

SHIFTING SEDIMENT CONCENTRATION AND SEDIMENTATION ZONES IN BANGANGA ESTUARY, ON THE ARABIAN SEA COAST (INDIA)

SHRIKANT KARLEKAR And UMESH KESKAR, Pune

ABSTRACT : The Konkan estuaries are complex water systems due to seasonally changing sediment input and changing hydrodynamics. A more complicated issue in the sedimentation of these estuaries is the shifting of sediment concentration zones alongwith tidal incursion and excursion, as well as river water input. This paper tries to identify the nature and pattern of shifting sediment concentration zones in Banganga estuary located in Thane district of Maharashtra.

INTRODUCTION

The estuaries are the semienclosed coastal inlets. Their free connection with the open sea and tidal penetration through the mouth of the inlet is their peculiar characteristic.

The river water discharge, the tidal incursion, progression and excursion, are the main hydrodynamic factors that govern the sedimentation in estuaries. An extensive literature exists on hydrodynamics and sedimentation of estuaries of the world {(Defant 1958, Struaten (1964), Lauff (1968), Hails J. Carr A (1975), Klein G.D.V. (1976), Fischer (1979), Kennedy (1982), McCave (1982), Green Wood (1984), and Leussen W.V. (1988)}. Although it is so, the study of estuarine sedimentation is extremely complicated. The fluvial and marine regimes influence the transportation, erosion and deposition in estuaries, which add to the complexity of the situation.

The study of estuarine sedimentation has gathered momentum since last decade or so. Many of the world estuaries are silting up due to heavy sediment supply. The metallic, non

metallic and biological flocculation is at increase due to the input of large quantum of Chemical pollutants in these inlets. Sedimentation is at rise and dredging of the estuarine tidal channels has become an urgent necessity.

The estuaries of the west coast of India, although small, narrow and elongated inlets along the littoral are quite significant as regards their hydrodynamics and sedimentation. Not much work has been done on these saline water ecosystems. There are, of course, a few local studies devoted to morphology of Konkan inlets (Belgalli (1990), Karlekar (1985, 1993) but there is not a single comprehensive study which considers hydrological basis of sedimentation. A detailed study of a few Konkan estuaries was carried out by the authors and the hydrological and sedimentological aspects of these estuaries ranging from micro to macro tidal environments were discussed (Karlekar 1993). The study, however, is in no way a complete analysis of Konkan estuaries and it is necessary that it is supplemented by many more such studies along the said coast.

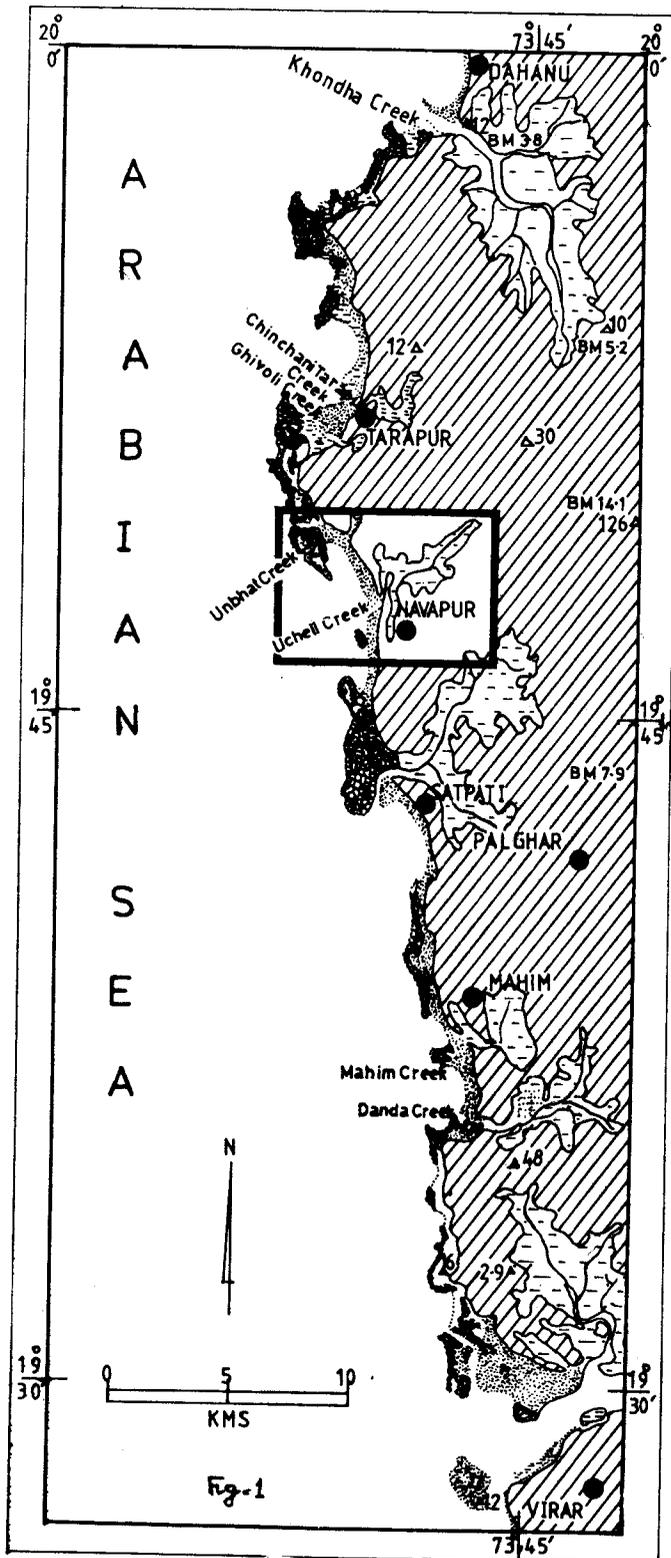


Fig-1

A more complicated issue in the sedimentation of Konkan estuaries is the seasonal shift in the areas of sediment deposition within the inlet. The zone of maximum sedimentation deposition keeps shifting seasonally. The tidal range, the ebb tide delay, length of the estuary, the overall shoreline configuration and the supply of freshwater through the river appear to be most decisive factors in the sediment concentration and settling in Konkan estuaries.

It is essential that the trends in the sedimentation of a specific estuary are known and the areas of maximum sedimentation are identified.

This paper tries to recognise such trends and zones of maximum sediment concentration in Banganga estuary. A distinct shift in the area of maximum sediment concentration is identified and discussed in the following pages.

THE FIELD SITE

The site of investigation is the tidal mouth of the river Banganga in Thane district of Maharashtra. (Fig. 1). It is popularly known as Ucheli Creek (19° 48' N and 73° 43' E). It is an important estuary in Palghar Taluka and the rapidly decreasing fish catch due to release of nearby Tarapur industrial wastes in the inlet has been a matter of great concern in last few years. The area is also affected by beach erosion and transgression of sea (Daily Maharashtra Times,

Bombay). The estuarine channel is 5.9 km. long. The average daily tidal range is 3.9 m. The tidal discharge through the estuary in fair weather season is estimated to be about 3659.2 m³/sec. Ebb tide delay period in the estuary was observed to be 1 hour and 40 minutes in pre monsoon period. There is a large input of chemical effluents in the estuary from the nearby industrial units. A macrotidal range is responsible for more availability of salt water. The salt water and fresh water ratio keeps on changing according to seasons.

The estuarine channel is 1.3 m deep at ebb and 2.2 m deep at flood tide.

DATA ACQUISITION AND METHOD OF STUDY

The field site was visited in pre monsoon, monsoon and post monsoon season of three successive years from 1990 to 1992. In addition to the geomorphic mapping of sedimentary features in and around the estuary, surface water samples were collected in each season from 30 different places at flood tide as well as ebb tide. The tidal circulation pattern was studied by releasing a tracer dye 'Rhodamine B'. The velocity of tidal current was measured simultaneously near mouth, in mid estuary and near the head of the estuary. The quantity of suspended sediment in one litre water sample collected from various places was determined by simple filtration technique. The water analysis was carried out to obtain the electrical conductivity and salinity of the water. All the aspects of estuarine geomorphology were studied. However, only the areas of maximum sediment concentration and their seasonal shift is discussed in this paper.

DEPOSITIONAL BEHAVIOUR OF PARTICULATE MATTER

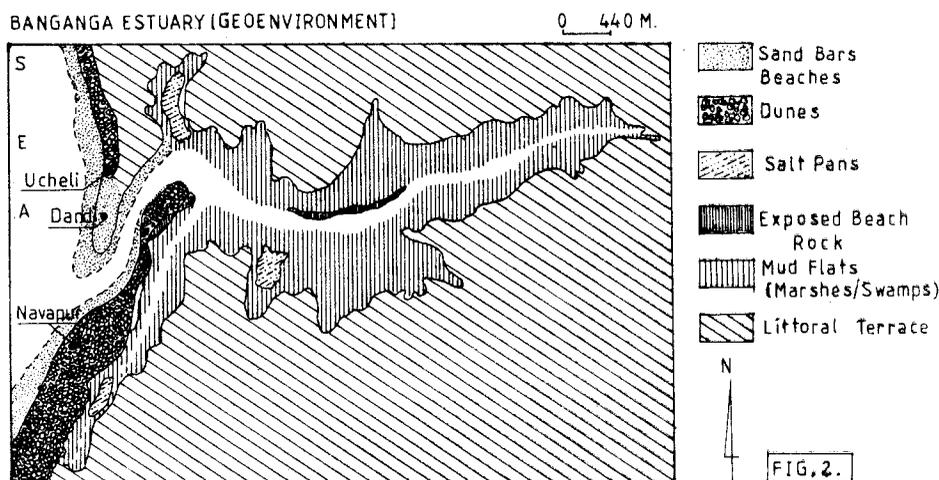
In any estuary, there exist numerous possibilities for transport and settling of suspended

matter. Basically it is governed by varying conditions of salinity. The salinity shows an increasing trend towards head in pre and post monsoon. These are the seasons in which Konkan estuaries are characterised by distinct salinity front 3 to 4 kms from the entrance of the estuary. There is a total reversal of these salinities in monsoon due to fresh water flow. The material in suspension is largely derived from estuarine margins. The ebbing tide brings all the material in lower estuary zone. The flooding induces ponding. More flooding redistributes the material throughout the cross sectional area of the estuary. This ebb and flow creates complex patterns of suspended sediment concentration. Moreover, the fine sediments show a tendency to form colloids due to coagulation and subsequent disaggregation of flocculated material.

Such a complex phenomenon is normally studied by determining the amount of suspended matter in surface water samples at flow and ebb (Evans et al 1975). The difference between flood tide suspended sediment and ebb tide suspended sediment at a number of fixed places in estuary is calculated. The rate of sedimentation can also be determined by using McCave's formula (McCave 1982) ($RC = C_{bw} \times 10^{-3} \text{ mg/cm/sec}$; where R_c is rate of sedimentation C_b is the concentration of suspended sediment of settling velocity w/cm).

The techniques used are not totally error free as the distribution of suspended sediment is a function of hydraulic sorting, flow intensity, and size, shape and density of matter. Nevertheless it helps in giving a better idea of zones of sediment concentration, which are otherwise not very easy to locate.

The composite map of geomorphic and sedimentary features of the field site (Fig. 2) shows extensive mud flats developed all over the inlet. A very narrow flood tide channel is



maintained in the estuary which is joined by many ebb tide channels from the mud flats. The flood velocity near mouth is 46.4 cm. sec. which increases to 46.8 near head. Ebb velocity near head is still higher, i.e. 47.5 cm/sec. Near mouth ebb velocity is 46.2 cm/sec. There is no progressive increase or decrease in flood and ebb velocity. Velocity of tidal currents shows within inlet variations due to clockwise flood circulation and anticlockwise ebb circulation pattern. The sand bars, the beaches and dunes bordering the littoral are the main sources of sediments in addition to estuarine margins, channel banks and intertidal flats. There is thus a heavy input of sediments in Banganga estuary. Most of it remains in estuary until it is finally deposited and a very insignificant proportion probably.

SEDIMENT DEPOSITION IN PRE-MONSOON

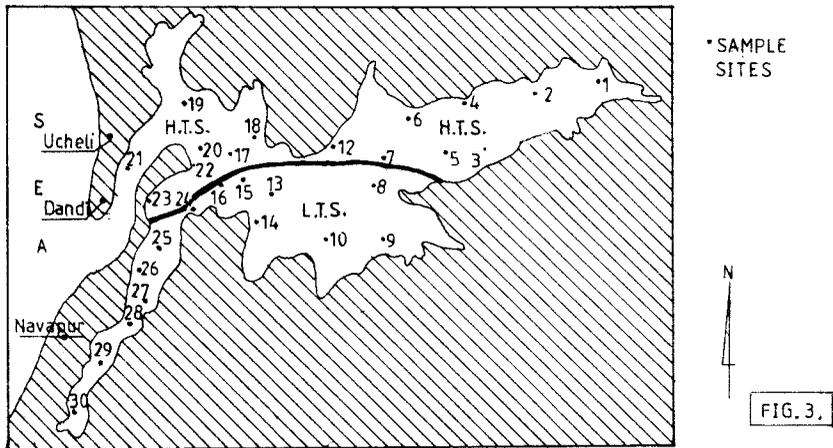
The difference between flood tide suspended sediment material SSM and ebb tide SSM at 30 sampling sites was plotted and a line of no difference was drawn to separate the zone of high tide and low tide sediment concentration (Fig. 3). It is very interesting to see that the

zone of low tide sedimentation is the southern part of the inlet. The northern part is exclusively an area of high tide sedimentation. The ponding effect is more pronounced in the northern part of the inlet at high tide in pre monsoon, since there is not much fresh supply from the land. It can be seen from Fig. 2 that flood and ebb tide velocities do not differ much in this part of the estuary. Tidal water remains more or less stagnant. The low tide flows in upper parts have a drag and water shows ponding in southern part where considerable amount of SSM is brought by ebb tides from the upper part of the estuary. It was checked in the field by repetitive sampling and confirmed that the ebb tide SSM is always more in the southern part than in northern part of the inlet in pre monsoon season.

SEDIMENT DEPOSITION IN POST-MONSOON

Immediately after the monsoon, when there is still some fresh water input to the estuary, pattern of SSM concentration is different. It was seen that the ebb tide SSM concentration is more all along the central scoured channel. Rest of the inlet area is a scene of high tide

BANGANGA ESTUARY (PRE MONSOON SEDIMENTATION)

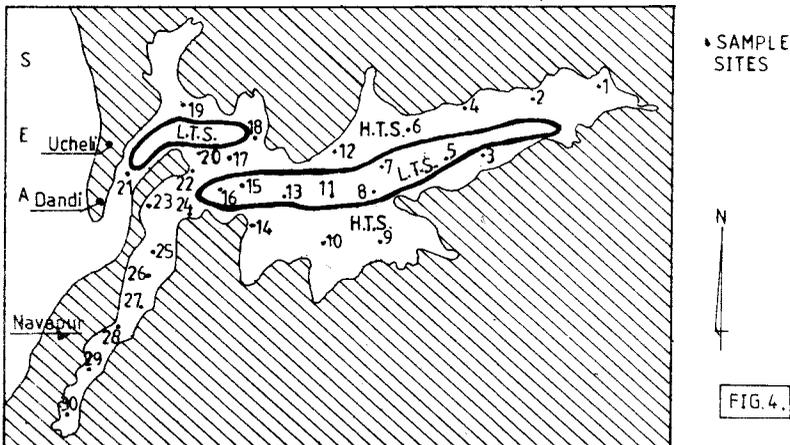


sediments. The elongated ridge of ebb tide sediments over the tidal channel is a clear indication of concentrated ebb flow supplemented by residual river line flow through the channel. At high tide due to strong tidal incursion, the movement of fresh water flow is arrested, leading to the distribution of sediments all over the estuary. (Fig. 4).

SEDIMENT DEPOSITION IN MONSOON

No distinct trend could be identified in the ebb and flood tide distribution of SSM in monsoon. This was mainly due to the mixing of tidal waves and river flow in the inlet. The areas of flood and ebb tide maximum SSM concentration in monsoon are very unstable and quickly merge into one other.

BANGANGA ESTUARY (POST MONSOON SEDIMENTATION)



H.T.S. = HIGH TIDE SEDIMENTATION
L.T.S. = LOW TIDE SEDIMENTATION

CONCLUSION

It is concluded from the above discussion that the pattern of SSM concentration and therefore the sedimentation keeps changing with the stage of tide and the season. In a full tidal cycle of 12 hours duration, there is a total change in the estuary as regards the sedimen-

tation. However throughout a season a specific pattern seems repeating with tidal stage with minor variations. Monsoon is a season of disturbed conditions of sedimentation due to mixing. Immediately after monsoon, the scoured tidal channel dictates the pattern of sedimentation whereas in pre monsoon the tidal incursion alone determines the sedimentation.

Table 1

AVERAGE SUSPENDED SEDIMENT CONCENTRATION FOR 3 YEARS (BET. 1990 AND 1992) IN PPM

Post Monsoon		Sample Site	Pre Monsoon	
Flood	Ebb		Flood	Ebb
396	39	71	410	394
405	409	5	413	260
419	423	7	380	550
430	421	10	359	750
433	487	11	347	1037
442	567	15	280	1369
445	277	17	5000	1487
403	103	26	321	330
366	82	29	100	267

Table 2

SEDIMENTATION RATE (G/LITRE) FOR 6 HRS OF FLOOD AND EBB

Post Monsoon		Sample Site	Pre Monsoon	
Flood	Ebb		Flood	Ebb
29.21	30.01	1	31	29.79
29.79	30.92	3	24.95	19.66
29.18	31.98	4	26.46	41.58
30.62	31.83	5	31.22	56.70
31.68	32.21	7	28.73	10.81
32.51	36.82	10	49.82	78.40
32.74	42.87	11	26.23	103.50
33.34	34.78	14	41.58	119.30

Table 2 (contd.)

Post Monsoon		Sample Site	Pre Monsoon	
Flood	Ebb		Flood	Ebb
33.42	20.94	15	2.12	112.42
33.64	35.38	17	378	7.94
33.19	22.23	18	226.8	60.78
32.13	17.01	24	34.25	49.75
30.47	99.94	26	24.27	39.16
27.68	7.79	29	7.56	25
26.91	6.20	30	11.49	29.19

Slightly similar kind of pattern in sedimentation has been identified by Buller A.T. *et al* (1975) for Tay estuary. They have observed that during periods of moderate river discharge and relatively quite marine conditions the fluvial suspended sediments entering the

estuary are low. Most of the material in estuary is derived from estuary margins. At flood tide the intertidal flats are covered by a shallow body of water. At ebb, the water highly charged with SSM drains laterally. Some water is ponded by tidal flooding from sea.

REFERENCES

- Abraham G. (1988). Turbulence and mixing in stratified tidal flows. *Physical processes in estuaries*, ed. Leussen W. V. Springer Verlag, London.
- Allersma E. (1976). Holocene tidal sedimentation. ed. Kellin G.D.V. *Benchmark papers in Geol.* Vol. 30, Hutchinson ross, Pennsylvania.
- Allersma E. (1982). Mud in estuaries and along coast. *Chinese Society of hydraulic engineering*, China, Publ. 270.
- Belgalli R. (1990). Sedimentary environments of Dudh river estuary. Palghar. *Unpub. M. Phil. dissertation*, University of Poona.
- Buller A.T., Green C.D., Memanus J. (1975). Dynamics and Sedimentation, the Bay in comparison with other estuaries. *Nearshore sediment dynamics and sedimentation*, ed. Hails and Carr, John Wiley, London.
- Defant A. (1958). *Ebb and flow*, University of Michigan, Canada.
- Evans G. and Collins M.B. (1975). The transportation and deposition of suspended sediment over the intertidal flats of Wash. *Nearshore dynamics and sedimentation* ed. Hails and Carr, John Wiley, London.
- Fischer H.B., List J.E., Koh R.C.R., Imberger J., Brooks N.H. (1979). *Mixing in inland and coastal waters*, Academic Press, New York.
- Ginsburg R.G. (1976). Tidal deposits. *A case book of recent examples and fossil counterparts*, Springer Verlag, New York.
- Greenwood B., Davis R.A. (1984). Hydrodynamics and sedimentation in wave dominated coastal environments. *Dev. in sedimentology* Vol. 39, Elsevier, Oxford.
- Hails J. and Carr A. (1975). *Nearshore sediment dynamics and sedimentation*. John Wiley and Sons, London.
- Hockstra P., Augustinus P.G., Terwindt J.H.J. (1988). River outflow and mud deposition in a monsoon dominated coastal environment. *Physical processes in estuaries* ed. Leussen W.V. Springer Verlag, London.

- Karlekar S.N. (1985). The tidal landforms of Uran Alibag Murud coast of Maharashtra. *Trans. Inst. Ind. Geog.* Vol. 7, No. 2 January 1985. University of Poona.
- Karlekar, S.N. (1993). *Coastal Geomorphology of Konkan*, Aparna Publications, Pune.
- Karlekar S. N. (1993). Konkan estuaries their hydrodynamics and sedimentation. *A lecture note*, Geological Society of India, Bangalore.
- Leussen W.V. (1988). *Physical processes in estuaries*. Springer Verlag, London.
- Lauft G.H. (1968). *Estuaries*, Am. Ass. Adv. of Sciences, Washington.
- Maharashtra Times* (daily) (22nd May 1991).
- Mc Cave I.N. (1982). Deposition of fine grained suspended sediments from tidal currents. Erosion and sediment yield. *Bench mark papers in Geol.* Vol. 63. Hutchinson Ross, Pennsylvania.
- Mohr A.W. (1982). Sediment control through dredging. *Estuaries Comparisons* ed. V. S. Kennedy Academic Press, New York.
- Kennedy V.S. (1982). *Estuaries Comparisons*. Academic Press, New York.
- Struaten L.M. J.U. (1964). Deltaic and shallow marine deposits. *Dev. in Sed.* Vol. 1. Elsevier Publishing, Amsterdam.

ADDRESS OF THE AUTHORS

1. Dr Shrikant Karlekar

Department of Geography,

S.P.College,

Pune - 411030

2. Umesh Keskar (Former Lecturer)

Evaluation Officer,

CASP Plan Project,

Pune - 411005