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Modeling Precipitating Tub (Settling Basin) For Reduction Sedimentation Effect in Irrigation Channel at Micro Hydro Power (Case Study At Gorontalo Province Irrigation Channel)

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ABSTRACT
Potential irrigation channels widely in Indonesia and suitable for turbine type Plopeler Open Flume. From observation this sedimentation processes was effect on turbin and quality electric power generated. This study was determine the relationship effect of sedimentation on parameter MHP and modeling sedimentation basin to reduce its influence.
The settling basin modeling into 3 design models and 2 codition,. MHP conditions in the rain without modeling with the data voltage deviation V_d = 17.6%, frequency deviation F_d = 6.8% and rotation deviation N_d = 6.8% at concentration sedimentation between 2.551 C (g/l) and 3.864 (g/l) where the value of C category (C > 2.5 (g/l) (bad sedimentation) MHP operates abnormally. By modeling setling basin designs III at time rain, was obtained deviation voltage V_d = 3%, deviation frequency F_d = 1% and the deviation of rotation N_d = 1% at a concentration of sedimentation C between 1.160 (g/l) and 1.340 (g/l) in which the value C category (under C <2.5 (g/l)), condition of the MHP normal operating.
This research beneficial to reduce the cost of investment the load control electronic equipment and reference in the development National Irrigation Project.
***Keywords* -** microhydro, irrigation, sedimentation , settling basin, modeling.

I. INTRODUCTION

1.1. Background

Potential irrigation channels widely spread in Indonesia, turbine type suitable for the irrigation channel is Plopeler Open Flume type turbine with a height of fall (head) effective relatively low (under 5 meters). From field observations of type Plopeler Open Flume turbine, effect of water quality if the process of sedimentation will cause the quality of the electrical power produced deteriorate and has made damage to electronic equipment household of consumen electriciti.

A research of *Sediment Management In Hydroelectric Projects* (K.G. Ranga Raju And U.C. Kothyari) This study is examining the problem of sediment in the canals on Hydro power plants with a model Alluvial river , this research is useful for consideration of a generation of MHP held on irrigation channels.

A research of *Settling and Non-Settling velocities in Irrigation Canals, Hamidieh and Ghods Irrigation Network, South of Iran,* (Gh. H. Karimi And H. Moazed). of this study is to examine the problem of sediment drift and settle on the irrigation channels, from this research is useful for *consideration of a generation of MHP held.*

A research *Controlling Erosion And Sediment Loss From Furrow-Irrigated cropland* (D. L. Carter, 'C. E. Brockway) Examining the problem of erosion and sedimentation of water in the canals in the irrigation channels Members solutions for the utilization of irrigation in the water for the livelihood of human beings including the utilization of the MHP.

A previous research of *Analysis Effect of Sedimentation In the MHP Type Turbine Open Flume in Irrigation* (Arifin et al) in this study showed how the amount of sedimentation concentration that affect in the type of turbine Plopeler Open Flume . In this study was to determine the relationship of the effect of sedimentation of irrigation channels in micro hydro power plant, and perform modeling sedimentation basin (setling basin) to reduce its impact on the MHP.

1.2. Problem Statement

The statement of problem of this study are as follows:

1) How much effect of variable concentration sedimentation.in MHP with water turbine propeller type open flume in irrigation channel .

2) How where to formulate the relationships of effect variable concentration sedimentation with the MHP consisting of a variable voltage generator, rotation turbine / generator, and the generator frequency is generated.
3) How does the modeling precipitating tub (settling Basin) in order to reduce the effects of sedimentation on the MHP in order to obtain the quality of power supply is within tolerance standard electrical appliances that consumers use.
4) What are the benefits of this model is applied to the Gorontalo Province Irrigation channels taking into account the efficiency of precipitator BPS (sediment to gravitate Building) existing.

1.3. Objectives of Research

Objectives to be achieved in research as follows:

1) Making analyst test on some specific conditions of concentration sedimentation C (g / l), the water discharge Q (m3/s), to record the effects on the generator output voltage V (Volt), rotating turbine-generator n (rpm), and the frequency f (Hz) of the MHP.
2) Make modeling precipitating tub (settling Basin) which can reduce the effect of sedimentation on the MHP to get quality power supply is within tolerance standard electrical appliances are used by consumers.
3) To obtain how much sediment concentration C (g/lt) of irrigation channels that can affect the micro hydro power plant of type turbine open flume propeller which is the object of this study.
4) To calculate the efficiency of BPS for consideration of Sedimentation modeling placement that is expected.

1.4. Benefits Research

The benefits of this research are:

1) Get a settling basin design for the MHP in irrigation channels and can be used as a scientific reference for the utilization of irrigation channels for mikrohydro plants nationwide.
2) Contribute to the utilization of electrical energy for the electric machines which use in agriculture which have been the hegemony for diesel engines with fuel oil price is more expensive, and also has an effect on the environment
3) Improving the rural economy that will drive the national economy and increase the ratio of the national electricity heavily influenced by rural residents
4) Be a source of funds allocated for the program of maintenance and rehabilitation of irrigation canals itself for relevant agencies which has been a problem for the region after the irrigation project was completed and handed over to the area.

II. BASIC THEORY

2.1. MHP On Irrigation channels

The preliminary study (Arifin et al 2007) in primary irrigation canal precisely on one dam taking water (inteke) Talumopatu village district. Tapa, the power that can be produced into electrical energy where power is generated in turn were able to move the processing tool farmland, agricultural products processing tool for facilities or other electrical appliances for household use during the day, and for lighting at night

Power generated by a MHP is :

Theoretical power $P = k . h . Q \quad [kW] \quad (1)$

Turbine power $P = k . h . Q \; \eta_t \quad [kW] \quad (2)$

Generator power $P = k . h . Q . \eta_t . \eta_g \quad [kW] \quad (3)$

Where ; P = power [kW], h = high effective fall (m) maximum [meter], Q = discharge (m3/s), tη = turbine efficiency, gη = efficiency of the generator, k = constant (9.8)

2.2. Sedimentation

Factors reciprocity between the properties of water flow and sediment properties were affected by the rains cause the lifting of sediment to gravitate. Sedimentation contained in irrigation channels may also affect the specific energy due to irrigation canal irrigation canals dimensional change. Concentration of sediment can be obtain from ratio of dry sediment weight and the total volume of the water sample is given by:

$$C = \frac{BK\ (mg)}{V(lt)} \qquad (4)$$

Where ; BK dry sediment weight (mg),
V = Volume of sample water (liter),
Sedimentation rate can be obtained from multiplying the water discharge and sediment concentration by the equation:

$Q_S = 0{,}0864\ C\ Q \quad (5)$

2.3. Efficiency of BPS (sediment to gravitate Building) On Irrigation channels

There are several methods for determining the efficiency of sediment deposition in the BPS, but in this study the method used is direct measurement calculations. The method of calculating the efficiency of direct sediment deposition sediment deposit process occurs by following equation:

$$E_p = \frac{V_p}{Q_{si} \times t} \qquad (6)$$

if $V_p = (Q_{si} - Q_{so})\ t$

$$E_p = \frac{Q_{si} - Q_{so}}{Q_{si}} \quad (7)$$

Where ; Ep = sediment deposition efficiency (%),
Q_{SI} = discharge sediment transport input (m^3/s),
Q_{SO} = discharge sediment transport output (m^3/s)
t = period of time (sec),
Vp = Volume of precipitation (m^3),

2.4. Type Turbine on MHP Irrigation

MHP in the irrigation channel has a high fall (head) effective relatively low (under 5 meters), where the turbine is used turbine types Plopeler Open Flume is included type reaction turbine which is a water turbine with the way it works to change the entire energy of water available into torsional energy. as show the Figure 1.

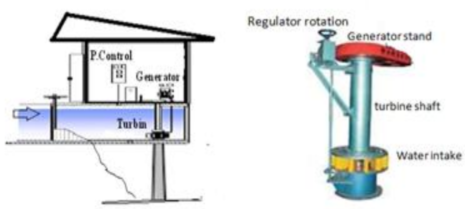


Figure 1 Open flume propeller turbine type

2.5. Generator on the MHP

Direct current flow in the rotor coil is rotated by a turbine, it will be product the electromagnetic force generating in the stator coil. As a result of the magnetic field will cause a rotating magnetic field surrounding the stator coil changes continuously.. The induced voltage will be sinusoidal and extent of which depends on the strength of the magnetic field and the rotation speed of the rotor. For three-phase generator, the stator coils placed three separate as far as 120^o from each other, In general, also on Power Mikrohydro (MHP) for small-scale uses 1-phase synchronous generator its output voltage as shown in Figure 2 with the illustrations as follows:

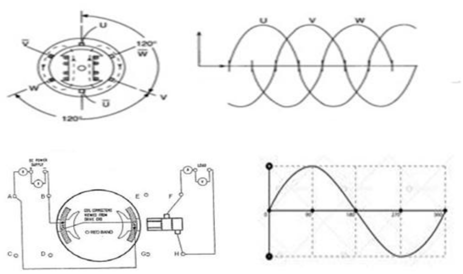


Figure 2. Form of output voltage 3-phase and one phase synchronous generator.

In the design 1-phase synchronous generator, sometimes there is a phenomenon in which waves generated not a pure sinusoida, because distortion occurs in the output waveform so-called harmonics. water turbine rotating synchronous generator reaches the actual speed by the prime mover, the field coil is excited by dc currents which cut the field flux conductor induce emf voltage (Ea). Then out in the stator winding terminal which amount is given by the equation:

E_a □ □cn□$_a$ (8)

Where ;
c = constant engine, n = synchronous rotation ,
□$_a$ = flux generated by field current
induced voltage Ea generated in the phase synchronous generators are not equal to the voltage at the terminals of the generator, it is due to their resistance and reactance sync anchor.
Equation voltage on the generator is

$Ea = V + I.Ra + jIXs$ *(9)*

In the power supply system, generally the power supply voltage deviation voltage (Vd) is permitted varies (+ 5%) and (-10%) according to the standard of PLN (Indonesian electricity company),
. The frequency is characteristic of the sinusoidal wave voltages and currents generated by the generator. Generator rotation speed is equal to a turbine wheel where the frequency is obtained:

$$f = \frac{P\,n}{60} \quad (10)$$

Where; f = frequency, n = speed (rpm), p = number of pole pairs generator.50 hz frequency used, and for the allowable frequency deviation can change the magnitude of ± 2%.

2.6. Effect of the sediment concentration, voltage frequency and rotation.

The influence of sediment concentration (C) of the MHP Open Flume Propeller turbine type of parameter voltage (V), rotation (n) and frequency (Hz) of this research is to use the statistic test because by theoretically not yet developed.
As for the statistical testing is as follows:

a. Make sediment concentration data summary table (as a function of the variable x), while voltage generator (v), rotating turbin-generator (n), frequency (Hz), (as variables y_1, y_2, y_3).

b. Determining the regression model with the following formula:

$y = b_O + b_1x.$ *(11)* Koefisien regresi linier, dihitung dengan rumus :

$$b_1 = \frac{n\sum_{i=1}^{n} X_i Y_i - \sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i}{n\sum_{i=1}^{n} X_i^2 - (\sum_{i=1}^{n} X_i)} \quad (12)$$

$$b_o = \bar{y} - b_i\bar{x} \quad (13)$$

c. Looking Correlation Coefficient

$$\rho = \frac{Cov\ (x,y)}{S_x S_y} \quad (14)$$

d. covariance can be searched using the formula:

$$Cov\ (x, y) = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{n-1} \quad (15)$$

Then the correlation coefficient obtained:

$$r_{xy} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{(N\sum X^2 - (\sum X)^2)(N\sum Y^2 - (\sum Y)^2)}} \quad (16)$$

Next to test the hypothesis of correlation Ho: There is no significant relationship between concentration sedimentation c (mg / lt) by, Voltage, Frequency and rotating turbine / gen n (rpm) H1: There is a significant relationship between cosenrtation sedimentation c (mg / lt) with Round turbine / generator (rpm)

To test the hypothesis in correlation with the search for the value of the correlation coefficient t statistic is then compared with t-table

$$t_o = \left|\frac{r\sqrt{n-2}}{\sqrt{1-r^2}}\right| \quad (17)$$

d. coefficient of Determination

To consider the regression model accuracy can be checked by calculating the coefficient of determination:

$$r_{xy} = \frac{n\sum_{i=1}^{n} X_i Y_i - \sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i}{\sqrt{n\sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i\right)^2}\sqrt{n\sum_{i=1}^{n} Y_i^2 - \left(\sum_{i=1}^{n} Y_i\right)^2}} \quad (18)$$

$$R^2 = \frac{SS_R}{SE_{YY}} = \frac{\sum_{j=1}{}^{n}(\bar{y}_i - \bar{y})^2}{\sum_{j=1}{}^{n}(y_i - \bar{y})^2} \quad (19)$$

R2 value is $0 \leq R2 \leq 1$ which is the amount of variability in the data obtained in the model regreasi.

III. RESEARCH METHODS

This research is to obtain the correlation sedimentation C (g / lt) at the irrigation channel influential on generator voltage V (Volt), turbine-generator rotation n (rpm) and the frequency f (Hz) so it needs a modeling precipitating tub (settling Basin) which can reduce the effect of sedimentation

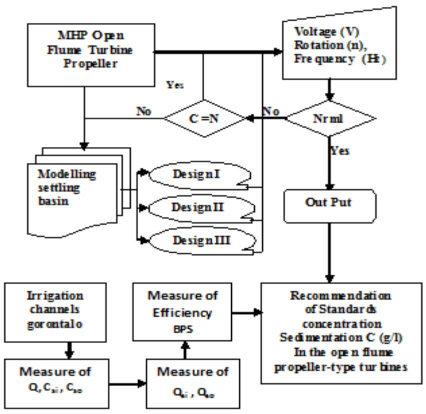


Figure 3
Flowchart research

MHP Type Open Flume Turbine Propeller to get standart quality power supply permissible, where such research flow chart in Figure 3. The study was done in three models design and 9 case scenarios ie: no rain, rain and after rain. In this study used test data by the statistical method is to determine whether there is influence of variable concentrations of sedimentation with variable voltage, rotation and frequency at the terminals of the generator on the MHP, from this research was obtained on the amount of concentration sedimentation safe for an MHP type of open flume, and feasibility the MHP installation on location points on the Irrigation channels in the province of Gorontalo

IV. DISCUSSION AND ANALYSIS

4.1. Overview of Research Object of MHP tulabolo.

Based of field conditions in this study with the parameter on measurements were obtained: A = 2.48 m^2, V = 0789 m/s, it is obtained: Q = 2.48 m^2 x 0789 m/s = 1.96 m^3/s, with k = 9.8 and higher draft tube h = 1.75 m, from equation 1.2, 3. theoretical power

P = k. h. Q = 33.614 [KW]

This power is divided into 6 generating units so that each plant produces theoretically power of 5.6 KW, the efficiency of each ie:.η draftube 0.95, η turbine 0.7, η generator 0,95, turbine power is

P = 3.92 [kW] So that the power generator the calculation results P = 3.5 [kW] per unit.

Generator MHP on the research capacity of 3 KW per unit. with existing data as follows:

Type	: ST – 10	Cos φ	: 1.0
Power :	3 KW	Exitasi Volt	: 80 Volt
Voltage :	220 Volt	Exitasi current	: 2 Ampere
Current :	13,6 A	Frekuency	: 50 Hz
Rotation :	1500 rpm	Standar :	Q/MDl001- 1998

The influence of sediment concentration (C) of the voltage (volts) on the MHP of the test statistic. 1hal of the table can be explained through correlation and regression equations

4.2. Determining the model

To determine the equation of model linear regression using equations 11, 12 and 13 as follows $y = b_O + b_1 x$. Where

$$b_1 = \frac{20(7954.76) - (42.762\ x3873.45)}{20(115.303) - (42.762)}$$

$$b_1 = \frac{-6541.2689}{2263.298} = -2.89$$

$$b_o = \bar{Y} - b_i\bar{X} = 199.85$$

Then the linear regression equation model the influence of sediment concentration on voltage generator is:

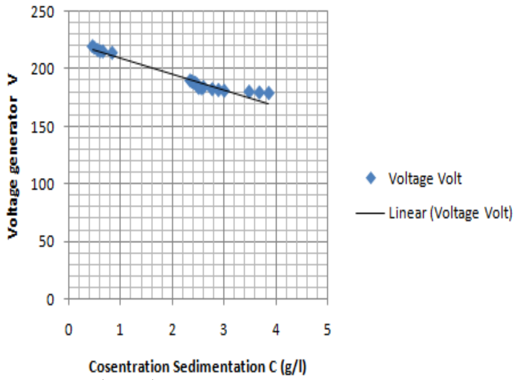
Y = -2.89 + 199.85 X

No	Concentration sediment C (g/lt), (X)	Voltage Volt (Y)	Circumstances of climate
1	2.551	182.94	Rains (12/01/2015).
2	2.329	189.68	After raining (12/01/2015).
3	0.451	219.87	No Rains (21/01/2015).
4	2.756	182.14	Rains (13/02/2015).
5	2.363	188.86	After raining (13/02/2015).
6	0.487	218.57	No Rains (22/02/2015).
7	2.87	181.44	Rains (14/03/2015).
8	2.397	188.25	After raining (14/03/2015).
9	0.55	216.65	No Rains (23/03/2015).
10	2.987	180.78	Rains (15/09/2015).
11	2.429	187.43	After raining (15/09/2015).
12	0.598	215.45	No Rains (24/09/2015).
13	3.467	179.86	Rains (16/10 /2015).
14	2.454	186.84	After raining (16/10/2015).
15	0.651	215.39	No Rains (27/10/2015).
16	3.663	179.24	Rains (17/11 /2015).
17	2.587	183.91	After raining (17/11/2015).
18	0.832	214.14	No Rains (28/11/2015).
19	3.843	178.76	Rains (18/12 /2015).
20	2.495	183.25	After raining (18/12/2015).

4.3. Coefficient correlation

coefficient correlation can be calculated using equation 16 as follows:

$$r_{xy} = \frac{-6541.2689}{\sqrt{(477.471356)(94851.4975)}}$$



$$r_{xy} = \frac{-6533.522}{\sqrt{45288873.12995561}}$$

$$r_{xy} = \frac{-6533.522}{\sqrt{45288873.12995561}} = -0{,}97$$

to 5.00 g/l (bad sedimentation).

table 2
Sediment concentration against voltage, frequency and rotation turbin generator that circumstances rains without Moddeling stling Basin

As for the linear regression equation obtained for each characteristic concentration of sedimentation with a voltage generator,

table 1
Data parameters sediment concentration against voltage without modeling Settling Basin.

From the calculation, the negative

No	Concentration sedimentation c (g/lt), X	Voltage Gen V (Volt)Y_1	Rotation tur/gen n(rpm),Y_2	Frekuency (Hz)Y_3
1	2.551	182.94	1437.6	47.92
2	2.562	183.72	1435.5	47.85
3	2.586	182.54	1430.4	47.68
4	2.756	184.14	1425.3	47.51
5	2.776	183.87	1422.9	47.43
6	2.792	182.64	1416.3	47.21
7	2.875	183.44	1415.1	47.17
8	2.889	181.34	1409.4	46.98
9	2.965	180.95	1404.9	46.83
10	2.987	181.78	1402.8	46.76
11	3.267	180.64	1398.3	46.61
12	3.447	181.24	1397.4	46.58
13	3.467	179.86	1391.1	46.37
14	3.487	181.24	1388.4	46.28
15	3.643	179.53	1376.7	45.89
16	3.663	181.24	1371.9	45.73
17	3.683	178.97	1365.3	45.51
18	3.864	178.84	1359.6	45.32
19	3.843	179.53	1357.8	45.26
20	3.864	178.41	1354.2	45.14

correlation coefficient of -0.97 indicates a negative relationship between cosentration sedimentation C (g / lt) with the generator voltage (volts), so when the cosentration sedimentation C increases, the generator voltage will drop, and vice versa. as shown in Figure 4.

Figure 4
Concentrations of sedimentation C relationship against Voltage

4.4. MHP in rainfall conditions.

At the time of rain sedimentation processes affecting the quality of the electrical power generated by the MHP. From Table 2 the average value obtained voltage deviation voltage V_d = 17.6%, F_d frequency deviation = 6.8% and the deviation round N_d = 6.8% in sediment centration C = 1.00 to 2.50 g/l (medium edimentation), 2.50

rotation generator and frequency generator when rainfall conditions where the linear regression equation model of each is as follows:

$$Y_{1h} = -0.07 + 181.56\,X$$
$$Y_{2h} = -1.06 + 1401.45\,X$$
$$Y_{3h} = -0.04 + 46.72\,X$$

Image characteristics are shown in Figure 5.

4.5. MHP in rainfall conditions with the Settling Basin Modeling Design III

The average value of the voltage on this third design modeling, obtained voltage deviation Vd = 3%, frequency deviation Fd = 1% and the rotating of generator deviation Nd = 1% in sediment concentration C = 1.00 to 2.50 g/l (medium sedimentation) , The sedimentation concentration change of position was to be good, so the conditions MHP operates normal conditions.

$$Y_{2h\ DS3} = -0.04 + 1477.60\ X$$
$$Y_{3h\ DS3} = -0.03 + 49.20\ X$$

The image characteristics of sediment concentration against voltage, rotating and Frquency generator when rainy conditions on Settling Basin Modeling Design III While the image shown in Figure 6.

4.6. Efficiency of BPS (sediment to gravitate Building) On Irrigation channels

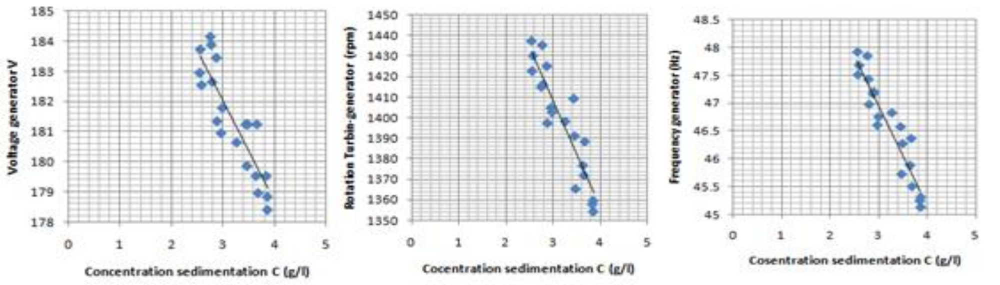


Figure 5. Characteristics of sediment concentration against voltage, rotation and frequency generator that circumstances rainy without Moddeling Setling Basin

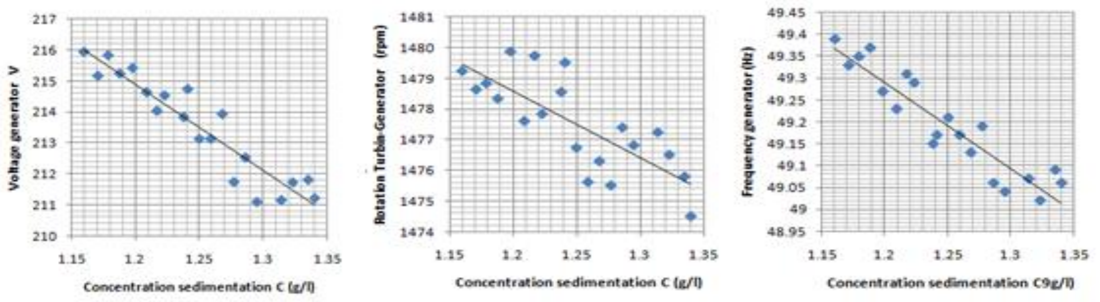


Figure 6. Characteristics of sediment concentration against voltage, rotation and frequency generator that circumstances rainy with Moddeling Setling Basin

Table 3
Sediment concentration against voltage, frequency and rotation turbin generator that circumstances its rains with Settling Basin Modeling Design III

Of the application of modeling design of III is in an ideal position from which the desired settling basin modeling. The Linear regression equation model of sediment concentration influence the voltage, rotating and frequency generator when it rains. of table 3 are:

$$Y_{1h\ DS3} = -0,01 + 198.35\ X.$$

To calculate the efficiency of BPS (sediment catcher Building), which is a complete building irrigation on irrigation networks scattered throughout the tissues of Gorontalo province irrigation 5 Observation post. At the observation post 01 Bone District Bolango parameters obtained is

High water level h = 1.19 m, A cross-sectional area = 6.798 m^2 , The flow velocity V = 0.94 m / s, Concentration of sediment input C_i = 0776 g / l Concentration of sediment output C_o = 0.271 g / l so that

Q = A x V x H = 3.966 m^3 / s

Q_{Si} = Q C_i = 3.966 x 0.776 = 3.101 kg/s

Q_{So} = Q C_O = 3.966 x 0.271= 1.083 kg/s

Then the efficiency of the equation 7 is obtained

E_P = (3.101 – 1.083) / 3.101 x 100 = 65.08 %

Of the 10 samples of measurement in the same manner, the obtained data for the overall sample Irrigation channel Gorontalo Province in tabular form as follows.

Table 20
Data Efficiency BPS for sample observation area 01-05 irrigation channels Gorontalo Province

No	Ep 01 (%)	Ep 02 (%)	Ep 03 (%)	Ep 04 (%)	Ep 05 (%)
1	67.49	65.08	63.63	61.80	64.99
2	66.74	65.15	63.44	61.91	64.31
3	67.04	64.05	63.09	61.74	64.39
4	67.42	64.76	62.47	61.65	64.88
5	67.08	64.28	63.77	61.49	64.75
6	67.71	64.22	63.29	61.20	64.59
7	67.68	64.95	63.90	61.76	64.53
8	67.75	64.56	63.12	61.64	64.70
9	67.22	64.89	63.39	61.60	64.96
10	67.49	63.61	63.29	61.92	64.85

From the five sample areas of operational observations irrigation canals in the province of Gorontalo, seen BPS efficiency levels are still low, thus settling basin modeling design which we designed in this study can optimize the operation of the MHP in irrigation canals.

No	Concentration sedimentation c (g/lt), X	Voltage V (Volt)Y_1	Rotation generator n(rpm),Y_2	Frequency (Hz)Y_3
1	1.179	215.83	1478.85	49.35
2	1.171	215.17	1478.65	49.33
3	1.160	215.94	1479.25	49.39
4	1.188	215.24	1478.35	49.37
5	1.217	214.04	1479.75	49.31
6	1.209	214.64	1477.62	49.23
7	1.198	215.42	1479.89	49.27
8	1.223	214.54	1477.85	49.29
9	1.250	213.14	1476.75	49.21
10	1.241	214.74	1479.53	49.17
11	1.238	213.84	1478.57	49.25
12	1.259	213.14	1475.63	49.17
13	1.286	212.54	1477.41	49.06
14	1.277	211.75	1475.52	49.19
15	1.268	213.94	1476.31	49.13
16	1.323	211.74	1476.52	49.02
17	1.295	211.11	1476.83	49.04
18	1.323	211.74	1476.52	49.02
19	1.340	211.23	1472.51	49.06
20	1.335	211.82	1475.81	49.09

V. CONCLUSION

From the discussion of the conclusions of this study are as follows:

1. In the all test analysis was conducted on statistical calculations negative correlation between sediment concentration C (g / lt) against parameters of the MHP. so that to accept the hypothesis H1 so stated that there is a significant relationship correlation between sediment concentration C (g/lt) against the generator voltage (volts),he turbine-generator rotation n (rpm), and the frequency f(Hz) of the MHP.
2. From the settling basin modeling research for the MHP open flume propeller type turbine on Irrigation channels of the 9 scenarios condition and 3 case of design, the ideal design model was obtained from the setling Basin Modeling Design III, where the condition of MHP normally operating.
3. From the discussion sediment concentrations numeral C to categories to normal operation at the MHP Irrigation channel turbine type Open Flume that was tested in this research is the average value of sediment concentration C = 1,249 (g/l) and the minimum value of sediment concentration C = 1.160 (g/l), while the value of maximum sediment concentration of C = 1.340 (g/l), which is a novelty of this research.
4. The results of the calculation of efficiency BPS (sediment to gravitate Building) spread along irrigation networks Gorontalo province of samples 5. observation post, the efficiency of BPS around 61.67% - 67.36%, so if the irrigation channels in Gorontalo province is used for the generation of MHP mikrohidro these research results worthy of consideration.

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