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Interpretation of Regression Model for Changes in The Main Estuary Flow Ranoyapo Amurang River

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Abstract
The physical study of changes in flow mass along the Ranoyapo river estuary can be based on position and time distributions for physical variables of flow density. Analysis of this variable and its changes along the river estuary can show the process of erosion or sedimentation that occurs in the estuary area. Data availability and physical variable profile of mass flow density produce function and rating curve of variable changes in flow density along the Ranoyapo river estuary at low tide and tide, which can then be useful to evaluate the process of transport material distribution which includes bed load, suspended load, and wash load along the river estuary. The analysis includes, (1) data multiplication techniques, (2) data modeling techniques for determining the rating curve for flow density variables. For modeling purposes, data is duplicated using linear interpolation techniques. The modeling of river flow mass yields the function and rating curve of changes in river flow mass density along the Ranoyapo Amurang estuary. Interpretation of the function, rating curves ρ_0, and $\rho_{0,6h}$ during low tide and high tide indicate that during low tide, there has been a deposition of the baseload, with a large proportion (decrease in gradient $\rho_0$which is quite large), while the deposition of the load rinse and baseload is relatively small (gradient $\rho_{0,6h}$ close to zero). At high tide, the baseload deposition in the estuary area increases, and the accumulation area shifts upstream following an increase in sea level. At high tide, the deposition of rinse loads and drift loads also increase, and the deposition area also expands due to shifting the position of the two function boundaries upstream, following sea-level rise. If the seawater moves back down, the sedimentation of the baseload, the drift load, and the wash load decreased.

Keywords: Interpretation, Model, Regression, Mass Density, Flow

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INTRODUCTION

Transport material determines changes in the concentration of mass density of river estuaries includes bed load, suspended load, and wash load. The quantity of transport material at one river cross-section can be expressed in terms of flow mass density (total mass of water plus volume unity transport material). Analysis of flow mass density variables and their changes along river estuary mathematically for data modeling and interpolation results can be described in the form of functions and rating curves, for partially and integrated can study the characteristics of river flow. The research will describe the physical variable profile of mass flow density which is then useful for evaluating the distribution process of transport material along river estuary.

Physical studies of changes in flow mass along the Ranoyapo river estuary can be based on the position and time distribution of physical variables of flow density. These physical variables are partially or integrated used by experts in assessing river flow characteristics (Bartnik et al, 1992; Billi and Paris, 1992; Foster et al., 1992, Jansson, 1992). Analysis of this variable and its changes along the river estuary can indicate erosion or sedimentation processes that occur in the estuary area. The availability of data and profile of physical variables of the mass density of river flow can be used as a reference for the determination of management and control policies for the utilization of Ranoyapo river resources. Theoretically, the function and rating curve of mass flow density according to the distance along the river estuary for the density data measured at a point around the mid-depth and approaching the river bed will show changes in the level of erosion and sedimentation of the river bed in the estuary area.

Data availability and physical variable profile of mass flow density produce function and rating curve of variable changes in flow density along the Ranoyapo river estuary at low tide and tide, which can further be useful for evaluating the process of transport material distribution which includes the bedload, load suspended load, and wash load along the river estuary.

The purpose of the study will be to interpret the function regression equation model and the rating curve of variable changes in flow density along the Ranoyapo river estuary at low and high tide.

LITERATURE REVIEW

Flow mass density is the mass of a water sample (containing sediment) per sample volume. Flow mass density indicates the concentration of sediment transported through a cross-section. Because the composition of the drift load is greater, then theoretically the profile of the flow density in the vertical direction, the drift load carried by the flow gets to the bottom of the river the greater the concentration.

This is according to the results of research by Kumajas Marthen (2005) which shows the vertical profile of mass flow density is in the form of negative exponential functions.

Jansson (1992) who measured and examined the relationship between rain duration, flowrate, and transport sediment concentration, found a significant relationship in the form of log-linear regression function between duration and discharge, between duration and concentration and log regression function between flowrate and concentration, suspended sediment.

R. J. Unclesand J. A. Stephens (2010), J. Z. Shi (2010), who conducted sediment transport research stated that in river flow, the amount of sediment transported depends on hydraulic conditions (flow velocity, turbulence, and slope of the river's bed). The relationship of floating sediment concentration to flow discharge is the relationship between flow density containing rinse loads and drift loads with flow discharge. This relationship shows that increasing the flow rate will increase the mass density of the flow.

Physical analysis of flow mass density variables is conducted between segments along the Ranoyapo Amurang river estuary in North Sulawesi Indonesia, (Maxi Tendean, 2019), which includes measurement data on the surface near the river bed (ρo) and measurement results at 0.6 depth (ρo,6h) provide a description, interpolation and accuracy of modeling determined based on the average bias value of the percentage of modeling results to interpolation results of data smaller than 5%, resulting in an exponential function of mass flow density at layers near the river bed surface (0) at low tide and attach to the general form:

$$\square_0 = k_0 + k_1 e^{-k2X} \qquad (1)$$

Interpolation and modeling of the flow mass density function at ($\square_{0,6h}$) produce a series of data for low and tide conditions. The accuracy of modeling is shown by the average bias of 5% smaller. The function of modeling results at low tide is a linear function with a negative gradient, the general form of the equation:

$$\square_{0,6h} = k_0 - k_1 .x \qquad (2)$$

where x is the distance from the reference point, k0 and k1 are constants, and the density function coefficient ($\square_{0,6h}$ respectively).

In the measurement conditions ($\square_{0,6h}$) when the tide changes sharply around the 305-meter position, the data modeling should be done separately for a range of 82 m m ≤ x < 305 m and 305 m m ≤ x ≤± 655 m. For 82 m ≤ x < 305 m the modeling function produces an equation:

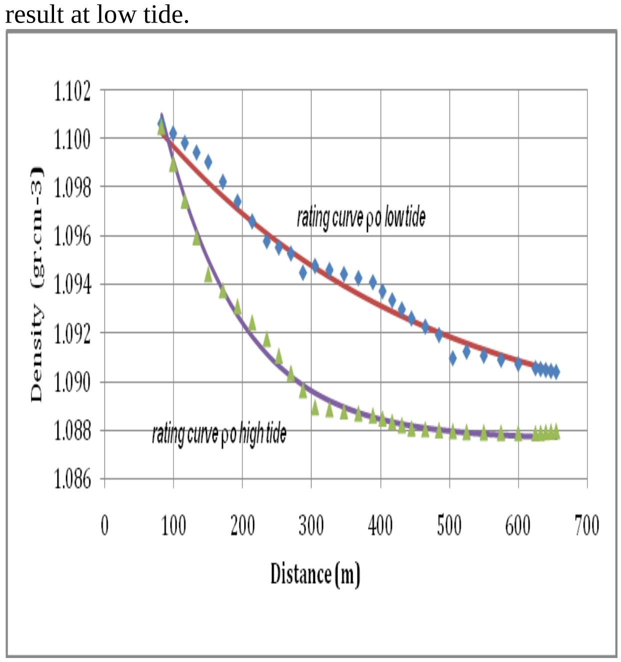
$$\square_{0,6h} = k_0 - k_1.x^{k2} \qquad (3)$$

where x is the distance along the estuary, calculated from the reference point. Constants k0, coefficients k1 and rank k2. For 305 m x 5 655 m, the modeling function produces a linear equation with a negative gradient of its general shape:

$$\square_{0,6h} = k_0 - k_1.x \qquad (4)$$

With the constant k0 and the coefficient of the function k1.

The rating curve of the modeling function and the interpolation data plot ($\square_{0,6h}$) at high tide are presented in Figure- (1) the rating curve of the data modeling result at low tide.



Picture 1. *Rating Curve* ρ_o at high and low tide.

Rating Curve (ρo) at low and high tide and interpolation plot data for low and tide are presented in Figure- (2).

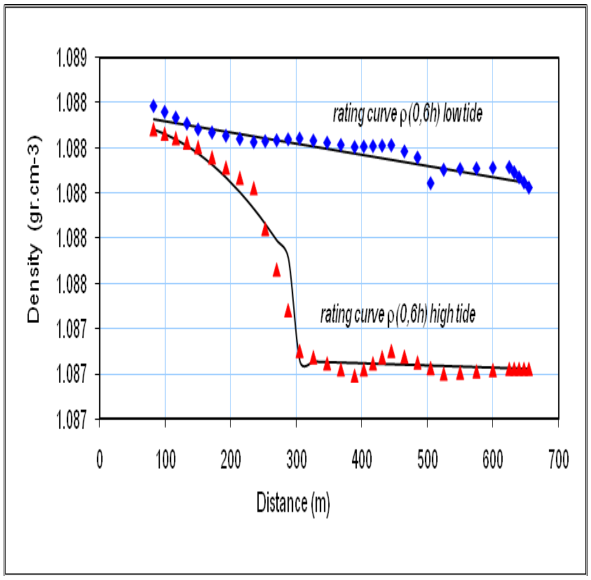


Figure-2. *Rating Curve* ($\rho_{o)}$ and ($\rho_{o,6h}$) at high and low tide.

Analysis and modeling of mass density data flow along the Ranoyapo Amurang river, producing a function and rating curve, (Maxi Tendean, 2019), as follows:

1. Density function and rating curve (ρ_0 for low tide in the form of exponential functions with general shapes such as equation- (1) and figure- (1)
2. The density function (ρ_0 for tides is in the form of an exponential function with general shapes like an equation- (1) and figure- (1)
3. The density function ($\rho_{0,6h}$) for the low tide is in the form of a linear function with a negative gradient; general form such as equation- (2) and figure- (2)
4. The density function ($\rho_{0,6h}$) for tides consists of two functions with general shapes such as equation- (3) and figure- (2) (for a range of 82 MX <305 m) and equation- (4) and pictures- (2) (for a range of 305m x 655 m.

The regression function (equations 1-4) and rating curve (figure1-2) from the modeling results of Ranoyapo Amurang estuary flow mass density, can interpret changes in flow mass density along the Ranoyapo Amurang river, and then evaluate the process of settling material transport (bed load, suspended load and wash load) along the river estuary.

METHOD

In general, this study would like to examine the physical variable changes in flow mass density along the Ranoyapo Amurang River in North Sulawesi, Indonesia, which is defined as the mass of water (containing sediment) per sample volume. Density data for each measurement point is obtained by dividing the mass data of the water sample by its volume using the equation:

$$\rho = \left(\frac{m}{V}\right) \qquad (5)$$

where m is the sample mass and V is the sample volume. The unit of measurement results is expressed in grams.cm-3 or kg/liter-[1]. Flow mass density data for each segment includes measurement data at the rivers bed surface layer (ρ_0) and measurement data at 0.6 depth ($\rho_{0,6h}$). To analyze physical function changes and determine the density variable rating curve flow mass along the river estuary, the flow path is determined based on the flow vector direction and flow segment according to river width, this can be done for the description of changes in flow density variables can steady, non-turbulent assumptions and cooperation.

Variation in flow mass density in the vertical direction requires measurement at 2 discrete points in the vertical direction. Because the spread of drift loads is more determined by hydrological parameters for data collection can be simplified by developing a "sediment rating curve" which connects the data of mass flow density to flow discharge.

Analysis of the data used includes (1) data doubling techniques, (2) data modeling techniques for determining the rating curve for variable flow density. For modeling purposes, data were duplicated using linear interpolation techniques such as those conducted by Foster et al. (1992), Kumajas Marthen (2005), Tendean Maxi, M. Bisri, M. Lutfi Rayes and Zetly E. Tamod.2012. The general form of the data interpolation equation (Cheney and Kincaid, 1994) is:

$$p(x) = y_0 + \frac{y_1 - y_0}{x_1 - x_0}(x - x_0) \qquad (6)$$

where (x0, y0) and (x1, y1) are the two coordinates (data pair independent variable and dependent variable) for which the price is known. p (x) is the dependent variable price for the price of the independent variable x. Modeling research variable data as a function of distance x is the process of determining the coefficients and constants of an experimental function, which are formulated based on the distribution of measurement results and interpolation data. Correlation criteria used are r> 0.99 and the average percentage bias of the modeling data to the interpolation data of <5% which then generates a general equation with the shape of the regression function and rating curve of the mass density of the flow along the estuary. The regression function and rating curve will describe and evaluate the process of transport material distribution along the river estuary of the Ranoyapo Amurang.

RESULTS AND DISCUSSION

The modeling of river flow mass density data at depths approaching the river's bed produces a flow mass density function as shown in equation (1) with a rating curve shown in figure-1. *Rating curve* $\square_0$ at low and tide, for *Rating curve* $\square_0$ modeling results (full line) and data interpolation plot data (rectangular box) measurements at low tide are located higher than the rating curve and data interpolation plot $\square_0$ at high tide. Up to a distance of 400 meters from the reference point, *Rating curve* $\square_0$ at high tide has a larger gradient compared to the rating curve at low tide, but for a distance of x> 400 meters, the rating curve becomes flat and shows from that position to the measurement location limit, water mass density becomes the same. This occurs because of the intermingling of the seawater mass with the rinse load and the floating load carried by river water, while the baseload has been deposited more upstream and causes the curve to become more curved.

Measurement results, interpolation, modeling, and rating curve density at the point of 0.6 depth ($\square_{0,6h}$). The function of modeling results at low tide is a linear function with a negative gradient, with the general form of equation (2). *Rating curve* $\square_{0,6h}$ and the $\square_{0,6h}$ interpolation plot data are presented in Figure-2. The rating curve of the modeling result (full line) shows a linear decrease in density with increasing distance, while the interpolation result data (rectangular box) resides around the graph of the modeling results.

The measurement data of $\square_{0,6h}$ at high tide shows a sharp change around the position of 305 meters, the The measurement data of $\rho_{0,6h}$ at high tide shows a sharp change around the position of 305 meters, the data modeling should be done separately for a range of 82 m ≤ x < 305 m and 305 m ≤ x ≤ ± 6555 m. At position 82 m ≤ x < 305 m, it produces equation (3). For 305 m ≤ x ≤ ± 655 m, produce equation (4).

Equation (4) is a linear equation with a negative gradient where the density decreases with increasing distance (along with the estuary) of the reference. The value of k1 is so small that the density for positions ± 305 m to the measurement limit (± 655 m) is almost constant. The average percentage of modeling bias for the range 82 m ≤ x < 305 m and 305 m ≤ x ≤ ± 655 m, respectively 0.00605 and 0.002, while the average percentage of bias for 82 m ≤ x < 655 m, amounting to 0.003 (smaller than the modeling criteria 5%). The curve rating function of the modeling results and plot of interpolation data $\rho_{0,6h}$ at high tide is presented in Figure-2. along with the rating curve resulting from modeling the data at low tide.

The combined rating curves (ρ_0 dan $\rho_{0,6h}$), the measurement results at low tide and high tide, for the entire measurement/analysis pathway are presented in Figures- (1), (2). The rating curve for the entire flow path should be of the same shape because the data distribution patterns in the three flow paths are the same. Interpretation of changes in density along the estuary can be based on flow curve vector rating analysis. Comparative analysis of *rating curve* ρ_0 dan $\rho_{0,6h}$ at low tide shows that the density in the layer near the bottom of the river surface has a greater value but the gradient is greater than the density at the point of (ρ_0) depth. This means that at each measurement position (or distance x from the reference), the price ρ_0 is always greater than the price of $\rho_{0,6h}$. These results are consistent with the theory that the layer near the bottom of the river surface has the highest flow density. This is due to the content of the baseload on the layer near the surface of the river's bed. These results are consistent with the results of research by Kumajas (2005) which presents a vertical profile of flow density at the Ranoyapo river mouth at zero position.

At high tide, the rating curve drops sharply exponentially to a position of about 500 meters from the reference, so on (towards the coastline) the rating curve is almost flat (the price density approaches constantly). Figure-1 shows that the value of at (tidal) settlements, for the x 500 m position is almost the same as the curve $\rho_{0,6h}$ price at low tide.

Physically this shows that the mass of water ρ_0 at high tide only contains rinse loads and drift loads so that the price is almost the same as the $\rho_{0,6h}$ density at low tide. The baseload on the layer near the river's bed surface has been deposited more upstream due to the slowing of the river flow which is held by the tide.

The *Rating curve* $\rho_{0,6h}$ at high tide shows a sharper gradient change in the upstream position which is about 305 m positions. At position x 305 m, the rating curves $\rho_{0,6h}$ is almost flat, which means the price of $\rho_{0,6h}$ is almost constant. This shows that position has been an intermingling between the mass of seawater and river water containing the rinse load and the drift load.

Concerning the process of transport material sedimentation, the analysis of *rating curve* ρ_0 dan $\rho_{0,6h}$ during low and high tide shows that during low tide, the bed load has been deposited, with a significant proportion (decrease in gradient ρ_0 quite large) figure-1, while the deposition of rinse load and baseload is relatively small (gradient $\rho_{0,6h}$ close to zero) figure-2. At high tide, the baseload deposition in the estuary area increases, and the accumulation area shifts upstream following an increase in sea level. At high tide, the deposition of rinse loads and drift loads also increase and the deposition area also expands due to shifting the position of the two function boundaries upstream, following the increase in sea level (figure-2). If the seawater moves back down, the sedimentation of the baseload, the drift load, and the wash load decrease. Physically it can be suspected that some of the drift loads and rinse loads that settle at high tide will erode and fall towards the sea when the water recedes; this needs to be further investigated.

CONCLUSION

Interpretation of the function *rating curve* ρ_0 dan $\rho_{0,6h}$ during low and high tide shows that low tide, the bedload deposition has occurred, with a large enough proportion (decrease in the gradient which is quite large), while the load deposition rinse and baseload are relatively small ((gradient $\rho_{0,6h}$ close to zero). At high tide, the baseload deposition in the estuary area increases, and the accumulation area shifts upstream following an increase in sea level. At high tide, the deposition of rinse loads and drift loads also increase and the deposition area also expands due to shifting the position of the two function boundaries upstream, following sea-level rise. If the seawater moves back down, the sedimentation of the baseload, the drift load, and the wash load decreased.

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