Evaluation on Flushing Operation Frequency of Sand Trap of Pendowo and Pijenan Weirs

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ABSTRACT

Sediment deposited in the sand trap of Pendowo and Pijenan Weirs are influenced by the water discharge that enters the sand trap, the soil conditions next to the sand trap, and flushing time. The off schedule of the flushing time is because of the farmers' water demand for their farming fields and fish ponds. These conditions would affect the sand trap performance. Thus, an evaluation is required. The objective of this study was to identify the performance of sand trap in Pendowo Weir and Pijenan Weir. Calculation of the irrigation water demand was aimed to identify the irrigation water discharge. Sediment that was taken from the sand trap was used to identify its index properties followed by the sediment transport calculation applying the Meyer-Peter and Muller formula. The results showed that the sand trap in Pendowo and Pijenan Weirs was still in a good performance, as indicated by their ability to hydraulically deposit and flush the sediment under frequent flushing operation in once every 6 months and 3 months during the rainy season at Pendowo and Pijenan Weir respectively. Further operation of the sand trap at both weirs with the same frequency will sustain the sand trap to function properly.

Keywords: irrigation water demand, sedimentation, sand trap.

1 PREFACE

Pendowo Weir and its sand trap were built on 1924-1925, and the sand trap shape has not changed until the present, and there were only rehabilitations that have been made on the broken gate and to elevate the channel's embankment. Pijenan Weir and its sand trap were built in 1926 and developments have been made at the time of Japanese colonization in 1943. The existing sand trap construction in Pijenan Weir is the weir construction that had been repaired in 1982-1983. At its initial construction, Pendowo Weir irrigated sugarcane field of 1,433.19 Ha, and now it irrigates rice field of 1,094 ha. Pijenan Weir had been reconstructed in 1982–1983 in order to increase irrigated rice field of 600 ha. Currently, it could irrigate rice field of 2,305 ha.

Changes in vegetation type influence the water demand and flow discharge. The flow discharge would affect sediment in the sand trap (Hidayah, 2013). In addition to that, the amount of deposited sediment in the sand trap is also originated from the area surrounding the sand trap, as well as from the frequency of flushing time of the sand trap. The off-schedule flushing time both in the sand trap of Pendowo Weir and Pijenan Weir are caused by demands from the farmer in order to fulfill their water demand for crops and fish farming. Change in the flushing period would affect the performance of the sand trap; therefore evaluation for the sand trap performance is required.

This research aimed to analyze the sand trap performance in Pendowo Weir and Pijenan Weir at the current time condition according to the Irrigation Planning Standards. This research is expected to be able to give benefits in discovering the sand trap performance in Pendowo Weir and Pijenan Weir. Therefore, it could provide input for the stakeholders, which is the Water Resource Agency of Special Region of Yogyakarta, in taking the right policy, particularly regarding operational and maintenance of the settling basin in Pendowo Weir and Pijenan Weir.

2 LITERATURE REVIEW

2.1 Irrigation Water Needs

Irrigation water demands are mostly fulfilled from the surface water. The necessity for water irrigation is determined by various factors such as land preparation, water needs for vegetation, percolation and seepage, water layer change and effective rainfall (Setyono, 2016). The water need for crops on the field is defined as consumptive water need by inserting the plant coefficient factor, *kc*.

2.2 Sedimentation

Rivers flow always carry sediments. Sediments could be in any location in the flow, depends on the balance between the upward velocity of the particle (tractive force and lift force) and the velocity of particle sedimentation (Asdak, 2004).

2.3 Sediment Transport

Both theory and empirical approach have been widely used to find sediment transport. Choosing the right theory or approach for sediment transport is still quite difficult, that is why the sediment issue is interesting to be studied.

2.4 Sand Trap

A suspended particle that has to be deposited are presupposed of $0.5^0/_{00}$ of water discharge that flows through the sand trap. The size of the fine sand grain is particles with diameter more than 0.06 – 0.07 mm, mostly are deposited (60% – 70%) (Directorate General of Water Resources, 1986). Cleaning the sand trap and deposition sediment from the settling basin could be conducted hydraulically (hydraulic flushing), manually (manual flushing) as well as mechanically (mechanical flushing). (Directorate General of Water Resources, 1986).

3 THEORETICAL BASIS

3.1 Sediment Transport

The method used in the calculation of sediment transport is Meyer Peter Muller equation which is shown in Equation 1.

$$\gamma_w \frac{R_h}{h} \left(\frac{k}{k'}\right)^{3/2} h\, S = 0.047\,(\gamma_s - \gamma_w)\, d_m + 0.25\left(\frac{\gamma_w}{g}\right)^{1/3} (q_B')^{2/3} \quad (1)$$

in which γ_w is specific weight of water (kg/m^3), γ_s is specific weight of sediment (kg/m^3), R_h is hydraulic radius (m), S is energy gradient, d_m is representative diameter which varied between d_{50} - d_{60} (m), $q_B{}'$ is bed load level in channel, weight per time and width (kg/m.s), and $\frac{k}{k'}$ is effect of basic configuration (rippled).

3.2 Evaluation of Sand Trap

The volume of deposition sediment in sand trap comes from 0.5‰ of water discharge (*Qn*) that enters at a period of flushing (*T*) (Directorate General of Water Resources, 1986) as shown as in Equation 2.

$$V = 0.0005 \times Qn \times T \quad (2)$$

in which *V* is the sediment volume that deposits in a sand trap, *Qn* is normal discharge (m^3/s), and *T* is full time of sand trap/flushing period (days)

The length of the sand trap could be calculated with Equation 3 (Directorate General of Water Resources, 1986).

$$\frac{H}{w} = \frac{L}{v} \quad (3)$$

In which *H* is the depth of flow depth (m), *w* is the settling velocity of sediment particle (m/s), *L* is the length of the sand trap (m), and *v* is the flow velocity (m/s).

3.3 Evaluation Sediment Deposition

Evaluation on sediment deposition could be conducted with *Camp* graph. The graph gives efficiency as a function from 2 parameters shown in Equation 4 (Directorate General of Water Resources, 1986).

$$\frac{w}{w_0} \text{ and } \frac{w}{v_0} \quad (4)$$

In which *w* is the settling velocity of particle that its size is out of the planned particle size (m/s), w_0 planned settling velocity (m/s), and v_0 average velocity of flow in a sand trap (m/s).

3.4 Evaluation of Sand Trap Flushing

The efficiency of the flushing depends on the adequacy of the shear force at the surface of deposition sediment, and also to the adequate velocity that would keep the material stays suspended (Directorate General of Water Resources, 1986; Graf & Altinakar, 1998). The relation between shear stress and Reynolds number is calculated with Equation 5 and Equation 6.

$$\frac{\tau_o}{(\rho_s - \rho) g d} \quad (5)$$

$$R_{e*} = \frac{U_* d}{v} \quad (6)$$

whereas τ_0 is the shear stress (kg/m^2), ρ_s is sediment density (kg/m^3), ρ is water density (kg/m^3), *d* is grain diameter (m), *g* is gravitational acceleration (m/s^2), R_{e*} is Reynolds number, U_* is shear velocity (m/s), and *v* is viscosity (m^2/s).

4 RESEARCH METHODOLOGY

4.1 Research Location

Research location of Pendowo Weir and Pijenan weir was on the flow of Bedog River that starts from Merapi Mountain and ends to Progo River at Bantul Regency, Special Region of Yogyakarta. Pendowo Weir is located in Pendowoharjo Village, Sewon Sub-district; and Pijenan Weir is located in Wijirejo Village, Pandak Sub-district.

4.2 Data Source

Primary data:

a) Interview with weir's operators and local residents nearby the weir.
b) Bed load sampling
c) Measurement of flow velocity and channel's cross-sectional area and wetted perimeter.

Secondary data:

a) Water Resource Agency of Special Region of Yogyakarta
b) Operators of Pendowo Weir and Pijenan Weir.

4.3 Research Implementation

Research implementation included several states, which were: historical tracing of weir, sampling, measurement on the flow velocity and the channel's wet cross-sectional area, sample testing stage, and data analysis stage. Historical tracing of the weir and sand trap was conducted through interviews, in order to discover the year of construction of the weir and sand trap, vegetation type in the Irrigation Area, the area of the agricultural field, and normal water discharge.

Sediment sampling stage in this research was conducted by collecting bed load sample in the sand trap. The volume of the taken sediment was considered to be adequate for laboratory testing, which included specific weight and sediment grain gradation testing.

Measurement of the flow velocity was conducted with 10 m distance and travel time that was required by the float to reach 10 m. Travel time was counted using a stopwatch. At the time of flow velocity measurement, cross-sectional area and wetted perimeter of the channel was also measured, in order to discover the flowing water discharge at the time of normal flow and flushing.

Sediment sample testing was conducted by Soil Mechanic Laboratory of Universitas Gadjah Mada in Yogyakarta, which consisted of analyses on sediment grain size distribution and specific weight of the sediment.

Sediment load in the sand trap was calculated and analyzed using Meyer Peter Muller method. Evaluation of deposition and flushing of the sand trap was analyzed from the sediment grain with the Camp graph and Shields graph.

5 RESULT AND DISCUSSION

5.1 Description of Initial Condition of Sand Trap in Pendowo Weir

Calculation of water needs for sugarcane vegetation of 1,433.19 Ha was conducted with Penman method; rainfall data was obtained from Sapon Rain Station; and climatology data was obtained from Wates Station.

$$\text{Sugarcane water needs (NFR)} = Etc + P + LP - Re = 7.36 + 0 + 0 - 2.08 = 6.28 \text{ mm/day}$$

$$\text{Water needs at intake gate} = \frac{6.28}{0.65 \times 8.64} = 1.12 \text{ l/s/ha}$$

Total water needs at intake gate for a sugarcane field of 1,433.19 ha is 1.61 m^3/s. Water discharge of 1.61 m^3/s was used to calculate the fill time of sand trap in Pendowo Weir, based on Irrigation Planning Standards, as shown in Table 1. Table 1 shows that full the fill time of sand trap with the discharge of 1.61 m^3/s at time of rain season is 9 days, therefore sand trap flushing is needed.

5.2 The Current Condition of the Sand Trap of Pendowo Weir

Agricultural area for Pendowo Irrigation Area at the current time is 1,094 ha and has a cropping pattern of rice – rice – secondary crop (*palawija*). Normal water discharge for irrigation at the intake gate at the time of rain season was based on net water needs for rice during the growing period (Cholilul, C., 2014).

$$\text{Net water needs for rice (NFR)} = Etc + P + LP - Re = 6.36+1+0-0.72 = 6.64 \text{ mm/day}$$

$$\text{Water needs at intake gate} = \frac{6.64}{(0.65 \times 8.64)} = 1.18 \text{ l/s/ha}$$

Total water needs at intake gate for a paddy field of 1,094 ha is 1.3 m^3/s.

Deposited sediment in Pendowo Weir's sand trap depends on the amount of water discharge that flows through the sand trap, soil properties around the sand trap, and the channel that enters in the middle section of the sand trap. Research on the field gave a result on the sediment volume with a discharge of 1.3 m^3/s during the rainy season, as shown in Table 2. Table 2 shows that field research on April 16th, 2016 gave a result that during the half year of flushing period, the sand trap was filled with sediment of 335.9 m^3 (59.24%).

The volume of the sand trap that had not fully filled with sediment showed that the calculation of the Irrigation Planning Standards on sand trap volume is $0.5^0/_{00}$ from the normal water discharge on one flushing period did not match with the condition at the time of the research in Pendowo Weir's sand trap.

Fill time of the sand trap was calculated from the size of the sediment transport with Meyer Peter Muller equation. The sediment transport in Pendowo Weir's sand trap with a flow discharge of 1.3 m^3/s is $q'_B = 1.08 \times 10^{-5}$ ton/m.s. Total q'_B (for the entire width of the channel) is 3.9×10^{-5} ton/s

$$\text{Volume} = \frac{q'_B}{\gamma_s - \gamma} = 2.3 \times 10^{-5}\ m^3/s = 1.96\ m^3/day$$

Fill time of the Pendowo Weir's sand trap at the present condition is shown in Table 3. Table 3 shows that at a discharge of 1.3 m^3/s, the sand trap would be fully filled with sediment for 290 days.

Calculation of the percentage of sediment that deposits from normal discharge in the sand trap could be seen in Table 4. Table 4 shows that deposited sediment in Pendowo Weir's sand trap was 0.001% ($0.01^0/_{00}$) from normal discharge in the rainy season. The difference between the size of deposited sediment in sand trap based on Irrigation Planning Standards ($0.5^0/_{00}$) and actual present condition ($0.01^0/_{00}$) was caused by the difference in sediment transports at the sand trap.

Several matters that were studied to discover the performance of present sand trap were sediment grain gradation, sediment deposition, and sand trap flushing.

Test result from sediment gradation after intake gate showed that there were gravels that entered the sand trap in Pendowo Weir as much as 39.81%, in which the gravels entered the sand trap possibly because of the late closing of the intake gate at the time of the flood.

Table 1. Initial fill time of the Pendowo Weir's sand trap

Season	Normal discharge (*Qn*) m^3/s	Sand trap volume (*V*) m^3	Sand trap fill time (*T*) days
Rainy	1.61	567	8.15

Table 2. Sediment volume of Pendowo Weir's sand trap

Season	Sand trap volume m^3	Field Condition		
		Normal discharge m^3/s	Sedimentation time day	Sediment volume m^3
Rainy	567	1.3	183	335.9

Table 3. The fill time of the Pendowo Weir's sand trap at the present time

Season	Sand trap volume m^3	Sediment volume m^3/day	Sand trap fill time day
Rainy	567	1.96	289.12

Table 4. Sediment percentage in Pendowo Weir' sand trap

Season	Discharge m^3/s	Sand trap volume m^3	Sand trap fill time day	Percentage of sediment %
Rainy	1.61	567	289.12	0.001

Evaluation of sand trap size planning based on Irrigation Planning Standards is shown in Table 5. Table 5 shows that the sand trap's sediment sample for grain size under 0.013 mm would need sand trap with the length of more than 175 m. Based on the Irrigation Planning Standards, the size of deposited sediment in the sand trap was above 0.06 mm, therefore the length of a sand trap in Pendowo Weir is still adequate in depositing sediment.

Pendowo Weir's sand trap would deposit sediment from Bedog River and sediment that entered the side part of the sand trap. The grain size of the sand trap would give different deposit efficiency, which could be seen in Table 6. Table 6 shows calculation on comparison between the particles settling velocity and planned settling velocity; as well as a comparison between particles settling velocity and average flow velocity. The calculation result is inserted in the graph as seen in Figure 1.

Figure 1 shows the sediment deposition of 73.7%. Based on the Irrigation Planning Standard, the deposited sand particle is 60% – 70%, therefore Pendowo Weir's sand trap with its flow velocity of 0.19 m/s at the operational time of sand trap, would still be efficient to deposit the entered sediment.

Flushing in Pendowo Weir's sand trap is conducted with hydraulic method (hydraulic flushing). Evaluation of flushing of the sediment that entered Pendowo Weir's sand trap used sediment sample from the sand trap. The sediment movement of each grain size could be discovered with Shields graph, as shown in Figure 2. Figure 2 shows that hydraulic flushing in Pendowo Weir's sand trap could be conducted perfectly, in which all the grains' sizes (d_{10}–d_{100}) were located above the line, therefore the particle moved when flushing was conducted.

Table 5. Effective length of Pendowo Weir' sand trap

Size distribution	Diameter (mm)	w (m/s)	H (m)	V (m/s)	L (m)
d_{10}	0.013	0.00032	0.61	0.19	362.19
d_{20}	0.029	0.00090	0.61	0.19	128.78
d_{30}	0.044	0.00220	0.61	0.19	52.680
d_{40}	0.056	0.00330	0.61	0.19	35.120
d_{50}	0.071	0.00500	0.61	0.19	23.180
d_{60}	0.120	0.01200	0.61	0.19	9.660
d_{70}	0.160	0.01800	0.61	0.19	6.440
d_{80}	0.230	0.03200	0.61	0.19	3.620
d_{90}	0.370	0.05800	0.61	0.19	2.000
d_{100}	9.500	0.75000	0.61	0.19	0.150

Table 6. Calculation result of sediment deposition in Pendowo Weir' sand trap

Size distribution	Sieve diameter (mm)	w (m/s)	w_0 (m/s)	v_0 (m/s)	w / w_0	w / v_0
d_{10}	0.0130	0.0003	0.004	0.19	0.08	0.00167
d_{20}	0.0290	0.0009	0.004	0.19	0.225	0.004698
d_{30}	0.0440	0.0022	0.004	0.19	0.55	0.011484
d_{40}	0.0560	0.0033	0.004	0.19	0.825	0.017227
d_{50}	0.0710	0.0050	0.004	0.19	1.25	0.026101
d_{60}	0.1200	0.0120	0.004	0.19	3	0.062642
d_{70}	0.1600	0.0180	0.004	0.19	4.5	0.093964
d_{80}	0.2300	0.0320	0.004	0.19	8	0.167046
d_{90}	0.3700	0.0580	0.004	0.19	14.5	0.302771
d_{100}	9.5000	0.7500	0.004	0.19	187.5	3.915146

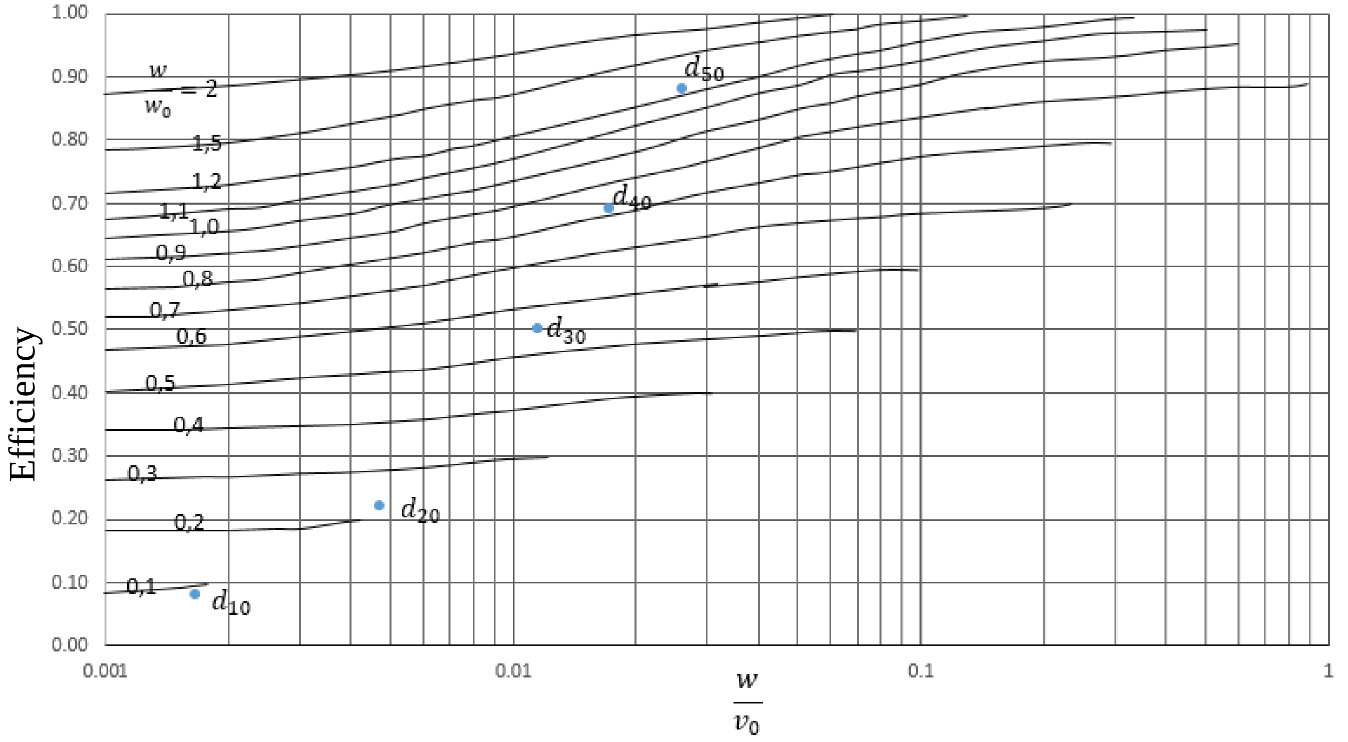

Figure 1. The efficiency of sediment deposition (Pendowo).

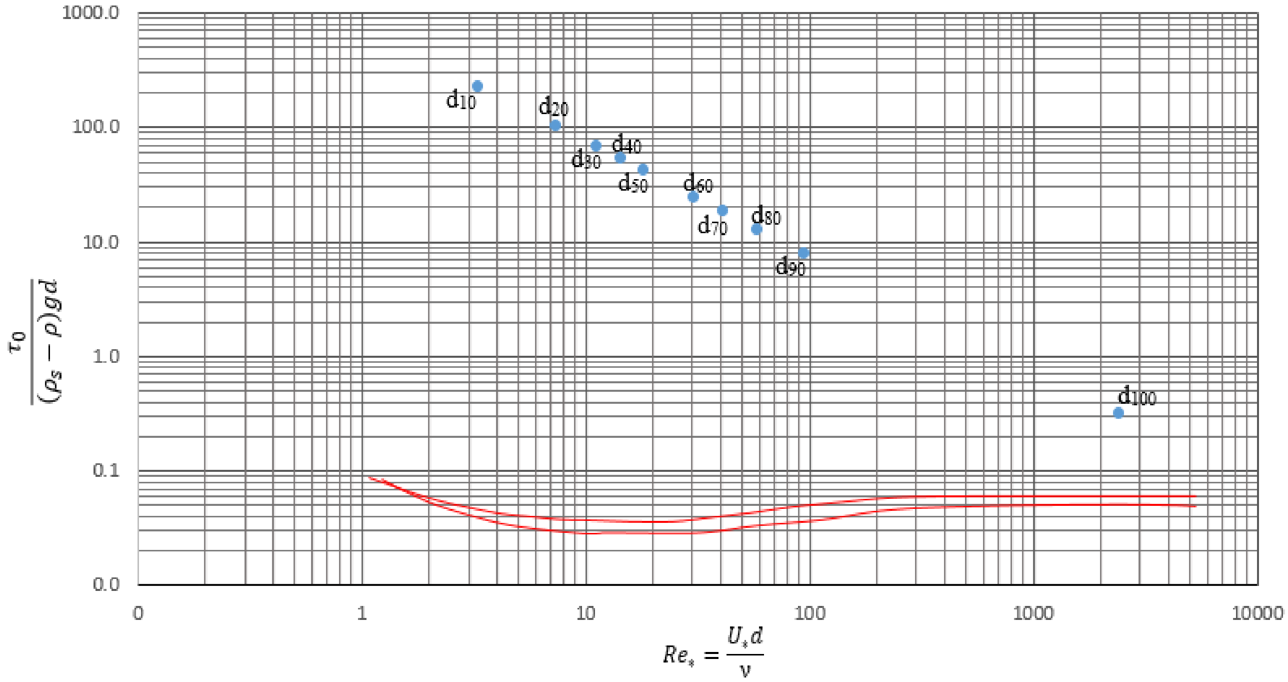

Figure 2. Initial movement of sediment at the time of sand trap flushing.

5.3 Description of Initial Condition of the Pijenan Weir's Sand Trap

At its early construction in 1983, Pijenan Weir was used for irrigation in the area surrounding Pijenan Weir, with cropping pattern of rice – secondary crop – secondary crop in area size of 600 ha. Normal water discharge at intake gate on the dry season was based on the net water needs for the secondary crop at growth time.

Water needs for secondary crop (*NFR*)

$= Etc + P + LP - Re$

$= 4.57 + 0 + 0 - 0$

$= 4.57$ mm/day

Water needs at intake gate

$$= \frac{4.57}{(0.65 \times 8.64)} = 0.81 \text{ l/s/ha}$$

Water needs at intake gate for field area of 600 ha was 0.49 m^3/s. Water discharge of 0.49 m^3/s was then used to calculate the fill time of Pendowo Weir's sand trap based on the Irrigation Planning Standard as shown in Table 7. Table 7 shows that the fill time of sand trap with the discharge of 0.49 m^3/s at time of the dry season is 50 days, therefore sand trap flushing is needed.

5.4 Present Condition of Pijenan Weir's Sand Trap

Agricultural land size for Pijenan Irrigation Area at present time is 2,305 ha, with cropping pattern of rice – rice – secondary crop. Normal water discharge on intake gate is based on net water needs for the secondary crop at growth time.

Water needs for secondary crop (*NFR*)

$= Etc + P + LP - Re$

$= 3.75 + 0 + 0 - 0.07$

$= 3.68$ mm/day

Water needs at intake gate

$$= \frac{3.68}{(0.65 \times 8.64)} = 0.65 \text{ l/s/ha}$$

Total water needs at intake gate for field area of 2,305 ha is 1.51 m^3/s.

The result from field research showed the sediment volume with the discharge of 1.51 m^3/s at time of the dry season, as shown in Table 8. Table 8 shows that field research at October 22nd, 2016 gave a result that the sand trap in 3 months flushing periods (dry season) was filled with sediment of 370.6 m^3 (35.1%).

Table 7. The initial fill time of Pijenan Weir's sand trap

Season	Normal discharge (*Qn*) m^3/s	Sand trap volume (*V*) m^3	Sand trap fill time (*T*) days
Dry	0.49	1,056	49.89

Table 8. Sediment volume in Pijenan Weir's sand trap

Season	Sand trap volume m^3	Field condition		
		Normal discharge m^3/s	Normal discharge m^3/s	Normal discharge m^3/s
Dry	1,056	1.51	90	370.6

Table 9. The fill time of Pijenan Weir's sand trap at the present time

Season	Sand trap volume m^3	Sediment volume m^3/day	Sand trap fill time day
Dry	1,056	4.41	239.4

Table 10. Sediment percentage of Pijenan Weir's sand trap

Season	Discharge m^3/s	Sand trap volume m^3	Sand trap fill time day	Percentage of sediment %
Dry	0.49	1,056	239.4	0.01

The volume of the sand trap that had not fully filled with sediment showed that the calculation of the Irrigation Planning Standards on sand trap volume is $0.5^0/_{00}$ from the normal water discharge on one flushing period did not match with the condition at the time of the research in Pijenan Weir's sand trap.

Full time of the sand trap was calculated from the size of the sediment transport with Meyer Peter Muller equation. The sediment transport in Pijenan Weir's sand trap with a flow discharge of 1.51 m^3/s is:

$$\gamma_w \frac{R_b}{h}\left(\frac{ks}{ks'}\right)^{3/2} hS = 0.047(\gamma_s - \gamma_w)d_{50} + 0.25\left(\frac{\gamma_w}{g}\right)^{1/3}(q'_B)^{2/3}$$

$$q'_B = 2.04 \times 10^{-5} \text{ ton/m.s}$$

Total q'_B (for the entire width of the channel) is 8.17×10^{-5} ton/s

$$\text{Volume} = \frac{q'_B}{\gamma_s - \gamma} = 5.1 \times 10^{-5}\ m^3/s = 4.41\ m^3/day$$

Full time of Pijenan Weir's sand trap at the present time could be seen in Table 9. Table 9 shows that with the discharge of 1.51 m^3/s, the sand trap would be fully filled with sediment for 240 days.

Calculation of the percentage of sediment that deposits from normal discharge in the sand trap could be seen in Table 10. Table 10 shows that deposited sediment in Pijenan Weir's sand trap was 0.01% ($0.1^0/_{00}$) from normal discharge at the time of rainy season.

The difference between the size of deposited sediment in sand trap based on Irrigation Planning Standards ($0.5^0/_{00}$) and actual present condition ($0.1^0/_{00}$) was caused by the difference in sediment transports at the sand trap.

Several matters that were studied to discover the performance of present sand trap were sediment grain gradation, sediment deposition, and sand trap flushing. The test result of grain gradation showed that sediment that entered in the sand trap was sand and silt/clay. The intake gate design in Pijenan Weir has a higher base (elevation of +29.462 m) from the weir's flushing gate (elevation of +28.312 m), which then prevents larger grains (gravels) to enter the sand trap. Evaluation of sand trap size planning that was based on the Irrigation Planning Standards is shown in Table 11.

Table 11 shows that the sand trap's sediment sample for grain size under 0.039 mm would need sand trap with the length of more than 240 m. Based on the Irrigation Planning Standards, the size of deposited sediment in the sand trap was above 0.06 mm, therefore the length of a sand trap in is still adequate in depositing sediment.

Pijenan Weir's sand trap would deposit sediment from Bedog River. The grain size of the sand trap would give different deposit efficiency. The efficiency of the sediment deposition of various sizes could be seen in Table 12.

Table 12 shows calculation on a comparison between the particles settling velocity and planned settling velocity; as well as a comparison between particles settling velocity and average flow velocity. The calculation result is inserted in the graph as seen in Figure 3.

Figure 3 shows the sediment deposition of 76.3%. Based on the Irrigation Planning Standard, the deposited sand particle is 60% – 70%, therefore the sand trap with its flow velocity of 0.24 m/s at the operational time of sand trap, would still be efficient (good) to deposit the entered sediment.

Flushing in Pijenan Weir's sand trap is conducted with hydraulic method (hydraulic flushing). The sediment movement of each grain size could be discovered with Shields graph, as shown in Figure 4. Figure 4 shows that hydraulic flushing in Pijenan Weir's sand trap could be conducted perfectly, in which all the grains' sizes (d_{10}–d_{100}) were located above the line, therefore the particle moved when flushing was conducted.

Table 11. Effective length of Pijenan Weir's sand trap

Size distribution	Diameter (mm)	*w* (m/s)	*H* (m)	*V* (m/s)	*L* (m)
d_{10}	0.020	0.00042	0.98	0.24	560.00
d_{20}	0.039	0.00160	0.98	0.24	147.00
d_{30}	0.048	0.00240	0.98	0.24	98.00
d_{40}	0.058	0.00330	0.98	0.24	71.27
d_{50}	0.086	0.00700	0.98	0.24	33.60
d_{60}	0.140	0.01750	0.98	0.24	13.44
d_{70}	0.210	0.02800	0.98	0.24	8.40
d_{80}	0.360	0.05900	0.98	0.24	3.99
d_{90}	0.680	0.11500	0.98	0.24	2.05
d_{100}	2.000	0.30000	0.98	0.24	0.78

Table 12. Calculation result of sediment deposition on Pijenan Weir's sand trap

Size distribution	Sieve diameter (mm)	w (m/s)	w_0 (m/s)	v_0 (m/s)	w / w_0	w / v_0
d_{10}	0.0200	0.0004	0.004	0.24	0.105	0.001765
d_{20}	0.0390	0.0016	0.004	0.24	0.400	0.006724
d_{30}	0.0480	0.0024	0.004	0.24	0.600	0.010086
d_{40}	0.0580	0.0033	0.004	0.24	0.825	0.013868
d_{50}	0.0860	0.0070	0.004	0.24	1.750	0.029416
d_{60}	0.1400	0.0175	0.004	0.24	4.375	0.073540
d_{70}	0.2100	0.0280	0.004	0.24	7.000	0.117664
d_{80}	0.3600	0.0590	0.004	0.24	14.750	0.247935
d_{90}	0.6800	0.1150	0.004	0.24	28.750	0.483264
d_{100}	2.0000	0.3000	0.004	0.24	75.000	1.260689

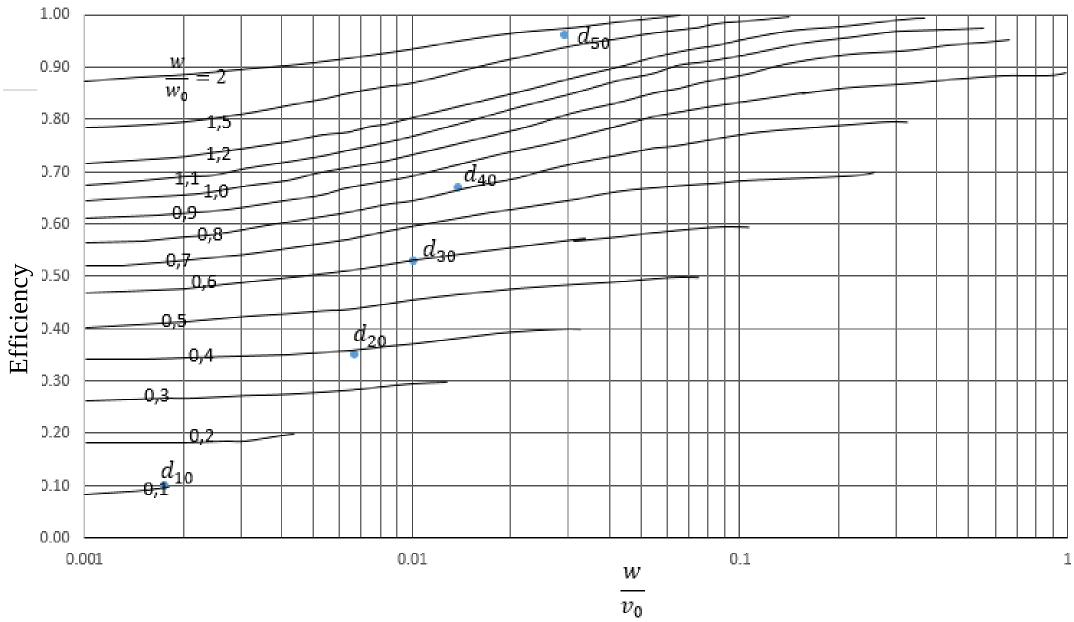

Figure 3. Efficiency on sediment deposition (Pijenan).

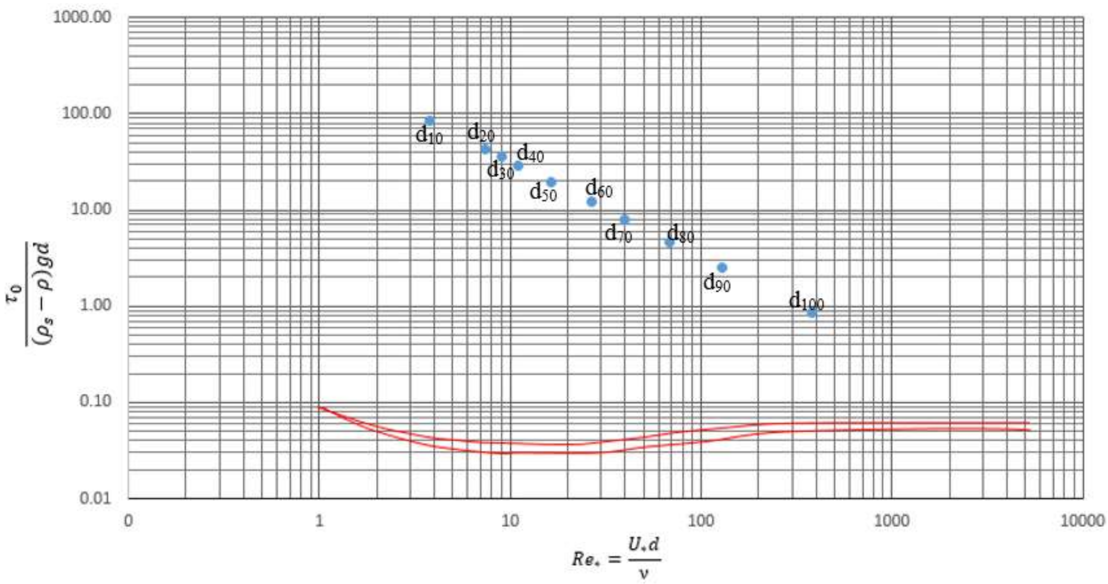

Figure 4. Initial Movement of Sediment at time of Sand Trap Flushing.

6 CONCLUSIONS AND SUGGESTIONS

6.1 Conclusion

The conclusion from the research on the sand trap in Pendowo Weir and Pijenan Weir are described as follows:

a) Pendowo Weir's Sand Trap
Performance of sand trap in Pendowo Weir is still good, in which the sand trap could deposit and flush the sediment hydraulically with flushing period of the sand trap once in every 6 months at the time of rainy season. Sediment that deposited in the sand trap according to Irrigation Planning System is of $0.5^{0}/_{00}$ from normal water discharge, in which it does not correspond to the condition in Pendowo Weir's sand trap. Sediment that deposited in Pendowo Weir's sand trap was of $0.01^{0}/_{00}$ from the normal water discharge.

b) Pijenan Weir's Sand Trap
Performance of sand trap in Pijenan Weir is still good, in which the sand trap could deposit and flush the sediment hydraulically with flushing period of the sand trap once in every 3 months in the dry season. Sediment that deposited in the sand trap according to Irrigation Planning System is of $0.5^{0}/_{00}$ from normal water discharge, in which it does not correspond to the condition in Pijenan Weir's sand trap. Sediment that deposited in Pijenan Weir's sand trap was of $0.1^{0}/_{00}$ from the normal water discharge.

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