CHAPTER 76

GEOMORPHOLOGICAL STUDIES OF THE ESTUARY OF RIVER NETRAVATI NEAR MANGALORE

E. J. John[1] and K. P. Cheryan[2]

ABSTRACT

A number of factors such as wave conditions, tides, river flows, sediment charge, and ocean currents affect the features of an estuary. The understanding of the morphology of an estuary is essential on purely scientific considerations as well as applied to harbours. An attempt is made to study these inter-related and unsteady features and their combined effect on an estuary qualitatively. The estuary selected for the study is the one near Mangalore on the West Coast of India at latitude 12° 51' north and longitude 74° 50' east, where two rivers, viz., river Netravati and river Gurpur meet together and join the sea. An effort is made to analyse the changes in the estuary in terms of prevailing wave conditions, river flows and sediment transport.

INTRODUCTION

The understanding of the behaviour of an estuary is essential on purely scientific considerations as well as applied to harbours. A number of factors are varying seasonally and year after year, which affect the condition of the estuary, and hence haphazard observations will not yield any accurate results. As a preliminary to comprehensive study of river estuary problems, it is desirable to investigate in a general manner the behaviour of a selected estuary, viz., the estuary of river Netravati and river Gurpur. During the monsoon period these rivers carry large quantity of discharge with good percentage of sediments. Ocean currents and waves are also predominant during this season. Most of the changes in an estuary occur during this period. Changes during the rest of the year are quite

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[1]Assistant Professor, Department of Applied Mechanics and Hydraulics, Karnataka Regional Engineering College, Suratkal, India.

[2]Assistant Engineer, Neendakara Port, Quilon, India. Formerly post-graduate student at Karnataka Regional Engineering College, Suratkal, India.

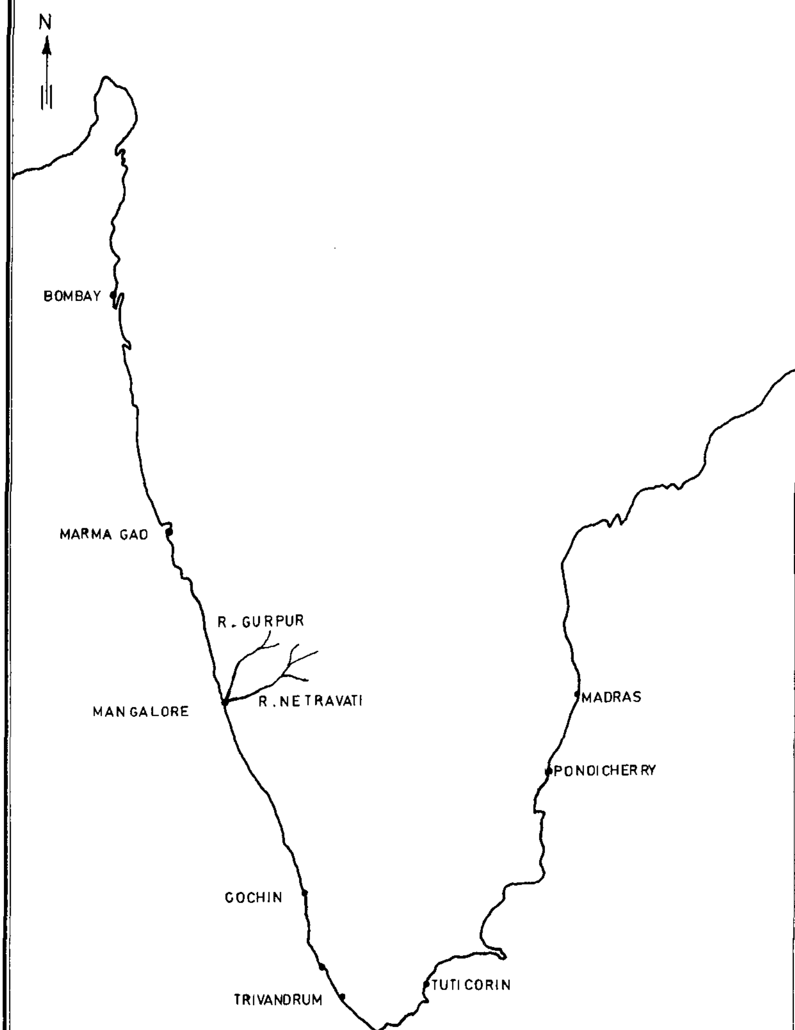

FIGURE.1. MAP OF SOUTH INDIA SHOWING THE AREA OF STUDY.

insignificant. Hence in this study it is proposed to examine the general morphology of the estuary prior to and after a monsoon period. An effort is made to analyse the changes in the estuary in terms of prevailing wave conditions, river flows and sediment transport.

The estuary selected for the study is the estuary near Mangalore at 12° 51' north and longitude 74° 50' east, where two rivers, viz., river Netravati and river Gurpur meet and join the sea together. The river Netravati is having a catchment area of 3160 sq. km. and a maximum discharge of 8170 m^3/s. and the river Gurpur is having a catchment area of 665 sq. km. and a maximum discharge of 1140 m^3/s. A map of South India showing the location of the area of study is given in Fig. 1 and a detailed map of the estuary is given in Fig. 2.

FIELD STUDY

Some informations about the morphology of the estuary can be obtained by studying the maps covering the area under investigation. Since these maps are generally updated from time to time any change in the morphology must be seen in these maps. In the present case, three maps (i) Geodetic traverse survey map prepared in 1904 (ii) Hydrological survey map of Mangalore Port prepared by Capt. G. P. Ranson in 1949 and (iii) a map prepared in connection with Mangalore Port investigations in 1953 were available for detailed study. Since the latest map referred only to 1953, it was found necessary to prepare a fresh map of the area showing relevent changes. This map of the area was prepared with reference to three important land marks, which were all shown in the earlier maps. Contour maps of the area within the estuary, near the river mouth and outside the mouth into the sea were also prepared before and after monsoon period, by taking soundings from a country boat. The position of the boat was fixed by two theodolotes kept on either bank. Sediment samples were collected from the sea bottom, near the mouth of the river and inside the estuary.

River discharges were determined by establishing river gauges in the two rivers beyond the tidal zone.

Tide records from the tide gauge set up within the estuary were collected and studied. The mixed type of tide occurs at Mangalore. Mixed tides are

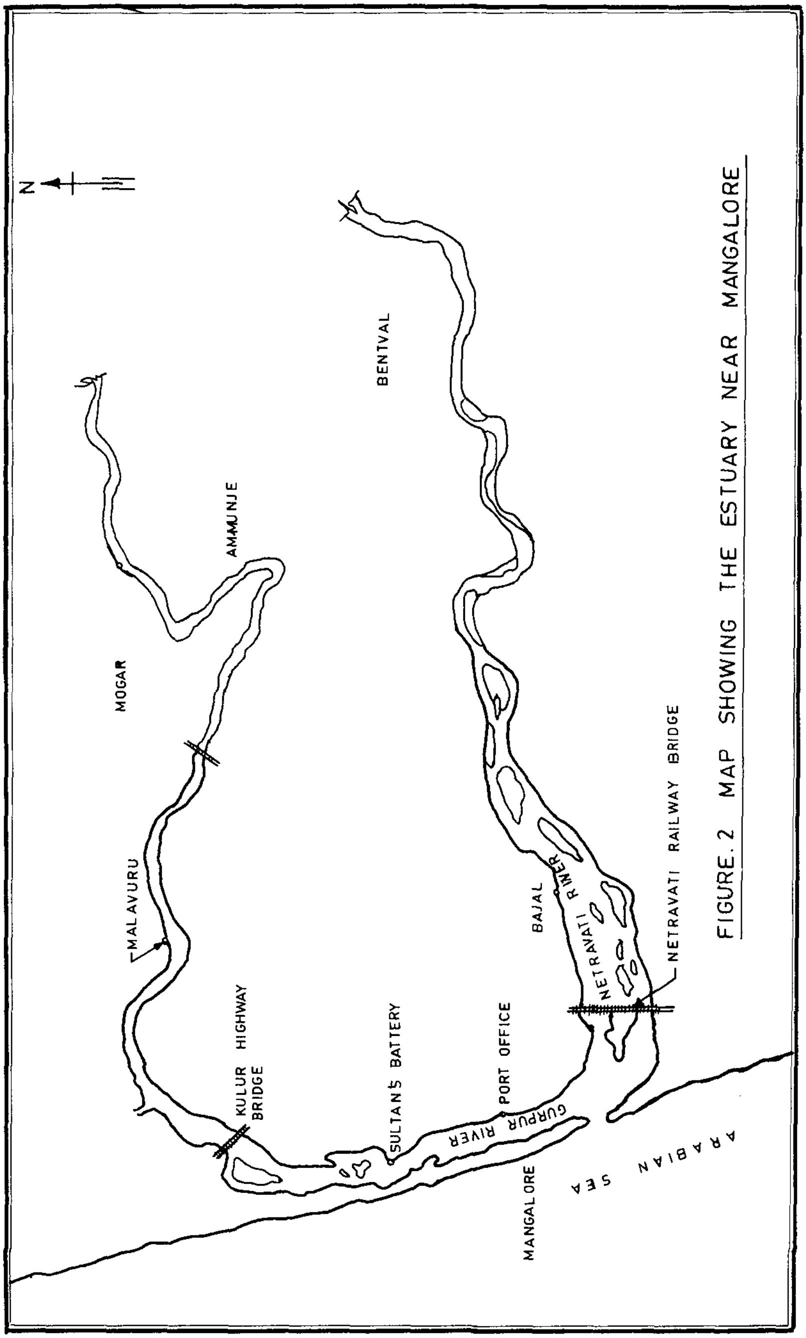

FIGURE. 2 MAP SHOWING THE ESTUARY NEAR MANGALORE

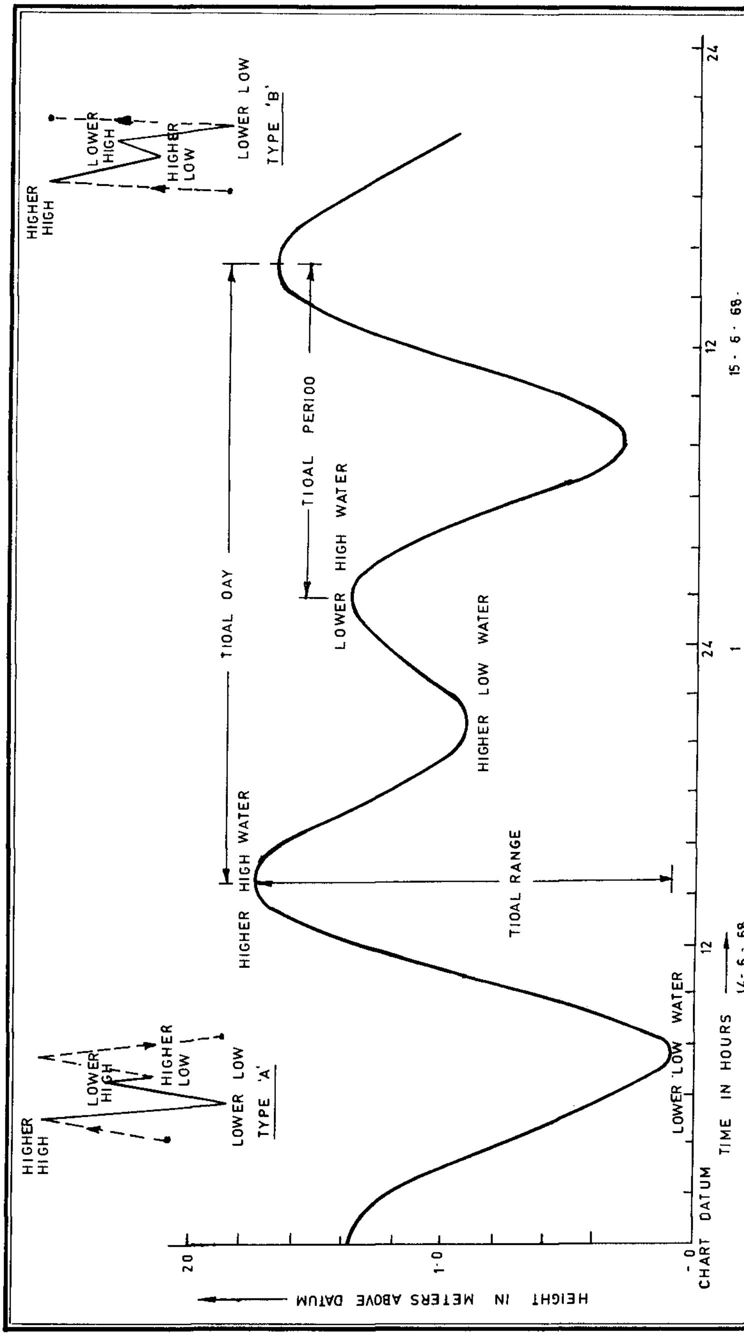

FIGURE 3. A TYPICAL TIDE AT MANGALORE.

characterised by significantly unequal high waters and low waters on most lunar days in a month. Salient features of this type of tides are shown in Fig. 3. The tides alternate from high water to low water. There are two high waters and two low waters in a tidal day. So we can distinguish them as a higher high water and a lower high water. Similarly the low waters may be classified as a higher low water and a lower low water. Another aspect revealed on the examination of the tidal graph is that it has two definite sequence of occurrences of high and low waters. These sequences may be classified as type 'A' and type 'B' and these are shown in Fig. 3. In type 'A' tides, a higher high water is followed by a lower low and from there to a lower high. From the lower high position, the tides fall to a higher low and rise back to a higher high. This cycle is repeated. In type 'B' tides, a higher high water is followed by higher low and from there to a lower high. From the lower high position, the tides fall to a lower low and rise back to a higher high. Type 'A' and type 'B' tides are counted for the year 1968 and found to be totalling 111 and 240 respectively. On some days in July the types could not be distinguished due to large fluctuations in the river stages due to floods.

GENERAL MORPHOLOGY

From the morphological study conducted for one season it will be difficult either to hindcast the previous history or to forecast the future trends. The first and foremost aspect that strikes an observer is that the sand spits on either side of the river mouth are entirely different in character and appearance. The most striking differences are listed below:

Description	North Sand Spit	South Sand Spit
Beach material	Fine sand	Coarse sand
Colour of beach material	Fairly bleached	Reddish brown
Elevation of the spit	Low	High
Slope of the beach	Gentle	Steep
Topography	Slightly wavy, the waves being parallel to the coast	Permanent ridges and valleys. A few of them parallel to the coast and many at an angle
Width	500-600 meter wide, wider towards the river mouth	400 meters at the base narrowing towards river mouth
Habitation	Inhabited	Scarcely inhabited

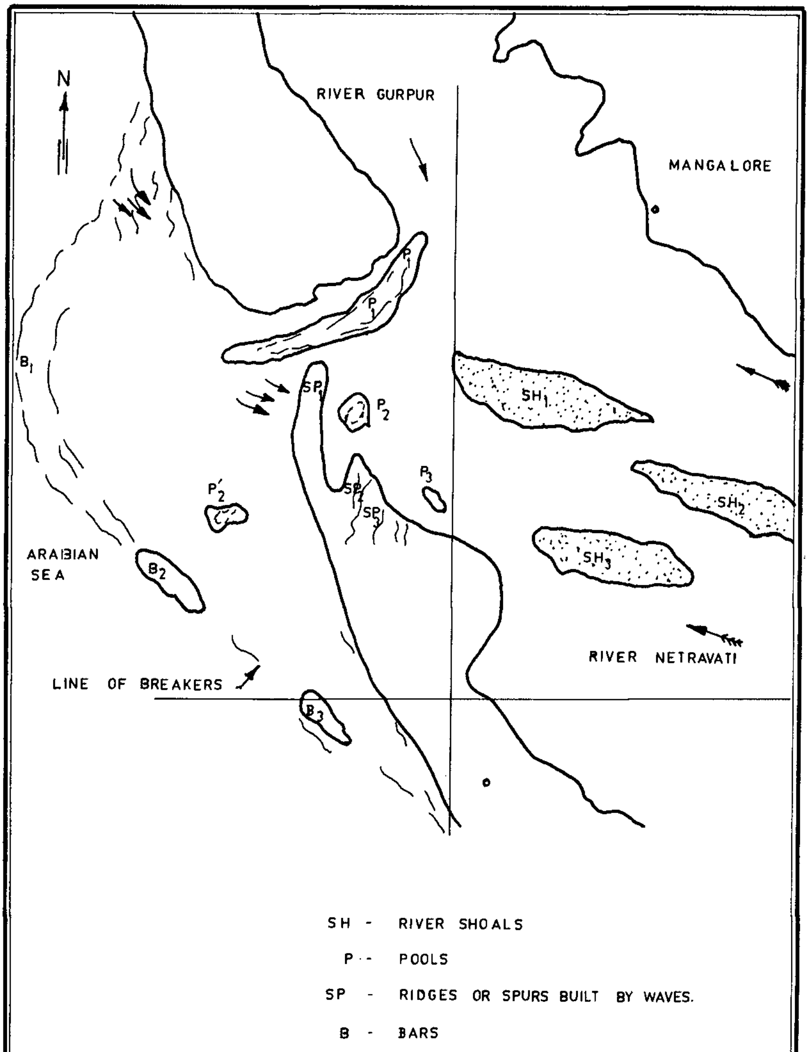

FIGURE 4. FEATURES OF THE ESTUARY

These evidences indicate that the source of the materials on these two sand spits are different. Further the mode and time of deposition may also be different.

The prominent features of the present position of the estuary are marked in Fig. 4. Starting from the river towards the sea, they are:

1. Sand deposition or shoal inside the estuary marked 'SH' acting as a guide bank for the present channel of the river.

2. Pool or area of large depth 'P' extending from just inside the river mouth, through the gut upto the bar.

3. The projecting spur on the southern sand spit marked 'SP', created by the west north-west wave action at the river mouth and

4. The off-shore bar marked 'B' formed at the present river mouth.

Now looking to the south of the present system, we can identify the discarded remnants of similar systems, the more southward they are, the less prominent. They are marked in Fig. 4 with the corresponding suffixes using the same notation. In the case of pools south of present gut, they are intruded by sand-spit, dividing them into two halves one inside the estuary and one in the sea. The features in the portion of the pool within the sea are fast disappearing due to constant action of waves. The features inside the rivers are also being distorted slowly. There are permanent ridges on the southern sand spit.

Examination of the geodetic traverse survey map shows that the southern bank of the river Netravati extends from the railway bridge towards west. This indicates that the river had a straighter course earlier. Now the south sand spit has been built up virtually across the river. The river now practically flows as a narrow channel close to the northern bank.

A comparison of maps prepared in 1905 (G.T.S.), in 1949 (G.P.Ranson), in 1953 (Mangalore Port authorities) and in 1968 (the authors) shown in Fig. 5 reveals that the river mouth is gradually migrating towards north.

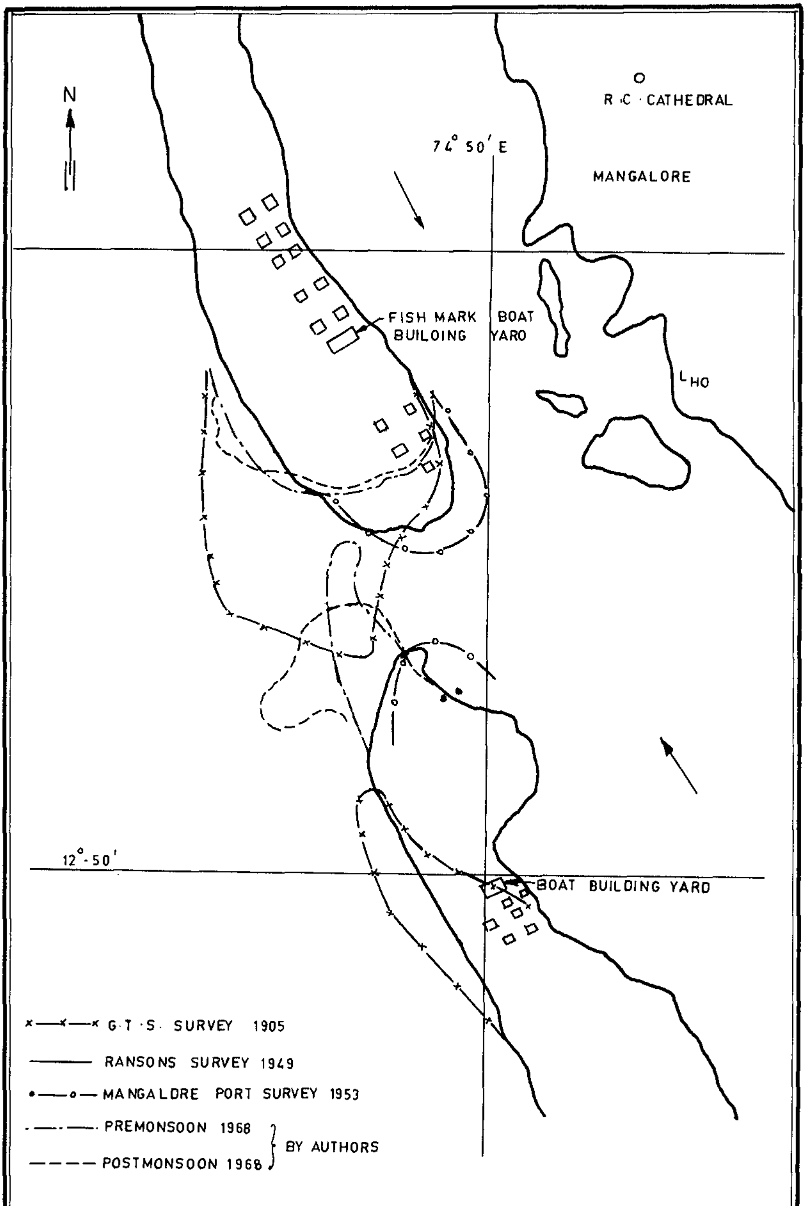

FIGURE.5. COMPARISON OF MAPS.

LITTORAL DRIFT

By the radioactive tracer studies and the flourescent sand studies conducted by the Mangalore Harbour Project and Central Water and Power Research Station, Poona (4), it has been concluded that the predominant direction of littoral drift in the region is from north to south.

The river discharges are deep brownish yellow in colour due to the admixture of lateritic ferrous compounds. When the coloured river water is ejected into the body of blue expanse of water one can easily observe the path taken by the river water into the sea, by mere visual observation of the contrasting colours. This aspect has been noticed during the study. This method of observation is quite useful to understand the diffusion pattern of the river into the sea waters at different stages of discharge. It is noticed that the river water is taking an abrupt southerly turn, as soon as it enters the sea.

The river Gurpur, is taking an abrupt turn southwards near Kulur leaving only a narrow land strip of 500-600 m. wide between the river and the sea (Fig.2). It would be natural to assume that the river Gurpur had once flown straight towards west at Kulur to join the sea and this inference has been confirmed by Cheryan (3). Between Kulur hills and Suratkal hillocks, there is a vast area of flat low-lying land. The river might have changed its course several times to build such a wide plain. The sand spit separating the Gurpur river and the sea exhibits certain curves at two places, one at Sultan's Battery and another south of it, indicative of former river mouths. Cheryan (3) while conducting geological and geotechnical studies at Panambur, reported evidences of an old river bed. All these indicate that the river Gurpur had a separate exit into the sea at first and later it was forced to flow southwards to join Netravati. This shifting might have taken place during a long period of time. It can only be the littoral drift that had contributed to the maximum for this shift.

MORPHOLOGY OF ESTUARY

During the major part of the year, fair weather prevails and the estuary is under the action of tides only as there is very little upland discharge. The tidal prism for Mangalore estuary for a spring tide of 1.77 m. is found to be 21 million m^3. and for an average tide of 1.25 m. it is 13 million m^3. The limit specified by Ippen (5) for a well-mixed estuary is to have the ratio

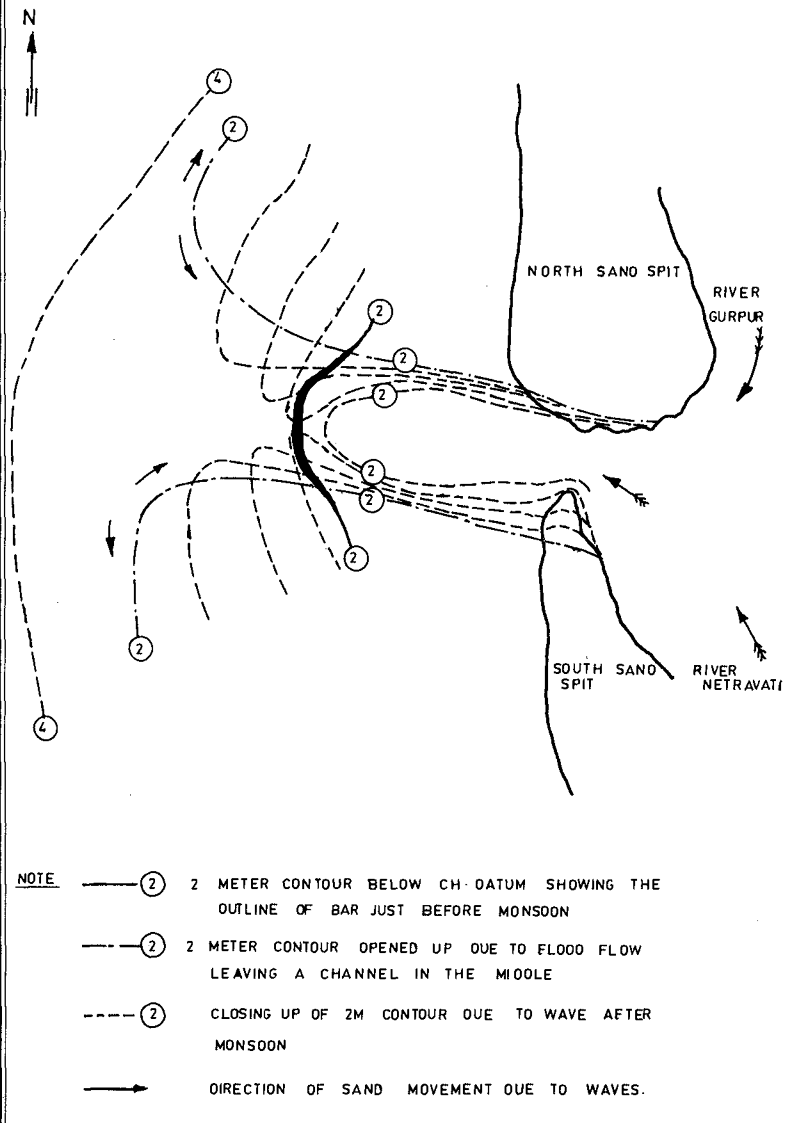

FIGURE.6. DEVELOPMENT OF BAR AT THE RIVER MOUTH

of fresh water discharge to tidal prism to be of the order of 0.1 or less. This gives the values of 49 m^3/s. and 24.5 m^3/s. for the discharge for a spring tide and average tide respectively. The summer flows in both the rivers are found to be obviously less than these quantities. Hence during most part of the year, i.e., from November to end of May, the estuary is in a well-mixed stage. During this period, the salinity is found to intrude about 20 km. in the river Netravati and to about 15 km. in the river Gurpur. Particularly no sediments are being brought into the river from the catchment area, outside the monsoon season. Also the bed materials of the river are not affected by tidal velocities. But the real problem to be considered at this time is not the action of salinity on the upland sediments, but due to the sediments brought in from the sea by tidal action.

As explained earlier, there are two types of tides, viz., type 'A' and type 'B' prevalent in the estuary. It can be seen that for type 'A' the larger range occurs from higher high to lower low. This means that the larger velocities occur at the ebb flows in a tide. In the case of type 'B' tides, the larger range is noticed when the tide rises from a lower low to a higher high. This means that for this type of tides, the flood flow will have larger velocities. From the number of different types of tides, already given, it can be seen that for two-third portion of the year flood velocities are predominant and for one-third portion of the year ebb velocities are predominant. A similar type of study has been conducted for the West Coast of U. S. (7). In this estuary the flood currents are stronger than those during the ebb. This aspect is a major factor which affects the sedimentation in the estuary.

OFF-SHORE BAR

The bar that is formed at the mouth of the estuary is of the form as shown by the 2 m. contour in Fig. 6. In the pre-monsoon survey it was like a wall built across the gut. The floods had breached the bar and a wide channel of 4 m. depth carved through the barrier. The materials had spread out like a fan. No appreciable changes in the 4 m. and 6 m. contours were noticed. The bar is again rebuilt by the waves after the floods receded. The extent to which the bar is broken depends on the intensity of peak discharge during the monsoon season.

'PALIKE' OFF MANGALORE COAST

'Palike' is a fascinating phenomenon observed along the Mangalore Coast. The name 'Palike' is locally used for the condition of the sea when it becomes calm locally at some regions, when all other regions are rough. These calm regions are noticed at certain locations, lasting for a few days only. The appearance of large quantity of semi-decayed leaves and twigs is associated with the formation of these calm regions. These leaves are fragments say 1 cm. to 2 cm. in size. They are deposited on the shore by the waves in large heaps, sometimes 1 m. to 1.5 m. in thickness. These leaves are partially decayed and black in colour. At the surf zone the waves are stirring up a huge quantity of leaves which gives a black tinge to the water. Fishermen throng to such areas to fish in the calm waters, as they find it hazardous to go elsewhere into the sea due to rough weather.

In this connection, the mud banks along Kerala Coast (6) has to be mentioned. These mud banks get stirred up during heavy storms and the mud is thrown in suspension creating a viscous medium. The waves passing through this get dampened, thus creating a zone of relatively calm area. But no report of the occurrence of leaves has been made in this connection.

Regarding 'Palike', the local people had different versions of explanations and experiences to quote. Some reported of having experienced a strong current leading into the calm region from one side and diffusing out through the other sides. They explained that the leaves are found at the exit of these currents. Some reported the presence of clusters of leaves and clay which gave a spongy reaction when prodded with a sounding rod. Lumps of leaves loosely cemented together by clay particles are seen floating on the water, and are washed ashore on the beach.

A possible explanation for the large deposition of leaves would be that they are brought down by the floods of the season and are deposited on the shore by waves. But this seems highly improbable as the 'Palike' leaves are in small pieces and separated from the twigs and in a semidecayed condition.

There are a number of rivers on the west coast discharging an enormous quantity of water into the sea. They carry bed load, suspended load and floating debris. The suspended sediments and the floating debris do not settle down fast. They are carried by the ocean currents. When they reach regions with eddies, the suspended sediments and debris will be just sucked in. In such pockets flocculation takes place and clay particles settle down. In this downward movement, they stick to the leaves and weigh them down. The large percentage of leaves inside the clay mass prevents the development of cohesive bonds between the particles. Deposits of this type may be accumulated in a few isolated places. The violent storm waves will stir up the heap of loosely held material. The leaves will start floating in the water. The presence of such large quantity of flaky pieces of leaves and clay particles thrown into suspension will dampen the waves in the area. Some of these leaves may be thrown off the mass and carried to the shore. Thus the leaves brought to the shore may be only a portion of a large mass, which is situated away from shore.

CONCLUSIONS

The estuary is subjected to a number of phenomena such as tides, ocean currents, littoral drift etc. A qualitative study of these inter-related and unsteady features and their combined effect on the estuary is made. On the basis of the study, the following conclusions can be drawn.

1. The river Gurpur might have joined the sea independently at some place north of the present position.

2. After it has joined the river Netravati as at present, the river mouth is migrating gradually towards north, as is seen from the comparison of maps shown in Fig. 2.

3. The limit specified by Ippen (5) for a well-mixed estuary is satisfied by the estuary for most part of the year.

4. A horse-shoe shaped submerged bar is formed at the mouth of the estuary after the monsoon, which is broken during the subsequent monsoon to allow flood waters.

5. 'Palike' (calm areas within a very rough sea) is a fascinating phenomenon observed along the Mangalore Coast.

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