RESEARCH ARTICLE OPEN ACCESS

Simulation of the Effect of Flow Velocity on Floating Sediment Concentration at the Jeneberang River Estuary with the Nays2DH Model

[1]Mukhsan Putra Hatta, [2]Vickky AnggaraIlham,[1]Evi Aprianti
[1]Department of Civil Engineering, Faculty of Engineering, Hasanuddin University
[2] Students of the Master Program in the Department of Civil Engineering, Faculty of Engineering, Hasanuddin University
Corresponding Author: Mukhsan Putra Hatta

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I. INTRODUCTION

The main problem that often occurs at river mouths is sediment deposition, causing a small flow that can interfere with the discharge of river discharge into the sea. this event resulted in the occurrence of current dynamics that affect the processes that occur in the estuary.

Analyze the flow patterns and sediments transport is one part of estuary engineering. For this reason, it is necessary to have a model that can simulate the dynamics of the estuary. The required model can be a physical model and a numerical model. One of the two-dimensional numerical models that can be applied to hydrodynamic cases is the Nays2DH model from iRIC (International River Interface Cooperative), a two-dimensional (2D) model that is capable of completing calculations of flow patterns, sediment transport, river bed changes and cliff erosion. Modeling simulation is in the Jeneberang river estuary in the city of Makassar.

II. LITERATURE REVIEW

A. Dynamic Fluid Computation Simulation

Computational fluid dynamics is a set of methodologies that allow computers to provide numerical simulations of fluid flow. The whole system, is transformed into a virtual form, and can be visualized through a computer.

B. The basic equation of the Nays2DH Model

The equation used is a two-dimensional unsteady flow in cartesian coordinates of the Continuity equation and Momentum equations. the basic Suspended sediment concentration equation is Lane Kalinske.

1. Continuity Equation

$$\frac{\partial h}{\partial t}+\frac{\partial (hu)}{\partial x}+\frac{\partial (hv)}{\partial y}=0$$

2. Momentum Equation

X axis direction

$$\frac{\partial (uh)}{\partial t}+\frac{\partial (hu^2)}{\partial x}+\frac{\partial (huv)}{\partial y}=-gh\frac{\partial H}{\partial x}-\frac{\tau_x}{\rho}+D^x+\frac{F_x}{\rho}$$

Y axis direction

$$\frac{\partial (vh)}{\partial t}+\frac{\partial (hv^2)}{\partial x}+\frac{\partial (huv)}{\partial y}=-gh\frac{\partial H}{\partial x}-\frac{\tau_x}{\rho}+D^x+\frac{F_x}{\rho}$$

3. Lane Kalinske Equation

$$q_{su}\,5.55\left[\frac{1}{2}\frac{u_*}{w_f}\exp\left(-\frac{w_f}{u_*}\right)\right]^{1.61} w_f r_b \qquad (4)$$

III. METHODOLOGY

A. Research types and variables

A simulation study of sediment transport and flow pattern in Jeneberang estuary is quantitative research that each stage of data analysis focuses on numeric data. This study is systematic - from the preparation of research, preparation of simulation modeling, implementation of modeling simulations until the writing of simulation results.

B. Simulation Procedure

Modeling simulation using the Nays2DH iRIC module software has three main stages namely pre-processing, solver, and post-processing. In the Pre-Processing stage generally contains data input on the software and the boundary conditions needed to run the simulation.

The solver stage can also be considered as the calculation phase of modeling simulation (running modeling) conducted by I-RIC software. Running modeling requires time depending on the ability of the computer to process it and the number of grids in the simulation and the amount of time step used. If a simulation failure occurs, a calculation window will pop up that fails, then it is necessary to double check the boundary conditions of the simulation, the simulation grid, or the included mapping attributes.

Post-Processing is the stage of presentation, analysis, discussion and conclusions of successful simulation results. Presentation of the results of the simulation can be either graphic or animated visualization about the conditions during the simulation modeling. The parameters that can be presented by the Nays2DH module on I-RIC software are flow depth, water level elevation, river bed changes, river bed elevation, froude numbers, vorticity, shield number, flow speed, suspended load flux, and bed load flux.

Sumber :(http://i-ric.org/en/introduction)

FIGURE 1 Chart of operation of the iRIC Software

C. Modeling Areas

To find out the distribution of Sediment Locations at the Jenenang River estuary, the modeling location is attempted to reach a location that allows it to still be affected by the hydrodymic process of the river estuary. The Modeling Area used is 351,000 m² using topographic and bathymetric data with a distance density of 20x20.

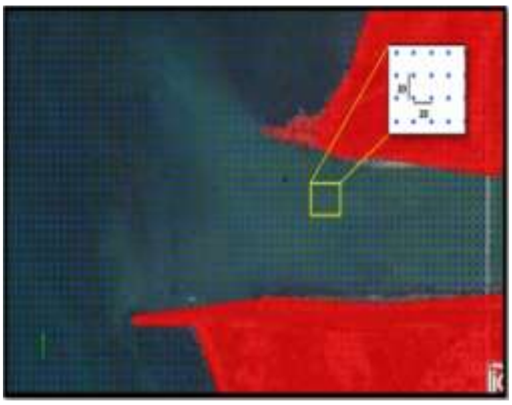

FIGURE 2 Topographic and bhatimetric points

The grid used in this simulation is grid i, j = (241x71), = 17,111 m² with a density at = 20 m and dj = 20 meters. The simulation limit width is 6000 meters from the initial point of the grid.

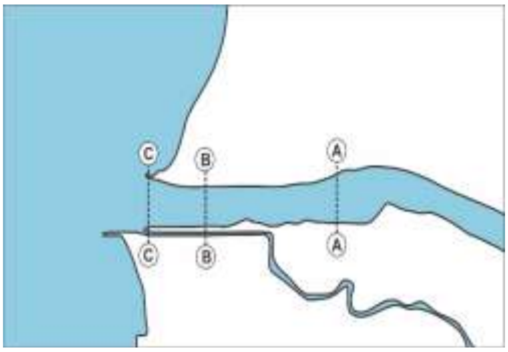

FIGURE 3 Location Cross section

Tabel 1. The location of the cross-sections on the grids of the models

Cross Section	Distance (m)	Grid	
		I	J
A	460	49	26 - 48
B	400	107	29 - 48
C	440	129	26 - 47

Grid cross section is used as data in analyzing and explaining all the hydrodynamic processes, especially the pattern of flow velocity and distribution of sediments that occur at the Jenenang river estuary. The results obtained are presented in the form of simulation results display and relationship graphs.

D. Discharge plan

Data analysis is intended to determine rainfall design, discharge plan flooding, and other hydrological characteristics. Hydrological analysis includes the analysis of rainfall data, design rainfall analysis, and the calculation of rainfall transfers to design flood discharge. The results of hydrological analysis are the discharge of flood design with various repetitive periods. The calculation of flood discharge design is based on the calculation of Hydrograph Synthesis Unit using Nakayasu method.

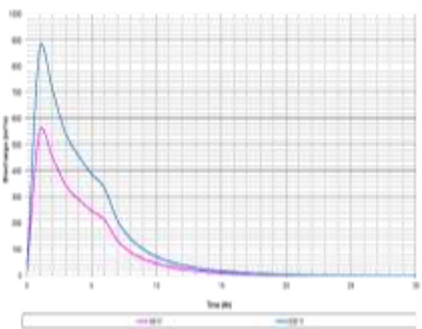

FIGURE 4 Synthesis Unit Hydrograph Nakayasu

Discharge plan used in the modeling are Q 5 years and Q 20 Years disputes because Q 20 years is assumed to be flood discharge and compare all parameters obtained with 2 return period debit comparisons.

E. Sediment Diameter

Determination of the diameter of the sediment in this case is through a filter analysis experiment conducted in a laboratory, so that from the results of these experiments we can get a uniform grain value or d50 from the sediment. The value of the diameter of the sediment grains (d50) obtained is = 4.76 mm.

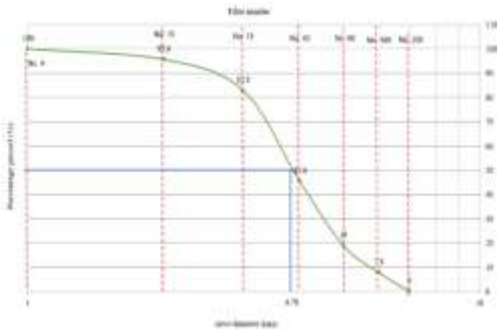

FIGURE 5 Graph analysis filter

IV. RESULTS AND DISCUSSION

A. Model validation and calibration

Speed validation consists of 5 points as shown in Figure 18, the results obtained are a percentage value of 6.06% to 9.83% the difference in the ratio of flow velocity of measurement in the field with the speed of the simulation results ranging from 0.07 - 0.3 m/s.

FIGURE 6 Location Measurement of flow velocity

Tabel 2. Validation of field measurement results with simulation results

Locations	current velocity measurement field (m/s)	current speed simulation results (m/s)	Difference (m/s)	Percentage (%)
A	4.97	5.27	0.3	6.036
B	2.32	2.51	0.19	8.190
C	3.05	3.35	0.3	9.836
D	4.45	4.53	0.08	1.798
E	3.15	3.22	0.07	2.222

B. Validasi HasilPerhitungan

To validate the calculation results from the Nays2DH modeling simulation the diffusion coefficient is used in the form of Courant numbers

$$Cr = \frac{U \cdot \Delta t}{\Delta x} \leq 0.5$$

If the Courant number (Cr) is smaller than 0.5, the numerical diffusion has no effect on the calculation results. But if the Courant number (Cr) is equal or greater than 0.5 the simulation results become incompatible with what actually happened to the problem being modeled.

Tabel 3.Calculation Validation with Courant Numbers

Locations	current speed simulation results (m/s)	Courant Number (Cr)
A	2.51	0.00502
B	4.53	0.00906
C	3.22	0.00644

C. HasilSimulasi

Modeling simulation in Jeneberang river estuary with Nays2DH model results obtained from the parameters of flow depth, flow level elevation, Sediment concentration and flow velocity patterns. The parameters obtained are used in data processing and analysis of flow and sedimentation patterns and the relationship graph between parameters. To further explain the results obtained, the modeling is divided into several cross sections, each result of the parameters obtained will be varied with a 5 year and 20 year discharge plan.

D. Flow Velocity Simulations

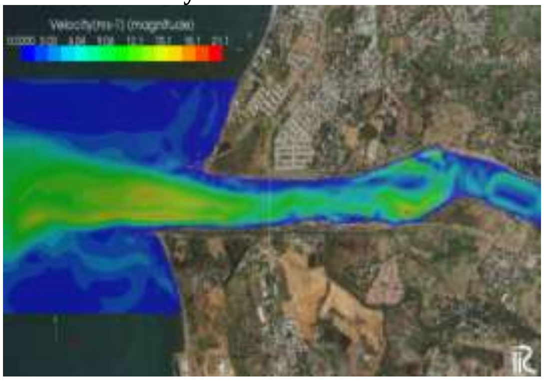

FIGURE 7 Velocity t = 3720 Q 5-Yr

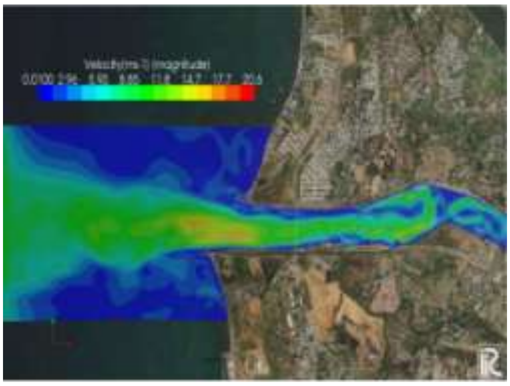

FIGURE 8 Velocity t=3720 Q 20-Yr

From the simulation results it can be seen the value of flow velocity in each section at discharge 5 years and 20 years. To better know the relationship between the results of the simulation, a graph of the results of each piece is made as shown in the graph below

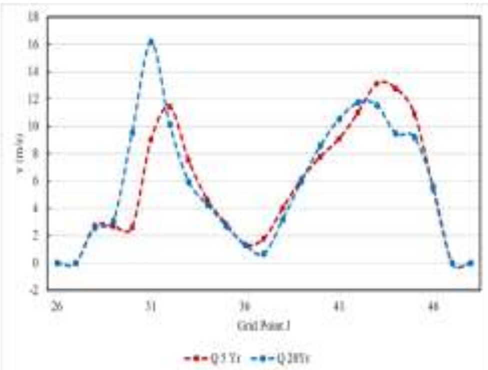

FIGURE 9 Velocity of sections A-A

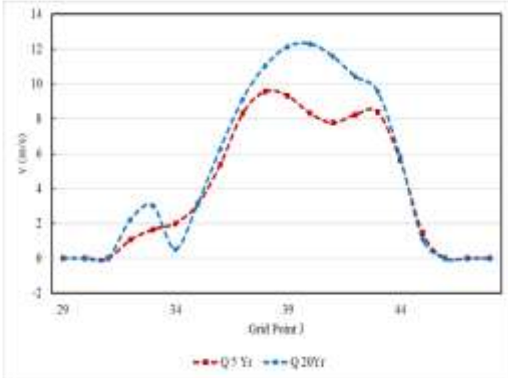

FIGURE 10 Velocity of sections B-B

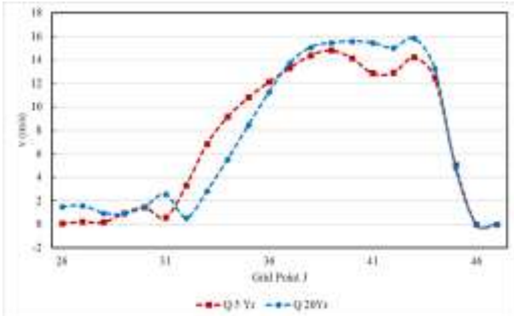

FIGURE 11 Velocity of sections C-C

From the graph the speed simulation results show that the highest flow velocity value on the discharge 20 year. Graph sections A-A piece graph shows the highest speed on Grid 31 on the discharge20 year. And on the 43 grid the highest speed on the discharge 5 year return period. Graph sectionsB-B shows the value of flow velocity at Q5 and A 20 years is very significant on grid 40. In the C-C section the velocity value model shows that there is a similarity between Q5 and Q 20 but the highest speed value still occurs in the Q 20 year.So that the simulation results look that the value of flow velocity is greatly influenced by the magnitude of the flow discharge that occurs.

E. Simulations Suspended sediment Concentration

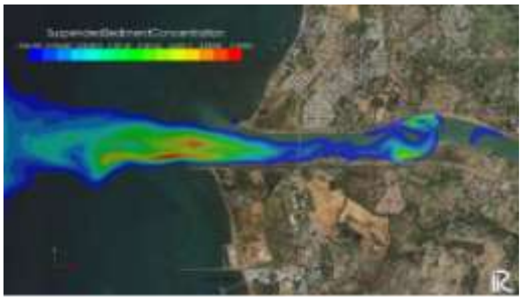

FIGURE 12 Suspended sediment Concentration t=3720 onQ-5 Yr

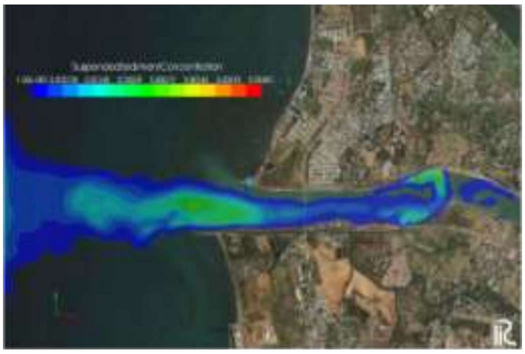

FIGURE 13 Suspended sediment Concentration t=3720 on Q-20Yr

From the simulation results it can be seen the floating sediment concentration of each piece as shown in the Graph below

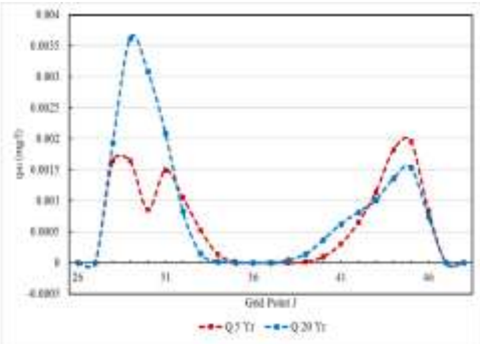

FIGURE 14 Suspended sediment Concentration section A-A

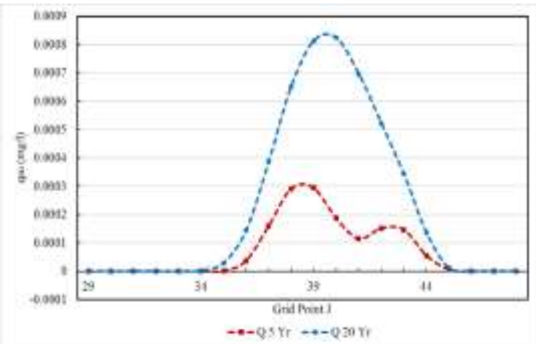

FIGURE 15 Suspended sediment Concentration section B-B

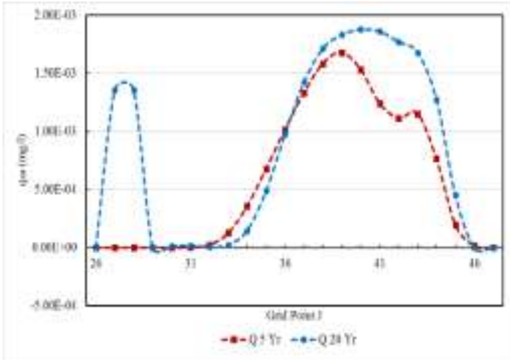

FIGURE 16 Suspended sediment Concentration section C-C

From the graph the simulation results in each repeat period have decreased concentration due to the discharge value at the end of the simulation has decreased and the flow forces acting on the sediment grains. so the discharge and flow velocity have a large influence on sediment concentration.

F. Relations between floating suspended sediment concentration and velocity.

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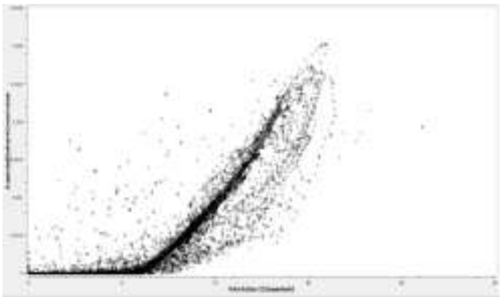

FIGURE 17 Relations between floating suspended sediment concentrationand velocity on t=3730 at Q-5Yr

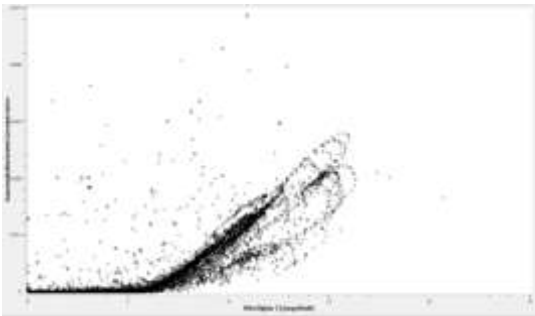

FIGURE 18 Relations between floating suspended sediment concentrationand velocity on t=3730 at Q-20 Yr

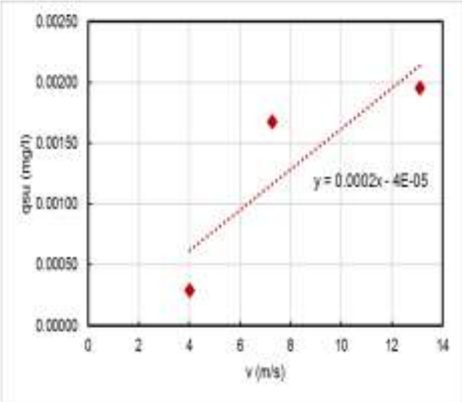

FIGURE 19 Relations between floating suspended sediment concentrationand velocity at Q-5 Yr

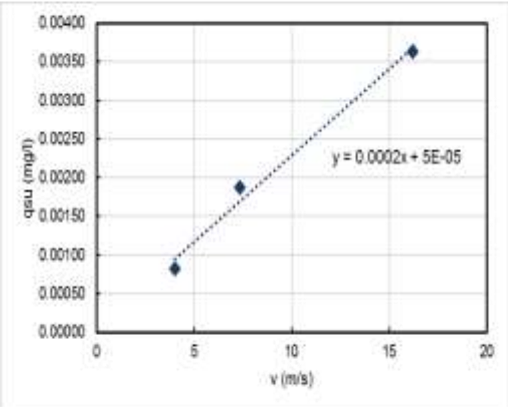

FIGURE 20 Relations between floating suspended sediment concentrationand velocity at Q-20 Yr

The results obtained in the relationship of flow velocity and Suspensed sediment concentration at Q-5 yr and Q-20 yr show that any increase in flow velocity is followed by an increase in floating sediment concentration at the same discharge.

V. CONCLUSIONS AND SUGGESTIONS

A. Conclusions

From the simulation results of suspended sediment concentrationsdischarge at Q-5 yrand Q-20 yr shows that sediment concentrations occur at greater than Q-5 yr than sediment concentrations at Q-20yr,this is caused by the effect of speed. The smaller the flow velocity, the large floating sediment concentration deposits and vice versa if the high flow velocity of the floating sediment concentration deposits is relatively small.

The flow velocity pattern that occurs at the Jeneberang river estuary has a different return period at the crossing point. The pattern of flow velocity is strongly influenced by flow discharge, river surface roughness and vortices. Pattern Distribution Sediment concentration of drift at the mouth of the Jeneberang river is influenced by discharge, topography, depth of flow, flow velocity, number and shear stress.

B. Suggestions

1. Further research is needed regarding the flow and sedimentation patterns that occur at the Jeneberang river estuary using the parameters of discharge and tide.
2. The accuracy of the simulation results needs to be tested more deeply through regular form so that it can be compared with the results of analytical calculations. For the form of complex models need to be done by comparing the results of physical models in the laboratory.

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