

## Macrobenthos of Vembanad estuary in relation to the deposition of degraded water fern *Salvinia* and other macrophytes

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**Abstract.** Composition and seasonal abundance of macrobenthos seems to be influenced by the density of decaying macrophytes, especially the water fern *Salvinia*, deposited at the bottom of the estuary, at the rate of 356.76 g/m<sup>2</sup>, 400.6 g/m<sup>2</sup> and 221.65 g/m<sup>2</sup> during premonsoon, monsoon and postmonsoon respectively. In dynamic areas with high oxygen level, the weed deposits were associated with high biomass of bivalves and other regions of denser weed deposits were poorer in biomass and dominated by polychaets. A steady long term increase in the abundance of amphipods attaining the highest density of 70,290/m<sup>2</sup>, seems to be partly due to the progressive ingression of exogenous macrophytic biomass into the estuary. The possible role of cumulative deposition of macrophytic biomass in bringing about a gradual alternation in the estuarine benthic communities and its significance in the food chain has been discussed.

**Keywords.** Macrophytic deposition; *Salvinia*; macrobenthos; Vembanad estuary.

### Introduction

The Vembanad estuary (09° 28' - 10° 10'N, 76° 13' - 76° 31'E), the largest one of its kind on the west coast of India, has been subjected to considerable anthropogenic environmental alterations as a result of bunding and reclamation for agriculture, aquaculture, harbour and urban development, discharge of domestic and industrial effluents and overexploitation in recent times (Qasim and Madhupratap, 1979; Gopalan *et al.*, 1987). The altered environment turned to be conducive for the proliferation of some of the exotic hydrophytes dominated by the water fern *Salvinia* which has emerged as a threat to the normal use of waterways in Kerala since three decades.

The *Salvinia* growing in vast stagnant freshwater areas and low-saline regions are transported to the lower reaches of the estuary particularly during the monsoon months. When the rivers run low, the tidal water sweeps the weed upstream and this results in the building up of vast blankets of weed over the estuary, where they undergo decay under the influence of high salinity and settle down. Some observations on this weed as a bio-pollutant has been carried out Sydney *et al.* (1975). The fauna associated with the floating weed as well as the influence of the floating weed mat on the estuarine benthos has been studied by Gopalan and Nair (1975). The potential value of the allochthonous organic matter, accumulated in the estuary as a result of microbial decomposition of *Salvinia* has been pointed out by Radhakrishnan *et al.* (1979).

So far, no quantitative study has been carried out to estimate the decaying weed biomass deposited at

the bottom of the Vembanad estuary and its influence on the benthic organisms. Most of the earlier investigators on the benthic fauna of this estuary have focussed their attention on Cochin backwaters (Desai & Krishanan Kutty, 1967; Kurian, 1967, 1971, 1972; Jayasree, 1971; Ansari, 1974; 1977; Gopalakrishna Pillai, 1977). But some studies cover wider areas extending from Cochin to Alleppey (Devassy & Gopinathan, 1970; Kurian *et al.*, 1975).

Eventhough, detritus derived from macrovegetation forms an important link in the food chain of most estuarine systems (Fox, 1950; Newell, 1965; Darnell, 1967; Odum & De La Cruz, 1967), the increased input of macrovegetation seems to alter the benthic habitat (Lee and Olsen, 1985) as has also been apprehended by Qasim and Madhupratap (1979) in the case of Cochin backwaters. This fact necessitates the studies on benthos in relation to the role and source of detritus. Against this background, the present communication brings out the results of a study undertaken in 1980-81 to estimate quantitatively, the degraded macrophytic deposits in relation to the seasonal distribution and abundance of macrobenthos in the estuary.

### 2. Materials and methods

Bottom materials were collected for macrophytic and benthic samples, from four stations each, in ten regions (figure 1) between Alleppey and Azhikode using a van veen grab (0.048 m<sup>2</sup>) during premonsoon, monsoon and postmonsoon (April 1980 to March 1981). (Macrobenthic samples could not be collected from Kumbalam to Alleppey during monsoon and postmonsoon months). The grab and samples were sieved

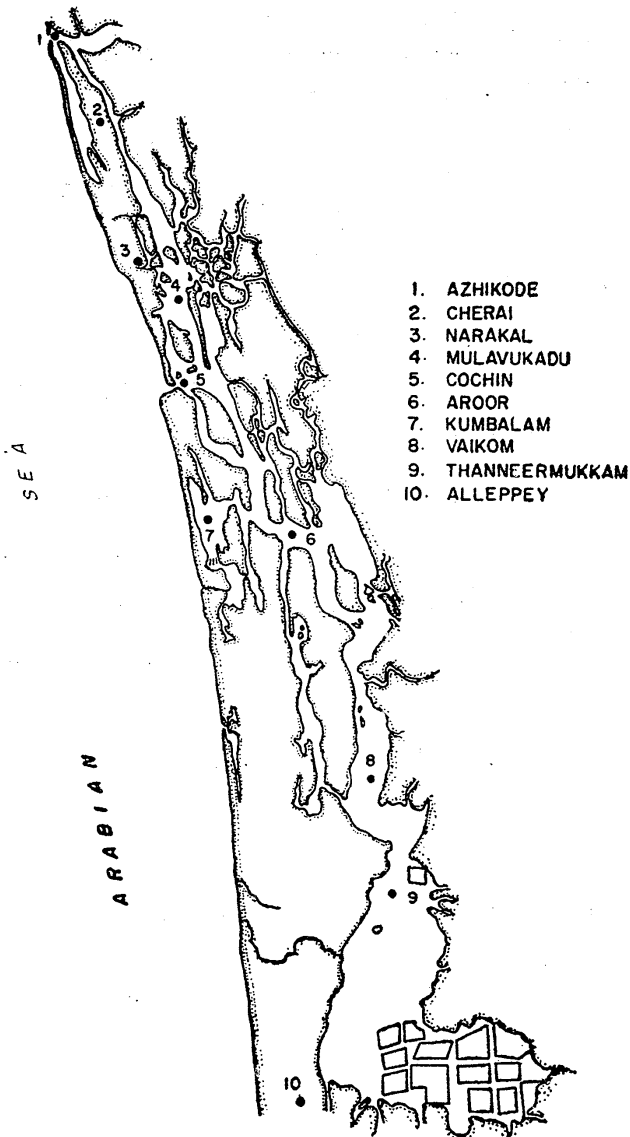


Fig. 1 Map of Vembanad estuary showing sampling regions

through a 0.5 mm mesh sieve and everything retained in it were preserved in 5% formalin. The macrobenthos were then sorted out in the laboratory. From the residue, the macrophytic material comprising mainly the fibrous remains of *Salvinia* weed was separated, pressed between blotting paper and wet weighted. Biomass (dry weight) of macrobenthos is expressed excluding calcareous portions such as shells of bivalves and tubes of polychaetes.

To calculate the ratio of the weight of sieved plant matter to that of undisturbed macrophytic biomass at the bottom, separate samples were collected. Each sample was divided into two parts, blotted and wet weighted. One part was sieved (0.5 mm mesh) to obtain the fibrous residue. Both the parts were then

dry weighed to find the ratio between the biomass of fibrous materials and that of undisturbed weed deposits. This has provided the conversion factor to estimate the biomass (dry weight) of undisturbed weeds from its fibrous residue, which varies between 13% to 20% at various regions depending up on the state of degradation.

Physico-chemical parameters were measured following standard procedures.

### 3. Results

#### 3.1 Physico-chemical parameters:

Studies on the hydrographical parameters of Vembanad estuary suggest three definite seasons viz. premonsoon (February to May) of high salinity, monsoon (June to September) of very low salinity, and postmonsoon (October to January) of raising and fluctuating salinity.

Temperature, salinity, pH and dissolved oxygen values of surface and bottom waters taken at ten regions in the estuary during premonsoon and monsoon are given in tables 1 and 2 respectively.

Temperature was generally found to be slightly higher during premonsoon than monsoon and surface waters were having higher temperature than bottom waters in most regions.

Salinity was found to be high during premonsoon and nearly equal in both surface and bottom waters. But during monsoon, low-saline or near fresh water condition prevailed at the surface in most regions, but the bottom water of some of the regions retained higher salinity. Distortion of salinity pattern in the Vembanad estuary may be due to its peculiar geographical features. The construction of bunds have resulted in near fresh water conditions throughout the year in areas south of Thanneermukkon.

Nearly the same pH was observed in the surface and bottom waters in all regions and generally, a higher pH occurred during premonsoon than monsoon. The occurrence of higher pH during premonsoon at the barmouth regions (Azhikode and Cochin) could be attributed to the marine influence and that at Thanneermukkom to the shell deposition there. The general occurrence of a lower pH during the monsoon may be due to the riverine discharge and land run-off which flow through acidic soils prior to entering the estuary.

Dissolved oxygen values were higher in regions having greater tidal movements. Higher values of



dissolved oxygen were observed during monsoon than premonsoon. The usual inverse relationships between dissolved oxygen and salinity as well as dissolved oxygen and temperature were also observed.

### 3.2 Macrophytic deposits

As can be seen from table 3, the deposition of degraded weed matter, mainly contributed by *Salvinia* were present at all sampling regions in the Vembanad estuary. On an average, there were 356.76 g/m<sup>2</sup>, 400.6 g/m<sup>2</sup> and 221.65 g/m<sup>2</sup> of weed biomass (dry weight) deposited at the bottom of the estuary during premonsoon, monsoon and postmonsoon respectively. Among the regions, the highest average value of deposited macrophytic biomass, 1243.66 g/m<sup>2</sup>, for all seasons was obtained inside the Thanneermukkom bund with maximum value of 1815 g/m<sup>2</sup> during premonsoon. At the same

time, minimum value of 5.5 g/m<sup>2</sup> was observed at Azhikode during the postmonsoon, with average annual value of 77.66 g/m<sup>2</sup>.

### 3.3 Macrobenthos

Seasonal distribution of macrobenthic biomass, together with their numerical abundance has been shown in table 3. Their composition and abundance in the estuary is shown in table 4. Major groups of animals contributing to the macrobenthos were bivalves, polychaetes, amphipods, isopods and tanaidaceans. Others such as decapods, sea anemones, echinoderms and fish larvae were represented in smaller numbers. Among six regions between Azhikode and Aroor, highest average value of macro-benthic biomass 94.4 g/m<sup>2</sup>, for all seasons was obtained at Azhikode, with 94.84 g/m<sup>2</sup> during premonsoon dominated by bivalves,

Table 3. Distribution of degraded macrophytic biomass in the Vembanad estuary in relation to the biomass of macrobenthos (numerical values in brackets)

Region	Macrophytic Biomass (g/m <sup>2</sup> dry weight)			Macrobenthic Biomass (g/m <sup>2</sup> dry weight)		
	Premonsoon	Monsoon	Postmonsoon	Premonsoon	Monsoon	Postmonsoon
1. Azhikode	24.0	203.5	5.5	94.84 (1160)	51.55 (73,500)	136.82 (1400)
2. Cherai	49.5	517.0	176.0	15.485 (440)	30.87 (4580)	0
3. Njarakkal	113.75	418.0	176.0	2.654 (325)	29.029 (1240)	0
4. Mulavukadu	308.0	358.5	379.5	13.345 (528)	7.212 (220)	3.14 (70)
5. Cochin	198.0	693.0	121.0	92.054 (1308)	110.04 (64692)	24.84 (1380)
6. Aroor	139.7	132.0	38.5	9.138 (640)	0.013 (20)	2.68 (4)
7. Kumbalam	451.0	330.0	165.0	8.51 (157)	—	—
8. Vaikom	341.0	242.0	240.0	4.096 (140)	—	—
9. Thanneermukkom	1815.0	980.0	836.0	5.819 (260)	—	—
10. Alleppey	127.6	132.0	77.0	47.522 (595)	—	—

Table 4. Composition and abundance of macrobenthic biomass (g/m<sup>2</sup> dry weight) in Venbanad estuary (numerical values in brackets)

Region	Premonsoon				Monsoon				Postmonsoon			
	Bival- ves.	Poly- chaetes	Amphi- pods	Isopods & Tanaids	Bival- ves.	Poly- chaetes	Amphi- pods	Isopods & Tanaids	Bival- ves.	Poly- chaetes	Amphi- pods	Isopods & Tanaids
1. Azhikode	84.04 (860)	10.8 (300)	0	0	0	3.84 (110)	45.68 (70290)	2.03 (3100)	136.82 (1400)	0	0	0
2. Cherai	0	15.48 (430)	0	0.005 (10)	0	28.08 (780)	2.301 (3540)	0.489 (260)	0	0	0	0
3. Njarakkal	0	2.52 (70)	0.026 (40)	0.108 (215)	0	28.80 (800)	0.039 (60)	0.190 (380)	0	0	0	0
4. Mulavukadu	0	13.25 (368)	0.065 (100)	0.30 (60)	0	7.20 (200)	0.007 (10)	0.005 (10)	0.98 (10)	2.16 (60)	0	0
5. Cochin	76.22 (780)	15.70 (436)	0.021 (32)	0.113 (60)	46.88 (480)	21.17 (588)	40.19 (61848)	1.800 (1776)	0	24.84 (1380)	0	0
6. Aroor	0.78 (8)	8.20 (228)	0.026 (40)	0.132 (264)	0	0	0.013 (20)	0	1.96 (20)	0.72 (20)	0	0
7. Kumbalam.	4.55 (47)	3.96 (110)	0	0	—	—	—	—	—	—	—	—
8. Vaikom	0	4.08 (113)	0.013 (20)	0.303 (7)	—	—	—	—	—	—	—	—
9. Thanneermukkom	0	5.76 (160)	0.039 (60)	0.020 (40)	—	—	—	—	—	—	—	—
10. Alleppey	44.96 (460)	2.52 (70)	0.042 (65)	0	—	—	—	—	—	—	—	—

51.55 g/m<sup>2</sup> during monsoon dominated by amphipods and 136.82 g/m<sup>2</sup> during postmonsoon dominated by bivalves again. The weed deposition in this region were 24.0 g/m<sup>2</sup>, 203.5 g/m<sup>2</sup> and 5.5 g/m<sup>2</sup> during premonsoon, monsoon and postmonsoon respectively. Next to Azhikode, the higher average value of macrobenthic biomass 75.644 g/m<sup>2</sup> for all seasons was obtained at Cochin with 92.054 g/m<sup>2</sup> during premonsoon dominated by bivalves, 110.04 g/m<sup>2</sup> during monsoon almost matchingly contributed by bivalves and amphipods and 24.84 g/m<sup>2</sup> during postmonsoon dominated by polychaetes. The weed deposition in this region were 198.0 g/m<sup>2</sup>, 693.0 g/m<sup>2</sup> and 121.0 g/m<sup>2</sup> during premonsoon, monsoon and postmonsoon respectively. Lowest value of macrobenthic biomass 3.94 g/m<sup>2</sup> for all seasons was obtained at Aroor, with 9.138 g/m<sup>2</sup> during premonsoon dominated by polychaetes, 0.013 g/m<sup>2</sup> during monsoon dominated by amphipods and 2.68 g/m<sup>2</sup> during postmonsoon dominated by bivalves. Macrophytic deposition here were 139.7 g/m<sup>2</sup>, 132.0 g/m<sup>2</sup> and 38.5 g/m<sup>2</sup> during monsoon, premonsoon and postmonsoon respectively.

The highest numerical abundance of macrobenthos 73500 /m<sup>2</sup> was recorded at Azhikode during monsoon,

dominated by amphipods, 70,290/m<sup>2</sup> followed by isopods and tanaids, 3,100/m<sup>2</sup> and then polychaetes 110/m<sup>2</sup>. This was followed by a density of 64,692/m<sup>2</sup> observed at Cochin, also during monsoon dominated by amphipods 61,848/m<sup>2</sup> followed by isopods and tanaids 1,776/m<sup>2</sup>, polychaetes 588/m<sup>2</sup> and then bivalves 480/m<sup>2</sup>.

Polychaetes were represented at all the ten regions sampled during premonsoon. Among the six regions samples in other seasons, it was not recorded from Aroor during monsoon, and also from Azhikode, Cherai and Njarakkal during postmonsoon. During premonsoon, polychaetes contributed the greater percentage of macrobenthic biomass in regions where the total macrobenthic biomass was relatively poor and in regions like Azhikode, Cochin and Alleppey where the total macrobenthic biomass was high the percentage of polychaete biomass was relatively low (figure. 2). During monsoon, similar percentage composition values as in premonsoon were observed for polychaetes except at Aroor, where it was not represented. During postmonsoon polychaetes were not represented in samples from Azhikode, Cherai and Njarakkal but contributed 68.789%, 100% and 26.865% at Mulavukadu, Cochin and Aroor respectively

(figure 2). Largest number of polychaetes were observed at Cochin, 1,380/m<sup>2</sup>, during postmonsoon, followed by Njarakkal, 800/m<sup>2</sup> and Cherai, 780/m<sup>2</sup>, both during monsoon.

Maximum number of amphipods were observed at Azhikode, as mentioned earlier followed by Cochin 61,848/m<sup>2</sup> (40.19 g/m<sup>2</sup>) both during monsoon. Amphipods contributed 88.612%, 36.52% and 100% of macrobenthic biomass at Azhikode, Cochin and Aroor respectively during monsoon. They contributed to less than 1% of total macrobenthos in most regions during premonsoon, but were absent in the postmonsoon samples.

Largest number of isopods and tanaidaceans (74% comprising tanaiids) were observed at Azhikode, 3,100/m<sup>2</sup>, followed by Cochin 1,776/m<sup>2</sup>, both during monsoon. Like amphipods, these organisms were represented in smaller numbers from most regions during premonsoon, but not encountered in the postmonsoon samples.

Highest density of bivalves, 1,400/m<sup>2</sup> (136.82 g/m<sup>2</sup>) followed by 860/m<sup>2</sup> (84.04g/m<sup>2</sup>) occurred during postmonsoon and premonsoon respectively at Azhikode. Next to it, 780/m<sup>2</sup> (76.22 g/m<sup>2</sup>) and 480/m<sup>2</sup> (46.86 g/m<sup>2</sup>) occurred at Cochin during premonsoon and monsoon respectively. At Alleppey also relatively high density, 460/m<sup>2</sup> (44.96 g/m<sup>2</sup>) of bivalves were observed during premonsoon. Generally, an inverse relationship could be seen between the percentage of contribution of bivalves to that of polychaetes (figure 2).

4. Discussion

In coastal shallow water systems like estuaries and lagoons, the detritus derived mainly from the decay of macro-vegetation generally forms a more important link in the energy pathway than the grazing food chain (Darnell, 1967, Odum and DeLaCruz, 1967). In this perspective, the macrophytic biomass derived from aquatic weeds dominated by *Salvinia* is expected to influence the benthic productivity of the Vembanad estuary where on an average 309.67 g/m<sup>2</sup> of plant

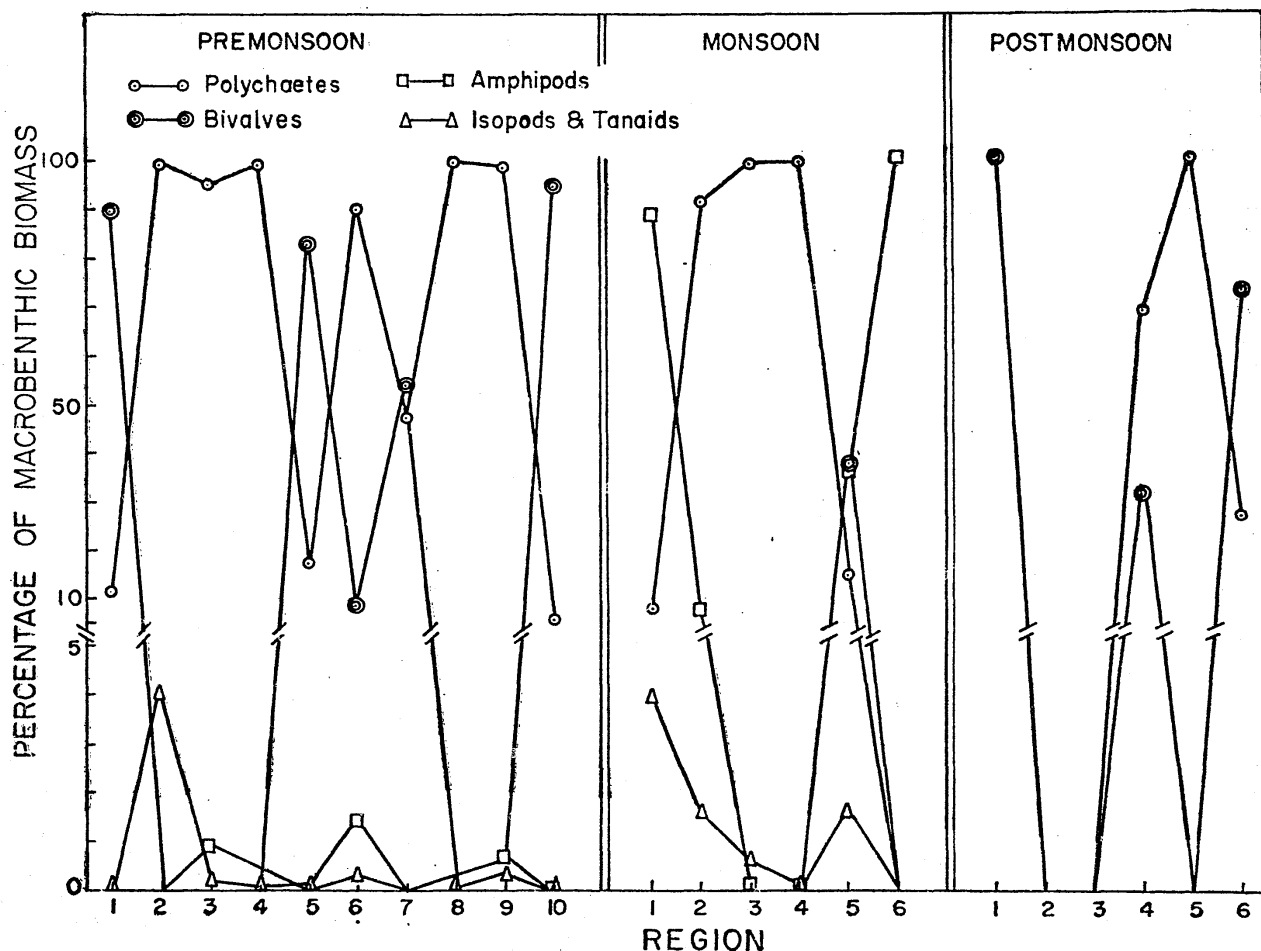


Fig. 2 Percentage biomass composition of macrobenthos in different regions of Vembanad estuary

matter was observed during the present study. In general, the density of benthic organisms has shown considerable reduction in recent times (Qasim & Madhupratap, 1979). The reason for this can be attributed to a combination of different natural and anthropogenic factors from which it is difficult to isolate the exclusive impact of decaying weed deposition on the benthos. It can be seen that in dynamic areas having high dissolved oxygen level such as Azhikode and Cochin, the weed deposits are associated with relatively high macrobenthic biomass mostly contributed by bivalves and other regions of dense weed deposition were found to be poor in biomass and dominated by polychaetes (tables 1 and 2 and figures 2 and 3). High organic content at the bottom and the consequent low oxygen level is reported to kill oysters at the bottom (Friedrich, 1982). In less dynamic areas, occurrence of relatively lower levels of dissolved oxygen and pH (tables 3 and 4) might be due to the presence of decaying macrophytes. The larger storage of organic matter

by macrophytes compared to phytoplankton may be expected to create areas of anoxic bottom water as it decays, and to hinder the successful settling of oyster spats (Lee and Olsen, 1985). Benthic organisms like bivalves with limited mobility are susceptible to such changes. A comparison of the data on the estimated biomass of bivalves in Cochin backwater shows steady reduction in the past two decades (Gopalan and Vengayil 1986), a period during which the weed problem has steadily increased in the estuary. Apart from the low oxygen and pH levels, the settling spats of filter feeding bivalves might be getting smothered under the decaying weed biomass.

As can be seen from tables 2 and 4, higher biomass of amphipods were recorded at Azhikode  $45.68 \text{ g/m}^2$ , (numbering  $70,290/\text{m}^2$ ) and Cochin,  $40.19 \text{ g/m}^2$  (numbering  $61,848/\text{m}^2$ ) during monsoon when low-saline conditions prevailed in these regions. Availability of decaying macrophytes in low-saline conditions

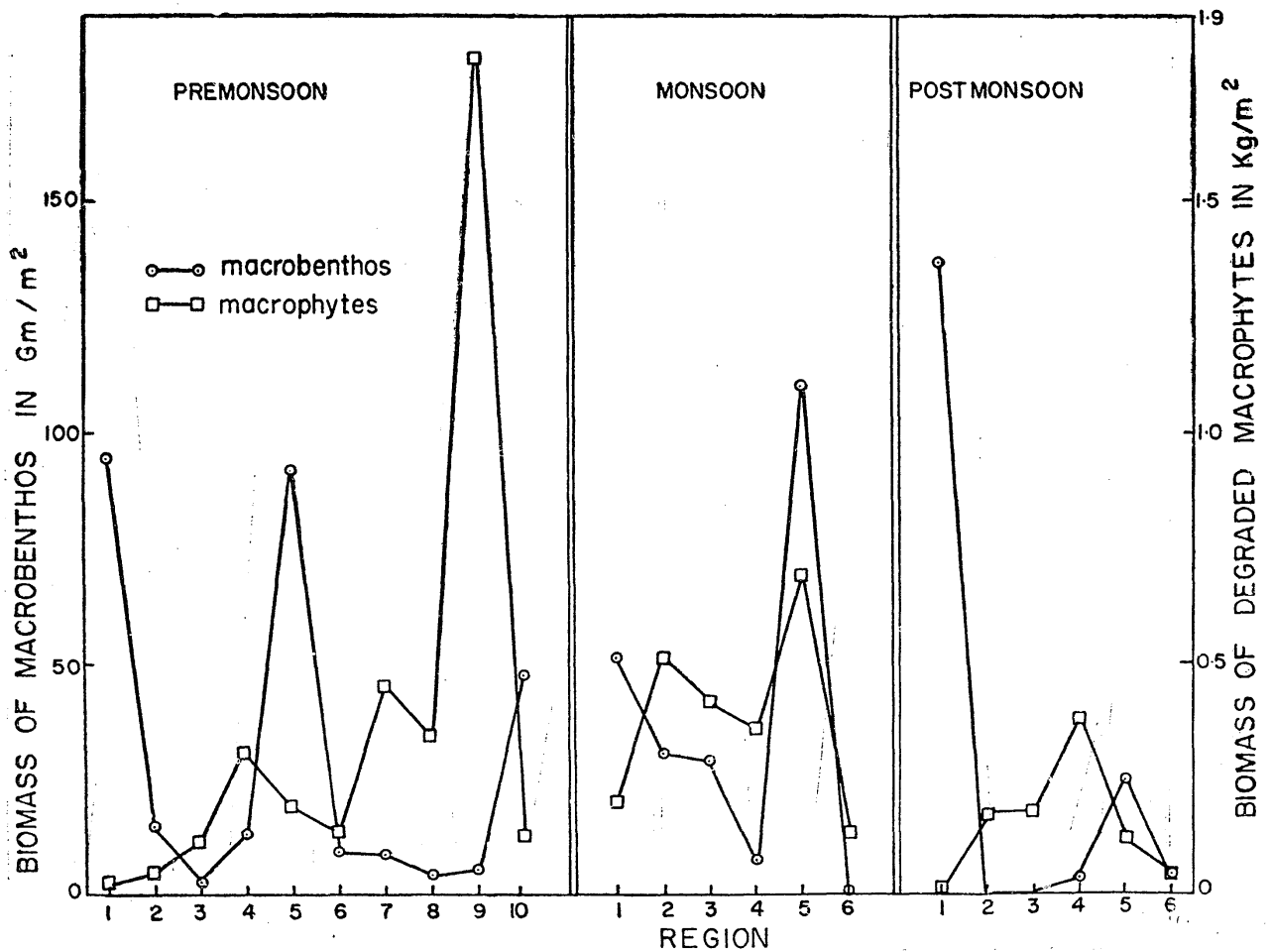


Fig. 3 Biomass macrobenthos in different regions of Vembanad estuary in relation to the biomass of macrophytes.

seems to promote the population of amphipods as has been observed in Lake Pulicat (Raman *et al.*, 1975).

Amphipods were not recorded from the macrobenthic samples of Cochin backwater collected during 1965–1966 (Desai and Krishnan Kutty, 1967). Kurian (1972) recorded 35,000/m<sup>2</sup> as the highest density of macrobenthos in the estuary dominated by amphipods. Kurian *et al.* (1975) and Gopalakrishna Pillai (1977) have further recorded amphipods as the dominant group among the crustacean fauna of Vembanad lake. During the present study the maximum density of amphipods were found to be as high as 70,290/m<sup>2</sup> mainly constituted by *Corophium* sp. These evidences indicate that the growth of amphipod population is promoted by the increased input of macrophytic biomass into the estuary. Their dominance in Cochin and Azhikode shows that they prefer low salinity and high dissolved oxygen levels, besides the presence of large quantities of plant matter. Isopods and tanaidaceans showed almost a similar seasonal trend as in the case of amphipods.

Uniformly high biomass values of burrowing polychaetes were obtained at regions of Njarakkal and Cherai during monsoon when the weed biomass were highest in these regions. These burrowing, deposit feeding animals can withstand low oxygen condition and high sulphide content in the sediment up to 4.9 mg/l (Remani *et al.*, 1983), whereas the tube dwelling polychaete *Diopatra neopolitana* which formed the dominant species in dynamic areas (Desai and Krishnan Kutty, 1967) were absent in these regions.

The present study clearly points out that the abundance and distribution of macrobenthos is considerably influenced by the decaying macrophytic biomass settling at the bottom of the Vembanad estuary.

The protein content of *Salvinia* has been reported to be relatively 'poorer than other common aquatic macrophytes (Majid, 1983). The low protein content (13.1%) of *Salvinia* detritus (Gopalan, 1978) deposited in all regions of the estuary seems to be inadequate for the growth of juvenile prawns which support a major fishery in this region. However, the association of large number of organisms, particularly meiofauna like nematodes 860/m<sup>2</sup> harpacticoids and cyclopoids 39,772/m<sup>2</sup> and ostracods 2,184/m<sup>2</sup>, with the floating *Salvinia* weed mat (Gopalan and Nair, 1975) indicates that the role of macrophytic detritus in the food chain of the estuary needs detailed investigation and assessment.

It has to be mentioned here that a tendency for eutrophication has been observed in the Vembanad

estuary in recent years (Gopalan *et al.*, 1987). Inflow of more exogenous organic matter into such a system can only intensify the problem of eutrophication. This further points at the practical need to control the proliferation of aquatic weeds and also such anthropogenic alterations which augment the production of exotic weeds like *Salvinia*.

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