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INFLUENCE OF SALINITY LEVELS ANALYSIS ON SETTLING VELOCITY OF FINE SEDIMENT GRAINS IN CILIWUNG ESTUARY

Salinity Levels on Settling Velocity of Fine Sediment Grains

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Abstract. estuarine sediment transportation hold a very complex method, which is the combined impact result of periodically shuttle flow, ocean waves, and the electrochemical property of sea water. Settling velocity (SV) is such a parameter fundamental for sediment researchers so that its accurate resolution has been regarded as a top priority in correcting modelling numerical and conceptual understanding of fine sediment dynamics. This experimental study to have goal to analyze the effect of salinity levels on the settling velocity of fine sediment grains in the Ciliwung estuary, Jakarta. The method used is direct measurement using the hydrometer analysis method. The result of experiment shows salinity levels affect the settling velocity of fine sediment grains in the Ciliwung estuary. The higher salinity, faster the settling velocity of fine sediment grains. The average settling velocity at distilled water salinity 0 ppt is 1.083 mm/minute, sea water with salinity 0.3 ppt is 1.537 mm/minute, and sea water with salinity of 0.6 ppt of 1.561 mm/minute. So, salinity have affects to the SV, if the salinity is high then SV is also high and if the salinity is low then the SV is also low.

Keywords : *settling velocity; salinity; fine sediment; estuary*

1. INTRODUCTION

Natural rivers around the world have winding channel characteristics with different sizes of bottom sediment grains and different flows [1]. Transport of estuarine sediment have a highly complex method, which is the combined effects result of periodically reciprocating flow, ocean waves, and the electrochemical characteristic of sea water[2] [3]. There is a growing interest in the suspended sediments transport in estuaries due to both the high dredging costs associated with problems of siltation in harbors and channels of navigation, and environmental problems[4][5]. One of the major parameters required for successful numerical simulations of suspended sediment distributions and the estuarine turbidity maximum is settling velocity (SV)[6]. SV or also known as falling velocity in sedimentology and morpho coastal dynamics, especially for those fine sediment estuaries is a critical parameter in the sediment under-standing behavior and dynamics. The SV directly determines of vertical distribution of Suspended Sediment Concentration (SSC) and flux of near-bed deposition, and its accurate determination has been regarded as a priority in characterizing fine sediment transport[7]. The height affects the SV, the larger particles that will occur, the greater the SV [8]. The goal of this study is to analyze the effect of salinity levels on the settling velocity of fine sediment grains in the Ciliwung estuary, Jakarta. Salinity and settling velocity have engagement, and those should be concerned related with sedimentation due to settling velocity is affected by salinity level.

SV is such a parameter fundamental for sediment researchers so that its accurate determination has been regarded as a top priority in improving correcting numerical and conceptual understanding of fine sediment dynamics[9]. Salinity has also been documented by Burt in 1986 as having the ability to alter fine sediment SV in some bracket is hand saline waters. Higher salinity may induce greater SV over the entire SSC range according to Burt (1986). Positive ions of contained in natural sea waters, carry positive electric charges which benefit for the growth of flocs. However, higher saline content does not always favor SV; SV reaches a maximum value at a salinity of 10–15 practical salinity units (PSU) for Tamar Estuary mud by Al Ani et al in 1991[7]. The natural distribution of salinity is influenced by several factors, including rainfall, the flow of fresh water into the sea directly or through rivers and glaciers, evaporation, ocean currents, mixing turbulence, and wave action. In addition, salinity also affects the speed of sediment deposition. If the salinity is high then the sediment deposition rate is also low[8].

Fall or settling velocity studies started by Stokes and was subsequently followed by different researchers resulting in a variety of equations with two common assumptions[4]. The settling velocity in the previous research of a particle in a quiescent fluid was derived by equating the effective weight force to the drag force with respect to the particle shape. In case of very fine sediments (silt) or a large depth, the settling process can continue during the slack water period[10]. Other previous research shows the SM12 method is well-suited to application in computational models of estuarine dynamics with high-level closures and also in simpler cases[11]. Research that has been carried out by A.J. Manning et al. presents the findings of the depositional velocity of recent laboratory studies investigating flocculation dynamics for three different mud/sand mixtures at concentration (0.2–5 $g.l^{-1}$) and turbulent shear stress (0.06-0.9 Pa) in a mini-annular flume [12] .

And other previous research the estuarine hydrodynamics was characterized as well-stratified[13]. In freshwater, the sediments suspended existed mainly in a dispersed state[14][15], and fine sediment is anticipated to form floc as soon as it meets saline water[16]. In estuarine waters, the suspended sediment occurred largely as coagulated flocs with their behavior significantly affected by the salinity gradient and vertical stratification[7][17]. In the upper diluted water, the in situ median diameter of suspended sediments was closely related to salinity, but in situ SV and apparent density varied less with salinity[7]. Common problem occurred on downstream rivers and estuaries is sedimentation. Salinity and settling velocity have engagement, and those should be concerned related with sedimentation due to settling velocity is affected by salinity level. Such is the case with the problem that occurs in the Ciliwung estuary. A sedimentation process can result in silting, rising water levels, and obstruct river flow from the middle to downstream. Based on description and previous research above, this study has purpose to analyze the effect of salinity levels on the settling velocity of fine sediment grains in the Ciliwung estuary, Jakarta.

2. METHODS

This study is direct measurement research uses the hydrometer analysis method which can also be called the sedimentation test, which is a method to calculate the grain size distribution of soil based on soil sedimentation in water. The sample location in the old Ciliwung estuary, Jakarta and there are 2 sampling points showed in Figure 1, namely

1. approx. 50 meters before the floodgate, and the depth when sampling is 1.8 m,
2. right at the floodgate with a depth of 2.4 m.

Figure 1 : Google earth of research location

The testing time started there are 14 times experiment, from the time in minutes, are 1,2,3,4,8,15,30,60,120,180,240,300,360, and 420. And the samples tested had a mass of 50 grams. The water used in the test is distilled water with salinity 0 ppt, sea water with a salinity of 0.3 ppt which is taken before the floodgate, and sea water with a salinity of 0.6 ppt which is taken right at the floodgate. The steps of the research carried out at the Civil Engineering Laboratory of the Politeknik Negeri Jakarta are as follows:

1. Prepare tools and samples as shown in Figure 2
2. Weighting the sample with a mass of 50 grams as shown in Figure 3
3. The sample is allowed to stand for approximately 24 hours as shown in Figure 4a
4. Samples are blended as shown in Figure 4b
5. Conduct a settling velocity test by putting the mashed sample into a measuring cup as shown in Figure 4c

Figure 2 : Sample of mud and water from Ciliwung estuary

Figure 3 : Weighting samples

Figure 4a

Figure 4b

Figure 4c

Figure 4a : The sample is allowed to stand for approximately 24 hours
Figure 4b : Samples are blended
Figure 4c : Conduct a settling velocity test by putting the mashed sample into a measuring cup

3. RESULTS AND DISCUSSION

Table 1 below is the experimental data on the settling height of the fine sediment and the settling velocity got when the sample was tested by adding distilled water, where 0 of the pH and salinity. Obtained when the sample was tested by adding water with salinity 0.3 ppt and 0.6 ppt. For the settling height shown in table 1 and figure 11, the longer the testing time, the lower the settling height of the grains. This also happened to the settling velocity, the longer the testing time the slower the settling velocity as shown in table 1 and figure 12. With a relatively long settling height, the researchers also tested using a mixture of samples with salinity 0.3 ppt and 0 ,6 ppt.

Table 1: Experimental data of grain - settling height and velocity of sample with different salinity

Time (t (minute))	Settling height of Sample + water salinity 0 ppt r (h (mm))	Settling height of Sample + sea water salinity 0,3 ppt (h (mm))	Settling height of Sample + sea water salinity 0,6 ppt (h (mm))	SV with sea water salinity 0 ppt v(mm/minute)	SV with sea water salinity 0,3 ppt v(mm/minute)	SV with sea water salinity 0,6 ppt v(mm/minute)
1	45	30	31	3	2	3
2	42	28	28	2	5	3
3	40	23	25	2	4	4
4	38	19	21	0,75	2,25	3,75
8	35	10	6	1,428571429	0,428571	0,285714286
15	25	7	4	0,333333333	0	0
30	20	7	4	0,133333333	0,13333333	0
60	16	3	4	0,066666667	0,01666666	0,016666667
120	12	2	3	0,033333333	0	0
180	10	2	3	0,03333333	0	0
240	8	2	3	0	0	0
300	8	2	3	0,03333333	0	0
360	6	2	3	0	0	0,01666666
420	6	2	2	-0,01428571	-0,0047619	-0,0047619

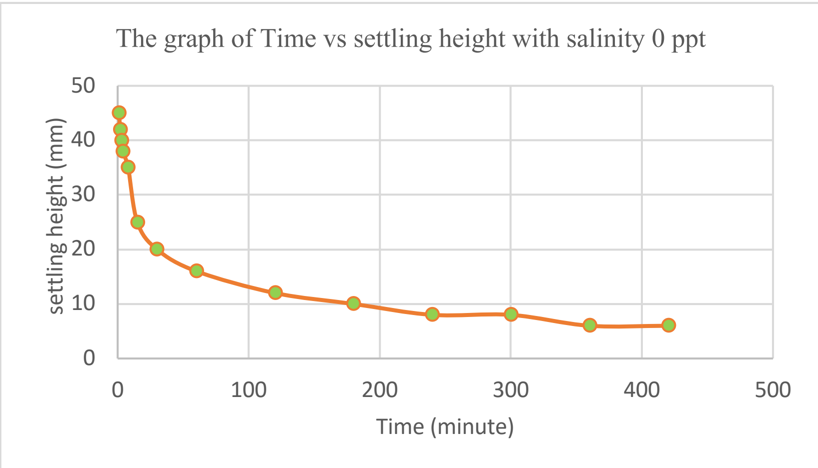

Figure 5: The graph of Time vs settling height with salinity 0 ppt

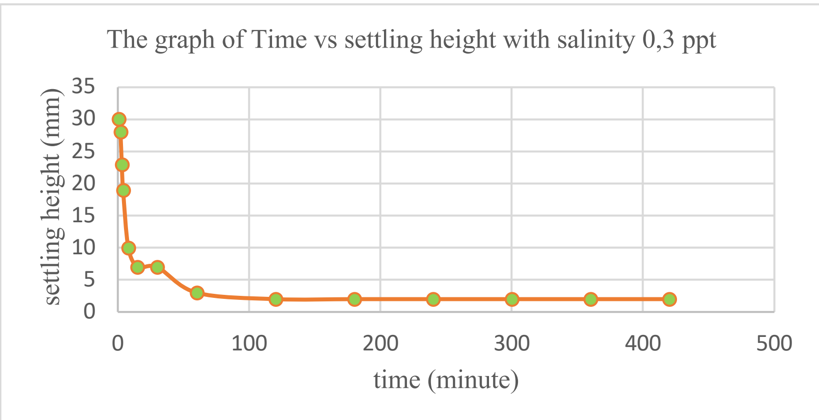

Figure 6 : The graph of Time vs settling height with salinity 0,3 ppt

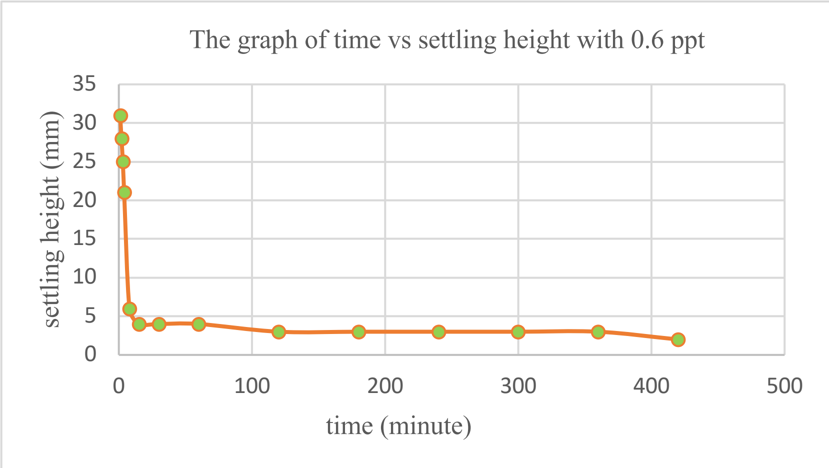

Figure 7: The graph of time vs settling height high with 0.6 ppt

Figure 8 shows the experimental results of the fine grain drop height in the sample added with distilled water that has a salinity of 0 ppt in each time interval. There are using 14 times interval, namely the range from the 1st minute to the 450th minute. The maximum drop height of fine grains is found in the first interval, namely the 1st to 4th minute, with a settling height value ranging from 38 to 45 mm. Figure 9 is the drop height of the fine grains in the sample added with seawater which has a salinity of 0.3 ppt. It can be seen that the maximum drop height of fine grains is also found in the first interval, namely the 1st to 4th minute, with the settling height value ranging from 19 to 28 mm. There is a difference in the height of settling to be shorter with the height of settling in the sample mixture added with water that has a salinity of 0 ppt. Figure 10 is the result of an experimental result of the fine grain drop height in the sample added with seawater which has a salinity of 0.6 ppt. It can be seen that the height of the fine-grained fall reaches its maximum at interval 1. Followed by the second interval, which is between the 8th – 60th minute, and the minimum settling height is at the 3rd interval, which is the 120th – 420th minute. The experimental results on the graph are linear with experiment at salinity 0 ppt and 0.3 ppt.

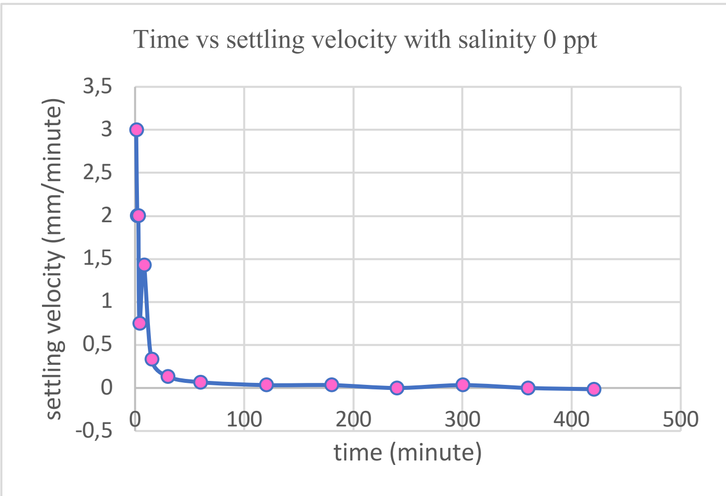

Figure 8 : The graph of time vs settling velocity with distilled water salinity 0 ppt

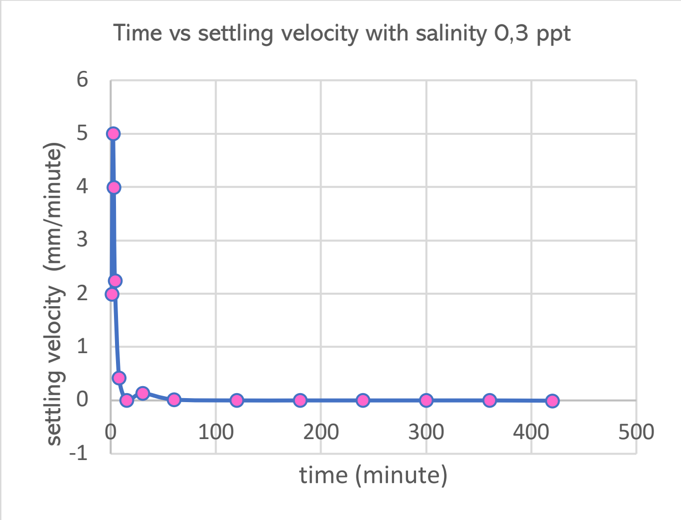

Figure 9 : The graph time – settling velocity with sea water salinity 0.3 ppt

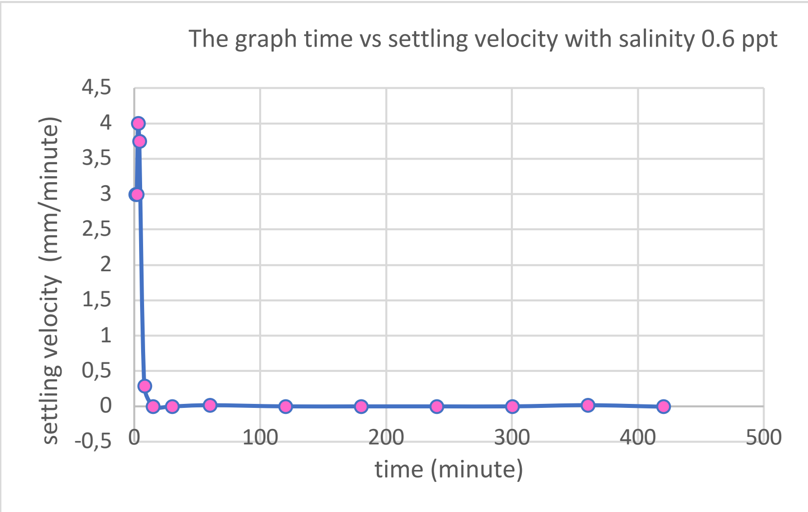

Figure 10: The graph time vs settling velocity with sea water salinity 0.6 ppt

Figure 11 shows the experimental results of the settling velocity of fine grains at each time interval on the sample added with distilled water which has a salinity of 0 ppt. It is calculated using the average velocity equation, namely the height of the fall divided by the change in time. The SV of fall is presented in a graph as a function of time vs. settling velocity of fall. The relationship that is seen is that the longer the experiment time the slower the grain SV, so that it takes a long time to get the sedimentation results until the deposition process stops[18]. The maximum SV calculated is in the first interval, which is between the 1st to 4th minute time span with a large settling velocity ranging from 0.75 mm/minute – 3 mm/minute. The results of the analysis in the 8th minute the SV of settling fine grains rose again at a value of 1.5 mm/minute. Figure 9 shows the experimental results of the SV of fine grains at each time interval on the sample added with seawater which has a salinity of 0.3 ppt. The results of the analysis show that the settling velocity of fine grains is inversely proportional to the time interval. However, there are some data that are not uniform, namely between the 1st and 2nd minute, and the 15th – 60th minute. The maximum settling velocity is in the 2nd minute, which is 5 mm/minute. Figure 12 shows the experimental results of the SV of fine grains at each time interval on the sample added with seawater which has a salinity of 0.6 ppt. The results of the analysis show that the SV of fine grains is inversely proportional to the time interval. However, there are some data that are not uniform, namely between the 1st and 3rd minutes, namely in the 1-2 minute it has a SV of 4 mm/minute but in the 3rd minute it rises to 4 mm/minute. However, even so, the overall settling velocity of settling velocity fine grains is inversely proportional to the time interval determined in the experiment. The maximum settling velocity is in the 3rd minute, which is 4 mm/minute.

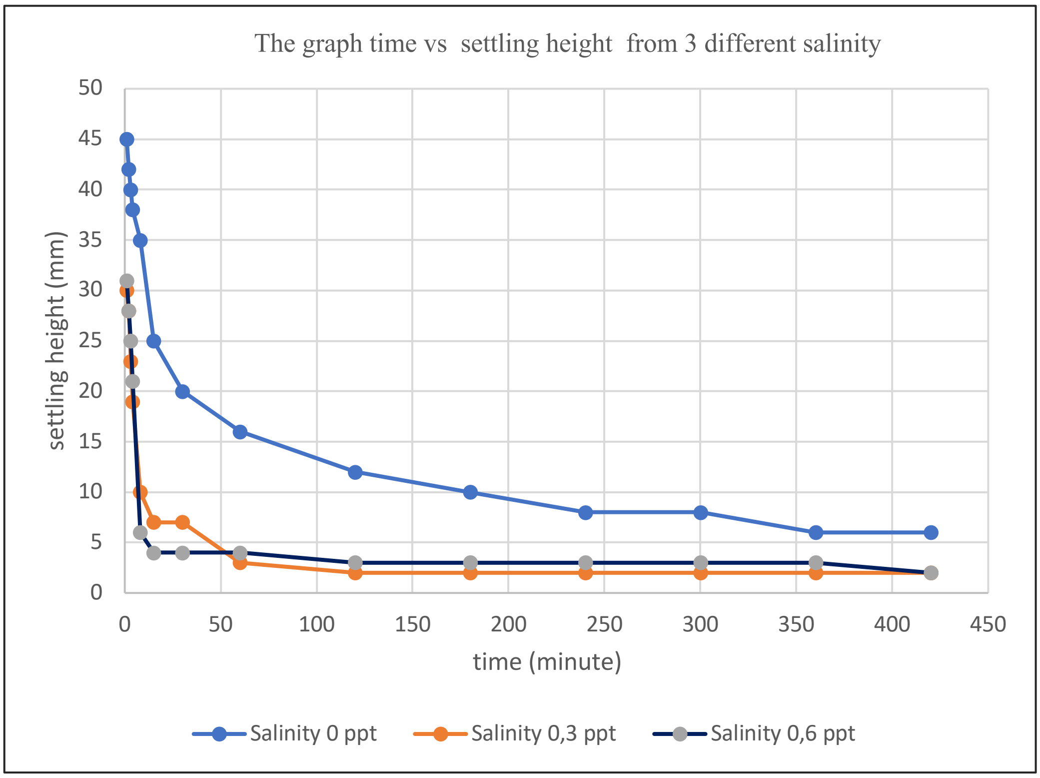

Figure 11: The graph of comparison time vs settling height from 3 different salinity

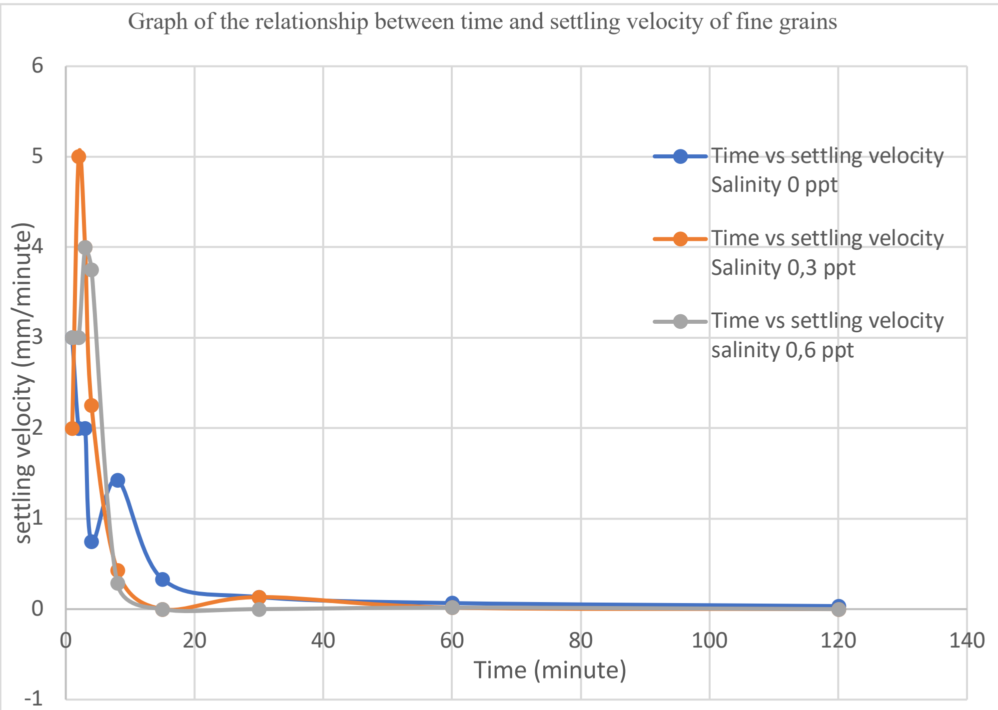

Figure 12: Comparisons of settling velocity of fine sediment in three different salinity

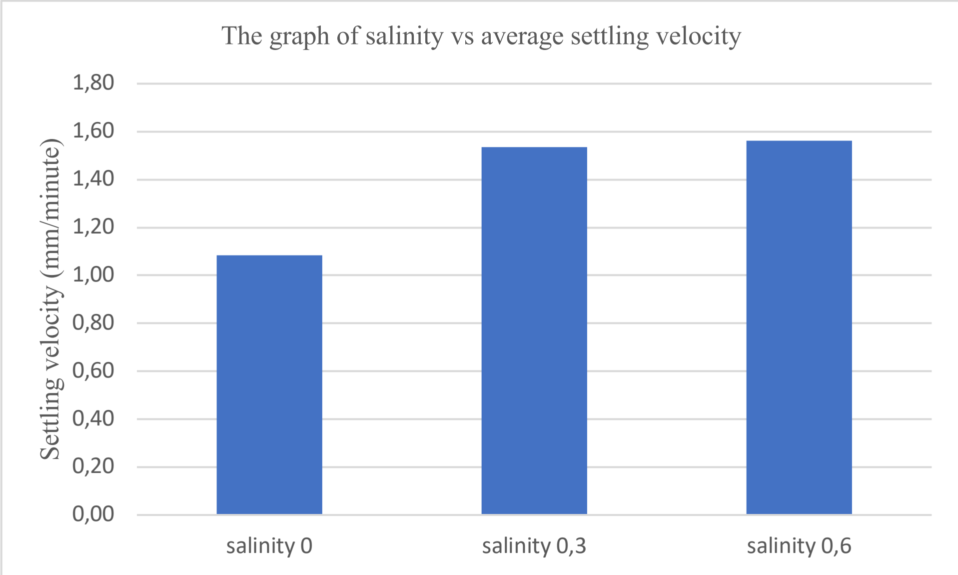

Figure 13: Average settling velocity of fine sediment in three different salinities

The model of hydrodynamic calculates the vertical velocity and the turbulent overspread [11]. The settling velocity of sediments in varies of estuary in space and time; it's in one estuary may not be comparable with that in another. Density and concentration of sediments in the water column have the same size, the settling velocity may be different under different conditions of hydrodynamic[19]. Determine the settling velocity of muddy sediments is much more complex than sand, because of its dependence on the state of flocculation, which in turn of depends on the concentration of sediment, the characteristics of turbulence, the water and sediment properties, and the time/space-history of all of these. In a laboratory study conducted by Mignot, 1968 has shown a clear effect of salinity on the rate of deposition of cohesive materials[20]. The results of the research that have been carried out by the current researcher are in accordance with previous laboratory studies which show that salinity is indeed a relevant factor as shown in Figure 11 and Figure 12. Figure 11 shows a graph of time to drop height of soil grains, from the figure it can be seen that the more the longer the observation time, the shorter the drop height of the soil grains. The maximum drop height of soil grains is in the sample using a salinity of 0 ppt, which is about 5 – 45 mm. Samples mixed using 0.3 ppt salinity, overall have a higher fine grain drop than using samples mixed using 0.6 ppt salinity. However, the difference between salinity 0.3 ppt and 0.6 ppt is not that significant but can still be observed.

Figure 12 shows a graph of the results of the study between the time and SV of settling fine grains at the study site. The results showed unstable data, there were some parts that suddenly rose and tended to fall. However, if we take the average fall settling velocity of 3 different salinities, it can be seen that the settling velocity of the fine grains with the addition of salinity will accelerate the settling velocity. Specific finding from this research is relationship between salinity level and settling velocity on Ciliwung estuary as shown in figure 13, namely the average settling velocity at 0 ppt salinity is 1.083 mm/minute, 0.3 ppt salinity is 1.537 mm/minute, and salinity 0.6 ppt is 1.561 mm/minute. So, salinity have affects to the SV, if the salinity is high then SV is also high and if the salinity is low then the SV is also low. From the results of this study, the recommendations that the author can give to the community and local governments are information on sediment characteristics that can provide solutions for adding appropriate facilities/infrastructure in sedimentation control activities, especially rivers that empties into Jakarta Bay and are influenced by tides.

4. CONCLUSION

Salinity affects the settling velocity of fine sediment in the Ciliwung Estuary, the higher salinity, faster the settling velocity of fine sediment, the average settling velocity at distilled water with 0 ppt salinity is 1.083 mm/minute, sea water with salinity 0.3 ppt is 1.537 mm/minute, and sea water with salinity of 0.6 ppt of 1.561 mm/minute. So, salinity have affects to the SV, if the salinity is high then SV is also high and if the salinity is low then the SV is also low.

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