

Short Communications

Residual fluxes and suspended sediment transport in the lower reaches of Muvattupuzha river, southwest coast of India

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Spatial and seasonal variation of different physical processes governing the transport of salt and sediment of the Muvattupuzha river are discussed. Salt and suspended sediment due to tidal pumping was directed upstream, salt transport due to vertical shear was upstream irrespective of seasons. Suspended sediment concentration was higher during flood tide.

Knowledge of the fluxes of suspended sediment, salt and water are important to understand the dynamics of the estuarine system¹. In the present study, an attempt has been made to estimate and compare various dispersion mechanisms such as residual fluxes of water, Stokes drift and vertical shear in the tidal and residual current at 4 stations in the lower reaches of the Muvattupuzha river, under varying dilution intensities. Emphasis has been given to study intra-tidal variation of suspended sediment concentration with concurrent salinity and current observation.

The study area (Fig. 1) is characterised by the presence of the two large basins of the Periyar and Muvattupuzha rivers. The Muvattupuzha river empties into the Cochin backwaters, which is subjected to the tidal effects through the Cochin barmouth. Average depth of the study area is 5.5 m. Width of the cross section—I is 633 m and that of section-II is 1012 m. Tides in the region of study being semi-diurnal, synoptic field measurements for 13 h were made at 4 stations during May and August 1990, which respectively represent the low and high fresh water discharge period (data from Central Water Commission, Cochin). Measurement include vertical profiles of current speed, direction, salinity and suspended sediment concentration. Vertical profiles of current speed and direction were made using indigenous rotor current meter (accuracy for velocity $\pm 2 \text{ cm.s}^{-1}$ and direction $\pm 2.68^\circ$, designed at NIO, Goa, India). Vertical profiles of salinity is accomplished by Beckman salinometer (accuracy 0.01×10^{-3}). Water level at the observation site was recorded using a graduated tide pole, suspended

sediment concentration at surface, mid depth and bottom were determined by vacuum filtration of water samples through pre-weighed $0.45 \mu\text{m}$ millipore filter paper². Cubic splines^{3,4} were used to interpolate data at fixed fraction of the non-dimensional depth ($\eta=0$ at the surface and $\eta=1$ at bottom).

Basic properties of the stations are given in Table 1. Tide averaged depth was higher during August 1990 at all stations by an amount $< 50 \text{ cm}$. Appreciable salinity gradient of $< 3 \times 10^{-3}$ was observed in the upstream direction. Vertical salinity gradient of 5 to 8×10^{-3} was observed during May at all stations.

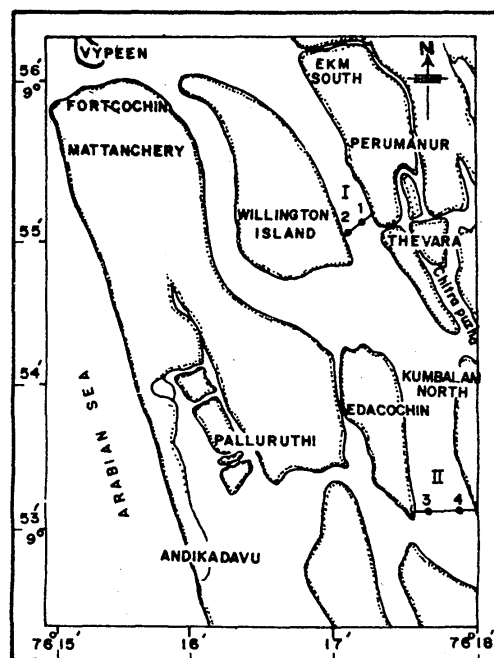


Fig. 1—Study area with location of stations

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Longitudinal salinity gradient did not exhibit seasonal fluctuation as it depends both on the tide and the river discharge. Higher vertical salinity gradient at section-I could be attributed to the influx of Chitrapuzha river which joins the system 1 km upstream of this section. Tide-depth average suspended sediment (Table 1) concentration did not vary much between May and August.

Residual flux of water—A summary of the observed

Table 1—Basic properties of stations

St No.	H (m)	S ($\times 10^{-3}$)	T (°C)	F (mg.l^{-1}) ($\times 10^{-3}$)	S _B ($\times 10^{-3}$)	S _S ($\times 10^{-3}$)
May 1990						
1	6.40	26.94	30.33	103.49	29.05	24.28
2	6.40	26.96	30.25	90.36	28.54	23.79
3	6.92	23.35	30.85	91.36	27.04	19.32
4	5.05	23.70	30.75	80.06	26.70	18.35
August 1990						
1	6.73	8.60	24.68	77.00	12.70	03.40
2	6.62	5.42	24.61	60.21	06.29	02.00
3	7.24	2.30	25.96	108.88	03.49	01.20
4	5.05	2.60	26.06	83.11	03.65	01.20

H : Tide averaged depth

T : Tide-depth averaged temperature

F : Tide-depth averaged suspended sediment concentration

S = Tide-depth averaged salinity

S_B, S_S : Tide averaged salinity at bottom and surface respectively

residual fluxes of water is given in Table 2. Negative sign shows that transport is directed upstream and positive sign indicates the downstream transport. Eulerian residual flow (u_E , Table 2) was upstream at all stations during May and changes its direction towards downstream in August. Direction of the Stokes drift (u_S , Table 2) was upstream irrespective of the season. Stokes drift arises because of the partially progressive nature of the tide, resulting from the frictional dissipation of tidal energy in the estuary. Langrangian residual flow which is the sum of residual current and stokes drift follows the direction of the residual flow as the magnitude of Stokes drift was very low.

Residual fluxes of salt—Values of the observed fluxes of salt computed are given in Table 2. Residual transport salt due to residual discharge of water (F_L) was upstream during May and downstream during August. Generally the salt transport due to tidal pumping (F_{TP}) was directed upstream. Magnitude of Stokes drift was higher at section-I due to the strong tidal influence available there, since its close proximity to the barmouth. Large transverse variation in F_{TP} was observed in section-I. This indicates the predominant flood channel in the eastern flank of the estuary. Residual transport of salt due to vertical shear was directed upstream irrespective of the season. Net salt transport was upstream during May and August though the magnitude was less in August. Fischer⁵ accredited this net upstream transport even during high freshets to the transverse shear.

Table 2—Axial component of residual fluxes

St. No.	u_E^*	u_S^*	u_L^*	$F_L^{\$}$	F_{TP}	$F_V^{\$}$	$F^{\$}$	G_L^+	G_{TP}^+	G_V^+	G^+
May 1990											
1	-09.5	-2.5	-12.0	-325	-146	-09.0	-489	-1340	-1734	83	-2991
2	-12.3	-3.4	-15.7	-423	-166	-09.0	-599	-1400	-1366	61	-2707
3	-03.8	-1.6	-05.4	-188	-166	-21.0	-255	-700	-985	281	-1404
4	-01.4	-2.9	-04.3	-97	-78	-28.0	-285	-304	-285	-16	-605
August 1990											
1	7.2	-1.2	6.0	52	-150	-2.0	96	136	-1666	166	-1364
2	4.5	-1.1	3.3	17	-34	-4.0	-21	286	106	3	395
3	2.6	-1.1	1.5	3	-32	-7.0	-36	613	133	-222	524
4	3.3	-1.2	2.1	12	10	-9.0	-31	122	-563	131	-310

Units: * = cm.sec^{-1} , \$ = $10^{-3} \text{ cm.sec}^{-1}$, + = $\text{mg.l}^{-1}.\text{cm.sec}^{-1}$

u_E —Depth averaged Eulerian residual current

u_S —Stokes drift

u_L —Langrangian residual flow of water

F_L (G_L)—Residual transport of salt (suspended sediment) due to residual flow of water

F_{TP} (G_{TP})—Residual transport of salt (suspended sediment) due to tidal pumping

F_V (G_V)—Residual transport of salt (suspended sediment) due to vertical shear in the tidal and residual current

F (G)—Net transport of salt (suspended sediment)

Residual transport of suspended sediment—Residual transport of suspended sediment due to the residual discharge of water was directed upstream during May and August (Table 2). Tidal pumping of suspended sediment was directed upstream during May, probably due to resuspension of bed sediment and associated upstream transport, whereas in August tidal pumping of suspended sediment was irregular both in magnitude and direction. Suspended sediment transport by the tidal pumping was in general high at section-I, in particular at st. 1. This was possibly due to the easily erodable bed material at st. 1 and the presence of flood channel described earlier in the salt transport mechanism. Suspended sediment transport associated with vertical shear was downstream at

section-I during May and August. At section-II, direction of the vertical shear transport was not consistent.

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