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Shoreline Evolution Due To Construction of Rubblemound Breakwaters at Munambam Inlet

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ABSTRACT: Munambam, latitude 10°10'N, longitude 76°10'E, is a fishing village in Ernakulam district at Ernakulam-Trissur border, located between Ernakulam and Paravoor towns. This estuary is located where a branch of Periyar River joins the Arabian Sea. Chalakudy and Pullut rivers also join this branch of Periyar River. This estuary is 40 km North of Cochin Harbour and 85 km South of Ponnani Port. To develop Munumbam as a fishing harbour, two rubble mound breakwaters were constructed. This paper highlights the impacts of construction of these rubble mound breakwaters on the Munumbam geomorphology. The changes in the bathymetry of the area before and after the construction of breakwaters are studied. An attempt is made to predict the future shoreline of the area. LITPACK module of MIKE software is used for modeling the area. The results of the detailed analysis of the shoreline changes in the estuary are presented.

KEYWORDS: Munambam, breakwater, bathymetry, MIKE, modeling

I. INTRODUCTION

Munambam, latitude 10°10'N, longitude 76°10'E, is an estuary where a branch of Periyar river joins the Arabian sea. Chalakudy and Pullut rivers also join this branch of Periyar river. Both banks of the estuary are well-developed areas. The Northern bank of Munambam harbour is 22 km away from Kodungalloor municipal town, whereas, the Southern bank is 12 km away from Paravoor town. This estuary is 40 km North of Cochin harbour and 85 km South of Ponnani port. Munambam is an important fishing centre. The sea off Munambam is rich in prawns.

Munambam inlet is located on the West coast of India, in Kerala state, at the junction of Northern branch of river Periyar and the Arabian sea. Azhikode port and Munambam fisheries harbour are located upstream of the inlet on the Northern and Southern banks respectively. The main occupation of its inhabitants is fishing. Munambam is a major fishing harbour of Ernakulam and Trissur districts. It is also the mouth of the districts' major river Periyar, which can be seen from the Munambam Muziris beach.

A. Background Information:

Kerala state has a coastline of 590 km length. Ernakulam and Trissur districts constitute 46 km and 54 km respectively, which together constitute 17% of the state's coastline. Munambam fishing centre is situated in Ernakulam district at Ernakulam- Trissur border.
There are 1241 mechanized boats and 2205 traditional crafts in Ernakulam district. Munambam is a thriving fishing village in the District. Azhikode is another fishing village in Trissur district. Both are situated on either sides of the Periyar River mouth. Munambam estuary is about 40 km North of Cochin harbour and 85 km South of Ponnani Port. Active fishermen population of the project area is about 1075.

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The average annual landings of Munambam-Azhikode area are 25000t of which motorized boats contribute the maximum. Catfish, Sardines, Anchovies, Perches, Elasmobranches, Sciaenids are the important fish varieties available in this centre with prawns taking a sizeable percentage during the peak monsoon.

In 1967, the Government of Kerala appointed M/s Indopol to study the feasibility of establishing a fishery harbour at Munambam. M/s Indopol, in their studies in 1968, had recommended the construction of a fishery harbour at Munambam. Government of Kerala accepted the recommendation and sanction was accorded for conducting the detailed investigations and model studies. Government of Kerala declared Munambam as a minor port in the year 1975.

B. Model Studies

Hydraulic model studies were conducted at Central Water and Power Research Station (CWPRS), Pune to suggest recommendations for constructing fishing harbour at Munambam. Tidal model to scale 1/350 horizontal and 1/60 vertical was constructed for the studies. Due to the vast changes in the hydrography, revised model studies were carried out at CWPRS and their final recommendations as per their specific note number 2970 dated 20/05/1992 [1] are given below:

- The alignment of the channel to be dredged is with a whole circle bearing of 230°.
- With the construction of the two breakwaters flushing action in the channel increases progressively.
- The breakwaters may be constructed for a length of 360m (South) and 625m (North), of which 200m may be constructed initially and results studied using prototype.
- The rubble mound bund section is considered depending upon economy.

C. Project Details

The project was opened for activities on 07.08.2000. At present the following facilities are constructed:

- Two rubble mound breakwaters of length of 360m (South) and 625m (North)
- RCC wharf -440m long and 6m wide
- Auction Hall-2 Nos. 96x15m and 76x15m
- Landing & parking area-6500 sq.m
- Administrative office
- Gate & Gate house
- Canteen and provision store
- Locker hall
- Toilet block
- Water supply arrangements

D. Project Sanction

The construction of fishery harbour at Munambam commenced during 1989 as per the administrative sanction of Government of Kerala on 22.03.1989 and Government of India's sanction on 11.10.1988 for an estimated cost of Rs. 710 lakhs. The cost of construction of the completed components worked out to Rs 1952 lakhs.

E. Project Implementation

The Executive Engineer, Harbour Engineering Division, Munambam was responsible for the implementation of this project. All the components included in the project proposal were constructed. The project was opened for activities on 07.08.2000.

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II. OBJECTIVES OF STUDY

The objective of this project work is to study the following aspects of the Munambam area using LITPACK Module of MIKE software:

- Bathymetry changes
- Sediment transport trends
- Shoreline changes before and after the construction of breakwaters
- Predicting the future shoreline

III.DESIGN DATA

The bathymetry details, hydrographic charts and shoreline survey charts required for the studies were collected from the Harbour Engineering Department, Munambam. The wave data required for the analysis were collected from Center for Earth Science Studies (CESS), Trivandrum, and the Harbour Engineering Department, Trivandrum. The river discharge data was collected from the Central Water Commission, Ernakulam.

1V. METHODOLOGY AND SOFTWARE USED

For studying and better understanding of wave induced sediment transport and littoral drift, the wave climate was divided into two major seasons -the fair weather season (November –April) and rough weather season (May - October). An analysis was carried out for their representative wave parameters.

The images of the bathymetries of the area before (1983) and after the construction of the breakwaters (2011) were digitised using the MIKE software. The 2 D image of the area and the plot composer image of the area were generated. Then analysis of study area using the LITPACK module of the MIKE software [3, 6] was carried out.

V. INTERPRETATION OF RESULTS

A. Bathymetry

The 2D bathymetry shows that the Munambam area has almost a parallel coastline. Large amounts of sediment deposits were found in the inlet area before the construction of breakwaters. Sand bar formation also occurred in the area which caused many accidents and deaths. Before the construction of breakwaters (1983), the depth in the inlet area varied between -5 to 0m.

After the construction of breakwaters (2011), there was a considerable change in the bathymetry of the area mostly due to dredging activities being carried out in the area. Presently, the depth at the inlet varies between -11 to 0 m. The bathymetries also show the rivers (Periyar and Chalakudy) joining at the Munambam inlet. Heavy accretion is seen upto the tip of the Northern breakwater. The level of accretion at the Southern breakwater is comparatively less.

B. STP Analysis

The plots of velocity, mean concentration and quantity of sediments Vs depth were plotted for different depths, each for breaking and non-breaking conditions. A comparison was made for fair weather and rough weather seasons. Variations in the graphs observed were mostly attributed to the bathymetry changes of the area and due to the seasonal changes.

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1. Velocity Profile

It is noted that both in fair weather and in rough weather seasons and also for breaking and non breaking conditions, the velocity profile decreases as depth increases. This is due to the effect of bed friction or bed roughness. In breaking condition, the velocity increases towards the surface due to wave breaking and the resulting swash.

2. *Mean Concentration Profile*

It is observed that both in fair and in rough weather seasons and also for breaking and non breaking conditions, the mean concentration profile increases as depth increases. The fair weather sediment concentration is very less compared to the rough season sediment concentration. This is due to the high wave activity during the rough season and the corresponding high bed shear stress that will churn up the sediments from the sea bottom.

3. *Mean Suspended Sediment Transport Profile*

The suspended sediment transport is very heavy during the rough season when compared to the fair weather season. In non breaking wave condition, generally, the suspended load increases towards the bottom of the sea as the bed shear stress, corresponding suspended sediment concentration and bed load transport are high at the sea bed. But it may vary due to local bathymetry. In breaking condition, it is considered that the wave breaks at the assumed depths and the breaking is not due to effects of the sea bottom. It is to be noted that the bed transport decreases due to the broken waves as the wave ceases to "sense the bottom" due to breaking. At this condition, the suspended load transport profile decreases.

C. LITDRIFT Analysis

The plots of longshore current velocity, wave height, sediment flux and accumulated sediments Vs distance were plotted for 400, 1400 and 2500m normal to the coastline. A comparison is made for fair weather season and rough weather seasons.

1. Cross shore distribution of longshore current

The longshore current distribution shows almost similar magnitude for 400m cross section during both rough and fair seasons. But it shows large variation for 1400m and 2500m cross section. The variations in the magnitude of the longshore current velocity may be due the difference in wave heights between the fair and rough weather seasons and also due to the change of incident wave direction during these two seasons. During the fair weather season the prominent direction of wave approach is 240° and during rough season it is 250°.

2. Cross shore distribution of wave height

The wave height profile, normal to the shore for various sections were analysed. The wave height first decreases due to the reduction factor representing the decrease in radiation stresses due to the directional spreading of the approaching waves. As the wave approaches the shore, the wave height increases due to shoaling and finally collapses by wave breaking. The breaker wave heights during fair weather season and rough weather season and the depth at which wave breaking occurs can be analyzed from the plots obtained.

3. Cross shore distribution of sediment flux

The cross shore distribution of sediment flux was studied for sections at 400m, 1400m and 2500m. The sediment flux was higher near the coastline due to longshore sediment transport. Higher sediment flux was recorded for rough weather season compared to fair weather season.

4. Accumulated Sediment Transport

Accumulated sediment transport is the cumulative transport of the sediments from shore to offshore. The sediment transport includes both bed load transport and suspended load transport. It is seen that the accumulated sediment transport is more during rough weather season than in the fair weather season. It is observed that the sediment transport is more at the Southern section than at the Northern section. This indicates that the coast is undergoing accretion. Northern side of the harbour shows higher accretion than the Southern side.

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5. Annual Sediment budget

The plots represent sediment rose diagrams for 400m and 1400m cross sections. The rose plots represent the percentage of sediment flow Vs wave height for different wave directions. From the plots it can be observed that maximum sediment transport occurs due to waves coming from 240° N. The different wave height contribution for this wave direction can be studied from the plot. The annual sediment budgeting is based on the input annual wave climate, which is represented by the yearly wave climate rose diagrams.

Similarly the rose plot for annual sediment budget with wave period is also plotted using the annual wave climate diagrams. The contribution of each wave period from different directions towards the sediment transport can be observed from the rose plot.

D. LITLINE Analysis

LITLINE module is used to study the effect of wave climate on the shoreline changes. Initially, the coast is assumed to be without any seawalls or breakwaters and the effects were simulated for a period of about 2 decades (from 1983 to 2000), and it was found that the coast showed depositional tendency towards the Northern side. A Southerly shift in the river mouth was also observed. The validation of the model result was done by comparing it with the real shoreline data for the year 2000 obtained from the Harbor Engineering Department. The model results agree closely with real field data. Then, breakwaters and sea walls were incorporated in to the model and the shoreline was predicted for the year 2015. Heavy accretion is observed till the tip of the Northern breakwater compared to the Southern breakwater. This result confirms the predominant direction of littoral transport along the Kerala coast. It is found that accretion dominates the shoreline changes at Munambum and there is a net advance in the shoreline. Thus, the breakwaters were found to be very effective in trapping the littoral sediments along the Munambum shoreline.

VI. CONCLUSION

This paper attempts to study the shoreline changes occurring at Munambam inlet, located in the West coast of India in Kerala state, before and after the construction of breakwaters. It also studies the effectiveness of the breakwaters constructed at the inlet. For the study, the LITPACK module MIKE software is made use of. The results of the various modules of LITPACK -LITSTP, LITDRIFT and LITLINE are analysed. The analysis results show that the area has been undergoing heavy accretion. The model results agree with the field observations. Heavy accretion is observed till the tip of the Northern breakwater compared to the Southern breakwater. This may be attributed to the trapping of littoral sediments moving from North to South. The predicted shoreline for the year 2015 also shows accretionary trend near the Northern breakwater. It is found that accretion dominates the shoreline changes at Munambum and there is a net advance in the shoreline. Thus, the breakwaters are found to be very effective in trapping the littoral sediments along the Munambum shoreline.

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