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INTISARI

Bendungan Serayu merupakan salah satu bendung yang dibangun di ruas sungai dengan kemiringan dasar sungai yang landai. Bendungan Serayu yang dibangun pada tahun 1993 digunakan untuk memenuhi kebutuhan air irigasi untuk daerah irigasi Gambarsari - Pesangrahan dengan luas lahan irigasi ± 20.795 ha dan untuk memenuhi kebutuhan air baku di Kabupaten Cilacap. Karena bendung ini terletak di segmen sungai yang landai, dengan karakteristik tersebut bendung akan mudah meningkatkan sedimen di bagian hulu bendung akibat rendahnya kecepatan aliran dari bendung bagian hulu. Kajian ini dimaksudkan untuk menganalisis peningkatan sedimentasi pada bendung hulu berdasarkan analisis transpor sedimen model Shen dan Hung. Analisis peningkatan sedimen di hulu bendung dilakukan untuk tahun studi 2007-2036. Hasil penelitian ini menunjukkan bahwa peningkatan sedimentasi di hulu Bendungan Gerak Serayu terus berlanjut sepanjang tahun 2007-2036. Kemudian dengan menggunakan analisis prediktif model polinomial orde dua, hingga tahun 2036 terjadi peningkatan sedimentasi di bagian hulu Bendungan Serayu sebesar 15.392 ton/hari.

ABSTRACT

Serayu Barrage is one of the weirs built in the river segment with a gentle slope of the riverbed. Serayu barrage, which was built in 1993, is used to meet the needs of irrigation water for irrigation areas Gambarsari - Pesangrahan with an area of $\pm 20,795$ ha of irrigated land and to meet the needs of raw water in Cilacap Regency. Because this weir is located in a sloping river segment, with these characteristics the weir will easily increase sediment upstream of the weir due to the low flow velocity of the upstream weir. This study is intended to analyze the increase in sedimentation in the upstream weir based on Shen and Hung's model of sediment transport analysis. An analysis of the increase in sediment upstream of the weir was carried out for the study year from 2007-2036. The results of this study indicate that the increase in sedimentation upstream of the Barrage of Serayu's motion continued throughout the years 2007-2036. Then with using predictive analysis of the second order polynomial model, until 2036, occurs increased sedimentation in the upstream Serayu Barrage of 15,392 tons/day.

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1. INTRODUCTION

Serayu Barrage is one of the weirs in Banyumas Regency. This weir is used to meet water needs in the Irrigation Area D.I Gambarsari - Pesangrahan and serves the fulfillment of water needs in the Banyumas and Cilacap areas as well as in Kebumen with a total irrigation area of 20,795 ha. In addition to irrigation services, this weirs also functions to supply raw water for the domestic municipal and industrial cities of Cilacap. Kroya and Maos amounted to 5.26 m3 / sec [1] [2] [5] [7] [13]



Figure 1 Serayu Barrage Location (Google-Earth, 2016) [1] [12].

The weir, which was built in 1993 and started operating in 1996, has technical specifications such as length of weir = 121.20 m, width of weir = 109.60 m. Operational doors built on this weir are in the form of 8 radial doors, with specifications B = 10.7 m, R = 9.0 m. This weir is equipped with an Intake / Retrieval Building in the form of 4 doors with a planned discharge of 32.10 m3 / s and a mud bag channel with a length specification of 273.28 m and a discharge of 2 channel lines 2 x 16 m3 / s (Dinas ESDA-BM Banyumas, 2016) [1] [12]



Figure 2 Lay out of Serayu Barrage (Dinas ESDA-BM Banyumas, 2016) [1] [12]



(a) (b) Figure 3 Existing Condition Serayu barrage in Upper (a) and Down Stream (b) (2018) [1] [12]

The Serayu Barrage is located in the Serayu River segment which has a gentle slope. One of the characteristics of a weir with these characteristics is that it is easy to increase the sediment upstream of the weir due to its sloping contours and causes sediment deposits to tend to be high. Besides indicated by the turbidity of river water, many deltas have been formed upstream of the weir. This indicates that the surface area of the river has begun to decrease due to sediment or sediment that forms the delta. The development of sediment in the upstream is felt to have continued to increase since previous years since the weir was functioning. By narrowing the riverbed, or silting due to sedimentation, will result in a reduction in discharge capacity in the mobile weir [1] [2] [5] [7].



Figure 4 Sedimentation in Upper Serayu Barrage[1]

Serayu Barrage has a very important role in providing water to irrigate rice fields in Banyumas Regency, Cilacap and partly in Kebumen Regency and raw water supply in parts of Cilacap Regency. Increased sedimentation or narrowing of the river's face upstream of the weir, will result in reduced capacity of the river and weir. This will impact on water supply both irrigation and raw water [1] [2] [5] [7] [9].

M. Syahril Badri K., Hang Tuah Salim, Aditya Riadi G, 2006, conducted a study related to the Sediment Transport Model in the Serayu Watershed Based on the 1 Dimensional Mathematical Model [4] [14]. From the simulation results obtained by the dam base elevation for each formula used. The formula that gives the best results, Ackers-White, the combination of Toffaletti with Meyer-Peter and Müller gives results that are close to the dam bottom measurement data [14]. For Vanoni's formula, and the combination of Toffaletti with Schoklitsh gives greater deposition results from the measurement data. Whereas other sediment transport formulas on average provide too little depositional value. The measurement results show the sediment content in the mouth of the river Serayu Total Suspended Solid sediment concentration of 98-126 mg / 1.

Meanwhile, from T. Marhendi's research, 2008, it was explained that the increase in the peak of the Serayu river flooding each year experienced changes in the factors of rainfall intensity, duration of rainfall, soil moisture, and the destruction of rain retention areas in the watershed [6]. The effect of rainfall intensity on surface runoff depends on the infiltration capacity. If the intensity of rainfall exceeds the capacity of infiltration, the amount of surface runoff will increase in accordance with the increase in rainfall intensity and this will increase sedimentation entering the river.

Andry Rustanto, Dhruba P. Shrestha, Victor G. Jetten, 2010, through his research explained that based on the analysis of Landsat image classification, the dominance of land cover in the Serayu River watershed was dominated by forests and dryland agriculture in the period 1989 to 1999 [8] While in the next period up to 2003, the dominance of land cover in this area was dry land agriculture and plantations, while up to 2009 it was dominated by plantations and dry land agriculture. Changes in land cover in the Serayu Hulu watershed during the period 1989 to 1994 were dominated by the conversion of forests, plantations, shrubs and rice fields into dry land agriculture. Meanwhile, during the period 1994 to 1999 the dominance of changes in land cover was from forests, dry land agriculture, shrubs and rice fields to plantations. Changes in rice fields, forests, dryland agriculture, plantations and grasslands into shrubs dominated the change in land cover between 1999 and 2003 in this area. While the conversion of paddy fields, dry land agriculture, forests and shrubs into plantations dominated the change in land cover in the Serayu Hulu River watershed between 2003 and 2009 [3].

To overcome the high sedimentation in the River Basin, what needs to be done is to reduce the rate of land erosion that occurs in the reservoir catchment. Efforts to reduce the rate of erosion can be considered as an effort to manage the potential capability of raindrops through its kinetic energy and hydraulic gradients at the surface of the ground so that ground conductivity by water mass can be reduced or prevented [6]. The process of natural sediment transfer is greatly influenced by the conditions of the hydrological cycle. There are two understandings of the phenomenon of the hydrological cycle namely the ancient and modern views (Mays, 1996 in T. Marhendi, 2014) [11] [27]. According to ancient concepts, the condition of the hydrological cycle is something that is naturally awakened or given. While the modern concept states that human activity is very influential on the conditions of the hydrological cycle. this shows that there is a significant change in land cover in the Serayu Hulu watershed and this has led to increased land erosion and sedimentation entering the river.

2. MATERIALS AND METHODS

2.1. Research Location

The research location is in the upper of the Serayu Barrage and Serayu River.



Figure 5. Location of Research [1] [12]

Location Serayu Barrage is located in Kebasen Village, Rawalo District, Banyumas Regency, Central Java Province or more or less 4.2 km from the meeting delta of the Logawa River and the Serayu River. The weir is located at coordinates 7.5187 ° S, 109.2058 ° E. The analysis is focused on the upstream location of the Gerayu Serak weir and Serayu River weir upstream [1] [2] [7] [12].

2.2. Research Data

Data in this study include [3] [4] [6] [7] [8] [13]:

- 1). Measurement / recording data of sedimentation in the upper of e Serayu Barrage 2005-2016
- 2). Measurement data / recording of annual flood discharge 2005-2016
- 3). Map of Basin Serayu Upstream
- 4). Erosion and Sedimentation Data of Upper Watershed Serayu River
- 6). Rain Data for 2005-2016

The data comes from agencies / agencies related to the management of the Serayu Barrage, such as the Banyumas Regency Public Works Agency, BBWS Serayu-Opak, BPSDA Progo-Opak-Serang, and PT Uni Indonesia Power [1].

2.3. Hydrologic and Sediment Prediction Analysis

Data analysis conducted in this study included hydrological analysis, sedimentation analysis of sediment transport models, predictive analysis of sedimentation development [8] [9] [10] [11] [13].

Hydrological analysis is used for the analysis of discharge increased and analysis of sediment increased based on flow discharge [18] [19] [20] [21]. Hydrological analysis was carried out to obtain the Serayu River flow hydrograph, if discharge data were not available in the data year. The stages of the implementation of hydrological analysis are carried out according to the availability of data using the Mock model [1]. In general, debit data recording is often not available well enough, in the sense of:

a. There is no record of discharge to the river to be analyzed

b. The location for recording debits does not fit the analysis control point

c. Recording data is not long enough

d. Recording data only records peak debits

e. No data are available for recording debit and rain pairs at the same time and the recording duration is relatively short (for example hours).

To overcome this, flow hydrograph analysis can be done using the rain-flow transformation method. Sedimentation analysis of the sediment transport model is used to determine the development of sedimentation in the upstream of the Serayu weir movement.

While the prediction analysis of the development of sedimentation is used to predict the development of sedimentation upstream of the srayu weir using statistical models. Analyzes were performed using the statistical (regression) method for several different equations using 2005-2016 data. Several regression models are used such as the linear regression model and the 2nd order polynomial regression model [1].

One prediction analysis of sedimentation increased upstream of the Serayu Barrage was carried out by regression analysis. Regression analysis is one of the statistical tools based on the properties of the relationship between two variables or several variables. This regression analysis is done to get a prediction equation from a set of data or variables so that it can estimate its value based on one other variable or several other variables. In this case the variable used is a quantitative variable. In this study a regression analysis is used to obtain the selected equation that will be used to predict the magnitude of the increase in sedimentation in the upstream of the Serayu Barrage in the future [8] [9] [10] [11].

2.4. Transport Sediment Analysis

Sediment transport analysis is intended to calculate the increase in sediment upper Serayu Barrage. Sediments transported upstream of the Serayu Barrage through the Serayu river channel will be partially deposited along the Serayu River channel, and some of which will be transported upstream of the weir [3] [15] [16] [17] [22]. The volume of sediment that settles upstream of the weir includes suspension sediment and bottom load through the river channel and the volume of sediment that enters the dam upstream directly. To calculate the volume of suspension sediment entering the weir, the following formula is used:

$$Q_s = a Q_w^b$$

(1)

with,

Qs = suspension sediment discharge (ton / day)

QW = river flow discharge (m3 / sec)

a, b = constant (depending on field measurement data)

To find out or determine the volume of sediment that settles, the methods of Shen and Hung (1971) [10] [18] [19] [23] [24] [26] [29] [30]. Shen and Hung (1971) Assume that sediment transport is so complex that no reynolds number, fraude number or a combination of both can be found to explain sediment transportation with all conditions. Shen & Hung tried to find the dominant variable that dominated the rate of sediment transport, they recommended a regression equation based on 587 laboratory data sets. The Shen and Hung regression equation can be written as follows:

 $Log_{ct} = -107404,45938164 + 324214,74734085 Y -306329,58908739Y^2 - 109503,87232539 Y^3$

(2)

 $Y = \left(\frac{VS^{0,57}}{\omega^{0,32}}\right)^{0.00750189}$ with: Y = Parameters ω = Sediment fall speed (m / s) V = flow velocity (m / s) S = Slope of the Channel Q_s = Qw x ct

with:

 $Q_{s} = Sediment Discharge (ton / d)$ $Q_{w} = Flow Discharge (m3 / s)$ Ct = Sediment Concentration (mg / l)

3. RESULTS AND DISCUSSION

Bagian ini menjelaskan hasil penelitian dan pembahasan secara komprehensif. Hasil disajikan dalam bentuk grafik dari analisis nilai *slump*, nilai kuat tekan beton dari masing-masing jumlah penggunaan pasir lahar dingin (0-100%) pada setiap umur beton, perbandingan kuat tekan beton, dan peningkatan kuat tekan beton pasir lahar dingin dengan pasir sungai.

3.1 Hydrologic Analysis

Based on flow data in the upstream of the Serayu River Dam, there are a number of data on flow flow records for 2007-2016. This data is then used to analysis the increasing of discharge and analysis of sedimentation based on flowrate. The mean flowrate during 2007-2016 is presented in Table 1 below [1].

		Flow Rate
Number	Year	mesuarement
		(m ³ /sec)
1	2007	210,80
2	2008	190,22
3	2009	182,41
4	2010	204,60
5	2011	148,33
6	2012	300,49
7	2013	347,89
8	2014	342,37
9	2015	326,53
10	2016	473,97

Table 1 Flow rate of Serayu River on Serayu Barrage Control Point 2007-2016

Source : Analysis, 2021 [1]

(3)

(4)



Figure 6 Flow Discharge of Serayu River and Increase in Annual 2007-2016

Referring to Table 1, it can be seen that since 2007-2010, the average flow rate tends to be stable around 200 m3/s, has decreased in 2011 around 148 m3/s and has increased from 2012 and reached 473.97 in 2016. These results showed that there has been a change or increase in the discharge of the Serayu River in the upper reaches of the Serayu Barrage in 2012-2016 with an increased in discharge by an average of 79% or an average increase in discharge of 158 m3/s. Referring to the increase in discharge, it can be explained that there has been a significant increase in discharge upstream of the Serayu Barrage.

Number	Year	Prediction of Flow Rate (m ³ /sec)
1	2007	210,80
2	2008	190,22
3	2009	182,41
4	2010	204,60
5	2011	148,33
6	2012	300,49
7	2013	347,89
8	2014	342,37
9	2015	326,53
10	2016	473,97
11	2017	428,70
12	2018	457,22
13	2019	485,73
14	2020	514,24
15	2021	542,75
16	2022	571,26
17	2023	599,78
18	2024	628,29
19	2025	656,80
20	2026	685,31
21	2027	713,82

Table 2 Prediction of Flow Discharge Serayu River on Serayu Barrage Control Point 2007-2036

22	2028	742,34
23	2029	770,85
24	2030	799,36
25	2031	827,87
26	2032	856,38
27	2033	884,90
28	2034	913,41
29	2035	941,92
30	2036	970,43

Source: Analysis, 2021



3.2 Analysis of Sediment Increasing Using Transport Sediment Models

The sediment transport model is a model that can be used to determine the amount of sediment in rivers. The model used in this study is the model of Shen and Hung (1971) [1] [23]. This model assumed that sediment transport is so complex that neither Reynolds number, Fraude number nor a combination of the two can be found to describe sediment transport under all conditions. Using this model, the sediment upstream of the Serayu Barrage can be calculated as in Table 2.

Table 3 Sediment Rate on Upper Serayu Barrage 2007-2016

Year	Qs (Ton / Day)
2007	0.417
2008	0.367
2009	0.383
2010	0.492
2011	0.263
2012	0.833
2013	1.182
2014	0.950
2015	0.979
2016	1.768

Sumber : Analisis, 2021 [1]



Figure 8 Increased Sediment Discharge In Upper Serayu Barrage 2007-2016 (T/D)

3.3 Analysis Prediction of Sediment Increased

Based on the analysis of sediment predictions using statistics, the results of the analysis in Figure 6 and Table 3 are as follows.



Figure 9 Statistical Analysis to Predict the increase of sediments in Upper Serayu Barrage [1]

Referring to Figure 8, using a second order polynomial regression model, it appears that the equation can be used to predict the development of sediment in the upper reaches of the Serayu Barrage with an R2 value of 0.8182. This figure showed that the model can be used to predict the development of sediment in the upper reaches of the Serayu Barrage considering its value is above 0.8. Based on this equation, the results of the prediction of sediment development until 2036 can be seen in Table 3.

Table 3 Sediment Prediction in Upper Serayu Barrage 2007-2036

Number	Year	Qs (T/D)
1	2007	0,417
2	2008	0,367
3	2009	0,383
4	2010	0,492
5	2011	0,263
6	2012	0,833
7	2013	1,182
8	2014	0,950
9	2015	0,979

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10	2016	1,768
11	2017	1,919
12	2018	2,282
13	2019	2,684
14	2020	3,125
15	2021	3,603
16	2022	4,120
17	2023	4,676
18	2024	5,270
19	2025	5,902
20	2026	6,573
21	2027	7,282
22	2028	8,029
23	2029	8,815
24	2030	9,640
25	2031	10,502
26	2032	11,403
27	2033	12,343
28	2034	13,321
29	2035	14,337
30	2036	15,392

Source: Analysis, 2021



Figure 10 Predictions Sediment Increased in Upper Serayu Barrage until 2036

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4. CONCLUSION

Based on the results of the analysis, it can be concluded as follows prediction of increased sedimentation upstream of the Serayu Barrage will continue throughout the year 2036. Using the prediction of the 2nd order polynomial model, until the year 2036, there will be an increase in sedimentation in the upstream of the Gerak Gerak Serayu to 15,392 tons /day. This research recommends that upstream of the Serayu dam needs arranging to control sedimentation.

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