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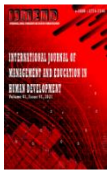

Effect of Flow Velocity on bedload Sediment Transport at the Jeneberang River Estuary with Nays2DH Model Simulation

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ABSTRACT

Numerical simulation modeling using the Nays2DH model from iRIC (International River Interface Cooperative) which is a two-dimensional (2D) model that examines problems in river estuaries both flow velocity and sediment distribution so that it becomes a reference in handling, planning estuary engineering and improving the optimization of river estuary functions. . The Nays2DH model simulation follows the structure of dynamic fluid computing, namely Pre-Processor, Solver and Post-Processor.

The methodology used is to apply it to the case of changes in sedimentary deposits in the estuary and compare the output with the theoretical predictions. A mathematical model is made based on a mathematical formulation that correctly describes the physical processes that occur, based on an appropriate solution method for the formulation. The basic equations in modeling are continuity, momentum, and sediment transport model equations Mayer-Peter and Muller

From the simulation results, the relationship between flow velocity and bottom sediment transport illustrates that the relationship that occurs is linear between the magnitude of the flow velocity followed by the value of the bottom sediment transport in each time period and the same discharge. So from these results, we get an equation of the relationship between flow velocity and bottom sediment transport for the 5-year return period discharge and the 20-year return period. The distribution of sediment at the mouth of the Jeneberang river shows that the bottom sediment transport is concentrated on the side of the mouth of the Jeneberang river. The flow velocity that occurs at the mouth of the Jeneberang river has a difference in each return period at the cross section point. Flow velocity is strongly influenced by flow discharge, river surface roughness, flow depth, flow velocity, froude number and shear stress.

Keywords : *Bedload Sediment, Flow Velocity. Nays2DH, iRIC*

I. INTRODUCTION

The main problem that often occurs in river mouths is sediment deposition, causing the appearance of the flow to be small which can interfere with the discharge of river discharge into the sea. This event resulted in the dynamics of currents that affect the processes that occur in the estuary. One of the efforts in estuary engineering is to analyze the flow patterns and sediment transport that occur. 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) which is a two-dimensional (2D) model that is able to complete calculations of flow patterns, sediment transport, river bed changes, and erosion that occur in riverbank. The location of the simulation of flow velocity and sediment transport modeling is at the mouth of the Jeneberang river, Makassar city.

II. LITERATURE REVIEW

2.1 Dynamic Fluid Computing Simulation

Computational fluid dynamics (computational fluid dynamics) are methodologies that allow computers to provide numerical simulations of fluid flow. The whole system, transformed into a virtual form and can be visualized via computer.

2.2 Sediment Transport Mechanism

Sediment grains in the flow will be subjected to forces that work both the forces that maintain the position of the grains and the forces that will make the sediment grains move. The forces acting on the grains are the forces acting in the vertical direction, namely the gravity of the grains, the buoyant force, and the hydrodynamic lifting force due to the flow, then the forces acting in the horizontal direction the frictional force, and the hydrodynamic drag force. Other parameters that cause sediment grains to move are water flow, flow velocity, and gradation of sediment grains. It is important to know the initial motion of the sediment grains because the initial motion of the sediment grains is a critical condition, namely the condition when the flow forces acting on the sediment grains reach a certain value.

2.3 The basic equation of the Nays2DH

The equations used are two-dimensional unsteady flow in Cartesian coordinates of the Continuity equation, the Momentum equations, and the Meyer-Peter and Muller sedimentary equations.

1. **C**ontinuity equation

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

2. Momentum equations

on the x axis direction $\frac{\partial(uh)}{\partial t}+\frac{\partial(hu^2)}{\partial x}+\frac{\partial(huv)}{\partial y}=-gh\frac{\partial H}{\partial x}-\frac{\tau_x}{\rho}+D^x+\frac{F_x}{\rho}$ on the 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. Meyer-Peter and Muller sedimentary equations

$$q_b=8\left(\tau_*-\tau_{*c}\right)^{1.5}\sqrt{s_g g d^3 r_b}$$

III. RESEARCH METHODS

3.1. Research type and variables

Simulation research on sediment transport and flow velocity at the mouth of the Jeneberang river is quantitative, namely research in which each stage of data analysis focuses on data in the form of numbers. This research is also made systematically starting from research preparation, preparation of simulation modeling, implementation of modeling simulations to writing simulation results.

3.2. Simulation Procedure

The modeling simulation using the iRIC software, the Nays2DH module, has three main stages, namely pre-processing, solver, and post-processing. The Pre-Processing stage generally contains input data on the software and the boundary conditions required to run the simulation. This solver stage can also be said to be the calculation stage of the modeling simulation (running modeling) carried out by the iRIC software. Running modeling takes time depending on the ability of the computer to process it and the number of grids in the simulation and the number of time steps used. In the event of a simulation failure, a pop-up window for a failed calculation will appear, it is necessary to re-check the simulation boundary conditions, the simulation grid, or the attributes mapping entered. Post-Processing is the stage of presenting, analyzing, discussing, and giving conclusions from the successful simulation results. The presentation of the simulation results can be in the form of graphics or moving animation visualizations about the modeling conditions during the simulation time. The parameters that can be presented by the Nays2DH module in the I-RIC software are flow depth, water level elevation, river bed changes, river bed elevation, Froude number, vorticity, shield number, flow velocity, suspended load, and bedload.

3.3. Modeling Area

To find out the distribution of sediment locations at the Jeneberang River estuary, the modeling location is endeavored to reach locations where it is possible to still get the influence of the hydrodynamic process of the river estuary. The modeling area used is 351,000 m² using topographic and bathymetric data with a density of 20x20.

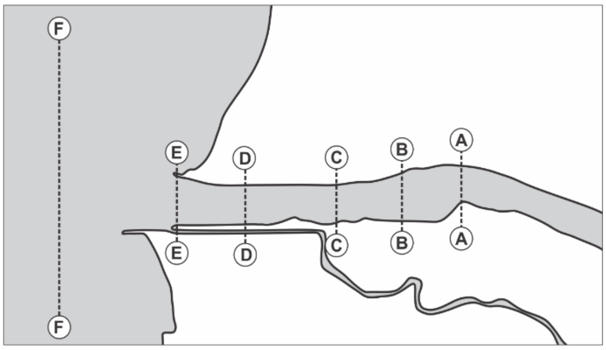

Figure 1. Modeling Area **Cross section of the model**

The grid used in this simulation is a grid of i,j = (241x71), = 17,111 m² with a density of di=20 m and dj = 20 meters. The width of the simulation boundary is 6000 meters from the starting point of the grid. The cross-sectional grid is used as data in analyzing and explaining all hydrodynamic processes, especially the pattern of flow velocity and distribution of sediments that occur at the mouth of the Jeneberang river. The results obtained are presented in the form of a display of simulation results and relationship graphs.

3.4. Discharge Plan

This data analysis is intended to determine the design rainfall, design flood discharge, and other hydrological characteristics. The hydrological analysis includes analysis of rainfall data, analysis of design rain, and calculation of rain transfer to design flood discharge. The result of the hydrological analysis is the design of flood discharge with various return periods. The calculation of the design flood discharge is based on the calculation of the Synthesis Unit Hydrograph (HSS) using the Nakayasu method.

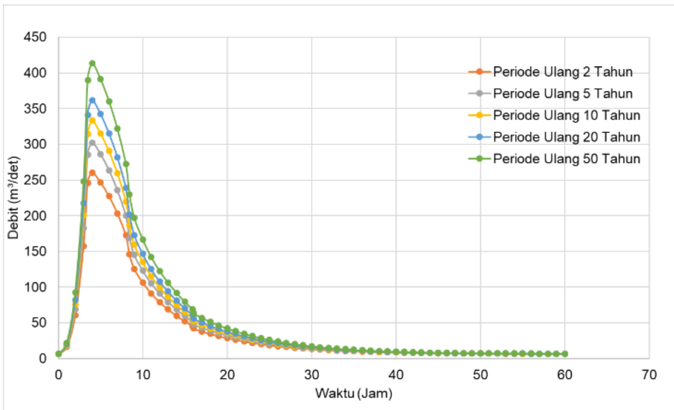

Figure 3. Hidrograf Satuan Sintesis (HSS) Nakayasu

The discharges used in the modeling are Q 5 years and Q 20 years with the reason that Q 20 years is approaching flood discharge and this study focuses on comparing the parameters of the results obtained in the simulation with 2 comparisons of the discharge period.

3.5. Sediment Diameter

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

IV.RESULTS AND DISCUSSION

4.1. Model validation and calibration

Velocity validation consists of 5 points as shown in Figure 18, the results obtained are percentage values of 6.06% to 9.83% the difference between the comparison of flow velocity measurements in the field with the simulation results ranging from 0.07 to 0.3 m/s

Figure 4. Location of Flow Velocity Measurement

Table 1. Validation of field measurement results with simulation results

Lokasi	Kecepatan Pengukuran Lapangan (m/s)	Kecepatan Hasil Simulasi (m/s)	Selisih (m/s)	Percentage (%)
A	1.30	1.34	0.045	4.500
B	0.73	0.79	0.061	6.100
C	0.76	0.81	0.047	4.700
D	0.52	0.57	0.051	5.100
E	0.28	0.32	0.045	4.467

Comparison of flow velocity measurements in the field with the speed of the simulation results. Velocity validation consists of 5 points as shown in Figure 17, the results obtained are percentage values of 4% to 6% the difference between the comparison of flow velocity measurements in the field with the simulation results ranging from 0.045 to 0.041 m/s.

4.2. Calculation result validation

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

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

If the Courant number (Cr) is less than 0.5, the numerical diffusion has no effect on the calculation results.

Table 2. Validation of calculations with Courant bilangan numbers

Lokasi	Kecepatan Pengukuran Lapangan (m/s)	Bilangan Courant (Cr)
A	1.34	0.0168
B	0.79	0.0198
C	0.81	0.0203
D	0.57	0.0143
E	0.32	0.0080

The results obtained from the validation of calculations with Courant numbers are that Cr is less than 0.5 so that the simulation model used is close to the actual situation.

4.3. Simulation results

Modeling simulations at the Jeneberang river estuary with the Nays2DH model obtained results from parameters of flow depth, flow level elevation, bottom sediment transport and flow velocity patterns. The parameters obtained are used in data processing and analysis of flow and sedimentation patterns as well as graphs of the relationship 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 5-year and 20-year planned discharges.

The flow distribution pattern at the Jeneberang river estuary can be seen from the simulation results that there are similar flow patterns from each return period, but the flow velocity is different in each cross-section, this is influenced by river morphology, flow rate, flow velocity, and flow rotation. As in the flow pattern around the river meander, it rotates (vortices) due to the force that arises because the flow hits the river wall. This flow pattern causes sediment deposition. This event occurs starting from the upstream side of the river when there is a downward flow pattern and the flow velocity will reverse vertically, and the flow is followed by the carrying of the basic material so that a spiral flow is formed in the area around the river meander.

The flow conditions that form the vortex have an impact on the erosion of the riverbed, namely by being carried away or transported by the riverbed material which will result in the emergence of sediment deposits. This event continues until there is a balance that occurs in the flow of the river. vector flow pattern on each piece of scalar shape at Q 5 years and Q 20 years

4.4. Velocity simulation

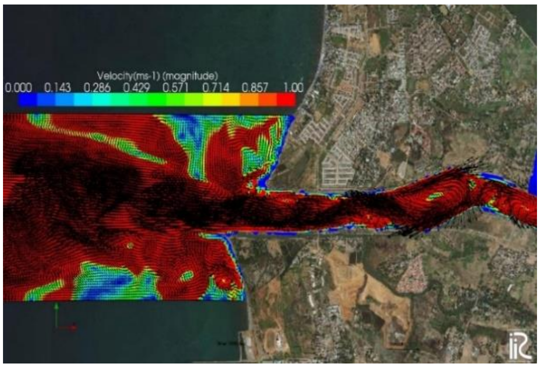

Figure 5. Velocity t=1200 Q 5-Yr

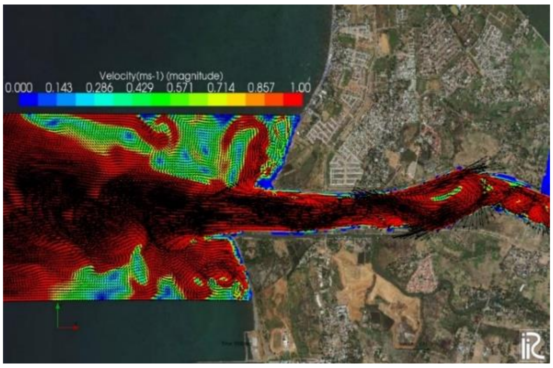

Figure 6. Velocity t=1200 Q 5-Yr

In cross section A-A the average discharge in Q5 years is 0.565 m/s in Q 20 years is 0.361 m/s, B-B cuts in Q5 years average discharge is 0.516m/s in Q 20 years is 0.762 m/s. The results obtained are that the speed value of Q 5 years is greater than Q 20 years, which occurs in Pieces A-A, and F-F, the value of speed Q 20 years is greater than Q 5 years, which occurs in pieces B-B, C-C, D-D, and E-E.

Table 3. Average speed of cross section

Potongan	Kecepatan Rata-Rata (m/s)	
	Q 5 Thn	Q 20 Thn
A - A	0.565	0.361
B - B	0.516	0.762
C - C	0.191	0.858
D - D	0.014	0.916
E - E	0.269	0.357
F - F	0.866	0.032

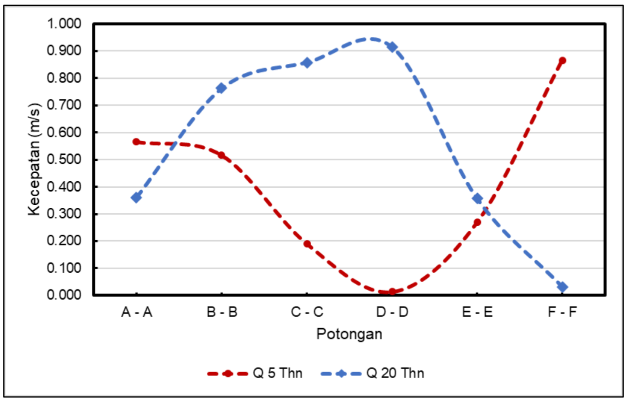

Figure 7. Average Velocity relationship graph in cross-section

The graph above illustrates the flow velocity at each cross-section. In sections A, B, C, D, it can be seen that the maximum velocity value occurs at the 20 year Q discharge. From the velocity data in the cross-section, it can be seen the value of the average velocity and the maximum velocity to see the relationship between the velocity of the flow in each section. The results obtained from the average velocity data for each slice at the 20-year return period discharge are a decrease in speed from the D-D Piece = 0.916 m/s to the F-F cut = 0.032 m/s. This is caused by the relationship between the input discharge of the return period Q 5 years and Q 20 years with the cross-sectional distance.

From the graph, the speed simulation results show that the highest flow velocity value is at discharge for a 20 year return period. The AA section graph shows the highest speed on Grid 31 at a 20 year discharge period. And in Grid 43 the highest velocity is at a 5 year return discharge. The value of flow velocity at Q5 and A 20 years is very significant on grid 40. In the CC cut, the velocity value increase model shows that there are similarities between Q5 and Q 20 but the highest velocity value still occurs in the discharge period Q 20 years. So from the simulation results, it can be seen that the value of the flow velocity is strongly influenced by the magnitude of the flow discharge that occurs.

4.5. Bedload sediment Transport Simulation

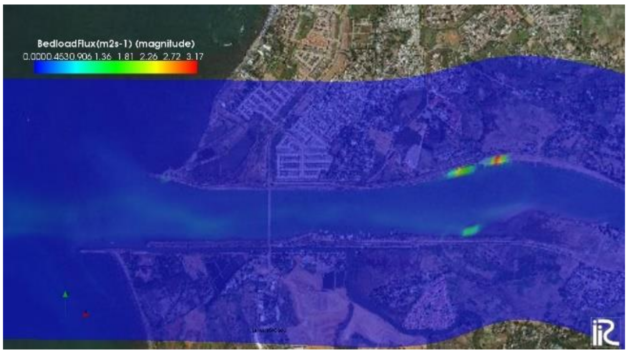

Figure 8. Bedload Sediment t=3540 on Q 5 Yr

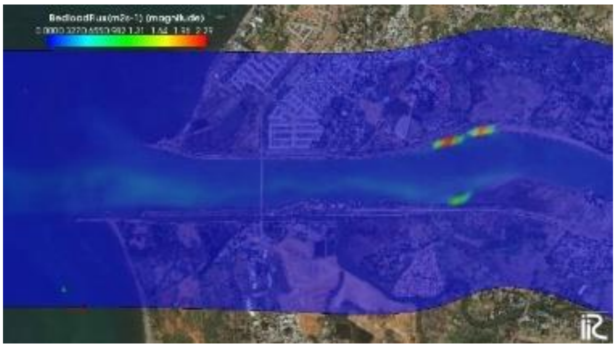

Figure 9. Bedload sediment t=3540 on Q 20 Yr

Simulation results on the cross-section of AA at the position of points 27 and 32 of the bottom sediment transport that occurs tend to be the same but at the position of the location of point 37 the value of bottom sediment transport at Q 5 years = 0.0025 m²/s tends to be greater than the discharge Q 20 years = 0.001 m² /s

Table 4. Transport of bedload sediment mean cross-section

Potongan	Angkutan Sedimen Dasar Rata-Rata (m²/s)	
	Q 5 thn	Q 20 thn
A - A	0,0006	0,0004
B - B	0,8638	0,8291
C - C	0,0363	0,0864
D - D	0,0124	0,0124
E - E	0,0682	0,0960
F - F	0,0418	0,0241

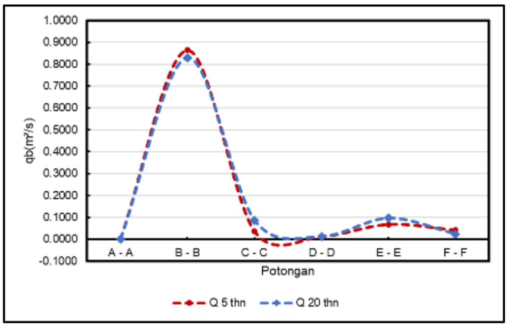

Figure 10. Average bedload sediment relationship graph in cross-section

the scalar display shows that the bottom sediment transport occurs in the river meander of 0.8638 m² / s in Q 5 years while at Q 20 years it is 0.8291 this is because the flow velocity that occurs is experiencing and deflection by river walls which causes bottom sediment to be retained and this process which causes changes in the elevation of the riverbed. The distribution pattern of floating sediment concentration and bottom sediment transport at the mouth of the Jeneberang river is influenced by discharge, topography, flow depth, flow velocity, Shields number, and shear stress. So it can be concluded that the distribution of bottom sediment transport that occurs is influenced by the width of the river, the flow rate, and the forces acting on the sediment grains.

4.6. Relationship of flow velocity with bedload sediment transport

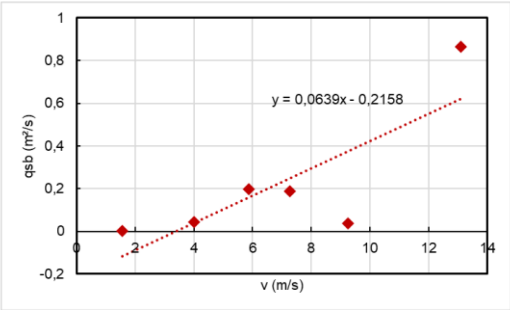

Figure 11. Relationship of flow velocity with bedload sediment transport at Q-5 Yr

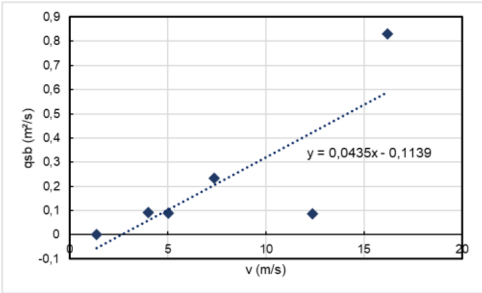

Figure 12. Relationship of flow velocity with bedload sediment transport at Q-20 Yr

From the simulation results, the relationship between flow velocity and bottom sediment transport illustrates that the relationship that occurs is linear between the magnitude of the flow velocity followed by the magnitude of the bottom sediment transport value in each time period and the same discharge. So from these results, the equation for the relationship between flow velocity and bottom sediment transport is y = 0.0639x - 0.2158 for 5-year discharge and Y= 0.0435x - 0.1139 for 20-year discharge.

V.CONCLUSIONS AND SUGGESTIONS

5.1. Conclusions

The distribution of sediment at the mouth of the Jeneberang river shows that the bottom sediment transport is concentrated on the side of the mouth of the Jeneberang river. The flow velocity that occurs at the mouth of the Jeneberang river has a difference in each return period at the cross-section point. Flow velocity is strongly influenced by flow discharge, river surface roughness. flow depth, flow velocity, Froude number, and shear stress. The relationship between flow velocity and bottom sediment transport illustrates that the relationship that occurs is linear between the magnitude of the flow velocity followed by the magnitude of the value of bottom sediment transport in each time period and the same discharge.

5.2. Suggestions

1. There is a need for further research on sedimentation transport that occurs at the mouth of the Jeneberang river using discharge and tidal parameters.
2. The level of accuracy of the simulation results needs to be tested more deeply through the form of the model so that it can be compared with the results of the analytical calculations.
3. For complex models, it is necessary to compare the results of physical models in the laboratory.

REFERENCES

Amini, A., Heller, P., Cesare, G. D., Schleiss A. J. 2014. Comprehensive Numerical Simulations of Sediment Transport and Flushing of a Peruvian Reservoir. *Reservoir Sedimentation*. P: 211-9.

Arafat, Y., Pallu, M. S., Maricar, F., Lopa, R. 2016. *Hydrodynamics and Morphological Changes Numerical Model of the Jeneberang Estuary. Int. J. Innov. Res. Adv. Eng*. 8:21-9.

Ali, Md. S., Hasan, Md. M., Haque, M. 2017. Two-Dimensional Simulation of Flows in an Open Channel with Groin-Like Structures by iRIC NAYS2DH. *Math Probl Eng*. P: 1-10.

Baja, S., Ramli, M., Lias, S. A. 2009. Spatial-Based Assessment of Land Use, Soil Erosion, and Water Protection in The Jeneberang Valley, Indonesia. *Biologia*. 64.3: 522-26.

Brunner, G.W. 2016. HEC-RAS : River Analisys System Hydraulic Reference Manual Version 5.0. US Army Corps of Engineers : Hydrolic Engineering Center. Davis.

Hatta MP. *Simulasi Model Banjir Dua Dimensi Nays2d Flood-Iric Pada Hilir Das Jeneberang*.makalah disajikan dalam Pertemuan Ilmiah Ke-36 HATHI.Kupang 2018

Istiarto. 2014. Materi Kuliah Transpor Sedimen : Model Hidrodinamika CFD dibidang Hidraulika Saluran Terbuka.Universitas Gadjah Mada. Yogyakarta.

Jhon D, Anderson,JR.(1995).Computational Fluid Dinamycs.New York.McGraw-Hill,Inc.

Liu, L., Zhu, H., Huang, C., Zheng, L. 2018. Evolution Mechanism of Meandering River Downstream Gigantic Hydraulic Project I: Hydrodynamic Models and Verification. *Math Probl Eng*. P:1-21.

Liu, W., Hsu, M., Kuo, A. Y. 2002. Modelling of Hydrodynamics and Cohesive Sediment Transport in Tanshui River Estuarine System, Taiwan. *Marine Poll Bull*. 44: 1076-88.

Lakatua,M.P.2017.Model numerik pola sebaran sedimen di teluk Ambon luar.Tesis tidak diterbitkan.Makassar:Fakultas Teknik.Universitas Hasanuddin

Manual.U.S.Department of the Interior Bureau of Reclamation.Colorado

Nelson, J. M., Shimizu, H., Takebayashi, H., McDonald, R. R. 2010. The International River Interface Cooperative: Public Domainsoftware for River Modeling. *2ndJFIC2010*.

Shimizu Y,Inoue T,Hamaki M,Iwasaki T.2011. Nays2DH Solver Manual.River center.Hokkaido

Osman, Y., Rahim, R., Pallu, S., Baja, S. 2016. GIS-3D Analysis of Susceptibility Landslide Disaster in Upstream Area of Jeneberang River Watershed, South Sulawesi, Indonesia. *Int. J. Innov. Res. Adv. Eng.* 8:1-9.

Pan, C., Huang, W. 2010. Numerical Modeling of Suspended Sediment Transport Affected by Tidal Bore in Qiantang Estuary. *J. Coast. Res*. 6:1123-32.

Sarkawt Hamarahim Muhammad.2017. Aplication of numerical modeling to Studi River dinamics:Hidro-geomorphological evolution due to extreme events in the Sandy River,Oregon.tesis Tidak diterbitkan.Oregon.Civil and Environmental Engineering.Portland State University.

SRTM DEM. Shuttle Radar Topography Mission, https://earthexplorer.usgs.gov/ [diakases pada 18 agustus 2019]

Sakka.2012. *Model perubahan garis pantai disekitar delta sungai jeneberang,Makassar,Sulawesi Selatan*.Disertasi tidak diterbitkan.Bogor:Sekolah Pasca Sarjana.Institut Pertanian Bogor.

Trevethan, M., Ianniruberto, M., Oliveira, M., Martilinne, A., Filizola, N., Gualtieri, C., Hydrodynamic and Morphodynamic Features Observed about The Confluence of the Negro and Solimões Rivers, Brazil.

Tri Nur Cahyo.2012. Hidrodinamika dan sebaran materi padatan tersuspensi di perairan pelawangan barat,segara anakan Cilacap.Tesis tidak diterbitkan.Bogor.Sekolah pascsarjana. Institut Pertanian Bogor

Triatmodjo,B.1999.Teknik pantai.Yogyakarta:Beta Offset.

Triatmodjo,B1995.Hidraulika II.Edisi II. Beta Offset:Yogyakarta

Triatmodjo,B.2012.Hidraulika I.Cetakan Ke-13. Beta Offset:Yogyakarta

Triatmadja,R.2016.Model matematik Teknik pantai.Yogyakarta:Beta Offset.

Triatdmodjo. (2001). Penggunaan Metode Interpolasi Polinomial untuk mendapatkan ketelitian tinggi dalam penyelesaiaan persamaan transpor.FORUM TEKNIK Jilid 25,No 1

Versteeg H K,Malalasekera W.1995.An introduction to Computational Fluid Dynamics the finite volume method.London:Longman Group Ltd.

Wang, C. H., Wai, O. W. H., Hu, C. H. Three-Dimensional Modeling of Sediment Transport In The Pearl River Estuary. *Workshop on Advanced Computational Modelling In Hydroscience & Engineering.*

Wongsa, S. 2014. Simulation of Thailand Flood 2011. *IJET*. 6: 452-8.

Yung-ping, Y., Ming-jin, Z., Yi-tian, L., Wei, Z. 2015. The Variations of Suspended Sediment Concentration in Yangtze River Estuary. *J. Hydrodyn*. 27.6: 845-56.