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ANALYSIS OF SEDIMENT RATE ON CHANNEL IRRIGATION SANREGO IRRIGATION REGIONAL OF KAHU DISTRICT OF BONE REGENCY SOUTH SULAWESI PROVINCE

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ABSTRACT

This research aims to determine the amount of sediment (sediment-rate) that occurs on the channel point to review and to provide an overview and explanation of the value of the correlation coefficient (R) is based on the relationship between sediment discharges (Q_S) with water discharge (Q_W). This research is conducted by measuring directly on location with measuring the water level in each cross section of the channel and water sampling to test concentrations in the sediment. The results of research showed that the rate of sediment on the Primary Channel of Sanrego is 4.253 kg/day, Secondary Channel of Batu-Batu is 0.0593kg/day, Tertiary Channel of Palakka 1 is 0.0403 kg/day, Palakka Tertiary Channel 2 is 0.0155 kg/day, Tertiary Channel of Batu-Batu 1 is 0.000578 kg/day, Tertiary Channel of Batu-Batu 2 is 0.0199 kg/day, with an average correlation coefficient (R) of 0.960, it shows the relationship between sediment discharge (Q_S) with water discharge (Q_W) has a positive direct perfect connection, which is between $0.6 < R < 1.0$. While on the Secondary Channel Palakka of 1.218 kg/day, with a correlation coefficient (R) of 0.210, this shows the relationship of sediment discharge (Q_S) and water discharge (Q_W) has a direct positive relationship is weak, that is between $0 < R < 0.6$.

Keywords: sedimentation-rate, irrigation channel, sanrego irrigation area, linier regression.

INTRODUCTION

Process of a river sedimentation includes a process of erosion, transport, deposition and compaction of sediment itself [1]. As known, sedimentation in the river occurred due to the deposition of sediment concentrations in the river flow that comes from the erosion in the upper reaches of the river. This applies also process of irrigation channels in a dam. Damage to the watershed causes increasing transport sediment flow in to the irrigation channel. If the flow rate is low there will be a precipitation process in the irrigation channel. Stacking the material continues to precipitate more and will form the delta.

Sanrego River is located in Bone regency, South Sulawesi Province, precisely in the Village Sanrego, District Kahu. Sanrego river is one of the rivers that have an important role to people's lives. This river used as a container to support the functions as irrigation, flood control, water providers and one of the tourist place. Irrigation channels that is the primary channel, secondary and tertiary experiencing slow performance. One of factors that affect the performance of the irrigation channel is the sediment.

Sediment which contained in the channel can cause dimensional changes channel of origin, and can affect the specific energy so that the channel cross section may indirectly result in less than optimum performance of the irrigation channels [2].

This study aims to determine the rate of sedimentation in the primary channel, secondary, and tertiary Sanrego Irrigation Area.

Based on the above, the authors would like to examine further by writing the title "Analysis of Sediment Rate on Channel Irrigation Sanrego Irrigation Regional of Kahu District of Bone Regency South Sulawesi Province".

LITERATURE REVIEW

Definition of sediment

Sediment is the result of erosion, either in the form of surface erosion, gully erosion, or other types of soil erosion. Sediment generally settles at the bottom of the foot of the hill, in the floodwaters, waterways, rivers, and reservoirs. Sedimentation rate is the number of results sediment per unit area of the catchment area (DTA) or the watershed (DAS) per unit time (in tonnes/ha/year or mm/ year). Results sediment (sediment yield) is the amount of sediment derived from erosion in the catchment area are measured at a certain period of time and place. The results obtained from measurements of sediment are usually dissolved in the river sediment (suspended sediment) or direct measurement in the reservoir [3].

According [4], states that the large volume of sediment transport is mainly dependent on flow speed, because of changes in the rainy season and dry seasons, as well as the speed changes are influenced by human activities.

As a result of changes in the volume of sediment transport is the occurrence of erosion in some places as well as the deposition in other places on the basis of irrigation channels, those the dimensions of the channel will be changed so that the volume of water carried is also reduced. To estimate the changes that have been developed many formulas based on experiments in the laboratory and in the field of hydraulics. These calculations are still not rigorous yet, because:

a. Interaction between flow and sediment transport is very complex and therefore it is generally difficult to be written mathematically correct.

b. Measurements of sediment transport are difficult implemented carefully, so that the transport formula can not be checked properly.

Sediment transport can move, shift, move along the base line or float on the river flow, depending on the:

a) Composition (the size and density, and etc.)
b) Flow conditions (flow speed, flowdepth, and etc.)

Types of sediment transport

Sediment can be classified into two parts is based on the transport mechanism and is based on origin [4], as follows:

a. According to the transport mechanism can be divided into two (2) types, namely;

1) Bed load

The movement of particles in the water flow of the river by means of rolling, sliding and jumping up and down on the surface of the riverbed.

2) Suspended load

Consists of fine grains are always floating in the river. The tendency of particles to settle is always offset by diffusive action of a turbulent flow of river water.

b. According to origin, the ingredients in the sediment transport can be divided in to two (2) types, namely;

1) Bed material load

Transport material is derived from the body of the river itself, and it can be transported in the form of basic charge or floating charge.

2) Wash load

Cargo transport rinse is in the form of fine particles of clay (silt), dust (dust) carried by the river flow. This charge comes from the weathering of rock or soil layer (particles) watersheds. The particle-particle carried away by surface runoff or wind into the river.

Transport material is derived from the results of erosion in river basin areas (DAS). This material can only be transported as cargo and general drift consist very fine materials <50μm.

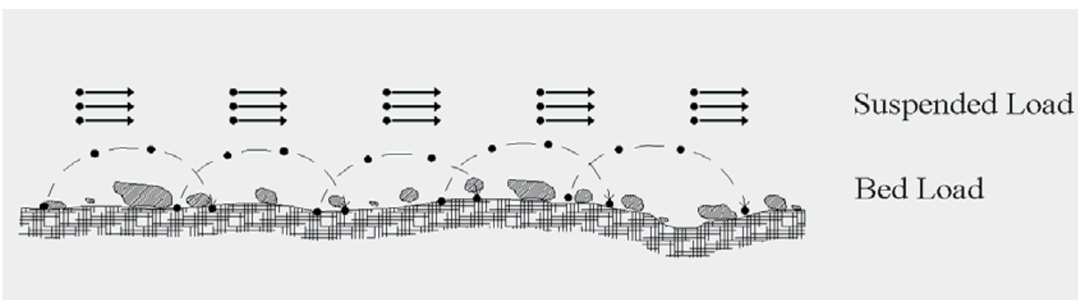

Figure-1. Distribution of sediments.

Creation discharge curve

The flow rate is obtained by passing a broad face the flow and the flow velocity. Both of these parameters can be measured on a cross section (station) on the river. Wide look is obtained by measuring the flow of water surface elevation and the riverbed. When the basic and riverbanks unchanged (no erosion and sedimentation) riverbed elevation measurements performed only one time. Then with measuring the water level for a variety of conditions, ranging from small to large discharge flow (flood), can be calculated face for a wide variety of the water levelthe flow rate is also calculated together with the measurement of water level. Therefore, it can be calculated (rating curve), which is the relationship between water level and discharge. With the discharge curve has been made, then the river flow can be calculated simply with measuring the water level. The use of the discharge curve can only be done if the river is not influenced by tides [5].

According [5], states that the form face lengthwise and crosswise river is irregular. In addition, because of the influence of water viscosity and hardness wall, the vertical velocity distribution has a parabolic shape with zero speed, and more speed into the middle of growing large by paying attention to the distribution, the influence of speed should be done in several vertical and measurement points will give better results. From the data speed at some point on the vertical in order to calculate the speed of the average speed in the area around the depth.

Measuring flow

Discharge is the amount of water flowing on the river channel or per unit of time. The method commonly applied to establish river discharge is a method of river profile (cross section). In this method, the discharge is the result of multiplying the vertical cross-sectional area of the river (river profile) with the speed of water flow:

$$.Q_w = A \times V \quad (1)$$

Where:

Q = Discharge (m^3/det)
A = Vertical cross-sectional area (m^2)
V = Velocity (m/det).

Before to conduct measurements, the choice of location is an important thing that must be considered because of the suitability of the location will influence accuracy of measurement results. Criteria for an ideal location to make the measurement are:

1) There is novortex.
2) Profile flat with no obstacles river water flow
3) The current centralized and not wide the river when the water level rises.
4) Special for measurements on large rivers there must be a strong bridge.

a. Profile creation river

Profile river or river channel geometry is affected the magnitude of the flow rate of the river, so that in the calculation of the discharge needs to create the profile of the river, in the following manner;

1) Choose representative locations (to represent) for discharge measurements
2) The size of the wide of river (horizontal cross section)
3) For the the wide river of into 10-20 sections with the same spacing interval
4) The size of the water depth at each interval by using stick

b. Discharge measurement with current meter tool

Measurements of flow velocity with a Current Meter is following the procedure as following:

1) Preparing one unit Current Meters
2) Measure the channel cross sections that will be used as a test channel
3) All the equipment once it is ready, then divide the flow cross section into 3 (three) sections or part of the surface of the same width.
4) Measure the height of water wet channel cross-section, the width of the wet surface and the water surface width of each margin.
5) Insert the stick and propeller Current Meters into the channel and placed on each depth 0,2H: 0,6H: and 0,8H, (H = high water level of basic channels). Selected according to the depth of the flow.
6) Placing Propeller perpendicular facing the flow stream, after right at the position in question and then press the keys on the counter along with it also starts the stopwatch until at a certain time interval (50 seconds) counter and stop the stop watch, then record the number of turns (N) on the counter.
7) Coping the above experiment is repeated 3 times for some of the water level (H) in accordance with the specified flow changes.
8) Calculating the speed of each measurement, calculate the average speed.

Calculating flow rate to the equation, as follows;

$$V = a.N + b \qquad (2)$$

Where:
V = Velocity (m/det)
N = Number of rounds
a, b = Constants (This value defined in the calibration)

Measurements of sediment drift

Sediment load floating (suspended load) can be seen as the basic material of the river (bed material) that is floating in the river basin and consists of grains of fine sand which is always supported by the water and very little interaction with the bottom of the river, because it is always pushed to the top by turbulence. Measurements of sediment transport float carried out to determine the concentration of sediments, sediment grain size and sediment production drift [4].

a. Sediment concentrations

Sediment concentration can be expressed in various ways, among other things:

1) Expressed by the ratio between the weight of dry sediment contained in one volume of sediment along the water of a sample, usually expressed in units of mg / l, g / m^3, kg / m^3 or ton / m^3;
2) Expressed by comparing the volume of sediment particles are contained in one unit volume of water sample, usually expressed in units %;
3) The concentration of sediments can also be expressed in parts per million (ppm), if the concentration is low, calculated by dividing weight by weight of drysediment sample and multiplying the quotient by 10^6.

b. Particle size

Sediment grain size is usually expressed in units of mm; this data is an important parameter in the investigation of the sediment problem. Differences in grain size may indicate differences in how transport and source. Sediment production can be expressed in units of weight or unit of volume, for unit of weight to unit area ratio is, for example, expressed in ton / km2 or kg / ha, to unit volume ratio is a unit of time, example m^3/ year. To change the unit of weight unit of volume must be determined specific weight of sediment. Sediment concentration measurements can be performed by conventional means, namely measuring sediment concentration in a vertical, by taking sediment sample.

According [4] that in taking sediment sample, both in rivers and in the channel, used several methods such as point method, the method of in tointegration and concentration measurement methods in place (*In Situ*).

1) Method of integration points

In general, this method used for measure the concentration of sediment in the river drift wide or on a river that has spread sediment concentrations varies. At a

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cross-section determined several vertical measurements of the distances are made so that the flow velocity and sediment concentration at each vertically adjacent each have a small difference, this work requires a lot of experience in the field, so that the results are good, the minimum required three vertical.

The number of measurement points can vary depending on the depth of flow and sediment grain size floated. This method can be divided into two, namely *Multipoint Method*

At many points method, sampling sediments are usually carried out more than five measurement points.

a) Simplified method

The simply methods can be conducted by:

(1) Measurement of one point (0.5 point or 0.6 depth of the flow).
(2) Measurement of two pointsis done at 0.2 and 0.8 depth of flow.

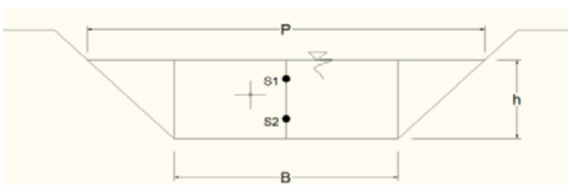

Figure-2. Two measurement point.

(3) Measurement of three points is conducted in 0.2; 0.6 and 0.8 depth of flow.

These measurements will be used to determine the drift of sediment discharge, then each measuring point should also be measured velocities.

2) Method of integration depth

In this event a sample of sediment is measured by moving the sediment measuring instrument up or down in a vertical motion with the same speed. These measurements can be performed on the entire depth or at a vertical depth is divided into several depth intervals. These measurements can be divided into two ways, namely:

a) Equal discharge increment (EDI)

At a cross-section is divided into several sub cross sections, in which each sub cross section should has the same discharge. Then the sediment measurements are conducted in this way in the middle of each of the sub-sectional.

b) Equal width increment (EWI)

At a cross-section is divided into a number of vertical lines with the distance of each vertical measurement are made the same. Measurements of sediment transport sediment drift on any vertical lines is conducted by the integration of depth and move the measuring instrument increasing or decreasing at the same rate for all vertical lines. Therefore, this measurement method also called ERT (Equal Transit Rate). Volume obtained will be proportional to flow in each part of the cross section. So that the number of samples of each of the vertical lines can be accommodated in one sample bottle.

3) Method of measurement of concentration in place (In Situ)

Sediment concentration measurement method can be carried out directly on-site measurements (in situ), for example nuclear gauge or with a photo electric turbidity meter.

c. Production drifting sediment discharge

With the assumption that the concentration of sediment evenly on the entire cross sections the river, so the sediment discharge may be calculated as the multiplication of concentration and water discharge are formulated [3], as following:

$$Q_{Sm} = 0{,}0864 \times C_S \times Q_w \quad (3)$$

Where:
Q_{Sm} = Sediment drift discharge (ton/year)
C_S = The concentration of sediment load drift (mg/liter)
Q_w = Water discharge (m^3/second)

Concentration levels (C_S) can be obtained by the equation;

$$C_S = \frac{1000}{V} \times (a-b) \times 1000 \quad (4)$$

Where:
C_S =The concentration of sediment load drift (mg/liter)
V = The volume of sediment samples (ml)
b = Weight bowls containing sediments (gr)
a = Weight empty bowls (gr)

Drifting sediment concentration determination (C_S)

Sediment drifting samples are analysed directly in the laboratory always drifting directly. After precipitated during 1-2 days, sediment concentration is determined by weighing the dried sediment content and divide by the volume of sediment samples + water. Sediment concentration is always expressed in units:

a) mg/l, or g/l or g/m^3, kg/m^3, or
b) parts per million, or
c) stated in the %.

The conversion factor can be seen in table 1 with the assumption the density of water (water density) = 1.0 g/cm^3 and sediment particle density of 2.65 g/cm^3 and the dissolved solids content of less than 1000 ppm.

Table-1. The conversion factor of sediment concentration drifting (in ppm to g/l).

Concentration (ppm)	**Concentration** (g/l)	**Concentration** (ppm)	**Concentration** (g/l)
0 - 15900	1,00	322000 - 341000	1,26
16000 - 46800	1,02	342000 - 361000	1,28
46900 - 76500	1,04	362000 - 380000	1,30
76600 - 105900	1,06	381000 - 399000	1,32
106000 - 133000	1,08	400000 - 416000	1,34
134000 - 159000	1,10	417000 - 434000	1,36
160000 - 185000	1,12	435000 - 451000	1,38
186000 - 210000	1,14	452000 - 467000	1,40
211000 - 233000	1,16	468000 - 483000	1,42
234000 - 256000	1,18	484000 - 498000	1,44
257000 - 279000	1,20	499000 - 514000	1,46
280000 - 300000	1,22	515000 - 528000	1,48
301000 - 321000	1,24	529000 – 542000	1,50

RESEARCH METHODS

Location and time of research

Location research in Irrigation Sanrego Regional the Channel Primary Sanrego, Channel Secondary Palakka, Secondary Batu-Batu Channel, and Third Level Palakka 1, Third Level Palakka 2, Third Level Batu-Batu 1, Channel Tertiary Batu-Batu 2 and the Soil Mechanics Laboratory Department Civil Engineering State Polytechnic of Ujung Pandang.

Preparation and implementation of the research lasted for 3 (three) months, commencing early April 2015 until early July 2015. The implementation of site surveys and measurement of flow rate in the channel and the water sampling, conducted over two (2) weeks, the beginning of early April 2015 until mid-May 2015. While testing in Soil Mechanics Laboratory is testing concentration sediment, held for 2 (two) weeks, the beginning of May 2015 until mid Juny 2015. Data compilation, processing and analysis of data, evaluation and presentation of data, both obtained from measurements in the field and laboratory test results, carried out during the five (5) weeks, which is the end of Juny 2015 until the end of the month of July 2015.The variables observation in this study consisted of sediment load magnitude irrigation channels per time (kg/day) in which the required supplementary data such as water discharge channel, the flow velocity, flow depth and sediment load drifting.

Tools and materials research

The tools and materials used according to the sequence of events described in Table-1 below:

Table-2. Activities, materials and equipments.

No.	Schedules	Materials	Tools
1	Measurement of flow depth	-	Ruler
2	Measurement of average water velocity	-	Stop watch, Current meter
3	Measurements of sediment drift	Water and sediment transported	The sample bottle, permanent marker
4	Wide measurement channel	-	Meter

Implementation of research

a) Creation of guess vertical ruler

Ruler made of wood vertical expect a length of 200 cm, the rod is made of measurement scale (cm). This stick is used to measure the depth of the flow. Number of measuring sticks as many as 1 piece.

b) Preparation of sample bottles

Sample bottles are used to take sediment load in the form of plastic bottles of bottled water with a diameter of 2.5 cm (mouth of the bottle). The sample bottle is used to take samples at the primary irrigation canal, secondary, and tertiary respectively by 2 pieces each time of observation.

c) The meter is prepared to measure the width of the cross section of the river wet.

RESULTS AND DISCUSSIONS

Research result

Based on the measurement of primary data that has been conducted in the field, namely in the form of channel dimensions in this case the primary channel, secondary, tertiary, and the flow rate by using a current

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meter, as well as the conditions around the area of observation on Irrigation Area Sanrego, which then becomes the basis for data processing to get the sedimentation rate.

Before making curved sediment drift, first calculated discharge of river water which in turn will generate a graph of sediment drift (Q_{sm}) and flow (Q_w), as shown in Table-3, below; as:

Table-3. Results of analysis of sediment drift calculation (Qsm).

No.	**Channel name**	**Date**	**Constants average**	**Debit (Q) average** (m^3/second)	**Average Cs** (mg/lt)	**Sediment drift** (Qsm) (ton/day)	**Sediment average drift** (Average Qsm) **ton/day**	**Sediment average drift** (Average Qsm) **kg/day**
1	Primary Sanrego	30/4/2015	0.0864	12.396	0.00106	0.00113	0.00113	1.131
		1/5/2015	0.0864	14.691	0.00104	0.00132	0.00132	1.316
		2/5/2015	0.0864	17.877	0.00117	0.00181	0.00181	1.806
							Total	4.253
2	Secondary Palakka	30/4/2015	0.0864	4.080	0.00100	0.000399	0.000399	0.399
		1/5/2015	0.0864	4.390	0.00104	0.000393	0.000393	0.393
		2/5/2015	0.0864	4.224	0.00104	0.000426	0.000426	0.426
							Total	1.218
3	Secondary Batu-Batu	3/5/2015	0.0864	0.323	0.00106	0.0000294	0.0000294	0.0294
		4/5/2015	0.0864	0.223	0.00104	0.0000199	0.0000199	0.0199
		5/5/2015	0.0864	0.0982	0.00117	0.00000989	0.00000989	0.00989
							Total	0.0593
4	Tertiary Palakka 1	3/5/2015	0.0864	0.130	0.00106	0.0000119	0.0000119	0.0119
		4/5/2015	0.0864	0.151	0.00104	0.0000136	0.0000136	0.0136
		5/5/2015	0.0864	0.147	0.00117	0.0000148	0.0000148	0.0148
							Total	0.0403
5	Tertiary Palakka 2	3/5/2015	0.0864	0.0619	0.00106	0.00000566	0.00000566	0.00566
		4/5/2015	0.0864	0.0352	0.00104	0.00000315	0.00000315	0.00315
		5/5/2015	0.0864	0.0662	0.00117	0.00000667	0.00000667	0.00667
							Total	0.0155
6	Tertiary Batu-Batu 1	6/5/2015	0.0864	0.0349	0.0000349	0.000000105	0.000000105	0.000105
		7/5/2015	0.0864	0.0466	0.0000466	0.000000189	0.000000189	0.000189
		8/5/2015	0.0864	0.0572	0.0000572	0.000000283	0.000000283	0.000283
							Total	0.000578
7	Tertiary Batu-Batu 2	6/5/2015	0.0864	0.0972	0.001057	0.00000887	0.00000887	0.00887
		7/5/2015	0.0864	0.0546	0.001037	0.00000489	0.000000489	0.00489
		8/5/2015	0.0864	0.0607	0.00117	0.00000613	0.00000613	0.00613
							Total	0.0199

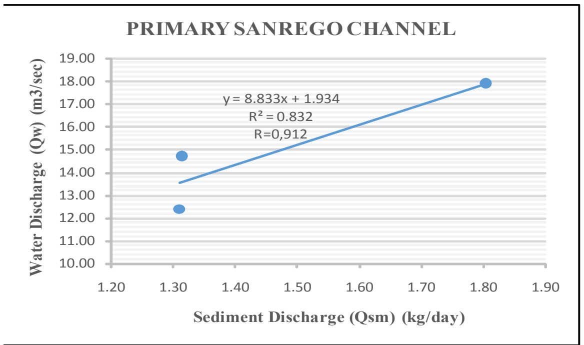

Figure-3. Relationship sediment discharge and water discharge on the primary Sanrego channel.

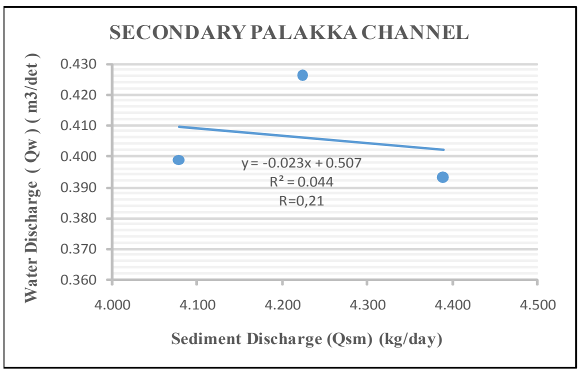

Figure-4. Relations sediment discharge and water discharge on the secondary Palakka channel.

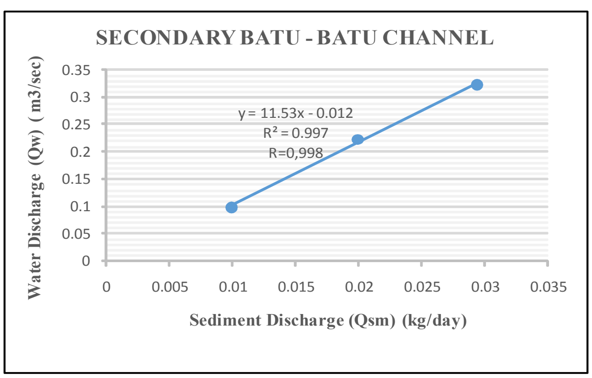

Figure-5. Relations sediment discharge and water discharge on the secondary Batu-Batu channel.

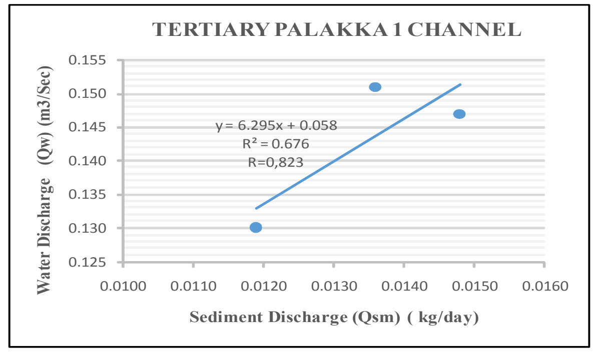

Figure-6. Relations sediment discharge and water discharge at the tertiary Palakka 1 Channel.

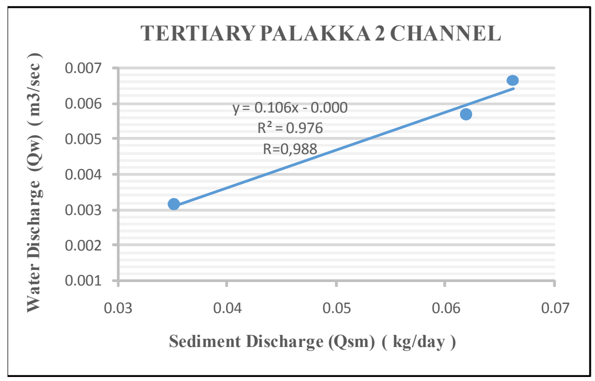

Figure-7. Relations sediment discharge and water discharge at the tertiary Palakka 2channel.

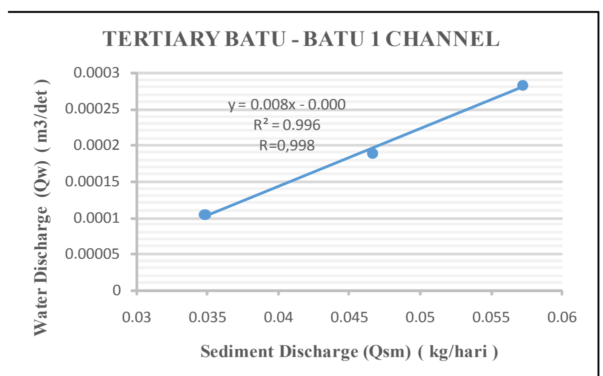

Figure-8. Relations sediment discharge and water discharge at the tertiary Batu-Batu 1 channel.

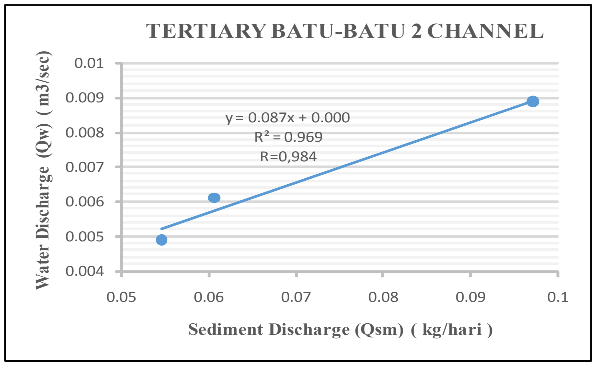

Figure-9. Relations sediment discharge and water discharge at the tertiary Batu-Batu 2 channel.

DISCUSSION OF THE RESULTS

Based on seven (7) point review the measurement location, good dimension measurement channels, the measurement speed to get the flow rate, as well as the measurement of sediment concentration to obtain sediment discharge, turns on Channel Secondary Palakka, as shown in Figure-4, is obtained by the relationship between sediment discharge versus proportional to the flow rate. Based on linear regression equation, namely y = - 0,023x + 0.507 with a correlation coefficient (R) = 0.21, shows the relationship of sediment discharge and flow rate on the secondary channel Palakka have a direct positive correlation is weak, that is between 0 <R <0,6 [6].

While at Channel Primary Sanrego, Secondary Batu-Batu Channel, Third Level Palakka 1, Third Level Palakka 2, Third Level Batu-Batu 1 and Tertiary Batu-Batu 2 Channel, as shown in Figures 3, 5, 6, 7, 8, and 9, obtained by the relationship between sediment discharges is directly proportional to flow rate. Based on linear regression equations, respectively; the Primary Sanrego Channels, namely y = 8,883x + 1.934 with a correlation coefficient (R) = 0.912, the secondary Batu-Batu channel, namely y = 11,53x-0.012 with a correlation coefficient (R) = 0.998, in the Tertiary Palakka 1 channel , namely y = 6,2951x + 0.0581 with a correlation coefficient (R) = 0.823, in the Tertiary Palakka Channels 2, namely y = 0,1066x-0.0006 with a correlation coefficient (R) = 0.988, in the Tertiary channel Batu-Batu 1, i.e. y = 0,008x-0.0002 with a correlation coefficient (R) = 0.998, in the Tertiary Batu-Batu2 Channels, namely y = 0,087x + 0.0005 with a correlation coefficient (R) = 0.984, shown the relationship discharge sediment and flow on Channel Primary Sanrego, Secondary Batu-Batu Channel, Third Level Palakka 1, Third Level Palakka 2, Third Level Batu-Batu 1 and Tertiary Batu-Batu 2 Channel, has a direct relationship positively perfect, which is located between 0.6 <R <1.0 [6].

CONCLUSIONS

Based on the results are obtained as described in the discussion, it can be in the following conclusion;

a) The result of the discharge curve (Rating Curve) by using a graphical method is the higher the water level, the water flow would be even greater. By using this discharge curve of water level can be used to determine the flow rate in the channel at a sampling of sediment. Besides the discharge channel can also be used to estimate the amount of sediment deposition (ton / day).
b) Using the calculation method available instantaneous volume of sediment drift (suspended load) is:
   - Primary Channels Sanrego amounted to 4.253 kg/day
   - Secondary Palakka Channels is 1.218 kg/day
   - Secondary Batu-BatuChannels is 0.0593 kg/day
   - Tertiary Palakka 1 channel is 0.0403 kg/day
   - Tertiary Palakka 2 channel is 0.0155 kg/day
   - Tertiary Batu-Batu 1 channel is 0.000578 kg/day
   - Tertiary Batu-Batu 2 channel is 0.0199 kg/day
c) The grade point obtained in this research is in the form of dissolved materials (solute) in the form of very small particles and the particles in the channel hovering or particles that make the water appear muddy.

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