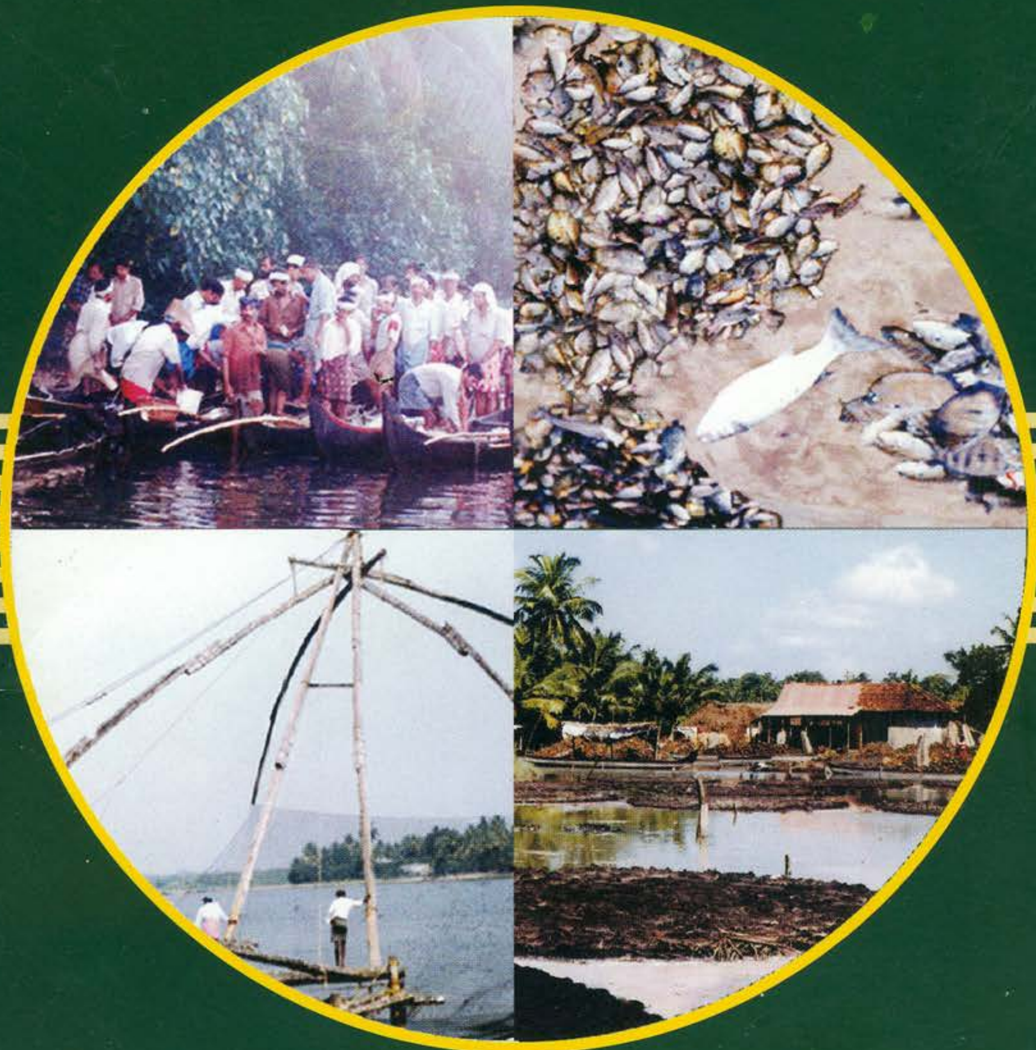
FISHERIES AND ENVIRONMENT ASSESSMENT IN SELECTED BACKWATERS ON THE SOUTH WEST COAST OF INDIA



Central Inland Fisheries Research Institute
(Indian Council of Agricultural Research)
Barrackpore, Kolkata 700 120 West Bengal

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BACKGROUND INITIATIVE ON THE PROJECT

Coastal wetlands are known to be indispensable habitat to a variety of biologically and economically important resident and migratory aquatic fauna. Moreover, the interdependence of the adjoining marine and the estuarine zones in completion of the life cycle processes of innumerable aquatic species is amply described in fishery literature. The biological importance of the chain of about 30 backwaters / estuaries / wetlands (locally called as *kayals*) along with the canals on the south-west coast of India are of special significance in this context (Fig. 1). This is all the more evident since the adjoining marine coastal zone continues to be one of the most productive fishery zones in the world contributing to about 0.6 million tones of fish annually.

These interconnected backwaters together are a unique ecosystem supporting high biodiversity and a rich commercial fish and shellfish fauna. These *kayals* are preferred habitats for about 200 resident or migratory fish and shellfish species and form the crux of the 62500 ha backwater fishery resource in the State of Kerala. The fishing activities in these backwaters support about 0.2 million fisherfolk and provide full time employment to about 50000 fishermen. Moreover, these wetlands are recognized nursery grounds of prawns like *Penaeus monodon, P. indicus, Metapenaeus dobsonii, M. monoceros* , crabs and finfishes like mullets, whitings, perches, pearlspot, and the breeding ground for the freshwater caridian prawns (*Macrobrachium* spp.). Edible oysters occur in all these wetlands with an abundance in Ashtamudi, Vembanad, Mahi, Valapattanam, and Neeleswaram. Remnants of thick mangrove habitats once flourished in these water bodies are visible n several of these wetlands, now spread to an area of about 1670ha.

Besides, 41 of the 44 rivers in the State flow into these backwater systems before they empty into the sea. Several of the fish species inhabiting the lakes share both the river and lake environments in their varying life stages. The giant freshwater pawn *Macrobrachium rosenbergii* for whom the Vembanad backwater ecosystem forms a natural abode, is a classical example of this behaviour. The need to protect, preserve and optimally exploit such ecosystems is imperative and is beyond the scope of argument.

Of late, these systems are reported to be under severe environmental stress arising from a variety of anthropogenic activities. Scientific monitoring of these ecotypes aiming at their rational fisheries management has been, highly inadequate. The available literature mainly pertains to the ecological characteristics, seldom taking into consideration the interrelationship with the fishery. Several reports are available on the flora and fauna, and the soil and water quality emanating from the Department of Aquatic Biology and Fisheries (University of Kerala), Cochin University of Science and Technology, CMFRI, National Institute of Oceanography, etc. However, these studies were mostly restricted to Cochin backwaters including the Vembanad lake, Veli, Kadinamkulam and Ashtamudi backwaters.

A comprehensive and worthwhile study was therefore, necessary to create a database on the fishery resources of these backwaters for its long-term monitoring management. Based on this CIFRI, conducted the environmental and fishery investigations in eleven of these backwaters along the south west coast of India in Kerala during 1996-98. The first year (1996-97) of the study was restricted to the environmental characteristics and the second year (1997-98) was devoted to the fishery investigations. The backwaters nvestigated are listed below.

	Backwaters	Abbr. Used	District	Area (ha)
1	Kadinamkulam	KDK	Trivandrum	347
2	Achuthengu	ANG	-do-	552
3	Ashtamudi	AST	Kollam	6424
4	Kayamkulam	KYK	Kollam/Alp	1652
5	Azhikode	AZK	Trissur	696*
6	Chettuva	CTV	Trissur	714
7	Ponnani	PNI	Trissur	908**
8	Kadalundi -Beypore	KDL/BPR	Kozhikode	1192
9	Mahe	MHE	Kannur	88
10	Valapattanam	VPM	Kannur	3074
11	Neleswaram	NEL	Kasargod	825

* Kodungallur-Azhikode estuary ** Ponnani+Puthuponnani

Source : Kerala Fisheries – An overview. 1992. Department of fisheries, Govt. of Kerala.

penetration in the Vembanad lake extending from the Cochin bar mouth to Alappuzha. Hydrological features in relation to salinity distribution were also studied by a few more workers. These include the work of Cherian (1967) Qasim and Gopinathan (1969), Ramamirthan *et al*. (1986, 1987) and Wellershaus (1972).

The nature of sediment and the distribution and dynamics of nutrients like nitrate, nitrate ammonia, phosphate and silicate in the Vembanad lake particularly in the Cochin backwater system has been a major area of research by several authors. Sankaranarayanan and Quasim (1969) and Sanakaranarayanan and Panmpannayil (1979) concentrated their research on the nutrient regimen in the water and sediment phases of Cochin backwaters in relation to other environmental features. Murthy and Veerayya (1972) gave a detailed account of the phosphorous content in the sediments of the Vembanad lake. Eswara Prasad (1982) has described the sediments of the Vembanad farming area adjacent to the Vembanad lake. A similar study in the prawn fields in and around Cochin backwaters is also presented by Aravindakshan *et al*. (1992) Purandara and Dora (1987) had studied the textural characteristics and organic matter of the near shore and surface sediment samples of the Vembanad lake between Azhikode in the North and Alappuzha in the south. One major contribution was by Sarala Devi (1989) and Sarala Devi *et al.* (1992) on the temporal and spatial distribution of particulate organic carbon and particulate matter in Cochin backwaters, especially in the lower reaches of the Periar river.

Studies on the primary production and its relation with other environmental parameters in the Cochin backwaters have been a major area of research by several workers. The important works in this direction are the estimation of plant pigments by Quasim and Reddy (1967), the solar radiation and related aspects by Quasim et al (1968). In depth studies on the gross and net productivity by light and dark bottle method as well as C14 methods were undertaken by Quasim *et al* (1969). This study has brought out the production respiration and assimilation rates in relation to the environmental parameters, the solar radiation, chlorophyll contents, and the biological components. Sarala Devi *et al.* (1979), Unnithan *et al.* (1975) and Vijayan *et al.* (1975) documented the effect of organic pollution due to industrial pollution on the some water quality parameters in Cochin backwater. Ramani et al. (1980) studied the quality of sediment in Cochin backwaters in relation to pollution aspects. Sarala Devi and Venugopal (1989) conducted elaborate studies in the Cochin backwater on the benthic communities under the impact of industrial pollution.

BACKWATERS – A LITERATURE REVIEW

In Kerala, hydrography of backwaters/*kayals* were extensively studied by various investigators. The rapid rate of environmental deterioration of Kerala backwaters had been pointed out by the studies of Unnithan *et al.* (1975); Gore *et al.* (1979); Qasim and Madhupratap (1979). Cochin backwaters has been studied by Bristow (1938); Qasim *et al.* (1968); Qasim and Gopinathan (1969); Sankaranarayanan and Qasim (1969); Qasim and Sankaranarayanan (1972); Wellershaus (1972); Haridas *et al.* (1973); Balakrishnan and Shynamma (1975); Chandrika (1976); Silas and Pillai (1975); Sarala Devi *et al.* (1979); Remani *et al.* (1980); Sankaranarayanan *et al.* (1986); Anirudhan *et al.* (1987), Korapuzha estuary by Rao and George (1959); Krishnamoorthy and Vincent (1975), Kallai and Beypore by Krishnamoorthy and Vincent (1981). Backwaters of Thrissur district, Kottapuram Chettuva and Azhikkode kayal was studied in relation o trace metal pollution by Remeshan (1993). Kayamkulam estuary by Mary John (1958); Antony (1975) and Prabha Devi *et al* (1996). Variations in hydrographic features and nutrient content in the backwaters, Kallai, Beypore, Korapuzha and Mahi were reported by Sarala Devi *et al.* (1983).

Dharmaraj and Nair (1981) studied the distribution of inorganic nutrients in the Ashtamudi backwaters in relation to environmental factors. The seasonal changes in physico-chemical parameters of water and sediment nutrients of Ashtamudi estuary had been investigated by (Nair *et al.* ,1983b, c, d, 1984b; Abdul Azis and Nair, 1986, 1987; Nair and Abdul Azis, 1987; George Thomas, 1995, Geetha Bhadran, 1997). Kadinamkulam backwaters had been investigated by Nair *et al.* , (1984c,d); Bijoy Nandan (1991), Bijoy Nandan & Unnithan (1998); Veli lake by Gopinathan (1985); Madhukumar (1987); Arunachalam (1989); Sujatha (1993) and Poonthura backwater by Kahar (1988). George Thomas and Fernandez (1993) conducted studies on the hydrography and species composition of selected mangrove ecosystems of Kerala.

Several studies have been conducted on the various physico-chemical aspects of the Cochin estuary in a fisheries perspective. Balakrishnan (1957) was one of the earliest to study the surface salinity of the Ernakulam channel, attributed to the rapid salinity fluctuations due to the influence of tide. George and Kartha (1963) recorded the surface salinity of Cochin backwaters in relation to the tidal reime. Josanto (1971) analyzed the bottom salinity characteristics and the factors that influence the saltwater

One major area of ecological investigations in the Vembanad lake was the qualitative and quantitative distribution of the plankton population. Studies have been conducted on the variation and distribution of phytoplankton and the factors affecting its production. One of the earliest reports in this context was George (1958) who has given an account of the general composition of the plankton from the Cochin backwaters. Subsequent important contributions were those of Qasim and Reddy (1967) on the concentration of Chlorophyll, Qasim et al. (1969) on the organic production, Qasim et. al. (1974) on the contributions of microplankton and the nannoplankton, Gopinathan (1972) on the plankton biomass, Gopinathan et.al;. (1974), and Joseph and Pillai (1975) on the total cell counts and temporal distribution of the phytoplankton, Quantitative and qualitative composition of plankton in Vembanad lake extending from Cochin to Alappuzha has been investigated by several authors (Davassy and Gopinathan 1970, Devassy and Bhattathiri 1974, Gopalakrishnan et.al 1988). The phytoplankton was exclusively studied by Gopinathan (1972) in the Cochin backwaters where he reported the presence of 62 species of Bacillariophyceae, 24 species of Dinophyceae, 3 species of Myxophyceae and 2 species of Cilioflagellates.

Several literatures are available on the distribution and diversity of benthic fauna in the Vembanad lake during the pre-barrage phase, and that too concentrating on the Cochin area. Some of the earlier works in this direction incude that of Desai and Krishnankutty (1967), Govindankutty (1967), Jayasree (1995), Kurian (1967,1972), and Remani (1979). The notable contributions during the post barrage phase were by Aravindakshan *et.al.* (1992), and Gopalan *et. al.* (1987). Sarala Devi *et. al.* (1991) elaborated the coexistence of different benthic communities in the northern limb of Cochin backwaters. Nair *et. al.* (1983) gave an account on the population dynamics of amphipods in Cochin backwater area. Devassy and Gopinathan (1970), Kurian et. al (1975) undertook some of the investigations on the benthic fauna extending right from Cochin to Alappuzha.

Investigations on the distribution and abundance of fishes of Vembanad lake extending from Cochin to Alappuzha have been done by a number of workers. Pillai (1960) made a record of distribution of the *Hilsa ilisha* in the lake, while Shetty (1965) made a comprehensive description of the fishery practice along with a listing of the commercially important fish and prawn species of Vembanad lake. Kuttyamma (1980) assessed the distribution and abundance of prawns and prawn larvae in

Cochin backwaters. Raman (1964, 1967) made the first contribution on the biology of the *Macrobrachium rosenbergii* and tried to quantify its fishery in the lake. He also delineated the nursery grounds of *M. rosenbergii* in the river stretches that feed the lake. Raman *et.al.* (1975) also gave an account of the biology of Ambassis gymnocophalus from the Vembanad lake and compared with that of the Pulicat lake in Tamil Nadu. Kuttyamma (1980) assessed the distribution and abundance of prawns and prawn larvae in Cochin backwaters.

The fishery estimation during the post barrage phase of Vembanad lake were reported by Kurup and Samuel (1987), Gopinath (1956), Shetty (1965) Kurian and Sebastian (1982) and Kurup *et al.* (1993). Enumeration of the gear and fish landings was done by them category wise, sector-wise and species-wise. Kurup and Samuel (1987) listed 150 species of fishes belonging to 100 general categorized under 56 families. The impact of indiscriminated fishery practice and environmental stress on the *Macrobrachium* fishery of the lake has been described by Kurup (1994). The fishery and biology of four species of Macrobrochium viz., the *M. rosenbergii, M. idella, M. scabriculum, M. equidens* in the lake were described by him.

The clam fishery has been another important resource of the lake. Its fishery was studied by Kurup *et al.* (1993) and Rasalam and Sebastian (1976). The back clam, *Villorita cyprinoids* formed the major molluscan fishery in the Vembanad lake. The survey of the literature reveals that most work on the lake are available for the pre-barrage phase and that too restricted to the Cochin sector of the Lake. The information on the southern sector during the post barrage phase is scanty except for the contribution on the fishery by Kurup (1993) and Kurup and Samuel (1987). The pioneering and most recent scientific information available from the Vembanad lake in the post barrage phase is from the studies conducted by the Central Inland Fisheries Research Institute is during the 1994-97 period (Anon, 2000).

Objectives of the project

The ecology and fisheries of following backwaters as indicated in Fig 2 were investigated on a time scale basis as outlined below. Sampling was conducted from various stations in the backwaters are shown in the figures. The sampling work also covered the retting and from non retting zones.

1. Kadinamkulam	2. Anchuthengu	3. Ashtamudi	4. Kayamkulam
5. Azhikode	6. Chettuva	7. Kadalundi - Beypore	8. Ponnani
9. Mahe	10. Valapattanam	11. Neeleswaram	

In addition the water quality and plankton diversity of selected incoming rivers and canals in the Vembanad lake was also studied during the period.

Ecological parameters

i) Water quality: Temperature, transparancy, pH, dissolved oxygen, hardness, alkalinity, suspended solids, sulphides, nitrates, phosphate,

ii) Soil quality: Temperature, pH, nitrates, phosphates, organic carbon, texture, available nitrogen

iii) Estimation of chlorophyll-a in phytoplankton

iv) Environmental stress from pollution load: Estimation of COD/BOD_5/sulphides at selected sites.

v) Plankton and benthos: Qualitative and quantitative composition, and diversity.

Fishery parameters

vi) Fishery survey: Collection of fish landing data, estimation of CPUE, income distribution, and collection of data on craft & gear from the different landing centers in the backwaters are given in Table 1.

vii) Abundance of fish/shellfish larvae and young ones in the backwaters.

Analysis for water and sediment for various parameters as well as for primary productivity and chlorophyll were based on APHA (1995), Strickland and Parsons (1972) and Jackson (1973); that for plankton by Davis (1955), Ward and Whipple (1959) and that for benthos by Holme and Mc Intyre (1971), Fauvel (1953). The fish catch, its composition, catch per unit effort (CPUE) were also estimated from the different backwaters (Talwar and Arun G. Jhingran, 1991; Gupta *et al*. 1997).

WATER QUALITY

The water quality parameters were recorded from the eleven backwaters during the pre- monsoon, monsoon and post monsoon periods (Figs. 3, 4 & 5).

Table 1 List of Fish landing centers in the various backwaters investigated during 1997-98

Sl. No.	Backwater	Landing Centres
1	Neeleswaram	Thai kadappuram (Azhithala), Madakkara Kavumchira, Orikadavu, Valiyaparambu kadavu Orkalam kadavu, Thai kadappuram jetty
2	Valapattanam	Kattampalli kadavu, Valapattanam Market
3	Mahi	Mahi Market
4	Ponnani	Veliyamkode Market, Beeyam kadavu Kundukadavu palam, Azhimukom jetty(Pallikadavu)
5	Chettuva	Anchamkallu, Chettuva palam, Kundazhiyoor Kandassam kadavu, Banglam kadavu
6	Azhikode	Anapuzha Market, Krishnankotta kadavu
7	Kayamkulam	Muttathumannel, Keerikadu jetty, Kanakakunnu Mahadevi kadu, Choolatheruvu, Kochiyude jetty Vettathukadavu
8	Ashtamudi	Peruman palam, Chavara South, Arinellur kadavu Kavummoola kadavu, Ashtamudi bus stand Neendakara palam
9	Anchuthengu	Pandakasala Market, Irrengu kadavu, Meeran kadavu Panayakadavu
10	Kadinamkulam	Perumkuzhi kadavu, Perumathura, Thazhampally kadavu Murukkumpuzha kadavu, Azhoor Market

pH was generally near neutral to alkaline in range. However, there was a reduction in its value particularly during the pre-monsoon period, owing to less mixing coupled with the impact or retting activity at certain stations. Anchuthengu, Kadinamkulam, Azhikode, Kadalundi and Chettuva recorded lower pH values. This was mainly due to the organic acids liberated during the retting. The mean pH values varied from 6.85 in Kadinamkulam to 8.12 in Chettuva backwater during pre-monsoon season. During monsoon, the variation was from 6.63 in Azhikode to 7.68 in Ashtamudi, whereas it varied from 6.74 in Ponnani to 8.20 in Neeleswaram during the post-monsoon period.

Moderate to low transparency values were observed in the systems (0.29-1.54m). Retting areas had significantly lower values, particularly during the pre-monsoon period due to the accumulation of coir pith and ret liquor containing organic acids like pectin, pentosan, phenol, tannin, *etc.* in the water body. Turbidity from runoff substantially reduced the transparency in these shallow systems during monsoon while organic pollution resulted in low transparency during the pre-monsoon season. The salinity values indicated mixo-haline condition of these systems with a range of 5.20-32.38 ppt during the pre-monsoon, 0.18 to 22.42 ppt during the monsoon and 0.5 to 28.6 ppt during the post-monsoon periods. Such high variation was also dependent on the tidal impact and sampling time.

The dissolved oxygen level did not exhibit wide variation during the monsoon while nil to low values were observed at certain stations during the post-monsoon and the pre-monsoon periods. The highly stressed environment was evident from the fact that on an average, 7 out of the 11 investigated water bodies recorded dissolved oxygen within a range of 1.73-4.57 ppm during the pre-monsoon survey. Marked depletion of dissolved oxygen leading to anoxic condition coupled with the presence of sulfide was the most conspicuous observation at certain stations. This was mainly due to the intense retting activity in these zones. The dissolved sulphides had an alarming concentration level in six of the systems during the pre-monsoon days. Sulfides exceeding 10mg/l coupled with nil-<2.0mg/l dissolved oxygen was prevalent in 12 of the 32 stations investigated during this season. Bottom layers of five sampling stations recorded no dissolved oxygen during the pre-monsoon months. This has been despite the exposure of the sampling stations to the tidal amplitudes twice a day.

The monsoon showers brought nutrients from allochthonous sources into the systems elevating the phosphate, nitrate and silicate concentrations in the water. Moderate to high COD values were observed during the post-monsoon when compared to the monsoon season. The high COD load could be due to the intense of retting activity and runoff from the surrounding areas.

The study indicated that retting of coconut husk in the backwaters has been the most contributing factor to the organic pollution leading to the depletion in the faunal resources in the backwaters as by the observati >r s especially during the pre-monsoon survey. Nine of the eleven systems investigated were subjected to rampant retting activity.

Table 2 Mean percentage variation in sediment quality in selected backwaters during1997-99 period

	PRE-MONSOON										
	NEL*	VPM	MHE	KDL	CTV	AZK	KYM	AST	ANG	KDK	MEAN
Temperature °C	0.00	29.83	29.33	30.60	30.17	31.37	32.00	32.10	32.50	31.50	31.04
pH	0.00	7.57	7.72	7.63	7.97	7.65	5.94	5.24	3.61	4.20	6.39
Conductivity (mmhos)	0.00	23.67	27.67	29.00	28.33	33.00	32.00	57.00	26.00	28.25	31.66
Organic carbon (%)	0.00	1.66	1.89	2.11	1.78	1.08	1.47	6.91	3.38	3.34	2.62
Available phosporus (%)	0.00	0.59	0.64	0.37	0.55	0.43	0.31	0.43	0.18	0.14	0.40
Calcium carbonate (%)	0.00	6.92	4.33	7.50	2.75	2.67	2.42	17.65	0.63	0.88	5.08

* sampling not undertaken

	MONSOON										
	NEL	VPM	MHE	PNI	CTV	AZK	KYM	AST	ANG	KDK	MEAN
Temperature °C	26.80	0.00	27.33	0.00	0	0	29.00	28.88	29.83	27.63	28.25
pH	7.42	6.74	7.81	6.49	7.7615	6.617	7.53	7.55	5.11	6.65	6.97
Conductivity (mmhos)	1.06	1.08	0.87	0.49	0.518	0.8316	9.57	16.16	1.61	25.49	5.77
Organic carbon (%)	0.73	1.25	0.92	0.79	1.3975	1.24	0.83	2.55	1.08	1.42	1.22
Available phosporus (%)	0.19	0.16	0.22	0.11	0.3795	0.9	0.18	0.34	0.07	0.11	0.27
Calcium carbonate (%)	0.95	0.63	0.92	0.94	3.75	0.328	0.44	8.08	0.29	1.25	1.76

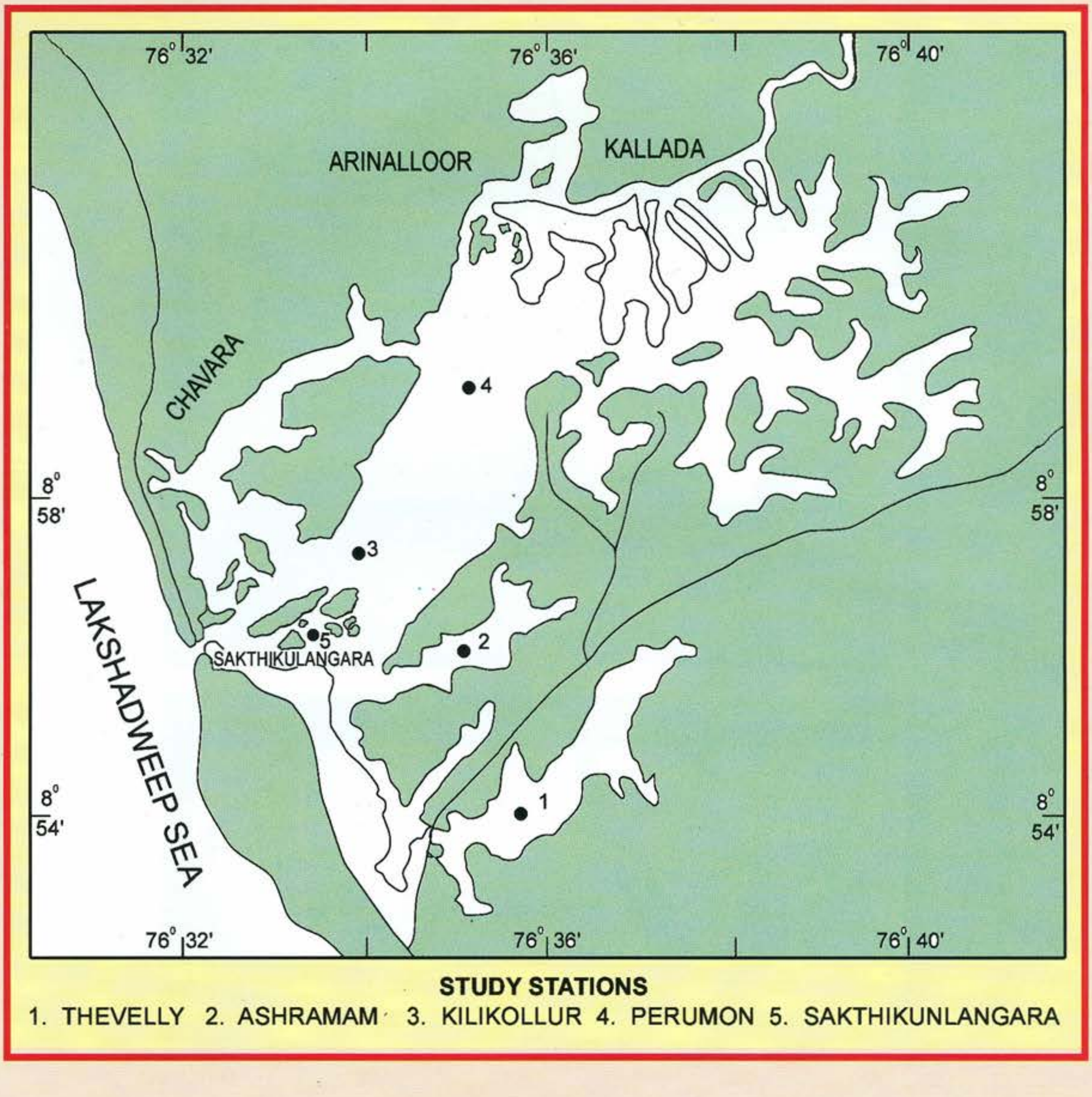
	POST MONSOON										
	NEL	VPM	MHE	PNI	CTV	AZK	KYM	AST	ANG	KDK	MEAN
Temperature °C	31.06	30.42	30.18	30.28	30.03	30.80	31.30	30.75	30.55	31.47	30.68
pH	7.54	6.16	7.65	5.03	6.63	7.10	7.32	6.87	5.81	5.76	6.59
Conductivity (mmhos)	9.96	3.23	5.01	3.55	5.55	3.24	21.95	40.88	4.18	14.91	11.25
Organic carbon (%)	0.45	0.59	0.28	0.88	0.14	0.63	1.63	0.65	0.55	2.77	0.86
Available phosporus (%)	0.45	0.24	0.39	0.16	0.30	0.28	0.32	0.45	0.12	0.08	0.28
Calcium carbonate (%)	3.05	3.00	3.63	2.00	3.13	2.85	4.44	6.92	2.44	2.00	3.34

SEDIMENT QUALITY

The sediment parameters showed wide variations between the different backwaters during the pre monsson, monsoon and post monsoon periods. The temperature was generally high during the pre-monsoon followed by the post-monsoon and the monsoon periods (Table- 2). pH0 showed acidic trends in many of the backwaters particularly towards the southern, represented by the Kadinamkulam, Anchuthengu, Ashtamudi and Kayamkulam backwaters. A lowest mean value of 3.61 was recorded in Anchuthengu backwater during the pre-monsson period. The acidic pH of the sediment could be due to the intense pectinolytic activity during retting of coconut husk in the backwaters resulting in lowering of the values. Conductivity and organic carbon values were also high during the pre-monsson period as compared to the other two seasons, indicative of the accumulation of organic matter and other materials during the period. The intense retting activity resulting in organic enrichment was also responsible for the higher organic content of the sediment in the southern backwaters as compared to the northern. Calcium carbonate was at its peak in Ashtamudi (Av.17.65%) during the pre-monsoon and the lowest in Anchuthengu backwater (Av. 0.29%) during the monsoon period. The mining activity of clams and oysters was more prevelant in the southern backwaters which could have resulted in higher values of calcium carbonate in the sediment. The available phosphorous content was high during the pre-monsoon with an average of 0.40% during the pre-monsoon followed by monsoon (Av.0.27%) and post- monsoon (Av. 0.28%) in the ten backwaters.

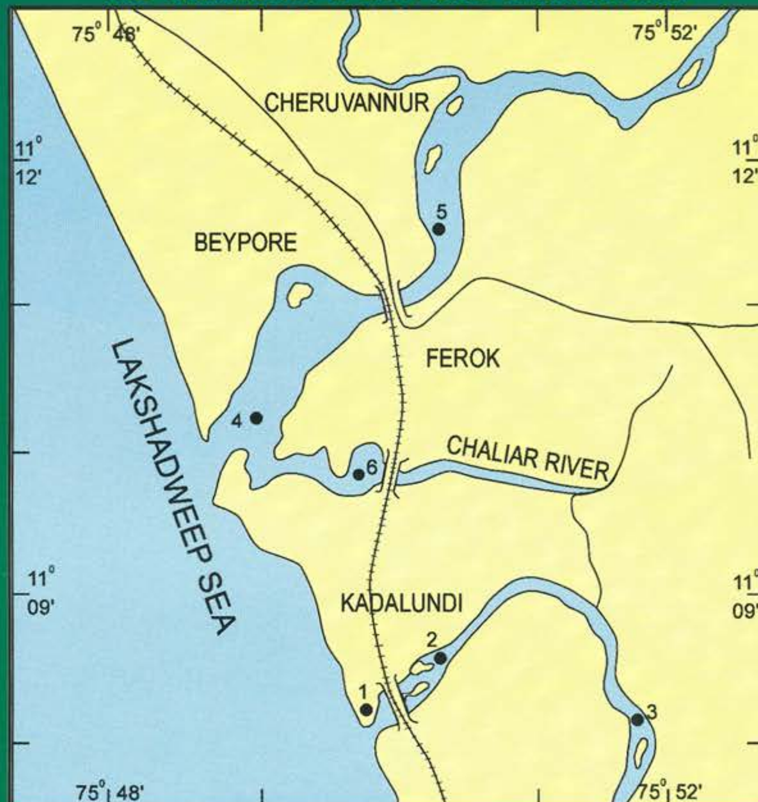
Sand fraction dominated in all the backwaters investigated followed by clay and silt. The northern backwaters were higher in the sand content as compared to the sothern systems (Table 3).

FIG. 1 MAP OF KERALA INDICATING THE MAJOR BACKWATERS, RIVERS & RETTING ZONES



THE ASHTAMUDI BACKWATER

THE KADALUNDI & BEYPORE BACKWATERS

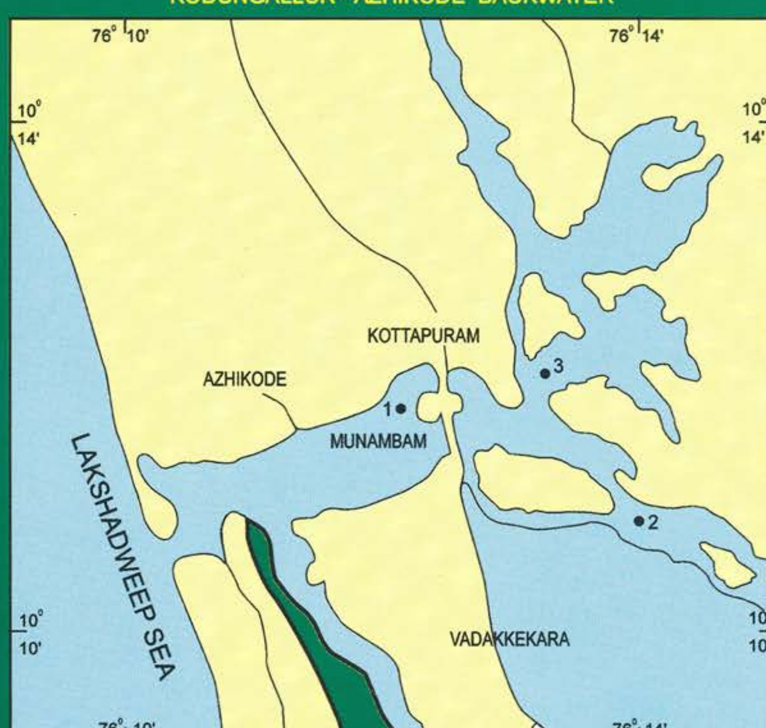


STUDY STATIONS

KADALUNDI
1. KADALUNDI AZHI
2. BALATHURUTHU
3. KADALUNDI SOUTH

BEYPORE
4. CHALIUM
5. FEROK
6. PALLIKADAVU (MAVOOR)

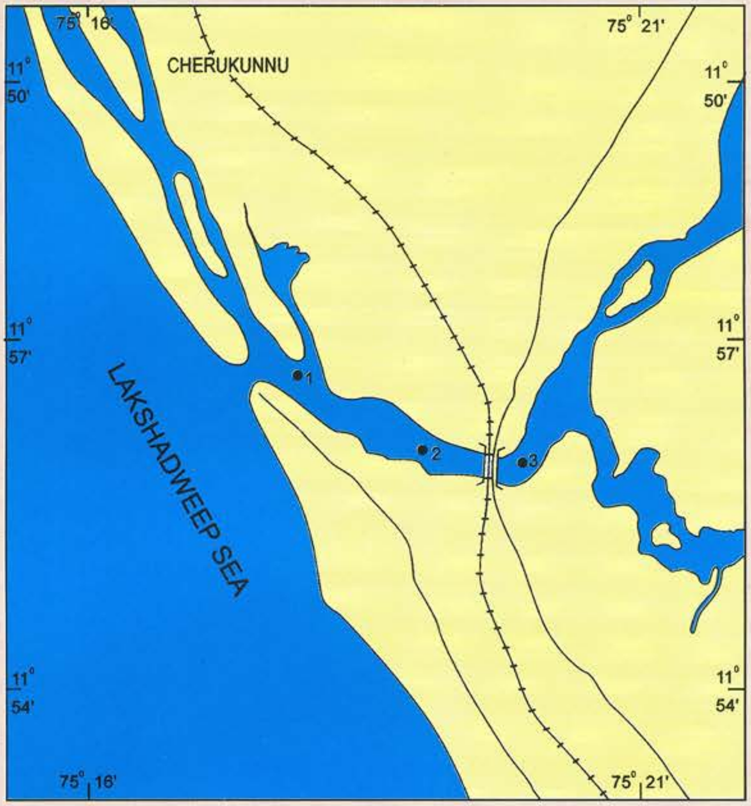
KODUNGALLUR - AZHIKODE BACKWATER



STUDY STATIONS

1. CHERIATHURUTHU 2. GOTHURUTHU 3. ANAPPUZHA

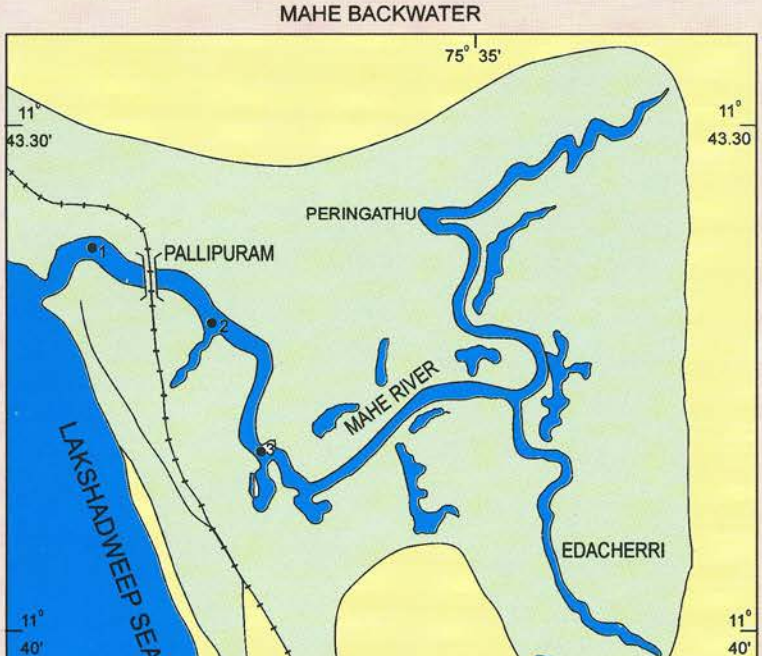
VALAPATTANAM BACKWATER



STUDY STATIONS

1. THATTUPURAM 2. POITHUMKADAVU 3. KARIYIL

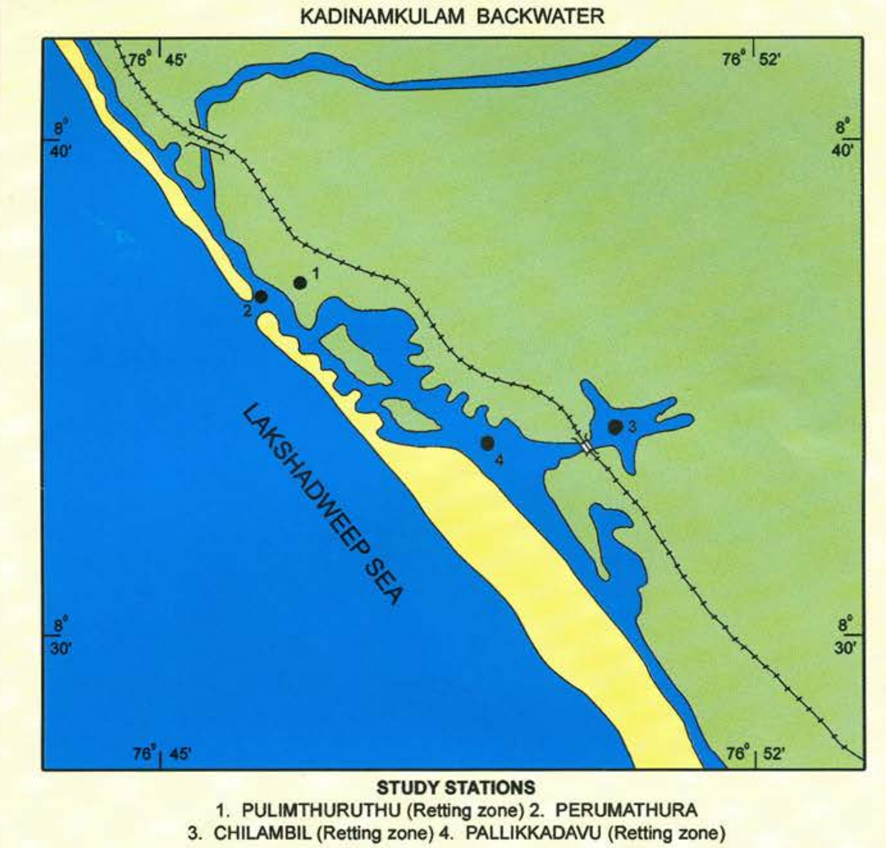
MAHE BACKWATER



STUDY STATIONS

1. PATHIKKAL 2. MANCHAKKAL 3. MAHE JETTY

FIG. 1 MAP OF KERALA INDICATING THE MAJOR BACKWATERS, RIVERS & RETTING ZONES



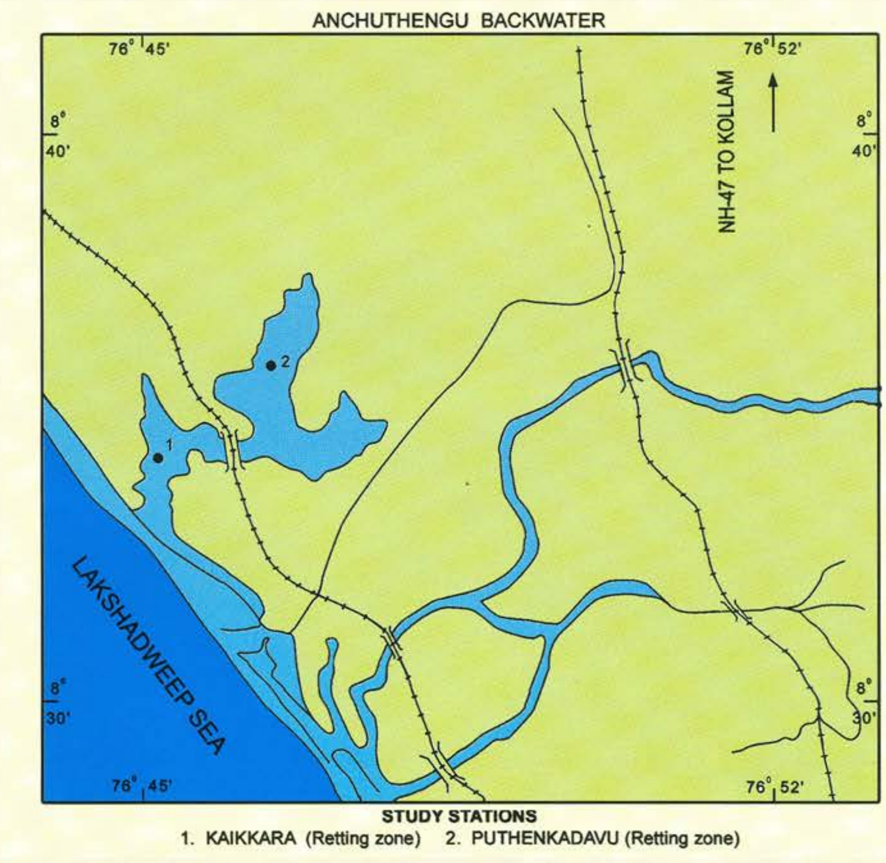


FIG. 2 MAPS OF SELECTED BACKWATERS INDICATING THE STUDY STATIONS DURING 1996-98

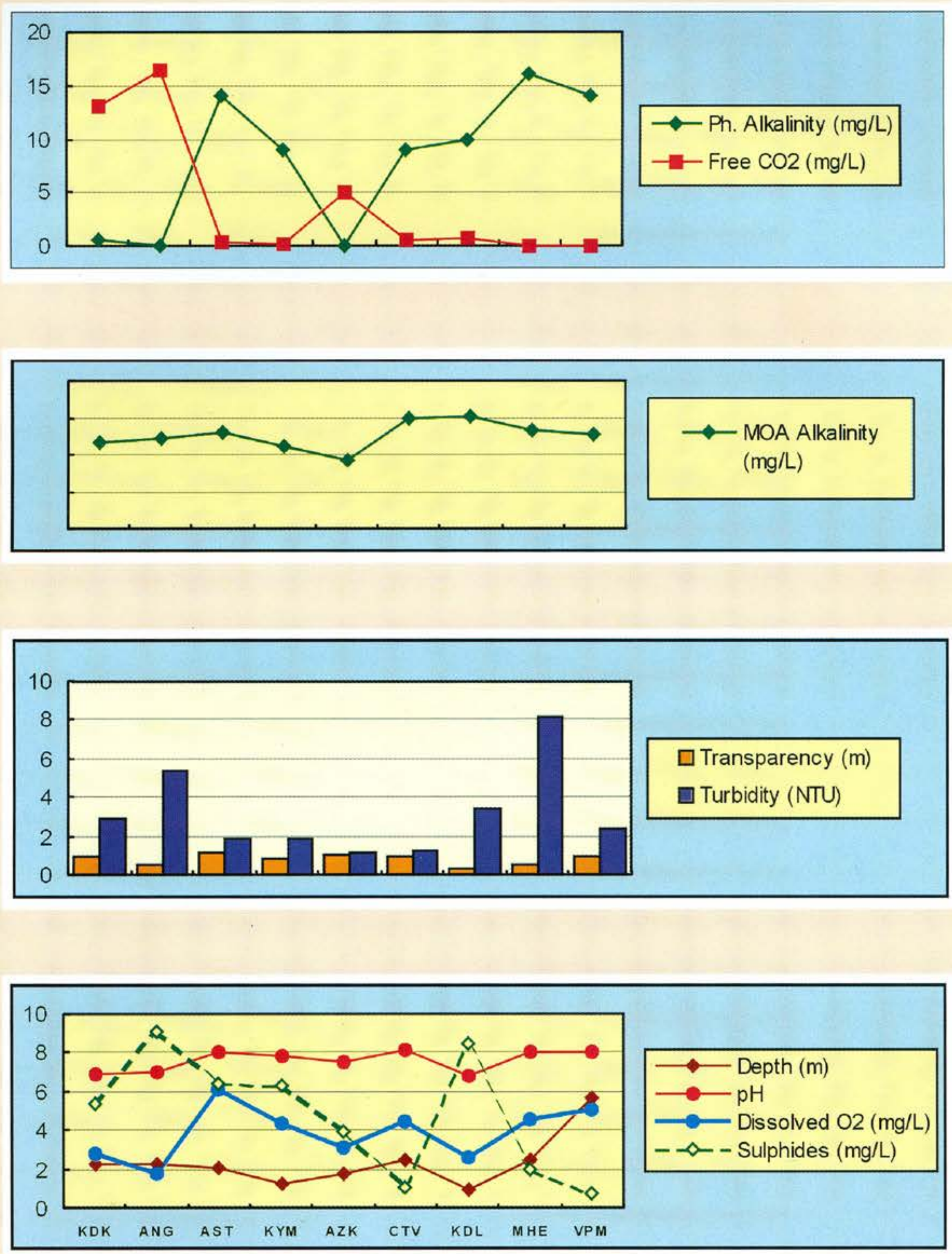


Fig. 3 Mean water quality variations in selected backwaters during pre monsoon period.

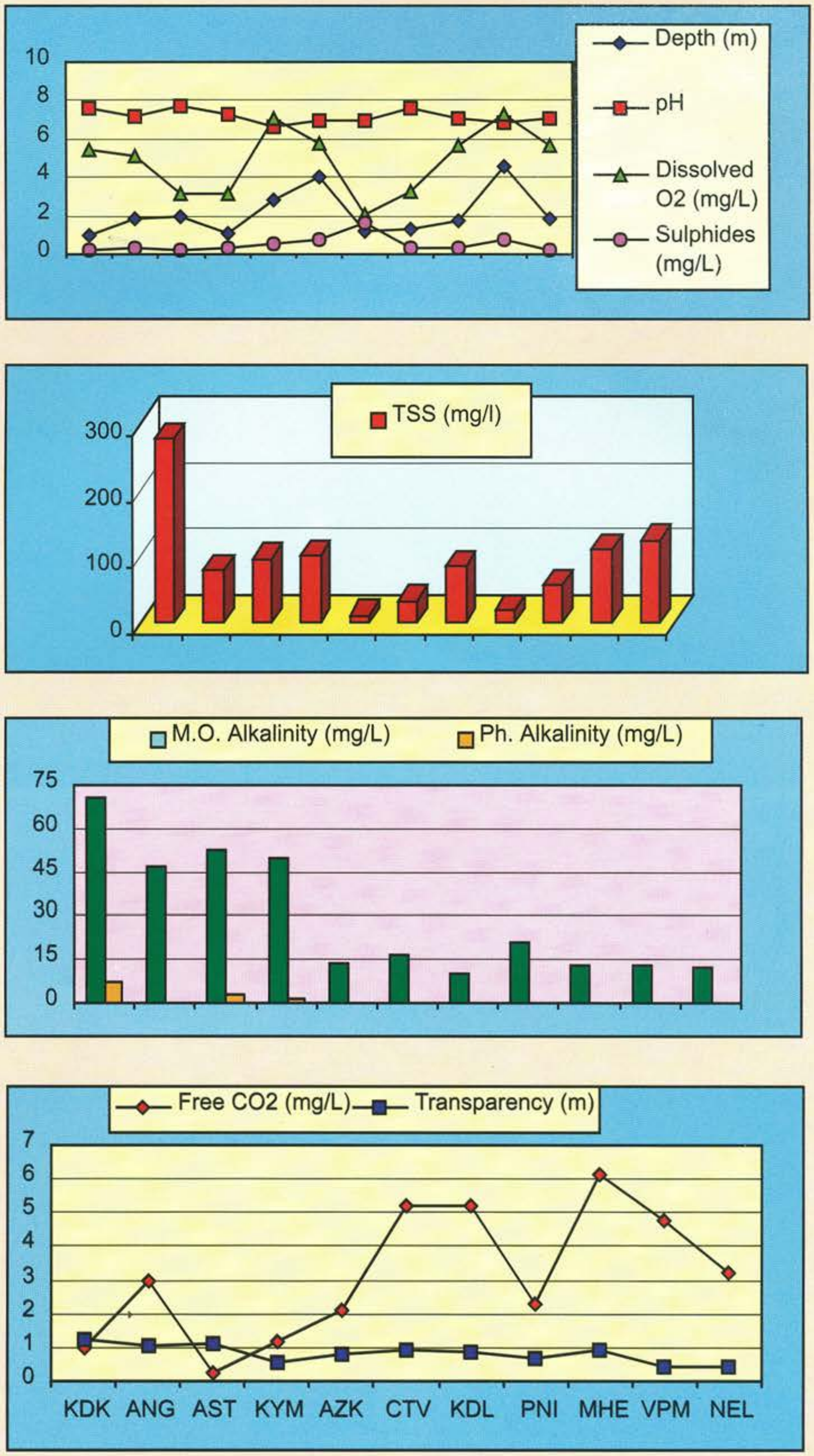


FIG. 4 MEAN WATER QUALITY VARIATION IN SELECTED BACKWATERS DURING THE MONSOON PERIOD

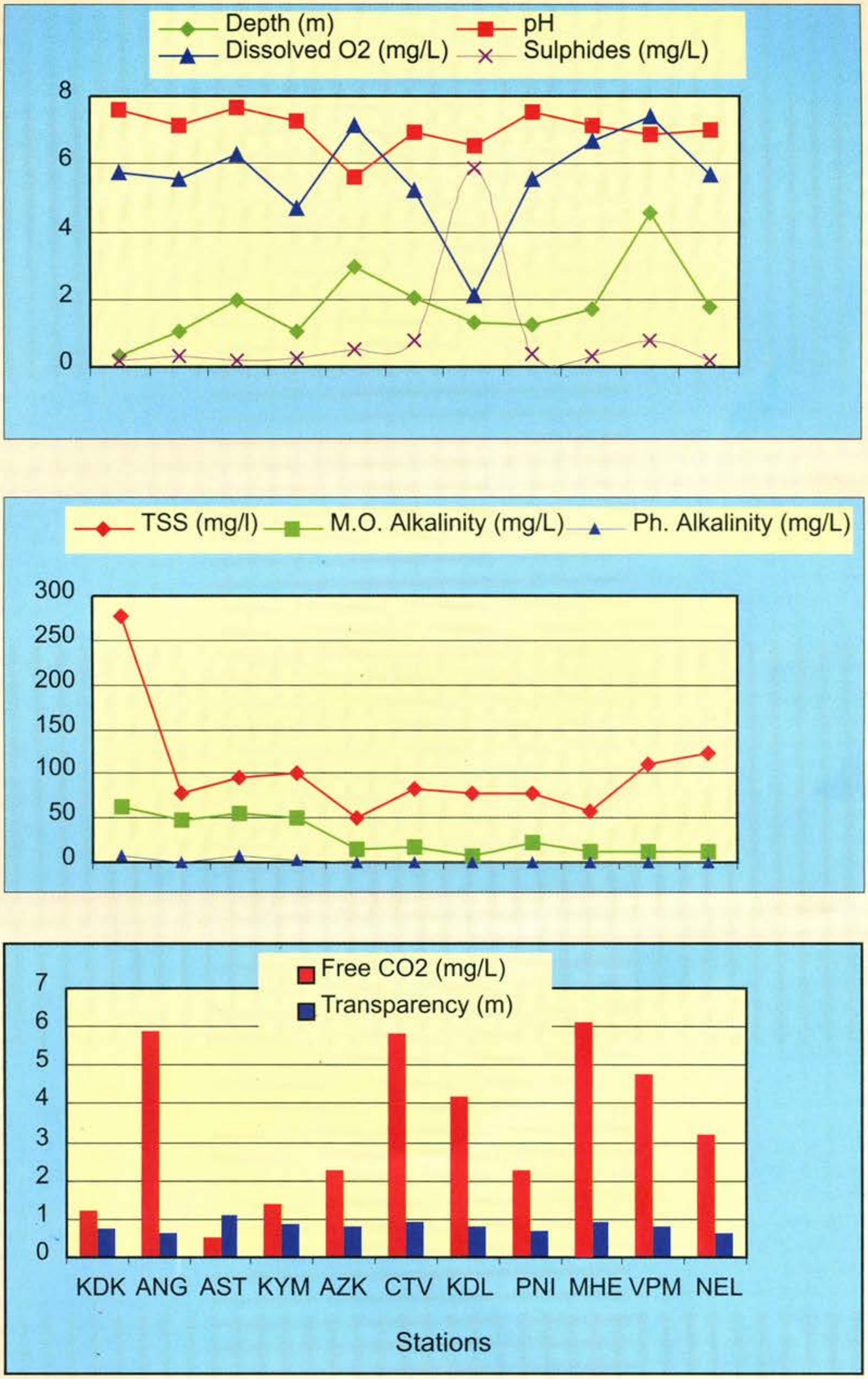


Fig. 5 Mean water quality variations in selected backwaters during post monsoon period.

Table 3 Mean percentage variation in sediment texture in selected backwaters during 1997-99 period

PRE-MONSOON	NEL *	VPM	MHE	KDL	CTV	AZK	KYM	AST	ANG	KDK	MEAN
Sand	0.00	33.94	34.20	37.12	31.22	37.26	53.42	30.47	28.49	38.26	36.04
Coarse sand	0.00	50.44	50.10	20.61	52.38	50.63	25.72	16.16	28.24	28.92	35.91
Silt	0.00	2.75	10.10	11.80	3.67	2.67	3.00	16.50	2.75	9.08	6.92
Clay	0.00	12.32	17.70	29.78	12.23	8.90	16.98	37.70	39.15	20.48	21.69

* sampling not undertakern

MONSOON	NEL	VPM	MHE	PNI	CTV	AZK	KYM	AST	ANG	KDK	MEAN
Sand	75.36	36.38	[illegible]	29.93	19.81	51.83	10.27	22.74	48.46	21.15	35.61
Coarse sand	19.39	54.27	[illegible]	67.50	55.35	37.47	59.53	45.71	45.98	70.59	50.80
Silt	2.18	3.55	[illegible]	1.25	5.40	1.45	4.75	16.83	2.77	3.50	4.38
Clay	2.57	4.90	5.07	1.21	11.96	8.45	21.34	13.86	2.30	10.59	8.23

POST-MONSOON	NEL	VPM	MHE	PNI	CTV	AZK	KYM	AST	ANG	KDK	MEAN
Sand	53.62	45.40	46.41	50.76	25.45	47.57	45.48	7.45	48.60	27.52	39.83
Coarse sand	27.41	37.91	31.02	38.39	47.05	44.14	19.29	49.84	48.60	41.23	38.49
Silt	8.10	3.82	2.83	1.31	6.56	1.55	10.81	16.71	3.81	5.29	6.08
Clay	10.44	12.17	9.57	8.78	20.71	6.05	23.90	25.19	13.00	19.09	14.89

The post-monsoon period was characterized by the peak sand fraction followed by pre-monsoon and the monsoon periods. Coarse sand also formed an important constitutent of the sediment texture contributing a mean of 50.80% (Av.) during the monsoon, 38.49% (Av.) during the post-monsoon and 45.91% (Av.) during the pre-monsoon. Silt distribution in the backwaters were very uneven without any steady pattern, where Ashtamudi had the highest average in all the three seasons followed by Kadalundi during the pre-monsoon and Kayamkulm during the monsoon and post monsoon periods. The clay fraction was maximum in the southern backwaters during all the three seasons with expectionally high mean value in Anchuthengu (Av.39.15%). This could be due to the high organic enrichment due to retting activity as well as the stressed condition due to the dry pre-monsoon months prevelant in the backwater.

IMPACT OF RETTING ACTIVITY IN THE BACKWATERS

There are several anthropogenic interventions affecting the sustainability of fisheries development in the country. Some of them are effluent discharge from factories / industries, organic pollution from various sources and a host of others. But, retting of coconut husk for the production of coir is the most extensiveand the most singular form of pollution on the south west coast of the country, affecting the entire backwater ecosystems of the region. Retting, is basically a " soaking process " where husks are arranged in bundles in huge coir nets known as "malis" and allowed to float freely in the backwaters, until they get soaked, become heavy and gradually sink to the bottom. Retting is a biological process involving bacteria, fungi and yeast. Large chunks of pectin, phenol, cellulose, hemicellulose and tannin are released from the husk into the surrounding medium, during different stages of retting.

In depth studies on the impact of retting activity on the backwater systems, was reported by Bijoy Nandan (1997, 2004). Acidic pH condition coupled with anoxia and production of high concentrations of hydrogen sulphide were the outstanding feature, in the environmental quality of the retting zones. The higher concentration of free CO2 in the retting zones could be attributed to the process of decomposition of organic matter like pectin, phenol, tannin etc. leading to a rise in temperature of the medium, thereby favouring production of the gas (Table 4 & Fig.6). The primary productivity mechanism was totally collapsed in the retting zones. It has thus shown that the productivity potency of the coastal ecosystems was adversely affected due to pollution from retting activity. The mean chlorophyll a (1.63mg/m3) and algal biomass (1.09 g/m3 wet wt.) values were very low in the retting zones as compared to the non-retting zones (chlorophyll a: 9.65 mg/m3 ; algal biomass : 6.46 g/m3 wet wt.). Studies by Bijoy Nandan (1997) have shown that the plankton, benthic fauna and fish biodiversity showed massive depletion in the retting zones as compared to the non retting zones. Mass mortality of fish and shell fishes were reported from the retting zones, particularly during the pre monsoon period affecting the sustainable fish production in this region as well as the adjacent areas.

Table 4 Mean values of physico-chemical characteristics of retting and non-retting zones in the backwaters

Parameter	Retting zone	Non-retting zone
Depth (m)	1.88	2.88
Transparency (m)	0.60	0.69
pH	6.92	7.99
Dissolved oxygen (mg/L)	2.43	7.60
Total sulfides (mg/L)	8.80	3.01
Turbidity (NTU)	2.62	1.60
Free carbon dioxide (mg/L)	6.4	3.5
Alkalinity (MO) (Mg/L $CaCO_3$)	103	91
Alkalinity (Ph.) (Mg/L $CaCO_3$)	6.7	10
Inorganic phosphate (mg/L P)	40.6	36.5

The biomass values of plankton in the retting zones, were greatly reduced, the lowest in the retting zones of Kadinamkulam (0.4ml/l) and the highest in the non- retting zones of Valapattanam (12.8 ml/l). The incidence, abundance and diversity of fauna were greatly depleted in the retting zones as compared to the non-retting zones. This depletion was more prominent during the pre monsoon period when the retting process attained its peak, resulting in anoxic conditions coupled with the formation of high concentrations of sulphide in the medium. The diversity index (H), richness index (d) and evenness index were generally low in the retting zones.

WATER QUALITY OF THE INCOMING RIVERS IN VEMBANAD LAKE AND ITS CANALS

The water quality of the four rivers viz., the Achancoil, Pamba, Manimala and Meenachal rivers and the municipal canals which drain into the Vembanad lake were studied for their water quality and the nutrient loading into the wetland (Fig. 7). The water from the rivers was characterised by high level of suspended solids and nutrients during the monsoon. The closure of Thaneermukkom barrage during the November-December period results in trapping of the nutrients brought to the lake by the rivers during the post- monsoon and pre-monsoon seasons. The water-borne nutrient trapping in the southern sector of the lake was thus estimated to be around 2462 thousand tons of NO3-N and 235.3 thousand tons of PO4-P annually (Table 5). These four rivers had a discharge rate of 6703 million m3 during the south-west monsoon season into the southern sector of the Vembanad lake. The rate during the post monsoon was to the extent of 2482 Mm3 including that of the north-east monsoon during November. The pre-monsoon season extending from January to May had a feeble discharge rate of 388 Mm3.

The water quality of the four canals leading to the lake indicated a marked deterioration with low transparency, high conductivity (917m S/cm), TDS (478.0 mg/l), alkalinity (116 mg/l), hardness (137 mg/l) COD (18 mg/l), and low dissolved oxygen (0.6-5.6; av.2.0 mg/l) during the monsoon months. Thejetty canal receiving much of the city sewage had 58.0 mg/l COD and 34 mg/l BOD during the summer. The canals are also drained into the southern sector of the Vembanad lake.

Table 5 Nutrient loading in to the Vembanad lake from the four rivers

Rivers load	Total discharge (million m^3/yr)		Nutrient concentration (mg/L)				Total nutrient ('000t/yr)	
	Monsoon	Other months	Monsoon		Other months			
			PO_4	NO_4	PO_4	NO_4	PO_4	NO_4
Achankoil	1263	805	299	11	214	17	549.9	27.6
Pampa	2349	1409	272	19	154	13	855.9	62.9
Manimala	1207	520	355	17	150	14	506.5	27.8
Meenachal	1884	636	256	57	106	15	549.7	116.9
TOTAL	6703 186.4	3370	Total during Monsoon				1927.3	
			Total during other months				534.7	48.8
			TOTAL				2462.0	235.2

DIVERSITY OF PLANKTON IN CANALS AND RIVERS

Phytoplankton in the canals and rivers were composed of green algae, blue greens, yellow browns, desmids, diatoms and dinoflagellates. Blue green algae formed the biggest component contributing an average of 49% for the three canals whereas it was 57% in the four rivers (Table 6). Green algae contributed 48.5% (av.) in the canals having 11 species, but only 20% formed the population in the rivers with 13 species. In the canals Phaeosphaera sp. had the highest mean percentage abundance (14.2%) followed by Microsproa sp., that in the rivers Pediastrum sp. (4.79%) and Hormidium sp. (3.24%) showed the peak incidence. Microcystis sp (10.96%), Spirulina sp. (18.39%) representing the blue greens contributed the maximum in the canals whereas in rivers it was Anacystis (25.56%) and Microcystis sp. (26.95%). Dinobryon was observed in the riverine zones with an average of 6.46%. Desmids (1.26% for canals; 15% for rivers) and Diatoms (0.77% for canals and 1.09% for rivers) contributed significantly to the biomass in both the water bodies investigated.

Table 6 Mean numerical abundance (no/m^3) and percentage distribution of Phytoplankton in the Canals and Rivers of Vembanad lake

	Canals					Rivers					
Phytoplankton	Canal : 1	Canal : 2	Canal : 3	**Mean (no/m^3)**	%	MHL	PMP	ACH	MNL	**Mean (no/m^3)**	%
Green Algae											
Acanthosphaera sp.											
Actidesmium sp.							42			11	0.02
Botryococcus sp.	1865	516	430	937	0.46		84			21	0.04
Closteriopsis sp.							273			68	0.11
Cylindrocapsa sp.									1247	312	0.52
Hormidium sp.		252		84	0.04	480	1755	4513	945	1923	3.24
Microspora sp.	9089	15789	50864	25247	12.49	3184	6916	2282	2640	3756	6.32
Monostroma sp.		63	129	64	0.03	172	258	120	168	180	0.30
P. duplex	960	4122	8160	4414	2.18	240	105	150	120	154	0.26
Pediastrum sp.	7742	10620	16800	11721	5.80	4639	680	1714	4335	2842	4.79
Phaeosphaera sp.		39888	47520	29136	14.42						
Schizogonium sp.									126	32	0.05
Spirogyra sp.	3731	11133	1080	5315	2.63	774	4980	301	357	1603	2.70
Ulothrix sp.	301			100	0.05		2289	570		715	1.20
Volvox sp.	5530	21420	29692	18881	9.34						
Zygnema sp.		6420		2140	1.06	387	129		1113	407	[illegible]
Sub Total	29218	110223	154675	98039	48.52	9876	17511	9650	11051	12022	20.24
%	34.45	54.68	48.37	48.52	48.52	7.01	55.65	52.09	23.66	20.24	20.24
Blue Green Algae											
Anacystis sp.	2107	1239		1115	0.55	58980			1740	15180	25.56
Aphanocapsa sp.	86			29	0.01	129	129		336	149	0.25
Gomphosphaeria sp.	430			143	0.07	1800	486	559	315	790	1.33
Lyngbya sp.					0.00	189	817	2674	512	1048	1.76
Merismopedia sp.	780		602	461	0.23						
Microcystis sp.	780	24360	41280	22140	10.96	63000	315	714		16007	26.95
Nostoc sp.	480	1320		600	0.30						
Oscillatoria sp.	20976	23365	60246	34862	17.25	860	1099	864	810	908	1.53
Skujaella sp.	5891	1239	3053	3394	1.68	86				22	0.04
Spirulina sp.	18480	34440	58553	37158	18.39		60			15	0.03
Sub Total	50010	85963	163734	99902	49.44	125044	2906	4811	3713	34119	57.45
%	58.96	42.64	51.20	49.44	49.44	88.77	9.24	25.97	7.95	57.45	57.45
Yellow Brown Algae											
Dinobryon sp.						233	351		14760	3836	6.46
Sub Total						233	351		14760	3836	6.46
%						0.17	1.12		31.60	6.46	6.46
Desmids											
Arthrodesmus sp								84		21	0.04
Closterium sp.		1982		661	0.33	129	728		447	326	0.55
Cosmarium sp.		1047		349	0.17	84	363		1140	397	0.67
Desmidium sp.		720		240	0.12	512	5787		5100	2850	4.80
Genicularia sp.						860	559	1333		688	1.16
Gonatozygon sp.		168		56	0.03	817	1488	270	5124	1925	3.24
M. americana					0.00	0	147	84		58	0.10
Micrasterias sp.		105		35	0.02	835	856	996	4500	1797	3.03
Onychonema sp.		344		115	0.06						
Sphaerozosma sp.		147		49	0.02			688		172	0.29
Spondylosium sp.	1500			500	0.25						
Staurastrum sp.	1569	63		544	0.27	1562	129	378		517	0.87
Xanthidium burkillii								63		16	0.03
Sub Total	3069	4576		2548	1.26	4799	10057	3896	16311	8766	14.76
%	3.62	2.27		1.26	1.26	3.41	31.96	21.03	34.92	14.76	14.76
Diatoms											
Asterionella sp.					0.00		147			37	0.06
Coscinodiscus sp.					0.00				86	22	0.04
Nitzschia sp.	1845	831	1376	1351	0.67	602	90			173	0.29
Pinnularia sp.					0.00	301	403	168	235	277	0.47
Pleurosigma sp.	86			29	0.01						
Tabellaria sp.	553			184	0.09				559	140	0.24
Sub Total	2484	831	1376	1564	0.77	903	640	168	880	648	1.09
%	2.93	0.41	0.43	0.77	0.77	0.64	2.03	0.91	1.88	1.09	1.09
Dinoflagellates											
Ceratium	42			14	0.01						
Sub Total	42			14	0.01						
%	0.05			0.01	0.01						
TOTAL	84823	201593	319785	202067	100.00	140855	31465	18525	46715	59390	**100.00**

Dinoflagellates were represented only by Ceratium (0.01%) in the canals. The study observed that the diversity of the planktonic species were generally low in the canals as compared to the rivers due to the severe impacted nature in the system due to the low oxygen and higher BOD5 and COD values. The dominence of Phaeospheara, Microspora, and Oscillatoria in the canals is indicative of the ability of these species to thrive in the impacted zones, which were resistant to the deteriorating waterquality condition. The numerical abundance and higher biomass of plankton in the riverine zone had a positive relationship with the nutrient loading in these zones particularly during the monsoonperiod.

PRIMARY PRODUCTIVITY

Primary productivity studies were conducted in the backwaters during the monsoon and post monsoon seasons. Both surface and bottom layer productivity were determined. The values are depicted below in Table 7.

Table 7 Gross and net primary productivity ($g/C/m^3/d$) in different backwaters

Backwaters KDK	NEL	VPM	MHE	PNI	CTV	AZK	KYM	AST	ANJ
Surface GP	0.75	0.65	0.37		0.71	0.77	1.10	0.85	0.38
Surface NP	0.52	0.60	0.30		0.45	0.53	0.92	0.43	0.28
Bottom GP	0.82	0.30	0.75	0.45	0.37	0.96	0.97	0.37	0.22
Bottom NP	0.45	0.15	0.60	0.38	0.30	0.52	0.75	0.22	0.20
Mean GP	0.79	0.33		0.58	0.57	0.98		0.71	0.30
Mean NP	0.49	0.23		0.42	0.41	0.72		0.33	0.24

The productivity values were generally low in most of the backwaters during the study. Earlier investigations conducted on the primary productivity in the Kadinamkulam backwater reported zero values at retting zones during October to May and 0.02-1.49gC/m 3 day at other stations and that in Ashtamudi the gross production rate was estimated at 143.88mgC/m3 /hr. The present results were in conformity with these studies.

CHLOROPHYLL PIGMENTS AND ALGAL BIOMASS

Quarterly estimation of chlorophyll pigments were conducted for samples collected from the backwaters. The quarterly variations were significant in almost all the systems as indicated in Fig 8. But there was a weak but discernible trend between different systems throughout the quarters. The Anchuthengu had consistently poor values indicating the severe stress originating from coconut husk. The tidal incursion and the water exchange between the sea and the Anchuthengu system have been poor and there results stagnation adding to the complexities of human-created pollution. The trend is corroborated with the environmental survey conducted under the project during 1997-98 in which low DO and high sulfide values coupled with poor biota were observed in this water body. Azhikode water body exhibited very poor pigment and alga biomass value. However, this is not supported with the environmental assessment conducted earlier.

COMMUNITY STRUCTURE AND BIODIVERSITY

Biomass

The mean seasonal biomass values varied from 0.52 in Azhikode to 5.85 ml/m3 in the Kadinamkulam backwater during the monsoon, whereas it varied from 0.28 in Mahe to 6.83 ml/m3 in Ashtamudi estuary during the post-monsoon period. The high amountof detritus, sediment and other suspended materials collected along with the plankton samples during the monsoon showers resulted in higher settling volume in this period. This could be the reason for the higher biomass recorded during the monsoon period. The summer values wer characterised by higher biomass volume in general, but a reduced volume at retting areas. Thus the highest value was obtained at Valapattanam (12.8 ml/m3) and the lowest at Kadinamkulam (0.4 ml/m3).

Phytoplankton

The Kadinamkulam estuary showed the maximum mean phytoplankton population during the monsoon period whereas the Chettuva estuary showed the maximum value in the post-monsoon period (Table 8). Desmidaceae had a higher representation in the northern backwaters (Neeleswaram to Azhikode) during the monsoon season whereas this was replaced by either Bacillariophyceae or Chlorophyceae during the post monsoon season. The southern backwaters except Ashtamudi were dominated by Bacillariophyceae during monsoon, which got replaced by Myxophyceae during the post monsoon season. During the pre-monsoon period Chlorophyceae, Myxophyceae and Chrysophyceae showed higher percentage incidence in the southern backwaters whereas Bacillariophyceae showed higher incidence in the northern backwaters. *Campylodiscus* sp. , *Staurastrum* sp. , *Micrasterias* sp.and *Spondylosium* sp. contributed to the higher density of Bacillariophyceae. Chlorophyceae represented by *Microspora* sp. , *Pediastrum* sp. and

Table-8 : Percentage distribution of PHYTOPLANKTON in selected backwaters during 1996-97										
Backwaters	NEL	VPM	MHE	KDL	CTV	AZK	KYM	AST	ANG	KDK
	PRE-MONSOON - 1996									
Chlorophyceae		-	-	1.6	-	3.3	-	0.5	13.3	-
Myxophyceae		-	1.1	6.4	-	3.3	30.4	62.6	20.0	82.1
Chrysophyceae		6.9	-	31.4	3.5	-	56.5	19.0	-	1.5
Desmidaceae		-	-	-	-	-	-	-	20.0	-
Bacillariophyceae		93.1	98.9	60.6	96.5	93.4	13.1	17.9	46.7	14.9
Pyrrhophyceae		-	-	-	-	-	-	-	-	1.5
TOTAL (No/m^3)		**27250**	**17750**	**6218**	**91700**	**6600**	**2300**	**12930**	**1125**	**7763**
Backwaters	**NEL**	**VPM**	**MHE**	**PNI**	**CTV**	**AZK**	**KYM**	**AST**	**ANG**	**KDK**
	MONSOON -1997									
Chlorophyceae	39.8	11.1	14.0	44.2	35.9	26.9	3.6	2.7	10.7	-
Myxophyceae	0.8	2.9	2.5	23.5	10.3	5.3	2.3	90.0	2.6	1.3
Chrysophyceae	-	-	-	0.4	0.6	-	-	0.7	-	-
Desmidaceae	43.5	66.3	62.3	27.3	36.1	58.8	6.2	0.6	29.0	2.5
Bacillariophyceae	16.0	19.7	21.2	4.7	17.0	9.0	87.9	4.5	57.8	93.2
Pyrrhophyceae	-	-	-	-	-	-	-	1.5	-	3.0
TOTAL (No/m^3)	**13748**	**26078**	**24879**	**6099**	**4823**	**2895**	**23025**	**57780**	**20933**	**71363**
	POST-MONSOON -1997									
Chlorophyceae	4.9	71.7	1.9	29.1	92.7	22.5	11.3	0.6	13.8	4.3
Myxophyceae	0.8	9.4	3.8	16.7	1.8	9.3	32.7	32.5	47.4	45.9
Chrysophyceae	-	-	-	1.8	0.1	-	4.0	-	0.8	-
Desmidaceae	-	-	2.9	47.7	3.8	19.4	16.7	0.4	23.0	2.8
Bacillariophyceae	85.6	18.9	88.4	4.7	1.6	47.1	33.1	5.5	15.1	46.9
Pyrrhophyceae	8.7	-	2.9	-	-	1.8	2.2	60.9	-	-
TOTAL (No/m^3)	**6600**	**795**	**3901**	**65438**	**81188**	**6810**	**10314**	**79375**	**23164**	**37075**

Table- 9 : Percentage distribution of Zooplankton in selected backwaters during 1996-97										
Backwaters	**NEL**	**VPM**	**MHE**	**KDL**	**CTV**	**AZK**	**KYM**	**AST**	**ANG**	**KDK**
PRE-MONSOON - 1996										
Foraminifera		6.38	6	0.6	4.97	0.5	-	0.4	-	-
Tintinnida		8.4	6	10.5	4.97	7.4	-	0.8	-	3
Polychaete larvae		0.3	-	-	6.1	-	-	-	-	-
Nematoda		0.3	-	0.6	1	-	-	0.8	-	3.8
Rotifera		17.4	23.9	38.1	14.4	8.3	32.2	32.6	28.8	34.8
Calanoid Copepoda		26.5	32.8	6.1	31.7	30.4	57.5	38.9	13.7	9.1
Cyclopoid Copepoda		7.4	-	1.7	12.9	7.8	2.2	5.1	2.7	1.5
Harpacticoid Copepoda		2.68	-	-	-	-	-	-	-	-
Copepod nauplii		27.2	31.3	38.6	22.4	40.7	6.1	21.5	54.8	31.8
Zoea		-	1.5	-	-	1.5	-	-	-	-
Decapod larvae		-	-	0.6	0.5	-	-	-	-	-
Insecta		1.5	1.5	3.3	3.5	3.4	1.5	-	-	15.2
Others		3					0.2	-	-	0.8
TOTAL (No/m^3)		**14900**	**3350**	**9050**	**10067**	**10200**	**64273**	**15900**	**5475**	**4950**
Backwaters	**NEL**	**VPM**	**MHE**	**PNI**	**CTV**	**AZK**	**KYM**	**AST**	**ANG**	**KDK**
MONSOON - 1997										
Centropyxis sp.	-	7.7	18.7	10	4	8.6	3.9	-	-	-
Foraminifera	-	1.3	-	-	1.2	12.9	1.3	-	-	-
Radiolaria	0.6	-	-	-	0.9	4.3	-	-	-	0.3
Tintinnida	11.6	3.9	6.2	21.5	11.8	15.1	-	-	-	-
Polychaete larvae	-	-	-	-	-	-	-	-	-	0.3
Nematoda	0.6	3.2	1.6	1.5	-	4.3	-	-	0.5	0.5
Gastrotricha	16.2	20	31.2	10.8	16.7	4.3	9	90.1	15.9	20.8
Rotifera	5.8	-	3.1	23.8	14.4	2.2	-	-	-	-
Ostracoda	13.3	11.6	7.8	7.7	13.3	3.2	11	2.2	20	19.2
Cladocera	-	-	3.1	-	-	7.5	-	-	-	-
Copepoda	26.6	17.4	10.9	10.8	20.2	5.4	15.5	3.4	28.6	34.8
Copepod nauplii	18.5	34.2	12.5	6.1	16.7	30.1	21.9	4.3	32.3	22.1
Insecta	1.2	0.6	4.7	7.7	1.4	2.2	37.4	-	2.7	-
Others	5.8	-	-	-	-	-	-	-	-	2.1
TOTAL (No/m3)	**4634**	**4154**	**2859**	**488**	**1309**	**279**	**5813**	**62500**	**9827**	**12898**
POST-MONSOON - 1997										
Centropyxis sp.	-	-	-	2	-	-	1	-	-	-
Tintinnida	-	-	-	2	-	2	-	-	-	-
Rotifera	1	12	5	45	26	25	42	91	31	86
Copepoda	50	32	37	23	38	36	35	5	29	5
Copepod nauplii	46	56	59	24	34	37	20	3	37	8
Amphipoda	-	-	-	-	2	-	-	-	-	-
Isopoda	-	-	-	-	-	-	1	-	-	-
Zoea	1	-	-	-	-	-	-	-	-	-
Insecta	-	-	-	-	-	-	1	-	1	-
Others	1	-	-	-	-	-	-	-	2	-
TOTAL (No/m^3)	**3400**	**750**	**1538**	**13613**	**4575**	**4170**	**12638**	**146925**	**4538**	**99975**

Hormidium sp.contributed to the high planktonic biomass in Chettuva and Ponnani estuaries. A total of 100 species of phytoplankton were recorded from the backwaters. The diversity index (H), richness index (d) and evenness index (e) of the phytoplankton showed peak values during the pre monsoon and post monsoon periods in the Valapattanam and Azhikode backwaters whereas minimum values were observed in the Kadalundi, Chettuva and Ashtamudi backwaters (Table 11 & Fig.9).

Zooplankton

The monsoon period showed the presence of 14 groups of zooplankton whereas the post monsoon showed 20 groups in the backwaters. But during the pre-monsoon study conducted in the same water bodies during 1996 showed the presence of only 12 faunal groups. The southern backwaters (Kayamkulam to Kadinamkulam) showed higher incidence and diversity of the different planktonic groups when compared to the backwaters in the nortern segment during monsoon as well as post-monsoon periods. During the pre- monsoon, the Kayamkulam backwater recorded the maximum numerical density (64273 Nos./m3) and the Mahe backwater recorded the minimum (3350 Nos./ m3). *Centropyxis* sp., the protozoan showed its maximum incidence in the Mahe and Azhikode estuaries during the monsoon period. The retting zones in the ten ecosystems showed considerably lower planktonic abundance and diversity, coinciding with the poor water quality condition in the corresponding areas. Azhikode recorded the highest diversity index value (H) during the monsoon period (2.74) and the lowest in Kayamkulam during the same season (Table 9, 11 & Fig.9 &10). Copepods and copepod nauplii formed an important component in all the ten systems in both the seasons. In the Neeleswaram backwater, 50% of the plankton were contributed by copepods during the post-monsoon period whereas the group formed 34.8% of the population during the monsoon period in the Kadinamkulam estuary. Altogether, 34 species of rotifers were recorded during the post- monsoon season alone in the ten backwaters. Brachionus species represented by *B. plicatilis, B. falcatus, B. calyciflorus* showed the maximum incidence among the rotifers in the present study.

Benthic fauna

Amphipoda, Polychaeta and Gastropoda formed the dominant groups in all the backwates during both the seasons. The monsoon as well as post monsoon periods showed higher numerical density in the southern backwaters when compared to the northern segments. Nemertea (Ribbon worms), a rare group was recorded in the Neeleswaram (0.5%) and Ashtamudi backwaters (0.4%) during the post-monsoon period. The pre-monsoon was charecterised by higher groups of benthic fauna like Oligochaeta, Polychaeta, Amphipoda, Insecta and Mollusca in the northern backwaters when compared to the backwaters in the southern side. The post monsoon period showed higher diversity index (H) and richness inde, (d) values when compared to the pre-monsoon and monsoon periods (Table 10,11 & Fig 9 &11) As observed above in zooplankton, the benthic fauna also showed considerable depletion in the retting zones of the present study. Thirteen groups formed the benthic population during the monsoon period whereas seventeen groups in the post-monsoon.

Insect fauna showed higher incidence and diversity particularly in the backwaters in the nortern side during the post-monsoon period. The retting zones in the backwaters showed higher dominance of Chironomus larvae and other insect larvae which clearly reflects the impacted condition created in these ecosystems due to rettingactivity.

Distribution of benthic polychaetes

Thirteen species of polychaetes contributed to the benthic population in the backwaters during the pre monsoon period (Table 12). In the southern backwaters, (Anchuthengu & Ashtamudi) Nephthys polybranchia and Prionospio cirrifera were the only species (100%) that contributed to the biomass whereas in the Kayamkulam, Chettuva, Mahe and Beypore systems it was represented by seven species. The capitellid worm P. cirrobranchiata showed the highest biomass (2400no/m2) in Kayamkulam backwater. The dominance of capitellid was a notable observation in the present investigation, which were resilient to the deteriorating water quality in these polluted zones. In the Kadinamkulam backwaters, also the retting activity was severe, grossly affecting the water quality condition and biota in these zones, where the capitellid species had the highest mean percentage incidence (77.09%). This

Table-10. Percentage distribution of BENTHIC FAUNA in selected backwaters during 1996-97										
Backwaters	NEL	VPM	MHE	KDL	CTV	AZK	KYM	AST	ANG	KDK
	PRE-MONSOON - 1996									
Oligochaeta		6.7	4.6	19.2	5.7	6.1	4.9	-	0.7	2.2
Polychaeta		9.2	43.1	28.3	29.4	68.1	61.7	2.2	0.4	-
Isopoda		-	0.5	-	1.4	0.7	-	-	-	-
Amphipoda		8.6	40.5	12.8	3.4	12.9	-	11.1	-	-
Decapoda		3.3	0.5	0.4	0.2	1.4	-	-	-	-
Chironomous larvae		0.3	-	0.6	0.5	-	-	-	0.4	7.3
Gastropoda		65.7	0.2	36.0	14.6	2.7	26.6	77.7	37.1	88.5
Bivalvia		6.1	9.3	2.7	44.0	8.2	5.7	2.0	61.1	1.0
Others		-	1.2	-	0.7	-	1.03	5.8	0.4	1.0
TOTAL (No/m^2)		**5325**	**3233**	**6526**	**3484**	**1224**	**3199**	**2515**	**2572**	**352**
Backwaters	**NEL**	**VPM**	**MHE**	**PNI**	**CTV**	**AZK**	**KYM**	**AST**	**ANG**	**KDK**
	MONSOON -1997									
Oligochaeta	-	-	-	-	-	2.4	6.6	0.3	-	-
Polychaeta	6.6	38.2	8.3	20.2	12.1	46.0	85.5	22.4	27.3	12.9
Isopoda	-	-	0.8	-	0.5	1.6	-	-	-	-
Amphipoda	63.7	15.4	10.7	-	83.9	32.4	4.7	41.9	10.1	-
Decapoda	-	-	4.1	-	0.1	0.4	0.3	0.5	-	-
Chironomous larvae	-	11.8	-	-	0.1	0.4	0.2	-	0.4	0.3
Gastropoda	14.9	14.7	9.1	60.5	0.5	9.6	0.3	26.6	0.7	86.0
Bivalvia	14.9	19.1	63.7	20.2	2.7	7.2	1.6	7.4	61.4	-
Fish & fish larvae			1.7	-	0.1	-	0.3	0.8		-
Others	-	0.7	0.8	-	-	-	0.5	0.2	0.2	-
TOTAL (No/m^2)	**504**	**680**	756	310	**7969**	**1250**	**3989**	**2695**	**14331**	**10188**
	POST-MONSOON -1997									
Nemertea	0.5	-	-	-	-	-	-	0.4	-	
Oligochaeta	2	16.4	12.0	0.2	18.5	3.4		0.1		
Polychaeta	31.9	41.3	10.4	61.2	19.3	5.9	41.4	13.8	35.9	34.7
Ostracoda	-	0.2	-	-	0.5	0.1	-	-	-	-
Isopoda	0.3	0.2	14.3	0.8	2.2	0.1				
Amphipoda	32	5.1	45.2	0.8	953.1	40.3	57.9	35.3	10.8	4.9
Decapoda	0.1	1.3	-	-	-	-	-	-	-	-
Chironomous larvae	0.1	0.4		0.8	0.3	-	-	-	0.1	52.2
Other insect larvae	3.4	0.2	1.2	0.8	0.5	-	-	0.5	0.1	1
Gastropoda	27.7	14.7	1.2	34.9	4.2	45.8	0.5	49.7		3.4
Bivalvia	1.7	17.6	13.1	0.2	0.8	4.1		0.1	53	3.6
Fish & fish larvae	-	-	0.4	-	-	0.1		0.1		0.1
Others	0.3	0.4	2.3	-	0.6	-	-	-	-	-
TOTAL (No/m^2)	**5013**	**2250**	**1619.0**	**303**	**4017**	**3375**	**4919**	**8846**	**4469**	**4029**

Table 11 Diversity, dominance, richness and evenness indices of Phytoplankton, Zooplankton and Benthos in selected backwaters during 1996-97

PHYTOPLANKTON

	Pre Monsoon										Monsoon										Post Monsoon									
	VPM	MHE	BPR	KDL	CTV	AZK	KYM	AST	ANG	KDM	NEL	VPM	MHE	PNI	CTV	AZK	KYM	AST	ANG	KDK	NEL	VPM	MHE	PNI	CTV	AZK	KYM	AST	ANG	KDK
H	3.85	2.54	2.73	1.81	2.11	2.16	1.36	2.86	2.21	1.82	3.55	3.61	3.55	3.76	4.44	4.02	1.95	1.00	3.29	1.82	2.81	2.29	2.00	4.62	2.06	[illegible]	3.10	1.88	3.53	2.88
c	0.24	0.21	0.19	0.07	0.34	0.29	0.42	0.17	0.22	0.35	0.14	0.11	0.13	0.12	0.05	0.08	0.45	0.78	0.12	0.51	0.24	0.25	0.45	0.07	[illegible]	[illegible]	0.15	0.38	0.12	0.17
d	0.35	0.36	0.39	0.40	0.31	0.42	0.45	0.34	0.51	0.38	1.89	1.95	1.60	2.57	3.14	2.40	1.05	2.00	1.78	1.27	1.42	0.60	1.04	3.29	1.34	2.01	1.13	1.08	1.66	1.06
e	1.45	1.10	1.06	0.82	0.76	1.03	1.23	1.08	1.38	0.87	1.15	1.14	1.21	1.14	1.28	1.27	0.76	0.33	1.24	0.64	1.01	1.28	0.83	1.24	0.71	1.24	1.21	0.69	1.18	1.09

ZOOPLANKTON

	Pre Monsoon										Monsoon										Post Monsoon									
	VPM	MHE	BPR	KDL	CTV	AZK	KYM	AST	ANG	KDK	NEL	VPM	MHE	PNI	CTV	AZK	KYM	AST	ANG	KDK	NEL	VPM	MHE	PNI	CTV	AZK	KYM	AST	ANG	KDK
H	2.50	2.17	2.04	2.03	2.73	2.20	1.59	1.88	1.52	2.18	2.00	1.66	2.40	2.64	2.26	2.74	0.93	0.39	1.00	1.14	1.28	1.36	1.19	1.91	1.66	1.68	1.71	0.57	1.72	0.72
c	0.19	0.25	0.28	0.31	0.19	0.28	0.47	0.31	0.40	0.27	0.32	0.43	0.22	0.18	0.26	0.20	0.64	0.85	0.61	0.55	0.45	0.43	0.47	0.31	0.32	0.32	0.34	0.83	0.32	0.75
d	0.37	0.43	0.47	0.39	0.43	0.43	0.35	0.35	0.43	0.41	0.96	0.73	1.05	1.15	1.13	1.67	0.37	0.09	0.44	0.64	0.49	0.30	0.27	0.52	0.35	0.35	0.63	0.67	0.47	0.34
e	1.09	1.05	1.26	0.29	1.13	1.06	0.76	0.96	1.09	1.05	0.94	0.85	1.11	1.26	1.03	1.14	0.67	0.57	0.62	0.58	0.79	1.23	1.08	1.06	1.19	1.21	0.87	0.25	1.00	0.45

BENTHOS

	Pre Monsoon										Monsoon										Post Monsoon									
	VPM	MHE	BPR	KDL	CTV	AZK	KYM	AST	ANG	KDK	NEL	VPM	MHE	PNI	CTV	AZK	KYM	AST	ANG	KDK	NEL	VPM	MHE	PNI	CTV	AZK	KYM	AST	ANG	KDK
H	1.71	1.75	1.80	2.08	2.03	1.48	1.45	1.16	1.09	1.54	1.49	2.22	1.83	1.35	0.84	1.93	0.88	1.93	1.39.	0.65	2.05	2.34	2.33	1.25	0.36	1.68	1.03	1.53	1.39	1.65
c	0.46	0.36	0.35	0.26	0.31	0.49	0.45	0.55	0.51	0.44	0.45	0.24	0.43	0.45	0.72	0.33	0.74	0.30	0.46	0.76	0.28	0.25	0.27	0.50	0.91	0.38	0.51	0.39	0.42	0.40
d	0.41	0.44	0.47	0.42	0.43	0.49	0.44	0.42	0.45	0.61	0.48	0.77	1.21	0.58	0.89	0.98	0.96	0.89	.84.	0.54	1.29	1.55	1.22	1.00	0.85	0.86	0.35	0.99	0.48	0.72
e	0.87	0.80	0.86	1.08	0.92	0.83	0.90	0.60	0.61	0.99	1.07	1.24	0.83	1.23	0.38	0.93	0.40	0.93	0.63	0.36	0.82	0.91	1.01	0.57	0.16	0.81	0.75	0.66	0.86	0.85

observation confirms with the studies conducted by Bijoy Nandan (2004) in the retting grounds of Kerala. The incidence, distribution and diversity of polychaetes in the northern backwaters were higher when compared to southern systems.The diversity index (H) was the highest in Beypore (1.54) and the lowest in Valapattanam backwater (0.10), whereas the dominance index ranged from 0.96 in Valapattanam to 0.27 in Beypore backwater. The richness index also attained its peak in the Beypore (0.78)and the lowest in Valpattanam (0.10), whereas the evenness index in Valapattanam (0.99) and Mahe backwaters (0.12) respectively. The diversity values reflected the distribution and abundance of the species in the different systems. Therefore,the highest values of diversity (H), richness (d) and low dominance (c) index in the Beypore system coincides with the peak faunal diversity in these zones as compared to Valapattanam and Mahe with having the lowest diversity (H) and high dominance (c) values.

Table 12 Percentage distribution of polychaetes (no/m^2) in selected backwaters of Kerala during the pre-monsson period, 1996

NAME	ANG	AST	KYM	KGR	CTV	KDL	BPR	MHE	VPM
Eunoe macrophthalma				5.43			0.62	33.33	
Ancistrosyllis constricta							9.26		
Ceratonereis mirabilis			8.14					5.21	48.86
Ceratonereis sp			9.95	2.47	31.37	4.00	8.64		
Nephthys polybranchia		100.	14.08	49.77	33.23	8.03	4.94	28.13	
Diopatra neapolitana					11.64			0.28	1.14
Diopatra sp								0.57	
Glycera papillosa									23.33
Polydora kempi									26.67
Prionospio cirrifera	100		3.57		3.70				
Prionospio cirrobranchiata			58.71			2.00	53.70		
Capitellides sp.			5.56		8.57	77.09	21.60		
Pectinaria neapolitana				42.33	11.48	8.88	1.23	32.48	

FISH LANDINGS AND CATCH COMPOSITION

Fishery survey was conducted quarterly in ten of the thirty backwaters along the southwest coast of India. The backwaters investigated together spread to 15102 ha, 22% of the total backwaters available in the State. Altogether, 46 landing stations around these backwaters examined for a period of 2-3 days in each quarter either continuously of intermittently in each quarter and the total landings were estimated based on average values for a day. Average fishing days in a month for each category gear was ascertained through repeated inquiry at each station and the total landings were computed through extrapolation.

Species' habitat and distribution

Ninety four species of fish and shellfish were identified that contributing to the fishery of these backwaters. The different species recorded in the backwaters based on their occurrence are given in Table 13. Their relative abundance were recorded for the various systems explored. .The common species that regularly contributing to the fishery are listed below along with the quantity exploited for each species. Of the 94 species listed, 63 have been recorded from the marine waters by different workers, thereby establishing a close relation ship of the backwater fishery with that of the marine system. Nineteen of them used to be predominantly recorded from the rivers/reservoirs and these take a sojourn to the backwater during the monsoon or immediately after the monsoon when the salinity remained very low in the upper reaches. Definite zone marking could be possible for the distribution of these species in the backwater. *Puntius filamentosus, P. sarana, Labeo dussumieri, Mystus malabaricus, Anabas testudineus, Channa* spp., Orechromis mossambicus, and *Mastacebelus armatus* could be cited as examples.

On the other hand, several almost purely marine forms were recorded from the backwaters during the summer season. *Rhinobatus halavi, Congressox talaboidenes, Lobotes surinamensis, Acanthurus strigosus, Eleotris fusca, Lepturocanthus savala, Platax orbicularis*, etc were also recorded from certain systems, though in stray numbers.

The major groups/species constituting the fishery with their relative contribution were estimated. *Etroplus suratehsis Penaeus indicus* and the *Metapenaeus monoceros* represented 2.0-13.9%, 2.5-29.6% and 1.0- 8.2% in the total catches. The mullets (1.5-16.5%), the Lutjanids (snappers, 1.1-11.4%), the carangids (1.0- -5.2%), the tiger perch *Therapon jarbua*, the reef cod *Epinephalus* spp., the banded barracuda *Sphyraena jello* , etc. the Mojarra *Gerres filamentosus* (1.0-6.1%) and the flathead *Platycephalus indicus* also also formed a commercially imp. Species in the fishery.. The comparatively less commercial ones like the silver bellies (*Leiognathus* spp.), the half beaks, the marine catfish (*Tachysurus* spp.), the anchovies (*Stolephorus* sp.)the flat fishes and the Ambassids gained importance due to their bulk contribution to the fishery. The comparatively less commercial ones like the silver bellies (*Leiognathus* spp.), the half beaks, the marine catfish (*Tachysurus* spp.), the anchovies (*Stolephorus* sp.)the flat fishes and the Ambassids gained importance due to their bulk contribution to the fishery (Table 13 & Fig. 12).

Among the prawns, the most significant contributor to the fishery by bulk was the *Metapenaeus dobsonii,*contributing to the tune of 10.0-53.4% to the total landings. *Penaeu indicus* was the most significant of all the species due to its considerable quantity (2.5-29/6%) and the attractive prize. The *M. monoceros (1.0-8.2%) followed the P. indicus* (Table 13 & Fig. 12). The Crabs also formed a very attractive fishery (approx. 1100t) serving both the domestic and international markets.

Table 13 Percentage contribution by various species/groups to the total landings from the ten backwaters duriong 1998-99.

Species/ Groups	Contribution (%) to total landings Range	Mean% of pooled data
Acanthurus spp.	0.0-4.9	0.47
Gerres spp.	1.0-6.1	2.72
Platycephalus sp.	0.1-3.1	1.08
Leiognathus spp.	0.3-5.9	1.08
Etroplus spp.	2.0-13.9	5.68
Megalops sp.	0.0-5.8	0.60
Tachysurus spp.	1.9-10.4	3.20
Ambassis sp.	0.0-8.6	2.92
O. mossambicus	0.0-14.7	0.94
Stolephorus sp.	0.0-3.3	1.57
Sillago sihama	0.0-3.8	0.81
Caranx spp.	1.0-5.2	1.29
Lutjanus spp.	1.1-11.4	1.50
Mullets	1.5-16.5	5.07
Flat fishes	0.1-3.6	1.21
Half beaks	0.1-2.5	0.26
Others	6.4-20.0	10.66
Fishes total	26.9-75.0	**41.20**
Metapenaeus dobsonii	9.2-53.4	33.06
M. monoceros	1.0-8.2	6.53
Penaeus indicus	2.5-29.6	9.19
P. monodon	0.0-9.0	1.22
Other penaeids	0.0-2.9	0.64
Non-penaeids	0.0-1.3	0.46
Prawns total	**13.9-70.5**	**53.1**
Crabs	**2.6-11.1**	**5.75**
Total yield (kg/ha.)	**246-2747**	**630.1**

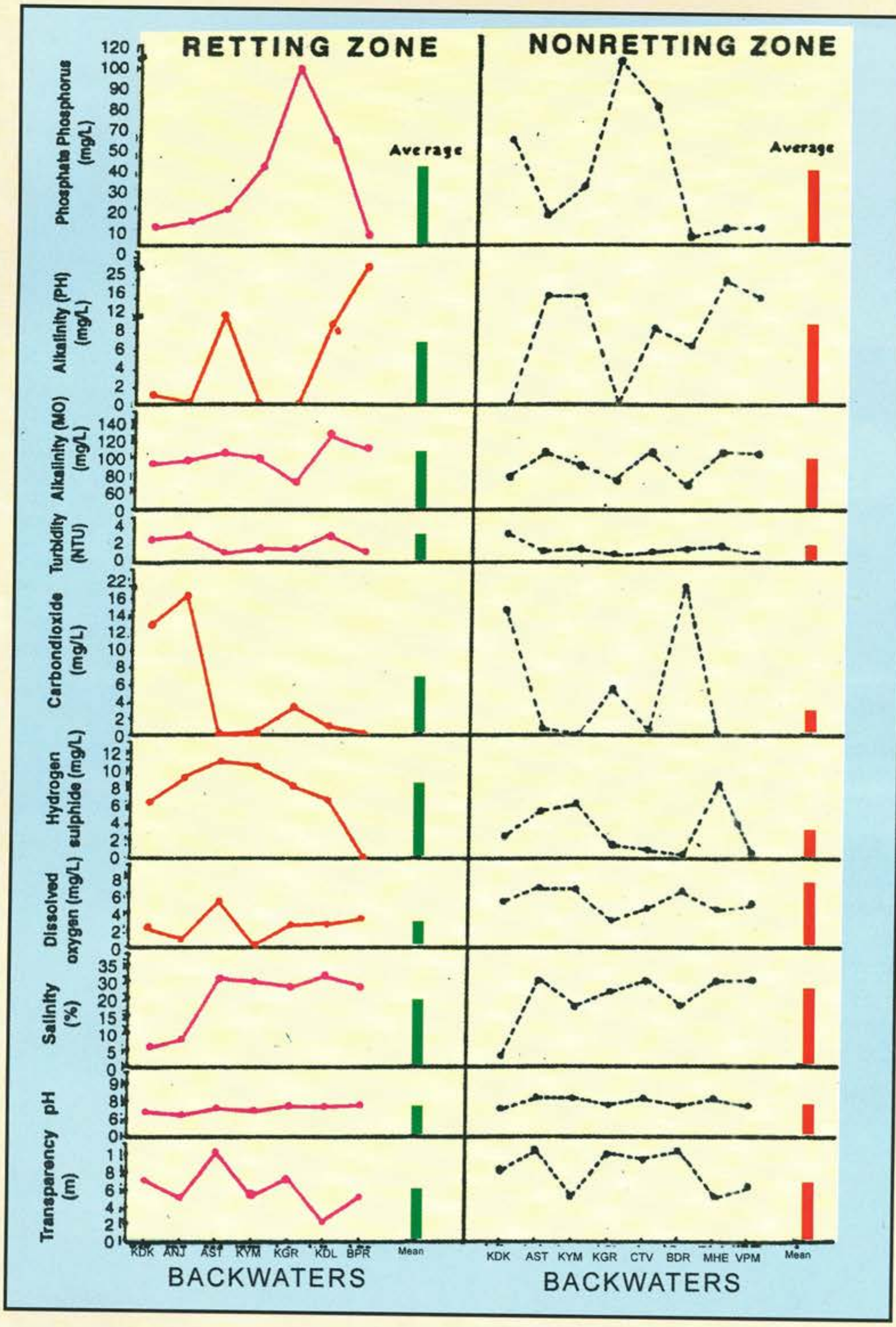
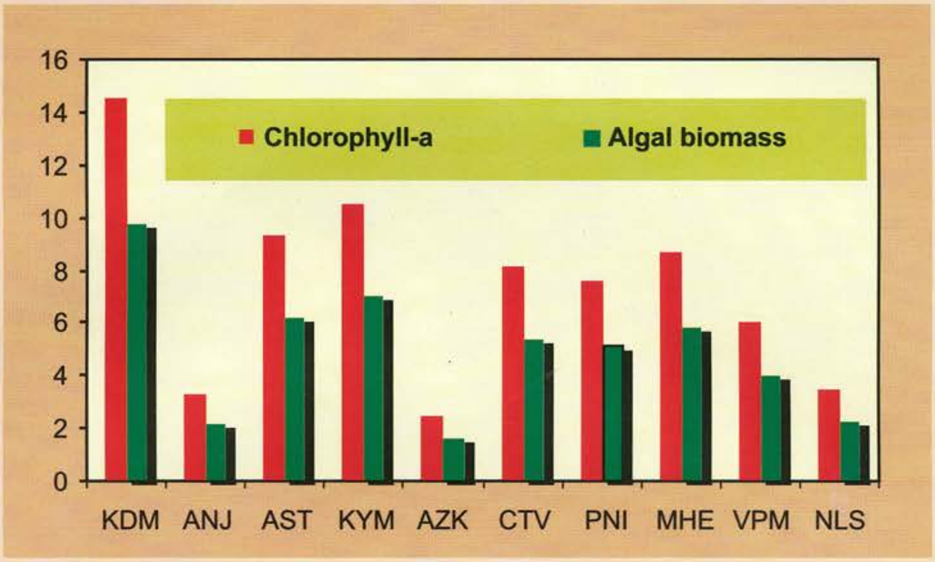


FIG. 6 WATER QUALITY CONDITION IN THE RETTING AND NONRETTING ZONES OF TEN SELECTED BACKWATERS OF KERALA DURING THE PRE MONSOON PERIOD, 1996



Backwaters

FIG. 8 MEAN CHLOROPHY II-a(mg/m3) AND ALGAL BIOMASS (g/m3 wet wt) IN SELECTED BACKWATERS DURING 1998-99

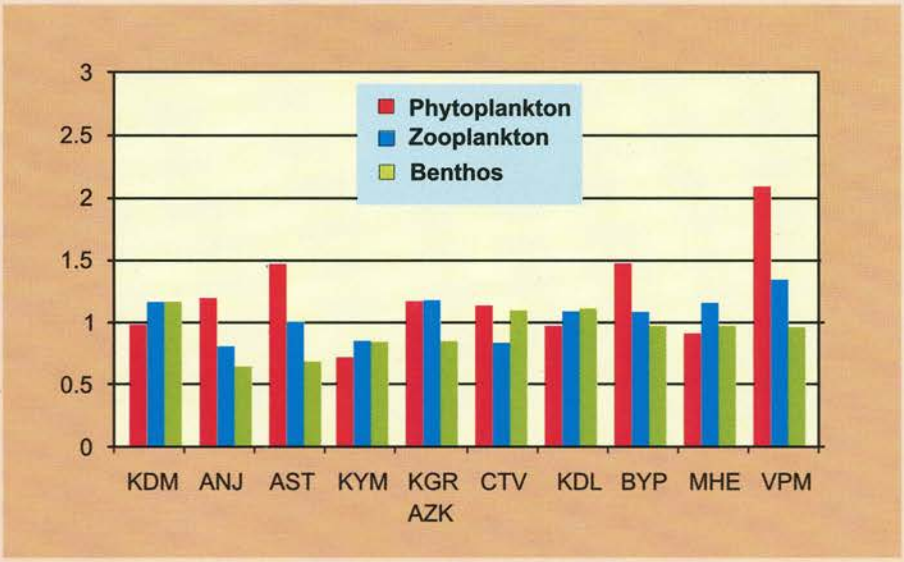


Fig. 9 Shannon Weaver Diversity index (H) for the phytoplankton (species), zooplankton (groups) and benthic organisms (groups) in the selected backwaters during May-June 1996

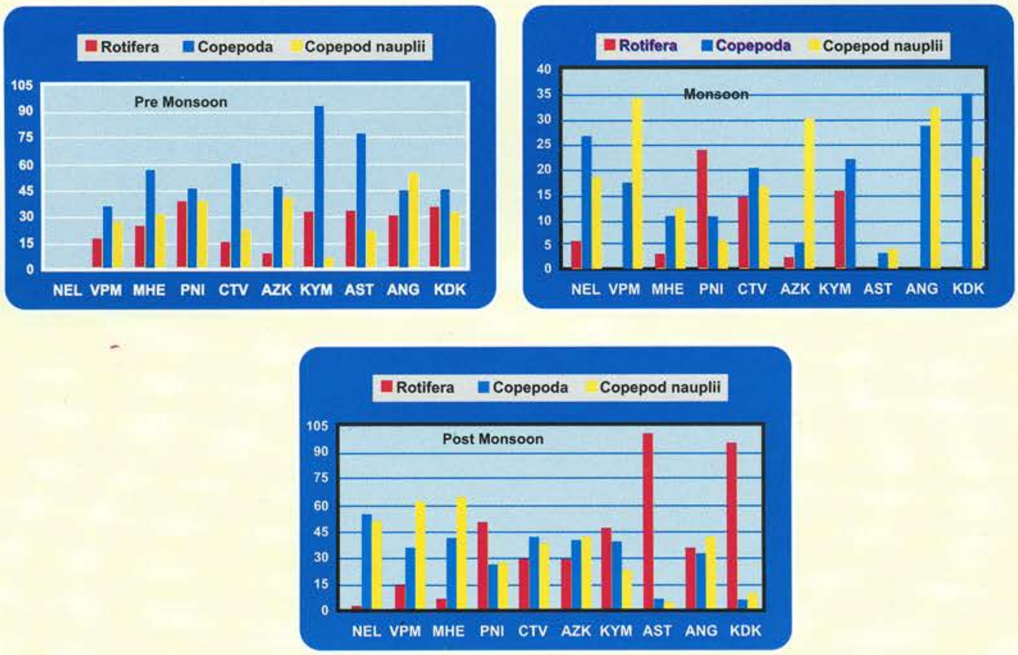


Fig 10 Seasonal mean distribution (%) of selected zooplankton in the backwaters

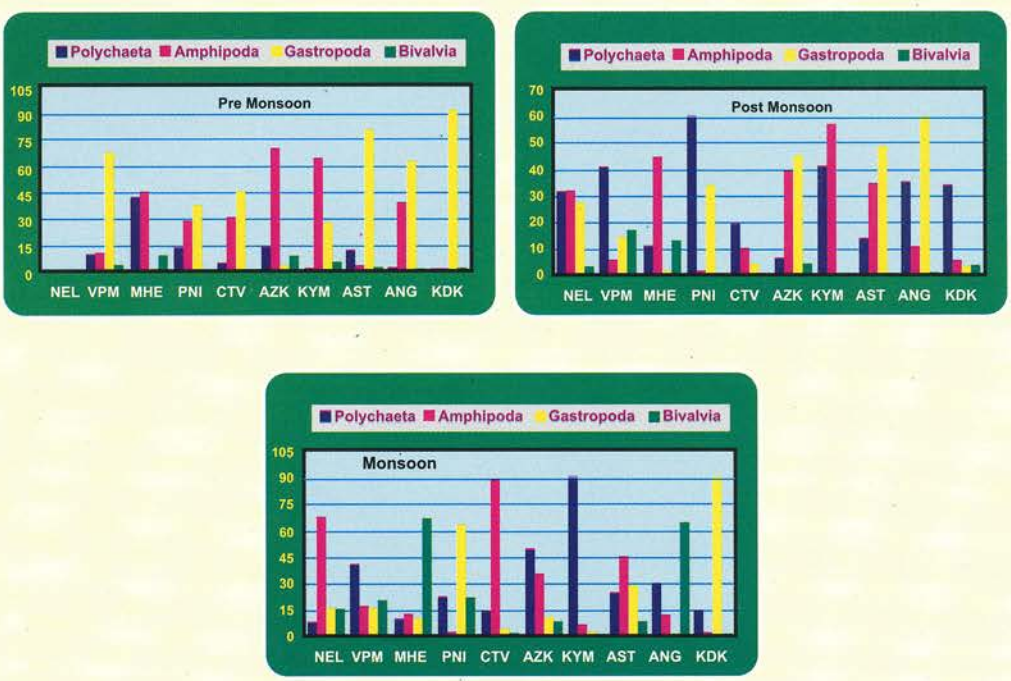
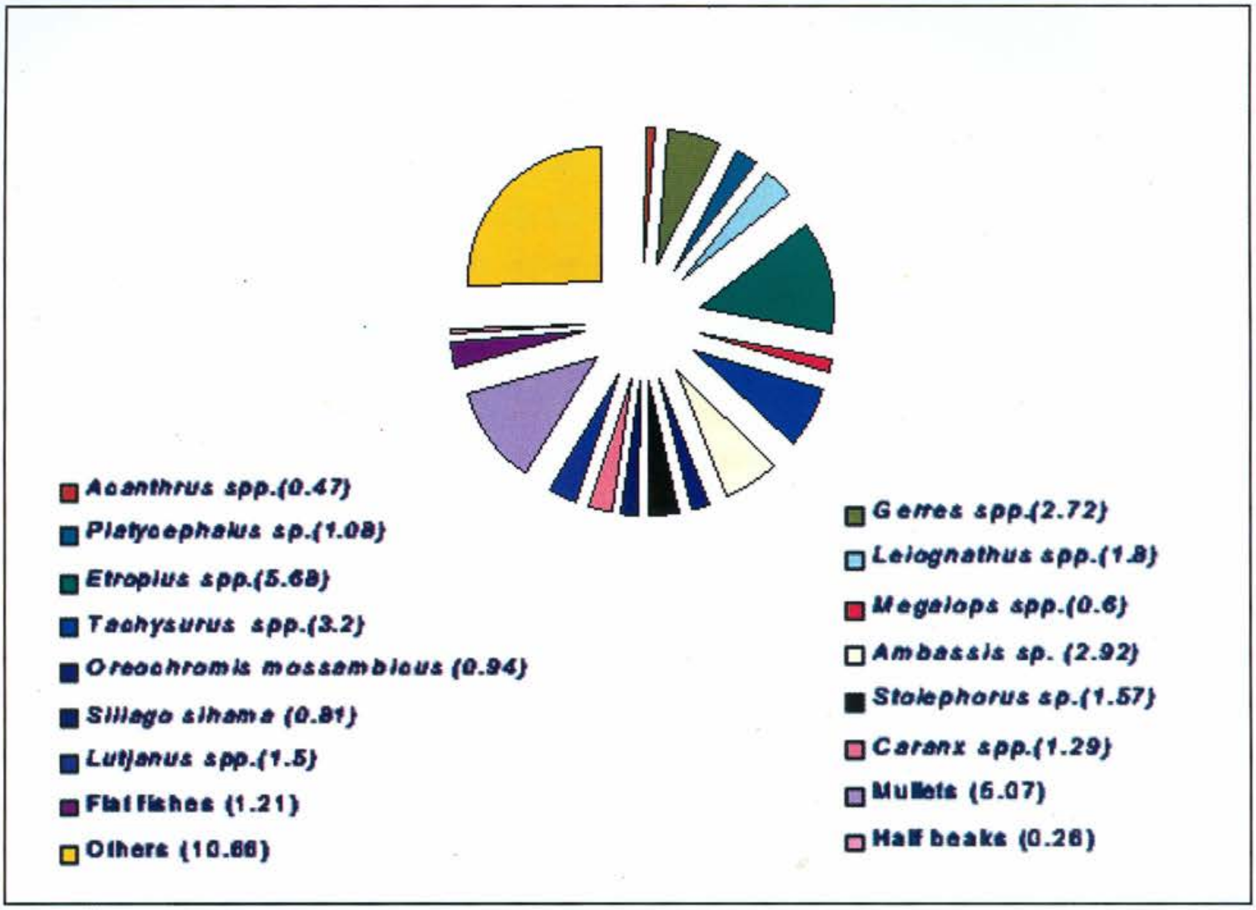


Fig 11 Seasonal mean distribution (%) of selected benthic fauna in the backwaters



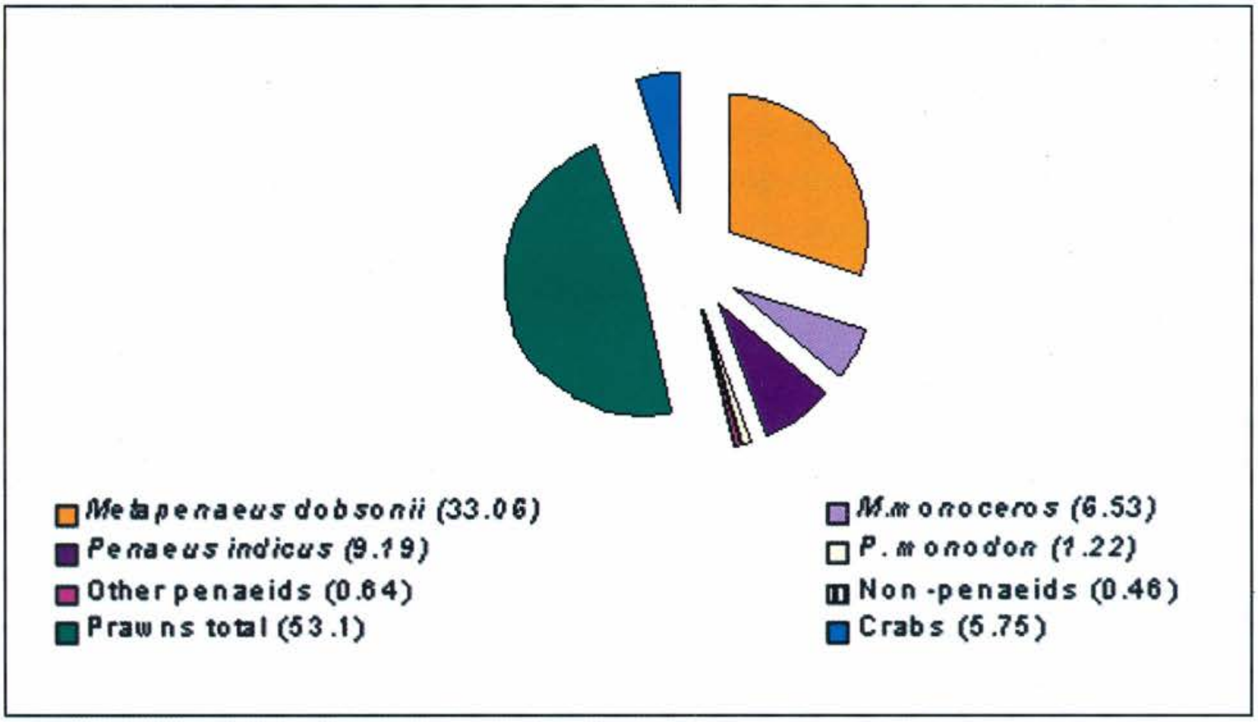
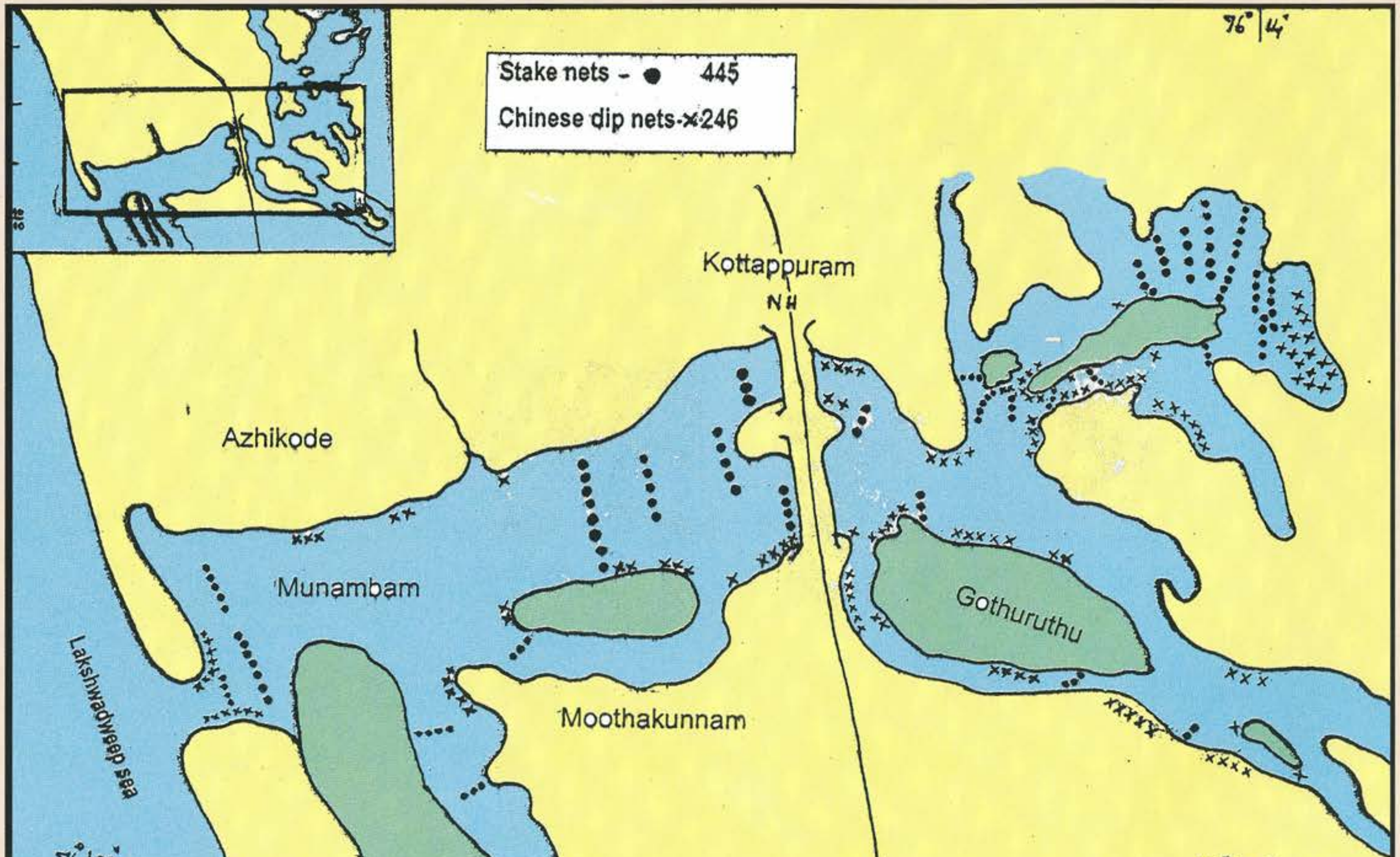


FIG. : 12 Percentage contribution of Fish and Prawn species in the backwaters during 1998-99

FIG. 13 DISTRIBUTION OF STAKE NETS AND CHINESE DIP NETS IN THE AZHIKODE BACKWATER



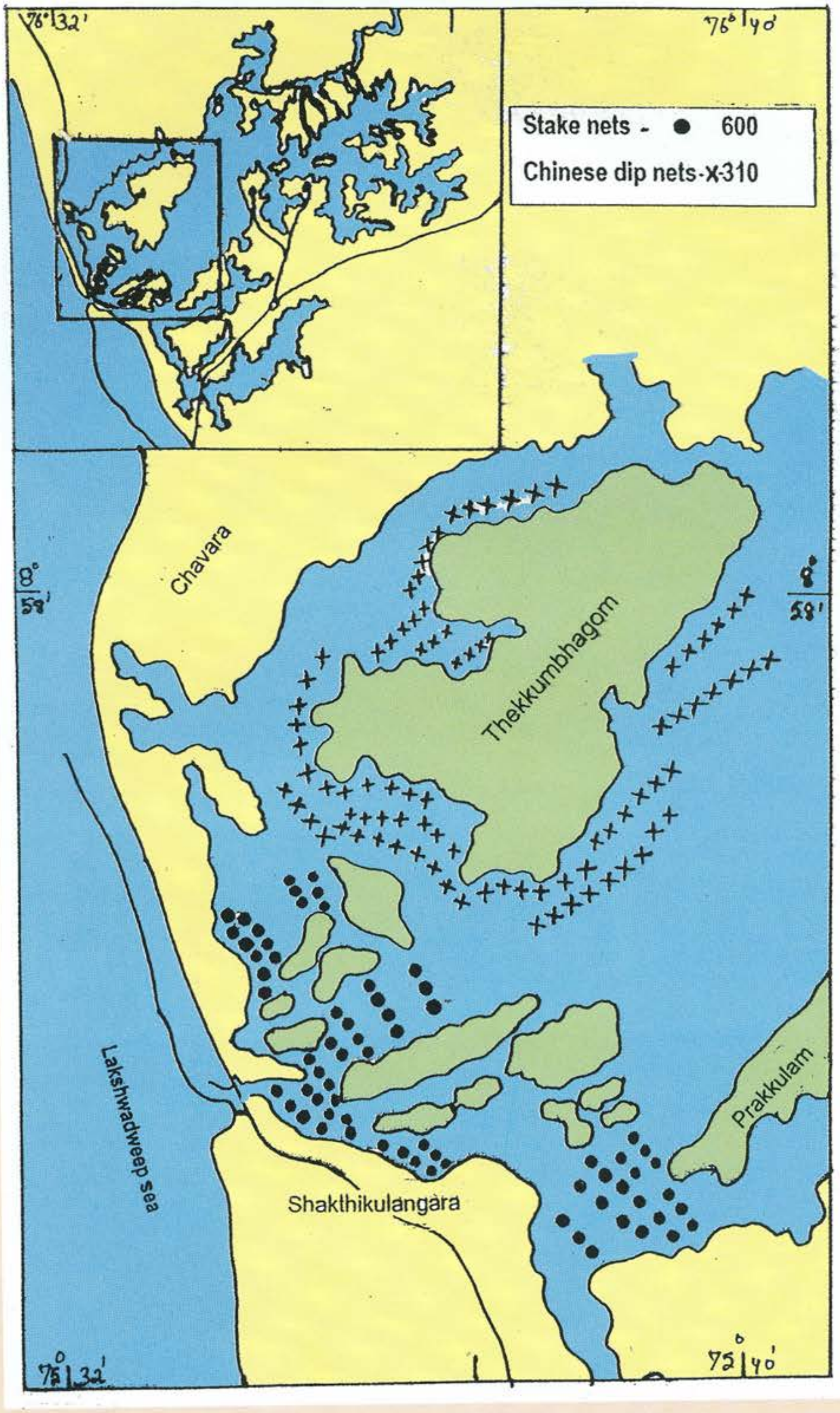


FIG. 13 DISTRIBUTION OF STAKE NETS AND CHINESE DIP NETS IN THE ASHTAMUDI BACKWATER

Table 13	Finfish/shellfish species recorded from selected backwaters (1998-99)											
Family	Sl.	Species name	Habitat	BACKWATERS								
	No.			KDK	ANJ	AST	KYM	AZK	CTV	PNI	MHE	VPM
FINFISHES												
Rhinobatidae	1	*Rhinobatus halavi* (Day)	M						*			
Megalopidae	2	*Megalops cyprinoides* (Broussonet)	E	**	**	**	**	**	**	**	**	**
Anguillidae	3	*Anguilla bengalensis* (Gray)	R	*	*	*	*	*	*	*	*	*
Ophichthidae	4	Ophichthys altipinnis (Kaup)	E				*					
Muraeresocidae	5	*Congresox talabonoides* (Bleeker)	M			**	**		***		**	
Clupeidae	6	*Nematalosa nasus* (Bloch)	M	**	**	**	**		**	**	**	**
	7	*Pellona ditchela* (Valenciennes)	M	**	**	**	**	**	**	**	**	**
Pristigasteridae	8	*Dussumieria hasseeltii* (Bleeker)	M			*			*	*		
Dussumieridae	9	*Stolephorus indicus* (van Hasselt)	M	***	***	***	***	***	***	***	***	***
Engraulididae	10	*Thryssa mystax* (Schneider)	M	***	***	***	***	***	***	***	***	***
Chanidae	11	*Chanos chanos* (Forskal)	E	**	**	**	**	**	**	**	**	**
Cyprinidae	12	*Puntius filamentosus* (Val.)	R	***	***	***	***	***	***	***	***	***
	13	*Puntius sarana* (Ham.-Buch,)	R	**	**	**	**	**	**	**	**	**
	14	*Labeo dussumieri* (Valenciennes)	R				*	**		**		
Bagridae	15	*Mystus malabaricus* (Jerdon)	R				**	*		**		
	16	*Horabagrus brachysoma* (Gunther)	E	*			*		*		*	*
Chacidae	17	*Chaca chaca* (Hamilton-Buchanan)	R						*		*	
Ariidae	18	*Arius platystomus* (Day)	E	****	****	****	****	****	****	****	****	****
	19	*Arius rostratus* (Day)	E	***	***	***	***	***	***	***	***	***
Hemiramphidae	20	*Hyporhamphus limbatus* (Val.)	M, E	**	**	**	**	**	**	**	**	**
	21	*Hemirhamphus cantori* (Day)	M, E	**	**	**	**	**	**	**	**	**
	22	*Hemirhamphus far* (Day)	M, E	**	**	**	**	**	**	**	**	**
Belonidae	23	*Strongylura strongylura* (van Hasselt)	M, E	**	**	**	**	**	**	**	**	**
	24	*Tylosurus crocodilus* (Le Sueur)	M, E	*	*	*	*	*	*	*	*	*
Platycephalidae	25	*Platycephalus indicus* (Linnaeus)	E, M	****	****	****	****	****	****	****	****	****
Centropomidae	26	*Lates calcarifer* (Bloch)	E, M	*	*	*	**	*	*	*	*	*
Ambassidae	27	*Ambassis commersoni* (Cuvier)	E, R	****	****	****	****	****	****	****	****	****
	28	*Parambassis spp.*	R, E	****	****	****	****	****	****	****	****	****
Serranidae	29	*Epinephelus tauvina* (Forsskal)	M, E	**	**	**	**	**	**	**		**
	30	*Epinephelus malabaricus* (Schneider)	M, E	**	**	**	**	**	**	**		**
Teraponidae	31	*Terapon jarbua* (Forsskal)	M, E	**	**	**	**	**	**	***	**	**
Sillaginidae	32	*Sillago sihama* (Forsskal)	M,E	****	****	****	****	****	****	****	****	****
Carangidae	33	*Caranx sexfasciatus* (Quoy & Gaimard)	M	***	***	***	***	***	***	***	***	***
	34	*Caranx nigripinnis* (Bleeker)	M, E	**	**	**	**	**	**	**	**	**
Lieognathidae	35	*Leiognathus equulus* (Forsskal)	M, E. R	*****	*****	*****	*****	*****	*****	*****	*****	*****
	36	*Leiognathus decorus* (de Vis)	M	****	****	****	****	****	****	****	****	****
	37	*Leiognathus splendens* (Cuvier)	M	****	****	****	****	****	****	****	****	****
Lutjanidae	38	*Lutjanus argentimaculatus* (Forsskal)	M, E	**	**	**	**	**	**	**	**	**
	39	*Lutjanus johni* (Bloch)	M	**	**	**	**	**	**	**	**	**
	40	*Lutjanus fulviflamma* (Forsskal)	M, E	**	**	**	**	**	**	**	**	**
Lobotidae	41	*Lobotes surinamensis* (Bloch)	M							*		
Gerridae	42	*Gerres filamentosus* (Cuvier)	E, M	****	****	****	****	****	****	****	****	****
	43	*Gerres oyena* (Forsskal)	M, E	**	**	**	**	**	**	**	**	**
Monodactylidae	44	*Monodactylus argenteus* (Linn.)	E									
Drepanidae	45	*Drepane punctatus* (Linnaeus)	M			**	**					
Scatophagidae	46	*Scatophagus argus* (Linnaeus)	E, R	***	***	***	***	***	***	***	***	***
Acanthuridae	47	*Acanthurus bleekeri* (Gunther)	M, E	**	**	**	**	**	**	**	***	**
	48	*Acanthurus strigosus* (Bennett)	M	**	**	**	**	**	**	**	**	**
Nandinae	49	*Nandus nandus* (Hamilton-Buchanan)	R	*****	*****	*****	*****	*****	*****	*****	*****	*****
	50	*Nandus marmoratus (Ham.-Buch.)*	R, E			*	*					

Table 13	Finfish/shellfish species recorded from selected backwaters (1998-99) (Table continued)												
Family	Sl. No.	Species name	Habitat	BACKWATERS									
				KDK	ANJ	AST	KYM	AZK	CTV	PNI	MHE	VPM	NEL
Cichlidae	51	*Etroplus suratensis* (Bloch)	E, R	****	****	****	****	****	****	****	****	****	****
	52	*Etroplus maculatus* (Bloch)	E, R	****	****	****	****	****	****	****	****	****	****
	53	*Oreochromis mossambicus* (Peters)	R	****	****	**	****	***	**	**	**	**	**
Mugilidae	54	*Liza tade* (Forskal)	M, E	****	****	****	****	****	****	****	****	****	****
	55	*Liza parsia* (Hamilton-Buchanan)	M, E	****	****	****	****	****	****	****	****	****	****
	56	*Mugil cephalus* (Linnaeus)	M, E, R	***	***	***	***	***	***	***	***	***	***
	57	*Valamugil seheli* (Forsskal)	M, E	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
	58	*Valamugil speigleri* (Bleekers)	M, E, R	****	****	****	****	****	****	****	****	****	****
Sphyraenidae	59	*Sphyraena jello* (Cuvier)	M	****	****	****	****	****	****	****	****	****	****
Gobiidae	60	*Glossogobius giuris* (Ham.-Buch.)	M, E. R	****	****	****	****	****	****	****	****	****	****
	61	*Oxyurichthys microlepis* (Bleeker)	M, E	****	****	****	****	***	***	***	***	***	***
	62	*Oxyurichthys tentacularis* (Val.)	M	****	****	****	****	***	***	***	***	***	***
	63	*Oxyurichthys formosanus* (Nichols)	M, E			***	**		*				
Eleotrididae	64	*Eleotris fusca* (Day)	E, R	*						**		*	
Trichiuridae	65	*Lepturacanthus savala* (Cuvier)	M, E			*	*			*		*	*
Anabantidae	66	*Anabas testudineus* (Bloch)	R	*			**	*		**			
Channidae	67	*Channa marulius* (Hamilton-Buchanan)	R	*		*	**			**			
	68	*Channa* sp.	R	*			**			**			
Mastacembelidae	69	*Macrognathus guentheri* (Day)	R	**		**	**			**			
	70	*Mastacembelus armatus* (Lacepede)	R	**	**	**	**	**	**	**	**	**	**
Bothidae	71	*Pseudorhombus javanicus* (Bleeker)	E, M	***	***	****	***	***	***	***	***	***	***
	72	*Pseudorhombus arsius* ((Ham.-Buch.))	M, E	*	*	*	**	*	**	*	*	*	*
Cynoglossidae	73	*Cynoglossus cynoglossus* (Ham.-Buch.)	M, E	***	***	****	***	***	***	***	***	***	***
	74	*Cynoglossus punticeps* (Richardson)	M	***	***	****	***	***	***	***	***	***	***
	75	*Cynoglossus lingua* Hamilton-Buchanan	M, E	***	***	****	***	***	***	***	***	***	***
Soleidae	76	*Euryglossa orientalis* (Bloch & Schneider)	E	***	***	***	****	***	***	***	***	***	***
Triacanthidae	77	*Triacanthus biaculeatus* (Bloch)	M			**	*			*		*	*
Tetraodontidae	78	*Tetraodon leopardus* (Day)	M, E	*	*	*	*	*	*	*	*	*	*
Teuthidae	79	*Teuthis vermiculata* (Day)	M, E	***	***	****	***	***	***	****	***	***	****
	80	*Teuthis java*	M	***	***	****	***	***	***	***	***	***	***
Stromateidae	81	*Stromateus cinereus*	M	***	***	****	***	***	***	***	***	***	***
Platacidae	82	*Platax orbicularis* (Forsskal)	M										*
SHELLFISHES	83	*Macrobrachium rosenbergii*	R, E		**	**	**	**	*	*		*	*
	84	*Macrobrachium idella*	R, E	****	****	****	****	****	****	****	****	****	****
	85	*Macrobrachium lamerrei*	R, E	***	***	***	***	***	***	***	***	***	***
	86	*Penaeus indicus*	M, E	****	****	****	****	****	****	****	****	****	****
	87	*Penaeus monodon*	M	***	***	***	***	***	***	***	***	***	***
	88	*Penaeus semisulcatus*	M	***	***	***	***	***	***	***	***	***	***
	89	*Metapenaeus monoceros*	M, E	****	****	****	****	****	****	****	****	****	****
	90	*Metapenaeus dobsonii*	M,E	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
		Stomatopod											
	91	*Oratosquilla nepa*	M, E	***	***	***	***	***	***	***	***	***	***
		Crabs											
	92	*Scylla serrata*	M, E	****	****	****	****	****	****	****	****	****	****
	93	*Portunus pelagicus*	M, E	***	***	***	***	***	***	***	***	***	***
	94	*Portunus sanguinolentus*	M, E	****	****	****	****	****	****	****	****	****	****

*****Abundant **** Moderate ***Frequent ** Rare *Occasional

The crab fishery chiefly contributed by the spotted crab *Portunus sanguinolentus*, the mud crab *Scylla serrata* and the Blue crab *Portunus pelagicus* formed a very attractive ishery serving both the domestic and international markets. The modest estimate was that the crabs contributed at least 2.6 to 11.1 % of the 10,000-t fishery of these ten backwaters.

The total landings from different backwaters varied from 96.8t from Mahe to 2899t from the Ashtamudi. The average yield/ha varied from 410 kg at Anchuthengu to 2747.3 t from Azhikode estuary. The low yield per unit area at Astamudi was due to its large area (6424ha). The high-density fish/prawn population at Azhikode is due to its wide access to the sea and the narrow stretch of the backwater spread. The system was well filtered by the Stake net (445 units) that brought huge quantity of *M. dobsonii*, *M. monoceros*, *P. indicus* and a whole lot of less commercial species. The Anchuthengu backwater brought less catch due to the denial of direct access to the sea and being a highly strained ecosystem resultant to pollution from coconut husk retting. The average value for the whole system was 630.1 kg/ha for the year.

The general observation is that the fishery of the backwater is less dependent on the local species and more dependent on the migratory marine species like the prawns, the crabs, the catfishes, the silver bellies, the barracudas, the anchovies, the carangids, the perches and so on. This, however does not undermine the contribution by the local resident species like the *Etroplus suratensis*, the resident mullets, *etc.*

FISHING GEAR AND EFFORT

The Craft and Gear

Over thirty types of well-differentiated gear were observed during the survey that could be broadly categorised into 10 categories (Table 14). The gear enumeration indicates that the density in (No./km^2) different systems ranges from 52 nos. in Ashtamudi to 174 in Mahe. The distribution of stake nets and dip nets in Ashtamudi and Azhikode backwaters are given in Figs.13 & 14. The density has been proportional to the area of the systems. On an average, one gear unit has the following composition and days of operation roughly averaging for the whole year.

Operation of stake nets and Chinese dip nets are influenced directly by the tidal strength. Hence their operation is generally restricted to a few days adjacent to full moon and new moon.

Table 14 Composition of fishing gears and period of operation

Unit	Composition	Av. No. days operated/month
Gill net :	One boat, two fishermen, four nets,	20 days
Cast net:	One boat, two fishermen, two nets,	20 days
Seine net	Two boats, five fishermen, one net	20 days
Stake net	Two fishermen, one boat, and four nets	12 days
Chinese dip net	One boat, two men, one net	15 days
Hook and lines	One boat, one man, 2-3 hooks	20 days
Scoop net	One boat, tow men, two nets	20 days
Ring net	One boat, one man, 15 nets (Crab nets)	20 days
Trawl net	One boat, one net, two men	20 days
Trap net	Two boats, two men, one trap	20 days

CATCH PER UNIT EFFORT

The catch per unit effort for different gear and for different systems is presented in Table 15. The CPUE exhibited wide variation from gear to gear, but exhibited a general trend for most of the backwaters. The high rate CPUE for the Stake net is largely offset by the limited days of operation and the low market value fish forming the bulk of the catch. Seine net too brought high CPUE, but again the catch composition is composed largely of small fishes, young fishes and the low priced *M. dobsonii*. (Table 16). The catch from this gear was subjected to wide variation.

Table 15 Total Fish/shellfish landings and yield density of gear and active fishermen at different backwaters during 1998-99

Backwaters (with area in ha.)		**Total landings (tonnes)**	**Yield (kg/ha)**	**Gear (No./km²)**	**Fishermen (No./km²)**
Kadinamkulam	(347)	351.9	1014	122	194
Anchuthengu	(552)	214.4	410	120	145
Ashtamudi	(6424)	2898.7	451	52	58
Kayamkulam	(1652)	1647.9	998	83	137
Azhikode(696)	1912.1	2747	158	152	
Chettuva	(714)	510.3	715	100	84
Ponnani	(757)	550.7	727	100	107
Mahe	(88)	96.8	1099	174	203
Valapattanam	(3074)	757.0	246.0	31	19
Neleswaram	(825)	891.0	1080	97	68
Mean values			**630.1**	**72**	**73**

Table 16 Average CPUE and % contribution by different gear to the total landings in backwaters during 1998-99

Gear	CPUE (kg/unit/day)	Contribution to total landings (%)
Gill net	3.9-12.1	26.31
Cast net	2.5-6.8	10.94
Seine net	11.3-74.7	17.76
Stake net	7.5-18.1	28.39
Chinese dip net	5.6-10.2	11.66
Hooks and line	2.3-10.3	2.13
Scoop net	2.3-2.9	0.89
Ring net	1.0-5.6	0.91
Trap net	3.8-8.7	0.46

FISHERMEN POPULATION AND INCOME DISTRIBUTION

The survey was restricted to the enumeration of active fishermen whose primary job was fishing in backwaters. The distribution of fishermen depending on various backwaters is presented in the Table 15. Their density per km2 varied from 58 in Ashtamudi to 203 in Mahe. (Av. 74nos. km2). Assuming that the average number per fishermen family as 5, the number of fisherfolk directly depending on these 10 backwaters covering 15100 ha is around 56,000.

The disposal of the landings brought ashore by the fishermen was, in general, through auction at the landing sites. Though majority of the fishermen was organised in to societies, the Societies seldom responded 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 t 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. Among the fishes, only the *Etroplus suratensis* fetched a reasonable price due to its good demand in the market.

An estimation of the price share indicated that on an average, fishermen received only 48-73% of the market price at the landing site through auction. The observations from randomly selected 20 cases from each system recorded the following;:

Percentage of market share by the fishermen and vendor at different landing sites:

Ashtamudi	61.4%	Mahe	73%
Kayamkulam	59.4%	Chettuva	58%
Ponnani	48.0%	Neleswaram	53.6%

At Mahe, the fishermen themselves used sell in the market adjoining the landing site and hence fetched a reasonable price.

SURVEY OF FISH LARVAE/YOUNG ONES

Locally fabricated stake nets (of mosquito cotton clothing) as per the design of the spawn collection nets used by CIFRI earlier during the riverine spawn prospecting were anchored in the backwater during high tide and receding tides. However, the result was discouraging with only very few no. of seed/young ones got collected in the tailpiece. Moreover, often the nets were clogged with mud, floating medusa, weeds, etc. Stray specimens of penaeid prawn larvae and juveniles, *Scatophagus argus*, silver bellies, small crabs, etc. were encountered, but that could not be considered a true indication of the fish and larval abundance in the systems. Several attempts were made at Neleswaram, Valapattanam, Kayamkulam and Ashtamudi backwaters with nosuccess.

GENERAL OBSERVATIONS

Economic and social reasoning

The survey clearly indicates indisputable contribution of the backwaters to the inland fish production of the region both for internal consumption and for the export. While the shellfish fishery largely support the export clientele (except *M. dobsonii*), the fishes serve the local populace. From the 15,100 ha backwater covered under the survey, the average yield per hectare was to the tune of 651kg. Considering that the coastal interconnected backwaters spread to over 65000 ha, the total annual yield should exceed 42315 tones.

MAJOR RECOMMENDATIONS OF THE PROJECT :

1. *The fishing effort should not be allowed increase further and has to be restricted at least to the current level till further suggestions are made based on population dynamics investigations conducted on major fish/shellfish species of the backwater systems.*

2. *No proper registration of the fishing gear and craft is being carried out except for the stake nets. The registration system followed under the Fishermen Welfare Board is not effective in regulating the fishery. Strict registration and licensing to all existing craft, gear and fishermen is to be immediately implemented.*

3. *There is an urgent need to restrict the mesh size of the stake net, Chinese dip net and the drag net to ensure more growing period to the young ones. Though a minimum mesh size of 25 mm (stretched) is advisable, considering that M. dobsonii is also to be exploited, the minimum mesh size may be restricted to 18mm.*

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. *Several of the stake nets are being deployed during the tide incursion to the back-waters against the norms. The enforcement machinery is to be strengthened to ensure that the stake nets are deployed only during the receding phase.*

6. *Considerable area of the backwaters has already been lost due to reclamation for agricultural, mining, urban area development and similar activities. Backwaters are priceless heritage serving to a variety of economic activities apart from fisheries. Further encroachment/reclamation are to be strictly regulated.*

7. *Several stretches of backwaters are subjected to extreme organic/industrial pollution. Hence pollution abatement measures are to be given top priority. Technology for alternate coconut husk retting practice has to be developed that free backwaters from organic pollution.*

8. *Reclaimed paddy lands such as at Kuttanad, Kattampally, etc are to be utilised to raise an additional crop of fish during the fallow period.*

9. *Ranching programme will be more effective after the implementing fishery regulations. Hence regulatory measures are to be strictly implemented to benefit from the currently envisaged massive ranching programme in backwaters/river stretches.*

The average density of active fishermen being 74 per km2 , the total fishermen directly depending on the backwater fishery is estimated at about 50000 nos. Therefore the fishermen population directly depending on the backwater fishery approximates 2.5 lakhs. Taking also in to consideration the innumerable population indirectly depending on the catch, the direct and indirect potential for employment generation is only assumable. The fishery undoubtedly deserves its due attention for both economic and nutritive reasons.

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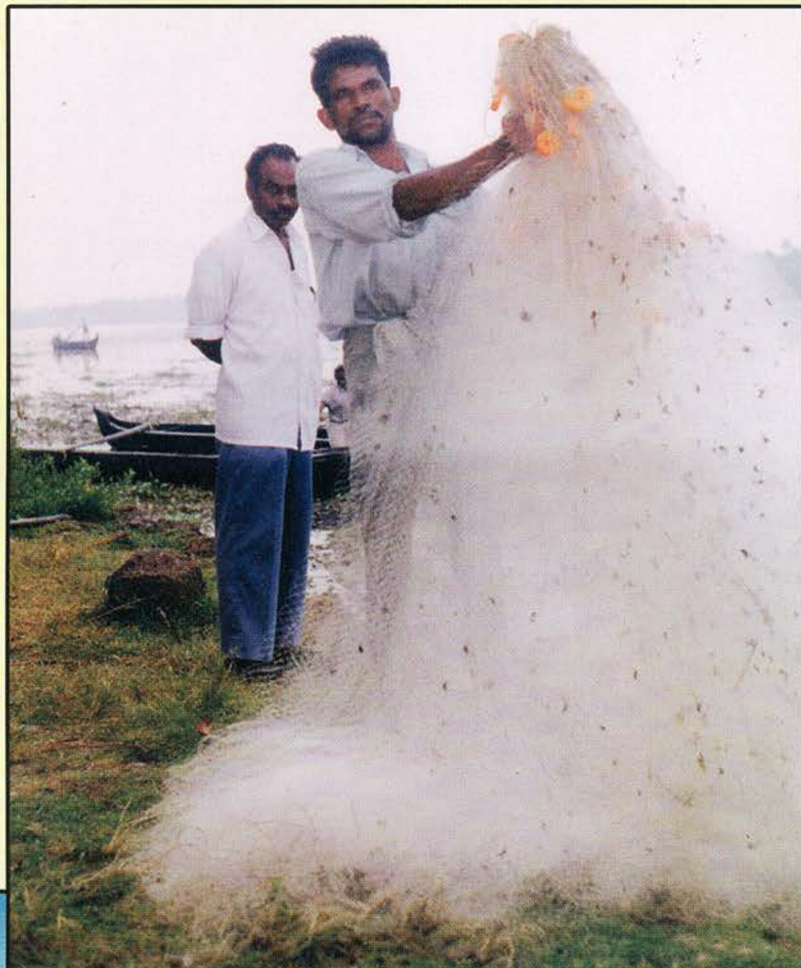
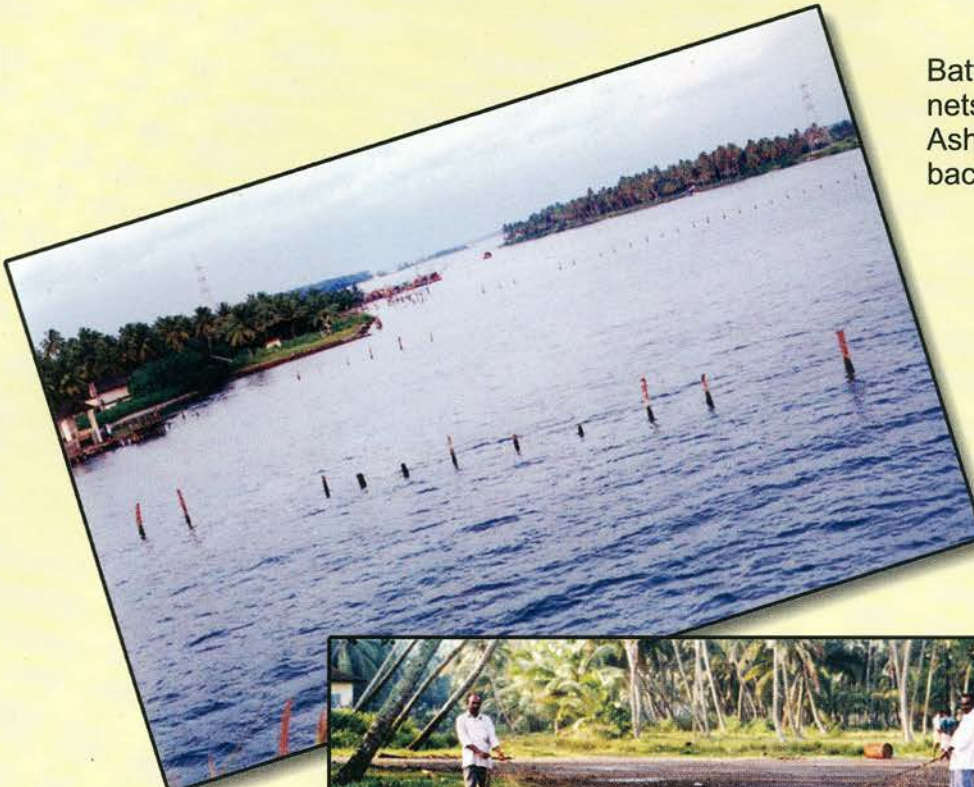
A GLIMPSE OF DIFFERENT FISHING GEARS AND LANDINGS IN THE BACKWATERS



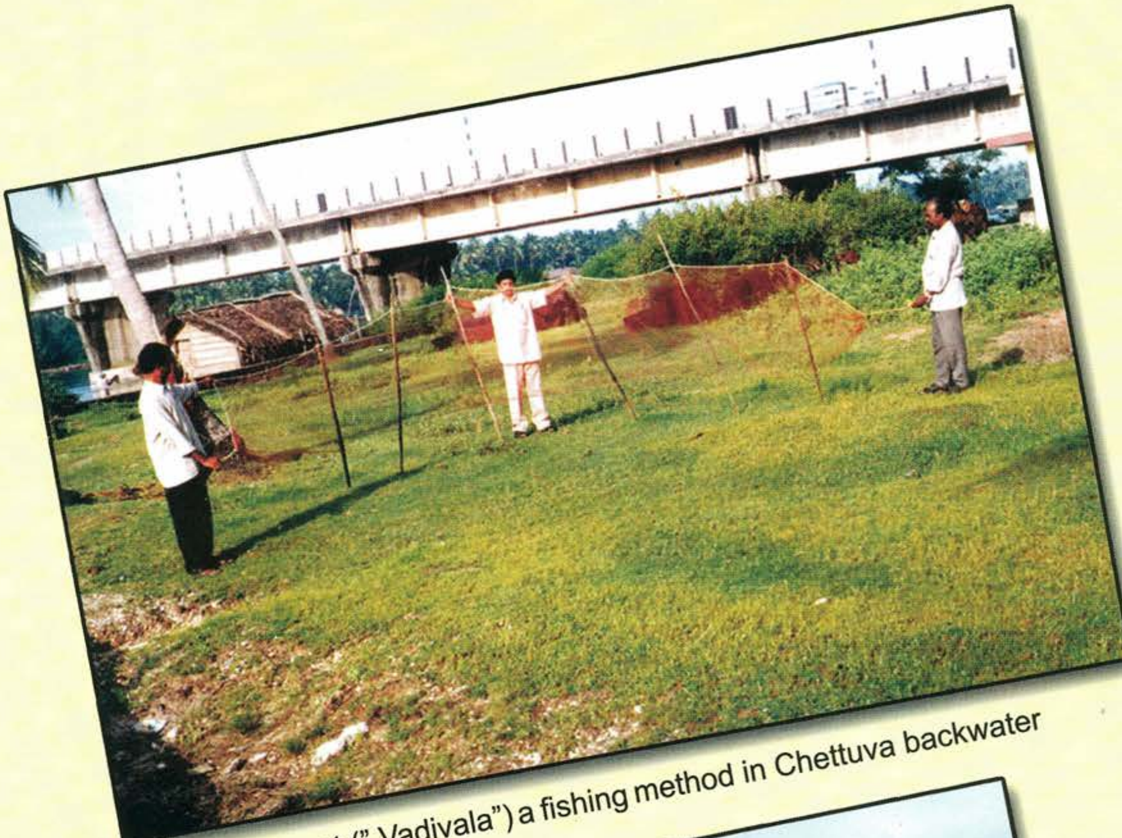
Gill net fishing in Kayamkulam backwater

Cast net fishing in
Kayamkulam backwater

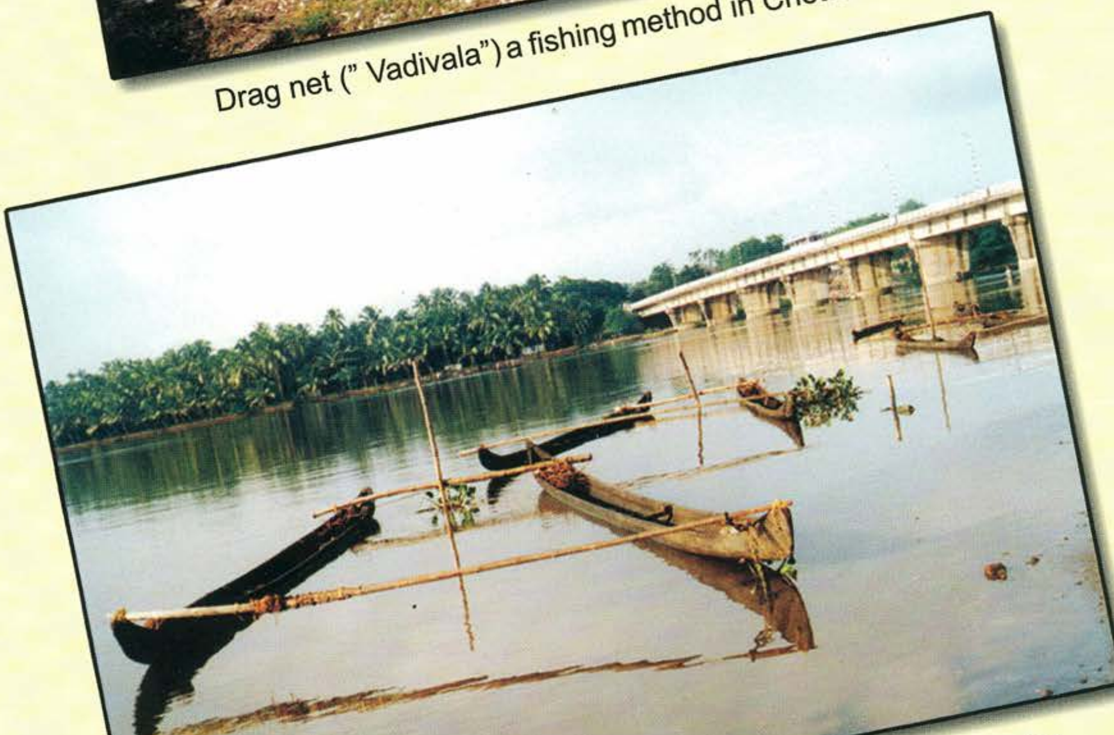


Batteries of Stake nets in the Ashtamudi backwater

A Closer view of Stake net before deployment in Valapattanam backwater



Drag net (" Vadivala") a fishing method in Chettuva backwater



Trap fishing using paired boat and chain in Chettuva backwater

Chinese dip net in operation in Ashtamudi backwater

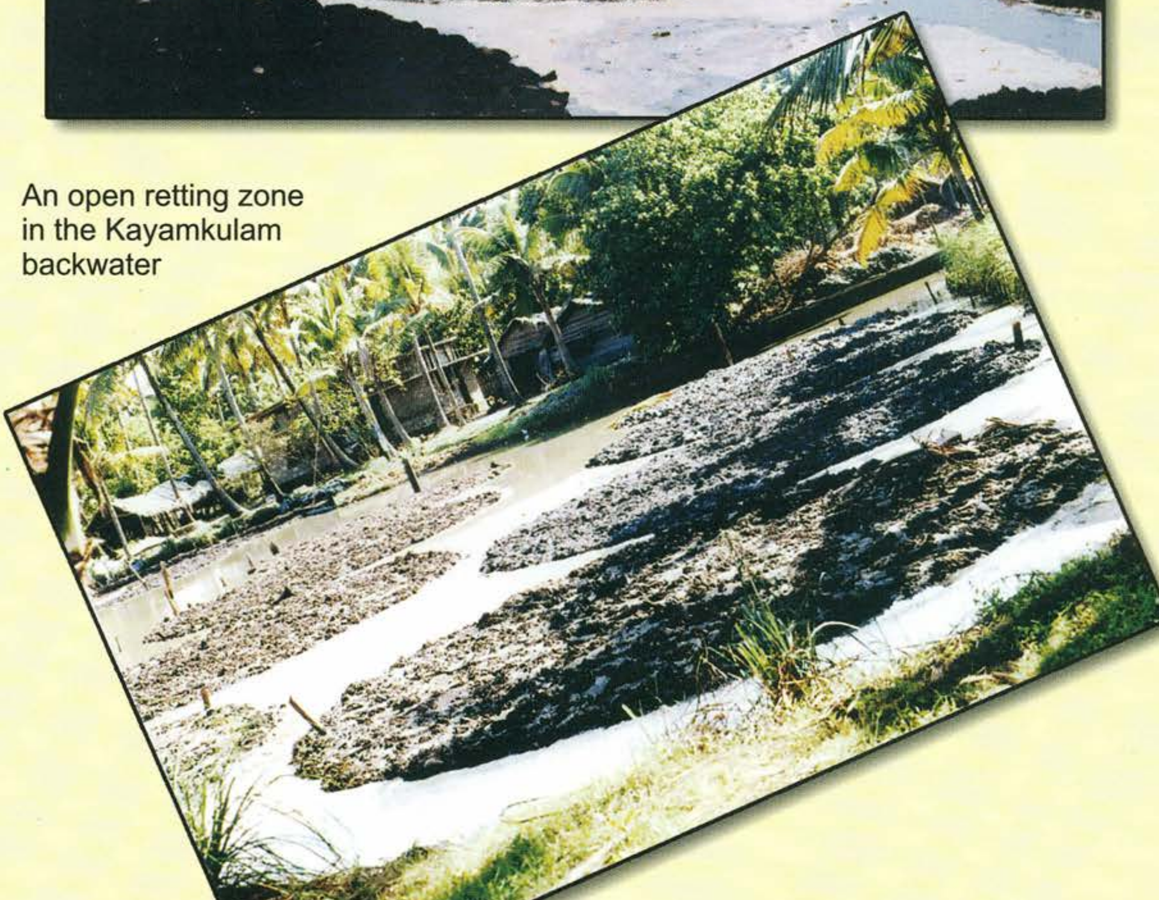
Seine net fishing in Vembanad backwater

A fish landing centre in Kayamkulam backwater

Fish catch in Anchuthengu and Ashtamudi backwaters ready for auction

RETTING ACTIVITY IN THE BACKWATERS

An open retting zone in the Kayamkulam backwater



A close view of the 'Malis' containing the bundle of coconut husks