ECOLOGY AND FISHERIES INVESTIGATION IN Vembanad Lake

CENTRAL INLAND CAPTURE FISHERIES RESEARCH INSTITUTE • BARRACKPORE

Ecology and Fisheries Investigations in Vembanad Lake

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Foreword

The Vembanad lake on the south-west coast of India in Kerala represents and symbolizes the nature's bountiful and varied gift of aquatic living resources to mankind. Obviously, the lake ecosystem has a high life carrying capacity and fosters a crucial role both biologically and economically. The need to protect preserve and optimally use such ecosystems is imperative and beyond the scope of argument. However, over the past several decades, various anthropogenic interference for manifold purposes especially construction of Thanneermukkom barrage, had adverse impact on the ecosystem and fishery.

It is thus imperative that the present status of fishery, carrying capacity of the lake and behaviour of major fishery in the post barrage phase is known in order to suggest appropriate remedial measures for rejuvenating the fishery. With this intention scientist of CIFRI conducted investigations on the lake. The bulletin attempts to present the findings in a systematic manner.

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THE GENESIS OF THE PROJECT

VEMBANAD LAKE a massive and vibrant coastal wetland ecosystem, stretches to over 24000 ha in area and contributes to over 50% of the total area of backwaters (Kayals) in Kerala State. More than 20,000 fishermen are directly dependent on the aquatic resources of this lake fetching over 7000 t of fish and shellfish annually. Its fishery wealth comprises of over 150 species, including the prized varieties such as the pearl spot, mullets, the giant freshwater prawn and the penaeid prawns. The fish and shellfish landed from Vembanad lake is valued at over Rs. 100 million annually.

Coastal wetlands are known to be an indispensable habitat to a variety of biologically and economically important resident and migratory aquatic and avian fauna. These are also recognized nursery grounds for several species of fish and shellfish. Moreover, the interdependence of marine and the adjoining estuarine zones in completion of the life cycle processes of innumerable aquatic species is amply described in fishery literature. The biological importance of Vembanad and the interconnected backwaters are to be viewed and assessed in this context. This is all the more evident since the adjoining marine coastal zone in the Lakshadwip sea continues to be one of the most productive fishery zones in the world contributing to about 0.6 million t of fish and fetching livelihood for 1.5 million fishermen.

On the other side, 41 of the 44 rivers in the State fill into the backwater system before they empty into the sea. This accounts for 5 % of India's annual freshwater budget. Vembanad lake itself receives the inflow from six major rivers of the State with a runoff volume of 24000 million m^3 per year. Several of the fish species inhabiting the lake share both the river and lake environments in their varying life stages. The giant river prawn *Macrobrachium resenbergii* for whom the Vembanad ecosystem forms a natural abode, is a classical example of this behaviour.

Nevertheless, over the past several decades, the unrestricted human interference for the heterogeneous purposes had irrevocable adverse consequences on the entity of the lake itself. The onslaught was on the increase during past few decades and it still continues. The most significant eventuality among these activities was the commissioning of the Thanneermukkom barrage across the lake in 1976. This has destroyed the continuity of the ecosystem prohibiting the sharing of its physical and biological identity between both the sectors. Thus, to quote Gopalan *et al.* (1983), in effect an area of 69 km^2 of brackishwater lying south of Thanneermukkom had been ecologically cut off from the rest of backwaters.

The lake had already been reclaimed considerably by 1976 to raise paddy crops, and the Kuttanad area encompassing a major share of the lake had grown into a principal rice bowl of the State. The bund was created at Thanneermukkom to protect the low-lying paddy fields from the tidal saltwater ingress during the November to May and to raise two crops of paddy in an area of over 6000 ha south of the barrage. However, faulty designing and partial implementation of the barrage had brought with it unanticipated misfortunes. The most discernible among them was a virtual stagnation of water mass in the southern sector and its adjoining canals and water ways during the summer, resulting in serious pollution and health hazards in the area. On the other hand, barrage sluices were unable to negotiate the monsoon rush from the four major rivers, and as a result, there were frequent floods during the monsoon bringing enormous misery to the people of Kuttanad.

There was another appalling consequence that took place ecologically. The sector that got cut off during the summer experienced a transformation from the estuarine phase to an almost freshwater phase resulting in a rapid decline in fish yield and the shrinkage in the species spectrum. The riverine or the estuarine species that essentially required a sojourn into the estuary or vice versa faced a sharp fall in their population size. The marine migratory and the resident estuarine species were restricted to the north of the barrage. The replacement of the estuarine species of the sector by the sweetwater species was not adequate to compensate the loss to the fishery.

The suggestions for appropriate remedial measures for rejuvenating the fishery required scientific documentation on the status of fishery as a whole, carrying capacity of the system and an information on the behaviour of major fishery in the sector during the post-barrage phase. It was in this context that the Central Inland Capture Fisheries Research Institute took up the challenge of charting systematically the time-scale changes in the ecosystem characteristics, the biodiversity and its seasonal transformations, and fishery transformation incorporating both the pre- and the post barrage phases.

DESCRIPTION OF THE VEMBANAD LAKE

The Vembanad lake spanning between latitudes 9° 28′ and 10°10′ N and longitudes 76° 13′ and 76° 31′ E is the biggest among the 30 backwaters in the State. This has an area of about 22750 km^2 spread in to three districts, *viz.*, Ernakulam in the north, Kottayam in the east and Alappuzha (Alleppey) in the south. The western side is bordered by a narrow belt of land separating the lake from the Lakshadwip sea. It extends to a length of 96.5 km from Azhikode in the north to Alappuzha town in the south. The lake north of Aroor is situated in the erstwhile Cochin State, and is generally referred to as the Cochin backwaters. **The southern portion from Aroor to Alappuzha is more commonly referred to as Vembanad lake and lies in the erstwhile Travancore State**. In strict terms, due to its continuity, both the water masses together constitute the Vembanad lake. The lake is narrow and sinuous in the north while much broader to a maximum of 14.5 km in the south. In its length of over 96 km running parallel to the sea from Azhikode to Alappuzha, the lake is mainly connected to sea only at two places, Azhikode and Kochi. Seasonal intrusion of seawater to the lake is also experienced through the Thottappally spillway, situated 20 km south of Alappuzha. A small connection controlled through the spillway exists at Andhakaranazhi, in Cherthaal taluk, about 25km north of Alappuzha town. It is a complex system encompassing estuary, lagoons, marshes and mangroves with intricate network of natural and man-made channels.

ORIGIN OF THE LAKE: The Vembanad lake is said to have originated around 5000-6000 years ago during the post glacial era when most of the world's coastal systems took shape. However, according to the geologists, the lake attained its present configuration in the 4th century A. D. The system was primarily a marine environment bound by an alluvial bar parallel to the coast line and interrupted by the Arabian sea at intervals. As a result of the catastrophic deluge that took place in 1341 A. D., parts of Alleppey and Ernakulam districts including a number of islands thus separated into a distinct water body from the sea with connecting channels at Thottappally, Andhakaranazhi and Cochin. During this period, the river Periar emptying at Kodungallur took a diversion through Varappuzha and opened into Cochin channel, giving rise to a number of islands lying scattered in the backwaters by the deposition of the alluvium in its course. This transformation from the original marine environment into an estuarine environment is evident by the large quantities of typically marine shells deposited in the Vembanad region. This transformation has been well explained by Gopalan *et al.*, 1983.

The Vembanad lake lying in Kuttanad region is a low lying area near the coast of the Kerala. It was originally a part of the shallow coastal area of the Arabian sea. Consequent to geological uplift, a shallow bay was formed into which the rivers draining from the mountains to the east discharge. The coast was formed by the silt deposits carried by these rivers. The bay thus transformed into a brackish water lagoon extending from Alappuzha in the south to Cochin in the North. In 1976 the lagoon was separated into two by the construction of the Thanneermukkom barrier. The barrier was constructed to prevent saline water intrusion into the lake during the dry season (summer months) and also to retain the fresh water from the rivers flowing into the lake. At the time of its construction, the barrier was relatively successful in keeping water in Kuttanad fresh and thereby enabling cropping during the summer months. However, the barrier has had various adverse ecological effects, which would be dealt in detail below.

SHRINKAGE OF VEMBANAD LAKE: Backwaters have been continuously subjected to the reclamation for various purposes such as agricultural expansion, agriculture practices, harbour development, urban development and other public and private uses. A few historical documents such as the Travancore Land Revenue Manual for the year 1834 testify that the local Government of the region had encouraged large scale reclamation to the *kayal* lands (Travancore State Manual, 1834). Of the reclamation for the agricultural purposes, paddy cultivation and paddy-cum-shrimp culture has contributed immensely to the horizontal shrinkage of the backwater system. In 1834 the Vembanad lake had an area of nearly 365 km^2. Accordingly to Pillai and Panikkar (1965) during the early phases, land reclamation and flood control work were largely undertaken at the initiative of private farmers with active assistance from the State Government. The details on reclamation of Vembanad lake for agricultural and aquacultural purpose is given in Table-1. About 2,200 ha area have been reclaimed till the beginning of this century. According to Kurian (1978), the reclamation activities were banned in 1903 as per the Government directive so that it did not hinder Cochin Harbour's development due to silt accumulation. But later on, an area of 5,200 ha was reclaimed up to 1931 (KSSP, 1978). Further, 1320 ha in the Southern part of Vembanad region was reclaimed for agricultural purposes. According to Gopalan *et al.* (1983) about 5100 ha. of the backwater has been converted into paddy-cum-shrimp culture areas till the 1970s. During 1901 to 1985, an additional area of 1500 ha was reclaimed by private owners for agriculture, cottage industry, and housing. The bunding and utlisation of the lake for paddy-cum-shrimp culture and other activities is being carried out even now in patches. Thus, out of 36500 ha of backwaters which existed till the middle of 19^{th} century, only about 23750ha (65.1%) is remaining now as open waters. Of this, coconut husk retting activity is estimated to occupy an area of about 500 ha.

Table 1. Reclamation of Vembanad lake over the years

Period	Area (ha)	% of area reclaimed	Purpose reclaimed
1834 - 1950	8805	24.12	Agricultural
1920-1936	365	1.00	Development of port
Till 1970s	5100	13.97	Paddy-cum-shrimp farming
1978	10.78	0.03	Fishing harbour programme
1970 - 1984	800	2.19	-do-
1900 – 1984	1500	4.11	Housing, industries, coconut husk retting
1981-85	141.7	0.39	Southerly extension of Wellington island by GCDA
1981-85 by GCDA and Cochin Town Planning Trust	23.91	0.07	Foreshoreurban development
1981-85	11.73	0.03	Cochin shipyard, CIFT, north Tanker berth, etc.

Source : Gopalan *et al.*, 1983

Besides the horizontal shrinkage, The lake also has been experiencing drastic decline in its depth. Siltation is a major factor contributing to gradual shallowing of the backwater. It is reported by Gopalan et al. (1983) that the average depth of Vembanad backwater has been reduced from 6.7 m to 4.4 m between the years 1920 and 1980. The sector-wise depth reduction is presented in Table–2. The authors estimate that by 1985, the water holding capacity of the lake from Azhikode to Alappuzha has been reduced to 22.83% of what was in the beginning of this century. The current level of depth in the southern sector of the lake observed under the present study was 2.2m, a further depletion of 0.8-1.3m in a span of 20 years approximating to 86000 ham.

Table 2. Reduction in depth range in different sectors of Vembanad lake over a period of 50 years

Sectors	Depth-range (in meters)	
	50 years ago	20 years ago
South of Thanneermukkom bund	8-9	3-3.5*
Between Thanneermukkom bund and Vaikom	8-9	3-4
Between Vaikom and South Paravoor	7-9	4-5
Between South paravoor and Aroor	5-6	3-4
Between Aroor and south of Wellington Island	7-8	7-8
Bolghatti to Cherai	3-4.5	2-2.5
Cherai to Munambam	3-6	2.5-4

* Recent (1994-96) studies recorded an average depth of 2.2m in this region.

RIVER DISCHARGE IN TO THE LAKE

The rivers, which directly drain into the Vembanad wetland system are Chalakudy (1700 km^2, 130 km), Periyar (5400 km^2, 244 km) and Muvattupuzha (1550 km^2, 121km), in the northen sector, and Meenachal (1250 km^2, 78 km), Manimala (850 km^2, 90 km), Pampa (2250 km^2, 176 km) and Achancoil (1500 km^2, 128 km) in the southern sector (Fig.1). The basins together cover an area of about 16200 km^2 out of which 22 % lies in the lowland, 23 % in the midland and the remaining 55 % in the highland. The rivers flow down the highlands over steep slopes of almost 60m/km and more, and traverse their midland stretches with much flatter slopes of about 1 m/km.

The rivers are estimated to bring in a total of 10074 million m^3 of water to the lake (Table-3). Of this, 66.54 % are brought in during the three months of the south west monsoon and 11.67 % during the north east monsoon in October. Only 22 % of the discharge are spread among the rest 8 months. Practically there is no seaward flow of river water during these months.

Fig. 1. Map of Vembanad lake indicating incoming rivers

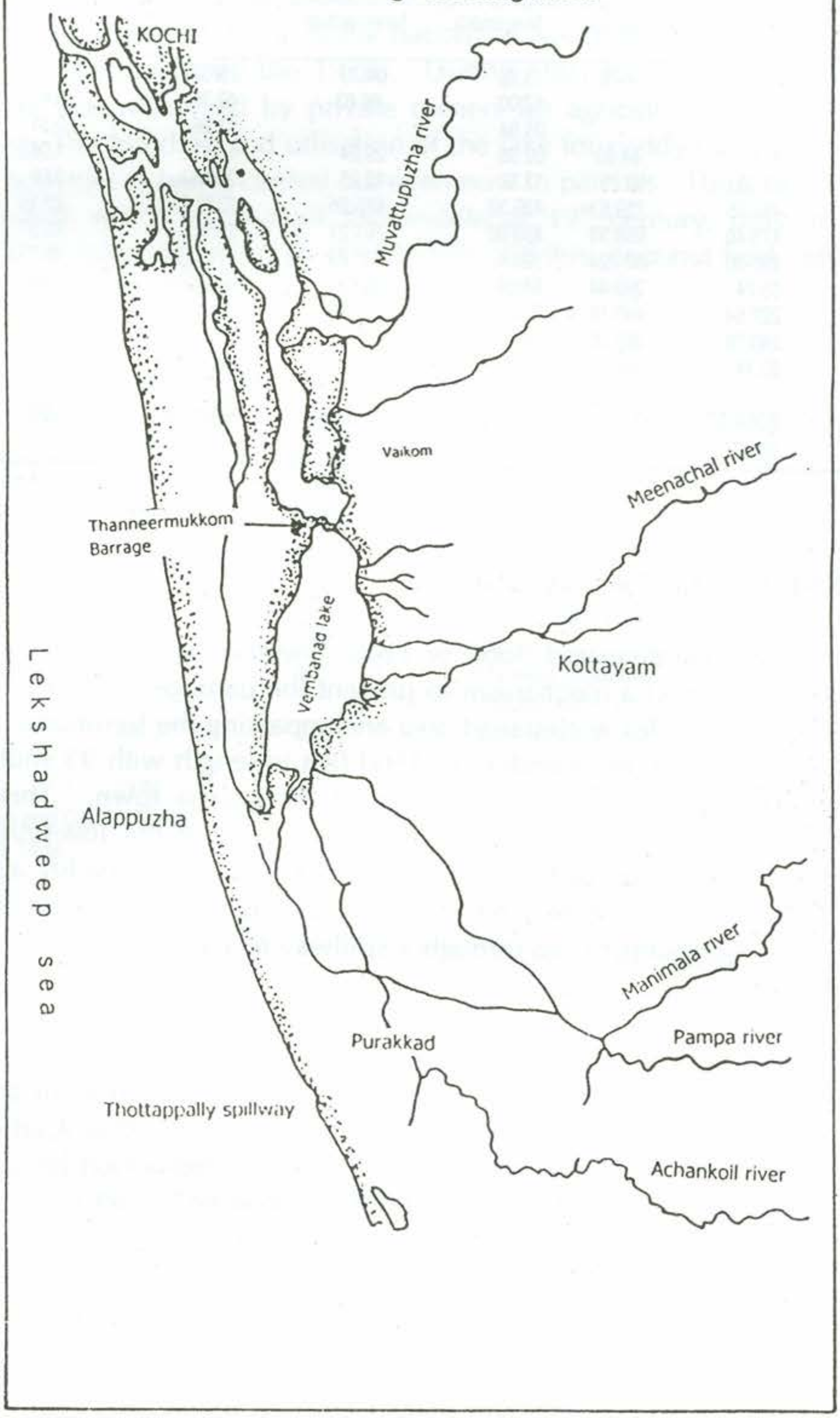


Table 3. Annual discharge (million m^3) from rivers in to the southern sector of the lake.

RIVERS	Achankoi	Pampa	Manimala	Meenachal	TOTAL	% of total
Jan	42.71	14.79	13.77	04.33	75.60	0.75
Feb	21.52	-	12.00	06.83	40.35	0.40
Mar	29.65	-	01.64	-	31.26	0.31
Apr	30.54	44.69	02.35	29.54	107.12	1.06
May	62.96	92.25	12.57	42.25	210.33	2.09
Jun	497.75	759.63	429.38	645.95	2332.71	23.16
Jul	473.40	958.33	453.06	701.21	2586.0	25.67
Aug	291.36	631.24	324.42	537.24	1784.26	17.71
Sep	83.74	260.44	64.54	90.68	499.40	4.96
Oct	227.54	448.16	214.04	282.63	1172.37	11.64
Nov	245.76	382.56	165.67	168.00	962.01	9.55
Dec	60.14	166.42	33.50	12.36	272.42	2.70
TOTAL	**2067.07**	**3758.51**	**1726.94**	**2521.02**	**10073.54**	**100**
%	20.52	37.31	17.14	25.03		

Compiled from the data obtained from Department of Irrgation, Govt. of Kerala.

THE THANNEERMUKKOM BARRAGE

Consequent to an unanticipated flood in 1949, The then Agriculture Minister of the State decided to find a mechanism to prevent the damage to the paddy crops in the reclaimed vast fields in Kuttanad area encompassing the Vembanad lake. As part of this strategy, a bund extending to 4500 feet in length with 93 shutters was planned at Thanneermukkom, 24 km north of Alappuzha town. This was to prevent the saline water incursion to the 6000 ha area of the low-lying paddy fields in the southern sector of the lake so that a second crop of paddy also could be raised in these fields. A leading channel was suggested to divert the flood waters from the four rivers to sea through a spillway at Thottappally, 20 km south of Alleppey town.

The project was implemented partially. Only 62 shutters were erected at the west and east ends of the barrage. The central portion was filled with earth. The shutters were to prevent the salinity incursion to the southern sector during high tides of November-December months, and were never intended to be closed permanently. But, in effect, due to practical problems in intermittently opening and closing the shutters, the barrage remained closed permanently for about six months from November-December to April-May. Only since 1992, the period of closure was reduced to four months, from December to April.

The Thottappally spillway was also constructed, but with out the lead canal. As a result, the floodwaters from the four rivers still continue to flood the paddy fields as before, occasionally with more severity. The Spillway and the barrage time again proved to be obstructions to the seaward flow, causing floods.

Tidal flow cutoff

Consequent to the commissioning of the barrage across the lake in 1976 and its closure during December to April end every year, the tidal inflow too remains cut off to this sector. The result is a virtual stagnation of the water mass in the southern sector for virtually four months of the year. This has destroyed the continuity of the ecosystem prohibiting the sharing of its physical and biological identity between both the sectors. Faulty designing and partial implementation of the barrage project had brought with it unanticipated misfortunes. The most discernible among them was a virtual stagnation of water mass in the southern sector and its adjoining canals and water ways during the summer, resulting in serious pollution and health hazards in the area.

With respect to the morphological features, the investigation under the present project has revealed the prominent time-scale changes in the southern sector of the lake. The ecological transformation in the sector from the estuarine phase to an almost freshwater phase resulted in a qualitative and quantitative change in the biota of the severed aquatic environment. The most apparent change was in the fish fauna. The less noticed but significant changes were among the smaller communities such as plankton and benthic organisms. The water and sediment properties also reflected the transformation. The following pages describe these transformations and put forth certain suggestions which may lead to the ecological restoration of the area for the better benefit of the users.

ACTION PROGRAMMES COVERED UNDER THE PROJECT

Analysis of water and sediment for their physico-chemical properties and nutrient status

Qualitative and quantitative distribution of plankton and benthic fauna.

Primary productivity estimations

Fishery : estimation of species-wise landings; with an emphasis on the pearlspot *Etroplus suratensis* and the river prawn *Macrobrachium rosenbergii*

Evaluation of changes in the ecology and fishery in the southern sector of the lake consequent to the commissioning of the Thanneermukkom barrage

The barrage at Thanneermukkom across the 23000 ha lake. It splits the lake into two distinct ecosystem causing changes in the fisheries and environment.

The dense growth of aquatic plants in the lake is a common sight in the lake after the commissioning of the barrage

Summary of the changes in areas covered under the Project :

LAKE AREA	The lake area in the southern sector was reduced by 48% between 1921 and 1950 due to reclamation, chiefly for paddy cultivation.
DEPTH	8-9 m depth in 1940s reduced to 2.1m by 1996 at south of Thanneermukkom barrage
TIDAL INFLUENCE	Experienced up to 80 km upstream in the southern sector rivers during 1960s; now reduced to 24 km upstream due to the commissioning of the barrage. Tidal influence is almost absent in the southern sector round the year either due to monsoon flow of the river or due to closure of the barrage in the summer.
WEED INFESTATION	The southern sector was almost clear of noxious weeds; Now thick infestation of *Eichhornia* and *Salvinia* observed
ORGANIC LOADING	Nutrient enrichment took place in the southern sector of the lake, compared to low value during pre-barrage phase. There is accumulation of organic carbon in the sediment in areas adjacent to the Punnamada Lake, paddy fields and west banks, south of barrage
BIODIVERSITY CHANGES	Significant changes in plankton qualitatively and quantitatively, the saline and euryhaline species more or less giving way to the freshwater or low salinity forms. There were changes in zoobenthos composition and abundance.
CHANGES IN FISHERY	The fishery in the southern sector underwent a complete transofrmation with the replacement of the saline migratory species by the freshwater species. The catches of several species dwindled.
SHARP FALL IN FRESHWATER PRAWN FISHERY	The fishery of the giant frshwater prawn experienced a sharp decline due to the prevention of the up and down breeding and larval migration of the species in the estuary due to the Thanneerkummom barrage. The catch of the species in the lake has declined from over 300 tonnes in the 60s to less than 100 tonnes in the 90s.

Most of the research on the ecology and fisheries of the Vembanad lake were conducted during the pre-impoundment phase, *i.e.*, before the commissioning of the Thanneermukkom barrage. The Cochin backwaters and its incoming rivers constituting the northern wing of the Vembanad lake have been the major area of interest to the researchers. Due to this, the literature based on studies extending up to the southern tip of the lake near Alleppey is rather few (Fig.2).

An account on the formative history of the Vembanad lake has been presented by Menon (1913) and Rasalam and Sebastian (1976). Gopalan (1976) has presented a comprehensive account of the history of reclamation and the consequent shrinkage of the backwaters, especially the Vembanad backwaters. Similarly, under the Indo-Dutch Collaborative Research Project on the Water Balance Study of the Kuttanad Region, various aspects of the ecology and fisheries of Vembanad lake were investigated and reported (Anon., 1989).

WATER QUALITY : 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 regime. Josanto (1971) analysed the bottom salinity characteristics and the factors that influence the saltwater 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), Ramamirtham *et al.* (1986,1987) and Wellershaus (1971).

SEDIMENT AND NUTRIENTS : 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 Sankaranarayanan and Panampannayil (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 sediment features of some prawn farming areas 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 the particulate organic carbon and particulate matter in Cochin backwaters, especially in the lower reaches of the Periar river. Seralathan *et al.* (1993) analysed and presented their findings on the features of the sediment and the distribution of organic carbon in the Cochin harbour area. .

PLANKTON : One major area of ecological investiagtions 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 report in this context was of 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 contribution 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 the spatial 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 (Devassy and Gopinathan 1970, Devassay and Bhattathiri 1974, Kumaran and Raz 1975, Gopalakrishnan *et al.* 1988). The phytoplankton were 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.

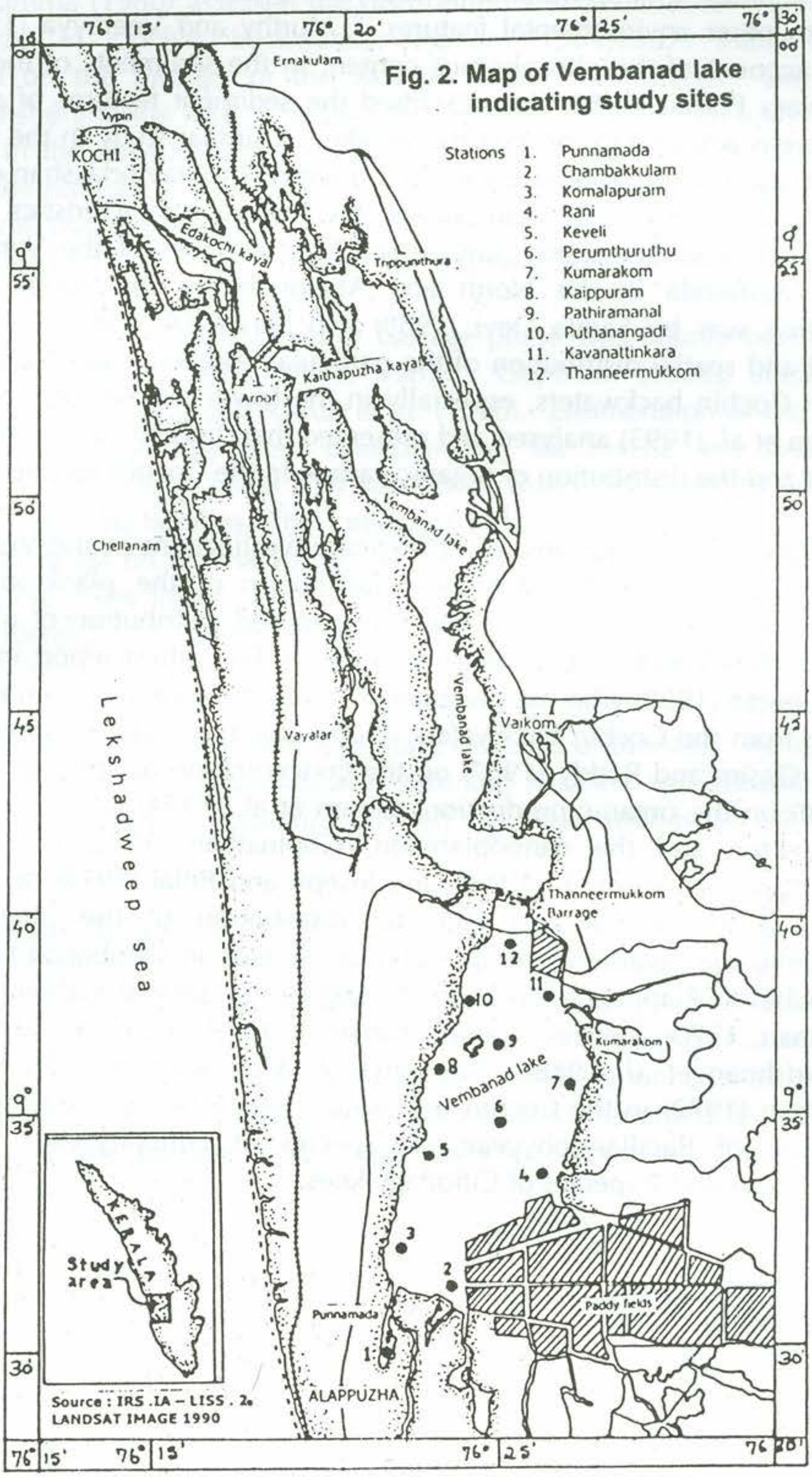


Fig. 2. Map of Vembanad lake indicating study sites

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 include that of Ansari (1974, 1977), Desai and Krishnankutty (1967), Govindankutty (1972), Jayasree (1971), Kurian (1967,1971, 1972), and Remani (1979). The notable contributions during the post barrage phase were by Aravindakshan *et al.* (1992), Gopalan *et al.* (1987) and Nair and Sarala Devi (1986). 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) and Gopalan et al (1987) undertook some of the investigations on the benthic fauna extending right from Cochin to Alappuzha.

PRIMARY PRODUCTION : 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 rediation 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 C^{14} 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.

POLLUTION : Sarala Devi *et al.* (1979), Unnithan *et al.* (1975) and Vijayan *et al.* (1976) documented the effect of organic pollution due to industrial pollution on some water quality parameters in Cochin backwater. Remani *et al.* (1980) studied the quality of sediment in Cochin backwaters in relation to pollution aspects. Sarala Devi *et al.* (1986) conducted elaborate studies in the Cochin backwater on the benthic communities under the impact of industrial pollution.

FISHERY: 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 the distribution of the *Hilsa ilisha* in the lake while George (1965) reported the unusual occurrence of mackerel. Shetty (1965) made a comprehensive description of the fishery practice along with a listing of the commercially important fish and prawn species of the 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 the *M. rosenbergii* in the river stretches that feed the lake. Raman (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 was mainly by Kurup and Samuel (1980a, 1980b, 1983, 1985, 1987). Gopinath (1953), Shetty (1965) Kurian & Sabastian (1982) and Kurup *et al.* (1990). 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 genera categorised under 56 families. The impact of indiscriminate fishery practice and environmental stress on the Macrobrachium fishery of the lake has been described by Kurup (1996). The fishery and biology of four species of *Macrobrchium 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 Achary (1987), Kurup *et al* (1990) and Rasalam and Sebastian (1976). The black clam, *Villorita cyprinoides* 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 (1996) and Kurup and Samuel (1980, 1987). The ecology stressing on the faunal transformation consequent to the barrage required more investigation to present a comprehensive change that occurred due to the barrage. The Report tries to compensate this lacuna to a reasonable extent.

ECOLOGICAL INVESTIGATIONS DURING 1994-97

Observations on the water quality parameters indicated a definite pattern of variation influenced by a combination of saline water intrusion through the barrage, and the extent of discharge by the four rivers into the lake south of the barrage (Table-4). The salinity remained the most important parameter influencing the general environment of the lake. Prior to the construction of the barrage, the tides of a mixed nature were felt during summer upto Pulikkezhu, 80 km south of Cochin connection to the sea, where the maximum tidal range was upto 5 cm, and at the Punnamada, the amplitude was to the extent of 22 cm. (Josanto, 1971). Contrary to this, during the post barrage phase, even in summer, the tidal range was restricted till Thaneermukkom Barrage at a distance of only 40 km. Any enhancement in the salinity further south of the barrage during the summer was due to the percolation through the damaged sluices of the barrage. The average pre-monsoon salinity at south of the barrage was 18.47 ppt during the pre-barrgae phase (Josanto, 1971), but reduced to an average of 2.8 ppt during the post-barrage phase. Comparatively higher salinity was observed at the western side of the lake caused by the coriolis force operating in the estuary and also due to the absence of any major freshwater inflow at this bank. The average salinity was 0.16 ppt during monsoon and 0.49 ppt during post monsoon season under the present investigation.

Temperature was 29.2-32.8 ^{0}C indicating a high heat budget for the system. The shallow nature of the sector (average: depth,1.95 m) coupled with moderate secchi disc transparency (average:1.26 m) brought almost the entire water column under the euphotic zone. The average pH of water was near neutral (6.8). During the pre-monsoon stagnation period, the pH was acidic (pH: 6.4; range: 4.5-6.88) particularly at stations 2, 4, 7 and 11 (Table 5 & Fig. 3).

The dissolved oxygen levels were moderate (with a monthly variation ranging from 6.0 to 7.2, average: 6.25 mg/L) at all the stations except at Station-1 where municipal discharge waters brought down the dissolved oxygen to 3.16 mg/L during the pre-monsoon period. The Chemical oxygen demand was also moderate to high (4.0-28.0 mg/L), again the exceptionally high value recorded at station-1 during the stagnant pre-monsoon period. The lake in general was characterised by low alkalinity (range : 4.0-156.0; average: 22.2 mg/L) except for station 1 and 2.

The nutrients were highly influenced by the monsoon discharges from the four rivers. The values (available nitrogen: 20-710, average: 213 μg/L; available phospho-rous: Tr.-72, average: 19 μg/L) gradually declined during the post-monsoon and pre-monsoon months. The zones receiving the municipal discharge (Station-1) and runoff from agricultural lands and human inhabitation were richer in phosphates and nitrates. The reduction in available phosphates could mainly be attributed to its loss to the sediment in the form of aluminium and iron-bound phosphates at a lower pH. . Silicates had rich concentrations varying from 34.5 to 47.0 mg/L (average: 38.5 mg/L).

Sediment Quality

The temperature, pH, conductivity, organic carbon, available phosphorus, calcium carbonate and texture properties of the sediment were analysed (See Table 4 & 5).

The pH of the sediment remained acidic in most of the stations during the study with an average value of 5.3. The monsoon values were low (average: 4.7). This could be due to the exposure of relatively higher acidic subsurface basin soil consequent to monsoon turbulence and bottom currents. Available phosphate (av. 34.2 mg/100g) in the sediment was high during the pre-monsoon consequent to the phosphorous adsorption from the water column. The augmentation was also aided by the enrichment from the settled plankton and the subsequent phosphorous release through the microbial activities. The phosphate values for the sediment phase had an invesre relationship with that of the water phase during the three seasons.

The organic carbon content had an average value of 2.7% during 1996-97. Stations 1-4 at the southern end of the lake had elevated levels of organic carbion (3.27-5.49 %) compared to the 2.8 % reported for this part of the lake by Murthy and Veerayya (1972) during the pre-barrage phase. This indicates an accumulation of organic matter in this part over the years. Predictably, the premonsoon season characterised by the stagnancy indicated higher values of organic carbon at all the stations. Free calcium carbonate was high during the pre-monsoon followed by the monsoon and post-monsoon periods.

Fig. 3. Variation in the water quality at different stations at Vembanad lake (Mean values)

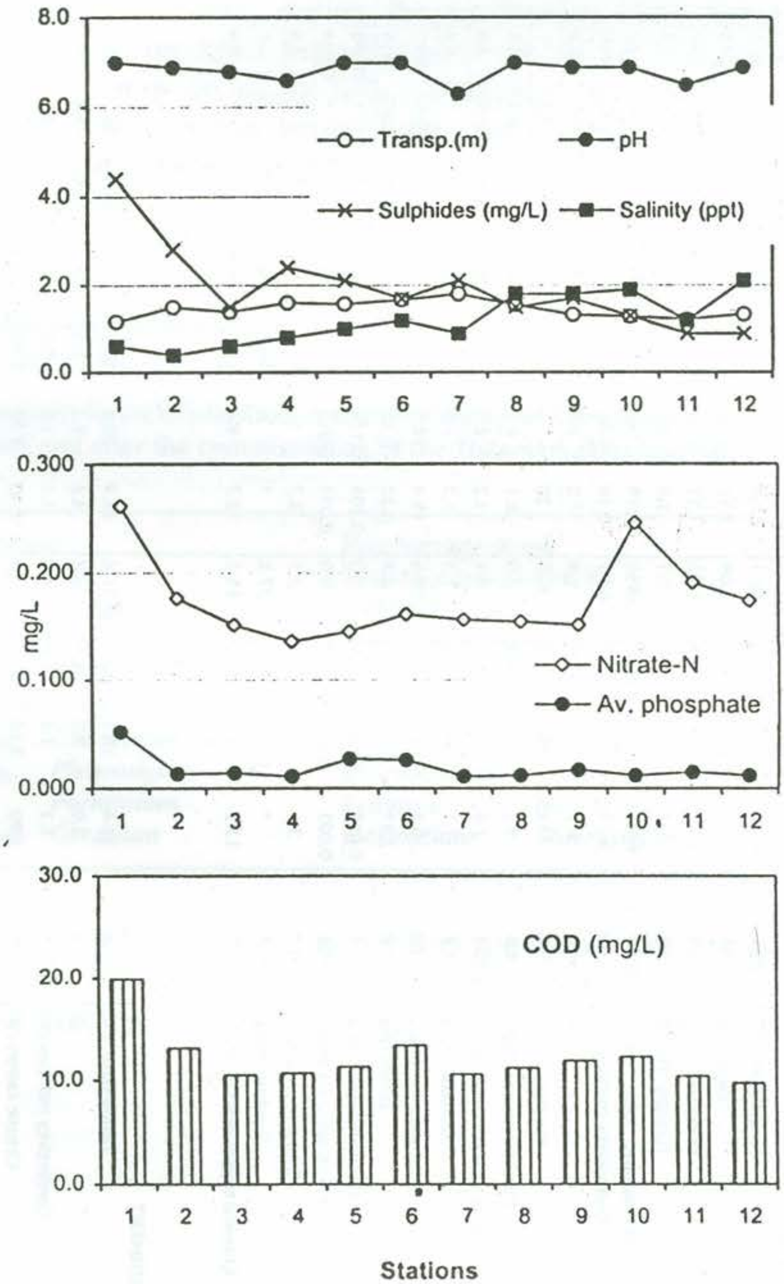


Table 4. Season-wise water and sediment characteristics in Southern sector of Vembanad lake (Mean values)

	Pre-Monsoon					Monsoon				Post Monsoon					
Months	Feb-95	Apr-95	Feb-96	Apr-96	Mean	Jun-95	Aug-95	Jun-96	Mean	Oct-94	Dec-94	Oct-95	Dec-95	Oct-96	Mean
WATER															
Temperature (°C)	30.1	32.0	30.2	31.9	31.1	28.6	28.1	30.8	29.2	27.9	29.4	30.6	29.1	29.8	29.4
Depth (m)	2.45	2.11	1.90	1.89	2.09	2.12	2.32	1.85	2.10	2.71	1.91	2.13	2.60	2.12	2.29
Transparency (m)	1.63	1.51	1.58	1.41	1.53	1.52	1.17	1.10	1.26	1.26	1.52	1.47	1.86	1.29	1.48
Turbidity (NTU)	3.3	4.7	2.7	1.7	3.1	2.3	3.2	0.8	2.1	5.2	8.5	3.9	9.6	2.7	6.0
Total dissolved solids (mg/L)	2080	4647	2460	6231	3855	218	146	176	180	320	884	167	1092	450	583
Conductivity (mMhos/cm)	3.96	9.23	4.42	9.67	6.82	0.20	0.08	0.24	0.17		0.92	0.10	1.36	0.70	0.77
pH	6.6	6.1	6.8	6.0	6.4	7.0	7.0	7.0	7.0	7.2	7.0	7.2	6.9	7.1	7.1
Hardness (mg/L)	348	773	366	823	578	30	5	71	35	13	57	1	131	71	54
Dissolved oxygen (mg/L)	6.8	8.1	6.4	6.6	7.0	6.1	6.7	5.9	6.2	5.9	6.4	6.5	6.5	5.6	6.2
Free carbon dioxide (mg/L)	20.8	2.6	2.3	2.6	7.1	3.2	2.5	2.8	2.8	14.9	11.8	2.8	2.5	3.8	7.2
Sulphides (mg/L)	1.7	3.3	0.4	0.5	1.5	1.3	1.1	0.6	1.0	*	*	5.6	4.0	0.5	3.4
Total alkalinity (mg/L)	60	10.9	14.7	*	28.5	15.4	12.3	12.4	13.4	36.1	35.0	14.7	15.5	13.9	23.0
Salinity (ppt)	1.9	3.87	2.01	3.47	2.8	0.22	0.13	0.12	0.2	0.36	0.50	0.19	0.77	0.65	0.49
Nitrate-nitrogen (mg/L)	*	0.048	0.043	0.022	0.0	0.205	0.178	0.533	0.3	*	*	0.098	*	0.236	0.167
Available phosphorous (mg/L)	0.028	0.003	0.008	*	0.0	0.031	0.013	0.031	0.0	*	*	0.024	0.004	0.025	0.018
Silicate-silicon (mg/L)	0.7	3.1	1.7	2.9	2.1	2.7	11	13.6	9.1	*	*	3.8	1.6	9.6	3.0
Sulphate (mg/L)	*	*	116.9	38.1	77.5	*	*	38.2	38.2	*	*	*	*	39.2	39.2
Chemical oxygen demand (mg/L)	*	13.3	14.6	17.3	15.1	12.7	8.6	11.4	10.9	*	*	9.4	9.3	*	9.4
SEDIMENT															
Temperature (°C)	31.0	32.4	30.3	32.5	31.6	28.9	28.1	30.8	29.3	28.2	30.0	30.3	29	30	29.5
pH	6.3	5.9	7.0	5.9	6.3	4.6	5.1	4.3	4.7	4.8	4.8	5.4	5.7	3.9	4.9
Conductivity (mMhos/cm)	*	5.3	2.6	4.6	4.2	1.7	1.5	5.0	2.7	*	2.2	1.2	1.0	4.8	2.3
Organic carbon (%)	2.89	2.90	3.10	2.20	2.8	2.40	2.97	2.79	2.72	2.73	2.74	2.60	2.40	2.80	2.7
Available phosphorous (mg/100g)	21.0	125.0	44.0	0.2	47.6	50.0	53.0	0.1	34.4	*	*	28.0	20.0	0.1	16.0
Free calcium carbonate (%)	0.90	2.20	2.30	2.50	2.0	2.30	3.88	1.00	2.39	1.90	0.67	4.50	3.20	0.80	2.2

* could not be measured

Table 5. Water and sediment characteristics in Vembanad lake during October 1994 to October 1996 (Mean values)

Months	Oct-94	Dec-94	Feb-95	Apr-95	Jun-95	Aug-95	Oct-95	Dec-95	Feb-96	Apr-96	Jun-96	Oct-96	Mean
WATER													
Temperature (°C)	27.9	29.4	30.1	32.0	28.6	28.1	30.6	29.1	30.2	31.9	30.8	29.8	29.9
Depth (m)	2.71	1.91	2.45	2.11	2.12	2.32	2.13	2.60	1.90	1.89	1.85	2.12	2.18
Transparency (m)	1.26	1.52	1.63	1.51	1.52	1.17	1.47	1.86	1.58	1.41	1.10	1.29	1.44
Turbidity (NTU)	5.2	8.5	3.3	4.7	2.3	3.2	3.9	9.6	2.7	1.7	0.8	2.7	4.1
Total dissolved solids (mg/L)	320	884	2080	4647	218	146	167	1092	2460	6231	176	450	1573
Conductivity (mhos/cm)	·	0.92	3.96	9.23	0.20	0.08	0.10	1.36	4.42	9.67	0.24	0.70	2.81
pH	7.2	7.0	6.6	6.1	7.0	7.0	7.2	6.9	6.8	6.0	7.0	7.1	6.8
Hardness (mg/L)	13	57	348	773	30	5	10	131	366	823	71	71	225
Dissolved oxygen (mg/L)	5.9	6.4	6.8	8.1	6.1	6.7	6.5	6.5	6.4	6.6	5.9	5.6	6.5
Free carbon dioxide (mg/L)	14.9	11.8	20.8	2.6	3.2	2.5	2.8	2.5	2.3	2.6	2.8	3.8	6.1
Sulphides (mg/L)			1.7	3.3	1.3	1.1	5.6	4.0	0.4	0.5	0.6	0.5	1.9
Total alkalinity (mg/L)	36.1	35.0	60.0	10.9	15.4	12.3	14.7	15.5	14.7		12.4	13.9	21.9
Salinity (ppt)	0.36	0.50	1.90	3.87	0.22	0.13	0.19	0.77	2.01	3.47	0.12	0.65	1.2
Nitrate-nitrogen (mg/L)				0.048	0.205	0.178	0.098		0.043	0.022	0.533	0.236	0.170
Available phosphorous (mg/L)			0.028	0.003	0.031	0.013	0.024	0.004	0.008		0.031	0.025	0.019
Silicate-silicon (mg/L)			0.7	3.1	2.7	11	3.8	1.6	1.7	2.9	13.6	9.6	5.1
Sulphate (mg/L)									116.9	38.1	38.2	39.2	58.1
Chemical oxygen demand (mg/L)				13.3	12.7	8.6	9.4	9.3	14.6	17.3	11.4		12.1
SEDIMENT													
Temperature (°C)	28.2	30.0	31.0	32.4	28.9	28.1	30.3	29	30.3	32.5	30.8	30	[illegible]1
pH	4.8	4.8	6.3	5.9	4.6	5.1	5.4	5.7	7.0	5.9	4.3	3.9	5.3
Conductivity (mMhos/cm)		2.2		5.3	1.7	1.5	1.2	1.0	2.6	4.6	5.0	4.8	3.0
Organic carbon (%)	2.73	2.74	2.89	2.90	2.40	2.97	2.60	2.40	3.10	2.20	2.79	2.80	2.71
Available phosphorous (mg/100g)			21.0	125.0	50.0	53.0	28.0	20.0	44.0	[illegible]	0.1	0.1	[illegible]
Free calcium carbonate (%)	1.90	0.67	0.90	2.20	2.30	3.88	4.50	3.20	2.30	2.5[illegible]	1.00	0.80	2.18

* could not be measured

The sediment texture showed that sand was the major fraction (44.7 %) followed by the clay (31.3 %) and silt (18.7). Studies conducted by Murthy and Veerayya (1972) during the pre barrage phase showed a silty sand condition, which was gradually paving the way for a silty clay with the clayey fraction increasing over the years as observed during the present investigation. Samples collected from the opposite side of the barrage during March, April and October 1996 had the silt+clay fraction only less than 5 %. This suggests an accummulation of the clay and silt in the stagnant portion of the lake over the years. Stations 1-3 had significantly high portion of the clay (42.0 %) and silt (22.1%) compared to the other stations (av. 27.8 % and 17.6 % respectively). Stations 1&2 were comparatively less influenced by the monsoon flow (Fig. 4).

The study revealed that the water and sediment characteristics showed wide spatial and temporal differences before and after the construction of the barrage, the differences being more pronounced at the south end of the lake.

Plankton Biomass

The variations in the plankton biomass (settling volume) with respect to the seasons and the sampling stations were determined during 1994-96. The pre-monsoon period showed the highest mean value for the plankton biomass (4.7 ml/m^3) followed by the post-monsoon (4.4 ml/m^3) and monsoon (3.4 ml/m^3) periods. The barrage remains open till early December, the biomass during the post-monsoon season was decided by the outflow to the sea. The closure of the barrage thereafter allowed the environment to be static, and the phytoplankton could utilize the trapped nutrients and flourish. Low biomass values observed during the monsoon period in the present study could be due to the dilution of the water mass and the transport of the biomass to the sea by the heavy monsoon discharge from the four rivers. The post-monsoon was the recovery season for the biomass as the plankton could utilize nutrients received through the runoff. The density of organisms in the samples presented a more realistic and reliable index of the abundance than the volume, since the suspended silt and dirt influenced the biomass determination.

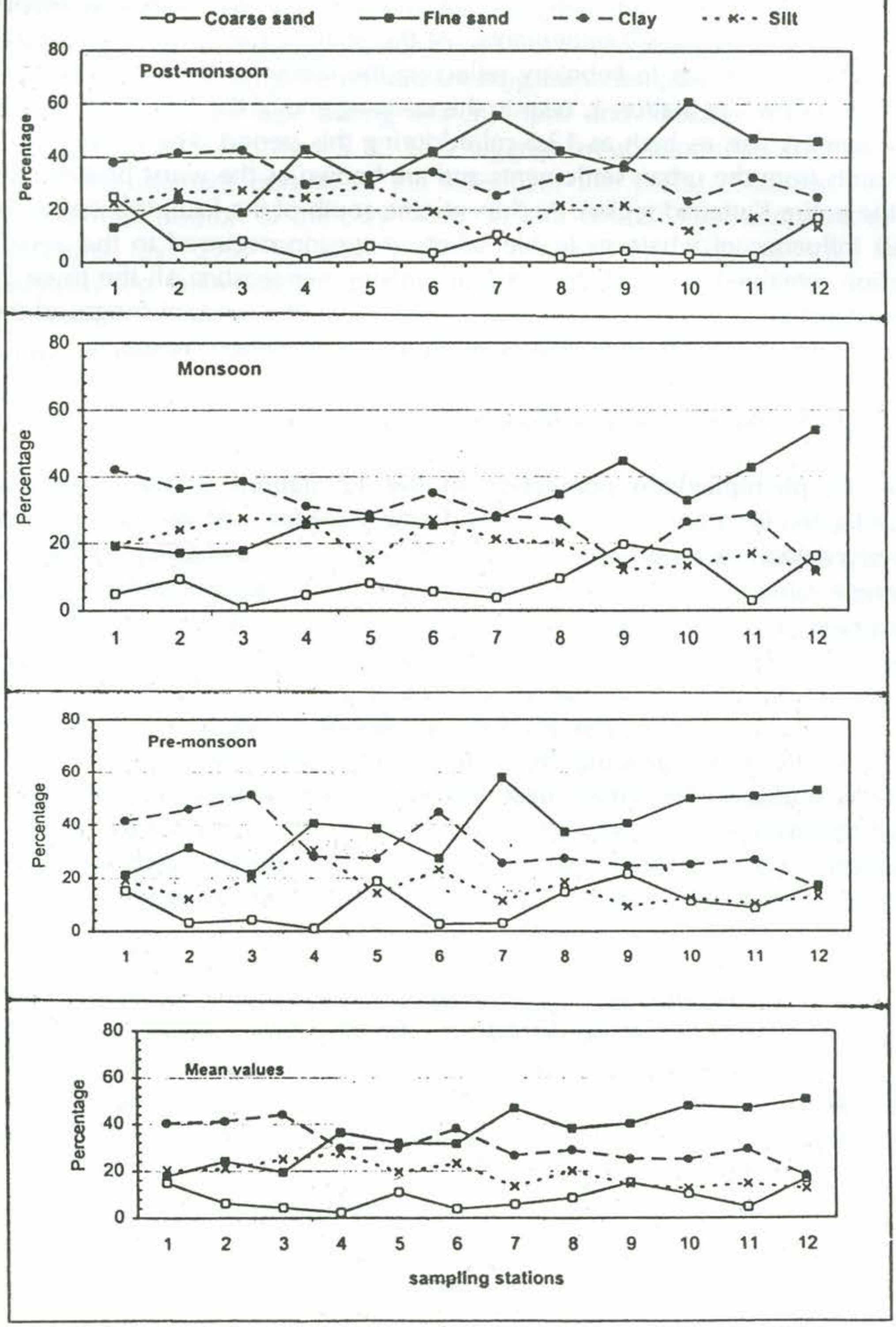
The mean biomass varied from 6.6 ml/m^3 to 0.3 ml/m^3 The values were generally high in stations 1,3 and 5. These stations are located nearer to the areas of human settlement on the western fringe. The average highest value was recorded at Station 5 near the denser settlements. At this station, the average biomass was 11 mg/L during October to February reflecting the inflow of the nutrients during the monsoon flow. At Station 1, near to the opening end of the city canals to the Lake, the biomass was as high as 13.5 ml/m^3during this period. The canals receive the effluents from the urban settlements and are known as the worst polluted segment of the entire Kuttanad region. At the extreme south of the lake, this station had the least influence of whatever feeble salinty incursion occurred to the Sector. This portion remained stagnant through out the summer season. All the three Stations that depicted high biomass concentration were on the western fringes of the lake, least influenced by the river flow even during the monsoon season.

Phytoplankton

The net phytoplankton population in the 12 stations of the Vembanad was investigated for a period of two years during 1994-96. At various sampling sites, phytoplankton had a density variation between 17797 and 60613 unit/m^3 with an average value of 30682 units/m^3. The overall density for the sector was higher for the green algae (42.6 %). The blue greens were concentrated at Station-1 with a percentgae contribution upto 70.6 %. *Anacystis* and *Trichodesmium* were also abundant at this place, indicating a eutrophic condition. The overall contribution by the greens and the desmids were prevalent during the monsoon and post-monsoon months indicating an improvement in the water condition due to the monsoon inflow. The green algae represented by 24 species contributed to the high phytoplankton abundance in the 12 stations of the Vembanad lake. The pre monsoon period (34796 no/m^3) showed a maximum numerical abundance followed by the monsoon (32773 no/m^3) and the post monsoon (24934 no/m^3) period (Table 6).

Studies conducted during the pre-barrage phase by Gopinathan *et al.* (1974) in the Cochin estuary, a part of the Vembanad Lake, observed a maximum phytoplankton abundance in the pre-monsoon and monsoon periods. Compared to the pre barrage phase, the diversity has been found on a higher side in the present investigation, influenced by the prevalence of freshwater condition during the

Fig. 4. Sediment composition n Vembanad lake during different seasons



summer. The pure saline forms that were abundant at this sector during the summer could not be recorded under the present condition. This observation is in conformity with the present study. Twenty four species of green algae, ten species of blue green algae, one species of yellow brown algae, 13 species of desmids and 19 species of diatoms formed the phytoplankton population in the present investigation. But, during the pre-barrage only about 30 species of phytoplankton was recorded from the same Sector by Joseph and Pillai (1975) within a salinity range of 0.2 to 33%. Moreover, the species present during the monsoon and post-monsoon period were qualitatively different from that of the pre-barrage phase. There was no perceptible change in the overall density of plankton population in the sector during the post-barrage phase. The dominant species like *Hormidium, Spirogyra, Microspora* and *Anacystis* recorded during the present study were not reported from the studies conducted during the pre barrage phase by Joseph and Pillai (1975).

Table.6 Dominant forms of plankton in southern sector of Vembanad lake before and after the commissioning of the Thaneermukkombarrage

Pre-barrage phase **Post-monsoon, 1971** **Salinity – 11-19.75 ppt** **(Nair, *et al.*, 1975,** **Joseph & Pillai, 1975)**		Post-barrage phase **Post-monsoon 1994-96** **<0.5ppt** **(Under present investigation)**	
Chaetoceros,	***Coscinodiscus***	***Spirogyra,***	***Microspora***
Skeletanoma,	***Pleurosigma***	***Botryococcus***	***Anabaena***
Nitzschia,	***Peridinium***	***Lyngbya***	***Micrasterias***
Gymnodinium	***Ceratium***	***Desmidium***	***Stuarastrum***

The replacement of high saline, euryhaline species of the pre barrage period by the low saline , freshwater forms from the present study (post barrage phase) was the most outstanding time - scale change observed in the present study.

The Shannon-Weaver diversity index (H) of the phytoplankton varied from 1.89 at Station 5 to 2.75 at Station 2. A mean diversity index value of 2.43 was recorded for the whole lake. The Station 2 showed the maximum diversity value and recorded 35 species of phytoplankton whereas station 5 had only 29 species recording lower diversity values. This may be attributed to the comparatively stable environment and a lower fluctuation of salinity at this place. The Station was also characterised by the dominance of the green algae.

Zooplankton

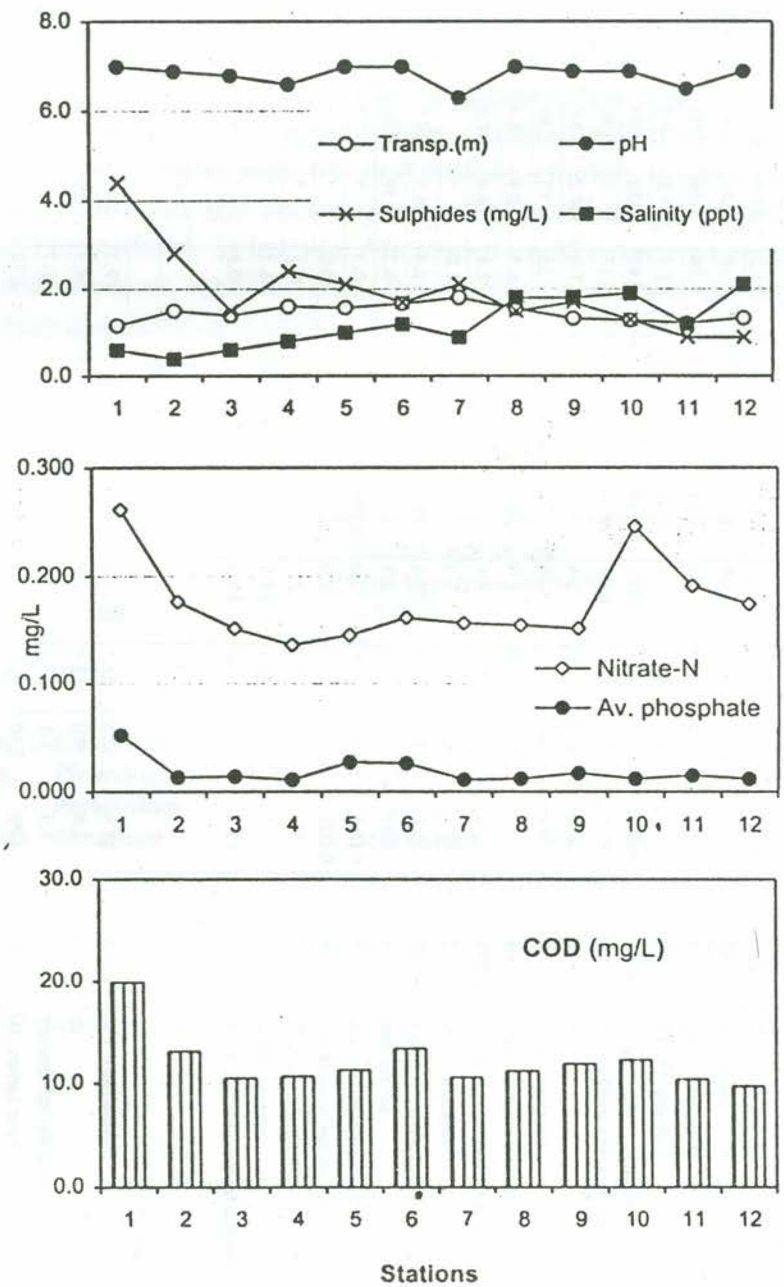
The zooplankton population in the 12 stations was categorised into 12 groups, namely, Foraminifera, Tintinnida, Protozoa, Rotifera, Nematoda, Polychaete larvae, Cladocera, Copepoda, Mysidaceae, Ostracoda, Insecta and Insect larvae, and Fish larvae. The foraminiferans were present only in the marine zone of the lake. The post-monsoon period recorded the highest numerical density of plankton whereas the monsoon period showed the lowest values. The wide variations in the zooplankton distribution were influenced mainly by the incidence of phytoplankton, pH and salinity. The present investigation is the first comprehensive report on zooplankton from this sector of the Vembanad lake.

The pre-monsoon period, marked by a higher mean salinity, exhibited higher numerical abundance of the zooplankton fauna. As mentioned above, the monsoon and the post-monsoon periods with low saline conditions had restricted abundance of the zooplankton. Apart from salinity, the strong currents downstream and the turbidity also might have rendered an unfriendly environment to many organisms during the monsoon.

Primary productivity

The gross and net productivity at stations 1 and 3 in the Vembanad Lake were studied. The gross productivity values showed an average value of 0.99 g C/m^3/day and the net productivity of 0.51 g C/m^3/day during the period 1996-97. Qasim *et al.* (1969) reported a gross productivity value ranging from 272 to 293 g C/m^2/year and the net productivity from 184 to 202 g C/m^2/year in the Vembanad lake during the pre-barrage phase. Nair *et al.* (1975) reported an average primary productivity of 200 mg C/m^3/day from this sector of the lake. The average productivity values

Fig. 3. Variation in the water quality at different stations at Vembanad lake (Mean values)



reported by Nair et al. (1983) was still lower (143mg C/m^3/hour) for the Ashtamudi lake. There seems to be an enhaced primary production activity during the post-barrage phase consequent to a more stable and richer nutrient level at this sector, triggered by the stagnancy during the post-monsoon season.

Benthic fauna

The benthic fauna was composed of 10 groups, mainly dominated by Amphipoda, Polychaeta and Oligochaeta at the 13 stations. The post monsoon period was the most favourable period for the incidence of benthic fauna. The low saline conditions coupled with high dissolved oxygen levels and presence of large quantities of plant matter (macrophytic biomass) could be the reasons for the high incidence and abundance of amphipoda during the present investigation. The nature of the sediment was an important factor that influenced the distributions of the benthic organisms. The high organic carbon content in combination with hgiher percentage of sandy clay during the post monsoon and pre monson periods could be one of the contributing factors for the rich ebnthic faunal diversity.

Ten species of polychaetes namely *Dendronereis* sp., *D. aestruarina, D. arborifera, Nereis chingrihattensis, Ceratonereis, mirabilis, Ceratonereis* sp. *Prionospio cirrifera, Prionospio* sp. and *Capitellid* sp. were identified during the period 1996-97 from the 12 stations. Polychaetes contributed 35% of the total benthic fauna in the present study. The diversity index (H), and richness index (d), evennes index (e) and dominance index (d) for the polychaete species were computed. The higher diversity of the polychaetes observed at the 12 stations during the study could be due to theri euryhaline nature, when compared to the reference station (13) where only *Ceratonereis* sp and *Dendronereis* sp. occured. *Villorita cyprinoides* formed the bivalve population whereas *Melanoides tuberculatus, Melampus* sp., *Indoplanorbis exustus* and *Viviparus* sp. represented the gastropod population during the study. Earlier studies conducted by Sabastian (1976) and Kurup *et al.* (1990) in the same study area reported the presence of bivalves, *V.cyprinoides, M. meretrix* and *M. casta*. The low saline nature of the bottom waters during the present study showed the presence of only one species of *V. cyprinoides*. The low values of diversity index (H), richness index (d) and evenness index (e) of the fauna were notable aspect of the study.

Pesticide residues in water, sediment and fauna of Vembanad lake

The pesticide residue (BHC, Endosulphan) levels in water, sediment, and *V. cyprinoides* were detected during the post monsoon period 1995. The B. H. C. level was detected in water, which varied from 0.048 to 0.152 µg/l and that in sediment from 0.0006 to 0.0127µg/g. The clam had endosulfan in their tissues @ 0.366 µg/g. The concentration levels were within the safe limits prescribed for fishery waters.

Characteristics of the major groups of benthic fauna

Nemertea: These are proboseis worms or nemertineans belonging to the phylum Nemertinea. This is on of the rarest group of benthic fauna observed from the Vembanad lake and this is the first account of nemertines from the backwaters. These benthic groups were present in all seasons showing its maximum mean biomass in the monsoon (39 no/m^3) followed by the pre monsoon (32 no/m^3) and the post monsoon (7 no/m^3). Station 1 receiving a heavy dose of agricultural and other domestic wastes showed the highest numerical abundance of the fauna (54 no/m^3) whereas station 11 showed the lowest (2 no/m^3).

Family		Species
1.	Tubificidae	*Aulodrilus* sp. *Aulodrilus remex* *Limnodrilus hoffmeisteri*
2.	Nereidae	*Namalycastis indica* *Dendronereis arborifera*
3.	Naididae	*Dero* sp. *Dero cooperi* *Hanochaeta* sp.

Amphipoda : *This group formed the biggest component (32.2%) of the benthic fauna in the 12 stations. The low saline conditions coupled with high dissolved oxygen levels and the presence of large quantities of plant matter (macrophytic biomass) could be the reason for the high incidence and abundance of amphipods during the present investigation. The amphipods belonged to the family Caprillidae, Gammaridae and Talitridae. Of the three families most of the species were represented by caprillids. Two species* Eriopisa chilkensis *and* Quadrivisio bengalensis *formed the population in the family gammaridae whereas only one species,* Parhyale hawaensis *representing the family Talitridae.*

Polychaeta: *The polychaete population in the Vembanad lake during the present study comprised of ten species. Earlier studies conducted in the same area by Gopalan et al (1987) reported polychaetes, only during the pre-monsoon period with a total biomass of 8.28 g/ m² dry weight. During the present study the post monsoon period was the most favourable phase for the high incidence and abundance of the fauna. The number of species observed in the present study was lower than that when compared to other systems mentioned above.* Dendronereis *sp.,* D. aestuarina D. arborifera, Ceratonereis *sp.,* C. mirabelis *and* Prionospio *sp. showed their occurrence even during the pre monsoon period when the salinity values were comparatively higher.*

Bivalves and Gastropods: Only one species represented by *Villorita ciprinoides* formed the bivalve population where as three species namely *Melanoides tuberculatus, Melampus* sp., *Indoplanorbis exustus* and Viviparus sp. formed the gastropod population (Table). The pre-monsoon period showed the highest incidence of bivalves and gastropods. About 75% of the gastropod population was contributed by species *Melanoides tuberculatus* whereas, *Indoplanorbis exustus* (0.11%) showed the minimum percentage incidence. The sandy clay nature of the substratum with high organic carbon content at stations 1,3 and 4 could be the reason for the low abundance and diversity for the fauna. In the other stations the sandy nature of the bottom and comparatively low organic content showed higher faunal incidence and abundance.

Fish and Fisheries

Twenty six landing centres were identified from around the fresh water sector of the lake and data on the total landings of fish and prawn were collected during the study period from these areas. About 38 species of fishes and 4 species of prawns were identified from the study (Table 7). The major fish species recorded from the investigation were *Etroplus suratensis, E. maculatus, Channa marulius, Labeo dussumieri, Puntius* sp. *Lutianus argentimaculatus, Mystus* sp., *Tachysurus* sp. and *Hemiramphus* sp.

The fishery of *M. rosenbergii, which was* to the extent of 305 tonnes during 1960-61 (Raman, 1965) in the lake, was reduced to about 39tonnes by 1987-88 (Kurup, 1989). This reduction is attributed to the barrage as it prevents the return migration of the spent brooders and the upward migration of the post larvae to the rivers. The barrage has posed an obstacle to them during their peak migration in November to February. The fishery has, of late, shown some recovery due to the reduction the closure season from 6 to 4 months, and also due to the damaged condition of some of the sluices.

There was a substantial change in the faunal composition when compared to the pre- and post-barrage phases. The impotrant faunal changes are indicated in Table 8.

Table 8. Alteration in species composition of fishes in the souther sector of the Lake Consequent to the barrage construction, (In comparison to the records of Shetty 1965

New entrants to the system	Species disappeared
Anguilla bicolor	*Nematolosa nasus*
Puntius sarana	*Hilsa ilisha*
P.filamentosus	*Tachysurus falcatus*
P.mahecola	*Ophichtyus microcephalus*
Labeo dussumieri	*Haplochilus lineatus*
Labeo rohita	*Mugil troscheli*
Catla catla	*Eleutheronema*
Tetradactylum	
Wallago attu	*Therapon puta*
Ompok bimaculatus	*Lutianus johnii*
Amblypharyngodon mola	*Leognathus* sp.
Heteropneustes fossilis	*Gerres oblonges*
Clarius batrachus	*Trichogaster brevirosteris*
Mastacembelus armatus	
Macrognathus guintheri	**Prawn**
Channa striatus	*Palaemon carcinus*
Anabas testudineus	

Quarter-wise yield of *E. suratensis* and *M. rosenbergii*

	Apr-Jun 1996	Jul-Sep. 1996	Oct-Dec. 1996	Jan-Mar. 1997	Average
Etroplus suratensis (Kg.)	59400.	23841	40206	78392	
Contribution to annual landings (%)	29.4	11.8	19.9	38.8	
CPUE (Kg/man-day)	2.53	1.52	1.83	2.21	**2.05**
M. rosenbergii (Kg.)	9410	13919	6863	908	
Contribution to annual landings (%)	25.9	52.9	18.9	2.5	
CPUE (Kg/man-day)	0.46	0.91	0.46	0.28	**0.62**

A view of the endangered fish species from Vembanad Lake.

Channa spp.

Puntius sp.

L. rohita

A view of the endangered fish species from Vembanad Lake.

M. rosenbergii

A country boat with clam *(Villorita cyprinoides)* meat for sale

Table.7 Fish landings from Vembanad (South of the barrage)

Species/Groups	1995-96 (Kg.)	%	1996-97 (Kg.)	%
Etroplus suratensis	136 895	46.9	202 040	52.77
Mullets	4 000	1.3	4 450	1.16
Channa striatus	4 935	1.7	5 912	1.54
Channa marulius	10 949	3.8	14 828	3.87
Labeo dussumieri	6 087	2.1	23 742	6.20
Labeo rohita	472	0.2	586	0.15
Cyprinus carpio			32	0.01
Puntius spp.			31 586	8.25
Lutianus argentimaculatus	6 491	2.2	4 212	1.10
Lates calcarifer	2 137	0.7	1 822	0.47
Scatophugus argus			3 852	1.01
Anabas testudineus			1 412	0.37
Mystus sp.	14 767	5.1	5 008	1.31
Horabagrus brachysoma			2 150	0.56
Techysurus arius			11 381	2.97
Hemiramphus sp.	18 389	6.3	25 578	6.68
Chanos chanos	1 739	0.6	1 370	0.36
Other species	19 258	5.02	82 089	29.1
Total fish	**291 953**	**70.3**	**382 841**	**78.9**

Contd............

Table 7 Contd.........

Macrobrachium rosenbergii	57 930	47.0	36 332	35.55
M. idella	27 002	21.9	33 250	32.53
Metapenaeus dobsonii	36 713	29.8	31 430	30.75
M. monoceros	1 067	0.9	1 188	1.16
Total prawn	**123 350**	**29.7**	**102 200**	**21.1**
TOTAL LANDINGS: (Excludings crabs & molluscs)	415 303		485 041	

Conclusions and Recommendations

The study reveals that the Thanneermukkom barrier commissioned in 1975 across the lake has considerably altered the ecology and fishery resources of the lake sector south of the barrage. The major changes observed during the post-barrage phase in comparison to that of the pre-barrage phase were the following:

A marked reduction in the depth due to the accumulation of the silt from the incoming rivers, bringing down the water holding capacity of the lake.

The tidal influence reduced from 80 km upstream to 40 km till the barrage during the summer

The increase in weed growth and a severe restriction on the natural flushing of the pollutants entering the sector during the summer months when the barrage remains closed.

Changes in spatial and temporal variations in the water and sediment quality - a steep reduction in the salinity, an elevation of nutrient level in the water phase, and an elevation of the organic carbon in the sediment. The changes were more pronounced in the southern end of the sector, where an eutrophication tendency existed, geared by the stagnancy consequent to the closure of the barrage during December to April.

Changes in the composition of the plankton and benthic organisms, the saline species largely giving way to euryhaline or freshwater species.

An enhancement in the primary production levels at the south end of the sector during the stagnant months.

The reduction in the upstream and downstream migration of fish and prawns. The stretch of the lake above the barrage becoming inaccessible to the euryhaline migratory fishes and prawns from the sea, the fish productivity of the sector dwindled. About 13 such euryhaline migratory species no more contribute to the fishery of this sector. Similarly about 16 stenohaline freshwater species found an entry to the commercial fishery of the Sector. The prized fishery of Macrobrachium rosenbergii got reduced to about 35% of its landings during the pre-barrage phase (1963-65).

The study indicates the necessity of maintaining the continuity of the lake between both sides of the barrage so that the tidal washings during the pre-monsoon months enables to naturally flush out the wastes and thereby reducing the stress on the environment at this Sector.

The continuity would also ensure the upward and downward migration of the fish and prawn any time during the year making the whole lake available to the euryhaline species. This would substantially improve the fishery of the lake as a whole. The upward and downward migration of the Macrobrachium species also would be facilitated leading to the rejuvenation of its fishery. The changes would have a salutary effect on the socio-economic condition of the fisherfolk engaged in fishery of the lake.

It is therefore suggested that there should be only periodic closure of barrage rather than permanently remained closed for about 4-5 months. The periodicity should depend on the tidal amplitude so that the second crop of paddy cultivation is not adversely affected due to the salinity intrusion, and the tidal amplitude does not reach the intake point of drinking water for the Kottayam town in Meenachal river.

A busy scene at one of the landing sites.

The landings – The species comprise of brackishwater, freshwater and marine migrant forms.

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