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FLOW AND SUSPENDED SEDIMENT CHARACTERISTICS OF THE ENTRANCE CHANNEL OF COONDAPUR PORT

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ABSTRACT

Studies carried out on flow and suspended sediment characteristics of the entrance channel region of Coondapur port for a period of one year revealed that the currents in the Gangolli estuarine mouth during the south-west monsoon were influenced more by river discharge and during the remaining period of the year, the currents in the mouth were controlled by tides. Currents in the sea at 12 m depth off the estuarine mouth generally followed the pattern of coastal currents prevailing along the west coast of India. The surface currents were generally directed towards north in the north-east monsoon period and towards south in the month of September (south-west monsoon). The surface current direction was towards north in March and towards south in April and May in the sea. Suspended sediment load near bottom was maximum in September and relatively high in the estuarine mouth. Suspended sediment load together with the currents appear to contribute to the siltation in the entrance channel of Coondapur port during the south-west monsoon season.

Key-words: Flow, suspended sediment, Coondapur port.

INTRODUCTION

Estuaries are very important because of their sheltered anchorages and the navigational access they provide to a broad hinterland. The river Gangolli which is formed by several smaller streams joins the sea near Coondapur town (Fig. 1). The extensive estuary has only one outlet to the sea. The port of Coondapur is located on the northern bank of river Gangolli. Manganese and iron ore are exported from this port. There is a bar just at the entrance of the river from the sea which maintains a depth of about 2 m at low water of ordinary spring tides. This is a navigational hazard for vessels entering the port. Bigger vessels anchor in the sea beyond the bar and the cargo is transported to the port and vice-versa by lighters. Even the smaller vessels cannot enter the port during the south-west monsoon season since the entrance channel near the mouth of the estuary is closed during this period due to increased siltation in that region. At present there is a proposal to develop this port as a better intermediate port. Since no information on aspects relating to currents and siltation in the entrance channel area of Coondapur port is available, a detailed study was undertaken on the flow and suspended sediment characteristics of the region. The results would help to understand the process of siltation in the entrance channel.

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MATERIAL AND METHODS

Currents were measured every month both at the surface (0.5 m below the surface) and near the bottom (0.5 m above the bottom) at two stations (C_1 in the estuarine mouth and C_2 in the sea, Fig.1) covering a tidal cycle from January to December, 1988 except during June-August, using a current meter (Environmental Engineers) from the boat, M.F.V. *Dolphin*. Simultaneously, bottom water samples were collected with a Nansen Reversing Water Bottle. For the estimation of suspended sediment load these water samples were filtered using Whatman No. 42 filter paper (pore-size : 1.1/μ). The tide at Coondapur was interpolated using the predicted tide data for Mangalore and Karwar ports. The wind speed and direction at Coondapur were interpolated using the wind data for Mangalore and Honavar.

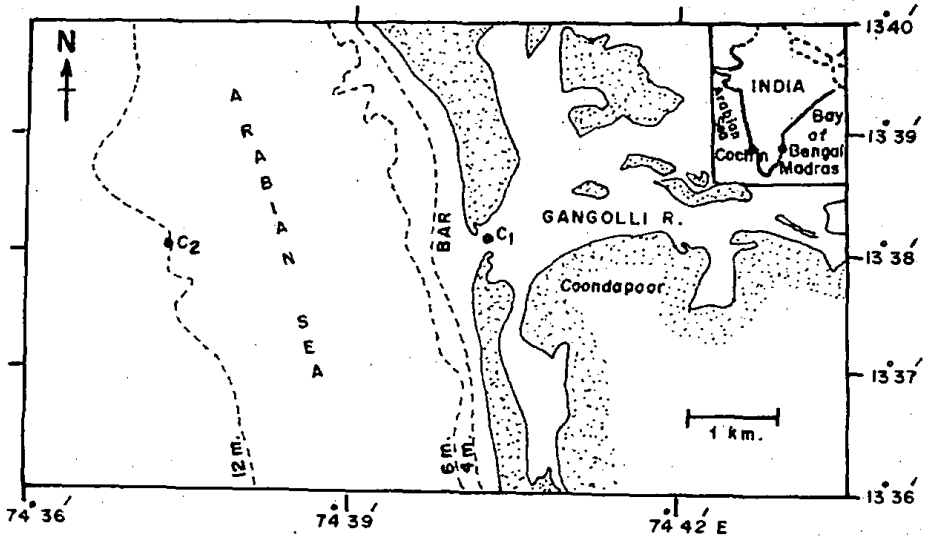

Fig. 1. Map showing the location of stations C_1 & C_2

RESULTS AND DISCUSSION

The Coondapur port entrance channel area is characterised by a mixed type of predominantly semi-diurnal tide. According to the Indian Meteorological department (1984), the year is divided into four seasons for this region of study i.e., premonsoon season (March to May), sowth-west monsoon season (June to September), post-monsoon (October to November) and north-east monsoon season (December to February). The winds at Coondapur are strong with directions between south-west and west during the south-west monsoon period. During the rest of the year winds are mainly from north and east in the forenoons and westerly or north-westerly in the afternoons (*Table I*).

Table I – Mean Wind Speed (Kph) and predominent wind direction for Coondapur.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
	6.8	7.0	6.8	7.1	7.9	8.0	8.3	8.0	7.6	5.8	5.8	6.6
M	N	E	E	E	E	W	W	W	W	E	E	N
E	NW	NW	NW	NW	NW	SW	SW	SW	SW	W	NW	NW

M – morning, E – evening

Currents: The variation in currents and suspended sediment load in the estuarine mouth and in the sea during a 12 hr tidal cycle for different months are shown in Figs. 2-4. In the north-east monsoon period of 1988, the maximum current speeds at surface and bottom were noticed in February and the minimum in January during both flood and ebb tide flows at station C_1 (Table II). At station C_2, the maximum surface and bottom current speeds were in December and the minimum in February (Table III). Surface currents in the sea were directed, generally, towards north during this season. Maximum, minimum and average current speeds during flood tide were, comparatively, more than that during ebb tide both for surface and bottom waters in the estuarine mouth. Maximum and minimum current speeds were higher at the bottom than that at the surface in the sea.

During the pre-monsoon season, the highest and lowest current speeds at surface and bottom were observed in April during flood tide flow at station C_1. During the ebb tide, the maximum current speeds at surface and bottom were in May and the minimum, in April to May at surface and in March at bottom. At station C_2 the highest surface and bottom current speeds were in May and April respectively. The maximum minimum and average values of surface, current speeds were higher during flood tide than during the ebb tide while it was vice-versa in the case of bottom waters. Bottom currents were stronger than the surface currents in the sea during this season. In September (south-west monsoon) the maximum and minimum and average values of current speeds during flood tide flow were much lower than in the ebb tide flow in the estuarine mouth. At station C_2, the values of surface current speeds were almost the same as the values of bottom current speeds. The surface and bottom currents in the sea were directed towards south at this time. During the post-monsoon period, the surface and bottom current speeds were highest in November and lowest in October during flood tide and ebb tides. The maximum, minimum and average values of current speeds at surface and bottom were comparatively higher in the ebb tide flow in the estuarine mouth in this season. Surface currents were stronger than the bottom currents in this season both in the estuarine mouth and in the sea. The surface and bottom currents in the sea were generally directed towards south in October and towards north in November.

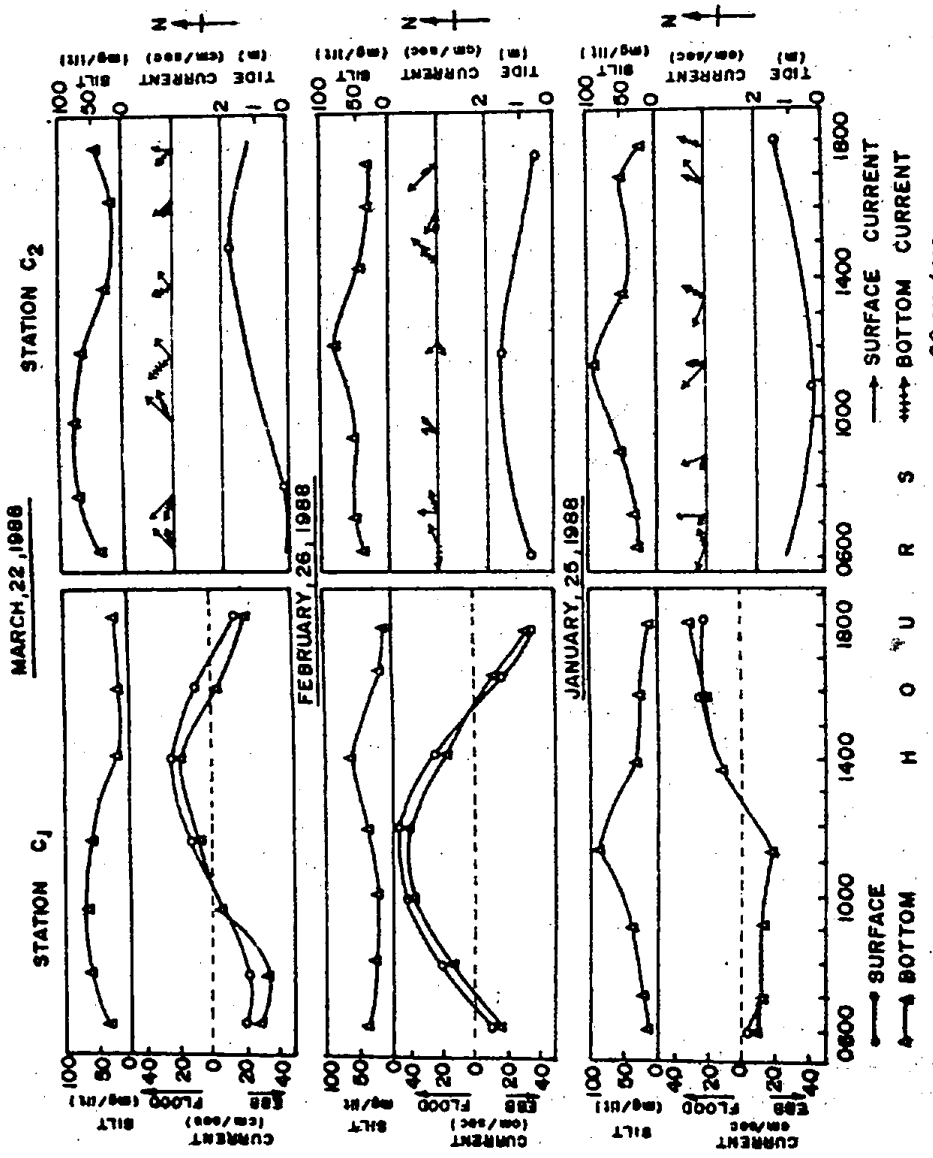

Fig. 2. Variation of current and suspended sediment load with tide at station C1 & C2 during January - March 1988.

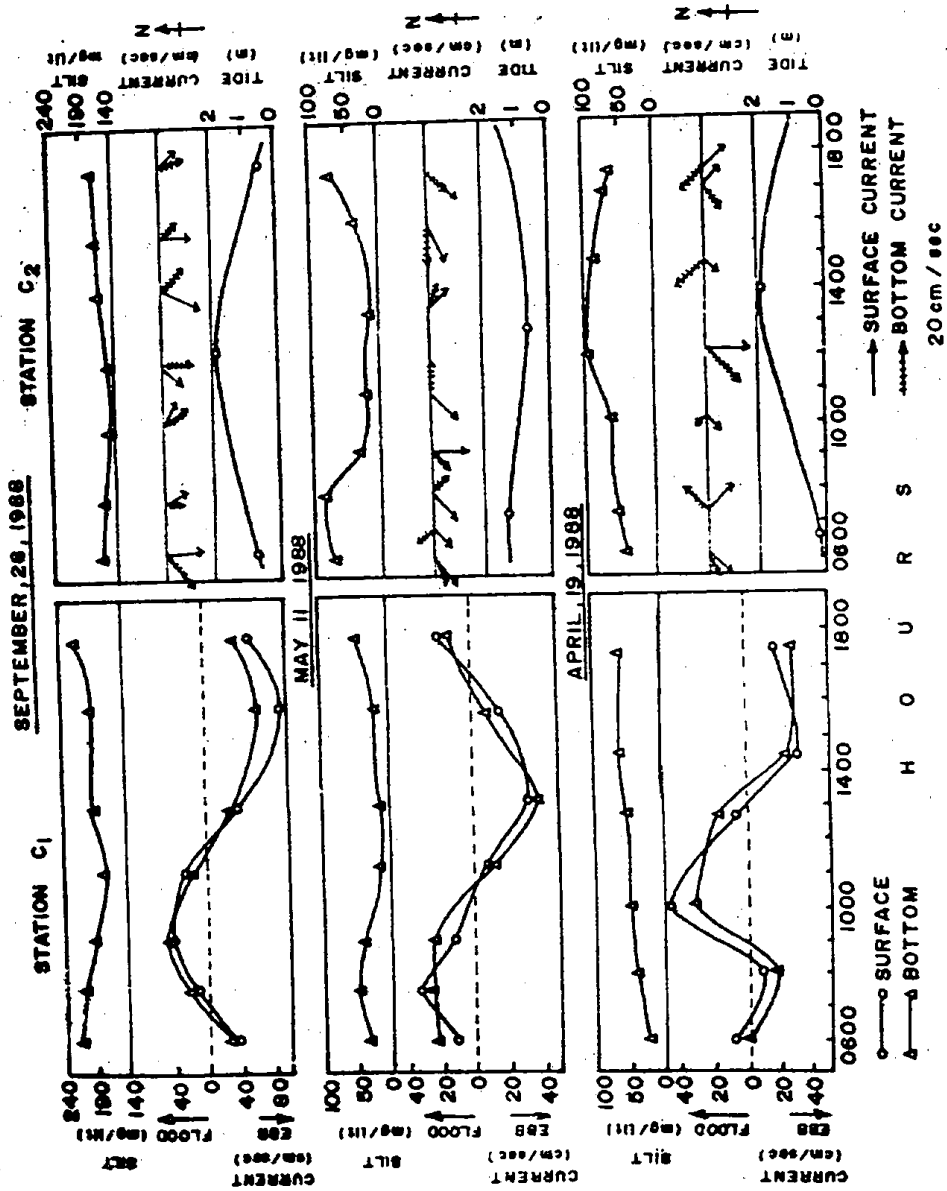

Fig. 3. Variation of current and suspended sediment load with tide at station C1 & C2 during April , May and September 1988.

Suspended sediment load : Wide fluctuations were observed in the values of suspended sediment load near bottom at stations C_1 and C_2 (Figs.2-4 and Tables II and III). During the north-east monsoon period, the bottom water suspended sediment load ranged from 10 to 86 mg/1 in the estuarine mouth (station C_1), while in the sea (station C_2), it varied from 15 to 92 mg/1. During the pre-monsoon season, the sediment load was lowest during the year for both the stations and the range was less at station C_1 (46 mg/1) than at station C_2 (73 mg/1). During September (south-west monsoon) the sediment load at both the stations was maximum and ranged from 173 to 215 mg/1 for station C_1 and from 149 to 170 mg/1 for station C_2. In this month, it was more during ebb tide compared to that of flood tide in the estuarine mouth. During the post-monsoon period, the values decreased comparatively but remained some what higher.

The circulation of water within an estuary is governed by strong tidal oscillations on which residual water circulations are superimposed. These residual circulations may be generated by non-linear interactions between the tidal flow and estuarine topography, density gradients, wind stress and the mass input due to freshwater discharge into the estuary (Uncles and Jordan, 1979). In the Gangolli estuarine mouth, the current variations during the north-east monsoon, pre-monsoon and post-monsoon months generally showed close relation with the tidal conditions (Figs. 2-4). The dominance of flood current speeds over ebb current speeds both for surface and bottom was observed during these three seasons (Tables II and III). The increased speed of currents during the south-west monsoon month of September in the estuarine mouth during ebb tide was due to the increased run-off from south-west monsoon rainfall. Thus, the currents in the estuarine mouth were greatly influenced by fresh-water discharge during the south-west monsoon period.

The currents in the sea are usually caused by wind stress on the surface of the sea as well as by density differences. In addition, tidal forces influence the currents very near to the coast. In the present study, the current variations in the sea off Coondapur at 12m depth were not dominated by tides as can be noticed from Figs. 2-4. Earlier investigations in the nearshore waters off Mangalore on the South Kanara coast had revealed that the influence of tides on currents was significant till 9 m depth and beyond that it was negligible (Gouveia and Varadachari, 1979). The surface currents in the sea off Coondapur were found to be directed generally towards north during January to March and November to December, and towards south in April, May, September and October. The changes in the wind direction from one season to the other near Coondapur can be noticed clearly from Table I.

During September, the surface current was directed generally towards south in the sea off Coondapur. Complete reversal of the current direction along the west coast of India is expected to take place by April, much ahead of the wind reversal and as expected the currents were directed towards south in April and May in the sea off

Table II – Currents and suspended sediment load during 1988 at Station C_1

Season	Currents (cm/sec)							Suspended sediment load (mg/l) Bottom water	
		Surface			Bottom				
	Tidal flow direction	Max speed	Min speed	Av speed	Max speed	Min speed	Av speed	Max	Min
NE monsoon	Flood	45	10	28	39	10	25		
	Ebb	38	5	22	37	7	22	86	10
Premonsoon	Flood	48	7	28	31	2	17		
	Ebb	32	8	20	37	4	21	62	16
SW monsoon	Flood	42	19	31	48	21	35		
	Ebb	85	35	60	62	29	46	215	173
Postmonsoon	Flood	63	9	36	45	6	26		
	Ebb	41	6	24	32	12	22	178	54

Table III – Currents and suspended sediment load during 1988 at Station C_2

Season	Currents								Suspended sediment load (mg/l) Bottom water	
	Surface				Bottom					
	Max Speed	Direction	Min Speed	Direction	Max Speed	Direction	Min Speed	Direction	Max	Min
NE monsoon	28	NNE	5	NW	34	ENE	7	ENE	92	15
Premonsoon	27	WSW	9	NE	30	SW	7	NW	85	12
SW monsoon	24	SSW	14	SSE	24	SW	12	S	170	149
Postmonsoon	54	ENE	10	S	28	S	12	ESE	138	26

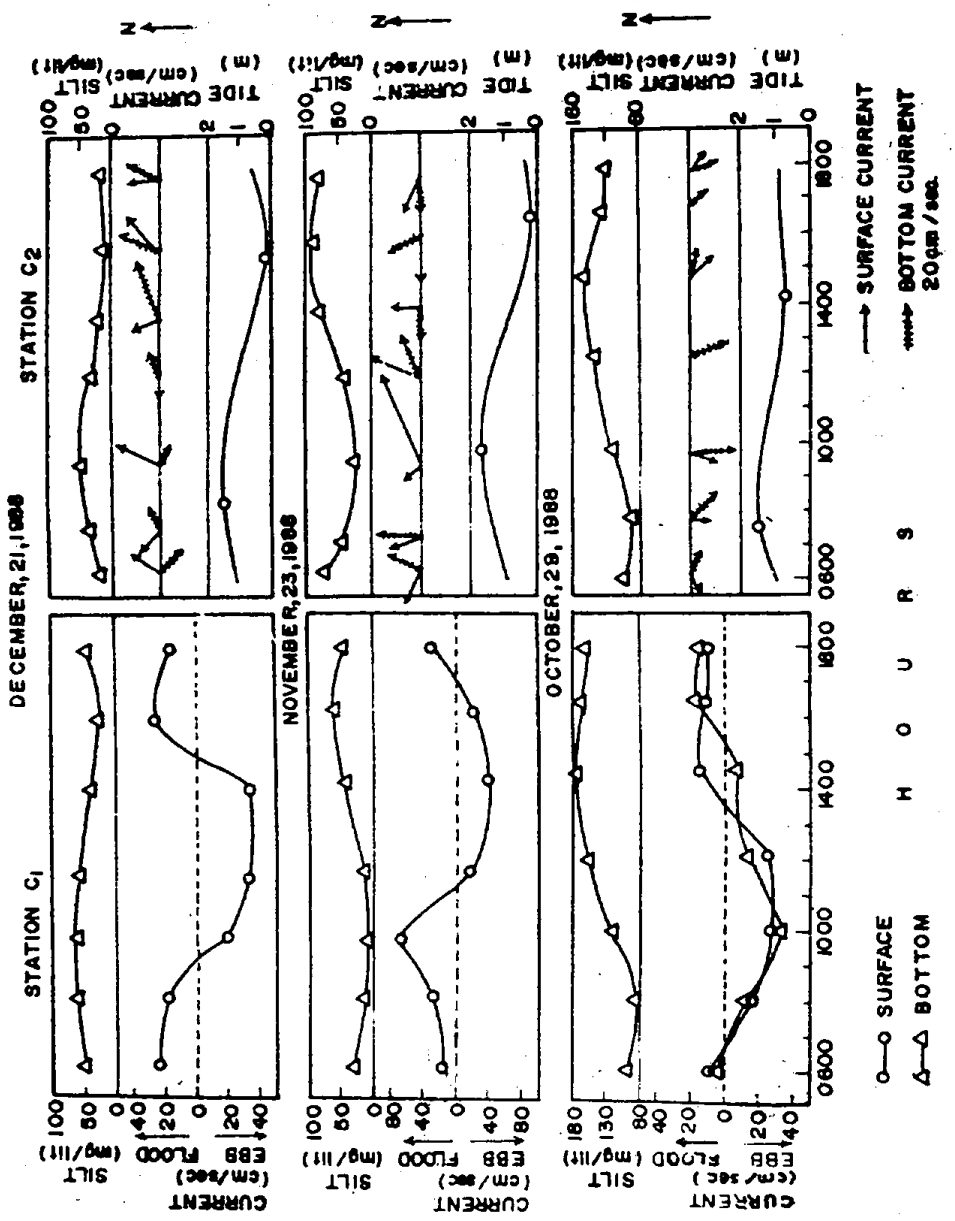

Fig. 4. Variation of current and suspended sediment load with tide at station C1 & C2 during October – December, 1988.

Coondapur. The winds during September were mainly south- westerly and westerly. During March, when the north-east monsoon was weakening and during November when the north-east monsoon was about to be established, the currents were generally towards north. October was a transition period between the two monsoons from the point of view of wind direction but the surface current continued to be directed towards south in the sea off Coondapur. The bottom current directions in the sea, generally, followed the pattern of surface current directions in the respective months eventhough there were slight variations between the two during certain times possibly be due to the shallow depth of the observation station in the sea in the present investigation.

Sediments are moved into an estuary and from there out into the sea as suspended load or bed load. Suspended load may move about as fast as the mean flow velocity whereas bed load movement occurs at a slower rate. Under turbulent flow, suspended particles are not necessarily maintained by suspension because there may be continuous exchange between the suspension and the bed (Dyer, 1972). Eventhough the relative importance of bed load transport to suspended load is not well established, suspended load is usually the prominent feature in most of the estuaries (Officer, 1981). The bottom water suspended sediment load in the estuarine mouth near Coondapur varied considerably with the state of tides and seasons. Maximum load of suspended material occurred during September and decreased during the post- monsoon season. Suspended sediment load near bottom was low during the pre-monsoon and north-east monsoon seasons. The tides in this area play an important role in the transportation of sediments in the entrance channel of Coondapur port particularly during north-east monsoon and pre-monsoon seasons. The transport of suspended load may be by processes generally known as advection and diffusion (Wright, Thom and Higgins, 1980). In the advective transport, there is a net horizontal movement of suspended material. In the diffusive transport, sediment is transported from a zone of higher concentration to one of lower concentration. Turbulence caused by waves and tides is mainly responsible for diffusive transport. In the entrance channel of Coondapur port, turbulence caused by strong ebb currents and wind waves during the south-west monsoon season seems to be responsible for the transport of large volume of suspended sediment load. The suspended sediment load near the bottom in the sea was noticed to be lower than that in the estuarine mouth during the south-west monsoon and post-monsoon seasons whereas it was reverse in the north-east monsoon and pre-monsoon seasons. The relatively higher values of suspended sediment load in the estuarine mouth during the south-west monsoon and post- monsoon seasons were due to the large quantities of sediments entering the estuary during the south-west monsoon season. During this time the waters were highly turbid with the influx of silt- laden land drainage. The higher values of suspended sediment load in the sea as compared to that in estuary during the north-east monsoon and pre-monsoon seasons were due to the turbulence and stirring at the bottom caused by increased wave action in the sea and also due to the decrease in

sediments entering the Gangolli estuary during these periods. The freshwater flow into the estuary was minimum during this period.

As can be noticed from the present study, current speeds both at the surface and near bottom were maximum in the Gangolli estuarine mouth during the south-west monsoon month of September in the ebb tide period. In the same month, suspended sediment load near bottom was highest. Such high values of ebb currents and suspended material were observed during the south-west monsoon season in the Cochin estuary by Gopinathan and Qasim (1971) and in the Netravati-Gurpur estuarine mouth by Reddy, Hariharan and Kurian (1979). In the Coondapur port entrance channel, density gradient between freshwater and saltwater could develop in the south-west monsoon season resulting in very distinctive patterns of circulation. During the south-west monsoon period, large quantities of suspended sediment brought by the Gangolli river system could fluctuate as it enters the sea resulting in siltation in the entrance channel of Coondapur port.

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