International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-8, Issue-4S February, 2019

Study of Mathematical Model Application in Analysis of Tello River Flood

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Abstract: River is a natural element that was instrumental in shaping the pattern of life of a community. For example, in the city of Makassar, one of the essential rivers is the river Tello. However, in addition to many benefits, often also causing disasters, namely floods. One way to cope with floods in this area are studying the phenomenon and the vulnerability of flood conditions in watersheds using hydrologic approach through flood search method known as kinematic Muskingum method. Results from this study are expected to provide an alternative solution with the optimal treatment approach the river hydrological conditions of Tello River. This research was conducted by processing rainfall data at three stations along the stream to get the value of flood discharge. Then proceed with processing the flood discharge plan with the inflow into the Muskingum method to get the value of the outflow. Segments of the river reviewed so far is 20 km and by dividing the share of the river as many as 5 segments with 4 km each. The value of x is determined between 0.1 to 0.3 and a K value of between 0.16 to 0.57. These values are used to calculate get the flood outflow of each segment of the river.

I. INTRODUCTION

Flood is one of the natural events that often occur. Lots of losses caused by flooding. Natural disasters such as floods can occur at any time, particularly in tropical areas like Indonesia. Lots of good disaster events recorded or not befall our country, including South Sulawesi. Flooding can occur due to high rainfall, intensity or degradation of marine use is wrong. To prevent that from happening, is used in various ways to control the flow of the river where lots of losses caused by flooding. Flooding can occur due to high rainfall, intensity, or the degradation of land use is wrong. Therefore, the role of search flooding (flood routing), which is part of the hydrological analysis becomes quite important. Search flooding could be interpreted as a procedure to determine / estimate the time and scale of floods in a point based on known data (or presumption data).

Many methods have been proposed and tested to forecast flood in high risk areas. Lai et al., (2015), integrated combined weights (subjective weight and objective weight) with Fuzzy Comprehensive Evaluation (FCE) approach to evaluate flood risk in the Dongjiang River Basin. The high risk areas detected using this approach, matched with the integrated risk zoning map and inundation areas of historical floods. Hence, this proved that the evaluation model is feasible and rational.

Revised Manuscript Received on February 05, 2019.

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In Malaysia, Noor et al., (2016) used non-inclusion residual method to forecast the water level at four river basins in Terengganu. The equations from this method were able to predict the water level at downstream area since it capable to provide overestimation of the water level at majority event. As for San and Khin (2015), they used Markov model to predict the river flood and this model was tested on the Ayeyarwady River in Myanmar. The results showed a close agreement between the predicted value and the actual amount of flooding in the river. Based on the above issues, this paper aimed to examine the Muskingum method application in search of flooding (flood routing) at Tallo River.

II. METHODOLOGY

This research is an application study of the search for flood phenomena and the prediction of maximum discharge of floods that will occur along the Tallo River flow area. Rainfall data is obtained from the Department of Public Works for the Development of Resources South Sulawesi Province Water Power (PSDA) in the form of rainfall data from 1999 to 2009 at 3 stations adjacent to the location study (Senre Station, Malino Station and Hasanuddin Station). This data is used to calculate the intensity of rainfall, and then the intensity is used to calculate the surface flow discharge and lastly calculate the trace of the Tallo river flood.

III. RESULTS AND DISCUSSION

The basic principle of solving the flooding calculations with the Muskingum method is the completeness of the discharge measurement data on the upstream and downstream sections of the river obtained at the same time. This value is used to determine the value of K and x. However, in this study the values of x and K was not calculated according to the formulation available because of the absence of discharge measurement data in the lower reaches of the river. Thus, the values of x and K are determined by trial and error method by setting a range for both the coefficient. To get the range of K values, Equation 1 is used.

$$W = 20\left({}^{H}/_{L}\right)^{0.6} \qquad (1)$$

Where

W: speed of flood flow (m/s)

t: flood arrival time (hours); t = K

L = river length (km)

H = elevation difference (m)

All of the above coefficients are known, except the elevation (H) of the riverbed being reviewed.

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As for elevation values, the upstream and downstream parts are taken from DEM data downloaded from the internet. DEM data is basic data or topographic contours (altitude). The 20km long river is divided into five segments with each 4km long. The following are the values of K based on the recapitulation of calculations of each segment of the river: Segment 1 (K= 0.32), Segment 2 (K = 0.57), Segment 3 (K= 0.16), Segment 4 (K= 0.20) and Segment 5 (K= 0.32).

Floods tracing with the Muskingum method can be calculated using Equation 2 to 7. Inflow data used is a flood discharge data plan for a 2-year repetition period.

$$I - O = \frac{dS}{dt} \quad (2)$$

$$S = k[xI - O(1-x)] \quad (3)$$

$$O_2 = C_0 I_2 + C_1 I_1 + C_2 O_1 \quad (4)$$

$$C_0 = \frac{kx - 0.5(\Delta t)}{k(1-x)+0.5(\Delta t)} \quad (5)$$

$$C_1 = \frac{kx + 0.5(\Delta t)}{k(1-x)+0.5(\Delta t)} \quad (6)$$

$$C_2 = \frac{k(1-x) - 0.5(\Delta t)}{k(1-x)+0.5(\Delta t)} \quad (7)$$

Where

I: flow of debit into a certain river trough.

x: is the value that shows the slope of the river. Getting steeper the slope, the greater the x value. In general, the value of x ranges between 0.1 to 0.3.

The inflow value used is from the flood discharge data plan for segment 1, while for segment 2 the inflow value is obtained from the outflow value of the previous segment, and so on up to segment 5. Based on the results of the interaction of inflow and outflow values with a value of x = 0.1 to x = 0.3, it is known that the largest discharge value is produced with the value of x = 0.1. Therefore, the value of x that is used in the value of the inflow and outflow values is 0.1. The following is a table of the results of the calculation. The data in Table 1 shows that the largest discharge value is in segment 1, namely the inflow of 899 233m^3 / sec and outflow of 801 330 m^3 / sec (for a 2-year repetition period).

Table. 1 Recapitulation of inflow and outflow for repetition period of 2 years for segment 1 to segment 5 of Tallo River

t (hours)	Segment 1		Segment 2		Segment 3		Segment 4		Segment 5	
	I (m^3/sec)	O (m^3/sec)	I (m^3/sec)	O (m^3/sec)	I (m^3/sec)	O (m^3/sec)	I (m^3/sec)	O (m^3/sec)	I (m^3/sec)	O (m^3/sec)
0	1021	1021	1021	1021	1021	1021	1021	1021	1021	1021
1	19766.	12139	12139	5848	5848	4639	4639	3561	3561	2752
2	86779	61553	61553	33474	33474	27217	27217	20987	20987	15783
3	201542	161596	161596	104462	104462	90113	90113	74255	74255	59514
4	380766	318530	318530	228662	228662	205426	205426	178409	178409	151534
5	608606	532553	532553	409771	409771	377159	377159	338498	338498	298989
6	899233	801330	801330	646953	646953	605441	605441	555324	555324	503140
7	676531	793345	793345	794995	794995	780700	780700	751697	751697	711436
8	567689	580718	580718	701070	701070	732448	732448	760273	760273	774726
9	476358	510034	510034	552269	552269	572318	572318	607146	607146	649739
10	399721	421893	421893	472555	472555	481517	481517	492436	492436	510785
11	335413	355646	355646	394075	394075	408815	408815	425422	425422	438931
12	281451	297993	297993	331332	331332	338957	338957	352080	352080	369670
13	241244	253177	253177	279157	279157	288041	288041	297134	297134	307124
14	214621	222260	222260	240238	240238	245110	245110	253691	253691	263261
15	190936	198529	198529	212292	212292	216618	216618	221133	221133	227416
16	169864	176406	176406	189181	189181	192595	192595	197662	197662	202455
17	151119	156996	156996	168217	168217	171594	171594	175505	175505	180515
18	134441	139655	139655	149676	149676	152467	152467	156355	156355	160314
19	119605	124247	124247	133152	133152	135759	135759	138937	138937	142793
20	97664	105349	105349	116208	116208	119022	119022	122537	122537	126113
21	89463	90743	90743	99210	99210	101924	101924	105390	105390	109324
22	81951	84665	84665	88262	88262	89515	89515	91607	91607	94317
23	75070	77144	77144	81467	81467	82481	82481	83608	83608	84998
24	68767	70777	70777	74460	74460	75658	75658	77170	77170	78626

IV. CONCLUSION

From the results of the study, it can be concluded that:

1. The values of x and K in the Telllo River segment which are assessed from the results of try and error is in a range between 0.1 to 0.3 for the x value. As for the value of K, it is obtained by using the time formula for flooding arrival for each segment, namely: Segment 1 (0.32) hours, Segment 2 (0.57) hours, Segment 3 (0.16) hours, Segments 4 (0.20) hours, and Segments 5 (0.22) hours.
2. Results of debit calculation of The Tello River outflows with the Muskingum kinematic method showed there was a dynamic decrement in the river segment.

For example, for a 2-year repetition period: segment 1 : 801330 m3/sec, segment 2 : 794995 m3/sec, segment 3: 780700 m3/sec, segment 4 : 760273 m3/sec and segment 5: 774726 m3/sec.

3. The value of the inflow compared to the value of outflow is not very different. This indicated the presence of water inflow from various sources entering the river flow other than rainfall from the downstream area of the river and the enactment of the concept of reservoirs in tracing floods.

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