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Physical Model Approach of Erosion and Sedimentation Movement in Front of Sluice Gate in the JSC Main Channel

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***Abstract*— The urban drainage system which always experiences flooding in the city of Palembang every year is the Jakabaring watershed. The Jabaring watershed is one of 33 points of frequent flood areas in Palembang City. This is because, until now, the Jakabaring River Basin (Watershed) area does not yet have pumping facilities. So that it often becomes a customer for flooding.**

For this reason, a physical model research is needed in the laboratory, namely with a standard flume with various variations in speed, time and sediment material in the form from river/channel of Jakabaring Sport City (JSC).

The results showed that the maximum relative erosion (de/t) occurred in front of the main gate of the JSC channel of 0.04. This means that in 30 minutes, there is an erosion of 12 cm in the model. The maximum relative sedimentation (dd/t) in front of the main JSC channel floodgate occurs at a maximum relative distance (x/t) of max 10, which is 0.05. This means that in 30 minutes, there will be sedimentation in the channel as big as 15 cm in the model.

***Keywords*— The Jakabaring watershed; langhaar method; erosion rete; sedimentation rate**

I. INTRODUCTION

River or open channel is a channel where water flows freely. In open channels, such as rivers (natural channels), the flow variables are very irregular with respect to space and time. These variables are channel cross-section, roughness, base slope, flow discharge turns and so on (Istiarto, 2015). River is a long channel above the earth's surface where water flows from rain and is always touched by water flow and is formed naturally (Sosrodarsono, 1994).

The complexity of the river system can be seen from the various components that make up the river, for example the shape of river channels and branching, river bed form, river morphology, and river ecosystem. The branching of the river will resemble a river tree starting from the first-order river to the n-order river. The riverbed formation when examined at a glance is very difficult to identify and characterize.

The shape of the meander groove is influenced by the longitudinal slope of the landscape, the type of riverbed material, and the vegetation in the area concerned (Maryono, 2007). The greatest benefit of a river is for agricultural irrigation, raw material for drinking water, as a drainage channel for rainwater and waste water, in fact it has the potential to become a river tourist attraction. In Indonesia, there are currently 5,950 watersheds (DAS).

Palembang city itself has 108 tributaries. There are 4 major rivers that cross the city of Palembang, namely the Musi River, Komering River, Ogan River, and Keramasan River. Of the 4 major rivers above the Musi River is the largest river with an average width of 504 meters and a maximum width of 1,350 meters around Kemaro Island. (Syarifudin, A, et al, 2018; Achmad Syarifudin, 2022)

Based on the division of river areas, there are 21 sub-watersheds, but only 18 sub-watersheds in the city of Palembang which empties directly into the Musi river in the city of Palembang, namely the Rengas Lacak, Gandus, Lambidaro, Boang, Sekanak, Weir, Lawang Kidul, Buah, Juaro, Batang, Sei Lively, Keramasan, Kertapati, Kedukan Ulu, Aur, Sriguna, Jakabaring and Plaju. (Department of PUPR of Palembang city, 2018)

The city drainage system which always experiences flooding in the city of Palembang every year, among others, is the Jakabaring watershed. Jabaring watershed is one of 33 flood-prone areas in Palembang City. This is because, until now, the Jakabaring Watershed (DAS) does not yet have pumping facilities. So it often becomes a flood subscription. (Sripo, 24 November 2020)

Simulation using physical modeling based on model scale from prototype to model in the laboratory with the same conditions in the prototype, namely existing conditions, normalization of river channels, drains, retention ponds, combined with pump systems and embankment construction, shows that in the existing conditions there are seven areas that flooded. (Achmad Syarifudin, 2022).

II. Research Methods

The research was carried out using the Hydraulics and Rivers laboratory at Bina Darma University with a laboratory scale (scale model) as shown in Figure 1.

Fig. 1. Research model in the laboratoy

A. Materials and tools

The materials used in this study include:

- the material used as the Buah river material is sand with a diameter of 0.025 mm to 2.36 mm. Before being used as experimental material, a sieve analysis was carried out to obtain a uniform grain diameter.
- to move the flow in the channel is water as well as to move sediment grains,
- The specifications of the tool are as follows:
    - -flexiglass for standard flume
    - length of the channels: 4.00 m
    - Width: 0.15 m
    - Depth: 0.20 m
    - the instrument meter used for scouring depth value.
    - Photo camera to take pictures when doing the experiment.
    - Video recorder to record experiment implementation.

B. Preparation of channel models in Research

This research was conducted using laboratory approach method with various variations in the flow rate, flow rate and time. The standard channel (flume standard), most of its components are made of glass and have important parts, namely:

The research approach is carried out with physical models in the laboratory with various variations of discharge, velocity and flow time. The standard flume is mostly made of glass and has the following important parts:

a. Aqueduct, the main place in this experiment, to drain water. In the form of a water flume with a size of 400 x 20 x 15 cm. This channel has transparent walls for easy viewing.
b. A reservoir that serves to accommodate water that will flow into the channel or out,
c. Water pump, serves to pump water so that it can be distributed along the gutters. This pump is equipped with an automatic on/off switch for 220/240 V, 50 Hz,
d. Discharge faucet, is a faucet that functions to regulate the size of the discharge coming out of the pump. Has a discharge opening scale of 6-9 range,
e. Slope adjustment wheel, located upstream and downstream of the channel that can be turned manually to adjust the desired bed slope. This bed slope control wheel has a scale for maximum positive bed slope + 3.0 % and maximum negative bed slope - 1.0 %.

C. Research Stages

The stages of this research are divided into:

1. The first stage is to collect references from journals, books, and other secondary data sources such as the BBWSS-VIII office, PU Pengairan of South Sumatra Province and PUPR of Palembang city as well as from other relevant agencies.
2. The second stage is conducting a field orientation survey to obtain the current (existing) field conditions, taking photos of the field (site) so that it can be used as initial research data.
3. The third stage is to collect river bed material, survey data and topographical measurements of the channel to be used as input data in conducting model simulations in the laboratory.
4. The fourth stage is conducting experimental simulations with various variations of discharge, velocity and flow time.
5. The fifth stage is to obtain experimental results, namely, the location and magnitude of erosion (scouring) that occurs with various discharges, velocity and time of flow.
6. The sixth stage, analyze the simulation results and conduct discussions
7. The seventh stage, making research conclusions and providing suggestions for further research by other studies. to make it clearer as in the flow chart as follows:

III. Results and Discussion

Dimensional analysis in this study uses Langhaar's theorem, this theorem is considered more in line with current conditions and in accordance with research because of the relatively few parameters. The results of the determination of dimensionless numbers are shown in table 1 below:

Dimensionless number

TABLE I. Dimensionless Number

ki	k1	k2	k3	k4	k5	k6
Parameter	**x (cm)**	**d_s (mm)**	**h (cm)**	**t (minute)**	**P (kg/cm^3)**	**g ($kg\ m/sec^2$)**
π1	1	0	0	-1	0	0
π2	0	1	0	-1	0	0
π3	0	0	1	-1	0	0
π4	0	0	0	1	0	0,5

$f(x/t ; ds/t; v) = 0$; $(v \approx 0)$

$(x/t) = f(d_d/t)$ focus on sedimentation rate

$(x/t) = f(d_e/t)$ focus on erosion rate

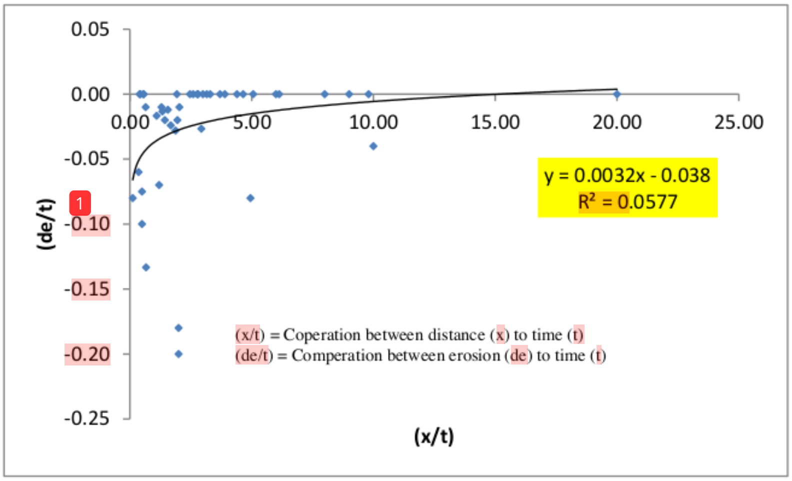

Fig 3. Comparison graph between (x/t) and (de/t)

In Figure 3. it can be seen that the maximum relative erosion depth (de/t)max occurred at the beginning of the channel near the sluice gate of 0.04. where $R^2 = 0.057$ within 30 minutes, means that statistically the value obtained is not significant and invalid and cannot be used.

During the first 5 minutes, there was a maximum relative erosion (de/t)max as shown in Figure 4. below:

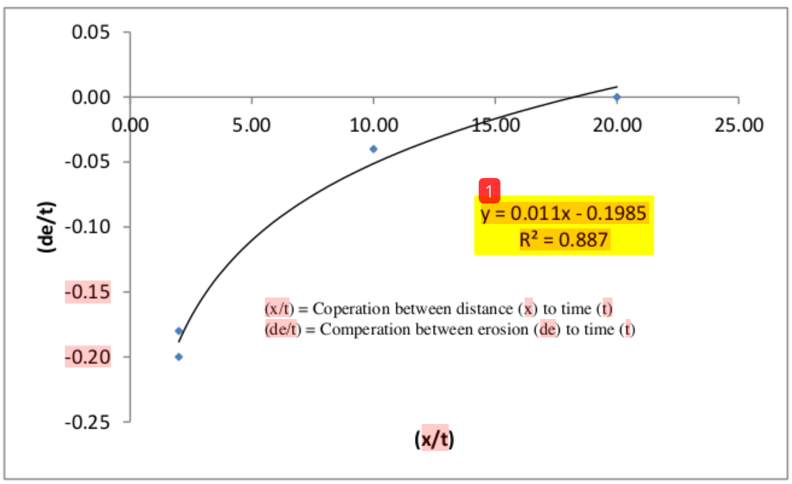

Fig 4. Comparison graph between (x/t) and (de/t) for 5 minutes

Figure 4 shows that the maximum relative erosion (de/t)max occurs before the floodgate is 0.18, meaning that for 5 minutes there will be an erosion of 9 cm in the model. $R^2 = 0.057$ within 30 minutes, means that statistically the value obtained is not significant and invalid and cannot be used.

At the time of 10 minutes (5 minutes second), there was a maximum relative erosion (de/t)max as shown in Figure 5. below:

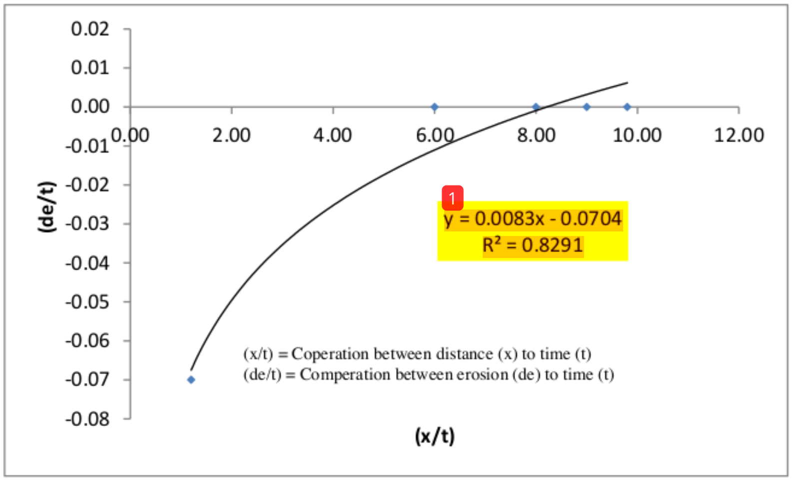

Fig 5. Comparison graph between (x/t) and (de/t) for 10 minutes

In Figure 5. it can be seen that the maximum relative erosion $(de/t)_{max}$ occurs before the floodgate is 0.07, meaning that for 10 minutes there will be an erosion of 0.70 cm in the model. $R^2 = 0.829$ within 10 minutes, means that statistically the value obtained is significant and valid and can be used.

At the 15 minutes (5 minutes third), there was a maximum relative erosion $(de/t)_{max}$ as shown in Figure 6. below:

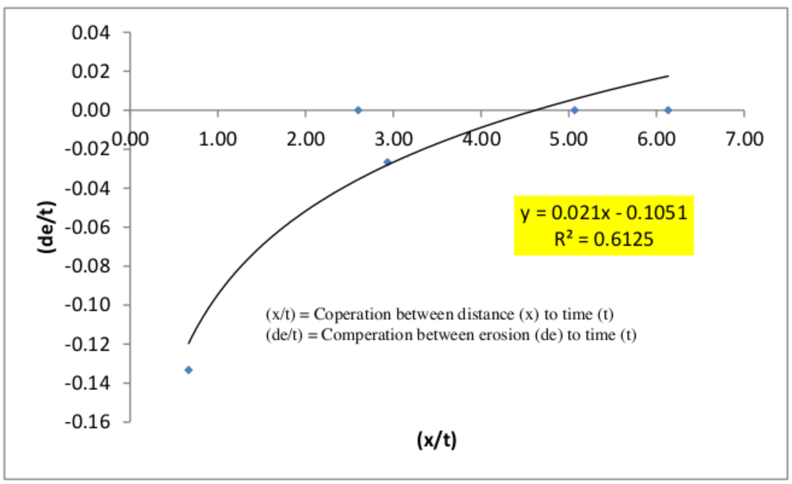

Fig 6. Comparison graph between (x/t) and (de/t) for 15 minutes

In Figure 6. it can be seen that the increase in relative maximum erosion $(de/t)_{max}$ occurred before the floodgate of 0.12 which means that for 15 minutes there will be an erosion of 1.80 cm in the model. $R^2 = 0.612$ within 15 minutes, means that statistically the value obtained is relatively significant, valid and can be used.

At the 20 minutes (5 minutes fourth), there was a maximum relative erosion $(de/t)_{max}$ as shown in Figure 7 below:

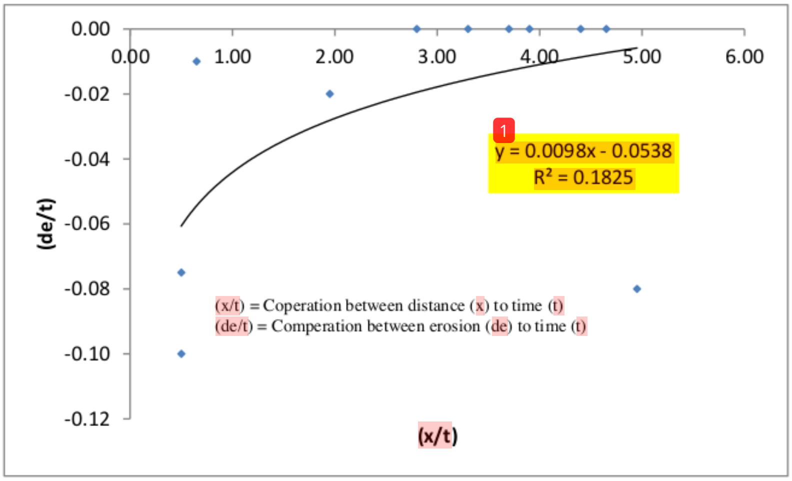

Fig 7. Comparison graph between (x/t) and (de/t) for 20 minutes

In Figure 7. it can be seen that the maximum relative erosion reduction $(de/t)_{max}$ occurs before the floodgate is 0.06 which means that for 20 minutes there will be an erosion of 1.2 cm in the model. $R^2 = 0.182$ within 20 minutes, means that statistically the value obtained is not significant and not valid and can not be used.

At the time of 25 minutes (5 minutes to five), there was a maximum relative erosion (de/t)max as shown in Figure 8. below:

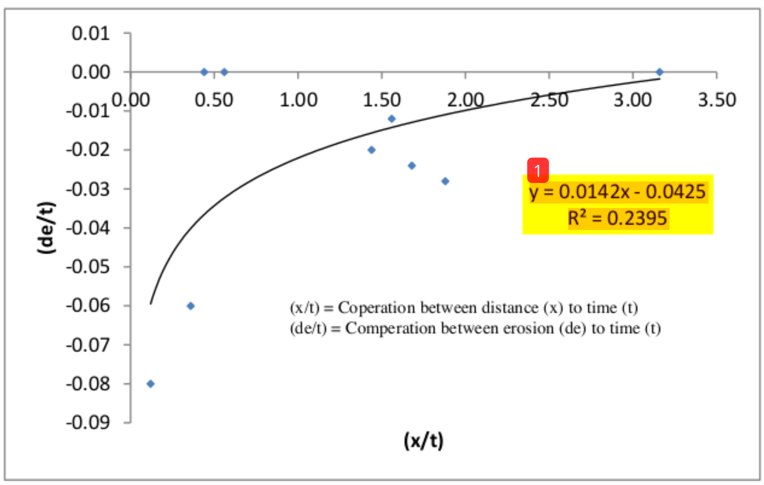

Fig 8. Comparison graph between (x/t) and (de/t) for 25 minutes

In Figure 8. there is an increase in the maximum relative erosion (de/t)max that occurs before the floodgate of 0.058 which means that for 25 minutes there will be an erosion of 1.45 cm in the model. $R^2 = 0.239$ within 25 minutes, means that statistically the value obtained is not significant and not valid and can not be used.

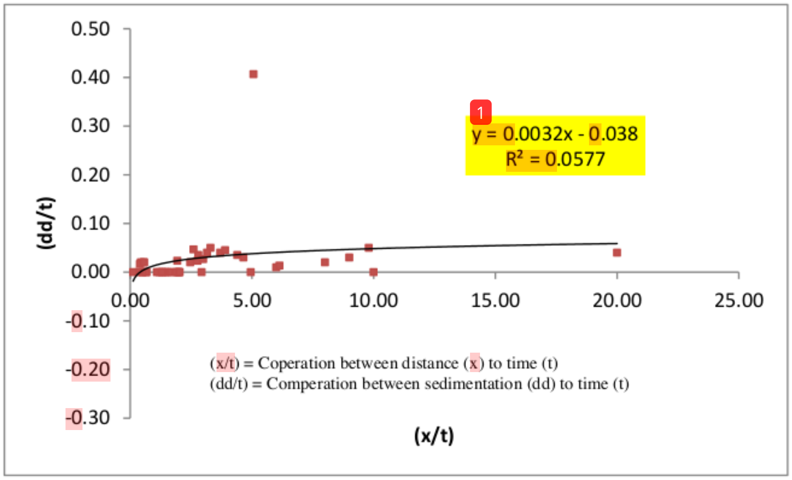

Fig 9. Graph of the relationship between (x/t) and (dd/t)

In Figure 9, it can be seen that the maximum sedimentation in the channel occurs at a maximum relative distance (x/t) of max 10, which is 0.05. This means that within 30 minutes, there will be 15 cm of sedimentation in the channel in the model. $R^2 = 0.057$ within 30 minutes, means that statistically the value obtained is not significant and not valid and can not be used.

During the first 5 minutes there was a maximum relative sedimentation $(d_d/t)_{max}$ as shown in Figure 10. below:

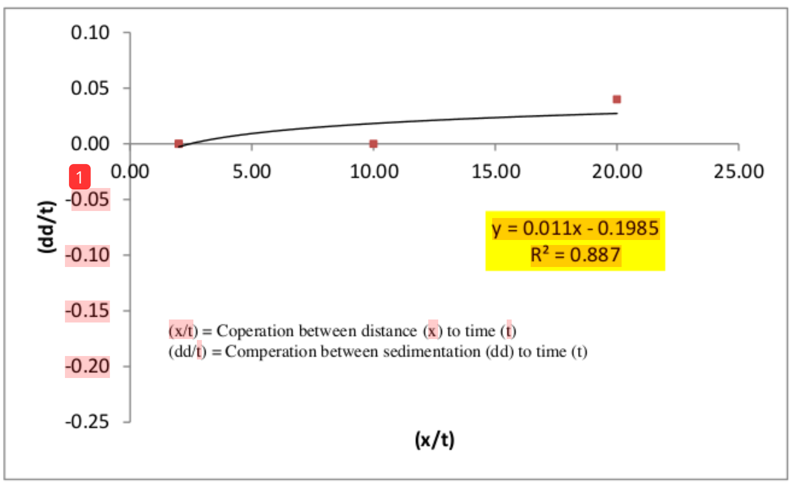

Fig 10. Graph of the relationship between (x/t) and (dd/t) for 5 minutes

In Figure 10. it can be seen that the maximum sedimentation in the channel occurs at a maximum relative distance (x/t) of max 20, which is 0.035. This means that in the first 5 minutes, there will be 0.7 cm of sedimentation in front of the JSC main channel sluice gate in the model. $R^2 = 0.887$ within 5 minutes, means that statistically the value obtained is significant, valid and can be used.

In the second 5 minutes (10 minutes) sedimentation occurs as shown in the following figure:

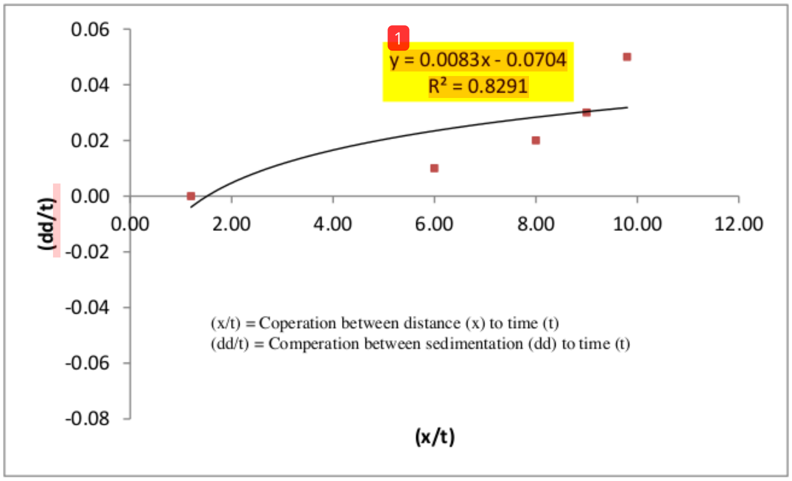

Fig 11. Graph of the relationship between (x/t) and (dd/t) for 10 minutes

In Figure 11. it can be seen that the maximum sedimentation in the channel occurs at a maximum relative distance (x/t)max 10, which is 0.035. This means that within 10 minutes, there will be 0.35 cm of sedimentation in front of the JSC main channel sluice gate in the model. $R^2 = 0.829$ within 5 minutes, means that statistically the value obtained is significant, valid and can be used.

During the third 5 minutes (15 minutes) sedimentation occurred as shown in the following figure:

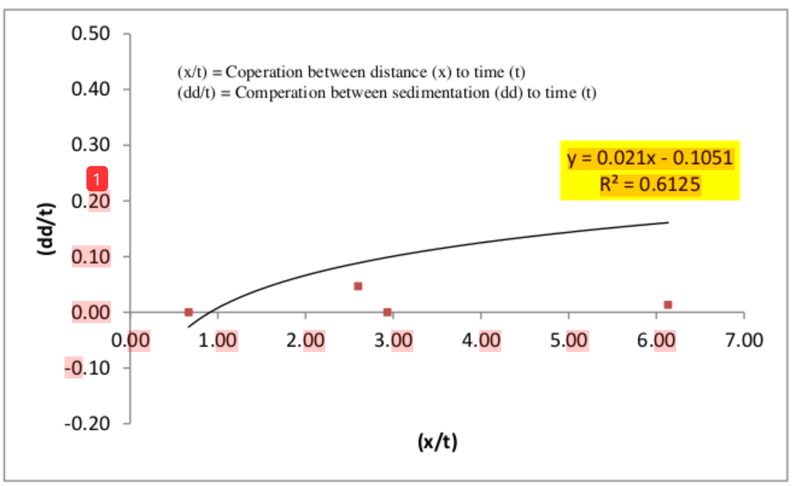

Fig 12. Graph of the relationship between (x/t) and (dd/t) for 15 minutes

In Figure 12. it can be seen that the increase in the maximum amount of sedimentation in the channel occurs at the maximum relative distance (x/t)max 6, which is 0.18. This means that in 15 minutes, there will be 2.70 cm of sedimentation in front of the JSC main channel sluice gate in the model. $R^2 = 0.612$ within 5 minutes, means that statistically the value obtained is relatively significant, valid and can be used.

During the fourth 5 minutes (20 minutes) sedimentation occurs as shown in the following figure:

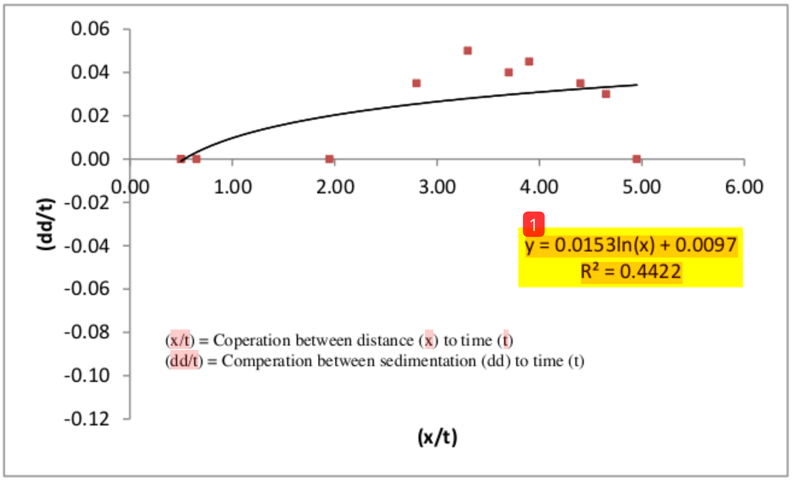

Fig 13. Graph of the relationship between (x/t) and (dd/t) for 20 minutes

In Figure 13. it can be seen that the increase in the maximum amount of sedimentation in the channel occurs at the maximum relative distance (x/t)max 6, which is 0.18. This means that in 15 minutes, there will be 2.70 cm of sedimentation in front of the JSC main channel sluice gate in the model. R^2 = 0.442 within 5 minutes, means that statistically the value obtained is not significant, not valid and can not be used.

During the fourth 5 minutes (20 minutes) sedimentation occurs as shown in the following figure:

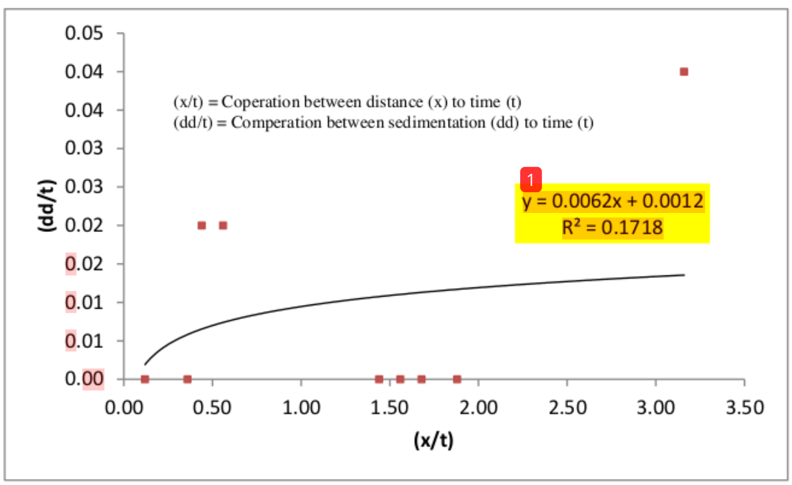

Fig 13. Graph of the relationship between (x/t) and (dd/t) for 25 minutes

In Figure 13, it can be seen that the maximum amount of sedimentation in the channel occurs at a maximum relative distance (x/t) of 3, which is 0.015. This means that within 25 minutes, there will be 0.05 cm of sedimentation in front of the JSC main channel sluice gate in the model. R^2 = 0.171 within 5 minutes, means that statistically the value obtained is not significant, not valid and can not be used.

IV. CONCLUSION

The maximum relative erosion $(d_e/t)_{max}$ occurred at the front gate of the JSC main channel of 0.04. This means that within 30 minutes, there will be an erosion of 12 cm in the model. Meanwhile, at 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes erosion occurred ranging from 0.01 cm to 1.45 cm in the model.

The maximum relative sedimentation $(d_d/t)_{max}$ in front of the JSC main channel sluice gate occurs at a maximum relative distance $(x/t)_{max}$ 10, which is 0.05. This means that within 30 minutes, there will be 15 cm of sedimentation in the channel in the model. Meanwhile, at 5 minutes, 10 minutes, 15 minutes, 20 minutes and 25 minutes sedimentation occurred ranging from 0.05 cm to 2.70 cm in the model.

The process of balancing erosion and sedimentation (equilibrium) occurred during the second 5 minutes (10 minutes) and the third 5 minutes (15 minutes) the experiment began to occur in the "sediment transport" balance in front of the JSC main canal sluice gate.

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