Proceedings of the 7th International Conference on Asian and Pacific Coasts (APAC 2013) Bali, Indonesia, September 24-26, 2013

COMPLEXITIES IN COASTAL SEDIMENT TRANSPORT STUDIES BY NUMERICAL MODELING

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ABSTRACT: Marine environmental studies related to erosion, accretion, pollution transport, dredge disposal, location of seawater intake, effluent disposal, etc., involve sediment transport studies. Numerical models use set of well linked mathematical equations arrived based on scientific principles as all natural phenomena are governed by certain rules which can be explained by scientific principles. Efficiency of numerical modeling greatly depends on quality of input parameters. When input parameters vary unpredictably with respect to time and space, many times fitting them well in numerical equations is a great task. Numerical modeling of coastal sediment transport uses input parameters such as data on suspended sediments, short duration time series data on tide, current, wave and wind, bathymetry and nature of seabed, etc. Tide is predictable to reliable extent as tide governing events and forces are cyclic in systematic natural processes. This is not same in cases of winds, waves, currents, river discharge and suspended sediment load in terms of magnitude and direction as they cannot be predicted accurately based on short term observations over space and time though their trend for a region can be obtained. If the coastal region includes rivers, obtaining reliable time series discharge data is very difficult due to irregular rainfall intensity and agricultural usage of river water in the region. Due to these conditions, numerical modeling in coastal sediment transport studies could not be validated well many times. In this manuscript, data on suspended sediment load at surface, mid-depth and bottom of a coastal location, off Dahej, west coast of India, observed every hour for 48 hours continuously have been presented and through which authors have tried to convey the complexities involved in accurate prediction of coastal sediment transport studies by numerical methods due to some unpredictable variations in the input parameters pertaining to the challenging coastal environments.

Keywords: Sediment transport, numerical modeling, pollution transport, coastal processes.

INTRODUCTION

Oceanographic studies related to erosion, accretion, pollution transport, dredge disposal, location of seawater intake, effluent disposal, etc., involve sediment transport modeling. Numerical models use set of mathematical equations arrived based on scientific principles as all natural phenomena are governed by certain rules which can be explained by scientific principles. Efficiency of numerical modeling greatly depends on quality of input parameters. When input parameters vary unpredictably with respect to time and space, many times fitting them well in numerical equations is a great task

Numerical modeling of coastal sediment transport uses input parameters such as data on suspended sediments, short duration time series data on tide, current, wave and wind, bathymetry and nature of seabed, etc. Tide is predictable to reliable extent as tide governing events and forces are cyclic in systematic natural processes. This is not same in cases of winds, waves, currents, river discharge and suspended sediment load in terms of magnitude and direction as they cannot be predicted accurately based on short term observations over space and time though their trend for a region can be obtained. If the coastal region includes rivers, obtaining reliable time series discharge data is very difficult due to irregular rainfall intensity and agricultural usage of river water in the region. Due to these conditions, numerical modeling in coastal sediment transport studies could not be validated well many times.

There are many methods to study longshore sediment transport in the marine environment. One of the methods is to use empirical equations with ship observed wave data (Chandramohan et al. 1992) to obtain the seasonal or annual net sediment transport trend over a region. Another method involves using residual fluxes of water (Revichandran et al. 1993). These methods do not predict sediment transport accurately due to factors such as random observation of forcing parameters, depth averaging sediment flux, empirical equations, etc. These methods are adopted for suggesting sediment movement over large area and do not predict erosion or accretion along the coast with reliable accuracy.

Another method in sediment transport studies is to use numerical modeling as this can handle large volume time series data on forcing parameters and suspended sediment load in water column (Babu et al. 2003 and

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Jayakumar et al. 2006) Reliability of this method greatly depends on quality of input parameters and simulated grid sizes.

In this manuscript, data on suspended sediment load at surface, mid-depth and bottom of a coastal location, off Dahej, west coast of India, observed every hour for 48 hours continuously have been presented and through which authors have tried to convey the complexities involved in accurate prediction of coastal sediment transport studies by numerical methods due to some unpredictable variations in the input parameters pertaining to the challenging coastal environments.

STUDY AREA

In the present study, a coastal location with geographical coordinates of 21˚43'10" N and 72˚30'25" E, off Dahej, west coast of India was selected (Fig. 1) Water depth at this location was around 16m.

Fig. 1 West Coast of India

DATA COLLECTED

Current Speed

Maximum current speed recorded using DCM12 current meter at surface and five different depths are shown in the Table 1. The maximum current speed varied from 2.97 m/s (Average 1.12 m/s) at the surface to 1.96 m/s (Average 0.72 m/s) 6.5 m above seabed during 24 days observation.

Table 1 Maximum current speed recorded DCM12

Depth	Max. Current Speed (m/s)	Average Current Speed (m/s)
Near surface	2.97	1.12
~14 m above seabed	2.88	1.16
~11.5 m above seabed	2.85	1.10
~9 m above seabed	2.02	0.83
~6.5 m above seabed	1.96	0.72

Current Direction

The surface current was predominantly between 0˚ and 30˚ during flood and 180˚ and 210˚ during ebb tide. The current at mid depth was predominantly between 330˚ and 360˚ during flood and 150˚ and 180˚ during ebb tide.

Suspended Sediment Concentrations

Water samples were collected at three different depths, i.e., near surface, mid depth and near bottom, using Niskin water sampler to estimate suspended load. The sampling was done at one hour interval for 48 hours. Known quantity of water was filtered through pre-weighed 0.45 µm Millipore glass fiber membrane filter papers. After the filtration process, the filter papers with sediments were dried at 65˚C temperature for 24 hrs and weighed. The difference in weight between empty filter paper and sediment filled filter paper was taken as suspended sediment load.

The variation of total suspended sediment concentration at surface, mid-depth and near bottom for every one hour interval for 48 hours is shown in Fig. 2. The suspended sediment concentration varied from 0.03 to 0.79, 0.06 to 1.10 and 0.05 to 1.62 g/l at surface, mid-depth and near bottom respectively. Corresponding mean values were 0.13, 0.32 and 0.63 g/l respectively.

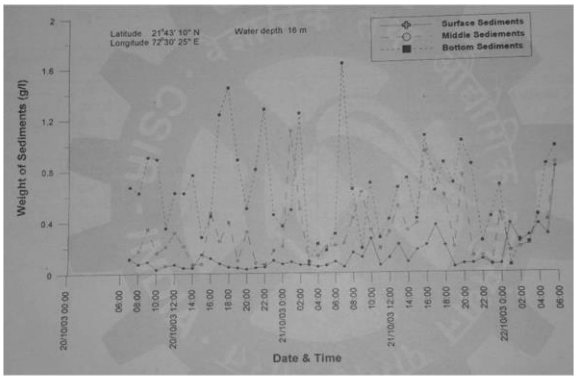

Fig. 2 The variation of total suspended sediment

DISCUSSIONS

In the sediment transport studies, currents play a major role as one of the forcing functions. Though current speed and direction vary over time and space, both vertical and horizontal dimensions, in general, time series current data is fed into the numerical model. Duration of time series current data decides the accuracy of the model results. In case of considerably deeper waters, where current speed and direction vary considerably at different depths, time series current data on different depths also helps in accuracy of the model. Taking average current speed and direction, in such cases, reveal unreliable results. Also, in some locations, seasonal variations in the environmental parameters are very high that one has to do modeling studies for both the extreme and fair weather conditions and offer advises accordingly.

As far as suspended load is considered, modelers generally use one time or short duration observed data. Also, they use depth averaged suspended sediment concentration for simplifying the running of the model. In the present case, a huge variation of suspended sediment concentration is observed in just 48 hours in all, surface, mid-depth and near bottom levels. This clearly shows that one time or short duration suspended load measurement could under estimate or over estimate the quantity of sediment transport and the result may not help to predict either erosion or accretion over a coastal region.

CONCLUSIONS

The authors conclude that sediment transport modelers need a thorough and long term understanding of the study location with respect to existing complexities in the region due to various marine environmental parameters over time and space. These complexities due to some unpredictable variations in the input parameters pertaining to the challenging coastal environments may lead to inaccurate prediction of coastal sediment transport studies by numerical methods, in particular to the prediction of accretion or erosion along coasts.

ACKNOWLEDGEMENTS

The authors thank Director, NIO, for providing facilities and constant encouragement to carry out this work. The efforts of all the participants of the field work in data collection are greatly appreciated.

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