Transport Suspended Modeling in Rupat Strait

Mubarak[1], Edison[1], Sri Fitria R [2] and Yeeri Badrun[2]

[1)]Faculty of Fisheries and Marine Sciences University of Riau
[2)]Faculty of Natural Sciences, University of Muhammadiyah Riau

ABSTRACT

In this study simulated the effects of suspended sediment from Sungai Mesjid. This simulation will be able to know how suspended sediment contributed of Sungai Mesjid in waters around Lubuk Gaung Industrial Estate. Hydrodynamic simulation of flow and sediment transport using the modules contained in MIKE21 software, using hydro-dynamics and Mud Transport Module. The hydrodynamic model has two-dimensional finite element method in horizontal and the mean depth. Modeling results showed that the sediment distribution of Sungai Mesjid with a concentration of 20 mg / liter (20 ppm), will spread to the Northwest when low tide and to the southeast when it receded.

Keywords: suspended sediment, hydrodynamic simulation, finite element methods

INTRODUCTION

The rapid development of the east coast at the Strait Malacca, especially in terms of development activities industrial, residential, and transportation cruise lines, ports, agriculture, fisheries and coastal reclamation. Development of the area indicated by the establishment of industrial zones such as Dumai Industrial Area in Industrial Area Lubuk Pelintung and Gaung. This development will have an impact on coastal ecosystems.

Poor water conditions in the area around the industrial area, often a debate about who is the cause, whether due to industrial activities or natural processes is by nature. According to Effendi (2007), the water body is characterized by three main components: hydrology component, the component chemical physics, and biological components. There are a variety of chemical physics parameters that can be used as a measuring tool to determine the level of water quality, such as temperature, brightness, turbidity, TSS, pH, and chemical compounds sharing of dissolved ions, and dissolved metals. For biological parameters of water quality can be spread through the identification of organisms plankton, benthos and nekton.

Specifically this study aims to conduct and analyze simulation of distribution patterns of suspended sediment from the Sungai Mesjid using 2-dimensional mathematical models in the Rupat Strait especially area Industrial area Lubuk Gaung. Outputs of this simulation was to determine the distribution of suspended sediment from the Sungai Mesjid to the Straits of Malacca so that it can be seen the amount of contribution to the Mosque River waters in the Strait Rupat conditions.

METHODS

Study area

Studies conducted in the Strait Rupat located in the administrative region of Bangsal Aceh District Sungai Sembilan of Dumai (Figure 1.). The area is located at the industrial zone in accordance with the spatial direction of Dumai (Regulation No. 11 of 2002). Geographically located at the coordinates 1 ° 44'37 .75 "N - 1 ° 43'11 .93" N and 101 ° 22'27 .93 "E-101 ° 23'13 .70" E, with the relative flat topography, slope of about 3% and the height of the surface approximately 1-2 m sea. Estuarine waters of the Strait of Rupat depths ranging from 9-21 m. The movement of water in the Strait Rupat strongly influenced the movement of water from the Strait of Malacca. Tidal patterns in the Rupat Strait with tidal patterns in the Malacca Strait, including the type double daily tides occur twice a day of ups and downs are almost twice as high.

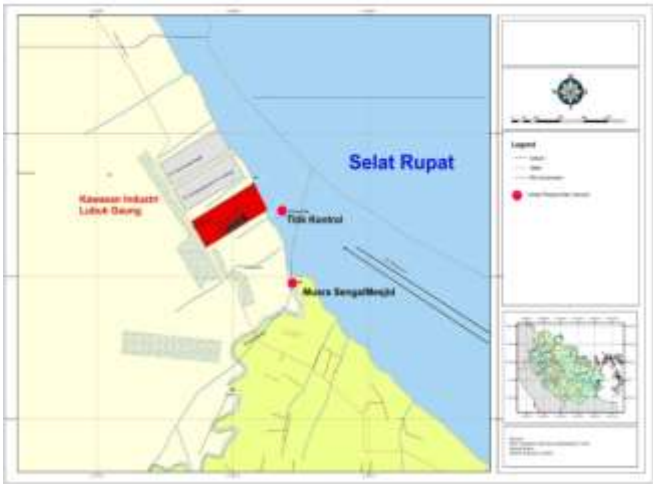


Figure 1. Lokasi kajian

In the study area there is a Sungai Mesjid which is one source of influence on the condition of waters in the study area (Lubuk Gaung). Mesjid river have a 23m wide in the center and 73 m at the mouth of the river. Mesjid river across the Dumai city and empties into the Strait of Malacca.

Design Model

Model area covers the waters around the Strait of Malacca in the Industrial area Lubuk Gaung.

Scenario Model

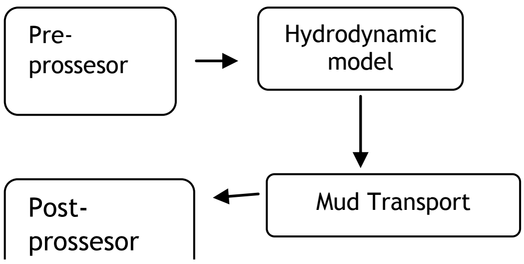
Hydrodynamics and sediment transport models simulated with entering data tidal, wind, wave and river water discharge Mosque. Simulation results will be compared with taking the measurements of concentration field at control point (101 ° 23'8, 064 "E 1 ° 43'41, 0796" N).
Based on the results of laboratory analysis, that the content of TSS in the estuary of Mesjid river by 20 mg /L. discharge effluent of Mesjid river of 363.75 m3/sec ..

Stages Hydrodynamic Simulation Models

Hydrodynamic model was run to simulate the flow generated by the tidal boundary condition on the input. Motion circulation currents in shallow water mass flow of water is assumed to be perfectly mixed (homogeneous) accumulation from surface to bottom waters and surface wind effect is assumed to reach the ocean floor. Therefore equation model was used to a depth integrated equation. In this model of sea water is considered as an incompressible fluid can not (incompressible fluid).

Design of Mathematical Model

Hydrodynamic simulation of flow and sediment pollutants using the modules contained in the MIKE 21 software, namely Mud Hydrodynamic and Transport Module. The hydrodynamic model is a model with two-dimensional finite element method with a mean horizontal depth. With these numerical models can predict flow patterns, water surface elevation and horizontal velocity components, either on a permanent flow conditions (steady flow) and no permanent flow (unsteady flow) and sedimentation.



ematic simulation

To simulate the distribution of sediment would require simulation of hydrodynamic flows first. Current simulation results are used as input for the simulation of sediment distribution. Simulation scheme can be presented in a flow chart as shown in the figure below.

a. Basic hydro-dynamics equations

Mathematical models used for hydrodynamic flow is based on two basic equations, the equation of mass conservation (continuity equation) and momentum equation, as follows:
The continuity equation:

$$\frac{\partial h}{\partial t}+\frac{\partial h\overline{u}}{\partial x}+\frac{\partial h\overline{v}}{\partial y}=hS \qquad \text{-1-}$$

Momentum equation:
Momentum equations for two-dimensional flow in the x and y directions can be written in the form of the following equation:

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+g\left(\frac{\partial h}{\partial y}+\frac{\partial a_0}{\partial y}\right)-\frac{\varepsilon_{xx}}{\rho}\frac{\partial^2 v}{\partial x^2}-\frac{\varepsilon_{yy}}{\rho}\frac{\partial^2 v}{\partial y^2}+\frac{gv}{C^2h}\sqrt{u^2+v^2}=0$$

with**:**
u = horizontal velocity x-direction flow,
v = horizontal velocity v -y direction,
t = function of time,
g = gravity ,
h = deep of water,
a_0 = elevation of the base face,,
ρ = density,
εxx = koef. normal turbulence exchange direction x
εxy = koef turbulence exchange tangential direction-x,
εyx = koef turbulence exchange tangential direction-x,
εyy = koef. tangential turbulence exchange-y direction,
C = koef. Chezy roughness (or koef. Manning, n = 1 / C h1 / 6).

b. Basic equations Mud Transport (MT)

Formula of the model is a two-dimensional system with a mean depth where the concentration is assumed uniform vertical direction. Mud Transport Module (MT) is an application on the basis of material transport sediment with clay or Clay. Mud Transport (MT) module is devoted to the modeling of non-cohesive material while using the cohesive mud transport module (MT). Basic equation on Mud Transport (MT) are expressed in the two-dimensional transport equation is based on the convection-diffusion equation sediment suspension are:

$$\frac{\partial C}{\partial t}+\overline{U}\frac{\partial C}{\partial x}+\overline{V}\frac{\partial C}{\partial y}=\frac{\partial}{\partial x}\left(Dx\frac{\partial C}{\partial x}\right)+\frac{\partial}{\partial y}\left(Dy\frac{\partial C}{\partial y}\right)+\alpha_1 C+\alpha_2 \qquad \text{-2-}$$

with :

C = concentration,
$\overline{U}$ = Average speed of the flow direction x,
$\overline{V}$ = Average speed of flow direction y,
Dx = effective diffusion coefficient of the x,
Dy = effective diffusion coefficient of the y,
α_1, α_2 = coefficient of source term

In the above equation, the turbulent diffusion coefficient in the direction of solid flow direction is formulated as follows
Dx=5.93H U*
While the coefficient of turbulent diffusion direction is perpendicular to the flow,
Dy=0.23 H U*
Shear acceleration calculate with:

$$U* = \frac{\sqrt{g}\bar{U}n}{H^{1/6}}$$

Where, H = deep of flow
U*= shear accelaration

RESULTS AND DISCUSSION

Primary data for the simulation obtained by direct measurement in the field include flow measurement and water quality in the estuary of Mesjid river and in the waters nearby Industrial Estate Lubuk Gaung as a control point.

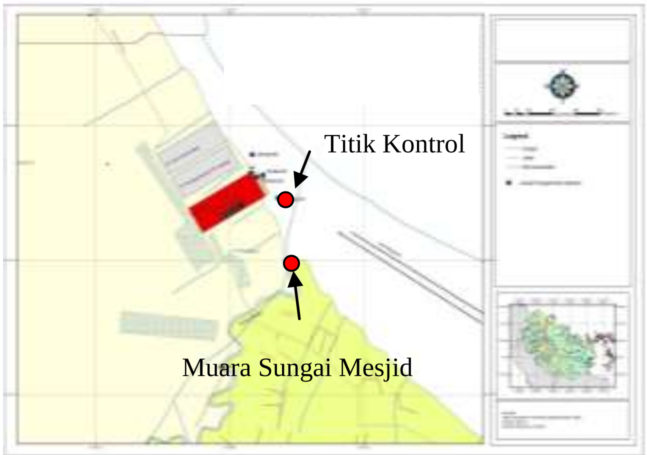


Figure 3. Location of the measurement point

MODELING

Domain Model

Domain models are used in modeling boundary and used as input placement models and boundary conditions. Domain boundaries is sea and land borders. Domain boundaries were enlarged compared with the area under review. This is to avoid boundary effects that occur in a matter of numerical hydrodynamic flow. The initial step in the study was the determination of the model domain, ie projects where the waters flow patterns will be simulated. The model domain will be represented in the element mesh (mesh) made of discrete batimetry map.

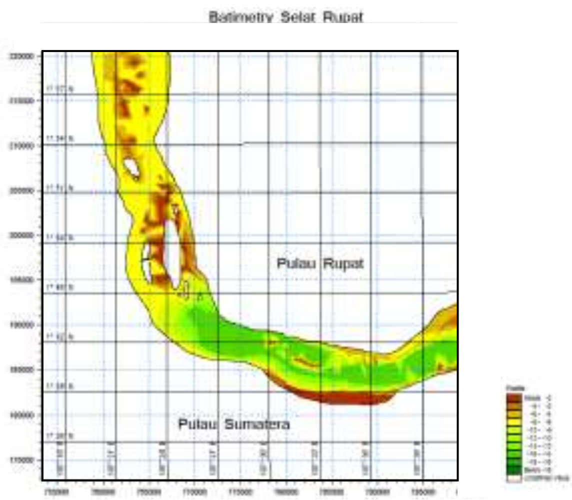


Figure 4. Batimetry Strait Rupat region

xt step is the input data and model parameters.
s :

Tide

Tidal data input in place on the outer boundary conditions (high seas) whose location is taken away from the site to be studied . This is done to avoid the boundary effect on the results of numerical count . Tidal data is input at the point of quests and Tanjung Tanjung Lebang.

Flow patterns

Simulation results are presented in the form of flow patterns and contours of velocity vector is happening . Results of flow patterns existing condition at the time of ups and downs are presented in Figure 5 . From the modeling results , the Straits Rupat experienced two ups and two downs with almost the same high and low tides occur sequentially . Such pairs of the type included in the daily tidal type double (bambang Triatmojo, 1996). Currents that occur in the waters of the strait Rupat is the current generated by the movement of long wavy posed by the spread of the tidal waterway. At Rupat Strait , at high tide , currents propagate from North to South and East and turned to rejoin the currents in the Strait of Malacca to the South-East and most entrance to the Strait of Bengkalis . In contrast at low tide , the current will move from the East to the West and North and turned out in the Strait of Malacca.

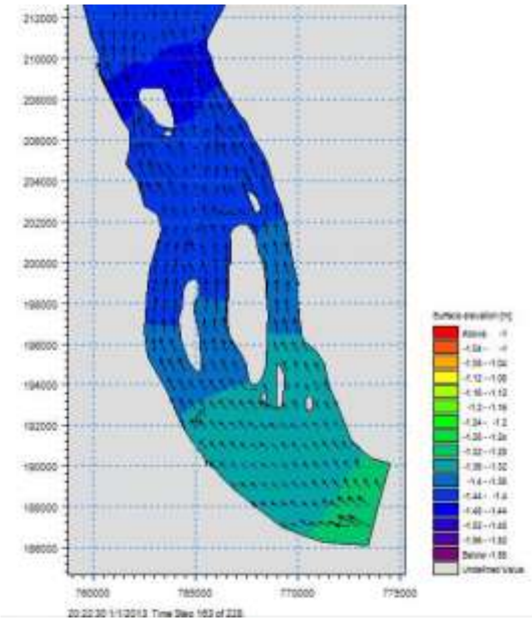
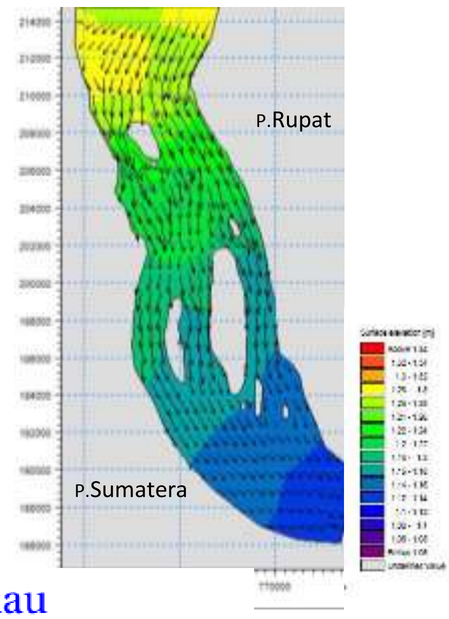


Figure 5. Current direction when the tide



ction when low tide

From the picture above, the change in the flow direction control point shows, when the tidal current direction leads to 140^{O} then turned towards the east direction and when the low tide current direction leads toward 340^{o} then turn toward the north.

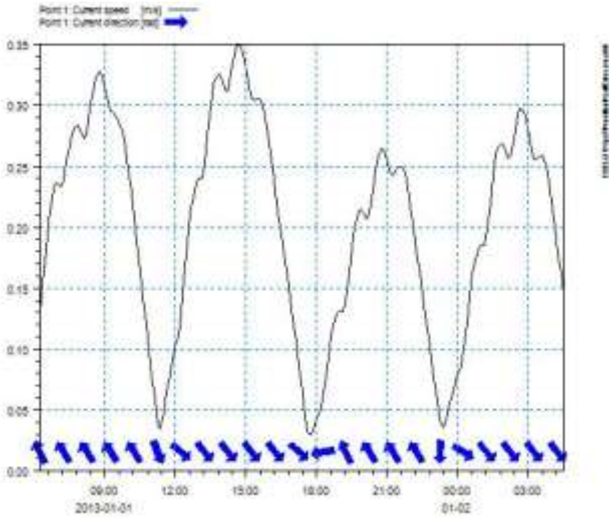


Figure 7. Speed and direction of current in control point

General flow velocity ranged from 0.05 to 0.35 m/s. The length of time equal to the time of low tide tide is 6 hours. Flow pattern which includes the direction and speed is an important mechanism in the distribution and transport of pollutants in the waste waters of the Strait Rupat.

RESULT

Sediment Distribution Patterns

Results of patterns of flow that occurs at high tide and at low tide will give tersuspense sediment distribution pattern (TSS) which occur in estuaries Rupat Strait. At high tide, the distribution of TSS mosque River will lead or tend to spread to the Southwest, while at low tide TSS distribution will lead to the Northeast. Based on the results of laboratory analysis that TSS concentrations at the mouth of the mosque by 20 mg / l and in the control point of 20 mg / l (Appendix 1).

Distribution of Sediment Concentration.

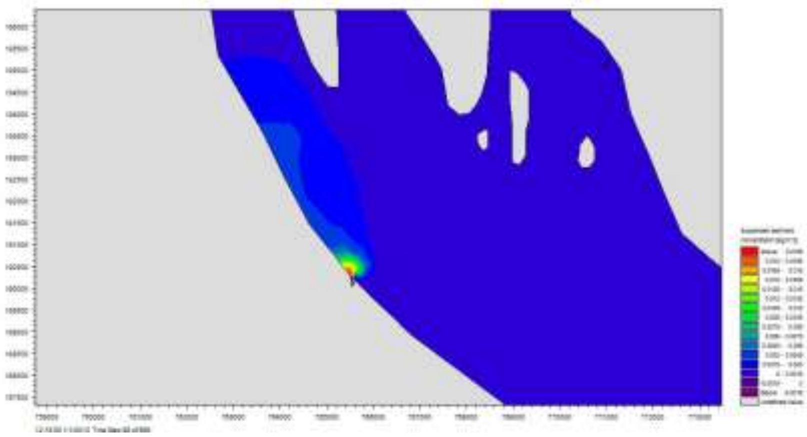


Figure 8. Direction of sediment distribution patterns at low tide

ɔint will always fluctuate, although small. This is by the flow velocity occurs. While the pace themselves in the area fluctuate widely studied due to the tide. From the modeling results, indicate that sediment concentrations fluctuate following changes in speed and direction of currents. When low tide TSS concentrations of 8,3 mg/l and when the tide 1 mg / lt. When these results were compared with measurements of the concentration of TSS in control point (20 mg / l), the concentration at the control point is greater than the modeling results. This suggests that the TSS content of the waters of the Rupat Strait especially around industrial areas Lubuk Gaung not only from the Mesjid River.

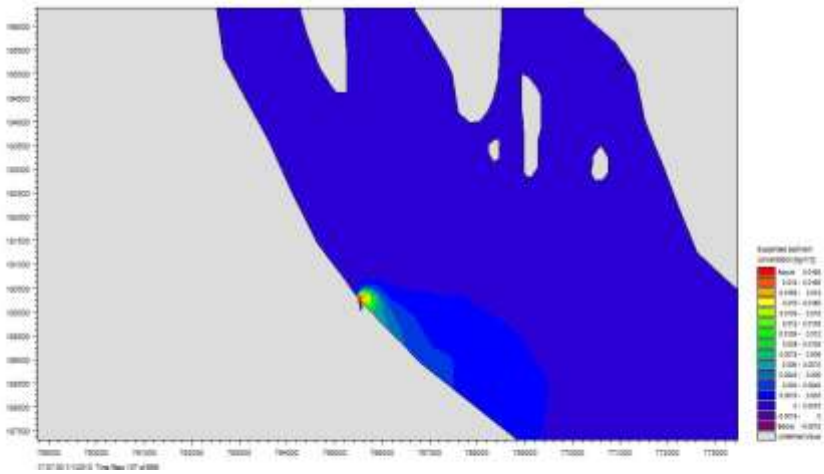


Figure 9. Direction of sediment distribution patterns at tide

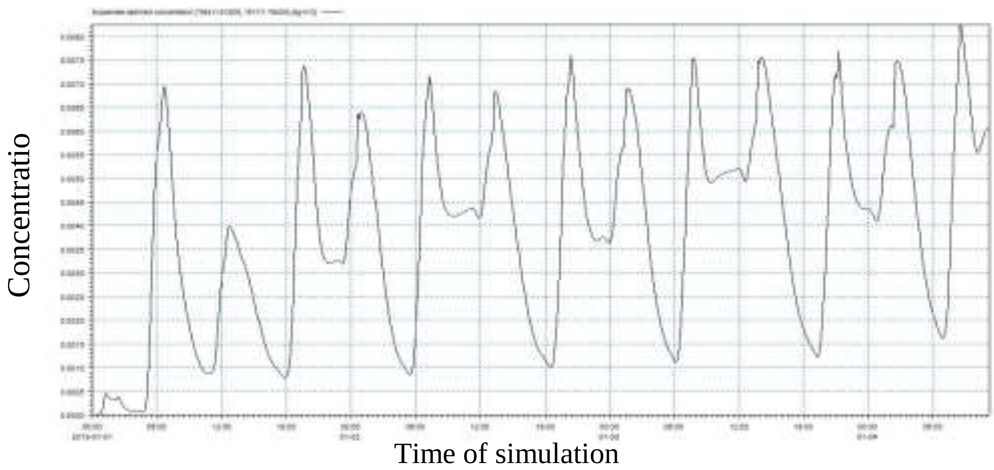


Figure 10. Graphs sediment concentration fluctuations on a control point

Another source of TSS can be derived from coastal erosion occurring naturally or from industrial activities located in the Industrial Area Lubuk Gaung.

CONCLUSION

From the results of the study the distribution of sediment with 2-dimensional finite element method with a case study of the Mesjid River TSS distribution obtained some conclusions as follows: TSS distribution of the river will lead to the northwest when tide and to the southeast when low tide.Highest concentration of TSS distribution Mesjid River to the point of control for 8.3 mg /l. TSS distribution of river Mosque is not the only seumber TSS into Rupat Strait..

SUGGESTION

of sediment with 2-dimensional finite element at Strait, suggested: Conducted follow-up study using 3-dimensional element method. Assessment is not only the suspended sediment particles, but also for other water chemistry parameters.

REFERENCES

Bambang Triatmodjo, 1996, Coastel, Beta Offset, Yogyakarta.

User Guide, 2007, Mike 21 FlowModel FM Mud Transport Module, DHI Software.