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EVALUATION OF DRAINAGE SYSTEM IN CEMAKA SLUM IN FLOOD EVENTS IN 2021

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ABSTRACT

Early in 2021, South Kalimantan experienced a major flood disaster caused by high rain intensity. Badan Nasional Penanggulangan Bencana (BNPB) reported that as many as ten regencies/cities experienced flooding in South Kalimantan Province, one of which was Banjarbaru City. One way to reduce flooding and inundation is to have a good, economic, and appropriate drainage system. The ability of the soil to infiltrate downstream influences the design of the drainage system. Soil absorption capacity can be measured by infiltration rate experiments. This study aims to analyze the rate of infiltration in the Cempaka Slum Settlement, Cempaka District, Banjarbaru City. The data used in this study are infiltration rate measurement data collected in the field using a double-ring infiltrometer (Turf Tec Infiltrometer), which is processed using the Horton method. Based on the results of the analysis of the inlet filtration rate in the Cempaka Slum Settlement, it was determined that the overall average inlet filtration capacity in the Cempaka Slum Settlement was 94,950 cm/hour with a very fast filtration rate classification.

Keywords: *Infiltration Rate, Horton Method, Flood, Cempaka Slum Settlement*

1. INTRODUCTION

Beginning in 2021, South Kalimantan experienced a major flood disaster caused by high rain intensity. Rainfall with a high intensity usually has a short duration and does not cover a large area. Conversely, rain in a large area rarely occurs with high intensity, but if it does, the duration is quite long (Novitasari, 2007). Based on data collected on January 17, 2021, Badan Nasional Penanggulangan Bencana (BNPB) reported that as many as ten districts/cities were affected by floods in South Kalimantan Province, including Tapin Regency, Banjar Regency, Banjarbaru City, Tanah Laut City, Banjarmasin City, Hulu Sungai Regency Tengah, Balangan Regency, Tabalong Regency, Hulu Sungai Selatan Regency, and Barito Kuala Regency (Jati, 2021). One of the flood events in Banjarbaru City occurred in the Cempaka Slum Housing, Cempaka District.

One of the ways to deal with floods is the existence of a good and economical drainage system. The ability of the soil to infiltrate downstream affects the drainage system that is made. Some of the rainwater that falls will flow on the ground surface to become surface runoff, and some will seep into the ground (Hadisusanto, 2010). If the soil absorption in the downstream part of a place has poor absorption ability, then when it rains, surface water that flows from the upstream to the downstream will cause puddles, and the water cannot enter the soil properly, so it can only seep in a short amount of time. Long time or not absorbed at all. This can lead to flooding when it rains with high intensity. Soil absorption capacity can be measured by infiltration rate experiments. According to (Hadisusanto, 2010), if the ratio of rain intensity is smaller than the rate of infiltration, then all the rainwater that falls will seep into the ground. Then, vice versa, if the rain intensity is greater than the infiltration rate, the rainwater that falls will produce surface runoff, which will burden the drainage channel. This study aims to analyze the rate of infiltration in the Cempaka Slum Settlement, Cempaka District, Banjarbaru City.

2. THEORETICAL STUDY

Flood

Floods are streams or puddles of water that result in economic losses and even fatalities (Asdak, 1995) (Amalia, 2011). Floods occur when water overflows due to insufficient channel cross-sectional capacity. In the upper reaches of the flood, currents are generally swift, with high scour but short duration. Whereas in the downstream, the current is not as fast (because it is gently sloping), but the duration of the flood is longer(Kusumo & Kurnia, 2009). Floods can be caused by natural disasters and/or human factors (Tyas, 2016) (Yuliana et al., 2022).

Infiltration Rate and Infiltration Capacity

The movement of water into the soil past the soil surface is called infiltration. There are two terms in infiltration, namely infiltration capacity and infiltration rate. Infiltration capacity is the maximum infiltration rate in a certain soil type, while infiltration rate is the infiltration rate whose value depends on soil conditions and rain intensity (Triatmodjo, 2008).

Horton's Method

Horton's method can be used to calculate infiltration rate and infiltration capacity. Horton stated that with increasing time, the infiltration capacity would decrease until it approaches a constant value. According to him, the decrease in infiltration capacity is controlled more by factors that work on the soil surface than the flow process in the soil (Susanawati et al., 2018). According to Horton (1940) (Hadisusanto, 2010), function and time are factors in soil infiltration with an empirical approach. The Horton Model equation is as follows:

$$ft = fc + (fo - fc)e^{-Kt} \quad (1)$$

description:

ft = infiltration rate or infiltration capacity at time t.

fc = infiltration rate constant

fo = initial rate of infiltration

e = 2.71828.

K = soil-saturated hydraulic conductivity

t = time

Table 1 Classification of Infiltration Rate According to Uhland and O'Neal, 1951

Criteria	Infiltration Rate (cm/jam)
Very Fast	>25,4
Fast	12,7 – 25,4
Rather Fast	6,3 – 12,7
Medium	2 – 6,3
Slightly Slow	0,5 – 2
Slow	0,1 – 0,5
Very Low	<0,1

Source: (Yunagardasari et al., 2017)

3. METHOD

This research was conducted in the Cempaka Slum Settlement, Cempaka District, Banjarbaru City, South Kalimantan. Primary data was obtained by observing the research location directly to determine the existing drainage conditions and measuring infiltration rates using a double-ring infiltrometer (Turf Tec Infiltrometer). The method used in this study is the Horton method.

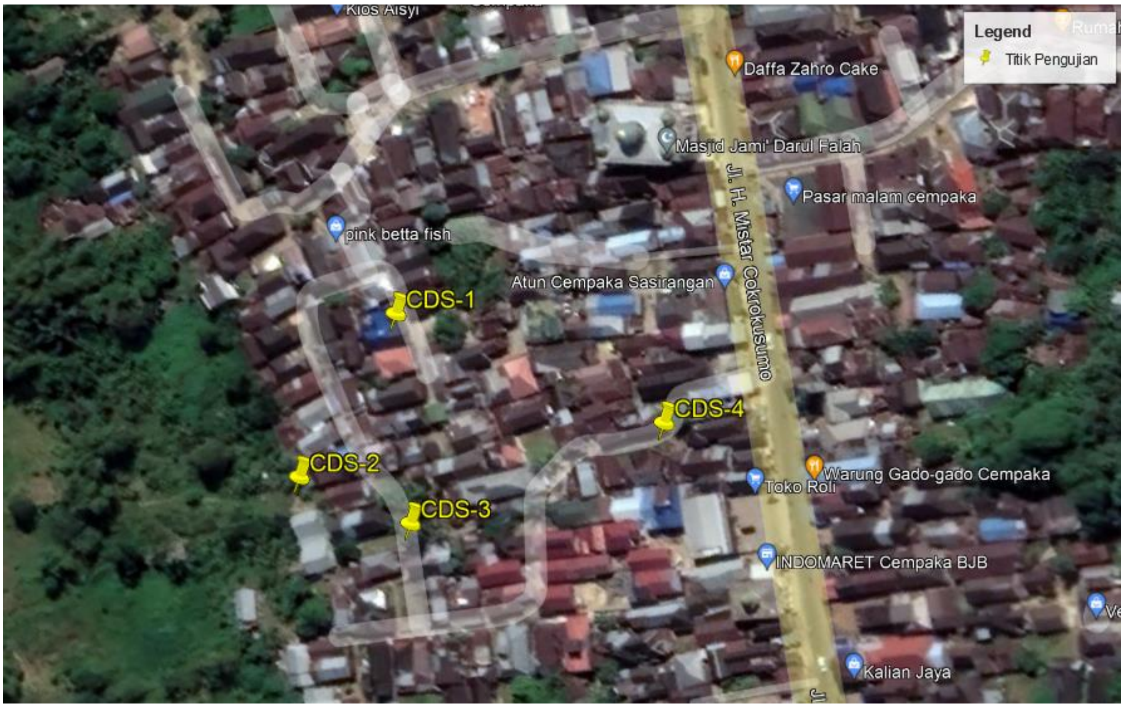
4. RESULT AND DISCUSSION

Research Sites

The location of this research was carried out in the Cempaka Slum Settlement, Cempaka Village, Cempaka District, Banjarbaru City, South Kalimantan Province. The location of this study is one of the areas prone to flooding and inundation when rainfall is high.

Observations were made on the condition of the existing drainage channel. Then, infiltration measurements were carried out at four test points around the drainage system. The following is an infiltration test point and its coordinates.

1. Point 1 (CDS-1) is located around the well and has coordinates 03°29’25.5” S and 114°51’04.4” E.
2. Point 2 (CDS-2) is located around the dead channel and has coordinates 03°29’26.6” S and 114°51’02.9” E.
3. Point 3 (CDS-3) is located around the secondary channel and has coordinates 03°29’27.44” S and 114°51’03.73” E.
4. Point 4 (CDS-4) is located around the well and has coordinates 03°29’27.5” S and 114°51’06.4” E.



Picture 1 Infiltration Test Point in the Cempaka Slum Settlement

Infiltration Capacity

The infiltration capacity is calculated using the Horton method, where the calculation method requires a constant value of k. The constant value can be found by using the value of m on the comparison curve between t (hours) and log (f-fc).

Table 2 Horton Method Infiltration Capacity Calculation Results

TESTING 1										
Number	Point Name	t (h)	f0 (cm/h)	fc (cm/h)	f0-fc (cm/h)	m	e	k	-k.t	f (cm/h)
1	CDS-1	0,250	59,8	36,0	23,8	-4,1676	2,7183	0,5529	-0,1382	56,69
2	CDS-2	0,417	32,4	18,0	14,4	-2,4401	2,7183	0,9443	-0,3935	27,72
3	CDS-3	0,250	26,9	9,6	17,3	-5,1440	2,7183	0,4479	-0,1120	25,05
4	CDS-4	0,167	13,5	10,8	2,7	-4,2262	2,7183	0,5452	-0,0909	13,27
TESTING 2										
Number	Point Name	t (h)	f0 (cm/h)	fc (cm/h)	f0-fc (cm/h)	m	e	k	-k.t	f (cm/h)
1	CDS-1	0,167	52,2	46,8	5,4	-4,2262	2,7183	0,5452	-0,0909	51,73
2	CDS-2	0,500	41,6	28,8	12,8	-4,4251	2,7183	0,5207	-0,2603	38,68
3	CDS-3	0,167	6,7	2,4	4,3	-3,3378	2,7183	0,6903	-0,1151	6,25
4	CDS-4	0,167	11,1	8,4	2,7	-4,2262	2,7183	0,5452	-0,0909	10,87
TESTING 3										
Number	Point Name	t (h)	f0 (cm/h)	fc (cm/h)	f0-fc (cm/h)	m	e	k	-k.t	f (cm/h)
1	CDS-1	0,250	11,5	7,2	4,3	-3,3378	2,7183	0,6903	-0,1726	10,84
2	CDS-2	0,417	19,9	10,8	9,1	-2,2264	2,7183	1,0349	-0,4312	17,24
3	CDS-3	0,167	8,7	6,0	2,7	-4,2262	2,7183	0,5452	-0,0909	8,47
4	CDS-4	0,167	18,3	15,6	2,7	-4,2262	2,7183	0,5452	-0,0909	18,07

From Table 2, the infiltration capacity at the CDS-1 point in the first test was 56.69 cm/hour, the second test was 51.73 cm/hour, and the third test was 10.84 cm/hour. The infiltration capacity value at the CDS-2 point in the first test was 27.72 cm/hour, the second test was 38.68 cm/hour, and the third test was 17.24 cm/hour. The infiltration capacity value at the CDS-3 point in the first test was 25.05 cm/hour, the second test was 6.25 cm/hour, and the third test was 8.47 cm/hour. The infiltration capacity value at the CDS-4 point in the first test was 13.27 cm/hour, the second test was 10.87 cm/hour, and the third test was 18.07 cm/hour.

Infiltration Rate Calculation

The value of the infiltration rate was calculated using the Horton method, and then the value was classified according to Uhland and O'Neal's speed. Table 3 shows the results of the analysis of the infiltration rate of the Horton method and the classification of infiltration rates according to Uhland and O'Neal (1951).

Table 3 Results of Infiltration Rate Analysis of the Horton Method and Classification of Infiltration Rate According to Uhland and O'Neal (1951)

TESTING 1			
Number	Point Name	f (cm/hour)	Classification
1	CDS-1	56,69	Very Fast
2	CDS-2	27,72	Fast
3	CDS-3	25,05	Fast
4	CDS-4	13,27	Fast
TESTING 2			
No.	Point Name	f (cm/jam)	Klasifikasi
1	CDS-1	51,73	Very Fast
2	CDS-2	38,68	Very Fast
3	CDS-3	6,25	Medium
4	CDS-4	10,87	Rather Fast
TESTING 3			
No.	Point Name	f (cm/jam)	Klasifikasi
1	CDS-1	10,84	Rather Fast
2	CDS-2	17,24	Fast
3	CDS-3	8,47	Rather Fast
4	CDS-4	18,07	Fast

Based on Table 3, the first test obtained the infiltration rate classification for point CDS-1 is very fast, point CDS-2 is fast, point CDS-3 is very fast, and point CDS-4 is fast. In the second test, it was found that the infiltration rate classification for point CDS-1 was very fast, point CDS-2 was very fast, point CDS-3 was moderate, and point CDS-4 was rather fast. The third test obtained the infiltration rate classification for point CDS-1 is rather fast, point CDS-2 fast, point CDS-3 rather fast, and point CDS-4 fast.

Average Capacity and Infiltration Rate

The average capacity and infiltration rate are used to determine the amount of soil absorption capacity and the rate at which water penetrates the soil in the Cempaka Slum Housing Complex.

Table 4 Average Capacity and Infiltration Rate

Point Name	Infiltration Capacity Value (cm/hour)			Amount (cm/hour)	Point Average (cm/hour)	Classification
	Testing 1	Testing 2	Testing 3			
CDS-1	56,69	51,73	10,84	119,26	39,753	Very Fast
CDS-2	27,72	38,68	17,24	83,63	27,876	Very Fast
CDS-3	25,05	6,25	8,47	39,77	13,255	Fast
CDS-4	13,27	10,87	18,07	42,20	14,065	Fast
Average Overall Infiltration Capacity				**284,849**	**94,950**	**Very Fast**

From Table 4, the average infiltration capacity at the CDS-1 point is 39.751 cm/hour with a very fast infiltration rate classification; at the CDS-2 point, it is 27.876 cm/hour with a very fast infiltration rate classification; at the CDS-3 point, it is 13.255 cm/hour with a fast infiltration rate classification, and at the CDS-4 point it is 14.064 cm/hour with a fast infiltration rate classification. Then, overall, the average infiltration capacity in the Cempaka Slums is 94,950 cm/hour with a very fast infiltration rate classification. Based on this, the problem of flooding lies in the capacity of the existing drainage channels to accommodate the discharge that occurs and the condition of the channels filled with garbage.

5. CONCLUSION

The conclusions are based on the results of the analysis of the infiltration rate in the Cempaka Slum Settlement; the overall average infiltration capacity in the Cempaka Slum Settlement is 94.950 cm/hour with a very fast infiltration rate classification. Based on this, the problem of flooding lies in the capacity of the existing drainage channels to accommodate the discharge that occurs and the condition of the channels filled with garbage.

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