

Fig 2. Effect of temperature on viscosity

at temperature. From the slope of the curves it is evident that the effect of temperature on the viscosity of LNR is very significant. In the lower temperature range of 20°C to 80°C slope is steeper, indicative of a larger reduction in viscosity. The sample with the highest initial viscosity developed comparatively less fluidity at

140°C than the low molecular weight samples. For low molecular weight LNR, a 30 fold reduction in viscosity was noticed when temperature increased from 20°C to 80°C. Whereas it was only a six fold reduction when the temperature rose from 60 to 140°C. In the case of the sample with the highest viscosity corresponding values were 22 and 10 respectively.

4. Conclusion

The present investigations indicated that liquid rubber samples of Brookfield viscosity less than 1,00,000 cps showed Newtonian tendency while higher viscosity samples showed pseudoplastic behaviour. Reduction in viscosity due to increase in temperature is faster at low temperatures and slower at high temperatures.

References

- Hardman K V and Lang A J. (1950). Properties and applications of depolymerised rubber. *Rubber Age* 66 (4), 419-422.
- Bristow G M (1985). Some possible new applications of LNR in development of liquid natural rubber. *Proceedings of UNIDO sponsored workshop, Abidjan. 20-24 January 1986.*
- Radhakrishnan Nair N (1989). Liquid natural rubber as a reactive plasticiser in nitrile rubber. *Proceedings of UNIDO sponsored workshop, Abidjan. 4-8 December, 1989.*
- Claramma N M (1991). Production of liquid natural rubber by thermal depolymerisation. *Indian J. Nat. Rub. Res.* 4 (1) : 1-7, 1991.



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SUSPENDED SEDIMENT TRANSPORT AND SHOALING IN THE MUNAMBAM FISHERY HARBOUR, KERALA

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Abstract: Results of the Monthly synoptic field observations of vertical profiles of suspended sediment concentration, current velocity and salinity carried out in the Azhicode estuary are presented with a view to understand the shoaling and siltation phenomena in the harbour region. Based on various physical and geomorphological data available on the harbour and near shore region, remedial measures are suggested to prevent the siltation and shoaling at the entrance channel and the sandbar formation at the harbourmouth. This paper also highlights various aspects of hydrodynamics in the lower reaches of the estuary.

Introduction

The Azhicode estuary is formed by the major arm of the Poyar river which joins the Arabian Sea at Munambam. The Chakkudy river joins the estuary about 10 km upstream from the mouth. Compared to Cochin estuary, Azhicode estuary is shallower, the maximum depth at the entrance channel being about 8 m. The width of the estuary near the barmouth is 750 m and at the inlet entrance, about 250 m. The average depth of the study area is about 3.5 m (Abraham Pylee 1987). Sedimentation in the

harbour region as well as the sand-bar formation across the entrance channel is a major menace to the safe entry and berthing of the fishing boats.

2. Materials and Methods

Study area and station location area shown in Fig 1. Monthly synoptic field observation of vertical profiles of velocity, temperature, salinity and suspended sediment concentration for one tidal cycle were carried out at all stations for a period of one year.

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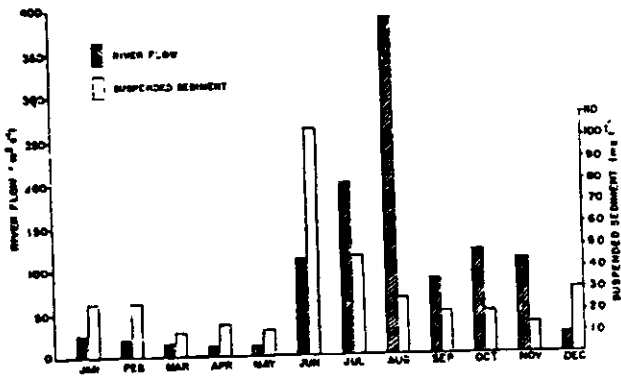


Fig 1. Monthly observation of river flow (Solid Bars) and suspended sediment concentration (Open Bar)

Current speed and direction measurements were made by rotor current meters. Measurements of vertical profiles of salinity and temperature were accomplished by Beckman electrodeless induction salinometer. Suspended sediment concentration at surface, mid depth and near bottom were determined by vacuum filtration of water samples through pre-weighed 0.45 μm millipore filter paper (Cremton and Beckley 1972). Cubic splines were used to interpolate the data at fixed fraction of the non-dimensional depth ($\eta = 0$ and $\eta = 1$ at surface and bottom respectively). Procedure for computing tide averages and depth averages as given by Kjerfve (1979) were followed.

3. Results and Discussion

Total river discharge into the estuary varied from $14 \text{ m}^3 \text{ s}^{-1}$ during May to $400 \text{ m}^3 \text{ s}^{-1}$ during August. Tides in the Azhikode estuary were semidiurnal, with maximum amplitude of 1 m and minimum amplitude 60 cm during spring and neap respectively. Fresh water input into the estuary during this period was $14 \text{ m}^3 \text{ S}^{-1}$ and the maximum diurnal amplitude of tide is 0.69 m. During this period tide was the principal factor which controlled the transport processes and the distribution of salinity and currents in the estuarine system. During ebb tide it was observed that high saline water penetrates well beyond Chennamangalam (12 km upstream). Longitudinal gradient in salinity between Azhikode and Chennamangalam was 9×10^{-3} at the surface. Increased influence of tide was very much manifested in the distribution, well mixed zone extended further landward and reached upto Gothuruth as implied by the orientation of 35×10^{-3} isohaline. Axial and vertical gradients were weakened and the the estuary become moderate to well mixed state.

Influence of increased river flow ($400 \text{ m}^3 \text{ s}^{-1}$) was reflected on the salinity distribution pattern during August. Initial response of the river flow rapid reduction in bottom salinity and a reduction in stratification, which implied that the increase in adverse barotropic pressure gradient was sufficient for a short period to prevent strong penetration of salinity into the upper estuary. Salinity plots are presented only for flood tide. Salinity was $< 1 \times 10^{-3}$ during ebb-tide in the entire estuary. It was observed that inspite of the increased river discharge vertical homogeneity is maintained in the lower 5 km reaches of the estuary as indicated by 32×10^{-3} isohaline. Further upstream vertical and axial salinity

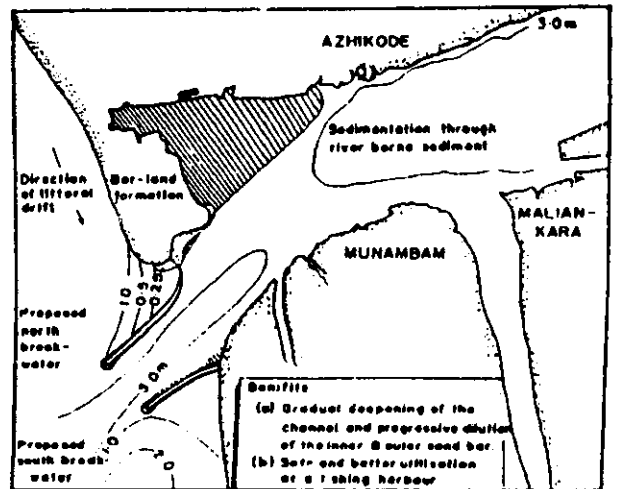
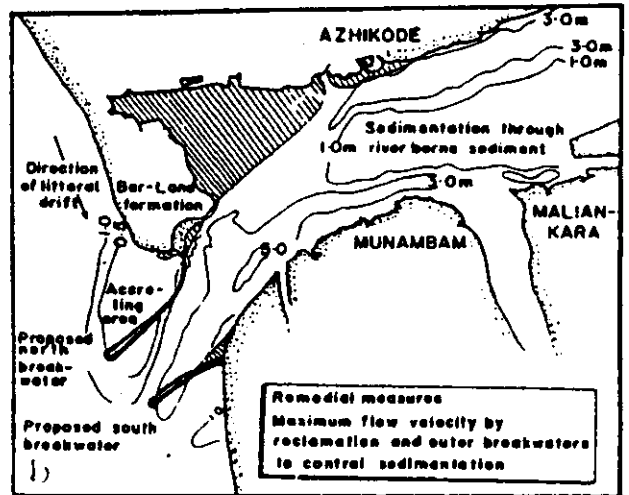
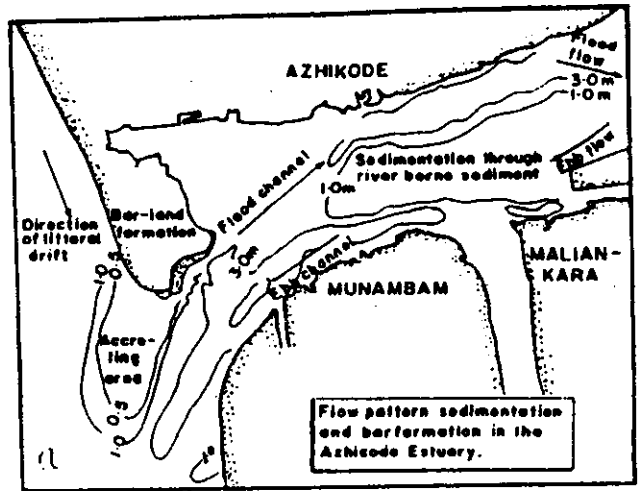


Fig 2. Siltation and shoaling at Munambam harbour and suggested preventive measures.

gradient increased and reached as high as 28×10^{-3} between Athuruth and Chennamangalam.

During the pre-monsoon period vertical gradient remained low (1 to 2×10^{-3}), at sections 1 & 2 and high (17.5×10^{-3}) at section-3, which showed stratification was more towards the head of the estuary compared to bar-mouth, where as during the monsoon period stratification was higher at the lower section, with fresh water at station-3, salinity gradient of 5×10^{-3} at section -2 and 9.5×10^{-3} at section-1. Thus it could be seen that density gradient circulation was limited to barmouth region during monsoon.

The eulerian residual current registered a net seaward flow throughout the year. Vertical gradient was negligible during pre-monsoon season at section -1 & 2, where as at section-3 velocity was higher from $\eta = 0$ to $\eta = 0.3$. This showed that circulation during pre-monsoon was controlled by tide rather than the winds. Residual flow was directed downstream throughout the water column during August, with comparatively higher velocity in those during March. At all the sections residual current increased from surface to bottom. Lower values of residual current at section-2 compared to other section could be attributed to topography of the region.

Sedimentation and sandbar formation in the Munambam Harbour

Sandbar was noticed at Munambam early in the seventies. The sand carried by the Periyar was deposited on both sides of the bar and reducing the outlet to a small and shifting channel of shallow depth. Position of the channel changes with the direction of the waves and the river flow. Fig-4 shows the monthly variation of river discharge and the mean suspended sediment concentration for the study area. From the figure maximum sediment concentration of 106 mg.l^{-1} was observed during June and minimum value of 12 mg.l^{-1} was observed during March. As a whole, suspended sediment concentration showed a river discharge dependent distribution pattern, with high values between June and September. Based on the data in fig 1 it is estimated that annual river borne sediment into the the estuary amounts to 7.8×10^4 tons. Adopting 12 mg.l^{-1} and 100 mg.l^{-1} as the average concentrations of suspended sediment during March and June respectively and $1.3 \times 10^8 \text{ m}^3$ as the average volume of the study area, total mass in suspension varies from 0.16×10^4 tons during March to 1.3×10^4 tons during June. A portion of this large quantity of riverborne sediment is getting deposited in the harbour region, due to the rapid reduction of flow velocity as the water flows-out in the shallow mud flat area (Fig-2a), resulting in the shoaling of the entrance channel and the adjacent region. It is observed that ebbflow is confined to the southern flank of the estuary.

To assess the processes behind the formation of sandbar across the entrance channel, some discussion of the waves, littoral and associated transports in the adjacent coastal area are of some value and data presented here are for a station 10 km north of Azhicode. This data holds good for Azhicode as the meteorological and coastal features are almost same for both the locations. Maximum wave height of 1.5 m is observed during June and minimum wave height of 0.45 m is observed during October. Wave period varies from 6 seconds during June to 11 seconds in the month of October. Littoral current is directed southward during June- September with speed in the range of $20\text{-}30 \text{ cm.s}^{-1}$. Weak northerly current was observed during October-February. Annual net littoral drift was southward and was estimated to be $6 \times 10^4 \text{ m}^3$, of this $2.5 \times 10^4 \text{ m}^3$ was during June alone (Sajeev, unpublished). Sudden increase in the vertical and horizontal extent of the sand bar during monsoon can be explained in the light of the large volume of littoral transport. Thus it is to be believed that the southerly littoral drift and the westerly winds are the major factors for the formation of sandbar. Part of the river borne sediment also may contribute its share to the formation of sandbar, but the extent of which has to be investigated further.

Based on the data collected, and the information available from various sources and also from the experience gained during the study of similar estuaries, we suggest that if the sand bar is dredged out and the dredged material is used to reclaim the shallow mud flat area (Shaded portion in Fig.2), it is possible to channelise the flow and thus attain the flow velocity sufficient to flush sediments out of the harbour region and thereby prevent shoaling. Construction of offshore structure either in the form of breakwater or groynes as shown in the figure, will prevent southerly and northerly littoral sediment transport and thereby the sandbar formation. Orientation, nature and length of the structure can be decided only after physical modeling. Fig.5c is a conceptual picture showing the benefits such as gradual deepening of the channel and progressive dissipation of the sand bar obtained on the implimentation of the preventive measures suggested.

References

1. Abraham Pylee, 1987. "Hydrography of the lower reaches of Periyar": M.Sc thesis, submitted to Cochin University of Science and Technology.
2. Kjerfve B, 1979. Estuarine Coastal and Marine Science, 9, 56.
3. Cranston R E and Buckley D E 1972. Report Series B1-R-72-7. Bedford Institute of Oceanography, Daltmouth, Nova, Scotia, 14.
4. Sajeev R. "Studies on coastal dynamics of Kerala" (unpublihsed).
5. Dyer K R 1979. In Estuarine hydrograpghy and sedimentation (ed). Dyer K R p 217 (Cambridge University Press).

