

# Model of Flow Velocity Distribution and Change Along the Amano Ranoyapo Estuary during Tides

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**Abstract**— River flow velocity is the movement of elements of water mass through the cross section of the river unity of time. Naturally, the speed (fluid movement) in the estuary area is controlled by two main factors namely river flow and tides. The measurement and determination of points (according to the depth and width of the Ranoyapo river mouth) must be such that the steady, non-turbulent or homogeneous flow requirements are met. The availability of data and the profile of the flow velocity variable can be used as a reference for the analysis of the flow velocity distribution model and changes along the Ranoyapo Amurang estuary at high tide. The velocity  $v_{0.6h}$  model at high tide shows that the velocity function is exponentially negative, where the velocity distribution  $v_{0.6h}$  at high tide at a position of 600 meters towards the coastline, has an exponential model function applicable to  $82 \text{ meters} \leq x \leq 600 \text{ meters}$ . The velocity functions  $v_0$  and  $v_{0.6h}$  at low tide produce the same model shape, the exponential (negative) function, in the condition of  $v_0$  when low tide is above the flow velocity at high tide, thus  $v_{0.6h}$  at low tide has a lower gradient than with the tide. Physically, this is due to the higher density of sea water, compared to the density of river water so that the profile of the boundary plane of the two water masses has a gradient decreasing upstream.

**Keywords**— *Model, Flow velocity, Tides*

## I. INTRODUCTION

River flow velocity (fluid) is the movement of elements of water mass through the cross section of the river unity of time. The general characteristics of fluid flow are a conceptual foundation in the field so that approaches can be established with empirical assumptions that guarantee the validity of measuring variables and calculation models. General flow characteristics proposed by reference [1] are, steady flow is a flow where each fluid particle passing through the same point, has the same speed. At another point fluid particles can have different speeds than the speed of fluid particles that pass through the first point. This condition can be achieved at a low flow rate or at a quiet flow condition. An unstable flow is a flow where the velocity of fluid particles passing through each point is a function of time, in other words the speed of a fluid particle passing through a cross section is a function of space and time. This condition occurs as in a stream that experiences hardening (rapid).

Fluid properties that are similar to the flow properties mentioned above, are described by reference [2], that is, steady, non-uniform and non-uniform and rotational-irrotational properties, assuming - physical assumptions that can be used as a basis for measuring and calculating river flow velocity. If steady, irreversible, incompressible, cooperative and non-viscous flow assumptions are met, then basic physical equations can be used in each area or point of view where physical variables (flow velocity) can have a certain and fixed price for an interval of time measurement. If these assumptions are not met, then physical equations can only be applied to areas that are microscopic and within a very narrow time interval, so as to describe a macroscopic phenomena, procedures and calculations become very complex.

Naturally, the speed (fluid movement) in the estuary area is controlled by two main factors namely river flow and tides. Tides are a parameter for determining fluid velocity according to time and position along an estuary. Requirements for measuring physical variables of flow (velocity) such as steady flow conditions, non-turbulent, and homogeneous often become obstacles or cause measurements must be made at many points of observation [1], [2]. Measurement and determination of measurement points (according to the depth and width of the Ranoyapo river mouth) must be such that the flow requirements.

The availability of data and profile of the flow velocity variable can be used as a reference for the analysis of the flow velocity distribution model and changes along the Ranoyapo Amurang estuary at high tide. The mathematical model that will be used is one model that is widely used in modeling environmental problems and is a way to describe important aspects of reality (processes, phenomena, objects, elements, systems, etc.) with the help of mathematics. In the replica / mock mathematical model implemented by describing natural phenomena / events with a set of equations. This research will measure, data duplication (data interpolation), data modeling for the purpose of determining the function of the flow velocity distribution model according to distance (along the estuary)..

**II. RESEARCH METHODS**

The measurement of flow velocity at one point in a river must meet the flow conditions: steady, uniform and irrotational. This condition is very difficult to apply along the river cross section. The method commonly used is to divide the cross section of the river into segments of the area where each segment is assumed to meet the flow requirements mentioned above. [3], [4], provide a benchmark for the number of segments taken is 20 segments obtained from the rules of segment / area width equal to 1/20 of river width. Some researchers. [5]–[8], states that the number of measurement segments in the direction of the river cross section to guarantee the flow requirements, can be determined by observing the flow conditions at the research location and basic measurements such as depth and depth. Segments with the same flow conditions, having the same depth and depth are defined as one measurement segment. Flow velocity according to depth or vertical distance from the riverbed is not the same. The simple method for measuring flow velocity in the vertical direction can be chosen from among the methods: (1) measurement of one point (point 0.5 or 0.6 depth of flow), (2) measurement of two points (carried out at 0.2 and 0.8 flow depth), (3) three-point measurement (carried out at 0.2; 0.6 and 0.8 flow depth), (4) measurement using distance interval criteria  $\leq 0.1$  depth. To get a vertical profile of flow velocity according to depth, measurement methods must be chosen with a measurement interval of  $\leq 0.1$  in. Determination of measurement segments according to the direction of the river width is sought to ensure measurements in steady, homogeneous and non-turbulent flow conditions, and are based on variations in surface flow velocity and depth. flow measured, the amount of basic data generated from the measurement is nine pieces of data. For the purpose of modeling, the data is duplicated using linear interpolation techniques. Using the linear interpolation technique for the multiplication of data in the field of hydrology, among others by: [5], [7], [9].

**III. RESULTS AND DISCUSSION**

The results of the identification of flow vectors, show three segments (main flow paths) and produce nine positions, (1250 meters away from the mouth of the estuary to the reference point) on which the measurement and analysis of variable flow velocity changes along the estuary. The measurement is carried out when the tide is at its maximum state and meets the requirements for measurement of variable flow velocity. Flow velocity variable data is measured at low tide starting from position-1 to position-2 to position-9 and when the tide is flowing data, measurements are made in the reverse direction, starting at position-9 to position-1. Data modeling of velocity functions  $v_0$  and  $v_{0,6h}$  at low tide results in the form of the same function model that is an exponential (negative) function, with the general form:

$$v = k_0 + k_1 e^{-k_2 X} \dots\dots\dots [4]$$

where  $v$  is the speed in units of  $cm \cdot det^{-1}$ ,  $k_0$ ,  $k_1$ , and  $k_2$  are constants and function coefficients whose prices and units are

presented in the following table,  $x$  is the distance extending estuary with respect to the reference towards the coastline.

Equation-4 for low tide, applies in the range  $82 \text{ m} \leq x \leq 655 \text{ m}$  calculated against the reference.

Continuous Summary Table of function models Speed and Mean% Bias Modeling, General equation:  $v = k_0 + k_1 e^{-k_2 X}$

Measurement	No. flow path	Measurement point	Water condition	function constant / rating curve			Average% of model bias
				$k_0$	$k_1$	$k_2$	
				$(cm \cdot det^{-1})^{-1}$	$(cm \cdot det^{-1})^{-1}$	$(cm \cdot det^{-1})^{-1}$	
-1	-2	-3	-4	-5	-6	-7	-8
1	1	$v_0$	recede	4.3217	3.68074	0.00138	1.3584
			tide	-0.9310	1.289.196	0.00627	
		$v_{0,6h}$	recede	-93.250	3.163.560	0.00032	
			tide	-38.932	3.251.850	0.00331	
2	2	$v_0$	recede	45.217	352.452	0.00140	
			tide	-15.950	1.245.657	0.00497	
		$v_{0,6h}$	recede	-91.877	3.098.472	0.00030	
			tide	-41.103	3.214.270	0.00328	
3	3	$v_0$	recede	44.988	339.506	0.00140	
			tide	-16.172	1.282.214	0.00488	
		$v_{0,6h}$	recede	-92.574	3.097.722	0.00029	
			tide	-40.784	3.184.820	0.00331	

The data in the Table shows the price of the constant model and the coefficient of the velocity function  $v_0$  at low tide for the three flow paths is almost the same, so it is concluded that the magnitude of the velocity and its change for points are the same distance to the reference (points in the direction of river width) have almost the same price. The constant and coefficient of the function model  $v_{0,6h}$  at low tide for the three flow paths is almost the same and it can also be concluded that the velocity at 0.6 depth points in the direction of the river's width (equal distance to the reference) is almost the same. The results of the analysis and modeling of velocity  $v_{0,6h}$  at high tide indicate that the velocity function is in the form of a negative exponential in the form of an equation model such as equation (3). The velocity distribution pattern  $v_{0,6h}$  at high tide shows zero prices starting at position 600 meters towards the shoreline, so the function of the velocity model (equation (3)) applies to  $82 \text{ meters} \leq x \leq 600 \text{ meters}$ . For positions  $x > 600$  meters the flow velocity at the point 0.6 depth becomes zero, as a result of resistance by the mass of sea water. Interpolation and modeling of velocity data in layers near the river bed surface ( $v_0$ ), for tidal conditions shows the shape of an exponential model function and fulfills equation (3) for an  $82 \text{ meter} \leq x \leq \text{interval. } 400 \text{ meters}$ . At a distance of more than 400 meters towards the coast (calculated against reference), speed  $v_0$  becomes zero. As is the case with flow velocity ( $v_{0,6h}$ ) and flow velocity ( $v_0$ ) at high tide, the gradient and position of zero speed will change depending on the height of the tide. The prices of modeling constants and the coefficient of the velocity function ( $v_0$ ) at low tide and tide in the three flow segments are almost the same, as shown by the function of equation model (3). In the condition of  $v_0$  when the tide is above the flow velocity at high tide, thus  $v_{0,6h}$  at low tide has a lower gradient compared to at high tide. Physically, this is due to the higher density of sea water compared to the density of river water so that the profile of the boundary plane of the two water masses has a downward gradient upstream. Under

these conditions, the lower layer of water mass will slow down in the upstream position [8].

#### IV. CONCLUSION

The velocity  $v_{0.6h}$  model at high tide shows that the velocity function is exponentially negative, where the velocity distribution  $v_{0.6h}$  at high tide at a position of 600 meters towards the coastline, has an exponential model function applicable to  $82 \text{ meters} \leq x \leq 600 \text{ meters}$ . The velocity functions  $v_0$  and  $v_{0.6h}$  at low tide produce the same model form, the exponential (negative) function, in the condition of  $v_0$  when low tide is above the flow velocity at high tide, thus  $v_{0.6h}$  at low tide has a lower gradient than with the tide.

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