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Central Inland Fisheries Research Institute
(Indian Council of Agricultural Research)
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Prepared

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INTRODUCTION

Kerala state is situated on the south west coast of the Indian peninsulabetween 8° 18' and 12° 48' north latitudes and between 74° 52' and 77° 22' east longitudes. The state has a total area of 38864 Km^2 as per records of the Surveyor General of India. The coast of Kerala is strikingly bordered by a string of backwaters, generally running parallel to the shoreline. These water bodies locally known as backwater occupy extensive areas. The sizes of these water bodies are significantly varied, the largest among them being the Vembanad (179 Km^2) and the smallest the Kalnad (0.3 Km^2). The peculiarity of these backwaters is the bar-built nature to the extent that they could be treated as coastal lagoons. But many of these are fed by perennial rivers. These backwaters originated as lagoons on which rivers kept their flow rendering estuarine characteristics to them. Hence, these water bodies are unique enough to be treated as a special intermediate class between lagoons and estuaries. Out of the 30 backwaters on the Kerala coast, seven are characteristically river mouth estuaries. The backwaters fall themselves into three major categories on the basis of their geomorphic and geological setting within the coastal plain. They are (i) those contained within the beach ridge complex area such as Vembanad and **Kayamkulam backwater** , (ii) those occurring within the Tertiary terrain, with possible modifications in morphological character through extensions along the throats by growth of spits, and (iii) those occurring within the Tertiary terrain extending upto the foothill margin of the coastal zone with abruptly rising laterite walls such as Ashtamudi backwater. Those of the first category have their long axis running parallel to the shoreline and are very narrow when compared to their length. Wholly set within the strandplain, these water bodies are separated from the sea by large barrier spits interrupted by tidal passes. On the contrary, the Ashtamudi belonging to the third category has its axis perpendicular to the shore.

KAYAMKULAM LAKE - *A Background*

The Kayamkulam lake is a typical estuary dotting the coast of Kerala between latitude 9° 09' and 9° 15' N and longitude 76° 02' and 76° 28' E (Figure 1). Lying parallel to the Lakshadweep Sea, the backwater was about 14.5 Km long and 0.8 to 2.4 Km wide in 1958. Planimetric assessment has shown that a 42.6% reduction in the backwater has occurred during the period until 1983. Vast segments of the backwater have been already converted into coconut plantations and various land use patterns are now visible in the area. Floodwaters of the Pamba and Achankoil rivers flow into the backwater through the commercial canal, which links the backwater with these rivers. The backwater is connected with the sea during the period of the inland water fish and shelllfish production in central Kerala. This backwater is also a natural nursery of the vast shrimp and prawn resources of the region. Arattupuzha, the fishing village famous for "Chakara" (the mudbank formation heralding the advent of a rich fishing season) is situated just on the landstrip separating the backwater from the Lakshadweep Sea. The backwater as well as the sea front also serve as the source of livelihood of thousands of fishermen directly and other citizens indirectly. The nearest town is Kayamkulam.

The shores of the Kayamkulam lake do not have much variety of character. The western shore of the main body of the lake is mostly sandy dotted here and there with fishing villagers and coconut plantations. The eastern shore as well as the shores of the inner arm of the lake are formed of lands reclaimed for coconut and rice cultivation. Two streams and a canal empty into the lake and during the monsoon months some of the flood waters of the Pamba and Achankoil rivers flow into the lake through the commercial canal which links the Kayamkulam lake with these rivers. A number of irrigation channels and a few small streams open into the lake and drain the water from the adjoining paddy fields during the

monsoon months, but in summer the mouths of these channels and streams are bunded up to prevent the ingress of saline water into the fields. Narrow stretches of mud-flats are laid bare along the margin especially in the southern half of the lake as the result of the fall in water level in summer. The bottom of the lake is largely sandy but overlain by silt, and in the deeper parts there is soft dark clay with a little admixture of fine sand. In such regions the vegetation is poor, except for an encrustation of the blue-green alga *Oscillatoria*. The shallow sandy regions, however, have a luxuriant algal growth, especially during the hot months. The lake is highly saline for the greater part of the year. The shallow warm waters, with abundant vegetation and plankton, form an ideal feeding ground for both adult and fingerling mullets.

REVIEW OF LITERATURE

Some of the works in on the ecology and biodiversity of the backwaters of Kerala are that by Nair, 1990, Abdul Azis and Nair 1986, Haridas et al 1973, Kurup and Samuel, 1987, Bijoy Nandan & Unnithan 1998, Anon 1992. CIFRI during 1994 to 2002 periods had undertaken indepth studies and surveys on the ecology in relation to the fish production potential in the Vembanad backwater and ten other backwaters including the Kayamkulam system of Kerala. Even though, several studies have been reported on the ecology and biota of the backwaters on the south west coast of India, indepth studies are limited, moreover some are more of a survey in nature.

Most of the research work done was undertaken prior to commissioning of the National Thermal Power plant in 1998 at the Kayamkulam backwater. The pioneering contribution in this direction was by Mary John (1955,1958), through a preliminary survey brought out the hydrography, sediment characteristics in the context of the biotic and fishery resources of the backwater. The author also

studied the taxonomy and characteristics of 15 species of grey mullets in the lake. The foraminifera from the backwater were investigated by Antony (1975), where the author reported 30 species of foraminiferans belonging to 16 gerara and 10 families. Kuttyamma (1980) studied the catch trends, size variations of prawn fishery and recruitment of prawn larvae in the lake. The water quality and benthic fauna of the backwater were investigated by Prabha Devi *et al.* (1996). The Department of Aquatic Biology & Fisheries, University of Kerala during 1990-1991 period made comprehensive studies on the impact of the proposed National Thermal Power plant on the Kayamkulam backwater (Anon, 1992). The study mainly dealt on the water quality assessment, the distribution and diversity of macrophytes, phytoplankton, zooplankton, benthos, fishes, crustaceans and molluscs. In addition thermal endurance studies based on experiments in fishes, prawns, clams were also undertaken during the study.

Later after commissioning the thermal power plant at Arattupuzha in the Kayamkulam backwater, studies backwaters, the Kayamkulam research programme on seasonal studies on the environmental and fishery resources of the selected undertaken in the water body are scanty. CIFRI as a pioneering effort during 1997-99 periods, under the research programme on seasonal studies on the environmental and fishery resources of the selected backwaters, the Kayamkulam backwater was investigated and suitable remedial measures for its management were suggested (Anon,1999).

Background information and Importance of the Project

Eventhough several research inputs on various aspects are available on the Kayamkulam backwater, the information on the catch data, gear wise yield and exploitation trends and strategies of the major prawn fishery of *Penaeus indicus*, *Metapenaeus monoceros* and *M. dobsonii* are not available. So, it it was in this context that the present work was suggested and undertaken in this direction. The proposed study has created an important base line data on the present status of prawn fishery in the Kayamkulam backwate based on time scale alterations. In

addition to the prawn fishery assessemt, the impact of the discharge from the thermal power plant on the lake *vis-a -vis* the environment and biota were also studied during 2000-02 period. The proposed project, therefore, aims at deriving norms for managing the proposed fishery on a long-term sustainable basis.

ACTION PROGRAMMES UNDER THE PROJECT

1. The total landings, species-wise yield, craft and gear survey and CPUE for 3 species of prawns, *Penaeus indicus*, *Metapenaeus monoceros* and *M. dobsonii* were investigated.

2. To suggest suitable modifications in the fishing gear (mesh size. *etc.*) fishing practices and fishing zones for ensuring a long-term healthy and sustainable fishery of the species.

3. Estimation of water and sediment quality.. distribution and diversity of plankton and benthos from the National thermal power plant zone, to assess the impact of thermal discharge on the backwater system.

Prawn fishery landings – Total catch, Percentage composition

Three commercially important prawn species viz., Penaeus indicus, Metapenaeus dobsoni and M. monoceros along with other minor prawns collected from the Kayamkulam backwater were investigated for their fishery and population characteristics. Seven major landing centres targeting these species were surveyed for two years from 2000-2002. A landing based approach was applied for the estimation of fish landings. Fishery survey was conducted on a fortnightly basis from

all the major landing centres around the lake, which brought ashore the targeted species. Investigations in the following major landing stations of Kayamkulam lake viz.

1. Mahadevikadu	*2. Choolatheruvu*	*3. Vettathu kadavu*
4. Kanakakkunnu	*5. Keerikadu jetty*	*6. Kochiyude Jetty*
7. Muttathumannel	*8. Ayiramthengu*	*9. Valiyazhikal*

The map of Kayamkulam backwater indicating the landing zones is given in Fig. 2. The average total landings estimated for two years of survey was worked out to be 545.39 t. for the *P. indicus*, for *M. monoceros* 222.18 t for *M. dobsoni*, 1409.53 t., other prawns 48.06 t and 2732.34 t for fishes. Exorbitant quantity of the very young mullets landed through the seine nets is not included in these landings. Month wise CPUE in respect of each gear was also estimated.

Based on the fishery survey conducted, the percentage contribution by these species to the total landings was estimated, *P. indicus* (545.39 t., 11.00 %), *M. monoceros* (222.18 t., 4.48 %), *M. dobsoni* (1409.53t., 28.43 %), other prawns (0.97 %) and fishes (55.12 %). The species were subjected to both recruitment over fishing and growth over fishing. The indiscriminate fishery has been mainly due to the use of the fine mesh, seine nets and the gill nets. These two gears fished about 57 % of the landings of these species. Enhancing the mesh size of the seine nets and restricting the number of the gill nets and seine nets suggest strict regulation of the exploitation. *M. dobsoni* share of 69.12 % and 66.36 % were contributed by stake net and dip nets respectively. The wanton harvesting of undersized prawns by stake nets and dip nets greatly contributed to the catch of these species in the backwater.

In the month of June 2001, an unusual catch of *Oxyurichthys tentacularis* (1217 kg) was caught in Muttathumannel by seine net due to sudden rain in that area. This is a rare phenomena reported by the local fishermen. In many of the centres (Choolatheeruvu, Kochiyudejetty and Keerikadujetty) the catches were very less due to heavy rain and resultant flooding. The percentage composition of the total landing including the year April 2001 to February 2002 was estimated to be as follows: *P. indicus* 11.48 %, *M. monoceros* 3.69 %, *M. dobsoni* 28.72 %, other prawns 1.16 % and fishes 55.01 %.

A considerable increase in the catch of the three species could be observed on comparison with the study conducted by CIFRI during 1988-99 period in the same backwater as given below.

	CIFRI Landings (1998-99)	CIFRI landings (2000-02)
P. indicus,	119.7 t.	545.39 t.
M. dobsoni	98.0 t.	222.18 t.
M. monoceros	453.4 t.	1409.53 t.

The increase in catch during the 2000-02 period in the current study is concomitant with the uncontrolled fishing of undersized prawns with the small sized mesh gears represented mainly by the stake nets, dip nets and seine nets.

When compared to the previous year (2000-01) a marginal increase was noticed in the case of *P. indicus* and fishes. On the other hand a slight decrease in catch was evidenced in the case of *M. Monoceros*, *M. dobsoni* and other prawn (*P.monodon*, *M. affinis*). The targeted species alone contributed to 43.9% of the total catch.

There are innumerable quantities of fishes and prawns in different nets, which include trash fishes, juveniles, small fishes and economically important fishes. The centres interest was only to estimate the targeted species viz., *Penaeus indicus*, *Metapenaeus monoceros*, *M. dobsoni*, other prawns and fishes. The gear-wise estimated catch were are as follows:

Table 1. Landing of the target species from Kayamkulam lake (in tones)

Gear	*P.indicus*	*M.mono-ceros*	*M.dobsoni*	Other prawns	Fishes	Total
Cast net	85.918	11.495	57.567	14.255	193.487	362.722
Dip net	99.998	32.009	419.365	3.433	77.127	631.932
Gill net	59.614	2.840	0.036	3.715	605.788	671.993
Ring net	0.017	-	1.915	0.239	94.062	96.233
Stake net	86.442	87.069	525.453	1.933	59.287	760.184
Scoopnet	0.157	0.246	-	1.359	48.460	50.222
Seinenet	193.786	87.325	376.395	22.215	1534.392	2214.113
Trap	19.462	1.200	28.801	0.907	119.732	170.102
TOTAL	**545.394**	**222.184**	**1409.532**	**48.056**	**2732.335**	**4957.501**

As can be seen from the Table 1, most of the nets like Cast net, Dip net, Stake net and Seine nets are effective gear for *M. dobsoni* , followed by *P. indicus and M. monoceros.* Seine net fetches more catch than the other nets (*P. indicus* 8.75 % *M. monoceros* 3.94 %, *M. Dobsoni* 17.00%, other prawns 1.0% and fishes 69.30%). Thus, a total of 2178.04 t of the targeted prawns were brought ashore during the study period.

Table 2. Percentage contribution by different gear for different species

Gear	*P.indicus*	*M.monoceros*	*M.dobsoni*	Other prawns	Fishes	Total
Castnet	23.69	3.17	15.87	3.93	53.34	7.32
Dipnet	15.82	5.07	66.36	0.54	12.21	12.75
Gillnet	8.87	0.42	0.01	0.55	90.15	13.56
Ringnet	0.02		1.99	0.25	97.74	1.94
Stakenet	11.37	11.45	69.12	0.26	7.80	15.33
Scoopnet	0.31	0.49		2.71	96.49	1.01
Seinenet	8.75	3.94	17.00	1.00	69.30	44.66
Trap	11.44	0.71	16.93	0.53	70.39	3.93

An analysis of the gear wise composition of the three species based on the studies during 1976-77 period by Kuttyamma (1980) in the same backwater is given below

	Kuttyamma (1980)	Present study (2000-02)
P. indicus,	58.0 %	11.0 %
M. dobsoni	5.0 %	4.48 %
M. monoceros	36.0 %	28.43 %

It could be observed that, the catch of prawns has drastically reduced during the present study in comparison with that during 1996-77period in the Kayamkulam backwater.

Craft and gear

About seven major types of fishing gear (trap and scare net are rarely used) were regularly being employed in the fishing of the species at the seven landing centres listed in the project (Table 3). The deployment of fishing gear at major landing centres in Kayamkulam lake for the target species are as follows:

Table-3. **Deployment of fishing gear at major landing centres at Kayamkulam backwater**

Gear	Av. No. of units/day	Gear	Av. No.of units/day
Cast net	131	Dip net	90
Gill net	223	Ring net	41
Scare (Stake) net	77	Scoope net	20
Seine net	286	Trap	27
		TOTAL	**895**

Catch per unit effort (CPUE)

A fishing unit consists of one boat, two fishermen and 25 kg nets. The fishing units employed in the commercial fishing varied from 30 to 50 per day per centre. The catch per unit of effort for different types of gear for the different species varied widely according to the habitat and distribution of the species. The fishing areas far from the bar mouth were characterized by the dominance of traps, scoop nets and ring nets *etc.*, targeted for the *Etroplus*. Stakenet is specifically meant for the prawn species and hence exhibited a higher CPUE for that species (Table 4). Similarly, Chinese dip net and seine net are primarily meant for the prawn catching but occasionally other unwanted fishes also entered during the operation. Thereby the CPUE showed lower values for seine net. The size composition of the commercial catches of *P. indicus*. *M. dobsoni and M. monoceros* obtained by different nets show some differences. When the catches of the three nets were compared, cast net mainly caught prawns of bigger sizes and those of small sizes by stake net. In Chinese dip net both large and small ones equally distributed. Although Chinese dip nets are operated throughout the year, the main fishing season in the Kayamkulam lake is from October to January. During the best season approximately 50 kg of prawn per net obtained during single night. In Kayamkulam lake maximum effort by sience net was observed during September, coinciding with the heavy landings in this gear

Table 4.The average CPUE for major gear for different species

Gear	*P.indicus*	*M.monoceros*	*M.dobsoni*	Total
Cast net	0.91	0.12	0.61	1.64
Dip net	1.54	0.49	6.47	8.50
Gill net	0.37	0.02	-	0.39
Ring net	-	-	0.06	0.06
Stake net	1.56	1.57	9.48	12.61
Scoop net	0.01	0.02	-	0.03
Seine net	0.94	0.42	1.83	3.19
Trap	1.00	0.06	1.48	2.54
AVERAGE	**0.90**	**0.39**	**3.32**	**3.62**

FISHERMEN POPULATION & INCOME DISTRIBUTION

The survey in the backwater mainly dealt on the enumeration of active fishermen who were solely involved in fishing in water body. Their density in the lake per km^2 was about 76 nos. The fish landings brought ashore by the fishermen were sold in general, through auction at the landing sites. Though majority of the fishermen was organised into societies, the societies very often respond to the monetary needs of the fishermen through arranging fair price sale. At the auction site, the vendors dictated the prices and often the fishermen were forced to sell the catch at poor prices having no other option the landing sites. Agents of the processing companies were ubiquitously present at all major landing centers for the purchase of prawn and crab species. These items received more or less steady price depending on the count of the harvested prawn. Percentage of market share by the fishermen and vendor at different landing sites in the Kayamkulam lake was about 55 %.

Impact assessment study

The backwaters and adjoining coastal water bodies are one of the rich areas of fish production constituting 40 % of the total catch in India. The backwaters also serve as the nursery for the vast prawn and shrimp resources. Of late, there has been large-scale pollution and consequent destruction of the fauna and flora of these waters. Pioneering studies were undertaken by CIFRI to assess the impact of thermal discharge on the ecology and biotic communities in the Kayamkulam lake from September 2000 to April 2002. Water, sediment, plankton, benthic fauna were collected from four selected stations in the NTPC zone on a bimonthly basis and analysed based on standard methods (APHA, 1995). The four stations selected were one, thermal discharge outfall zone (OF), two stations above outfall (AOF1 and AOF2) and two below the outfall (BOF1 and BOF2) (Fig. 2).

Water Quality

The Kayamkulam lake at the NTPC zone was shallow with an average depth of 1.77 m during the present study. The transparency was also low, with the minimum mean of 1.1m in OF, AOF1 and BOF2 and the maximum of 1.2 in the other zones. The turbid murky nature of the water could be observed in the zone due to the discharge from the NTPC plant, which could have lead to low transparency values in the study stations. The turbidity values indicated wide variations in the stations and ranged from 0.41 NTU in July 2001 in AOF1 and OF zones to 37.9 NTU in AOF1.

The average variations of temperature, salinity, dissolved oxygen, alkalinity, nitrate-nitrogen, phosphate, silicate of the surface waters at all stations are presented in Table 5. The water temperature varied from 27.5 to 32.5 °C in the four stations and average was 29.8°C. The variation in temperature between the different zones was not very significant and showed marginally higher values at the out fall as well as above and below the outfall zones. Salinity was observed to be low in all the stations (1.77 to 26.24 °/ppt and the average being 11.77 °/ppt) due to freshwater inflow into the backwater. With the onset of south-west monsoon the salinity values drastically reduced due to the heavy influx of water from rivers and canals The dissolved oxygen regime showed wide variations between the different zones of the study and the mean values varied from 5.2 in AOF1 to 6.1 mg/l in BOF1. The dissolved oxygen values below 5 mg/l was recorded in AOF1&2, in Sep to Jan 2000, May 2001and even reached the lowest of 3.8 mg/l in April 2002 in AFO1. pH of the backwater was more or less on the alkaline side, which varied from 6.86 in AOF2 in Sep. 2000 to 8.3 in the same zone in April 2002. The pH was acidic in all the four stations only during May 2000 ranging from 6.75 to 6.88. Free carbon dioxide was moderate to high in most of the zones during the present study. It reached a peak of 8.5 mg/l in BOF1 and AOF2, in September 2001. Total sulphide concentration was apparently higher

(mean 2.4 mg/l), in below the outfall zones as compared to the above the outfall zone (mean 1.9mg/l). Mean variation in selected water quality parameters is given in Fig.3.

BOD5 values were high in all the study zones varying from 4.71 in AOF1 to 7.2 mg/l in OF zone. It was maximum during the May 2001 period, when it reached a peak of 12 mg/l in the outfall and below outfall zones. The higher BOD5 coincided with the simultaneous increase in COD in all the zones. It ranged from a mean of 53.1 mg/l in OF to 69.6 mg/l in the BOF1 and the concentration reached a crescendo in BOF1(128 mg/l) in April 2002. The COD values during July were quite high which might be due to the release of discharge during these periods. On the other hand, COD during September was very low. The nutrient concentrations were high in most of the sites during the present investigation. Nitrate- nitrogen values ranged from 0.20 to 0.37 mg l^{-1} phosphate from 0.01 to 0.126 mg l^{-1} and silicate from 1.2 to 9.6 mg l^{-1} respectively. The comparatively high BOD5 , COD, nutrients and turbidity corresponding with frequently low dissolved oxygen were the outstanding water quality change observed in all the NTPC zones during the present study. This water quality change reflected the impacted nature of the zones due to discharges from the NTPC plant as well as due to pollution from retting of coconut husk in the adjacent regions of the NTPC zone.

Table 5. Physico-chemical characteristics of water in Kayamkulam Lake near NTPC Zone

	AOF_2	AOF_1	OF	BOF_1	BOF_2
Water temperature° C	**30.0**	**30.3**	**30.1**	**28.3**	**30.2**
	(27.5-32.5)	(27.5-32.5)	(27.5-32.5)	(28.0-32.5)	(28.5-31.5)
Transparency (m)	**1.2**	**1.1**	**1.1**	**1.2**	**1.1**
	(1.0-1.5)	(0.9-1.3)	(0.8-1.6)	(0.9-1.5)	(1.0-1.6)
Depth (m)	**1.5**	**1.4**	**1.2**	**1.4**	**1.6**
	(0.98-1.4)	(1.0-1.7)	(1.1-1.6)	(1.0-1.5)	(1.5-1.8)
PH	**7.8**	**7.6**	**7.5**	**7.6**	**7.3**
	(6.8-8.3)	(6.9-8.2)	(6.8-8.2)	(6.8-8.2)	(6.8-8.2)
Dissolved oxygen (mg/l)	**5.8**	**5.2**	**6.0**	**6.1**	**6.0**
	(4.1-6.8)	(3.8-7.0)	(4.8-7.9)	(4.6-8.0)	(4.3-7.5)
Free CO_2 (mg/l)	**2.6**	**3.2**	**4.6**	**2.4**	**2.6**
	(Nil-8.5)	(Nil-8.0)	(Nil-8.0)	(Nil-8.5)	(Nil-7.0)
Methyl orange alkalinity mg/l)	**53.8**	**59.4**	**52.9**	**53.3**	**55.9**
	(16.0-70.0)	(21.0-92.0)	(17.5-78.0)	(16.5-77.0)	(20.0-82.0)
Sp.conductivity (umhos/cm)	**17.6**	**18.2**	**13.5**	**15.2**	**15.0**
	(4.2-23.48)	(3.89-25.82)	(3.4-17.7)	(3.43-20.96)	(6.5-20.0)
TDS (mg/l)	**10.2**	**10.2**	**9.68**	**8.66**	**8.54**
	(1.51-17.45)	(1.81-15.29)	(1.85-17.2)	(1.87-17.3)	(1.93-16.94)
Turbidity (mg/l)	**5.3**	**8.1**	**8.2**	**8.0**	**8.1**
	(0.041-37.8)	(0.041-37.9)	(0.041-37.7)	(0.043-37.5)	(0.045-37.2)
Hardness (mg/l)	**1676.6**	**2144.7**	**2061.3**	**1854.9**	**1832.2**
	(140.14-3013.01)	(180.18-3353.4)	(310.3-4104.1)	(180.10-3703.7)	(200.0-4804.8)
BOD (mg/l)	**6.34**	**4.71**	**7.2**	**5.9**	**6.2**
	(1.0-10.0)	(0.5-9.5)	(3.0-12.0)	(3.5-12.0)	(1.5-12.0)
COD (mg/l)	**48.5**	**55.2**	**53.1**	**69.6**	**64.3**
	(2.0-95.0)	(1.0-96.0)	(1.0-95.0)	(1.0-128.0)	(1.0-120.0)
Salinity ($^0/_{000}$)	**12.8**	**12.92**	**11.63**	**10.61**	**10.88**
	(1.77-25.24)	(1.95-26.24)	(2.19-24.23)	(2.09-24.23)	(2.23-25.24)
Total sulphide (mg/l)	**1.9**	**2.3**	**2.2**	**2.4**	**2.4**
	(1.6-2.4)	(0.4-3.6)	(0.8-5.2)	(0.6-5.2)	(0.8-5.6)
Nitrate (mg/l)	**0.287**	**0.282**	**0.282**	**0.274**	**0.31**
	(0.252-0.366)	(0.200-0.344)	(0.180-0.352)	(0.184-0.348)	(0.248-0.352)
Phosphate (mg/l)	**0.049**	**0.060**	**0.045**	**0.056**	**0.305**
	(0.010-0.092)	(0.014-0.126)	(0.012-0.124)	(0.018-0.126)	(0.048-0.122)
Silicate (mg/l)	**4.53**	**4.33**	**4.69**	**5.1**	**5.54**
	(1.3-9.6)	(1.5-8.9)	(1.6-9.1)	(1.2-8.7)	(1.5-8.8)

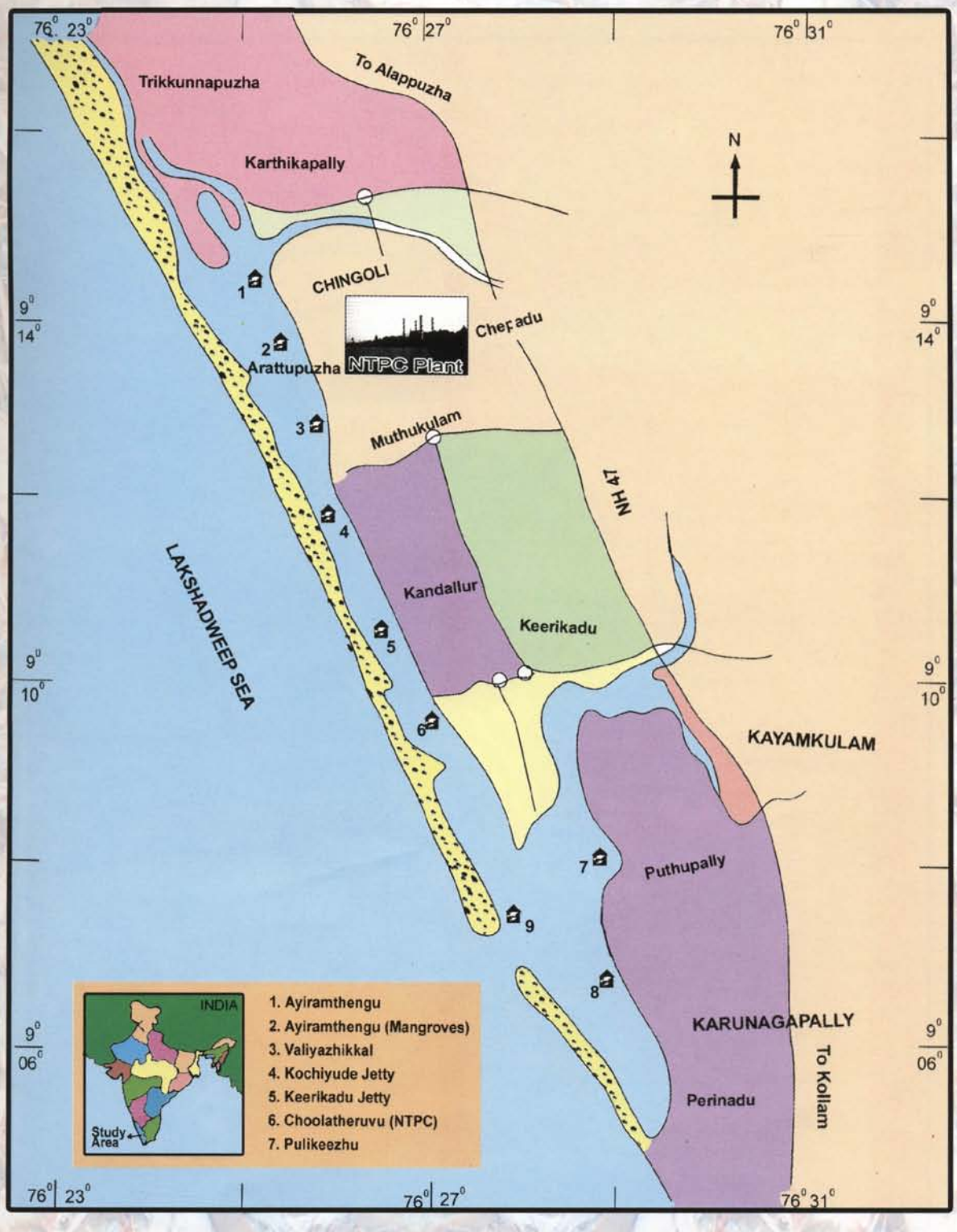

Fig - 1 MAJOR FISHERY LANDING CENTERS IN THE KAYAMKULAM BACKWATER

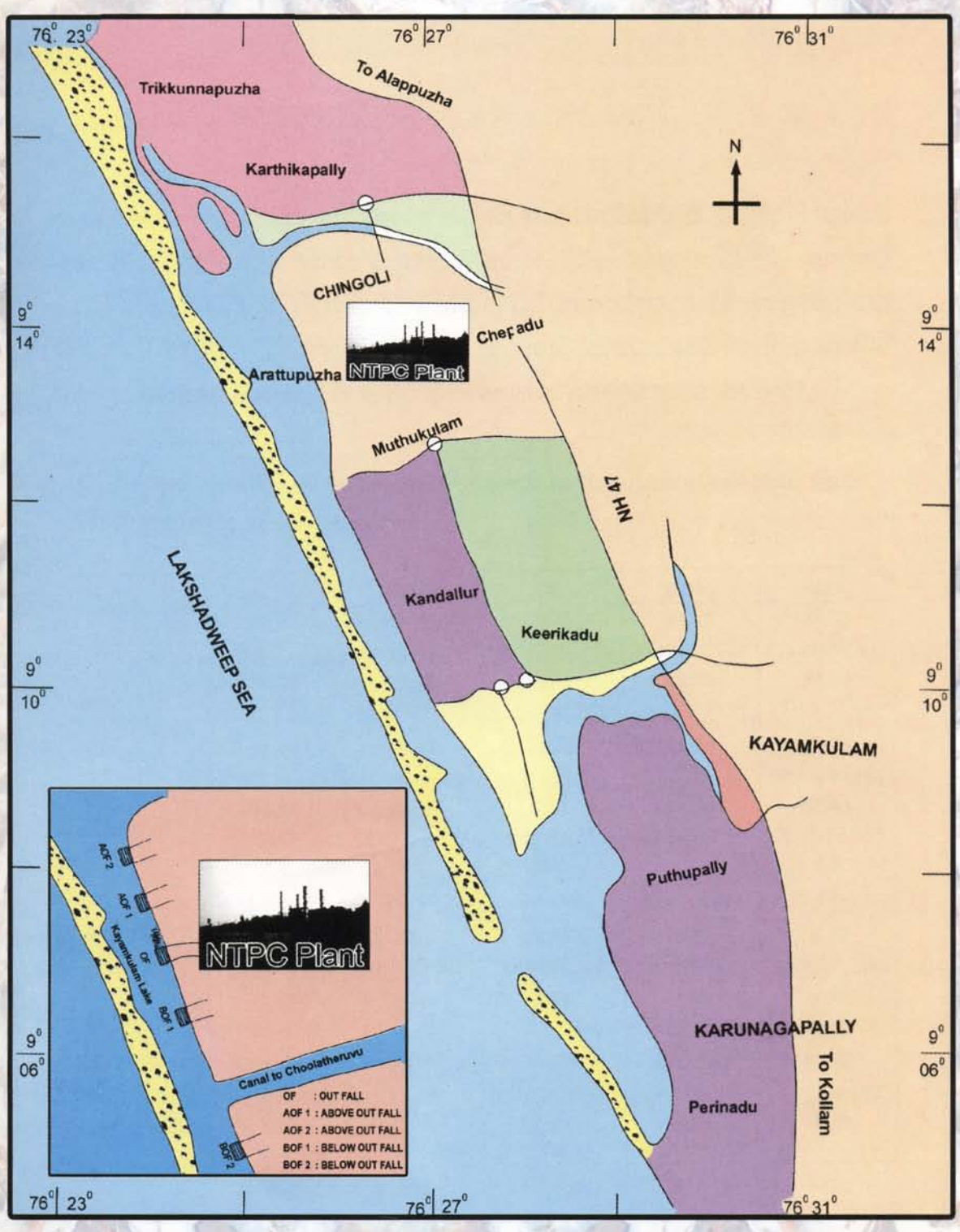

Fig - 2 MAP WITH INSET INDICATING THE STUDY STATIONS IN THE NTPC DISCHARGE ZONE OF KAYAMKULAM LAKE

Sediment quality

The sediment quality in the different zones is presented in Table 6. The pH values were highly acidic in the four zones during May and September 2001, ranging from 3.87 in AOF1 to 4.75 in BOF2. The mean calcium carbonate ranged from 1.90 in AOF1 to 3.77 % in BOF2. Sediment organic carbon was high in all the zones recording a highest average of 4.74 % below the outfall zone (BOF2).

Table 6. Sediment quality of selected stations in Kayamkulam lake near NTPC during 2000-02 period

Parameters	AOF_2	AOF_1	OF	BOF_1	BOF_2
Fine sand (%)	**58.77** (39.4-77.38)	**60.03** (43.97-72.18)	**71.43** (42.80-76.24)	**41.57** (8.08-58.74)	**49.72** (28.49-59.51)
Coarse sand (%)	**30.78** (6.91-43.43)	**27.53** (4.53-47.03)	**11.42** (1.91-43.86)	**13.80** (1.21-39.97)	**14.75** (2.30-52.83)
Clay (%)	**11.64** 0.90-23.65)	**18.32** (4.15-41.40)	**21.26** (6.15-37.65)	**32.54** (5.15-50.65)	**35.54** (2.15-49.15)
Silt (%)	**11.19** (0.75-52.75)	**6.66** (0.25-14.50)	**7.31** (1.25-16.15)	**10.84** (3.0-24.75)	**11.63** (1.25-16.50)
pH	**5.6** (5.0-6.7)	**5.6** (4.4-6.2)	**5.4** (4.4-6.3)	**5.3** (3.9-7.4)	**5.5** (3.9-6.5)
Organic carbon (%)	**2.65** (0.08-5.93)	**2.63** (0.76-5.67)	**3.05** (1.44-4.96)	**3.93** (0.49-5.6)	**4.74** (0.99-5.91)
CaCO3 (%)	**2.15** (0.25-4.50)	**1.90** (0.75-3.75)	**1.99** (0.25-5.00)	**2.89** (1.00-4.50)	**3.77** (1.75-6.75)
Av.Phosphorus (mg/100 g soil)	**0.180** (0.062-0.440)	**0.130** (0.088-0.420)	**0.172** (0.092--0.316)	**0.164** (0.068-0.268)	**0.167** (0.092-0.388)
Av. Nitrogen (mg/100 g soil)	**2.40** (0.56-6.16)	**2.70** (0.84-4.76)	**1.43** (0.28-4.48)	**1.78** (0.28-3.64)	**2.43** (0.15-5.60)

The thermal discharge accumulation and dissipation in the zones could be the reason for the higher organic carbon contents and acidic pH of the sediment in the region. The available phosphate showed low concentration all the four zones whereas the available nitrogen content was higher during the study periods.

Thus, from the preliminary studies it has revealed that, the conjoined effect of the thermal discharge and retting actfected the ecology of the region in terms of the water and sediment quality and biota of the NTPC zone in the Kayamkulam backwater.

MAJOR RECOMMENDATIONS OF THE PROJECT

1. *Immediate steps to restrict the mesh size of the stake net, Chinese dip net and the drag net to ensure more growing period for the juveniles. The indiscriminate fishery has been mainly due to the use of the fine mesh seine nets and the gill nets. Enhancing the mesh size of the seine nets and restricting the number of the gill nets and seine nets suggest strict regulation for exploitation. Though a minimum mesh size of 25 mm (stretched) is advisable and the limit may be restricted to 18 - 20 mm.*

2. *The fishing effort should be restricted, at least to the current level till further suggestions are made based on population dynamics investigations conducted on the prawns in backwater systems.*

3. *Effective and pr oper registration of the fishing gear and craft are to be carried out. The registration system followed under the Fishermen Welfare Board is not very effective in regulating the fishery. Strict registration and licensing to all existing craft, gear and fishermen is to be immediately implemented.*

4. *It has been observed that several units of purse seine are diverted to the backwaters during the closed season for marine fishing. This has to be totally prohibited.*

5. *The stake nets deployed at the tidal incursion near the bar mouth of the backwaters are without any restriction, which needs to be curbed. This has affected the recruitment, migration and development of the species in the lake. Strict enforcement machinery needs to deployed to ensure that the stake net fishing is restricted and are deployed only during the receding phase.*

6. *Reclamation of the productive backwaters for agricultural, mining, urban area development and similar activities, as well as extreme organic/industrial pollution has tremendously affected the fishery of prawns in the backwater. Awareness campaigns and strict legislations are to be implemented against the various anthropogenic interventions for rejuvenating the declining catch of prawns in the lake.*

7. *Eventhough from the preliminary investigations, it has been inferred that the NTPC thermal discharge had an apparent impact on the water and sediment quality and the biotic resources of the region, indepth studies are to be initiated for assessing the extent of the damage caused by the thermal and other impacts on the fragile ecosystem of the Kayamkulam backwater.*

Table 7. Phytoplankton diversity (No/m^3) in Kayamkulam lake near NTPC during 2000-02 period

Stations	AOF2	AOF1	OF	BOF1	BOF2
MYXOPHYCEAE					
Anabaena	4	2	18	12	1
Nostoc		2			1
Oscillatoria	30	22	9	16	8
Merismopedia			10	8	5
Agmenellum	2	10			
Apanotheca		2			
Nodularia	1				
CHLOROPHYCEAE					
Gymnodinium		10			
Ankistrodesmus		2	10		
Stephanodiscus	8	1	1		
Ulothrix	16		18	3	4
Pediastrum	4	2	6		1
Spirogyra	13	16	2	1	
Ceratium	18	70	2	38	3
Campylodiscus	3	10	2		
Peridinium	2	3			
Cephalodiscus	1	2			
Biddulphia	1		1		
Lauderia	3	2	1	2	
Chaetoceros	8	8	25	2	
Microsterias	1				
Closteridium		18			
Arthrodesmus	1	1		1	
Spaerolzosma	13				
Pleuotaenium		1		1	1
Microspora		1			
Chrysidiastrum	2	1	1		
Coscinodiscus	31	14	2	1	1
DESIMIDACEAE					
Closterium	5	4	20	9	2
Cosmarium	7				
Staurastrum	3	13		1	
Desmidium	1	2		1	
Scenedsmus		1		1	
BACILLARIOPHYCEAE					
Tabellaria	4	7	2	1	1
Pinnularia	2	6	2	1	
Navicula	2				
Surirella		1	1		
Fragilaria	1	1		2	1
Pleurosigma	4		7		
Gyrosigma	12	20	33	13	19
Melosira	27	15	21	2	1

Table 8 . Zooplankton diversity (No/m^3) in Kayamkulam lake near NTPC during 2000-02 period

Station	AOF2	AOF1	OF	BOF1	BOF2
PROTOZOA					
Undella hyalina	1	2	1		
Parundella	1	13	12	11	6
Coxliella	1	1			
Arcella	1	2	1		
ROTIFERA					
Brachionus	86	91	138	88	115
Lecane	1	2	1	1	
Keratella	2	1	2	1	1
Pompholyx	2	1	1		
Epiphanus	1	1			
Trichocerca logiseta	2	1	2		
Chromogster ovalis	4	1	2		
Asplanchana	4	2	3		
COPEPODA					
Diaptomus	36	33	44	48	55
Mesocyclops hyalinus	10	7	6	16	2
M. luckarti	3	6	1	2	8
Nauplius	393	456	588	451	13

Table 9. Benthic fauna (No./m^2)diversity in Kayamkulam lake near NTPC during 2000-02 period

Stations	AOF2	AOF1	OF	BOF1	BOF2
Isopods			25		
Oligochaeta					2000
Polychaeta	185	140	746	363	150
Ostracoda	5163	2357	3713	2872	1658
Amphipoda	67	575	357	670	175
Prawn	25	213	125		
Insect larvae		25	25		38
Gastropods	9053	1013	4475	6080	36013
Bivalvea	414	453	669	3178	934
Mosquito larvae			25	25	
Chironomid larvae	25	25	40		100
Miscellaneous	25	263	199	306	163
TOTAL	**14957**	**5064**	**10399**	**13494**	**35231**

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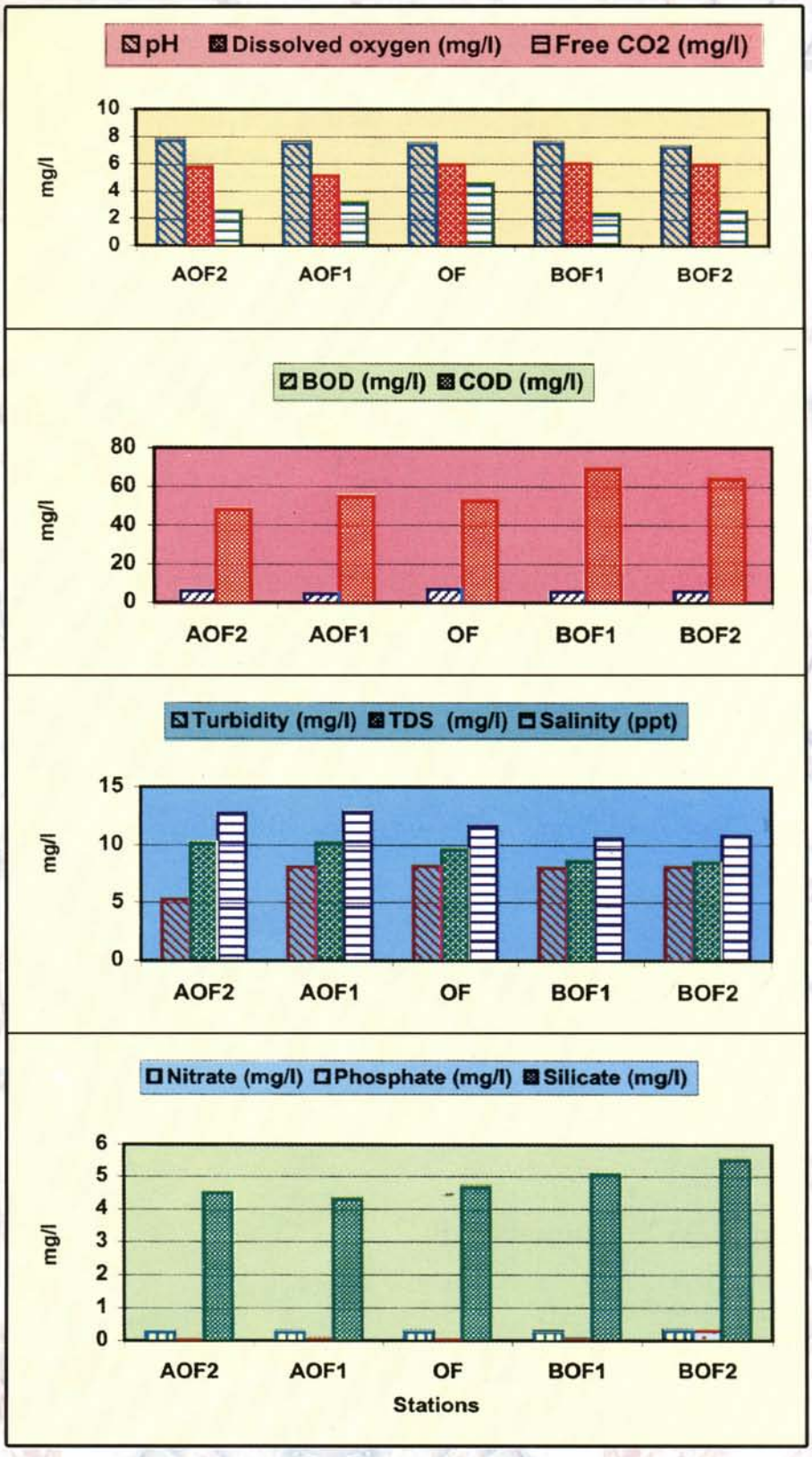

Fig. 3 Mean variation in selected water quality parameters in the different NTPC Zones during 2000-2002

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Chinese dipnet for operation in Kayamkulam lake

Prawn and fish species arranged by the fisherman on their "Vallom" (Country boat) awaiting auction

M. dobsoni

A catsh of *P. indicus, P. modonon, M. monoceros, M. dobsoni* and other spceies

Fishermen removing the seine net after a days fishing operating in the lake

Fishery landings being arranged by the fishermen in the Kochiyud jetty for auction

P. indicus

M. monoceros