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Study of Water Discharge Statistic and Arithmetic Flows using Awlr in Jeneberang River in Gowa

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Abstract:- Bili-bili dam is located in the upper part of the Jeneberang river where in this area there is an automatic water level measuring device or AWRL (Automatic Water Level Recorder). Continuous river discharge monitoring is very necessary to evaluate the watershed in the long term. The method used in monitoring the discharge is the discharge curve method or rating curve. The use of flow rate curve data that is not up to date can cause an error in the estimation of flood discharge. The purpose of this study is to find out how much is the debit and the percentage difference from the Rating Curve equation generated through the statistical and arithmetic methods. The method used in determining the price of H0 is Arithmetic. The results of this study conclude that the rating curve equation in 2009-2015 statistic method is Q = 3,335 X (H-83,67) 0,98 in 2016-2019 is Q = 5,898 X (H-88,67) 0,86 while arithmetic method in 2009-2015 is Q = 5,419 X (H-83,67) 1 in 2016-2019 is Q = 8,033 X (H-88,67) 1 and the difference in the value of river discharge and calculated discharge with statistic method in 2009-2015 an average of -3,036% in 2016-2019 an average of -1,68% while in arithmetic method in 2009-2015 an average of 72,13% in 2016-2019 an average of -71,65%. The result of this study are expected to be a reference method that can be used to calculated river discharge in other areas.

Keywords:- *Automatic Water Level, Rating Curve, River.*

I. INTRODUCTION

The river is a large and elongated surface water flow that flows continuously from upstream to downstream; the river is also one of the water resources that has potential that can be utilized for human welfare. One of the benefits of the river as a source of water is as a source of livelihood and the life of the people who live around the river. One of the rivers in Indonesia is the Jeneberang River.

In the Watershed (DAS) there is the Bili-Bili Dam which is the largest dam in South Sulawesi. The purpose of the Bili-Bili Dam is to prevent flooding in Makassar City and its surroundings. The Bili-Bili dam is located in the upper part of the Jeneberang river where in this area there is an automatic water level measuring device or what we usually know as Awlr (Automatic Water Level Recorder). This tool records the occurrence of changes in water level automatically and continuously.

The problem of inundation in the Jeneberang River has been around for a long time, this river often overflows during the rainy season as happened in December to January 1975 so that almost 2/3 of Makassar City is inundated. (Office of PSDA, 2015) and on January 24, 2019, extreme rainfall occurred which resulted in an increase in the TMA (Water Level) of the Bili-Bili Dam to +101.87 meters. The floodgates at the Bili-Bili Dam were forced to open and caused flooding in Gowa Regency and Makassar City.

II. THEORETICAL STUDIES

A. River

Rivers are fresh water from natural sources that flow from higher places to lower places and empty into the sea or larger lakes and rivers. [1]

B. River Morphological Forms

In general, the shape of the river can be classified into 3 (three) forms, including: [2]

1. Menadering River
2. Straight River
3. Braided River

C. Dam

Dam is a building in the form of earthfill, stone fill, concrete, and or masonry which is built in addition to holding and storing water, it can also be built to hold and accommodate mining waste (tailings), or accommodate mud so that a reservoir is formed (Government Regulation no. 37 of 2010 concerning Dams). [3]

D. Hydrological Analysis

The hydrological analysis in this study required water level data to be used as the basis for calculating the discharge after a relationship was made between the water level and the discharge results from measurements carried out periodically, which included measurements at low to high water levels. The discharge data is then used as data for various purposes, for example for the purpose of a power source, calculating water supply from an irrigation area, calculating water balance from a DPS and for other hydrological analysis. Thus the accuracy in calculating the discharge data also depends on the accuracy of the measurement of water level..[3]

E. Water Level

The water level (Stage Height, Gauge Height) of a river is the elevation of the water level (water level) in a cross section of the river to a fixed point whose elevation is known. The water level is usually expressed in meters (m) or centimeters (cm). Fluctuations in river water surface indicate a change in flow velocity and discharge.[4]

F. *Discharge*

Discharge, or the amount of river flow (stream flow) is the volume of flow that flows through a cross section of the river per unit time. Usually expressed in units of cubic meters per second (m3/s) or liters per second (l/s). Flow is the movement of water in a water reservoir, the main purpose of which is to create a rating curve for the water. Basically the discharge measurement is the measurement of wet cross-sectional area, flow velocity and water level. The general formula that is commonly used is:

$$Q = A.v \quad (1)$$

G. *Value Determination of H0*

There are three ways to determine the H0 price is trial and error, arithmetic and graphics.All discharge measurement data are depicted on logarithmic graph paper. Read on the Rating Curve for the prices of H1, H2 and H3 based on Q1, Q2 and Q3, the price of H0 is determined by the equation:

$$H0 = \frac{H_1 H_3 - {H_2}^2}{H_1 + H_3 - 2H_2} \quad (2)$$

H. *Rating Curve Analysis*

Rating Curve is a curve that describes the relationship between water level and discharge. It is made based on flowrate measurement data from various water levels, which include low to high water levels.

$$Q = K(H - H0)^n \quad (3)$$

I. *Coefficient Of Determination*

The coefficient of determination with the symbol (R2) is the proportion of variability in a data that is calculated based on a statistical model.The value of the coefficient of determination is $0 \leq R \leq 1$. If the coefficient of determination is 0, it can be concluded that there is no relationship between the y variable and the x variable.

$$R^2 = 1 - \frac{\Sigma(y-\hat{y})^2}{\Sigma(y-\bar{y})^2} \quad (4)$$

III. STUDY METHOLOGY

A. *Location of Study*

This research was conducted atBili-bili Dam is located in Bili-bili Village, Parangloe District, Gowa Regency, South Sulawesi Provinc/e, which is located 30 km east of Makassar City.

Fig 1: Research location (Bili-Bili Dam)

B. *Type of Research*

This type of research is descriptive, which is a type of research that aims to portray the phenomenon that is the focus or object of research. Descriptive research is research that intends to make depictions of situations or events. The methods used are field surveys and literature surveys.

C. *Data Collection Techniques*

- Primary Data

  Primary data obtained directly in the field in the form of river observations and interviews.

- Secondary Data

  Secondary data obtained from library materials that are relevant to this research and related institutions of the Pompengan Jeneberang River Basin Center which include:

Reading data using an AWLR (automatic water level recorder) device, is data on water level and discharge at the water guess post for the Jeneberang River Basin, especially the Bili-Bili Dam, which is used as the object of research so that it can strengthen the truth of the research results.Housing data: number of homes, population, percent of wastewater.

D. *Research Procedure*

This research was carried out through 4 stages, namely determining the location, collecting peer data, secondary data and evaluating the model.Rainfall analysis plan

- The first stage is the determination of the research location, the location is set on the Jeneberang River, Bili-Bili Dam, Bontomarannu District, Gowa Regency, South Sulawesi ProvinceSelection of spread types.
- The second stage is collecting research data consisting of primary data and secondary data. The primary data required include data on discharge and water level from 2009-2019 obtained from the reading of the AWLR (automatic water level recorder) device. Secondary data collection of data in the form of topographic map data and cross-sectional data of the river.
- The third stage is to make a rating curve using two methods, namely statistics and arithmetic with a polynomial equation model.
- The fourth stage is the evaluation of the model which aims to find out how good the equation model is when compared to the observation data. Evaluation of this model uses polynomial quadratic regression equation and coefficient of determination (R2).

IV. RESULT OF RESEARCH AND DISCUSSION

A. *Rating Curve Analysis*

The Rating Curve is made based on statistical & arithmetic analysis of the measurement data of discharge (Q) and water level (H) obtained from a tool installed on the Bili-Bili Dam, AWLR (Automatic Water Level Recording).

Number	Years	Qstatistic m^3/s	Qarithmetic m^3/s	Elevation m
1	2009-2015	15,548	25,872	88,444
2	2009-2015	9,446	15,597	86,548
3	2009-2015	9,471	15,640	86,556
4	2009-2015	9,960	16,460	86,708
5	2009-2015	21,865	36,574	90,419
6	2009-2015	53,641	90,971	100,456
7	2009-2015	31,801	53,501	93,542
8	2009-2015	39,722	67,055	96,043
9	2009-2015	26,262	44,053	91,799
10	2009-2015	56,299	95,551	101,301
11	2009-2015	56,459	95,826	101,352
12	2009-2015	19,650	32,815	89,725
13	2009-2015	19,605	32,738	89,711
14	2009-2015	16,923	28,196	88,873
15	2009-2015	44,883	75,911	97,677
16	2009-2015	35,867	60,453	94,825
17	2009-2015	39,413	66,527	95,946
18	2009-2015	46,990	79,531	98,345
19	2009-2015	1,360	2,180	84,073
20	2009-2015	47,316	80,090	98,448
21	2009-2015	37,145	62,641	95,229
22	2009-2015	25,217	42,272	91,470
23	2009-2015	9,565	15,798	86,585
24	2009-2015	1,360	2,180	84,073
25	2009-2015	3,838	6,250	84,824
26	2009-2015	1,360	2,180	84,073
27	2009-2015	3,992	6,505	84,871

Number	Years	Qstatistic m³/s	Qarithmetic m³/s	Elevation m
28	2009-2015	29,965	50,366	92,964
29	2009-2015	43,535	73,597	97,250
30	2009-2015	51,154	86,691	99,666
31	2009-2015	35,272	59,434	94,637
32	2009-2015	41,789	70,600	96,697
33	2009-2015	31,339	52,711	93,396
34	2009-2015	15,579	25,924	88,454
35	2009-2015	16,713	27,841	88,808
36	2009-2015	15,412	25,642	88,402
37	2009-2015	9,747	16,103	86,642
38	2009-2015	1,360	2,180	84,073
39	2009-2015	1,945	3,134	84,249
40	2009-2015	14,036	23,318	87,973
41	2009-2015	26,878	45,101	91,992
42	2009-2015	57,554	97,713	101,700
43	2009-2015	57,335	97,337	101,630
44	2009-2015	37,570	63,369	95,363
45	2009-2015	37,734	63,650	95,415
46	2009-2015	57,070	96,879	101,546
47	2009-2015	45,443	76,873	97,855
48	2009-2015	41,711	70,466	96,672
49	2009-2015	37,796	63,756	95,434
50	2009-2015	13,844	22,994	87,913
51	2009-2015	8,830	14,565	86,358
52	2009-2015	16,736	27,879	88,815
53	2009-2015	28,896	48,542	92,627
54	2009-2015	44,971	76,062	97,705
55	2009-2015	30,622	51,487	93,171
56	2009-2015	45,059	76,212	97,733
57	2009-2015	37,900	63,934	95,467
58	2009-2015	23,736	39,753	91,005
59	2009-2015	28,667	48,151	92,555
60	2009-2015	31,501	52,988	93,448
61	2009-2015	9,714	16,048	86,632
62	2009-2015	8,956	14,776	86,397
63	2009-2015	7,024	11,546	85,801
64	2009-2015	18,116	30,215	89,246
65	2009-2015	21,958	36,732	90,448
66	2009-2015	45,006	76,122	97,716
67	2009-2015	57,578	97,756	101,708
68	2009-2015	45,074	76,239	97,738
69	2009-2015	23,495	39,344	90,930

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Number	Years	Qstatistic m³/s	Qarithmetic m³/s	Elevation m
70	2009-2015	26,085	43,750	91,743
71	2009-2015	28,662	48,143	92,554
72	2009-2015	31,595	53,148	93,477
73	2009-2015	10,092	16,681	86,748
74	2009-2015	9,210	15,202	86,476
75	2009-2015	8,444	13,919	86,239
76	2009-2015	8,447	13,925	86,240
77	2009-2015	33,335	56,122	94,026
78	2016-2019	28,73	50,17	94,91
79	2016-2019	35,14	63,32	96,55
80	2016-2019	34,96	62,95	96,50
81	2016-2019	45,14	84,62	99,20
82	2016-2019	17,69	28,63	92,23
83	2016-2019	28,51	49,71	94,86
84	2016-2019	28,40	49,50	94,83
85	2016-2019	6,38	8,80	89,76
86	2016-2019	6,39	8,81	89,76
87	2016-2019	9,73	14,33	90,45
88	2016-2019	23,06	38,90	93,51
89	2016-2019	44,95	84,20	99,15
90	2016-2019	37,64	68,57	97,20
91	2016-2019	44,81	83,90	99,11
92	2016-2019	44,95	84,20	99,15
93	2016-2019	34,25	61,47	96,32
94	2016-2019	23,15	39,07	93,53
95	2016-2019	23,16	39,10	93,53
96	2016-2019	28,60	49,90	94,88
97	2016-2019	6,70	9,31	89,83
98	2016-2019	6,87	9,59	89,86
99	2016-2019	6,86	9,57	89,86
100	2016-2019	23,93	40,60	93,72
101	2016-2019	44,59	83,42	99,05
102	2016-2019	60,97	119,80	103,58
103	2016-2019	45,08	84,49	99,18
104	2016-2019	45,23	84,80	99,22
105	2016-2019	28,41	49,53	94,83
106	2016-2019	29,23	51,17	95,04
107	2016-2019	28,71	50,13	94,91
108	2016-2019	28,60	49,91	94,88
109	2016-2019	8,53	12,32	90,20
110	2016-2019	10,21	15,16	90,56
111	2016-2019	10,99	16,51	90,72

Number	Years	Qstatistic m^3/s	Qarithmetic m^3/s	Elevation m
112	2016-2019	10,15	15,05	90,54
113	2016-2019	28,15	48,99	94,77
114	2016-2019	41,55	76,88	98,24
115	2016-2019	48,78	92,56	100,19
116	2016-2019	45,23	84,80	99,22
117	2016-2019	28,41	49,53	94,83
118	2016-2019	29,23	51,17	95,04
119	2016-2019	28,51	49,71	94,86
120	2016-2019	28,60	49,91	94,88
121	2016-2019	8,53	12,32	90,20
122	2016-2019	10,21	15,16	90,56
123	2016-2019	10,99	16,51	90,72
124	2016-2019	10,15	15,05	90,54
125	2016-2019	28,15	48,99	94,77

Table 1: Table Result Qstatistic & Q arithmetic in 2009-2019

1. Analysis Value of H0

All water level data from the highest to the lowest were obtained from the AWLR tool from 2009-2019.

-The determination of H0 for 2009-2015 is as follows:

$$H0 = \frac{H1 . H3 - H2^2}{H1 + H3 - 2.H2}$$

$$H0 = \frac{84{,}07 \,.\, 101{,}71 - 86{,}36^2}{84{,}07 + 101.71 - 2 \,.\, 86{,}36}$$

$$H0 = \frac{1092{,}11}{13{,}05}$$

H0 = 83,67 m

-The determination of H0 for 2016-2019 is as follows:

$$H0 = \frac{H1 . H3 - H2^2}{H1 + H3 - 2.H2}$$

$$H0 = \frac{89{,}76 \,.\, 103{,}58 - 92{,}71^2}{89{,}76 + 103{,}58 - 2 \,.\, 92{,}71}$$

$$H0 = \frac{702{,}59}{7{,}92}$$

H0 = *88,67* m

2. Analysis value of K and n Statistical Method
   The analysis of K and n values used in the statistical method is the substitution and elimination method.
   - Analysis of the value of K and n statistical methods for 2009-2015

   $\Sigma(y) - m \log K - n\, \Sigma(x) = 0$
   $(100{,}114) - 77 \log K - n\,(60{,}754) = 0$
   $-77 \log K - 60{,}754\, n = -100{,}114$

   $\Sigma(xy) - \Sigma(x) \log K - n\, \Sigma(x2) = 0$
   $92{,}343 - 60{,}754 \log K - 61{,}493\, n = 0$
   $60{,}754 \log K - 61{,}493\, n = -92{,}343$

From the above equation, it can be seen that the coefficients of K and n are:

Log K = 0,523114

K = 3,335139

n= 0,984857

Log Q = Log K + n log (H-H0)

Log Q = 0,523114 + 0,984857 log (88,44 – 83,67)

$Q = K \,.\, (H-H0)^n$

$Q = 3{,}335139 \,.\, (H - 83{,}67)^{0{,}984857}$

- Analysis of the value of K and n arithmetical methods for 2009-2015

$$\frac{\log Q - \log Q1}{\log (H-H0) - \log H1} = \frac{\log Q2 - \log Q1}{\log H2 - \log H1}$$

$$\frac{\log Q - 0{,}338}{\log (H-H0) + 0{,}395} = \frac{1{,}990 - 0{,}338}{1{,}256 + 0{,}395}$$

$$\frac{\log Q - 0{,}85}{\log (H-H0) - 1{,}73} = \frac{1{,}651}{1{,}651}$$

= 1

LOG Q = 1 log (H-H0) + 0,73

$Q = 5{,}373\ (H-83{,}67)^1$

B. Analysis the difference in the percentage of Qstatistics and Qarithmatic with AWLR discharge

The calculation of the difference is used to determine the percentage comparison between the AWLR debit and the calculated debit, in addition to calculating the difference whose value is presented in percent to make it easier to find out what percentage of deviations occur.

-To calculate the percentage difference in the Qstatistics method for 2009-2015

Percentage difference:

$$= \frac{\text{AWLR debit} - \text{Q Calculation}}{\text{AWLR debit}} \times 100$$

$$= \frac{13{,}889 - 15.548}{13{,}888} \times 100$$

$$= -11.946\%$$

-To calculate the percentage difference in the Qstatistics method for 2009-2015

Percentage difference:

$$= \frac{\text{AWLR debit} - \text{Q Calculation}}{\text{AWLR debit}} \times 100$$

$$= \frac{13{,}89 - 25{,}87}{13{,}89} \times 100$$

$$= -86{,}272\ \%$$

C. Coefficient of Determination Test

- Coefficient of Determination of Rating Curve Equation Statistical Method 2009-2015

$$R^2 = 1 - \frac{\Sigma(y-\hat{y})^2}{\Sigma(y-\bar{y})^2}$$

$$R^2 = 1 - \frac{0{,}02}{2086{,}82}$$

$$R^2 = 1$$

- Coefficient of Determination of Rating Curve Equation Statistical Method 2009-2015

$$R^2 = 1 - \frac{\Sigma(y-\hat{y})^2}{\Sigma(y-\bar{y})^2}$$

$$R^2 = 1 - \frac{26{,}088}{2653{,}596}$$

$$R^2 = 0{,}9903.$$

V. DISCUSSION

The results of calculations using statistical and arithmetic methods in Figures 1 and 2 are parallel to the polynomial line. Figures 1 and 2 above show that the graph of the results of the calculation of the discharge using statistical and arithmetic methods has a correlation value of x which explains a lot about the y variable.

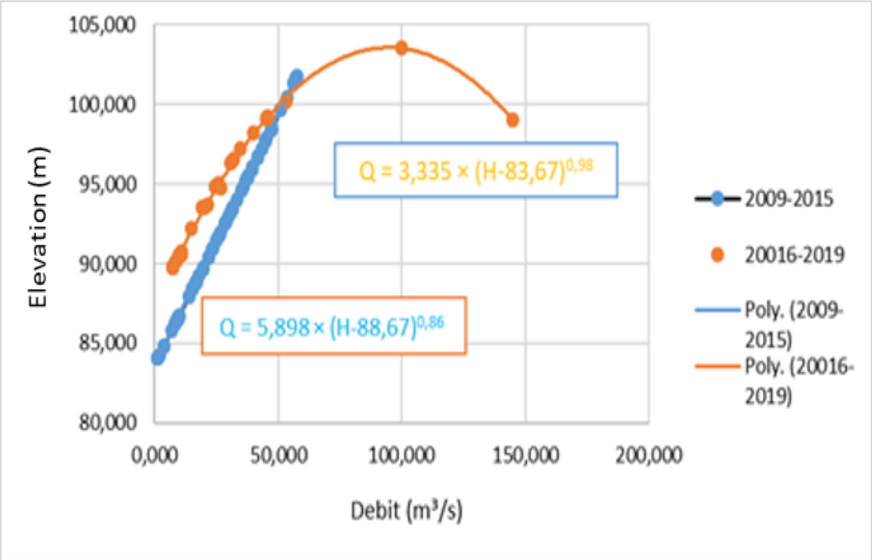

Fig. 2 : RelationQstatistics vs Elevation

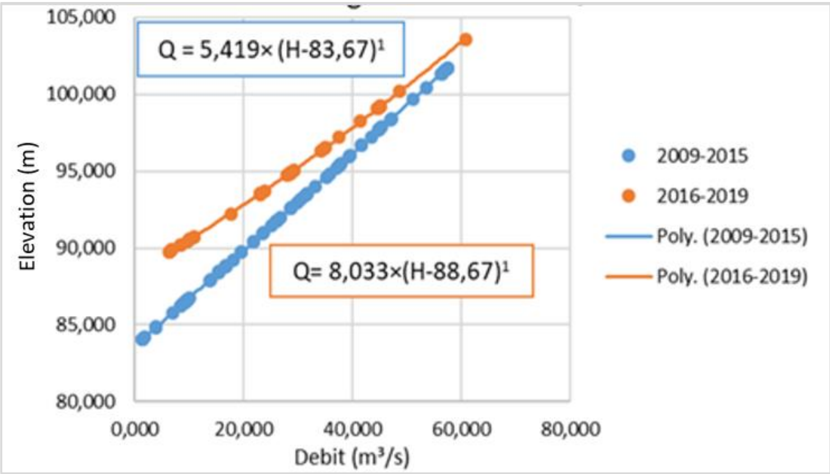

Fig. 3 : Relation Qarithmetic vs Elevation

VI. CONCLUSION

From the results of research study of water discharge statistic and arithmetic flows using awlr in Jeneberang River in gowa, it can be concluded that:

- The rating curve equation with the 2009-2015 Statistical method is Q=3,335x (H-83.67)0.98 and the 2016-2019 Statistical method is Q=5.898x(H-88.67)0.86. Arithmetic in 2009-2015 is Q=5,419x (H-83,67)1 and Arithmeticmethod for 2016-2019 is Q=8.033x(H-88,67)1.
- The difference between the field discharge value and the calculated discharge using the 2009-2015 statistical method is -3.036% in average and the 2016-2019 statistical method is -1.68% in average, while the 2009-2015 arithmetic method is on average by -72.13% and the Arithmetic method in 2016-2019 an average of -71.65%.

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