

SEASONAL CHANGES IN SUSPENDED SEDIMENT LOAD IN THE GAUTHAMI-GODAVARI ESTUARY

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ABSTRACT

Studies carried out on suspended matter characteristics of the Gautami Godavari estuary revealed that the concentration of suspended matter (CSM) during southwest monsoon is influenced mainly by the increased run off at both Neelarevu and Vrudha estuarine mouths. During pre-monsoon and northeast monsoon seasons, the CSM is mainly controlled by the tidal currents (10 cm/s to 150 cm/s) as the fresh water discharge during this period is minimum. Higher CSM (270 mg/l) at Vrudha estuarine mouth compared to Neelarevu (95 mg/l) estuarine mouth during this period could be due to the turbulence caused by wave action and tides.

Key-words: Gautami-Godavari estuary, suspended sediment, currents, turbulence.

River Godavari is one of the major rivers along the east coast of India, with a drainage basin area of 300,000 km² and with a maximum discharge of about 3330 m³ sec⁻¹. It divides into two primary distributaries at Dowlaiswaram. At Dowlaiswaram the fluvial system of the Godavari has been affected by a century old, "Low Dam". The major distributary flowing towards east is known as Gautami-Godavari, and the other major distributary flowing towards south is known as Vasista Godavari. The present investigation is pertained to primary Gautami-Godavari and its distributaries. The secondary distributary of Gautami-Godavari flowing towards east is called Neelarevu while the other flowing towards south is Vrudha. Each of these channels empties itself into Bay of Bengal independently. The river discharges huge quantities of fresh water during the southwest monsoon period generating complex hydrodynamical environment in the estuaries. The sedimentation processes in the estuary also assume importance as the river water collects large quantities of suspended matter along its course.

Extensive studies in Gautami-Godavari estuary have been carried out by Chandra Mohan (1963), Rama Sarma (1965), Ganapati and Rama Sarma (1965), Ranga Rao, Ramana and Reddy (1988) on hydrographical features and Naidu (1968) on texture, geochemistry and mineralogy of the sediments. Reddy, Venkatesh Prabhu, Venugopal, Hariharan and Narayana (1990) carried out flow and suspended sediment characteristic studies in the Coondapur port of Gangolli estuary along the west coast

of India. The present study was undertaken to investigate the behaviour of suspended sediment concentration in relation to currents in the Gautami Godavari estuary.

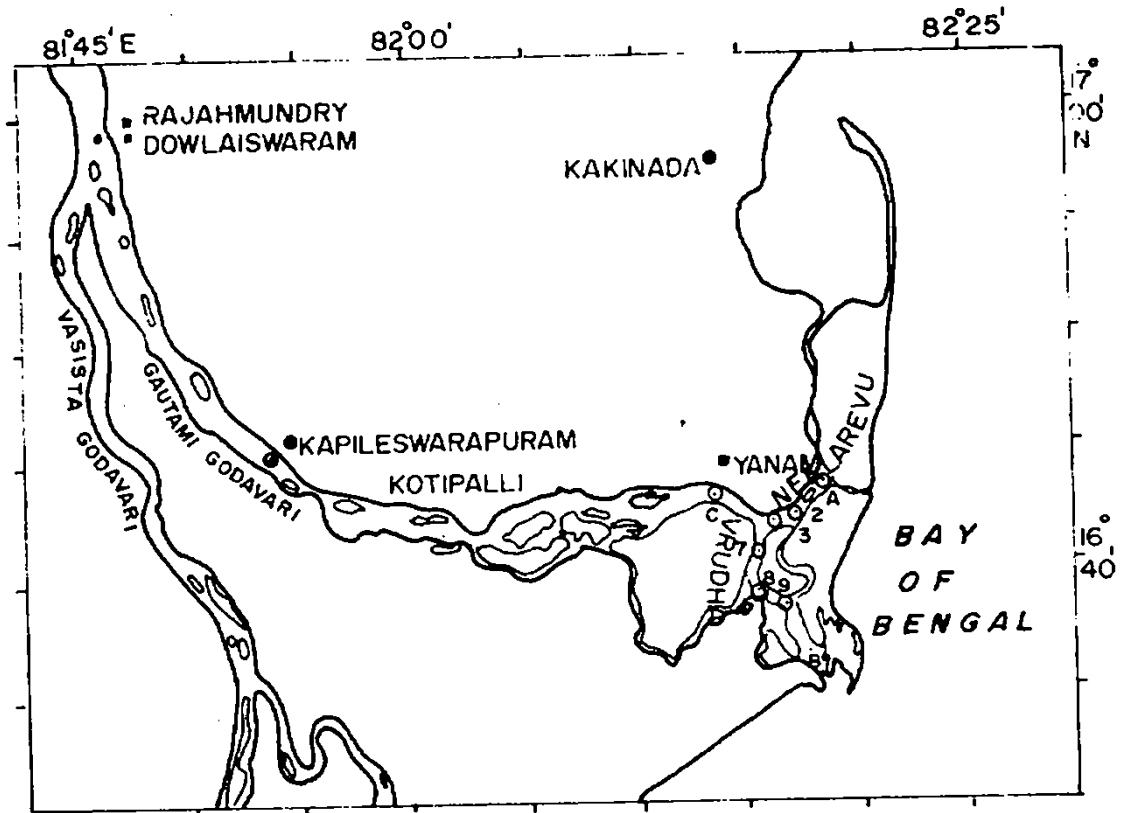


Fig. 1. Station location map.

Water samples were collected at surface and near bottom at an interval of two hours over a complete tidal cycle at three stations A, B and C (Fig. 1) in December, 1987 (northeast monsoon), April, 1988 (pre-monsoon) and during ebb tide in July, 1988 (southwest monsoon) using Niskin bottle. A fixed quantity of samples was filtered through a pre-weighed millipore membrane filter paper of $0.45 \mu\text{m}$ for obtaining the suspended sediment concentration. Currents were measured at hourly interval at every two metres depth using NIO Rotor Current Meter at all the three stations. In addition, suspended sediment samples were also collected during September 1988 all along the Godavari estuary at 8 stations (A to H).

Variability of currents and suspended sediment concentration during tidal cycle for each season at stations A (Bhyravapalem), B (Vrudha estuary) and C (Yanam) are presented in Figs. 2, 3 & 4 respectively. Maximum and minimum values of these parameters are given in Table I.

Concentration of suspended matter (CSM)

Wide fluctuations have been observed in the suspended load concentrations in both surface and bottom waters at all the three stns. A, B and C. During northeast

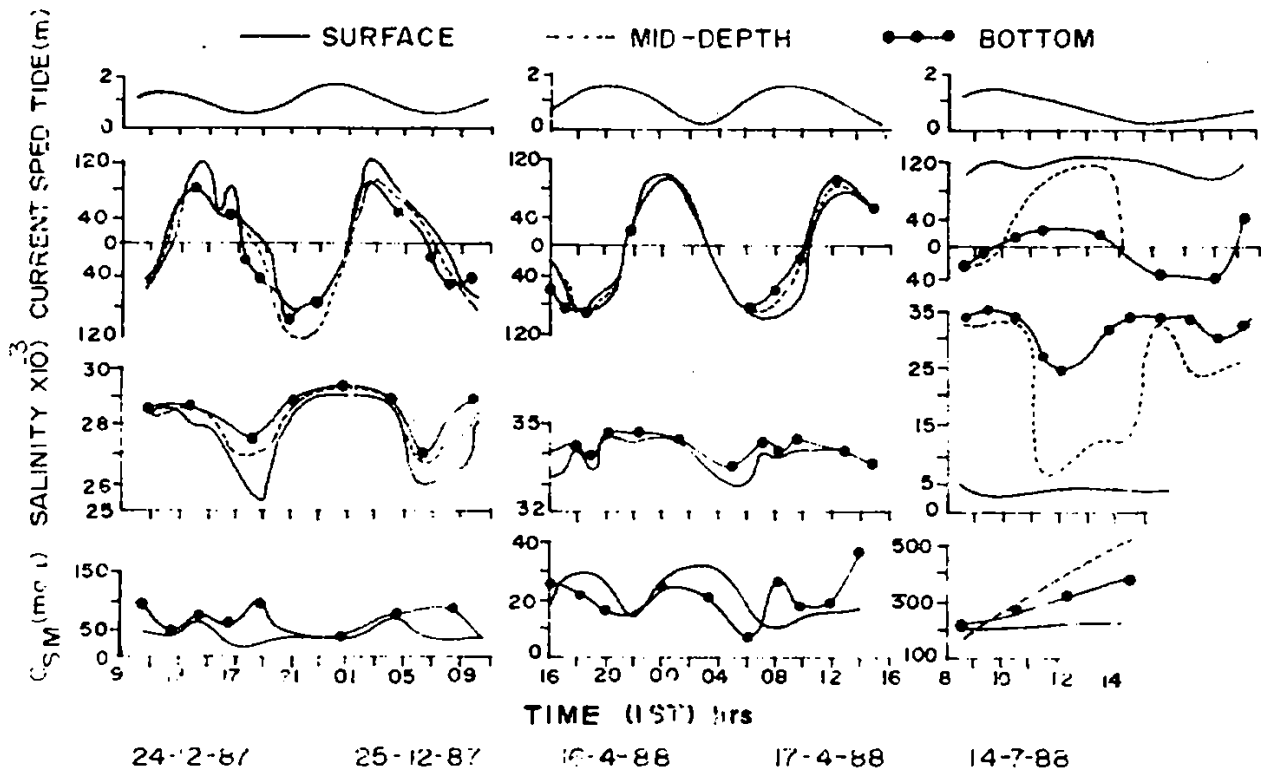


Fig. 2. Suspended matter and currents over a tidal cycle at station A.

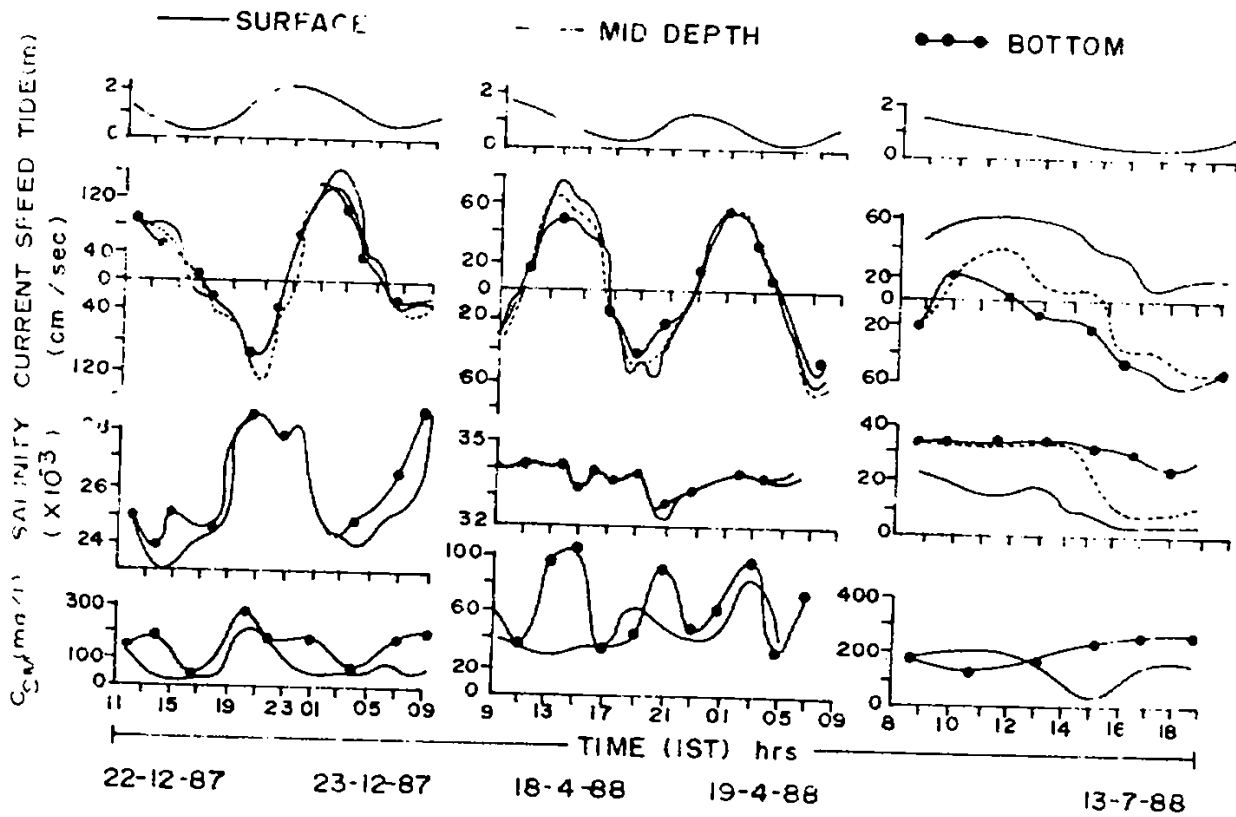


Fig. 3. Suspended matter and currents over a tidal cycle at station B.

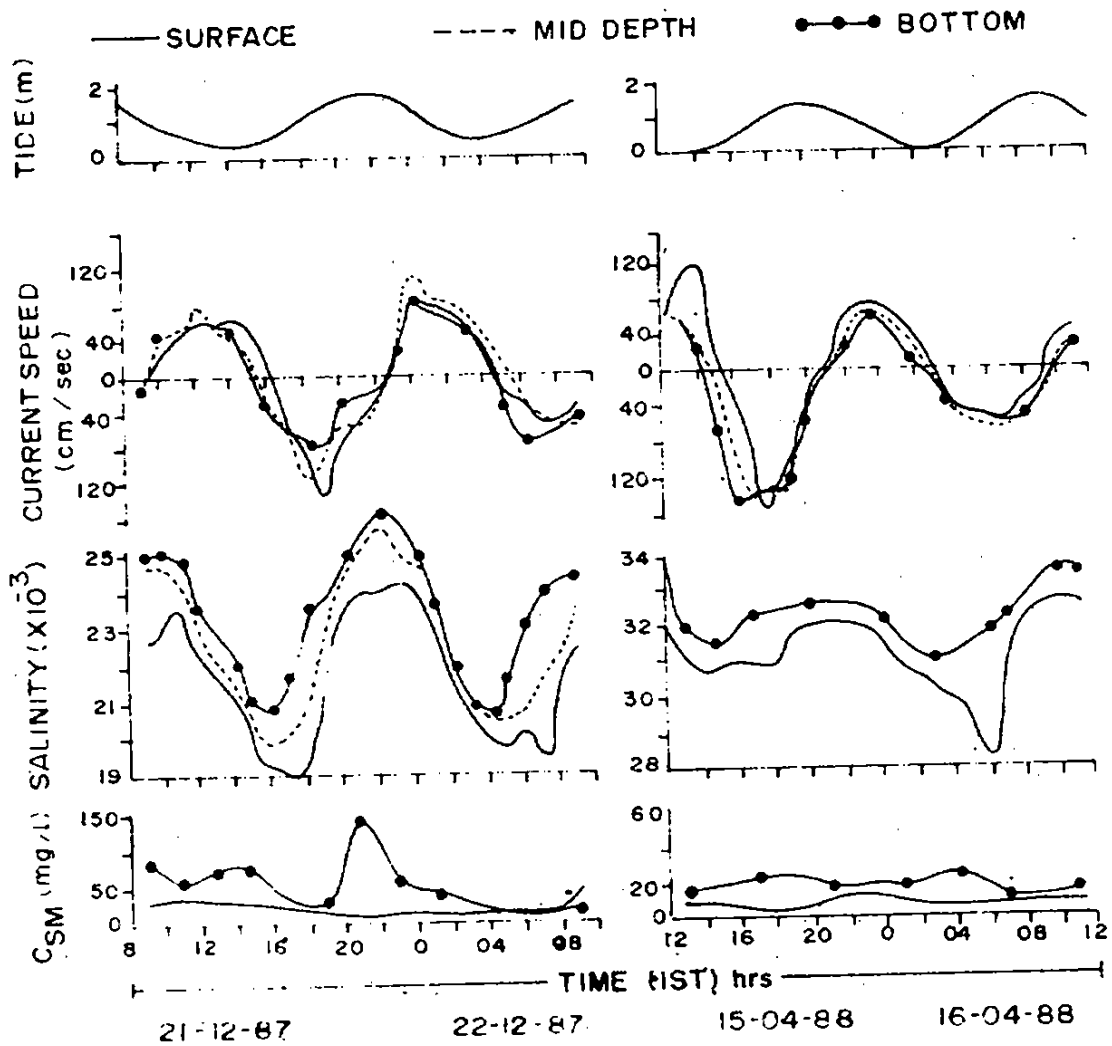


Fig. 4. Suspended matter and currents over a tidal cycle at station C.

monsoon CSM in the surface water ranges from 15 to 30 mg/l during flood and 10 to 70 mg/l during ebb tides at stn. A, while at stn. B it varied from 30 to 200 mg/l at flood and 20 to 210 mg/l at ebb tides at surface and 30 to 270 mg/l at flood and 50 to 180 mg/l at ebb in bottom waters. At stn. C, the CSM range during flood and ebb is more or less the same both in the surface and bottom which ranged between 10 and 50 mg/l. During premonsoon, the suspended sediment is noticed to be lowest at stn. C. The variation in surface waters over flood tide is 8-32 mg/l at stn. A, 41-80 at stn. B and 5-10 mg/l at stn. C, while at bottom, the variation is 6-25, 30-90 and 10-24 mg/l respectively. Similarly, the range at ebb is 8-32, 26-40, and 6-16 mg/l for stn. A, B & C in the surface and at bottom it is 15-38, 36-100 and 7-20 mg/l respectively. It may be mentioned here that during these two seasons, the fresh water flow into Gautami Godavari is less. Therefore, the tide in this area plays an important role in the transportation of sediments during northeast and pre-monsoon periods. During these two seasons, maximum CSM is found to be closely related to the current velocity in

Table I — Suspended load during 1987-88.

Season	Tidal flow direction	Suspended sediment load mg/l				Currents			
		Surface		Bottom		Surface		Bottom	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Station A									
NE Monsoon	Flood	30	15	95	25	84	21	100	21
	Ebb	70	10	75	35	117	30	84	33
Premonsoon	Flood	32	8	25	6	96	11	89	17
	Ebb	32	8	38	15	96	19	94	15
SW Monsoon	Flood	-	-	-	-	-	-	40	26
	Ebb	210	200	370	210	119	17	44	21
Station B									
NE Monsoon	Flood	200	30	270	30	123	24	112	10
	Ebb	210	20	180	50	160	40	125	20
Premonsoon	Flood	80	41	90	30	59	15	62	12
	Ebb	40	26	100	36	80	15	59	08
SW Monsoon	Flood	-	-	-	-	-	-	66	13
	Ebb	210	40	230	112	63	17	20	06
Station C									
NE Monsoon	Flood	50	10	140	15	135	18	79	16
	Ebb	40	15	80	25	93	17	85	25
Premonsoon	Flood	10	5	24	10	151	22	145	09
	Ebb	16	6	20	7	119	07	62	16
SW Monsoon	Flood	-	-	-	-	-	-	-	-
	Ebb	1200	818	888	743	-	-	-	-

the bottom and surface waters at stns. A and B and phase of the tide. This may be due to the proximity of stations A and B to the sea. The CSM at any location is affected due to two common processes, namely advection and diffusion (Wright, Thom and Higgins, 1980). In the advective transport, the suspended material is transported horizontally along the river stretch. In the diffusive transport, sediment is transported from zone of higher concentration to the zone of lower concentration. Wave action and tidal currents are mainly responsible for turbulent diffusive transport. With the reduction in the fresh water discharge after the cessation of the southwest monsoon, the funnel shape of Vrudha estuary mouth (stn. B) is modified with the formation of sand spit, which grows from the left bank and blocks a quarter of the river mouth. The growth of the incurred spit to some distance, first across the river mouth and then to about 200 m upstream of the Vrudha channel gives rise to a complex environment temporarily at the left bank of the estuarine mouth, which is partly a lagoon and partly a tidal flat (Naidu, 1968). At stn. B turbulence caused by this complexity seems to be responsible for the high concentration of suspended load (300 mg/l & 100 mg/l) during northeast and premonsoon period (Reddy, Venkatesh Prabhu, Venugopal,

Hariharan and Narayana, 1990). This is evident from the high current speeds noticed at this station during northeast monsoon (160 cm/sec). Since the area is shallow, resuspension by wind waves and tidal scour are also important factors and accounts for most of the suspended material.

During southwest monsoon season, suspended sediment at all stations was maximum and ranged from 200 to 210, 40 to 210 and 818 to 1200 mg/l in the surface waters and 210 to 370, 112 to 230 and 743 to 888 mg/l in bottom waters at stn. A, B & C respectively. The circulation of water within an estuary is governed by strong tidal oscillations on which residual water circulations may be generated by non-linear interactions between the tidal flow and bottom topography of the estuary, density gradients, wind stress and the mass input due to fresh water discharge (Uncles and Jordan, 1979). High velocity ebb currents (119 cm/sec) during southwest monsoon in the estuarine mouth (stn. A) was due to increased run-off in the catchment areas. Thus, the currents in the estuary are greatly influenced by fresh water discharge during the SW monsoon.

During this season the CSM shows a decreasing trend in Gautami Godavari along its course from upstream towards the confluence. At stn. C the CSM is 1200 mg/l while at estuarine mouths at stn. A it is 219 mg/l and at stn. B 40 mg/l during low tide. CSM for the month of September, 1988 at stns. A, B & C and other stations between A & C and B & C at different depths also supports the above findings (Table II). The CSM at bottom is found to be higher than that of surface at all these stations. The residual gravitational circulation with enhanced settling velocities as a result of flocculation is the main process in the longitudinal transport of fine-grained sediments in estuaries. In this theory it is thought that the dispersed fine sediment in the fresh water flocculates when it arrives in the mixing zone of the estuaries (Uncles and Jordan, 1979). The large aggregates will settle down faster to the lower part of the water column because of their high settling velocities.

Table II — Concentration of suspended matter (mg/l) over depth intervals along the Gautami Godavari estuary during September, 1988.

Depth (m)	Station Nos.							
	A	D	E	C	F	G	H	B
0	595	605	568	492	440	312	180	102
2	630	720	692	535	465	425	278	135
4	630		710	560	385			142
6	770			563	495			
8	665			612				
10	670			620				
12				585				
14				635				

The variation in the concentration of suspended matter over three seasons reveal that the suspended matter deposited or flocculated and settled as aggregates during southwest monsoon in the estuary is being reworked by the currents during northeast monsoon and carried out into the sea before they are resettled. Decrease in CSM in the estuarine waters during premonsoon at stations A & C is a result of non-availability of sufficient suspended material and inability of weaker currents to scour the bottom sediments.

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