

PHYSICAL CHARACTERISTICS OF CHAPORA ESTUARY

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Variation of current, salinity, suspended load and temperature are discussed for three seasons. This part of the estuary is situated in the "tidal section of the river" in monsoon and could be classified as type 2 corresponding to partially mixed during post and pre-monsoon seasons. Suspended load was maximum during monsoon. A linear dependence of mean attenuation coefficient on suspended load has been observed during post-monsoon season.

Chapora estuary which is situated in the northern part of Goa, joins the Arabian sea at about $15^{\circ} 36'N$. The estuary is narrow, the maximum width being about 900 m (near Oxel point), before joining the Chapora bay. Chapora bay has a narrow opening into the sea (width about 600 m). Tide in this area is of a mixed semi-diurnal type. Fresh water supply is maximum during monsoon and minimum in pre-monsoon. Observations were carried out in November 1972, June 1974 and July 1974. Observations made in the first week of June i. e., a few days before the onset of monsoon, were preceded by one or two pre-monsoonal showers. However, this can, by and large, be considered as pre-monsoon observations. November 1972 and July 1974 observations are typical of post-monsoon and monsoon respectively.

The station chosen for observations was situated near Macazana Colvale ferry crossing, about 13 km from the mouth (Fig. 1). Average depth over a tidal cycle at the station was about 7 m and the width

was about 250 m. Hourly observations of the parameters were made over a tidal cycle. Current speeds and directions near the surface, mid-depth and near the bottom were noted. Water samples were also collected from three depths. Temperature of the samples was recorded. Salinity was estimated by titration method and suspended sediment load by filtration and weighing technique. Secchi disc was operated only during pre and post-monsoon seasons.

Variations of current and salinity are shown in (Fig. 2).

During pre-monsoon the entire water column attained a maximum flood of 40 cm sec^{-1} . Maximum ebb current (50 cm sec^{-1}) was observed at surface and there was a marked depthwise decrease in ebb speed. Low and high waters preceded the slack by about an hour. Salinity structure showed negligible stratification during peak flood. Maximum gradient was observed at low water. About 2 hrs after highwater, surface

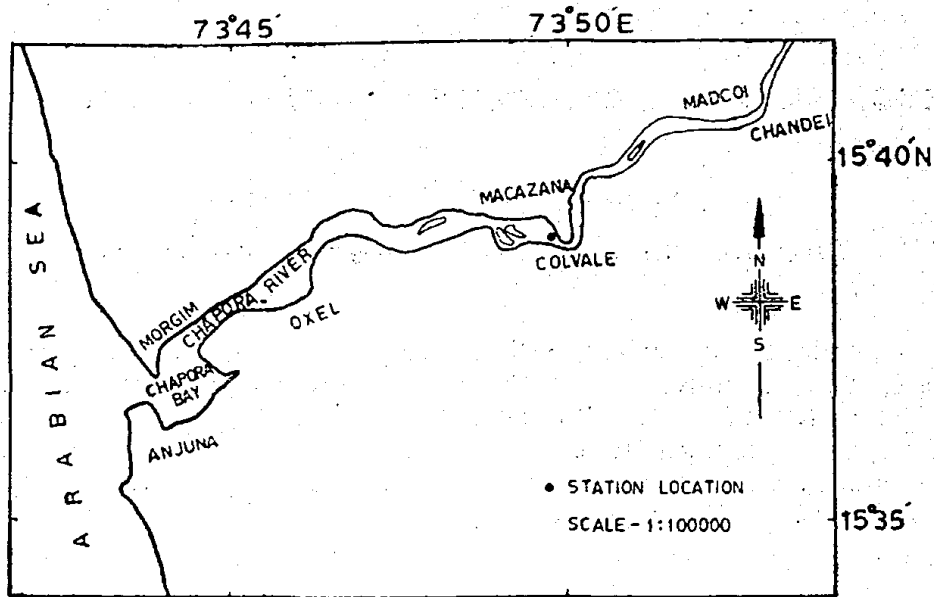


Fig. 1. Station location map.

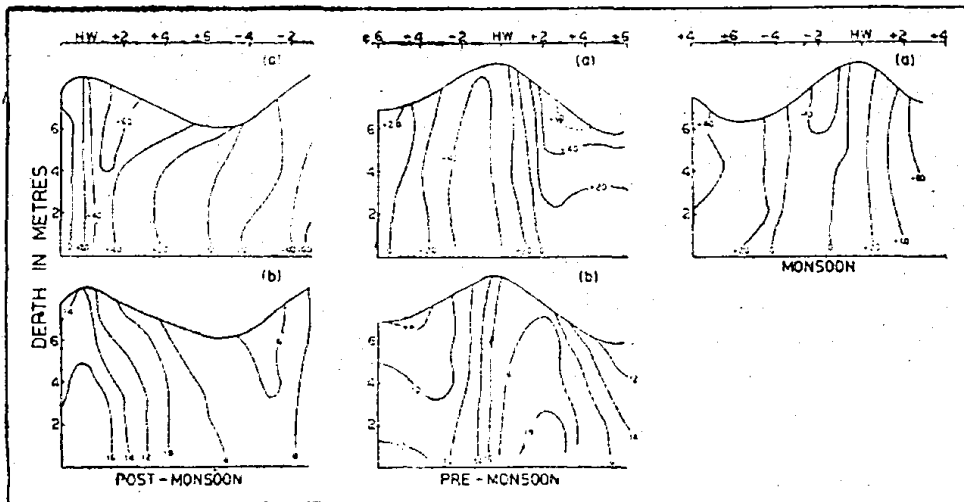


Fig. 2. Variation of (a) Velocity (cm sec^{-1} , + ebb and flood) and (b) Salinity (‰).

salinity was found to decrease while the bottom waters retained high salinity. Ebb current which showed a depthwise decrease caused the entrapment of high saline water near the bottom.

Due to the dominance of freshet over tides in monsoon, the current direction was predominantly downstream and flood was very weak (10 cm sec^{-1}). Ebb continued even after low water for about

2 hrs. The entire water column was free of salt throughout the tidal cycle indicating that this region of the estuary was situated in the 'tidal section of the river' during the monsoon.

During post-monsoon the ebb increased rapidly and maximum current (60 cm sec^{-1}) was observed 2 hrs. after high water and it extended from surface to mid-depth. Decrease in ebb was gradual. Flood was considerably faster near the bottom. Salinity increased with depth and maximum and minimum salinities were observed 1 hr. after high water and 2 hrs. after low water respectively.

Tidal mean velocities showed a net non-tidal circulation in pre-and post-monsoon seasons, with down stream velocities at the surface and upstream velocities near the bottom. However, in monsoon, due to the dominance of fresh over tides, this feature was absent and the net flow was downstream at all depths. Though the data is not comprehensive, the classification of estuary was attempted, taking the station as representative of section. Stratification ($\delta s / S_0$) and circulation (U_s / U_f) Parameters suggested by Hansen and Rattary (1966) were calculated, where δs is the surface to bottom salinity difference, S_0 is the sectional mean salinity, U_s is the mean surface velocity and U_f is the fresh water velocity. This estuary was classified as type 2, which is analogous to partially mixed Hansen and Rattary (1966), in pre and post-monsoon seasons (Fig. 3), the flow reversing at depth with advection and diffusion contributing to the upstream salt flux. This is in good agreement with the observed velocities. It is to be noted that this classification

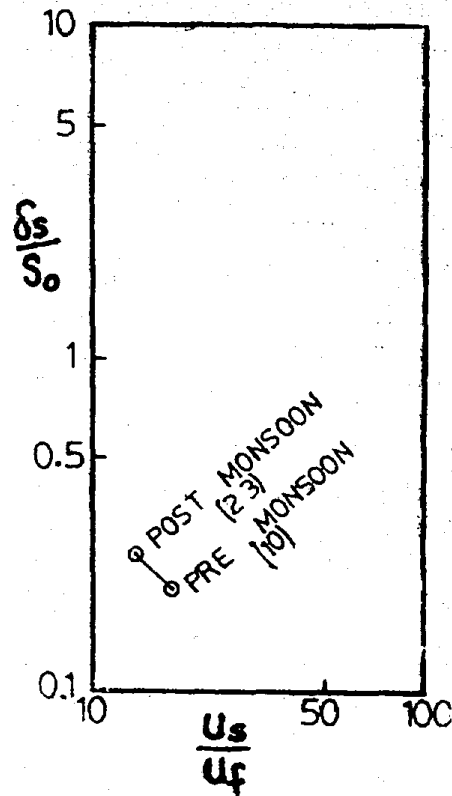


Fig. 3. Classification of the estuary. River discharge $\text{m}^3 \text{ Sec}^{-1}$ in parenthesis.

holds good to this part of the estuary and other regions can fall in any other type.

Temperature was maximum during pre-monsoon (30 to 30.5°C) and minimum during monsoon (26.5 to 27.3°C) with intermediate values (28.5 to 29.5°C) in post-monsoon. During pre-monsoon temperature variation was tide controlled (high temperature at highwater) whereas in monsoon the variation in temperature was diurnal.

Suspended load varied between 6 and 20 mg l^{-1} in pre-monsoon and from 2 to 14 mg l^{-1} in post-monsoon. The slightly higher values encountered during the

pre-monsoon may be the result of pre-monsoonal showers. It generally increased with depth and showed a semitidal fluctuation (increase with increasing current speed). Suspended load was more around high water than around low water. In monsoon suspended load was comparatively high (12 to 30 mg l⁻¹) and did not show any clear relation with current speeds. These are due to the freshet which can bring in large amount of suspended particles of different sizes, which react differently to current speeds.

Relation between mean attenuation coefficient \bar{K} and suspended matter is shown in Fig. 4, where $\bar{K} = 1.7/D$, D being secchi depth in metres. For pre-monsoon, when secchi depth was generally less than 1 m, suspended load of surface water was used. In post-monsoon secchi depth was more than 1 m and the mean seston content of surface and mid-water

was made use of. A linear relationship $Y = .778 + .049 X$ ($r = .9$) was obtained for post-monsoon season, when suspended load was less than 10 mg l⁻¹. Using a more direct method Jones and Wills (1956) have established a linear dependence of K on low values of seston. For pre-monsoon correlation was poor ($r = .4$). This was due to increase in suspended particles. Lack of correlation between K and high values of seston was reported Qasim et al (1968) for Cochin Backwater, where they found that the presence of yellow pigments also contributed to this feature. Seasonal variation in yellow pigments also might have contributed to the lack of correlation observed in Chappora estuary during pre-monsoon.

Maximum tidal currents (flood and ebb) of the order of 60 cm sec⁻¹ and 50 cm sec⁻¹ were observed in post and pre-monsoon respectively. In monsoon,

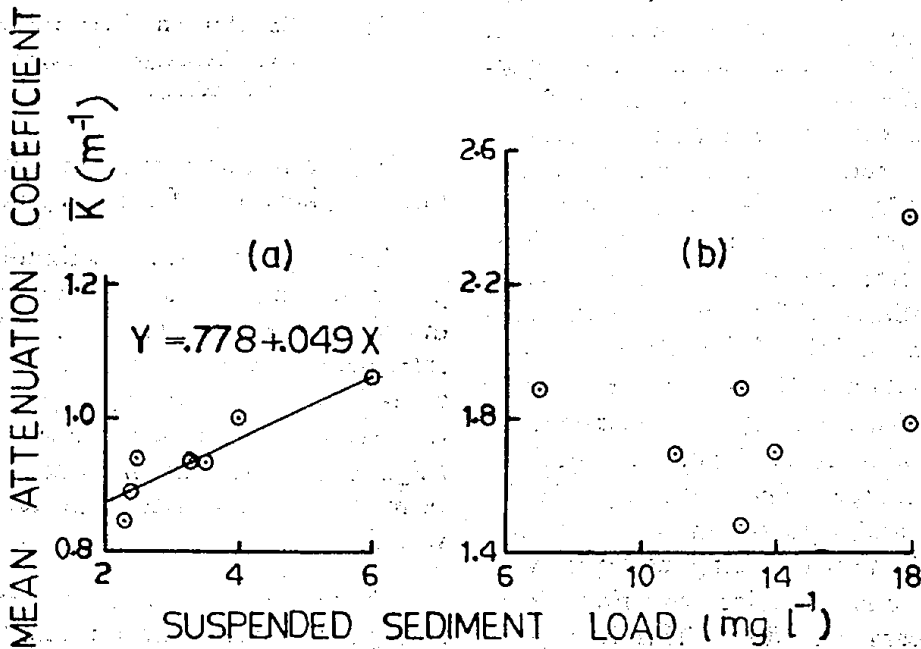


Fig. 4. Relation between mean attenuation coefficient and suspended load
 (a) Post-monsoon (b) Pre-monsoon

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due to the dominance of freshet, flood was very weak in this region (10 cm Sec^{-1}). Maximum salinities in post and pre-monsoon were 17‰ and 19.5‰, respectively and this was classified as type 2 estuary corresponding to partially mixed. A study at different parts of the estuary is necessary to know the variation of the type along its length. Suspended load showed semi-tidal fluctuation in post and pre-monsoon seasons. Linear relationship

was observed between mean attenuation coefficient and suspended load in post-monsoon.

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REFERENCES

- Hansen, D. V. and M. Rattary, Jr., 1966. New dimensions in estuary classification. *Limn. Oceanogr.*, 11 : 319-326.
- Jones, D and M. S. Wills., 1966. The attenuation of light in sea and estuarine waters in relation to the concentration of suspended solid matter. *J. mar. biol. Ass. U. K.*, 35 : 431-441.
- Qasim, S. Z., P. M. A. Bhattathiri and S. A. H. Abidi., 1968. Solar radiation and its penetration in a tropical estuary. *J. exp. mar. biol.* 2 : 87-103.