus</i>	3		23	26
<i>P. dayi</i>	74	40	514	628
<i>E. maculatus</i>	143	176	324	643
<i>E. suratensis</i>	43	23		66
<i>M. guentheri</i>	9		9	18
<i>A. lineatus</i>				
<i>A. panchax</i>				
<i>H. fossilis</i>	11			11
<i>Wallago attu</i>	9			9
<i>O. bimaculatus</i>	10			10
<i>O. malabaricus</i>	3			3
<i>M. bleekeri</i>		6		6
<i>Mystus oculatus</i>	87	39	146	272
<i>H. brachyosoma</i>	39		4	43
<i>C. marulius</i>	7			7
<i>C. micropeltus</i>	7			7
<i>D. malabaricus</i>			56	56
<i>M. cupanus</i>				
<i>G. giuris</i>				
Total/mean catch	485	358	1434	2277
No. of species	15	6	13	22

Fig. 6.7. Number of species collected by different types of gill nets.

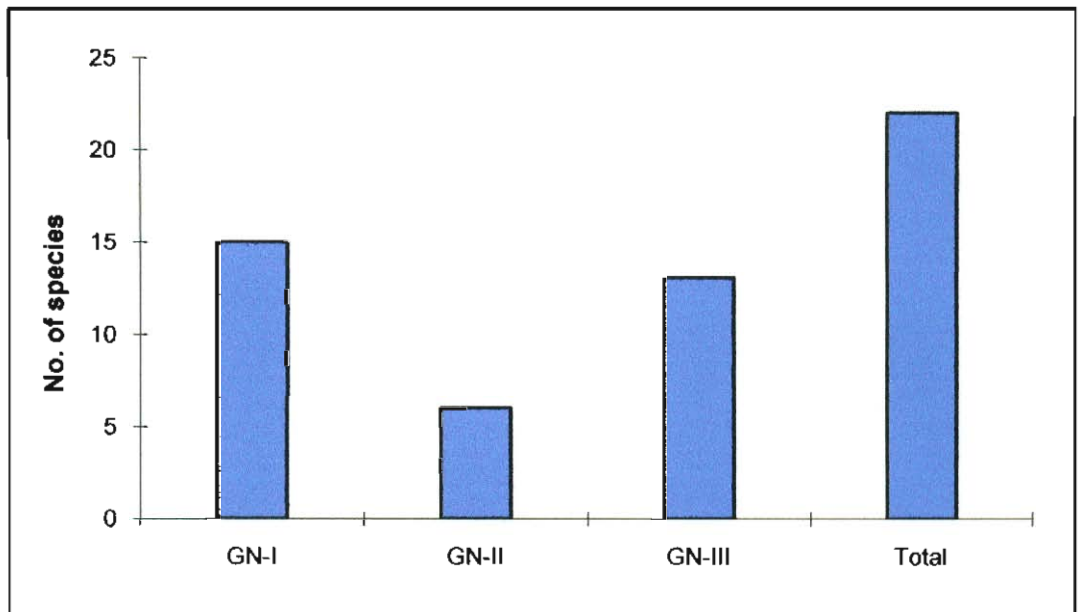


Fig. 6.8. Total fish catch (No./Haul) collected by different types of gill nets.

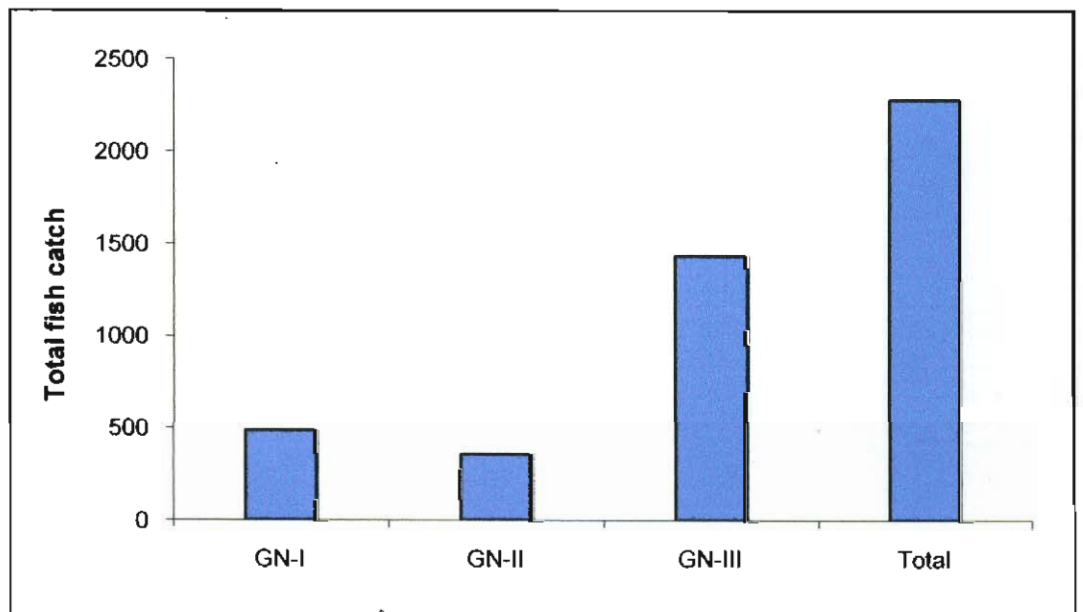


Table 6.19. Monthly percentage catch using gill net-I from Sasthamkotta lake

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>													
<i>P. filamentosus</i>					1.65					3.51	1.03	1.86	8.04
<i>P. amphibius</i>													
<i>P. dorsalis</i>													
<i>P. vittatus</i>													
<i>Puntius ticto</i>													
<i>X. cancella</i>					0.21								0.21
<i>H. limbatus</i>			0.21		0.41								0.62
<i>P. dayi</i>	8.25		1.03	1.65	2.68			0.41			0.41	0.82	15.26
<i>E. maculatus</i>	9.28		1.65		3.09	1.03	0.62	2.06	0.41	1.03	2.06	8.25	29.48
<i>E. suratensis</i>	1.24	0.82	1.03	1.65	0.41	0.21	0.41	1.03	0.41	0.82	0.41	0.41	8.87
<i>M. guentheri</i>						0.82	1.03						1.86
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>			0.41		0.41	0.62	0.21		0.21	0.21		0.21	2.27
<i>Wallago attu</i>		0.21		0.21	0.21	0.21		0.21		0.21	0.41	0.21	1.86
<i>O. bimaculatus</i>		0.21	0.21		0.41	0.21	0.21	0.41		0.21	0.21		2.06
<i>O. malabaricus</i>					0.21			0.21		0.21			0.62
<i>M. bleekeri</i>													
<i>Mystus oculatus</i>	5.15		1.86	2.06	2.06	0.41	5.15	0.41			0.00	0.82	17.94
<i>H. brachyosoma</i>		0.41	0.62	0.41	2.06	2.06	1.03	0.21	0.41		0.82		8.04
<i>C. marulius</i>	0.21			0.21	0.21	0.21		0.21	0.21	0.21			1.44
<i>C. micropeltus</i>	0.21			0.21	0.21	0.21		0.21	0.21	0.21			1.44
<i>D. malabaricus</i>													
<i>M. cupanus</i>													
<i>G. giuris</i>													
Total	24.33	1.65	7.01	6.39	14.23	5.98	8.66	5.36	1.86	6.60	5.36	12.58	100.0
Number	6	4	8	7	14	10	7	10	6	9	7	7	

Table 6.20. Gross seasonal catch(No/haul)by Gill net -I from Sasthamkotta lake

Types of fish	PREMONSOON			MONSOON			POST MONSOON			TOTAL		
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD
<i>Puntius sarana</i>												
<i>P. filamentosus</i>				8	2		31	7.75	6.11	39	3.25	5.12
<i>P. amphibius</i>												
<i>P. dorsalis</i>												
<i>P. vittatus</i>												
<i>Puntius ticto</i>												
<i>X. cancella</i>				1	0.25	0.5				1	0.08	0.3
<i>H. limbatus</i>	1	0.25	0.58	2	0.5	1				3	0.25	0.67
<i>P. dayi</i>	53	13.25	19.4	15	3.75	6.24	6	1.5	2	74	6.17	12.2
<i>E. maculatus</i>	53	13.25	24	33	8.25	5.38	57	14.25	17.5	143	11.9	15.2
<i>E. suratensis</i>	23	5.75	1.71	10	2.5	1.73	10	2.5	1	43	3.58	2.11
<i>M. guentheri</i>				9	2.25	0.71				9	0.75	0.71
<i>A. lineatus</i>												
<i>A. panchax</i>												
<i>H. fossilis</i>	2	0.5	1	6	1.5	1.29	3	0.75	0.5	11	0.92	1
<i>Wallago attu</i>	2	0.5	0.58	3	0.75	0.5	4	1	0.82	9	0.75	0.62
<i>O. bimaculatus</i>	2	0.5	0.58	6	1.5	0.58	2	0.5	0.58	10	0.83	0.72
<i>O. malabaricus</i>		0		2	0.5	0.58	1	0.25	0.5	3	0.25	0.45
<i>M. bleekeri</i>												
<i>Mystus oculatus</i>	44	11	8.96	39	9.75	10.8	4	1		87	7.25	9.33
<i>H. brachyosoma</i>	7	1.75	0.58	26	6.5	4.36	6	1.5	1.41	39	3.25	3.43
<i>C. marulius</i>	2	0.5	0.58	3	0.75	0.5	2	0.5	0.58	7	0.58	0.51
<i>C. micropeltus</i>	2	0.5	0.58	3	0.75	0.5	2	0.5	0.58	7	0.58	0.51
<i>D. malabaricus</i>												
<i>M. cupanus</i>												
<i>G. giuris</i>												
Total/mean catch	191	3.979		166	2.767		128	2.667		485	2.69	
No. of species	11			15			12			15		

Table 6.21. Monthly percentage catch using gill net-II from Sasthamkotta lake

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>													
<i>P. filamentosus</i>	0.66	0.56	3.35	0.84	2.23	1.12	0.28	0.84	4.75	2.10	3.35	1.40	21.48
<i>P. amphibius</i>													
<i>P. dorsalis</i>													
<i>P. vittatus</i>													
<i>Puntius ticto</i>													
<i>X. cancilla</i>													
<i>H. limbatus</i>													
<i>P. dayi</i>			0.56		0.28				2.79	2.23	4.19	1.12	11.17
<i>E. maculatus</i>	0.66	0.84	7.82	0.28	3.35	1.40	0.28	1.40	2.79	5.59	6.98	17.9	49.26
<i>E. suratensis</i>	0.66	0.84	1.12	1.40	0.28			1.12	0.28		0.28	0.56	6.53
<i>M. guentheri</i>													
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>			0.56						1.12				1.68
<i>Mystus oculatus</i>	0.58	0.56	2.23			0.84	0.28	0.56	0.28	0.56	2.79	1.21	9.89
<i>H. brachyosoma</i>													
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>													
<i>M. cupanus</i>													
<i>G. giuris</i>													
Total	2.55	2.79	15.6	2.51	6.15	3.35	0.84	3.91	12.0	10.5	17.6	22.2	100.0
Number	4	4	6	3	4	3	3	4	6	4	5	5	

Table 6.22. Gross seasonal catch(No/haul)by Gill net -II from Sasthamkotta lake

Types of fish	PREMONSOON			MONSOON			POST MONSOON			TOTAL		
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD
<i>Puntius sarana</i>												
<i>P. filamentosus</i>	19	4.75	4.86	16	4	2.94	39	9.75	5.85	74	6.17	5.02
<i>P. amphibius</i>												
<i>P. dorsalis</i>												
<i>P. vittatus</i>												
<i>Puntius ticto</i>												
<i>X. cancella</i>												
<i>H. limbatus</i>												
<i>P. dayi</i>	2	0.5	1	1	0.25	0.5	37	9.25	4.57	40	3.33	5.02
<i>E. maculatus</i>	34	8.5	13	23	5.75	4.57	119	29.75	23.7	176	14.7	18.2
<i>E. suratensis</i>	14	3.5	1.29	5	1.25	1.89	4	1	0.82	23	1.92	1.73
<i>M. guentheri</i>												
<i>A. lineatus</i>												
<i>A. panchax</i>												
<i>H. fossilis</i>												
<i>Wallago attu</i>												
<i>O. bimaculatus</i>												
<i>O. malabaricus</i>												
<i>M. bleekeri</i>	2	0.5					4	1		6	0.5	1.41
<i>Mystus oculatus</i>	11	2.75	3.79	11	2.75	1.71	17	4.25	4.03	39	3.25	3.01
<i>H. brachyosoma</i>												
<i>C. marulius</i>												
<i>C. micropeltus</i>												
<i>D. malabaricus</i>												
<i>M. cupanus</i>												
<i>G. giuris</i>												
Total/mean catch	82	3.417		56	2.8		220	9.167		358	4.97	
No. of species	6			5			6			6		

Table 6.23. Monthly percentage catch using gill net-III from Sasthamkotta lake

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	Ma y	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>		0.14		0.14	0.28		0.28	0.28	0.07	0.42	0.07	0.42	2.09
<i>P. filamentosus</i>	0.42	0.42	0.42	0.42	1.74	0.70	1.74	1.74	2.09	2.51	2.09	1.74	16.04
<i>P. amphibius</i>		0.21		0.21	0.35		0.35	0.35	0.14	0.21	0.14	0.21	2.16
<i>P. dorsalis</i>					0.07		0.07	0.07	0.21	0.21	0.21	0.21	1.05
<i>P. vittatus</i>		0.14		0.14	0.14		0.14	0.14	0.21	0.28	0.21	0.28	1.67
<i>Puntius ticto</i>		0.14		0.14	0.14		0.14	0.14	0.28	0.35	0.28	0.35	1.95
<i>X. cancella</i>													
<i>H. limbatus</i>		0.21		0.21	0.07		0.07	0.07	0.35	0.14	0.35	0.14	1.60
<i>P. dayi</i>	1.12	1.39	1.12	1.39	2.79	1.39	2.79	2.79	3.49	11.30	3.49	2.79	35.84
<i>E. maculatus</i>	0.21	0.35	0.21	0.35	2.51	0.70	2.51	2.51	2.79	5.93	2.79	1.74	22.59
<i>E. suratensis</i>													
<i>M. guentheri</i>		0.07		0.07	0.07		0.07	0.07	0.07	0.07	0.07	0.07	0.63
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>													
<i>Mystus oculatus</i>	0.84	0.35	0.84	0.35	0.07	0.35	0.07	0.07	1.74	1.88	1.74	1.88	10.18
<i>H. brachyosoma</i>									0.07	0.07	0.07	0.07	0.28
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>		0.14		0.14	0.35	0.07	0.35	0.35	0.56	0.70	0.56	0.70	3.91
<i>M. cupanus</i>													
<i>G. giuris</i>													
Total	2.58	3.56	2.58	3.56	8.58	3.21	8.58	8.58	12.06	24.06	12.06	10.6	100.0
Number	4	11	4	11	12	5	12	12	13	13	13	13	

Table 6.24. Gross seasonal catch (No/haul) by Gill net-III from Sasthamkotta lake

Types of fish	PREMONSOON			MONSOON			POST MONSOON			TOTAL		
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD
<i>Puntius sarana</i>	4	1		12	3		14	3.5	2.89	30	3.5	5.12
<i>P. filamentosus</i>	24	6		85	21.25	7.5	121	30.25	4.5	230	30.3	51.7
<i>P. amphibius</i>	6	1.5		15	3.75		10	2.5	0.58	31	2.5	4.12
<i>P. dorsalis</i>				3	0.75		12	3		15	3	5.2
<i>P. vittatus</i>	4	1		6	1.5		14	3.5	0.58	24	3.5	5.85
<i>Puntius ticto</i>	4	1		6	1.5		18	4.5	0.58	28	4.5	7.58
<i>X. cancilla</i>												
<i>H. limbatus</i>	6	1.5		3	0.75		14	3.5	1.73	23	3.5	5.85
<i>P. dayi</i>	72	18	2.31	140	35	10	302	75.5	57.9	514	75.5	123
<i>E. maculatus</i>	16	4	1.15	118	29.5	13	190	47.5	25.9	324	47.5	79.3
<i>E. suratensis</i>												
<i>M. guentheri</i>	2	0.5		3	0.75		4	1		9	1	
<i>A. lineatus</i>												
<i>A. panchax</i>												
<i>H. fossilis</i>												
<i>Wallago attu</i>												
<i>O. bimaculatus</i>												
<i>O. malabaricus</i>												
<i>M. bleekeri</i>												
<i>Mystus oculatus</i>	34	8.5	4.04	8	2	2	104	26	1.16	146	26	44.6
<i>H. brachyosoma</i>											1	1.73
<i>C. marulius</i>												
<i>C. micropeltus</i>												
<i>D. malabaricus</i>	4	1		16	4	2	36	9	1.16	56	9	15.2
<i>M. cupanus</i>												
<i>G. giuris</i>												
Total/mean catch	176	4		415	8.646		843	16.21		1434	16.2	
No. of species	11			12			13			13		

Table 6.25. Total monthly percentage catch using all gill nets

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>		0.09		0.09	0.18		0.18	0.18	0.04	0.26	0.04	0.26	1.32
<i>P. filamentosus</i>	0.35	0.35	0.79	0.40	1.80	0.61	1.14	1.23	2.06	2.55	2.06	1.71	15.06
<i>P. amphibius</i>		0.13		0.13	0.22		0.22	0.22	0.09	0.13	0.09	0.13	1.36
<i>P. dorsalis</i>					0.04		0.04	0.04	0.13	0.13	0.13	0.13	0.66
<i>P. vittatus</i>		0.09		0.09	0.09		0.09	0.09	0.13	0.18	0.13	0.18	1.05
<i>Puntius ticto</i>		0.09		0.09	0.09		0.09	0.09	0.18	0.22	0.18	0.22	1.23
<i>X. cancella</i>					0.04								0.04
<i>H. limbatus</i>		0.13	0.04	0.13	0.13		0.04	0.04	0.22	0.09	0.22	0.09	1.14
<i>P. dayi</i>	2.46	0.88	1.01	1.23	2.37	0.88	1.76	1.84	2.64	7.47	2.94	2.11	27.58
<i>E. maculatus</i>	2.20	0.35	1.71	0.26	2.77	0.88	1.76	2.24	2.28	4.83	3.29	5.67	28.24
<i>E. suratensis</i>	0.35	0.31	0.40	0.57	0.13	0.04	0.09	0.40	0.13	0.18	0.13	0.18	2.90
<i>M. guentheri</i>		0.04		0.04	0.04	0.18	0.26	0.04	0.04	0.04	0.04	0.04	0.79
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>			0.09		0.09	0.13	0.04		0.04	0.04		0.04	0.48
<i>Wallago attu</i>		0.04		0.04	0.04	0.04		0.04		0.04	0.09	0.04	0.40
<i>O. bimaculatus</i>		0.04	0.04		0.09	0.04	0.04	0.09		0.04	0.04		0.44
<i>O. malabaricus</i>					0.04			0.04		0.04			0.13
<i>M. bleekeri</i>			0.09						0.18				0.26
<i>Mystus oculatus</i>	1.67	0.31	1.27	0.66	0.70	0.44	1.19	0.22	1.14	1.27	1.54	1.54	11.95
<i>H. brachyosoma</i>		0.09	0.13	0.09	0.44	0.44	0.22	0.04	0.13	0.04	0.22	0.04	1.89
<i>C. marulius</i>	0.04			0.04	0.04	0.04		0.04	0.04	0.04			0.31
<i>C. micropeltus</i>	0.04			0.04	0.04	0.04		0.04	0.04	0.04			0.31
<i>D. malabaricus</i>		0.09		0.09	0.22	0.04	0.22	0.22	0.35	0.44	0.35	0.44	2.46
<i>M. cupanus</i>													
<i>G. giuris</i>													
Total	7.11	3.03	5.58	4.00	9.62	3.82	7.38	7.16	9.88	18.09	11.51	12.82	100.0
Number	7	15	10	16	21	13	16	19	18	20	16	16	

Table 6.26. Gross seasonal catch (No/haul) by all Gill nets from Sasthamkotta lake

Types of fish	PREMONSOON			MONSOON			POST MONSOON			TOTAL		
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD
<i>Puntius sarana</i>	4	1	SD	12	3		14	3.5	2.89	30	2.5	1.94
<i>P. filamentosus</i>	43	10.75		109	27.25	11.1	191	47.75	7.81	343	28.6	17.5
<i>P. amphibius</i>	6	1.5	4.86	15	3.75		10	2.5	0.58	31	2.58	1.24
<i>P. dorsalis</i>				3	0.75		12	3		15	1.25	1.07
<i>P. vittatus</i>	4	1		6	1.5		14	3.5	0.58	24	2	0.87
<i>Puntius ticto</i>	4	1		6	1.5		18	4.5	0.58	28	2.33	1.36
<i>X. cancella</i>				1	0.25	-				1	0.08	-
<i>H. limbatus</i>	7	1.75		5	1.25	1.15	14	3.5	1.73	26	2.17	1.51
<i>P. dayi</i>	127	31.75	1.15	156	39	14.1	345	86.25	56.4	628	52.3	40.4
<i>E. maculatus</i>	103	25.75	16.5	174	43.5	18.3	366	91.5	34.6	643	53.6	37.3
<i>E. suratensis</i>	37	9.25	22.1	15	3.75	3.59	14	3.5	0.58	66	5.5	3.63
<i>M. guentheri</i>	2	0.5	2.63	12	3	2.45	4	1		18	1.5	1.75
<i>A. lineatus</i>												
<i>A. panchax</i>												
<i>H. fossilis</i>	2	0.5		6	1.5	1	3	0.75		11	0.92	0.79
<i>Wallago attu</i>	2	0.5		3	0.75		4	1	0.57 7	9	0.75	0.35
<i>O. bimaculatus</i>	2	0.5		6	1.5	0.58	2	0.5		10	0.83	0.46
<i>O. malabaricus</i>				2	0.5		1	0.25		3	0.25	
<i>M. bleekeri</i>	2	0.5					4	1		6	0.5	1.41
<i>Mystus oculatus</i>	89	22.25		58	14.5	9.47	125	31.25	4.5	272	22.7	11.6
<i>H. brachyosoma</i>	7	1.75	13.9	26	6.5	4.36	10	2.5	1.92	43	3.58	3.33
<i>C. marulius</i>	2	0.5	0.58	3	0.75		2	0.5		7	0.58	
<i>C. micropeltus</i>	2	0.5		3	0.75		2	0.5		7	0.58	
<i>D. malabaricus</i>	4	1		16	4	2	36	9	1.16	56	4.67	3.31
<i>M. cupanus</i>												
<i>G. giuris</i>												
Total/mean catch	449	5.908		637	7.583		1191	14.18		2277	8.63	
No. of species	19			21			21			22		

Fig. 6.9. Seasonal catch (No./Haul) and species collected by Gill net

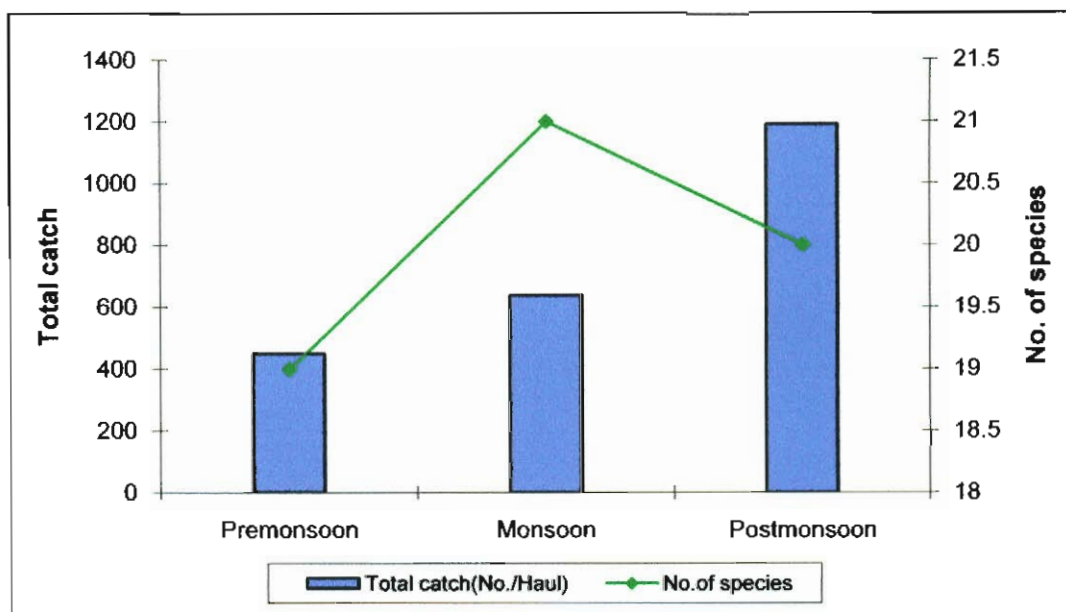


Table 6.26a. One way ANOVA of total catch by all gill nets comparing seasons

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Pre monsoon	19	449	23.63158	1159.98
monsoon	21	637	30.33333	2298.44
post monsoon	21	1191	56.71429	12109.3

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	15695.28	2	7847.63	1.47*	0.23	3.15
Within Groups	309035.3	58	5328.19			
Total	324730.6	60				

*p < 0.05

Table 6.27. Monthly percentage catch using cast net from Sasthamkotta lake

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>					0.06	0.02	0.02		0.09		0.02		0.2
<i>P. filamentosus</i>	0.13	0.06	0.13	0.1	0.66	0.88	1.08	0.55	0.47	0.89	0.24	0.46	5.61
<i>P. amphibius</i>					0.02	0	0.02						0.03
<i>P. dorsalis</i>					0.04	0	0.04						0.07
<i>P. vittatus</i>					0.04	0	0.04						0.07
<i>Puntius ticto</i>					0.02	0	0.02						0.03
<i>X. cancella</i>	0.02									0.15	0.05	0.07	0.29
<i>H. limbatus</i>	0.07	0.02	0.02	0.1	0.04	0.02	0.09	0.18		0.33	0.06	0.27	1.14
<i>P. dayi</i>	0.27	0.18	0.19	0.5	2.37	1.82	1.09	2.28	0.91	0.40	0.91	1.09	12.06
<i>E. maculatus</i>	0.36	0.37	0.46		0.51	0.33	0.27	0.27	0.36	0.46	0.33	0.46	4.17
<i>E. suratensis</i>													
<i>M. guentheri</i>					0.02								0.01
<i>A. lineatus</i>		0.02	0.02		0.04	0.02	0.02	0.04	0.04	0.04	0.02	0.02	0.25
<i>A. panchax</i>	0.02				0.02	0.04	0.02	0.04	0.02	0.02	0.02	0.02	0.2
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>	0.04				0.04	0	0.15						0.21
<i>Mystus oculatus</i>	0.18	0.27	0.15	0.1	0.49	0.46	0.27	0.46	0.27	0.24	0.27	0.33	3.48
<i>H. brachyosoma</i>					0.02	0.02							0.03
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>	5.47	5.63	6.38	4	11.7	12.6	9.66	9.48	1.09	1.82	2.74	1.28	71.81
<i>M. cupanus</i>					0.09	0.04	0.04	0.05	0.02		0.02		0.25
<i>G. giuris</i>													
Total	6.56	6.56	7.36	4.8	16.14	16.2	12.8	13.3	3.28	4.34	4.67	3.99	100.00
Number	9	7	7	5	17	16	15	9	9	9	11	9	18

Table 6.28. Gross seasonal catch (No/haul) by cast net from Sasthamkotta lake

Types of fish	PREMONSOON			MONSOON			POST MONSOON			TOTAL		
	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD	Total	Mean	SD
<i>Puntius sarana</i>	7	1.75	0.96	5	1.25	1.15	6	1.5	2.83	18	1.5	1.41
<i>P. filamentosus</i>	22	5.5	1.91	173	43.25	12.9	113	28.25	15	308	25.7	19.3
<i>P. amphibious</i>				2	0.5					2	0.17	
<i>P. dorsalis</i>				4	1					4	0.33	
<i>P. vittatus</i>				4	1					4	0.33	
<i>Puntius ticto</i>				2	0.5					2	0.17	
<i>X. cancella</i>	1	0.25					15	3.75	2.65	16	1.33	2.94
<i>H. limbatus</i>	9	2.25	1.5	18	4.5	4.04	36	9	7.94	63	5.25	5.95
<i>P. dayi</i>	65	16.25	9.46	415	103.8	32	182	45.5	16.4	662	55.2	42.7
<i>E. maculatus</i>	65	16.25	2.89	76	19	6.16	88	22	3.56	229	19.1	4.35
<i>E. suratensis</i>												
<i>M. guentheri</i>				1	0.25					1	0.08	
<i>A. lineatus</i>	2	0.5	0.58	6	1.5	0.58	6	1.5	0.58	14	1.17	0.72
<i>A. panchax</i>	1	0.25	0.5	6	1.5	0.58	4	1	0	11	0.92	0.67
<i>H. fossilis</i>												
<i>Wallago attu</i>												
<i>O. bimaculatus</i>												
<i>O. malabaricus</i>												
<i>M. bleekeri</i>	2	0.5		10	2.5	4.24				12	1	3.46
<i>Mystus oculatus</i>	38	9.5	4.2	92	23	5.42	61	15.25	2.06	191	15.9	6.88
<i>H. brachyosoma</i>				2	0.5					2	0.17	
<i>C. marulius</i>												
<i>C. micropeltus</i>												
<i>D. malabaricus</i>	1179	294.8	54.4	2380	595	83.5	380	95	40.4	3939	328	222
<i>M. cupanus</i>				12	3	1.41	2	0.5		14	1.17	1.51
<i>G. giuris</i>												
Total/mean catch	1391	31.61		3208	47.18		893	20.3		5492	25.4	
No. of species	11			17			11			18		

Fig. 6.10. Seasonal catch (No./Haul) and species collected by cast net.

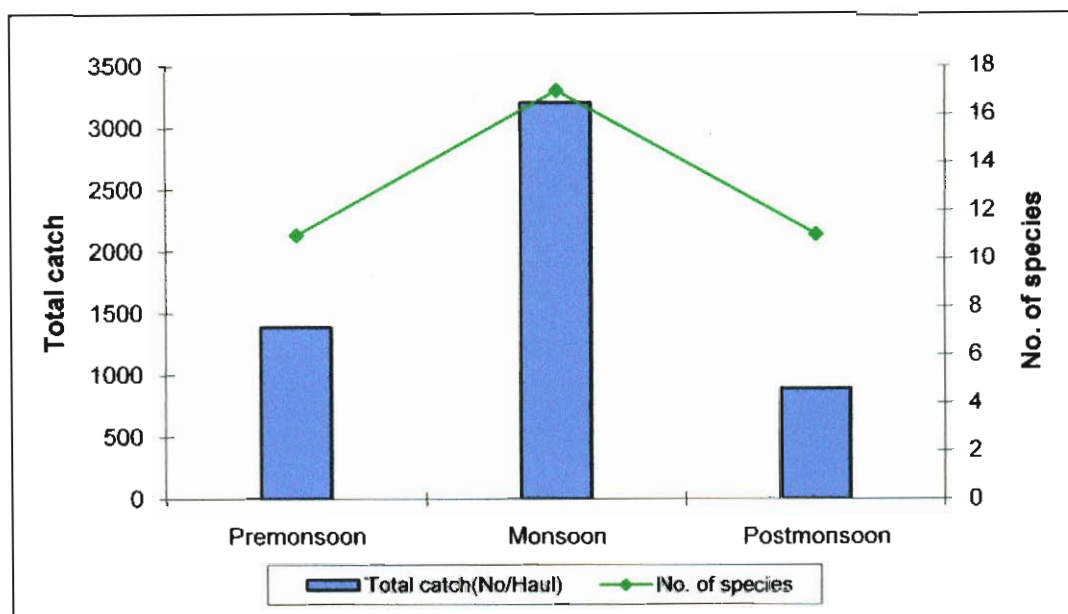


Table 6.28a. One way ANOVA of total catch by Cast net comparing seasons

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Pre monsoon	11	1391	126.4545	122466.1
monsoon	17	3208	188.1765	329964.3
post monsoon	11	893	81.18182	13087.56

ANOVA

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	79516.6	2	39758.3	0.21572*	0.806995	3.259446
Within Groups	6634965	36	184304.6			
Total	6714481	38				

*p < 0.05

DISCUSSION

The results of the present study using different types of nets during different months of the year revealed the existing pattern of the fish assemblages, and their variations in space and time in the Sasthamkotta freshwater lake. Results of encircling net sampling gave both spatial and temporal variations in fish assemblages while that of the other nets gave temporal variations only.

Sasthamkotta lake being a comparatively large freshwater lake, the 26 fish species obtained reveals the negligible fishery in the lake. Since there are only previous records from the study based on specimens collected from the catches of fishermen and survey reports (Thomas *et al.*, 1980) information could not be obtained regarding the actual fishery potential and distribution. Moreover, except the data published by Thomas *et al.* (1980) Prakasam (1991) and Joseph (1994) periodic assessment of the fish stock could not be made and hence the study has relevance and conducted.

In tropical lakes like Sasthamkotta, the main parameter, which influences the species composition and abundance, is monsoon rains. During the pre monsoon and the post monsoon seasons the volume of the lake decreases and this together with the comparatively high temperature affects the physical and chemical characteristics of the lake as in the reports of the lakes of other countries (Hamilton and Lewis, 1990; Rodriguez and Lewis, 1997). The decline in the depth of the lake and the increase in temperature result in variations in other parameters, which result in habitat changes and in breeding behavior and variation in spawning success, spawning pattern etc. These may directly or indirectly affect the availability of fish in gears, which in turn will be a reflection of their abundance in the catch in each station during different seasons. The variation in the number of species and number of individuals caught in different localities by encircling net from Sasthamkotta Lake may presumably be because of these changes.

The results also indicated the uniform and wide spread pattern of distribution of a few species in all the localities and the complete absence of a few species from certain localities during all the seasons. Moreover, a few species constituted the bulk of the collection. This general pattern of distribution and abundance has been reported from other lakes (Nordon, 1966; Zilberg, 1966; Derickson and Price, 1973; Oviatt and Nixon, 1973; Recksick and Mc Cleave, 1973; Haedrich and Haedrich, 1974; Stephens *et al.*, 1974; Allen and Horn, 1975; Stephenson and Dredge, 1976).

The fresh water lake in Sasthamkotta is unique in many features and the source of water for the lake is water from the seasonal rains and there is no springlet or stream that flows into the lake. Similarly there is no natural outlet for water from the lake. The depth of the lake increases abruptly from the banks. The lake remains virtually isolated from all other water masses where there is no scope for long term movement of any migrant species, the reason for the difference in species composition may be only local migration due to changes in environmental conditions.

In the previous studies by Thomas *et al.* (1980), 23 species and Prakasam (1991) and Joseph (1994) 27 species of fishes were collected. Their collections were mainly from local catches and survey with fishermen and the possibility of mixing with catches of fishes with the adjacent Kallada river or Ashtamudi estuary may not be refused. The present study was based on the extensive collection using different nets and hence reported the presence six species newly in the lake.

Abundance of fishes in each gear was estimated as percentage. Since 18 out of the total 26 species found in the lake were caught by cast net with a catchability of 50.6%, the efficiency of the net seems to be high. This better catchability may be due to the high frequency of operation of this net.

15 species from GN-I, 6 species from GN-II and 13 species from GN-III were obtained. Percentage abundance was found to be highest from GN-III. GN-

II had the lowest abundance. Out of the total number of 26 species of fishes obtained from the lake, 22 species were collected by the three gill nets.

Out of the 26 species, using encircling net 16 species were obtained and their distribution in different stations. The abundance estimations also revealed that a major portion of the catch is usually comprised by a few species rather than an even distribution during all seasons. Out of the 18 species caught by cast net, the bulk of the catch comprised <5 species. This can be attributed to the low trophic structure in which they are found with omnivorous feeding habit (Allen and Horn, 1975; Norman, 1980). These assemblages of low food chain species undergo periodic cycles and contribute regularly to the population, resulting in regular replenishment of the stock.

The difference in the species composition in different stations of the lake by encircling net need not be due to any effect of efficiency of the net. On the other hand the stations may remain as microhabitats. The bottom characteristics, hiding places, sediment characteristics etc vary among the different stations. Similar observations on the microhabitat related changes in species composition have been made earlier also (Lowe Mc Connel, 1975; Reid, 1986; Rodriguez *et al.*, 1990; Rodriguez and Lewis, 1997). According to Rodriguez and Lewis (1997), water temperature is an important factor, which determines the pressure of major taxa of fishes and their dominance in different areas of the lake. In certain lakes the suspended organic matter in turbid waters harbors microorganisms, which deplete dissolved oxygen. Fishes which cannot tolerate low dissolved oxygen may avoid such areas (Adite and Thielen, 1995). Hence the difference in the presence and absence of fishes in certain seasons may be due to the environmental variables existing in the locality.

The seasonal analysis of the gross fish catch from Sasthamkotta lake using all the gears revealed the high abundance during monsoon and low during pre monsoon seasons. This was due to the high abundance of small sized *Dayella malabaricus* from the cast net.

Comparison of the efficiency of the nets estimated by the catchability of species and number of fishes revealed that cast net is more efficient than all the other nets due to their mesh size method and frequency of operation. Due to the high frequency of operation and the catchability of small sized fishes in greater number, more fishes can be caught from the lake. By encircling net a specific area of the lake is completely encircled and the possibility of escaping of fishes from the net is reduced. However, gill net being a passive net the probability of fishes getting entangled is comparatively lower. The gill net is also a selective gear depending on its mesh size. Depending on the mesh size chances of smaller and very large sized fishes evading the net are more in gill nets (Hamely and Reiger, 1973; Jenson, 1986). This may affect the efficiency of gill nets in terms of catchability of total number of fishes and number of species.

CHAPTER VII
PISCINE DIVERSITY AND COMMUNITY
STRUCTURE

CHAPTER VII

PISCINE DIVERSITY AND COMMUNITY STRUCTURE

INTRODUCTION

The diversity of species or groups of organisms is much influenced by the functional relationship between trophic levels (Odum, 1971). According to Payne (1986), diversity is a measure of the degree of organization and efficiency with which energy, materials, space and time are used within a community. The degree of complexity of a community depends upon the number of species and the evenness with which individuals are distributed among species. The maintenance of diversity is of utmost importance in any ecosystem. But human interactions often result in the reduction of diversity within ecosystem, particularly through the loss of rare species.

Fish assemblages of fresh water habitats in general and that of Sasthamkotta lake in particular show great variation. Several reasons can be attributed to these variations. In aquatic ecology these variations in the structure of fish assemblages are highly important and hence measurement of these variations in their diversity is an important task of ecologists.

Many ecologists consider variations in diversity as indicators of the well being of the ecosystem. Moreover, the involvement of a variety of species and their abundance in the ecosystem make all diversity measurements important to interpret. In tropical lakes that are isolated and considered as 'Island' ecosystems the influence of climate on their species diversity of fishes is limited for their fluctuations. Previous studies on the diversity of fish assemblages concentrated on the number or richness of species as the index. More number of species was assigned to be associated with fewer hazards, better habitat status, lesser competitors and predators, more stable climate etc. (Sandhya, 2003).

Since the mere number of species in an assemblage does not convey the exact status of species diversity more authentic measurements of diversity indices

are made in aquatic habitats. Hence these diversity indices form the basis for assessing the status of fish assemblages and their variations. Patterns of breeding, local migrations due to climatic changes, variations in depth, dissolved oxygen content, availability of food, turbidity etc., may affect the availability of many species in particular sampling areas and sampling time which in turn may affect the species diversity during different months, seasons and also among different zones of the lake.

Geological connections with other water bodies affect the species diversity (Brown, 1981). Both number of species and number of individuals determines the Shannon index (H) (Shannon and Wiener, 1963; Margalef, 1968). Regarding the degree of dominance of certain important species over others, the dominance index of Simpson (Simpson, 1949) is estimated. Species richness (Pielou, 1966) is also estimated to measure the community structure of fish assemblages. In the present study an attempt was made to estimate the spatial and temporal variations in the diversity indices of the lake Sasthamkotta.

METHODOLOGY

Community ecology of the ecosystem was assessed in terms of different diversity indices. The diversity indices were found out for fishes of Sasthamkotta lake at the five stations selected. Monthly collections of samples from November 2004 to October 2005 were done and seasonal means were calculated. Index calculations were applied to the abundance data obtained during the study.

SHANNON-WIENER DIVERSITY INDEX (\bar{H})

Diversity index was found out using the formula given by Shannon-Wiener Index (Shannon and Wiener, 1963).

$$\bar{H} = -\sum [ni/N] \ln [ni/N] \text{ or } \bar{H} = -\sum [P_i] \ln [P_i]$$

INDEX OF DOMINANCE (C)

Index of Dominance was calculated using the formula by Simpson (1949)

$$C = \sum [ni/N]^2$$

RICHNESS INDEX (D)

Species richness was calculated using the standard formula by Margalef (1966)

$$d = \frac{s-1}{\log N}$$

EVENNESS INDEX (E)

Evenness index was calculated using the formula given by Pielou (1966)

$$e = \frac{\bar{H}}{\bar{H}_{\max}} \quad \text{or} \quad e = \frac{\bar{H}}{\log S}$$

where

ni = importance value of each species

N = total importance value

Pi = importance probability for each species (ni/N)

$\bar{H}_{\max} = \ln S$

For every formula the logarithm is the natural logarithm (Odum, 1971).

RESULTS

Values of Shannon Weiner diversity index estimated from samples collected from the selected five stations during different months and during the pre monsoon, monsoon and the post monsoon seasons are presented in Table 7.1 and Fig. 7.1. The highest value was noticed during June at Station I, when the species number was also high. The lowest value was observed at the same station during August, when the number of species was also low. When estimated on seasonal basis Station IV had the highest diversity index value (1.425) during post monsoon and pre monsoon seasons, as indicated by the high species composition (Table 7.1). The sampling station was located in the area near the filter house. Low values were recorded at station II during the monsoon period. Low values were obtained during the pre monsoon and post monsoon periods also in the station II. Annual values showed that the highest diversity index was at January and lowest in August. Diversity index showed significant variations among stations and seasons (Table 7.1a).

Regarding species richness index, the highest value of 2.217 was found at Station IV during December and the lowest 0.279 during August at Station II (Table 7.2; Fig. 7.2). Seasonal analysis showed the highest value (0.634) during the monsoon, 0.624 in the pre monsoon and 0.596 in the post monsoon season at the same Station (II). Regarding the annual variation December showed highest species richness. Variation was significant among stations and seasons (Table 7.2a)

Regarding species Dominance index, the highest value of 0.895 was found at Station II during March and the lowest 0.178 during December at Station IV (Table 7.3, Fig. 7.3). Seasonal analysis showed the highest value (0.634) during monsoon at station II, and lowest at station IV (0.281) during pre monsoon. Regarding the annual variation July showed highest species dominance. Variation was significant among stations and seasons (Table 7.3a)

Spatial and temporal variations in the evenness index are presented in Table 7.4 and Fig. 7.4, which also varied among stations, months and seasons. The highest value of 0.992 was noticed in Station IV during November and the lowest during March at Station II (0.175). Seasonally the highest value was obtained during the post monsoon season at Station IV and the lowest at Station V during the pre monsoon. Regarding the annual variation September showed highest species Evenness. Significant variation was noticed between stations and seasons (Table 7.4a).

The data of indices of fish catch using encircling net for all stations were pooled together and the different indices were estimated and presented in Table 7.5. The highest value of Shannon diversity index was found during the pre monsoon season followed by monsoon and post monsoon seasons. Richness index was highest during the monsoon season followed by the post monsoon the pre monsoon seasons. During the post monsoon season the highest value of dominance index was observed, followed by monsoon and pre monsoon seasons. Values of evenness index were the lowest during the post monsoon and the highest during the pre monsoon season.

The data for all the three gill nets of different mesh size were pooled together and the different indices were estimated and presented in Table 7.6. The highest value of Shannon index was found during the monsoon season followed by pre monsoon and post monsoon seasons. Richness index also followed the same trend, highest during the monsoon season followed by the pre monsoon the post monsoon seasons. During the post monsoon season the highest value of dominance index was observed, followed by pre monsoon and monsoon seasons. Values of evenness index were the lowest during the post monsoon and the highest during the monsoon season.

The data using cast net was pooled together and the different indices were estimated and presented in Table 7.7. Values of Shannon index and Evenness index followed the same trend, highest during the post monsoon season followed by monsoon and pre monsoon seasons. Richness index was high during monsoon season followed by post monsoon and pre monsoon seasons. Values of Dominance index were lowest during the post monsoon and highest during the pre monsoon season.

The data from all the nets was pooled together and the diversity indices were estimated to study the temporal variation of diversity in Sasthamkotta lake. The results are presented in Table 7.8 and Figs. 7.5 a,b. Values of Shannon index were the highest during the post monsoon (1.836) followed by the monsoon (1.646) and the pre monsoon (1.626) seasons. Species richness was the highest during the pre monsoon season (3.155) followed by the post monsoon (3.142) and the monsoon (2.832) seasons. Dominance index value was the highest in the monsoon season (0.301) followed by the pre monsoon (0.298) and the post monsoon (0.239) seasons. Regarding evenness index the highest value of 0.594 was found during the post monsoon and 0.519 during the pre monsoon and the lowest 0.511 during monsoon seasons.

Correlation between fish abundance, fish diversity index (Shannon index) and other water quality parameters is presented in Tables 7.9 to 7.13. At station I and II no significant correlations were noted between fish abundance and diversity index with water quality parameters. At station III fish index was negatively

correlated with potassium. At station IV significant positive correlation between species abundance and chlorophyceae was observed. Diversity index showed a positive relationship with chlorophyceae, cyanophyceae and dinoflagellata at station IV. Diversity index showed a negative correlation with gross primary productivity at station IV. At station V species abundance was negatively correlated with nitrite.

Table 7.1 Spatial and Temporal variation of Shannon Diversity Index

Month/season	S I	S II	S III	S IV	S V	Total
February	1.2	0.79	1.311	1.405	0.639	1.069
March	1.442	0.281	1.316	1.728	0.639	1.081
April	1.253	0.895	1.193	1.355	0.623	1.064
May	1.423	0.961	0.541	1.182	1.247	1.071
Premonsoon	1.33	0.732	1.09	1.417	0.787	1.071
June	1.523	0.591	0.851	0.865	1.228	1.012
July	0.655	1.091	0.373	0.54	1.228	0.778
August	0.279	0.403	0.974	1.178	0.87	0.741
September	1.445	0.79	1.343	1.188	1.228	1.199
Monsoon	0.976	0.719	0.885	0.943	1.139	0.932
October	1.064	0.882	0.767	1.356	0.623	0.939
November	1.2	0.591	1.24	1.09	1.013	1.026
December	1.322	0.882	0.799	1.766	1.471	1.248
January	1.24	0.76	1.805	1.487	1.064	1.271
Postmonsoon	1.207	0.779	1.153	1.425	1.043	1.121

Table 7.2 Spatial and temporal variation of Richness index

	SI	SII	SIII	SIV	SV	Total
February	0.882	1.059	1.559	1.072	0.869	1.088
March	1.221	0.882	1.573	1.41	0.869	1.191
April	1.036	1.137	1.276	1.226	0.736	1.082
May	1.454	1.384	1.039	0.985	1.07	1.186
Premonsoon	0.295	0.624	0.43	0.281	0.566	0.439
June	2.035	0.903	1.511	0.882	1.038	1.274
July	0.91	1.443	0.681	0.485	1.038	0.911
August	0.311	0.279	0.639	0.73	0.851	0.562
September	1.299	1.059	1.116	0.998	1.038	1.102
Monsoon	0.531	0.634	0.549	0.488	0.337	0.508
October	1.376	1.134	1.063	1.312	0.736	1.124
November	0.882	0.903	1.202	0.6	1.001	0.918
December	1.484	1.134	1.519	2.217	1.737	1.618
January	1.043	0.546	2.199	2.078	0.825	1.338
Postmonsoon	0.366	0.596	0.46	0.298	0.404	0.425

Fig. 7.1 Spatial and seasonal variation in Shannon diversity index of fish fauna at Sasthamkotta Lake

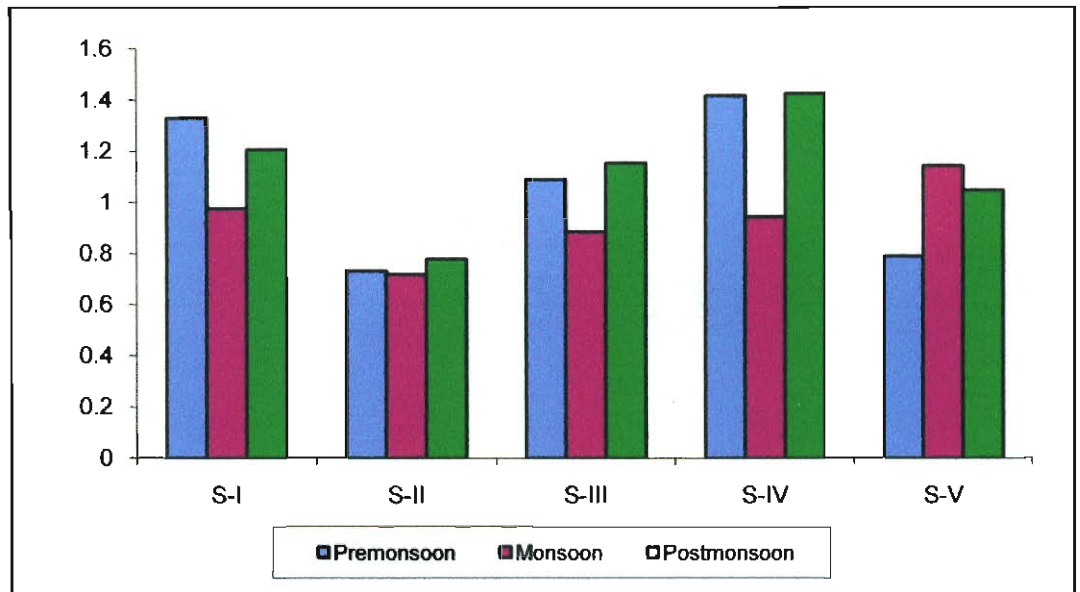


Table 7.1a Two way ANOVA comparing Shannon diversity index between stations and seasons

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.225(a)	14	.445	3.128	.001
Intercept	82.890	1	82.890	583.211	.000
Season	.372	2	.186	1.308	.275
Station	4.714	4	1.178	8.292	.000
Season * Station	.886	8	.111	.779	.622**
Error	13.218	93	.142		
Total	174.469	108			
Corrected Total	19.442	107			

** P < 0.01

Fig. 7.2 Spatial and seasonal variation in richness index of fish fauna at Sasthamkotta Lake

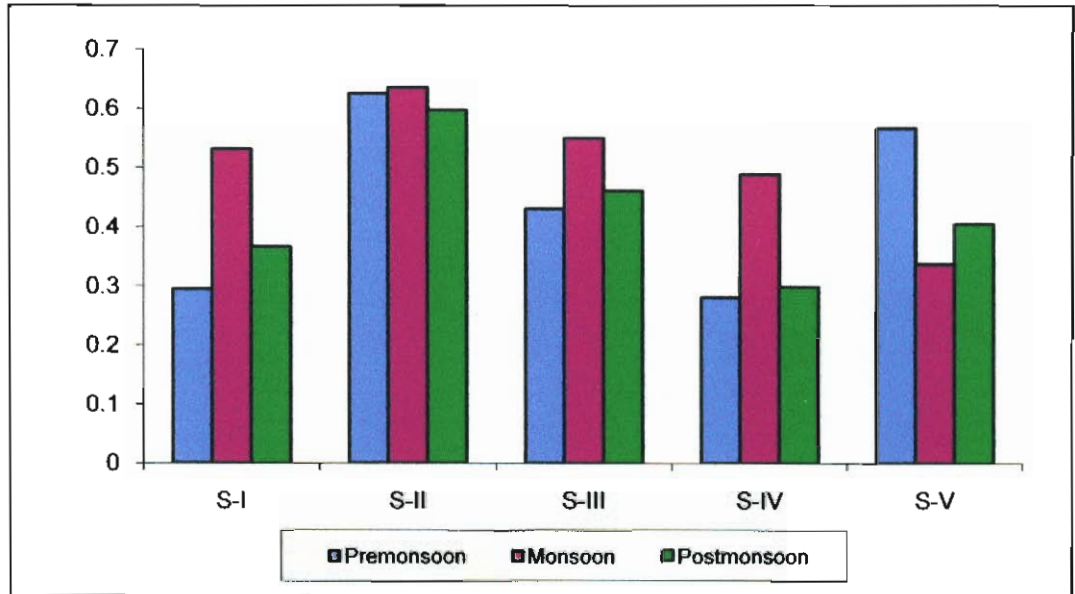


Table 7.2a Two way ANOVA comparing Richness index between stations and seasons

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9.863(a)	14	.705	2.487	.005
Intercept	102.121	1	102.121	360.447	.000
Season	.759	2	.380	1.340	.267
Station	6.234	4	1.559	5.501	.001
Season * Station	2.832	8	.354	1.249	.280**
Error	26.348	93	.283		
Total	235.036	108			
Corrected Total	36.212	107			

** P < 0.01

Table 7.3 Spatial and temporal variation of Dominance index

Month/season	SI	SII	SIII	SIV	SV	Total
February	0.294	0.581	0.269	0.286	0.622	0.41
March	0.284	0.895	0.33	0.206	0.622	0.467
April	0.318	0.505	0.36	0.323	0.676	0.436
May	0.285	0.516	0.761	0.31	0.344	0.443
Premonsoon	0.295	0.624	0.43	0.281	0.566	0.439
June	0.34	0.722	0.631	0.52	0.275	0.497
July	0.667	0.48	0.838	0.714	0.275	0.595
August	0.847	0.754	0.438	0.352	0.524	0.583
September	0.272	0.581	0.287	0.368	0.275	0.356
Monsoon	0.531	0.634	0.549	0.488	0.337	0.508
October	0.491	0.554	0.631	0.327	0.676	0.536
November	0.294	0.722	0.354	0.315	0.384	0.414
December	0.351	0.554	0.655	0.215	0.178	0.391
January	0.327	0.552	0.199	0.335	0.378	0.358
Postmonsoon	0.366	0.596	0.46	0.298	0.404	0.425

Table 7.4 Spatial and temporal variation of Evenness index

Month/season	SI	SII	SIII	SIV	SV	Total
February	0.866	0.57	0.815	0.784	0.582	0.723
March	0.805	0.175	0.735	0.831	0.582	0.625
April	0.699	0.646	0.741	0.756	0.449	0.658
May	0.731	0.597	0.336	0.852	0.775	0.658
Premonsoon	0.699	0.646	0.741	0.756	0.449	0.658
June	0.693	0.367	0.438	0.624	0.886	0.602
July	0.473	0.609	0.269	0.492	0.886	0.546
August	0.402	0.581	0.703	0.85	0.627	0.633
September	0.807	0.57	0.834	0.738	0.886	0.767
Monsoon	0.594	0.532	0.561	0.676	0.821	0.637
October	0.512	0.548	0.477	0.697	0.449	0.537
November	0.866	0.367	0.692	0.992	0.73	0.729
December	0.636	0.548	0.411	0.767	0.914	0.655
January	0.692	0.692	0.821	0.677	0.768	0.73
Postmonsoon	0.676	0.539	0.6	0.783	0.715	0.663

Fig. 7.3. Spatial and seasonal variation in Dominance index of fish fauna at Sasthamkotta Lake

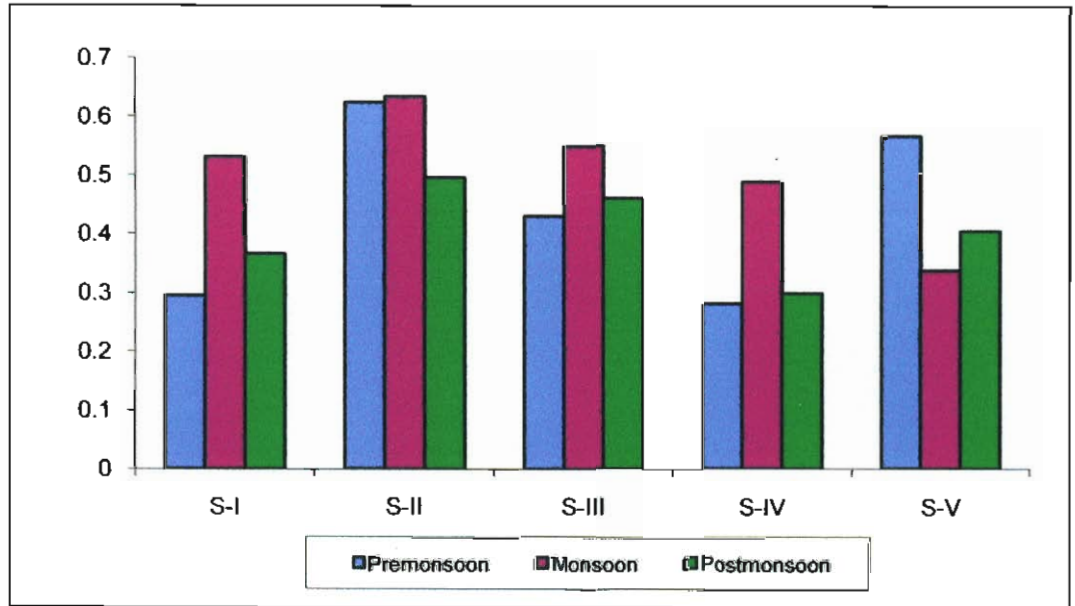


Table 7.3a. Two way ANOVA comparing Dominance index between stations and seasons

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.235(a)	14	.088	2.762	.002
Intercept	14.112	1	14.112	442.015	.000
Season	.045	2	.023	.706	.496
Station	.947	4	.237	7.418	.000
Season * Station	.222	8	.028	.869	.546**
Error	2.969	93	.032		
Total	21.071	108			
Corrected Total	4.204	107			

** P < 0.01

Fig. 7.4. Spatial and seasonal variation in Evenness index of fish fauna at Sasthamkotta Lake

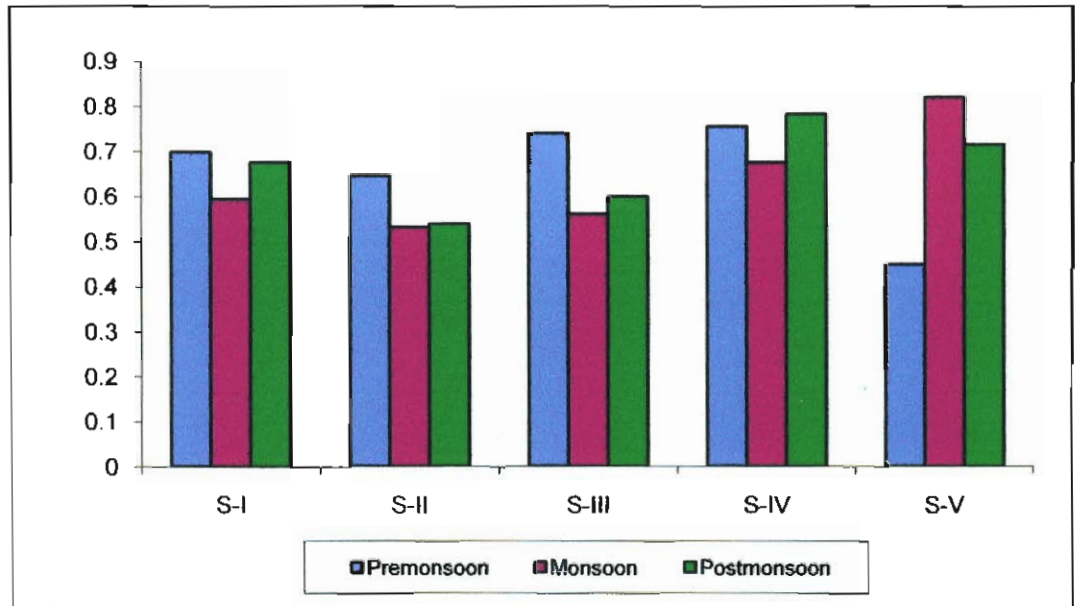


Table 7.4a. Two way ANOVA comparing Evenness index between stations and seasons

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.704(a)	14	.050	1.468	.139
Intercept	31.302	1	31.302	913.801	.000
Season	.004	2	.002	.059	.943
Station	.514	4	.129	3.752	.007
Season * Station	.174	8	.022	.635	.747**
Error	3.186	93	.034		
Total	54.667	108			
Corrected Total	3.890	107			

** P < 0.01

Table 7.5 Temporal variation of different Diversity indices of fishes using Encircling nets at all stations

Month/season	Richness	dominance	diversity	Evenness
February	1.354	0.216	1.682	0.809
March	1.897	0.321	1.594	0.641
April	1.597	0.252	1.644	0.714
May	1.908	0.339	1.497	0.624
Premonsoon	1.744	0.262	1.746	0.681
June	2.013	0.521	1.234	0.497
July	1.424	0.469	1.058	0.482
August	1.075	0.255	1.554	0.799
September	1.552	0.302	1.515	0.690
Monsoon	2.042	0.285	1.599	0.590
October	1.840	0.473	1.199	0.483
November	1.845	0.383	1.432	0.597
December	2.507	0.365	1.507	0.556
January	1.771	0.246	1.675	0.698
Postmonsoon	1.982	0.354	1.552	0.573

Table 7.6 Temporal variation of different Diversity indices of fishes using all gill nets

	Richness	Dominance	Diversity	Evenness
February	1.179	0.27	1.43	0.735
March	3.306	0.127	2.293	0.847
April	1.858	0.199	1.769	0.768
May	3.325	0.152	2.189	0.789
Premonsoon	2.947	0.187	1.971	0.669
June	3.711	0.185	2.056	0.675
July	2.687	0.152	2.033	0.793
August	2.927	0.163	2.068	0.746
September	3.534	0.196	1.999	0.679
Monsoon	3.098	0.175	2.112	0.694
October	3.139	0.181	2.007	0.694
November	3.156	0.266	1.69	0.564
December	2.694	0.197	1.897	0.684
January	2.642	0.254	1.769	0.638
Postmonsoon	2.824	0.216	1.867	0.613

Table 7.7 Temporal variation of different Diversity indices of fishes using cast net

	Richness	Dominance	Diversity	Evenness
February	1.359	0.700	0.733	0.333
March	1.020	0.746	0.595	0.306
April	1.001	0.763	0.564	0.290
May	0.718	0.713	0.599	0.372
Premonsoon	1.382	0.724	0.679	0.283
June	2.358	0.549	1.018	0.359
July	1.473	0.619	0.837	0.349
August	2.136	0.583	0.978	0.361
September	1.213	0.537	0.984	0.448
Monsoon	1.982	0.571	0.969	0.342
October	1.541	0.225	1.66	0.755
November	1.462	0.245	1.678	0.764
December	1.803	0.390	1.327	0.554
January	1.484	0.212	1.726	0.786
Postmonsoon	1.472	0.254	1.664	0.694

Table 7.8. Temporal variation of different Diversity indices of fishes for the entire lake of Sasthamkotta

Month/season	Richness	Dominance	Diversity	Evenness
February	3.247	0.175	2.010	0.641
March	3.151	0.176	1.990	0.644
April	2.704	0.162	2.030	0.690
May	3.093	0.177	2.024	0.621
Premonsoon	3.155	0.298	1.626	0.519
June	1.985	0.248	1.705	0.646
July	2.865	0.249	1.787	0.596
August	2.539	0.250	1.751	0.606
September	3.176	0.240	1.825	0.600
Monsoon	2.832	0.301	1.646	0.511
October	3.023	0.241	1.827	0.568
November	3.333	0.293	1.666	0.517
December	2.804	0.357	1.408	0.462
January	2.843	0.274	1.728	0.567
Postmonsoon	3.142	0.239	1.836	0.594

Fig. 7.5.a. Different monthly fish diversity indices for the entire lake

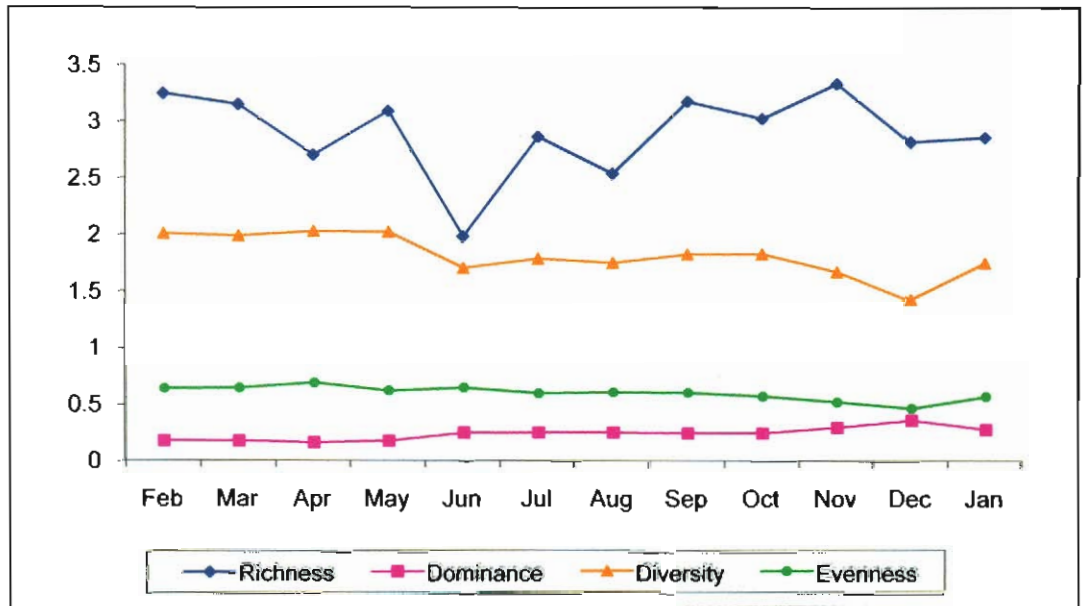


Fig. 7.5.b. Different seasonal fish diversity indices for the entire lake

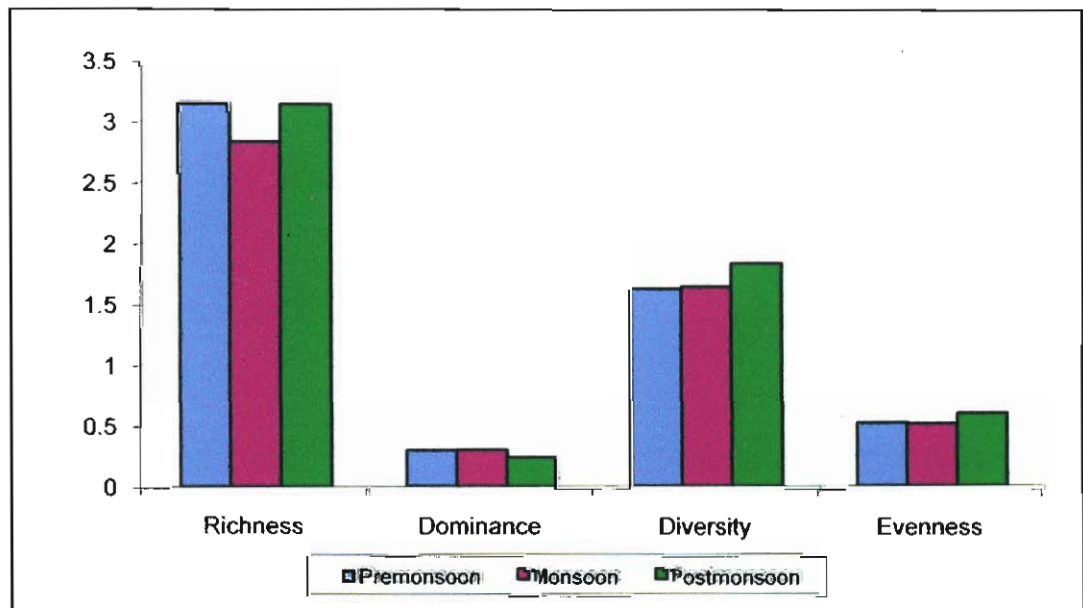


Table 7.9. Correlation between Diversity index of fish with water quality parameters at station I

	Cl	Bac	Cya	Din	Temp	pH	Tur	Tran	Do	Sili	Pho	No ₂	No ₃	K	Gpp	Npp	Chloro	Fish abund
Chlorophyceae	1																	
Bacillariophyceae	-.102	1																
Cyanophyceae	.266		1															
Dinoflagellata	.a	.a	.a	.a														
Temperature	.019	.228	.036	.a	1													
pH	-.166	-.213	.822*	.a	.218	1												
Turbidity	-.447	.319	.307	.a	-.476	-.170	1											
Transparency	-.299	-.031	-.189	.a	.657*	.028	-.447											
D. Oxygen	.080	.524	.012	.a	-.163	-.464	.414	1										
Silicate	-.018	-.305	.029	.a	.155	.268	-.051	-.437	1									
Phosphate	-.404	-.279	-.196	.a	-.192	-.160	.444	.032	.044	1								
Nitrite	-.262	-.064	.033	.a	.136	.175	-.031	.141	-.268	-.197	1							
Nitrate	-.255	-.110	.292	.a	-.045	.462	-.135	-.229	-.518	-.182	.498	1						
Potassium	-.376	-.163	-.451	.a	.525	.012	-.518	-.315	.311	-.016	-.076	-.051	1					
Gpp	.663*	.179	-.220	.a	-.002	-.366	-.232	.188	-.111	-.210	.036	-.181	-.366	1				
Npp	.106	.119	.768*	.a	-.170	.537	.145	.021	.320	-.276	.156	-.017	-.388	.211	1			
Chlorophyll	.238	-.480	-.069	.a	-.666*	-.087	.338	-.117	.263	.509	-.570	-.290	-.391	-.011	.012	1		
Fish abundance	-.304	-.066	-.210	.a	-.034	.054	.154	-.118	-.036	-.162	.275	.482	.172	-.150	-.030	-.178	1	
Fish D. index	-.534	-.176	-.276	.a	.285	-.063	-.108	-.386	.044	.246	.518	.203	.311	.087	-.142	-.385	.249	1

* Correlation is significant at the 0.01 level (1-tailed).

a Cannot be computed because at least one of the variables is constant.

Table 7.10. Correlation between Diversity index of fish with water quality parameters at station II

	Cl	Bac	Cya	Din	Temp	pH	Tur	Tran	Do	Sili	Pho	NO ₂	NO ₃	K	Gpp	Npp	Chloro	Fish abun	Fish index
Chlorophyceae	1																		
Bacillariophyceae	.232	1																	
Cyanophyceae	-.419	-.308	1																
Dinoflagellata	.504	.264	-.285	1															
Temperature	.278	-.224	-.732**	.237	1														
pH	-.080	-.189	.091	-.439	-.095	1													
Turbidity	-.262	.353	.647*	-.220	-.832**	.142	1												
Transparency	.131	-.369	-.504	.263	.758**	.425	-.486	1											
D. Oxygen	-.319	.507	.292	.375	-.512	.143	.463	-.479	1										
Silicate	-.509	-.669*	.260	-.583*	-.132	.232	-.022	.116	-.326	1									
Phosphate	.184	.513	.086	-.044	-.560	.145	.696*	-.238	.225	-.024	1								
Nitrite	-.044	.321	-.430	.032	.189	-.058	-.115	.221	.041	-.382	-.087	1							
Nitrate	.393	-.187	-.128	-.069	-.018	-.167	-.322	-.184	-.393	.053	.011	-.066	1						
Potassium	-.086	-.085	.670*	-.224	-.601*	-.027	.446	-.476	-.013	.043	.010	-.153	.052	1					
Gpp	.165	.594*	-.296	.289	-.036	-.164	-.050	-.377	.345	-.303	.019	-.148	-.140	.055	1				
Npp	-.066	.196	.483	-.039	-.762**	.490	.850**	-.244	.292	.164	.817**	-.181	-.064	.332	-.131	1			
Chlorophyll	-.477	.002	.466	.134	-.191	.184	.213	-.219	.562	-.128	-.236	-.176	-.332	-.019	-.103	-.022	1		
Fish abundance	-.236	.017	.159	-.283	-.387	.241	.320	-.130	-.013	.157	.373	.232	.501	.047	-.436	.472	.100	1	
Fish D. index	-.099	.234	-.050	-.103	-.344	.490	.232	-.154	.078	.226	.344	.112	.134	-.001	.082	.422	.112	.532	1

* Correlation is significant at the 0.01 level (1-tailed).

** Correlation is significant at the 0.05 level (2-tailed).

Table 7.11. Correlation between Diversity index of fish with water quality parameters at station III

	Cl	Bac	Cya	Din	Temp	pH	Tur	Tran	Do	Sili	Pho	No ₂	No ₃	K	Gpp	Npp	Chloro	Fish abun	Fish index
Chlorophyceae	1																		
Bacillariophyceae	.857	1																	
Cyanophyceae	.538	.088	1																
Dinoflagellata	a	a	a	1															
Temperature	.531	.666*	-.157	a	1														
pH	.256	.074	.322	a	-.401	1													
Turbidity	-.478	-.645*	.308	a	-.561	-.252	1												
Transparency	.439	.577*	-.221	a	.719	-.288	-.564	1											
D. Oxygen	.019	-.194	.361	a	-.488	-.049	.248	-.086	1										
Silicate	-.742	-.412	-.728	a	-.149	-.398	.293	.068	-.255	1									
Phosphate	.441	.456	.248	a	.173	-.259	-.153	.128	.492	-.438	1								
Nitrite	-.187	-.103	-.090	a	-.615*	.433	.029	-.218	.339	.151	.242	1							
Nitrate	-.045	.186	-.276	a	.183	-.104	.035	-.238	-.534	.161	-.011	-.149	1						
Potassium	-.297	-.295	.173	a	-.365	-.110	.554	-.546	-.010	0.23	-.018	.106	.032	1					
Gpp	.306	.261	.400	a	.057	-.181	-.071	-.030	.404	-.497	.780	.120	-.197	.324	1				
Npp	.469	.455	.277	a	.269	-.251	-.207	.073	.352	-.597*	.877	-.007	.162	.117	.786	1			
Chlorophyll	-.733	-.605*	-.225	a	-.337	-.422	.753	-.378	-.195	.682*	-.357	.019	.181	.666*	-.136	-.352	1		
Fish abundance	-.148	-.364	.384	a	-.300	.039	.234	-.514	.219	-.280	.014	-.138	-.335	.380	.425	.059	.125	1	
Fish D. index	.327	.286	-.013	a	.332	-.192	-.118	.273	.148	-.131	.190	-.337	.131	-.579	-.295	.088	-.443	-.468	1

* Correlation is significant at the 0.05 level (1-tailed).

a Cannot be computed because at least one of the variables is constant.

Table 7.12. Correlation between Diversity index of fish with water quality parameters at station IV

	Cl	Bac	Cya	Din	Temp	pH	Tur	Tran	Do	Sili	Pho	No ₂	No ₃	K	Gpp	Npp	Chloro	Fish abun	Fish index
Chlorophyceae	1																		
Bacillariophyceae	.255	1																	
Cyanophyceae	-.138	.476	1																
Dinoflagellata	-.138	.476	1.000**	1															
Temperature	.328	-.158	.112	.112	1														
pH	-.389	-.453	-.055	-.055	-.348	1													
Turbidity	-.229	.159	.059	.059	-.556	.349	1												
Transparency	.478	-.407	-.248	-.248	.791**	-.392	-.680*	1											
D. Oxygen	-.319	.399	.211	.211	-.477	.144	.450	-.572	1										
Silicate	.032	-.520	-.902**	-.902**	-.234	.212	-.031	.180	-.185	1									
Phosphate	.445	.234	-.141	-.141	.446	-.158	-.334	.373	.287	.049	1								
Nitrite	.359	.264	-.081	-.081	-.251	.277	.222	-.107	.382	.289	.447	1							
Nitrate	.798**	.045	-.319	-.319	.407	-.177	-.156	.365	-.478	.192	.359	.172	1						
Potassium	.076	.320	-.286	-.286	-.539	-.164	.652*	-.446	.041	.272	-.374	.122	0.115	1					
Gpp	-.047	.720**	.258	.258	.039	-.371	.043	-.329	.345	-.415	.223	-.001	-0.008	0.103	1				
Npp	.575	.246	-.002	-.002	.287	-.256	-.255	.205	-.499	-.111	.036	.029	0.704*	0.136	.206	1			
Chlorophyll	-.267	-.089	-.606*	-.606*	-.738*	.152	.419	-.464	.092	.651*	-.377	.037	-0.153	0.737**	-.159	-.229	1		
Fish abundance	.647*	.004	-.275	-.275	.199	-.531	-.480	.537	-.166	.304	.361	.229	0.483	-0.067	-.212	.315	-.097	1	
Fish D. index	.132	-.440	.233	.233	.444	-.063	-.478	.532	-.402	-.097	-.056	-.216	0.142	-0.518	-.569*	.146	-.472	.480	1

* Correlation is significant at the 0.01 level (1-tailed).

** Correlation is significant at the 0.05 level (2-tailed).

Table 7.13. Correlation between Diversity index of fish with water quality parameters at station V

	Cl	Bac	Cya	Din	Temp	pH	Tur	Tran	Do	Sili	Pho	No ₂	No ₃	K	Gpp	Npp	Chloro	Fish abun	Fish index
Chlorophyceae	1																		
Bacillariophyceae	.528	1																	
Cyanophyceae	.259	.675	1																
Dinoflagellata	.246	.427	.710**	1															
Temperature	.462	.717**	.426	.334	1														
pH	.295	.426	.013	-.164	.176	1													
Turbidity	-.064	-.115	-.102	.268	-.442	-.069	1												
Transparency	.116	.555	.446	-.019	.479	.500	-.498	1											
D. Oxygen	-.616*	-.796**	-.566	-.208	-.628*	-.521	.278	-.524	1										
Silicate	-.131	-.446	-.614*	-.862**	-.281	-.030	-.137	-.007	.166	1									
Phosphate	.571	.612*	.466	.690*	.619*	.145	-.072	.115	-.441	-.543	1								
Nitrite	.177	.445	.105	.338	.347	.634*	.073	.203	-.213	-.486	.605*	1							
Nitrate	.452	.507	.092	-.148	.241	.516	-.087	.095	-.746**	.151	.305	.198	1						
Potassium	.074	-.302	-.033	.055	-.676*	.117	.565	-.298	.032	.067	-.204	-.112	.121	1					
Gpp	.278	.503	.859**	.945**	.369	-.128	.057	.201	-.363	-.810**	.637*	.221	-.093	.062	1				
Npp	.515	.128	.453	.734**	.082	-.283	.399	-.290	-.085	-.548	.382	-.016	-.231	.358	.679*	1			
Chlorophyll	-.237	-.604*	-.474	-.442	-.659*	-.094	.314	-.338	.173	.579*	-.578*	-.498	.131	.704*	-.424	-.131	1		
Fish abundance	-.291	-.047	.063	-.139	-.187	-.497	.078	-.172	.049	.310	-.201	-.634*	.198	-.084	-.095	-.258	.255	1	
Fish D. index	-.404	-.509	-.116	.022	-.419	-.255	.148	-.449	.541	-.229	-.389	-.010	-.550	.193	-.053	.232	.021	-.377	1

* Correlation is significant at the 0.05 level (1-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

Diversity indices and their variation have been recognized as useful tools in assessing community structure in ecosystem (Magguram, 1988). In case of fish assemblages also, these indices have been used by several ecologists to interpret the patterns of their spatial and temporal variations (Haedrich and Haedrich, 1974; Matuszek *et al.*, 1990; Gido and Mathews, 2000). For the interpretation of species diversity, the relation between the number of individuals and the number of species are usually used. These indices are often correlated with several physico-chemical and biological aspects in lakes, streams, estuaries etc. Lake being insular habits and similar to island ecosystems, the influence of these parameters on the species diversity of their fish assemblages will be more pronounced (Mc Arthur and Wilson, 1967; Simberloff and Wilson, 1969; Vuilluemier, 1970). The basic parameter, that influences lake fish assemblages are the appearance of or establishment of water connection by other water bodies like small streams. This will enable immigrations or emigration of species. As a sequel to this, the species which have colonized the lakes may start showing variations due to environmental and biotic factors. These include changes in physical parameters, chemical parameters, habitat diversity, interaction between species like predation and competition and extinction due to severe adverse effects (Barbour and Brown, 1974). Pollution is said to influence the species diversity of fish assemblages and hence these indices have been used as indicators of pollution status of lakes (Amstrong *et al.*, 1971; Tramer and Rogers, 1973; Livingston, 1975). According to many observations pollution may not influence the diversity as such, unless it is so severe as to eliminate certain intolerant species and thereby affect the species richness and diversity. According to Livingston (1975), seasonal changes also influence the species richness in lakes. In general, tropical lakes possess more species richness and diversity than temperate lakes (Pianka, 1966; Warburton, 1978).

The fresh water lake in Sasthamkotta is unique in many respects. The source of water for the lake is spring water and water from the seasonal rains and there is no springlet or stream that flows into the lake. Similarly there is no natural outlet for water from the lake. The depth of the lake increases abruptly from the banks. The lake remains virtually isolated from all other water masses. Even though some fishes might have escaped from the lake into the Kallada river before the construction of the present bund during floods, there was no possibility for even the most daring species to get into the lake from the river with which it had only a one way contact. Hence the fish fauna of the lake might have been completely isolated for all these years (Thomas *et al.*, 1980).

The lake supports fishery of a very negligible magnitude compared to its area. The results of the present study revealed high species richness in Sasthamkotta lake during the pre monsoon (3.155) and diversity value (1.836) during the post monsoon season by using all the possible nets in the lake. Species dominance (0.301) and evenness (0.594) was highest during monsoon and post monsoon respectively. Compared to other lakes of similar type the indices were low (Pianka, 1966).

Variation was noted among the different sampling sites during the present investigation. Local processes operating at micro habit scale influence the fish assemblages and this can be attributed to the variations of the indices among different sites. Similar variations have been reported at microhabitat scale by Lowe-Mc Connell, (1975), Reid, (1986) and Rodriguez *et al.* (1990). When estimated on seasonal basis Station IV had the highest diversity index values during post monsoon and pre monsoon seasons. Among the seasons the highest value of 1.425 was noticed during post monsoon season at station IV. This sampling station was located in the area near the filter house. Low values were recorded at station II during the monsoon period. Annual values showed that the highest diversity index was at January and lowest in August. The high species richness noticed in station IV may be due to the less anthropogenic intervention

due to the protection of the locality by the state Government. Besides the high species richness species diversity index and evenness was also high in this station.

Gill nets are the major operating nets in Sasthamkotta lake (Thomas *et al.*, 1980). Hence diversity indices using all types of gill nets were used in the present study. Diversity index, richness and evenness indices were high during monsoon season whereas dominance was high in post monsoon period.

The highest value of Shannon index and Evenness index by using the cast net were during the post monsoon season followed by monsoon and pre monsoon seasons. Richness index was high during monsoon season followed by post monsoon and pre monsoon seasons. Values of Dominance index were lowest during the post monsoon and highest during the pre monsoon season

Monthly and seasonal variations in the various indices were also noticed during the present study. In high latitude lakes water quality parameters like pH, dissolved oxygen, alkalinity, conductivity, total dissolved salts etc., and biotic factors like primary productivity, competition for food etc also influence the diversity indices (Rahel, 1984; Werner *et al.*, 1978; Tonn and Magnuson, 1982).

However, in tropical climatic conditions variations in these parameters are limited or even very rare. In Sasthamkotta lake also no significant variations in these parameters were noticed (See Chapter III). Factors related to monsoon rain and subsequent changes in the lake volume, surface area and climate might be the important factor influencing variations in the diversity indices. Even though predation by large predators does not exist; smaller predators were present in the lake. Large top predators and piscivores can eliminate smaller species from similar lakes (Tonn and Magnuson, 1982). But the role of smaller predators was limited. Predatory effect by large piscivorous fishes does not exist and hence their role in diversity changes was not taken into account. Presence of large number of smaller species may contribute to enhanced species diversity.

Results of the present study revealed that in a tropical lake like, Sasthamkotta instead of a single factor like pH or conductivity as is noticed in

European lakes, interaction of many factors (both biotic and abiotic) are responsible for the spatial and temporal variations in diversity indices. The interaction of these factors and variations are primarily influenced by the monsoon prevalent in this tropical belt. Monsoon brings large quantities of flood water to the lake, increasing its volume, increasing surface area, increasing turbidity, increasing nutrient content and also increasing primary productivity. The monsoon rains also result in decline in water temperatures. All these trigger food production and swamping by several species. Thus, all these influence the species diversity of the lake and contribute to moderate species richness. Correlation between different water quality parameters with fish abundance and diversity index showed that the relationship was significant at stations III, IV and V indicated that factors like abundance of chlorophyceae, primary productivity and nitrite influence the abundance and diversity index of fishes in the lake. .

CHAPTER VIII
FISHERY POTENTIAL

CHAPTER VIII

FISHERY POTENTIAL OF SASTHAMKOTTA LAKE

INTRODUCTION

The freshwater lakes in India support a rich fishery. True fresh water lakes and their area are less when compared to other fresh water bodies. Hence their contributions in terms of fisheries are lower compared to estuarine and riverine fisheries. Sasthamkotta lake, though large in size supports a negligible fishery. So far no recorded data regarding the total catch or number of fishing gears in operation exists. The process of reclamation in Sasthamkotta lake catchment area is more intense and it has its negative impact on the fishery.

Lake Sasthamkotta is a major drinking water source to lakhs of people in the Kollam District. In addition the lake is a source of commercially important fresh water fishes. Gill nets are the major gear operating in this lake. Cast nets are rarely used since this lake is not a shallow lake. Encircling nets are also rarely used. A preliminary survey conducted during the present study indicated the existence of about 3 cast nets, 15 gill nets and 5 encircling nets operating in the lake. Seasonal rain and related change in physicochemical parameters are the main factors that influence the fishing days in a year. The fishing crafts used are purely traditional and non-mechanized. Brief description of the operation of these nets is provided in Chapter VI. Cast net is operated by a single person for several times in a day and is meant for in shallow zones, while encircling net is larger in size with small mesh size and is very efficient in terms of abundance, compared to the other two nets. Gill nets are highly selective with regard to the size of fish and species because of its passive mode of operation. Since these three types of nets are operated by local fishermen, it was decided to investigate the fishery potential and characteristics by experimental fishing using these three types of nets for a period of one year.

METHODOLOGY

To assess the quantity of fish caught daily by each type of nets/all types of nets and their seasonal and spatial variations, experimental fishing was carried out for a period of one year using the three types of nets. For estimating the fishery resources, their monthly fluctuations and contribution of each category of net to the fishery of the lake, experimental fishing employing all the three types of nets from the sampling station IV was done monthly. From the data, relative abundance of fishes was estimated by calculating the Catch per Unit Effort (CPUE), which is the weight in gram per unit operation of each species and for the monthly fish population. From the CPUE values, catch per day was projected for the different nets and different species.

Catch per day for the cast net was calculated as $CPUE \times 3 \times 10$; assuming 3 cast nets are operating regularly in Sasthamkotta lake and each net operates approximately 10 times a day. Catch per day for the gill net was calculated as, the average of CPUE by three gillnets $\times 15 \times 1$ (15 gillnets are operated regularly one time during night). Similarly catch per day for the encircling net was calculated as $CPUE \times 5 \times 3$; (5 encircling nets are regularly operated and each net operates approximately 3 times per day). Gill nets are the common gear used in Sasthamkotta lake. Cast nets and encircling nets were rarely used in the lake.

RESULTS

Based on the experimental fishing carried out using different nets in the lake, Catch per unit effort (CPUE) was calculated for each net and for each species monthly and seasonally and is presented in Tables 8.1 to 8.4. Value of CPUE was expressed as total catch in grams per operation of net per day.

Cast net Fishery

Monsoon is the most favourable season for cast net fishery as far as CPUE is concerned, followed by post monsoon and pre monsoon (Table 8.1). CUPE by cast net is represented in Table 8.2. Cast net fishery showed a high CPUE value during the month of June and lowest during May. The CPUE value of

Dayella malabaricus was higher compared to other fishes, which was collected in large numbers and *Puntius ticto* and *Puntius amphibius* showed the lowest value. *Parambassis dayi*, *Etroplus maculatus*, *Puntius filamentosus* and *Mystus oculatus* were also collected in larger quantities.

Gillnet Fishery

The CPUE values for the three types of gill nets were pooled together and average was taken to study the CPUE by gillnet. The results are presented in Table 8.3. Of the 22 fishes collected by gillnets from the lake, *Etroplus suratensis* showed higher CPUE values. The lowest value was shown by *Xenentodon cancila* whose abundance was also very low. The highest value of CPUE was recorded during November but the highest occurrence of *Etroplus suratensis* was in May. The lowest value was recorded during July, when the abundance value was also comparatively low. Premonsoon was the productive season followed by postmonsoon and monsoon (Table 8.1) in the fishery operation using gill nets.

Encircling Net Fishery

The results of CPUE from encircling net fishery are presented in Table 8.4. Using this net 23 species was collected, of which *Puntius filamentosus*, *Mystus oculatus*, *Etroplus maculatus* and *Xenentodon cancila* consisted the highest catch. *Horabagrus brachysoma* was the least in terms of weight. Maximum CPUE value was noticed during October and minimum during May. Encircling net fishery indicated a high production during postmonsoon season followed by premonsoon and monsoon seasons (Table 8.1).

The catch per day was estimated for different nets and presented in Tables 8.5 to 8.8; it showed the same trend as the CPUE. The average CPUE and catch per day by cast net (0.267 kg/net and 7.9 kg/day), gillnet and encircling net were 1.226 kg/net and 18.38 kg /day and 0.358 kg /net and 5.37 kg/day respectively. A comparison of CPUE and catch per day by the three different nets showed that the maximum fish catch was obtained by gill net and the CPUE value was also high compared to the other two nets, though the net operated only once in a day.

Table 8.1. CPUE (gm/haul) of different net type from Sasthamkotta lake

Month/Season	Encircling net	Gill net	Cast net	Total
February	298.6	1825.99	163.00	2287.59
March	431.8	1079.68	156.40	1667.88
April	398.6	1352.68	171.40	1922.68
May	220.4	1618.66	122.00	1961.06
Premonsoon	337.35	1469.25	153.20	1959.80
June	271.4	1114.35	515.20	1900.95
July	371.4	985.66	314.60	1671.66
August	426	756.99	374.00	1556.99
September	241.2	1017.02	461.40	1719.62
Monsoon	327.5	968.51	416.30	1712.31
October	486.4	1024.32	183.00	1693.72
November	330	1850.31	290.40	2470.71
December	402.6	992.65	195.40	1590.65
January	416.6	1090.33	260.60	1767.53
Postmonsoon	408.9	1239.40	232.35	1880.65
Average CPUE	357.91	1225.72	267.283	1850.91

Table 8.2. Catch per unit effort (gm/haul) by cast net from Sasthamkotta lake

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>					4	1	5		10		1.6		21.6
<i>P. filamentosus</i>	7	3	5	4	35	55	77	32	31	70	14	30	363
<i>P. ampibius</i>					0.8		0.8						1.6
<i>P. dorsalis</i>					1.6		1.6						3.2
<i>P. vittatus</i>					1		1						2
<i>P. ticto</i>					0.8		0.8						1.6
<i>X. cancella</i>	1.6									40	10	10	61.6
<i>H. limbatus</i>	5	1	1	3	2	2.4	6	30		45	3.6	35	134
<i>Parambassis dayi</i>	15	12	15	25	190	17.6	80	180	70	24	70	80	778.6
<i>E. maculatus</i>	20	20	30		65	35	30	36	32	40	30	50	388
<i>E. suratensis</i>													
<i>M. guentheri</i>					6								6
<i>A. lineatus</i>		0.4	0.4		0.6	0.4	0.4	1	1	1	0.4	0.4	6
<i>A. panchax</i>	0.4				0.4	1	0.4	1	0.4	0.4	0.2	0.2	4.4
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>	2				3		10						15
<i>M. oculatus</i>	12	20	10	10	40	35	20	40	18	40	30	25	300
<i>H. brachyosoma</i>					2	2							4
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>	100	100	110	80	160	164	140	140	20	30	35	30	1109
<i>M. cupanus</i>					3	1.2	1	1.4	0.6		0.6		7.8
<i>G. giuris</i>													
Total	163	156.4	171.4	122	515.2	314.6	374	461.4	183	290.4	195.4	260.6	3207.4

Table 8.3. Catch per unit effort (gm/haul) by gill net from Sasthamkotta lake

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>		4.0		4.0	10.0		10.0	10.0	5.0	13.3	5.0	13.3	74.7
<i>P. filamentosus</i>	14.3	12.7	22.7	14.3	76.7	25.0	43.3	46.7	103.3	106.7	91.7	76.7	634.0
<i>P. ampibius</i>		5.0		5.0	10.0		10.0	10.0	3.3	5.0	3.3	5.0	56.7
<i>P. dorsalis</i>					1.7		1.7	1.7	5.0	5.3	5.0	5.3	25.7
<i>P. vittatus</i>		1.7		1.7	1.7		1.7	1.7	3.3	3.3	3.3	3.3	21.7
<i>P. ticto</i>		2.0		2.0	1.7		2.0	2.0	6.0	5.0	6.0	5.0	31.7
<i>X. cancella</i>					6.7								6.7
<i>H. limbatus</i>		5.0	5.0	5.0	10.0		1.7	1.7	13.3	3.3	13.3	3.3	61.7
<i>Parambassis dayi</i>	208.3	41.7	61.7	75.0	51.0	50.0	28.3	36.7	100.0	333.3	100.0	85.0	1171.0
<i>E. maculatus</i>	176.7	10.0	121.7	7.3	111.7	58.3	50.0	91.7	138.3	183.3	193.3	416.7	1559.0
<i>E. suratensis</i>	1133.3	833.3	816.7	1200.0	116.7	66.7	133.3	533.3	300.0	700.0	216.7	333.3	6383.3
<i>M. guentheri</i>		10.0		5.0	2.7	100.0	102.7	2.7	8.3	3.3	8.3	3.3	246.3
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>			116.7		133.3	150.0	33.3		66.7	50.0		33.3	583.3
<i>Wallago attu</i>		16.7		25.0	25.0	25.0		16.7		33.3	133.3	16.7	291.7
<i>O. bimaculatus</i>		25.0	25.0		33.3	33.3	33.3	33.3		25.0	25.0		233.3
<i>O. malabaricus</i>					25.0			16.7		25.0			66.7
<i>M. bleekeri</i>			5.0						6.7				11.7
<i>M. oculatus</i>	143.3	11.7	78.3	40.0	54.0	23.3	102.3	9.0	68.3	71.7	91.7	83.3	777.0
<i>H. brachyosoma</i>		100.0	100.0	83.3	300.0	333.3	200.0	50.0	58.3	1.7	91.7	1.7	1320.0
<i>C. marulius</i>	66.7			66.7	66.7	53.3		66.7	66.7	133.3			520.0
<i>C. micropeltus</i>	83.3			83.3	73.3	66.7		83.3	66.7	140.0			596.7
<i>D. malabaricus</i>		1.0		1.0	3.3	0.7	3.3	3.3	5.0	8.3	5.0	5.0	36.0
<i>M. cupanus</i>													
<i>G. giuris</i>													
Total	1826.0	1079.7	1352.7	1618.7	1114.4	985.7	757.0	1017.0	1024.3	1850.3	992.7	1090.3	14708.6

Table 8.4. Catch per unit effort (gm/haul) by encircling net from Sasthamkotta lake

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>		13	10	13	6			6	25	20	15		108
<i>P. filamentosus</i>	54	188	136	110.6	179	25	106	102	272	137	196	162	1667.6
<i>P. ampibius</i>		20	79		6	5	10	3	4	5	1	79.6	212.6
<i>P. dorsalis</i>		1.2	1.2	2.6	6	3	31		1	1	9	5	61
<i>P. vittatus</i>	2	1.4	2.8	1.4	2.4			3	0.6	1.2	0.6	2	17.4
<i>P. ticto</i>					7					1	1	4	13
<i>X. cancella</i>	69	72	27	15	30		65	27	37	83	59	15	499
<i>H. limbatus</i>	20	4			5.2				5.6	40	4.6	8	87.4
<i>Parambassis dayi</i>	10.6	49.6	13	4.6	3	21.4	11	15	23	0.6	8.6	3	163.4
<i>E. maculatus</i>	40	31	55	11.6	14.6	259	38	41.6	69.2	5.2	36.6	34	635.8
<i>E. suratensis</i>													
<i>M. guentheri</i>						27					4	10	41
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>				2		5			1.6		1.6		10.2
<i>M. oculatus</i>	95	36	73	47	11	20	165	43	46	36	58	94	724
<i>H. brachyosoma</i>						6							6
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>													
<i>M. cupanus</i>		0.6	1.6	0.6	1.2			0.6	1.4		1.6		7.6
<i>G. giuris</i>	8	15		12							6		41
Total	298.6	431.8	398.6	220.4	271.4	371.4	426	241.2	486.4	330	402.6	416.6	4295

Table 8.5. Catch per day (Kg/haul) of different net type from Sasthamkotta lake

Month/Season	Encircling net	Gill net	Cast net	Total
	(Kg/5 hauls/ 3 times)	(Kg/25 hauls/ 1 time)	(Kg/3 hauls/ 10 times)	
February	4.479	27.3889	4.48	36.3479
March	6.477	16.1952	4.692	27.3642
April	5.979	20.2902	5.142	31.4112
May	3.306	24.2799	3.66	31.2459
Premonsoon	5.06025	22.03855	4.4935	31.5923
June	4.071	16.71525	15.456	36.2423
July	5.571	14.7849	9.438	29.7939
August	6.39	11.35485	11.22	28.9649
September	3.618	15.2052	13.842	32.6652
Monsoon	4.9125	14.51505	12.489	31.9166
October	7.296	15.3648	5.49	28.1508
November	4.95	27.75465	8.712	41.4167
December	6.039	14.89385	4.9629	25.8958
January	6.249	16.355	7.818	30.422
Postmonsoon	6.1335	18.592075	6.745725	31.4713
Average CPUE	5.37	18.3819	7.94358	31.6517

Table 8.6. Catch per day(Kg/haul) by cast net from Sasthamkotta lake

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>					0.12	0.03	0.15		0.3		0.048		0.65
<i>P. filamentosus</i>	0.21	0.09	0.15	0.12	1.05	1.65	2.31	0.96	0.93	2.1	0.42	0.9	10.9
<i>P. ampibius</i>					0.024		0.024						0.05
<i>P. dorsalis</i>					0.048		0.048						0.1
<i>P. vittatus</i>					0.03		0.03						0.06
<i>P. ticto</i>					0.024		0.024						0.05
<i>X. cancella</i>	0.048									1.2	0.3	0.3	1.85
<i>H. limbatus</i>	0.15	0.03	0.03	0.09	0.06	0.07	0.18	0.9		1.35	0.108	1.05	4.02
<i>Parambassis dayi</i>	0.045	0.36	0.45	0.75	5.7	0.53	2.4	5.4	2.1	0.72	2.1	2.4	23
<i>E. maculatus</i>	0.6	0.6	0.9		1.95	1.05	0.9	1.08	0.96	1.2	0.9	1.5	11.6
<i>E. suratensis</i>													
<i>M. guentheri</i>					0.18								0.18
<i>A. lineatus</i>		0.012	0.012		0.018	0.01	0.012	0.03	0.03	0.03	0.012	0.012	0.18
<i>A. panchax</i>	0.012				0.012	0.03	0.012	0.03	0.012	0.012	0.006	0.006	0.13
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>	0.06				0.09		0.3						0.45
<i>M. oculatus</i>	0.36	0.6	0.3	0.3	1.2	1.05	0.6	1.2	0.54	1.2	0.9	0.75	9
<i>H. brachyosoma</i>					0.06	0.06							0.12
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>	3	3	3.3	2.4	4.8	4.92	4.2	4.2	0.6	0.9	1.05	0.9	33.3
<i>M. cupanus</i>					0.09	0.04	0.03	0.042	0.018		0.006		0.22
<i>G. giuris</i>													
Total	4.485	4.692	5.142	3.66	15.46	9.44	11.22	13.84	5.49	8.712	5.85	7.818	95.8

Table 8.7 Catch per day (Kg/haul) by gill net from Sasthamkotta lake

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>		0.06		0.06	0.15		0.15	0.15	0.08	0.20	0.08	0.20	1.12
<i>P. filamentosus</i>	0.21	0.19	0.34	0.21	1.15	0.38	0.65	0.70	1.55	1.60	1.38	1.15	9.51
<i>P. ampibius</i>		0.08		0.08	0.15		0.15	0.15	0.05	0.08	0.05	0.08	0.85
<i>P. dorsalis</i>					0.03		0.03	0.03	0.08	0.08	0.08	0.08	0.39
<i>P. vittatus</i>		0.03		0.03	0.03		0.03	0.03	0.05	0.05	0.05	0.05	0.30
<i>P. ticto</i>		0.03		0.03	0.03		0.03	0.03	0.09	0.08	0.09	0.08	0.48
<i>X. cancella</i>					0.10								0.10
<i>H. limbatus</i>		0.08	0.08	0.08	0.15		0.03	0.03	0.20	0.05	0.20	0.05	0.90
<i>Parambassis dayi</i>	3.12	0.63	0.93	1.13	0.77	0.75	0.42	0.55	1.50	5.00	1.50	1.28	17.57
<i>E. maculatus</i>	2.65	0.15	1.83	0.11	1.68	0.87	0.75	1.38	2.07	2.75	2.90	6.25	23.38
<i>E. suratensis</i>	17.00	12.50	12.25	18.00	1.75	1.00	2.00	8.00	4.50	10.50	3.25	5.00	95.75
<i>M. guentheri</i>		0.15		0.08	0.04	1.50	1.54	0.04	0.12	0.05	0.12	0.05	3.70
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>			1.75		2.00	2.25	0.50		1.00	0.75		0.50	8.75
<i>Wallago attu</i>		0.25		0.38	0.38	0.38		0.25		0.50	2.00	0.25	4.38
<i>O. bimaculatus</i>		0.38	0.38		0.50	0.50	0.50	0.50		0.38	0.38		3.50
<i>O. malabaricus</i>					0.38			0.25		0.38			1.00
<i>M. bleekeri</i>			0.08						0.10				0.18
<i>M. oculatus</i>	2.15	0.18	1.17	0.60	0.81	0.35	1.53	0.14	1.02	1.08	1.38	1.25	11.65
<i>H. brachyosoma</i>	0.00	1.50	1.50	1.25	4.50	5.00	3.00	0.75	0.87	0.03	1.38	0.03	19.80
<i>C. marulius</i>	1.00			1.00	1.00	0.80		1.00	1.00	2.00			7.80
<i>C. micropeltus</i>	1.25			1.25	1.10	1.00		1.25	1.00	2.10			8.95
<i>D. malabaricus</i>	0.00	0.02		0.02	0.05	0.01	0.05	0.05	0.08	0.12	0.08	0.08	0.54
<i>M. cupanus</i>													
<i>G. giuris</i>													
Total	27.39	16.20	20.29	24.28	16.72	14.78	11.35	15.21	15.36	27.75	14.89	16.36	220.58

Table 8.8. Catch per day(Kg/haul) by encircling net from Sasthamkotta lake

Types of fish	PREMONSOON				MONSOON				POSTMONSOON				Total
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	
<i>Puntius sarana</i>		0.20	0.15	0.20	0.09			0.09	0.38	0.30	0.23		1.62
<i>P. filamentosus</i>	0.81	2.82	2.04	1.66	2.69	0.38	1.59	1.53	4.08	2.06	2.94	2.43	25.01
<i>P. ampibius</i>		0.30	1.19		0.09	0.08	0.15	0.05	0.06	0.08	0.02	1.19	3.19
<i>P. dorsalis</i>		0.02	0.02	0.04	0.09	0.05	0.47		0.02	0.02	0.14	0.08	0.92
<i>P. vittatus</i>	0.03	0.02	0.04	0.02	0.04			0.05	0.01	0.02	0.01	0.03	0.26
<i>P. ticto</i>					0.11					0.02	0.02	0.06	0.20
<i>X. cancella</i>	1.04	1.08	0.41	0.23	0.45		0.98	0.41	0.56	1.25	0.89	0.23	7.49
<i>H. limbatus</i>	0.30	0.06			0.08				0.08	0.60	0.07	0.12	1.31
<i>Parambassis dayi</i>	0.16	0.74	0.20	0.07	0.05	0.32	0.17	0.23	0.35	0.01	0.13	0.05	2.45
<i>E. maculatus</i>	0.60	0.47	0.83	0.17	0.22	3.89	0.57	0.62	1.04	0.08	0.55	0.51	9.54
<i>E. suratensis</i>													
<i>M. guentheri</i>						0.41					0.06	0.15	0.62
<i>A. lineatus</i>													
<i>A. panchax</i>													
<i>H. fossilis</i>													
<i>Wallago attu</i>													
<i>O. bimaculatus</i>													
<i>O. malabaricus</i>													
<i>M. bleekeri</i>				0.03		0.08			0.02		0.02		0.15
<i>M. oculatus</i>	1.43	0.54	1.10	0.71	0.17	0.30	2.48	0.65	0.69	0.54	0.87	1.41	10.86
<i>H. brachyosoma</i>						0.09							0.09
<i>C. marulius</i>													
<i>C. micropeltus</i>													
<i>D. malabaricus</i>													
<i>M. cupanus</i>		0.01	0.02	0.01	0.02			0.01	0.02		0.02		0.11
<i>G. giuris</i>	0.12	0.23		0.18							0.09		0.62
Total	4.48	6.48	5.98	3.31	4.07	5.57	6.39	3.62	7.30	4.95	6.04	6.25	64.43

DISCUSSION

Despite its larger area, Sasthamkotta lake supports a negligible fishery, which is mainly artisanal. Most of the fishing is for subsistence only. Since no mechanized vessels or modern gears/ crafts are involved, the fishery can be considered as small scale, consisted by a few food fishes only. Of the three types of fishing gears regularly used in the lake, gill net is more efficient with high catch ability in terms of weight and hence this gear is the one which is commonly used among the fishermen.

Generally, premonsoon are more productive with more fish catch by gillnets. The reduction in the water volume and subsequent reduction of the water column may be the reason for easy catch during the pre monsoon using gill nets whereas fish abundance was maximum during the postmonsoon season. The favorable season for cast net fishery was monsoon and for encircling net fishery was postmonsoon. Plankton production becomes considerably higher during the post monsoon and monsoon season. This high plankton availability as food results in high growth rate and also breeding activity, which will result in the higher abundance of fish and subsequent CPUE during the monsoon and post monsoon season (Sareena, 1998). The abundance and availability of food contribute to increase in abundance and CPUE of fish while factors like competition and predation act as limiting factors (Lowe-Mc Connel, 1987; Isaac and Ruffino, 1996).

Variation in the CPUE by different nets may be due to the mesh size and mode of operation. The size of the cast net being smaller and difference in sinking rate due to water depth, their operation is restricted to shallow areas of the lake only. Fast moving species and bottom living species can escape from this net and the comparatively low CPUE can be attributed to this. However, the smaller mesh size and operation by locating shoals result in a more effective fishing by this method. Smaller sized fishes and juveniles of larger fishes may be caught by this net, thereby affecting their stock in the lake. This may be the reason for low CPUE value by this net compared to the other nets. The catch per day value was also less since this net was rarely used in Sasthamkotta lake. Cast nets can well operate in shallow lakes (Sandhya, 2003).

The three types of gillnets in operation are of different mesh size and hence the CPUE by these nets also varied. Smaller mesh nets caught smaller fishes and larger mesh sized nets captured only larger fishes. This resulted in considerable variations in the size composition of the catch also. Hence the gill nets cannot be considered as detrimental to the fish stock in the lake. Similar observations have been made by Rahman *et al.* (1999). Compared to cast net and encircling nets, gill nets collected large sized fishes because of its large mesh size and that might be the reason for the high CPUE value though the abundance was low. The catch per day value was also high because of its constant use by the fishermen than the other two nets. Gillnets are most probably operated only once during night.

The catch per day value by encircling net was lower compared to the other two nets, even though the abundance was high. The smaller mesh size and mode of operation result in the capture of almost all fishes inhabiting the area of its operation. Smaller species and juveniles of larger fishes found in the area are completely fished from the area. Nevertheless it removes all wanted and unwanted species from this area and hence it can be considered detrimental to the fish fauna of the lake (Rahman *et al.*, 1999). Several species are over fished and their stocks are depleted. The smaller length (size) in the first catch also leads to subsequent low production. When smaller fishes are caught in large quantities, it reduces their reproductive potential, which in turn reduces the spawning stock. This also leads to depletion of stock (Isaac and Ruffino, 1996).

Another important aspect that emerged from the study is the drastic reduction of larger species from the lake. According to Bayley (1981) in multi-gear multi-species fishing in lakes larger species become considerably reduced resulting in their depletion or even becoming endangered. Certain larger species like *Horabagrus brachysoma*, *Wallagu attu*, *Channa marulius* and *Channa micropeltus* etc. which were once present in large quantities (according to the survey) were reduced considerably or even absent during the present study. The abundance of *Etroplus suratensis* were also reduced very much in the lake. The depletion in the fish catch lead the fishermen in Sasthamkotta lake to seek other occupation and the number of fishermen engaged in fishing also reduced.

CHAPTER IX
SUSTAINABLE MANAGEMENT
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In the global context water quality, climatic changes, interaction of aquatic environment with terrestrial environment, increased human population, introduction of species etc, are the main factors affecting the biodiversity of fresh water habitats.

Due to the increasing population, living aquatic resources of the world in general and that of India in particular are under constant pressure. One of the major groups of aquatic resources is the fresh water fishes, which contribute significantly to the commercial fisheries. Kerala State being in the tropical belt possess a very rich diversity of fresh water fishes occurring in streams, rivers, lakes, ponds, reservoirs, canals, estuaries etc. Several species of fishes occurring in such water bodies of Kerala are endangered or threatened. Of these several water bodies of Kerala fresh water lakes have received very little attention regarding documentation of their fish fauna. This has created difficulties in proper assessment of the fish fauna and their conservation. Only baseline studies will help in the assessment of the status and abundance of their fish fauna.

The scientific data available about Sasthamkotta lake is of the analysis of water conducted by the Public Health Engineering Department, under whose control the lake is kept up for supply of water to the Kollam Corporation and adjoining Panchayats. Some scientific studies carried out by Thomas *et al.* (1980), Pillai (1981), Nair (1988), Prakasam (1991), Joseph (1994) and CWRDM (2001). Nair and Girija (2003) suggested the significance of a holistic approach to Sasthamkotta lake.

Except the report of Thomas *et al.* (1980), no detailed information regarding the fish fauna of Sasthamkotta lake is available. The available information on the fish fauna of this lake is meager (Thomas *et al.*, (1980), Prakasam (1991)). This paucity of information made comparison or assessment of

the changes that have taken place during recent years to the ecological and fishery aspect almost impossible.

The lake supports fishery of a very negligible magnitude compared to its area. Since the lake is an enclosed water body, the fish fauna of the lake might have been completely isolated for all these years. The lake has a thin film of phytoplankton and zooplankton with a low rate of primary production. The existing low rate of production, in spite of leaching from the hills around, may be due to the complete isolation of the lake, and the very low fertility of the soil and unscientific agricultural practices in the catchment area. This may be the reason for the low fishery potential of the lake. Another reason may be the acidic nature of the lake reducing productivity.

During the present study, a total number of 26 species were obtained from Sasthamkotta lake. Thomas *et al.* (1980) and Prakasam (1991) reported 23 and 27 species respectively. The three species, *Spratelloides malabaricus*, *Amypharingodon melettinus* and *Danio devario* reported by Thomas *et al.* and *Tetradon cutcutla*, *Anguilla bicolor*, *Moringu raitaborua* and two species of prawns reported by Prakasam (1991) were not observed in the present study. Another six species were newly reported in the present study. They are *Dayella malabaricus*, *Puntius amphibius*, *Puntius dorsalis*, *Puntius vittatus*, *Puntius ticto* and *Ompok malabaricus*. Regarding the Shannon-Wiener indices of the entire lake of Sasthamkotta, species diversity and Evenness was high during the post monsoon season. Species dominance was highest during monsoon and species richness during pre monsoon period.

The present fishing operation in Sasthamkotta lake consists mainly of gill nets of different mesh sizes. During the present study, a serious decline in the fishery especially *Horabagrua brachysoma*, *Channa sp.* and *Heteropnusteus fossilis* were reported. *Horabagrua brachysoma*, once found in abundance was not a common fish now. *Etroplus suratensis* was also found in decreased number. Overfishing in the lake by local inhabitants and low productivity might have resulted in the reduction in fishery potential. The coliform count of the lake has become unlimited exceeding the prescribed ISI limits may also be one of the

reasons for the reduction of the fish. To replenish this fish scarcity and to conserve this biodiversity, fresh water fishery can be intensified by introducing native species which can be acclimatized to the lake. Care should be taken to maintain and monitor water quality parameters.

The catch per unit effort and the catch per day have shown that the fishery potential of the lake is negligible when compared to the area of the lake. The catch per unit effort and catch per day was high for gill net fishery and pre monsoon season was most suitable. The catch per unit effort for encircling net was higher than cast net but the catch per day was high for cast net due to the maximum number of operation. Monsoon was the suitable season for cast net fishery whereas post monsoon was the favorable season for encircling net fishery.

Abundance and diversity of biotic communities are influenced by various physicochemical parameters. The potentialities of an aquatic ecosystem are influenced by nutrient dynamics, productivity, standing stock and energy transfer. The physicochemical parameters are interdependent and they vary with seasons. Rainfall was highest during the monsoon season in the study period. Water temperature was always positively correlated with atmospheric temperature and negatively related with rainfall. Annual mean showed that water of Sasthamkotta lake was acidic except station I, near the Vallakadavu which may be due to the indiscriminate use of soaps and detergents. Comparatively low conductivity and turbidity and high transparency values were observed. Dissolved oxygen was high at all stations especially during post monsoon and monsoon seasons. Carbon dioxide content registered an apparent increasing trend from pre monsoon to monsoon at all the stations. At all stations alkalinity showed a decreasing trend from monsoon to pre monsoon. Salinity values registered highest values at station IV, near the filter house which is due to the discharge of waste water with excess chlorine after purification from the filter house. Hardness of the lake was within the prescribed limit of BIS (1991). Biological oxygen demand and chemical oxygen demand was highest during pre monsoon. Total suspended solids and total organic carbon was highest during pre monsoon and showed a positive correlation with conductivity.

High level of potassium content correlated with the rainfall at all the stations is due to leaching and siltation. Irrespective of the seasons station I is the site having high phosphate concentration due to the indiscriminate use of soaps and detergents. Nitrite and nitrate concentration was high in the present study especially at station III near the concrete bund. These are due to the unscientific agricultural practices and hence discharge of fertilizers and pesticides from the nearby rubber and other plantations. As the lake water is a drinking water source, it should be free from microbes. All the stations under study were polluted with total coliforms, faecal coliforms, *Escherichia coli* and faecal streptococci. The results showed that the number of these bacteria is far beyond the prescribed limits of Indian standards, usable not for drinking but for bathing also. Station I is the highly polluted site for all these four types of microbes. The count was highest during the monsoon and post monsoon seasons.

Texture analysis of the sediment showed the silty clay nature with high percentage of clay. Nitrogen content was high in the bund region, Station III for sediment analysis also. The sediment is acidic in nature with an increase in electrical conductivity associated with seasonal rain. Low organic content and potassium in the lake sediment observed is due to the heavy sand deposition and diminished organic detritus.

Gross primary productivity exhibited a low rate at this lake. Comparatively high values were during the post monsoon season might be due to the addition of nutrients through surface run off from catchment. Chlorophyll 'a' which is an indicator of phytoplankton abundance was highest during post monsoon and observed a direct relationship with silicate. Potassium exhibited an inverse relationship with chlorophyll 'a' which limits the plankton growth.

Planktonic studies in the lake showed an inversion of chlorophyceae to Bacillariophyceae in the abundance and dominance. In the previous studies, Chlorophyceae dominated in the lake water which is an indication of the good quality of water. During the present study, Bacillariophyceae dominated in number and species. *Navicula* sp. and *Nitzschia* sp. are tolerant in polluted water and are indicators of pollution. *Cocconeis* sp., *Fragilaria* sp., *Melosira* sp., *Nitzschia* sp.,

Navicula sp. and *Synedra* species were more abundant among the Bacillariophyceae in the lake. Presence of high number of Bacillariophyceae and reduction of Chlorophyceae may be considered as an indicator of increased water pollution of the lake. This can be well predicted due of the presence of macrophytes in the lake at certain pockets which were absent in sasthankotta before. Nutrient concentration and phytoplankton abundance was high in the Station III near the bund region. Here macrophytes are seen in abundance also. Urgent management options in this direction are warranted.

PROBLEMS THE LAKE FACES

Sasthankotta lake is the largest fresh water lake of Kerala, is one among the nineteen wetlands identified for intensive conservation and management by the Ministry of Environment and Forests under the national wetland programme. This wetland was declared as Ramsar site since 2002. This wetland has several values and attributes. This is the main source of drinking water to the lakhs of people at Kollam District, pondage for ground water recharge, receptacle for flood waters, sink for flood waters, sink for pollutants and an ideal habitat for fresh water flora and fauna. This wetland system is subjected to considerable pressure, especially due to disturbances in the catchment. The changes in land use and subsequent soil erosion have been a threat to this wetland ecosystem. The catchment area, is thickly populated; hence domestic or community waste water is indiscriminately discharged into the lake. Several house holds near the lake do not have proper sanitation facilities; local inhabitants in the catchment bathe and wash clothes and domestic animals in the lake using soaps and detergents. Human faeces in the catchment area make the water highly unfit for human use. The coliform count of the lake is exceeding the ISI limits making the water unfit for drinking and bathing. Part of the agrochemicals used in the catchment also finds their way into the lake. Because of the unscientific land use pattern in the catchment, sediment load entering into the lake has considerably increased, causing a reduction in the capacity of the water body. Macrophytes began to appear in certain pockets of the lake. All such activities, if continued without a check, would lead to the eutrophication of the lake.

Being a major source of protected water supply, the condition of the lake has reached a critical stage from the ecological point of view and if proper conservation measures are not taken, the lake is likely to deteriorate further.

CONSERVATION STRATEGIES

There is an urgent need to adopt long term conservation measures based on plans with sound ecological approach. Considering the above problems facing the wetland some mitigation measures are suggested.

1. Reduction in the lake volume is a major threat which may mostly be due to reclamation activity and siltation. Siltation diminishes the quantum of water flow; destruct the breeding grounds of fishes, habitat destruction of the fishes affect the benthic population and overall productivity of the lake. Afforestation in the catchment with indigenous species will help to prevent sedimentation of the lake. Quarrying in the catchment area is to be banned by law.
2. Resurvey of the lake should be conducted and strong measures should be taken to arrest further encroachment. At least an area of 200 meter from the boundary of the lake should be declared as the 'land regulation zone' and all human interference should be prohibited by suitable management programmes. Terracing on slopes to reduce erosion and reforestation of the 'LRZ' to check seepage should be practiced.
3. As there is no well planned drainage system in the watershed, wastewater from households, streets, market and other public places in the lake catchment are let out indiscriminately on to land which would ultimately reach the lake contaminating it. Providing facilities for recycling of domestic and other waste water and biodegradable solid wastes as fertilizers for plants could be considered.
4. Several inhabitants do not have sanitation facilities which are the main reason for the increased coliform count in the lake. Scientific sanitation facilities with reduction of the waste water flow to the lake should be

practiced at the catchments as well as by the pilgrims to the Sasthamkotta Temple.

5. Make alternate sources for bathing, washing clothes and cattle.
6. The waste water after purification process from the filter house is being continuously discharging into the same lake and to prevent this separate earth tanks are to be built for discharging and processing this waste water before it is discharged into the lake.
7. Regular and proper monthly monitoring of the water quality of the lake is to be implemented.
8. Tourism in the name of 'Ecotourism' is not at all suggested in this lake.
9. Awareness should be created among the students of the nearby schools and other educational institutions, farmers and the public in the catchment area about this valuable water source, ecological implications of the indiscriminate activities which adversely affect the lake ecosystem.
10. Creating awareness through interaction programmes and mass communication media. Functional literacy on the lake conservation should be introduced in a regional manner highlighting the importance of the lake with special reference to the significance as a drinking water source
11. Display Boards' are to be placed along the catchment area of the lake with attractive captions indicating the importance of the lake and 'DON'TS and DOS' in the lake.
12. Conservation of the flora and fauna of the lake.
13. Changes in the productivity and plankton should be monitored to maintain adequate measure for the maintenance of the lake more productive which in turn replenishes the water quality of the lake along with fishery potential.
14. A scientific monitoring unit should be constituted for the effective management of the lake water quality. A wet land management

committee would be formed with representatives of self help groups, Kollam Corporation, adjoining panchayats, NGOs, concerned government organizations and participating institutions.

15. Point source of the pollution should be identified and mitigation measures should be implemented at the same place itself.

In all attempts, we should exercise control on catchment activities which tend to increase pollution and degrade the ecosystem. Judicious utilization of the natural resource is to be planned.

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* Original not seen

APPENDIX

ജലപരിസ്ഥിതി

എസ്. ഗിരിജാകുമാരി



Assessment of faecal indicating bacteria of Sasthamkotta lake

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ABSTRACT

Sasthamkotta lake is the largest fresh water lake in Kerala and is the main drinking water source to lakhs of people in Kollam District and was included in Ramsar site in August 2002. The present study revealed that all the selected five stations were contaminated with faecal indicating bacteria such as total coliforms, faecal coliforms, *Escherichia coli* and faecal streptococci and Vallakadavu is the most highly polluted site.

Introduction

Ground water is one of the predominant sources of drinking and other water related requirements. Ground water has been the most exploited natural system due to the ever increasing demand of man for food, cloth, industrialization, enormous growth in population and agriculture. Quality changes in ground water due to pollution, large scale overdrafts on the reserves and indiscriminate disposal of industrial, human and agricultural wastes pose a great threat to the usefulness of the ground water. Lake pollution is a serious water pollution problem, which needs concern as it is known that a lake is less self assimilating than a flowing river. Also the stagnant water of the lake can only undergo aerobic purification which is a slow process.

Sasthamkotta lake is the largest freshwater lake in Kerala located between 9 00' - 9 05' N latitude and 75 35' - 76 40' E longitude. The lake has an area of 375 km having an average depth of 6.7m with a maximum of 13.9m (Anon, 1983). The major source of water in the lake are seasonal rains. (Thomas *et al.*, 1980). There is no inlet or outlet for the lake. The contour of the lake is irregular with an inverted

'F' shape which extends into the lake as pockets at several places (Prakasam, 1991). The lake is encircled by hills of laterite on all sides except for a small portion on the south eastern region where a raised bund extending for about 1.5km marks its boundary.

The need for protection of the lake started since 1980 and now also continuing. The lake which is the main drinking water source to lakhs of people in the Kollam district is now considered as a threatened ecosystem. This freshwater lake is included in the Ramsar site due to the endemism of the lake and other fragile characteristics of the ecosystem in Nov. 2002. The overall impact of anthropogenic activities in the lake has resulted in the deterioration of the water quality. Therefore the present study was carried out to assess the faecal indicating bacteria in this lake and suggested some measures to protect the drinking water source.

Materials and Methods

Water samples were collected from five different stations in Sasthamkotta lake during November 2004 to October 2005. The sites selected are Vallakadavu (site 1), Bharanikkavu (site 2), Near Concrete Bund

(site 3), Manakara (near filter house, site 4), Rajagiri (site 5) (Fig. 1). Samples were analysed seasonally (APHA, 1995). Samples were collected in sterilized bottles and brought to the laboratory in ice boxes and examined within 4h after collection. The analysis were mostly confined to the essential characteristics of drinking water, as specified by BIS (1991). Microbiology analysis was carried out following Mickie and Mc Cartney (1996).

Results

The study showed that irrespective of the location, water of Sasthamkotta lake is contaminated with total coliforms, faecal coliforms *Escherichia coli* and faecal streptococci. The datas on monthly collection of total coliforms, faecal coliforms, *Escherichia coli* and faecal streptococci are given in tables 1-4.

Maximum number of total coliforms were noted in the post monsoon period. The highest MPN values were 2500 in the station II and the lowest in the station IV (240 MPN/100ml) (Table 5). In the monsoon the maximum number of total coliforms were in the station I (1400MPN/100ml) and minimum in the station II (300MPN/100ml). In the pre monsoon the highest number of total coliforms were

observed in the station I (1200MPN/100ml) and lowest in station IV (320MPN/100ml). Station I and III showed high faecal contamination in the pre monsoon, monsoon and post monsoon seasons and IVth station shows the lowest number of total coliforms throughout the year.

Table 6 gives the comparison of average number of faecal coliforms at different stations in different seasons. Highest number of faecal coliforms (1400 MPN/100ml) was noted in the station I at monsoon and lowest number (40 MPN/100ml) in station IV in the post monsoon period. Station I has the maximum number of faecal coliforms in all the seasons and is highly polluted, 750MPN/100ml in pre monsoon and 1300MPN/100ml in post monsoon periods.

Maximum number of *Escherichia coli* (900 MPN/100ml) was noted in the station I at monsoon and the lowest number (8 MPN/100ml) in the station V at pre monsoon and IV at monsoon season (table 7). In the post monsoon the lowest number was 27MPN/100ml in station IV. The highest number of *E.coli* in pre monsoon and post monsoon are 160 and 240 MPN/100ml respectively.

Table 8 gives comparison of the average number of faecal streptococci at

Table 1. Showing the monthly count (MPN/100ml) of Total coliforms at different stations

Month	Station I	Station II	Station III	Station IV	Station V
November 2004	1235	831	1203	323	456
December	1197	815	1239	323	456
January 2005	1191	792	1196	319	439
February	1171	764	1163	316	450
March	1410	303	1122	511	912
April	1482	324	1148	532	907
May	1389	296	1033	480	882
June	1319	277	1097	478	898
July	1746	2509	1327	254	498
August	1747	2509	1323	245	520
September	1657	2496	1274	224	493
October 2005	1652	2488	1274	237	488

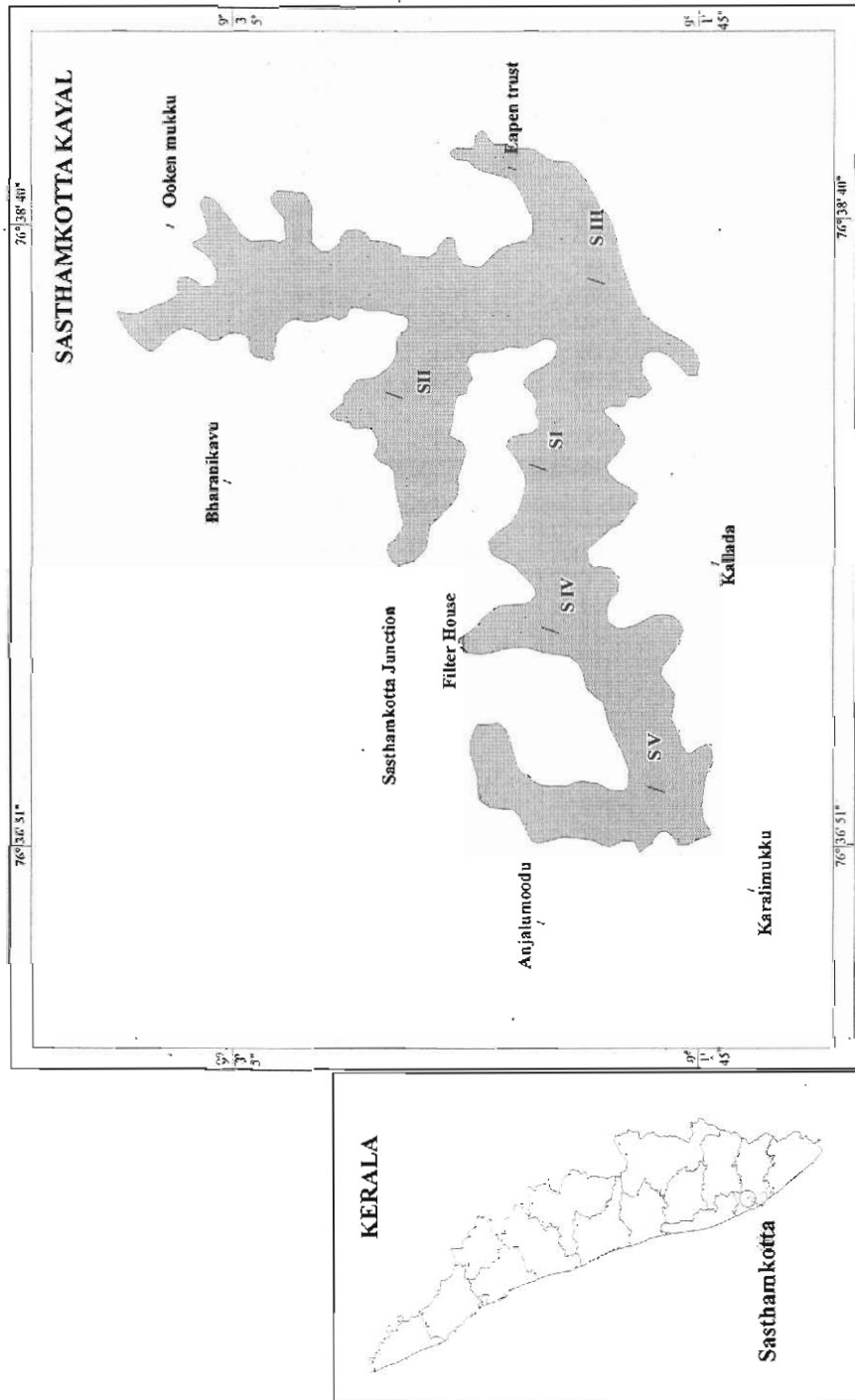


Fig. 1 Showing the study area and sampling site

Table 2. Showing the monthly count(MPN/100ml)of Faecal coliforms at different stations

Month	Station I	Station II	Station III	StationIV	Station V
November2004	768	405	204	50	150
December	810	403	210	50	161
January 2005	722	397	202	50	148
February	699	393	186	49	141
March	1425	170	258	64	287
April	1491	175	240	60	292
May	1383	166	234	57	274
June	1302	168	227	60	267
July	1332	1221	302	40	159
August	1339	1233	304	40	160
September	1244	1137	301	39	158
October 2005	1283	1211	295	40	154

Table 3. Showing the monthly count(MPN/100ml)of *Escherichia coli* at different stations

Month	Station I	Station II	Station III	StationIV	Station V
November2004	133	167	49	17	08
December	131	161	49	16	09
January 2005	127	156	48	16	08
February	128	155	48	15	08
March	954	23	50	08	173
April	903	22	50	08	180
May	873	24	49	08	168
June	869	22	50	07	159
July	247	145	144	27	34
August	243	140	144	27	34
September	238	138	135	26	32
October 2005	231	137	136	27	32

Table 4. Showing the monthly count(MPN/100ml)of Faecal streptococci at different stations

Month	Station I	Station II	Station III	StationIV	Station V
November2004	50	67	64	01	02
December	49	68	63	02	01
January 2005	48	65	58	01	02
February	50	66	57	02	01
March	74	11	72	01	01
April	72	12	71	02	02
May	67	11	69	02	02
June	67	11	66	02	01
July	82	114	147	01	04
August	83	144	141	02	03
September	77	139	134	02	03
October 2005	80	135	140	02	04

Table 5. Comparison of average number of Total Coliforms at different stations in different season

Season	Station	Mean	SD	F	p
Pre Monsoon	I	1200.0	24.8	1339.46	p<0.01
	II	800.5	29.1		
	III	1200.3	31.2		
	IV	320.3	3.4		
	V	450.3	8.0		
Monsoon	I	1400.0	67.1	485.34	p<0.01
	II	300.0	19.4		
	III	1100.0	49.3		
	IV	500.3	26.0		
	V	899.8	13.2		
Post Monsoon	I	1700.5	53.2	4025.83	p<0.01
	II	2500.5	10.3		
	III	1299.5	29.5		
	IV	240.0	12.7		
	V	499.8	14.1		

Table 6. Comparison of average number of Faecal coliforms at different stations in different season

Season	Station	Mean	SD	F	p
Pre Monsoon	I	749.8	49.4	580.78	p<0.01
	II	399.5	5.5		
	III	200.5	10.2		
	IV	49.8	0.5		
	V	150.0	8.3		
Monsoon	I	1400.3	79.2	912.75	p<0.01
	II	169.8	3.9		
	III	239.8	13.3		
	IV	60.3	2.9		
	V	280.0	11.5		
Post Monsoon	I	1299.5	44.6	1865.03	p<0.01
	II	1200.5	43.3		
	III	300.5	3.9		
	IV	39.8	0.5		
	V	157.8	2.6		

P<0.01 means variation at 1% level of significance.

Table 7. Comparison of average number of *Escherichia coli* at different stations in different season

Season	Station	Mean	SD	F	p
Pre Monsoon	I	129.8	2.8	2403.38	p<0.01
	II	159.8	5.5		
	III	48.5	0.6		
	IV	16.0	0.8		
	V	8.3	0.5		
Monsoon	I	899.8	39.2	1783.44	p<0.01
	II	22.8	1.0		
	III	49.8	0.5		
	IV	7.8	0.5		
	V	170.0	8.8		
Post Monsoon	I	239.8	6.9	1818.5	p<0.01
	II	140.0	3.6		
	III	139.8	4.9		
	IV	26.8	0.5		
	V	33.0	1.2		

Table 8. Comparison of average number of Faecal Streptococci at different stations in different season

Season	Station	Mean	SD	F	p
Pre Monsoon	I	49.3	1.0	1311.16	p<0.01
	II	66.5	1.3		
	III	60.5	3.5		
	IV	1.5	0.6		
	V	1.5	0.6		
Monsoon	I	70.0	3.6	1248.52	p<0.01
	II	11.3	0.5		
	III	69.5	2.6		
	IV	1.8	0.5		
	V	1.5	0.6		
Post Monsoon	I	80.5	2.6	1891.16	p<0.01
	II	139.8	3.8		
	III	140.5	5.3		
	IV	1.8	0.5		
	V	3.5	0.6		

P<0.01 means variation at 1% level of significance.

different stations in different season. Here highest number of faecal streptococci were noted in station III (141 MPN/100ml) at post monsoon season and lowest number noted is 2 MPN/100ml in station IV and V at all seasons. In the monsoon the highest number of faecal streptococci was 70MPN/100ml in station I and III. But in pre monsoon, the highest number was in station II(67MPN/100ml).

Discussion

The annual value of total coliforms ranged from 224 to 2504. Prakasam (1991) reported alarming number of total and faecal coliforms in this lake. The present study also agrees with this earlier work but the number of coliforms had increased. Contamination of water with coliforms makes water unsatisfactory for drinking (Powar *et al.*, 1988). Faecal coliforms by themselves are not disease causing although some strains are known to cause diarrhoea (SEU, 1991). Welch *et al.*, (2000) reported microbial contamination of both treated and untreated water in rural Trinidad revealing thereby that such contaminated drinking water was grossly unfit for human consumption.

Present study showed that Vallakadavu region of the Sasthamkotta lake is the highly contaminated site for total coliforms, faecal coliforms *Escherichia coli* and faecal streptococci due to human activities like bathing and washing. Bathing of cattle is usual there. Similar findings were also recorded by Joseph (1995) and human excreta were the main source of faecal pollution there. Station IV near the filter house is the least polluted site for all the faecal indicating bacteria. The filter house area is a protected area by the government of Kerala and hence anthropogenic intervention is low. Another reason is the increased chlorine content in the water. This is caused by the water reaching the lake after water treatment and this contains excessive chlorine. Royee

et al., (2003) reported that higher residual chlorine reduces the number of faecal coliforms.

The present observation showed that faecal pollution was highest during monsoon and post monsoon periods in Sasthamkotta lake. Lowest population of all bacteria was recorded in the pre monsoon months. Nair (1988) revealed that during rainy season large quantities of faecal matter were drained into the lake. This is the reason for the increased bacterial count during monsoon and post monsoon months in Sasthamkotta lake. Prajapathi and Mathur (2002) also noted that contamination of drinking water sources were highest in rainy season compared with summer season. Similar findings were also reported by Damodaran *et al.* (2005), Abhay Kumar (1990), Lakshmanaperumalasamy *et al.* (1981). Ward *et al.* (1985) noticed that during rainy season the coliform count was very high in ground water. Pillai (1981) found alarmingly high faecal coliform count during rainy season. This high increase in coliform count in Sasthamkotta lake is due to the seepage of water since the lake is surrounded by small slopy hills which hasten the flow of fertilizers, sewage and other faecal matter into the catchment area of the lake along with soil during rainy season. The domestic sewage from the thickly populated belt around the lake contributes the drainage of impurities to the lake. Another study by Prajapathi and Mathur (2002) also noted that contamination of drinking water sources were highest in rainy season compared with summer season. The acceptable limit of MPN/100ml prescribed for drinking purpose by Indian standard Limit is < 10 total coliforms per 100ml and 0 for faecal coliforms. For bathing the acceptable limit is 500 MPN/100ml for total coliforms and 100MPN/100ml for faecal coliforms (Singh *et al.*, 1995). The sample values observed in the present study in Sasthamkotta lake water exceeded the prescribed limit.

Conclusion

Significance of a holistic approach to Sasthamkotta lake was suggested by Sreekantan Nair *et al* (2003). Immediate steps are to be taken for protecting this fresh water lake through constant monitoring of water quality and co-ordinated planning both at local and national level. Indiscriminate use of this water source should be prevented. Open defecation should not be allowed and for this separate latrine should be provided for the local and awareness among them should be created. Better sanitation of the total environment is imperative for maintaining the ground water clean. Suitable strategies are to be developed to maintain the ecological balance of the system.

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BACTERIAL INDICATORS OF FAECAL POLLUTION AT SASTHAMKOTTA LAKE

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ABSTRACT

Bacteriological study of the Sasthamkotta Lake was conducted from November 2004 to October 2005 covering a total hydrological cycle with premonsoon, monsoon and post monsoon seasons. Monthly collection of water samples was taken from five different sites in the lake after Stratified Random Sampling. The bacterial load was compared with the permissible limits of Indian Standards and faecal index was calculated.

Keywords : Bacterial indicator, Sasthamkotta Lake, Faecal Index

INTRODUCTION

Wetlands have assumed significance due to their ability in supplementing human dietary requirements and various other ecological significances. The 'inland wetlands' covers an area of 34199.57ha in Kerala as per the Indian Remote Sensing Satellite data. Lakes are important aquatic ecosystems of Kerala aesthetically as well as ecologically sensitive. The lentic fresh water bodies are gaining momentum since they are used for various anthropogenic purposes. Lake pollution is a serious water pollution problem, which needs concern, as it is known that a lake is less self-assimilating than a flowing river. Also the stagnant water of the lake can only undergo aerobic purification, which is a slow process.

Sasthamkotta lake is the largest freshwater lake in Kerala located between

9 00' - 9 05' N latitude and 75 35' -76 40' E longitude. The lake has an area of 375 km having an average depth of 6.7m with a maximum of 13.9m. The major sources of water in the lake are seasonal rains. (Thomas *et al*, 1980). There is no inlet or outlet for the lake. The contour of the lake is irregular with an inverted 'F' shape, which extends into the lake as pockets at several places (Prakasam, 1991). The lake is encircled by hills of laterite on all sides except for a small portion on the southeastern region where a raised bund extending for about 1.5km marks its boundary.

The need for protection of the lake started since 1980 and now also continuing. The lake is the main drinking water source of lakhs of people in the Kollam district of Kerala is now considered as a threatened ecosystem. This freshwater lake is included

in the Ramsar site due to the endemism of the lake and other fragile characteristics of the ecosystem in November 2002. The overall impact of anthropogenic activities in the lake has resulted in the deterioration of the water quality. Sasthamkotta Lake is included in the MoEF list of 16 wetlands needing special conservation measures. The present study was carried out to assess the faecal indicating bacteria in this lake and suggested some measures to protect the drinking water source.

Bharanikkav (site 2), Near Concrete Bund (site 3), Manakara (near filter house, site 4), Rajagiri (site 5) (Fig.1). Samples were analysed seasonally (APHA, 1995). Samples were collected in sterilized bottles and brought to the laboratory in iceboxes and examined within 4h after collection. The analyses were mostly confined to the essential characteristics of drinking water, as specified by BIS (1991). Microbiology analysis was carried out following Mickie and Mc Cartney (1996).

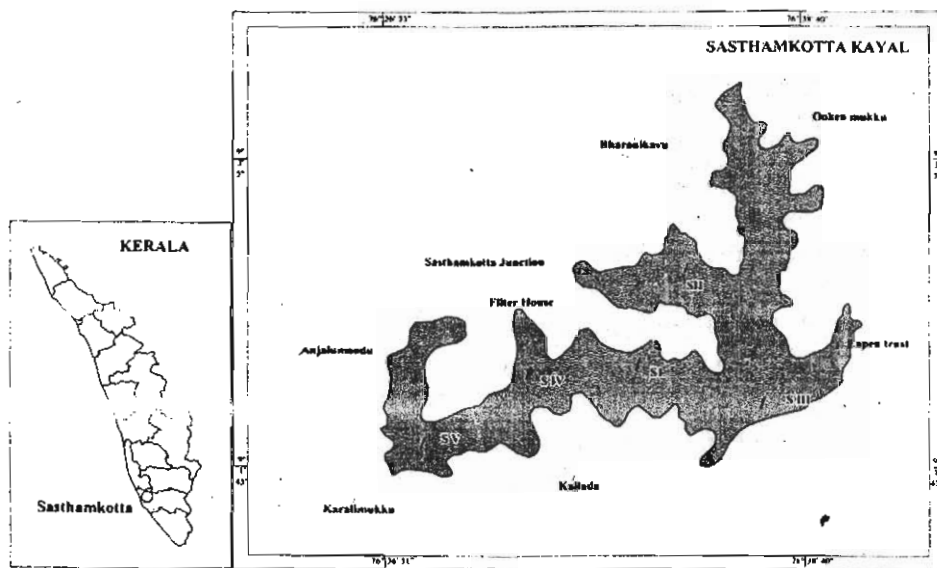


Fig. 1 Study area and sampling sites

MATERIALS AND METHODS

Water samples were collected from five different stations in Sasthamkotta Lake during November 2004 to October 2005. The sites selected are Vallakadavu (site 1),

Faecal Index

Ratio between faecal coliforms (FC) and faecal streptococci (FS) provide the faecal index. (Geldreich, 1974). An index greater than 4 indicates pollution of human

Faecal Pollution of Sasthamkotta Lake

origin while a value less than 0.6 indicates faecal pollution of animal origin. A ratio between 0.6 and 4 indicates mixed^r faecal pollution.

RESULTS

The seasonal variation in the MPN number of the faecal coliforms and faecal streptococci were studied during a period of one year commencing from November 2004

to October 2005. The monthly data are depicted in tables I and II. The mean values of faecal coliforms range from 50 MPN / 100ml to 1150 MPN /100ml (Table III). Highest number of FC were observed in the Vallakkdavu (Station I), 1400 MPN /100ml at monsoon and lowest number at filter house area (Station IV), 40MPN/100ml during premonsoon, monsoon and post monsoon

Table 1 : Monthly count (MPN / 100 ml) of faecal coliforms at different stations

Month	Station I	Station II	Station III	Station IV	Station V
November	768	405	204	50	150
December	810	403	210	50	161
January	722	397	202	50	148
February	699	393	186	49	141
March	1425	170	258	64	287
April	1491	175	240	60	292
May	1383	166	234	57	274
June	1302	168	227	60	267
July	1332	1221	302	40	159
August	1339	1233	304	40	160
September	1244	1137	301	39	158
October	1283	1211	295	40	154

Table 2 : Monthly count (MPN / 100 ml) of faecal streptococci at different stations

Month	Station I	Station II	Station III	Station IV	Station V
November	83	144	141	02	03
December	77	139	134	02	03
January	80	135	140	02	04
February	50	67	64	01	02
March	49	68	63	02	01
April	48	65	58	01	02
May	50	66	57	02	01
June	74	11	72	01	01
July	72	12	71	02	02
August	67	11	69	02	02
September	67	11	66	02	01
October	82	141	147	01	04

season. Vallakkdavu site has the highest count of faecal coliforms at all seasons and is highly polluted; 750 MPN /100ml during premonsoon and 1300 MPN /100ml during post monsoon season.

average number of faecal streptococci at different stations in different seasons. During the post monsoon period a maximum count of FS was noted in the bund area (Station III) 141 MPN /100ml and the minimum number noted was in station IV and V (2

Table IV shows comparison of the

Table 3 : Comparison of average number of faecal coliforms at different stations in different seasons

Season	Station	Mean	SD	F	P
Pre monsoon	I	749.8	49.4	580.78	p<0.01
	II	399.5	5.5		
	III	200.5	10.2		
	IV	49.8	0.5		
	V	150.0	8.3		
Monsoon	I	1400.3	79.2	912.75	p<0.01
	II	16.8	3.9		
	III	239.8	13.3		
	IV	60.3	2.9		
	V	280.0	11.5		
Post monsoon	I	1299.5	44.6	1865.03	p<0.01
	II	1200.5	43.3		
	III	300.5	3.9		
	IV	39.8	0.5		
	V	157.8	2.6		

Table 4 : Comparison of average number of faecal streptococci at different stations in different seasons

Season	Station	Mean	SD	F	P
Pre monsoon	I	49.3	1.0	1311.16	p<0.01
	II	66.5	1.3		
	III	60.5	3.5		
	IV	1.5	0.6		
	V	1.5	0.6		
Monsoon	I	70.0	3.6	1248.52	p<0.01
	II	11.3	0.5		
	III	69.5	2.6		
	IV	1.8	0.5		
	V	1.5	0.6		
Post monsoon	I	80.5	2.6	1891.16	p<0.01
	II	139.8	3.8		
	III	10.5	5.3		
	IV	1.8	0.5		
	V	3.5	0.6		

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MPN /100ml) during all seasons of the year. The highest FS count during monsoon was in Vallakkdavu site (70 MPN /100ml) and during premonsoon was in station III (70 MPN /100ml).

DISCUSSION

The present study showed that the five stations at Sasthamkotta lake under study were polluted with FC and FS. The highest number of FC and FS were noted in the

Table 5 : Faecal index of water at Sasthamkotta Lake at different seasons in different seasons

Season	Station	Faecal index
Pre-monsoon	I	1.5
	II	6
	III	3.3
	IV	33.2
	V	100
Monsoon	I	20
	II	15
	III	3.4
	IV	33.5
	V	186.6
Post- monsoon	I	16
	II	8.5
	III	2
	IV	22
	V	45

The faecal indices at the five stations were calculated (Table.5). The data showed that site I, II, III, IV and V indicated pollution of human origin whereas the site III (near the concrete bund) is polluted in mixed way by both human and animal origin. (FS were <2 in the IV and V site and FC count was high and hence a high faecal index). The mixed type of contamination in the bund area was due to the agricultural run off from the nearby plantations.

monsoon followed by post monsoon seasons and lowest number of bacteria were reported during premonsoon periods. It is revealed that during rainy season large quantities of faecal matter were drained into this lake. Pillai (1981) found alarmingly high faecal coliform during rainy season in S.Lake. Similar findings were reported by Lekshmanaperumalasangam *et al* (1981) in Vembanadad lake, Damodaran and Suresh (2005) in Tirupati town ground water, Royce

and Prakasam (2002), Prajapathi and Mathur (2002) also noted that contamination of drinking water source was highest in rainy season compared with summer season. The high count is due to the flow of domestic and other sewage, human and cattle excreta, agricultural and other pollutants.

Vallakkdavu region of Sasthamkotta Lake is the highly contaminated site due to human activities like bathing and washing of human and cattle. Similar findings were reported by in this lake by Joseph (1994).

The acceptable limit of MPN/100 ml prescribed for drinking purpose by Indian standard Limit is, 10 total coliforms per 100ml and 0 for faecal coliforms. For bathing the acceptable limit are 500 MPN/100 ml for total coliforms and 100 MPN/100 ml for faecal coliforms. (Singh and Singh, 1995). The sample values observed in the present study in S.Lake water exceeded the prescribed limit, which infers to the need for

a comprehensive drainage management of the catchment area.

Faecal coliforms originate from non-faecal sources also such as plants and soils (Geldreich, 1974). Faecal streptococci are considered as supplementary evidence of faecal pollution. They are better indicators than faecal coliforms because FS neither multiply nor found in water or virgin soils (Venkateswaran and Natarajan, 1987). Site I, II, III, IV and V has a faecal index higher than 4 in all seasons which indicate pollution of human origin. Similar data were reported by Vaidya et al (2001) in Bhavnagar coast. This showed that the lake water of Sasthamkotta was polluted as a result of anthropogenic interferences directly and indirectly. The faecal coliform count shows high pressure by man to this natural lake which is used as a source of drinking water for Kollam District. Better management of this lake is recommended to avoid colic disorders to lakhs of people who depend on this lake alone as their drinking water source.

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SIGNIFICANCE OF A HOLISTIC APPROACH TO SASTHAMKOTTA LAKE - AN OVERVIEW

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ABSTRACT

Sasthamkotta, the largest freshwater lake, the main drinking water source to Kollam district is now considered as a threatened ecosystem by its inclusion in the Ramsar site since 1989. On an overall view of the environmental attributes related to the ecosystem, it is seen that the excessive erosion, agrochemical run off from the rubber plantations & paddy fields, floating of Acacia pollens on the lake water surface, domestic sewage from the thickly populated belt around the lake etc cause serious threat to the ecosystem. The paper deals the general observations that emphasises the need to have a holistic approach in analysing the environmental characteristics of the ecosystem towards developing suitable strategies to conserve this wetland.

1. Introduction

The Sasthamkotta Lake is the largest freshwater lake in Kerala located between 9°00'-9°05'N latitude and 75°35'-76°40'E longitude. The lake has an area of 3.75 km² having an average depth of 6.7m with a maximum of 13.9m. The water spread area for three distinct time periods—post monsoon, dry and monsoon shows 3.82, 3.35 and 3.85 sq.km respectively. The lake has a capacity to hold 22390 million litres of water and serves as the source of drinking water for half a million people of Kollam district. But it is estimated that from the catchment area 27397 million litres of water flow into the lake every year². This wetland has several values and attributes, as it is a source for drinking water in the Kollam town and adjoining panchayaths; pondage for ground water recharge, receptacle for flood waters, also serves as sink for pollutants and ideal habitat for flora and fauna.

The need for protecting and conserving the ecosystem was realised by the local population, Central and state Governments etc. Accordingly, the Sasthamkotta Lake was declared as a Ramsar site in 1989. Though detailed investigation on the ecology of some important south Indian lakes are carried out, a holistic study on the ecology of Sasthamkotta Lake is still lacking (Prakasam 1991). Many scientists from CWRDM, CED, and CESS etc have studied

on the environmental attributes of Sasthamkotta Lake but these are confined to specific components in detail. Suitable and effective strategies can be developed for the conservation of the lake, if only a holistic approach is taken to study the ecology of Sasthamkotta Lake taking into consideration all the environmental attributes including flora and fauna. Hence a preliminary survey was conducted both physically and through available literature.

2. Results and Discussion

The region has a warm humid climate. Since Sasthamkotta Lake is nearby Kallada River and Ashtamudi kayal, these exert significant influence on the climate of the area. Forest cover, which existed in early forties have almost disappeared and presently cash crops are being grown in the hilly region causing changes in the hydrological cycle of the area. A little of the forest cover still remains undisturbed only within the surroundings of the sacred temple. Acacia plantation spans most of the lake surroundings. These may cause serious environmental problems due to less biodegradation of leaves as compared to indigenous species. The pollens of Acacia are commonly seen floating on the lake water surface.

Major crops are paddy in the west Kallada and rubber occupies a major area in the elevated regions of

Sasthamkotta. A declining trend in paddy cultivation is mainly observed. The paddy fields that may serve as temporary reservoir of water during the monsoon seasons, recharging the ground water sources also act as basin for the deposition of silt washed down from west Kallada.

As the catchments of Sasthamkotta Lake is in the process of laterisation, the inhabitants of the area are engaged in the occupation of laterite brick quarrying as a result of which pits are formed in various places within the catchment area (STEC Report). Several tree species can be seen uprooted due to these practices. Coconut leaves are dipped in to the lake water for curing to use for thatching. As a result, oxygen depletion in the lake water by letting in free carbon dioxide may occur. Before conveying drinking water to Kollam, the lake water is subjected to a chemical treatment for purification and the residue after pumping out the clean water is let back into the lake.

Sheet erosion, i.e. peeling away the surface soil and depositing in the lake is the main type of erosion in the watershed area (Deepa 1997). In many of the places, the 'A' Horizon is seen in the deep portion of the corrugated terrains. The erosion agent is mainly precipitation. The livestock is allowed to loiter in the area especially during the sprouting season of grasses.

3. Conclusion

Pollens of Acacia, common scenery as seen floating on the lake water surfaces may cause serious environmental problems. The rubber plantation now occupying a major area of the wetland demands huge quantity of fertilizers and this may result in the accumulation of a large quantity of organic and inorganic nutrients in the lake water thereby deteriorating the water quality. Sheet erosion is a major threat to the area. The overgrazing causes heavy

consolidation of soil resulting in retarded infiltration and permeability. The excessive soil erosion has not only reduced the reservoir capacity but also has done serious damage to the quality of water. The domestic sewage from the thickly populated belt around the lake contributes to the drainage of impurities to the lake, in addition to the drainage from watersheds subject to the application of agrochemicals. On the above circumstances, it is felt that a holistic approach to understand the environmental attributes of Sasthamkotta Lake needs to be undertaken extensively. With the data collected from the field, mathematical models of complexities shall be established, for predicting hydrological and water quality parameters, for understanding the impacts of basin characteristics on hydrology and water quality and for generalisation of results for application in other identical limnosystems towards developing suitable strategies to maintain the ecological balance of the system. In addition to these hydrological investigations, sedimentation survey, constant monitoring of water quality and co-ordinated planning both at local and national level will perhaps be a right step to conserve this threatened ecosystem.

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FAECAL COLIFORM POLLUTION AT SASTHAMKOTTA LAKE**S. Girijakumari,****Dewson Board Pampa College,
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Contamination of surface and ground water is a serious environmental issue; chemical contamination from industries and biological contamination from untreated sewage are the major hazards. Sasthamcotta lake is the largest freshwater lake in Kerala and is the main drinking water source to lakhs of people in the Kollam District. The overall impact of anthropogenic activities in the lake has resulted in the deterioration of the water quality. Human excreta have posed great threat to the potability of Sasthamcotta lake water. Scientific studies are meager in this area though this is the main drinking water source for lakhs of people. Therefore an attempt was carried out to assess the faecal indicating bacteria of the lake. Assessment of coliform load at Sasthamcotta Lake was conducted from Nov.2004 to October 2005 covering a total hydrological cycle with premonsoon, monsoon and post monsoon seasons. Monthly collection of water samples was taken from five different sites in the lake after Stratified Random Sampling. The bacterial load was compared with the permissible limits of Indian Standards. The mean values of faecal coliforms range from 50 MPN/ 100ml to 1150 MPN/100ml. Highest number of FC were observed in the Vallakkdavu Station, 1400 MPN/100ml and is highly polluted. The acceptable limit of MPN/100ml prescribed for drinking purpose by Indian standard Limit is 0 faecal coliforms per 100ml and for bathing 100MPN/100ml for faecal coliforms. The sample values observed in the present study in S.Lake water exceeded the prescribed limit, which infers to the need for a comprehensive drainage management of the catchment area.

SEASONAL ANALYSIS OF BACTERIAL INDICATORS AT SASTHAMKOTTA LAKE

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Introduction

Quality changes in ground water due to pollution, large scale overdrafts on the reserves and indiscriminate disposal of industrial, human and agricultural wastes pose a great threat to the usefulness of the ground water. Lake pollution is a serious water pollution problem, which needs concern as it is known that a lake is less self assimilating than a flowing river. Sasthamkotta lake, the largest fresh water lake of Kerala, has an area of 375 km having an average depth of 6.7m with a maximum of 13.9m (Anon, 1983). The major source of water in the lake is seasonal rains as there is no inlet or outlet for the lake. The need for protection of the lake started since 1980 and now also continuing. The lake is the main drinking water source to lakhs of people in the Kollam district is now considered as a threatened ecosystem which is included in the Ramsar site in Nov.2002.

When sanitary and hygienic conditions become poor, public health in terms of bacterial infection are of greater risk due to lack of efficient sewage disposal systems and monitoring (Rashid Umar *et al.*, 2001). Due to population increases in the catchments and failed sanitation facilities, the lake is getting polluted. The main microbial pathogens include viruses, bacteria and some protozoa which are transmissible through faecal oral route. The overall impact of anthropogenic activities in the lake has resulted in the deterioration of the water quality. The present study was carried out to analyse seasonally the faecal indicating bacteria.

Materials and Methods.

Water samples were collected from five different stations in Sasthamkotta Lake during November 2004 to October 2005. The sites selected are Vallakadavu (site 1), Bharanikkav (site 2), Near Concrete Bund (site 3), Manakara (near filter house, site 4), Rajagiri (site 5). Samples were analyzed seasonally (APHA, 1995) and were collected in sterilized bottles and brought to the laboratory in iceboxes and examined within 4h after collection. The analysis were mostly confined to the essential characteristics of drinking water, as specified by BIS (1991). MPN (Most Probable Number) tube test is the technique used for total coliforms (TC), faecal coliforms (FC), *Escherichia coli* (*E.coli*) and faecal streptococci (FS). Monthly data were pooled into seasonal data.

Results

The results are presented in table. During the study period high count of total coliforms and faecal coliforms were recorded at all the stations. Monsoon and Post monsoon seasons show the high bacterial count except station II for *E.coli*. The faecal indicators like faecal coliforms and faecal streptococci are highest during post monsoon at all stations. The presence of faecal bacteria suggests the presence of pathogenic organisms and indicates high risk of infections like diarrhoea, cholera, infectious hepatitis etc. Station I (Vallakkadavu) is the most polluted area for all the four bacterial indicators studied.

Table : Showing the mean values of TC, FC, FS and E.coli.

Station	Season	TC	FC	FS	E.coli
I	Pre Monsoon	1200.0	749.8	49.3	129.8
	Monsoon	1400.0	1400.3	70.0	899.8
	Post Monsoon	1700.5	1299.5	80.5	239.8
II	Pre Monsoon	800.5	399.5	66.5	159.8
	Monsoon	300.0	169.8	11.3	22.8
	Post Monsoon	2500.5	1200.5	139.8	140.0
III	Pre Monsoon	1200.3	200.5	60.5	48.5
	Monsoon	1100.0	239.8	69.5	49.8
	Post Monsoon	1299.5	300.5	140.5	139.8
IV	Pre Monsoon	320.3	49.8	1.5	16.0
	Monsoon	500.3	60.3	1.8	7.8
	Post Monsoon	240.0	39.8	1.8	26.8
V	Pre Monsoon	450.3	150.0	1.5	8.3
	Monsoon	899.8	280.0	1.5	170.0
	Post Monsoon	499.8	157.8	3.5	33.0

Conclusions

Contamination of water with coliforms makes water unsatisfactory for drinking. Faecal coliforms by themselves are not disease causing while some strains are known to cause diarrhoea (SEU, 1991). Welch et al. (2000), reported that microbial contamination of both treated and untreated water in rural Trinad revealing thereby that such contaminated drinking water was grossly unfit for human consumption. Human excreta are the main source of faecal pollution in the lake. The domestic sewage from the thickly populated belt around the lake contributes the drainage of impurities especially during rainy season. Prajapathi and Mathur (2002) also noted that contamination of drinking water sources were highest in rainy season compared with summer season. The acceptable limit of MPN/100ml prescribed for drinking purpose by Indian standard Limit is < 10 total coliforms per 100ml and 0 for faecal coliforms. For bathing the acceptable limit is 500 MPN/100ml for total coliforms and 100MPN/100ml for faecal coliforms (Singh et al, 1995). The sample values observed in the present study in Sasthamkotta lake water exceeded the prescribed limit.

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