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Replanning the Drainage System in Residential Area

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Abstract—*Drainage system is a crucial infrastructure in a residential area because it determines the feasibility and comfort of the living environment. However, drainage systems are often inadequate and cause localized flooding. Preliminary surveys conducted by housing complexes in Kediri, Indonesia show that there are still many drainage channels whose capacity does not match the rainwater discharge. As a result, residential areas often flood, causing health impacts for the community. For this reason, this study describes an approach to re-planning the drainage system to support the creation of clean and healthy living areas. Studies in the field show that the problem of inadequate drainage systems is caused by several factors, namely poor initial planning, increased rainfall, increased population, lack of maintenance, and the habit of some people who still throw kitchen waste into waterways. In other words, the water discharge is increasing while the capacity of the drainage channels is actually increasingly limited due to sedimentation. Re-planning is done by making a drainage channel design whose specifications have been calculated with a minimum discharge return period of 10 years. In addition, discharge of wastewater from household activities must be included as a calculation variable.*

Keywords—*Drainage system, planning, residential area, water discharge.*

I. INTRODUCTION

One particular problem that is always relevant in regard of development planning that is less than optimal is flooding. Every year, flooding becomes a discussion that keeps recurring because this problem always arises, especially during the rainy season (Krisnayanti, 2017; Prameswari, 2017). Residential areas with poor drainage systems often become flood points. Floods are generally caused by high water discharge due to high rainfall, while the drainage channels are unable to accommodate the incoming water. As a result, the water stagnates and causes flooding. In addition to increased rainfall, the main factor of the flood phenomenon is an imbalance between population growth and the drainage system. This is because drainage channels not only drain rainwater but also waste water that comes from every house (Persada, 2015). According to Suripin (2004), the quality of the drainage system represents the quality of urban planning.

In Indonesia, flood has become a common phenomenon since it occurs almost every year, thus demanding a continuous solution to the problem because floods cannot be completely resolved. Kediri is one of the districts in East Java, Indonesia which frequently experiences flooding (Lubis et al., 2015). Kediri Regency has an area of 1,386.05 km2 and consists of 26 districts, one of which is Pare District. Pare District was chosen as the research area because it is a residential area that is currently growing rapidly. Data from the Central Bureau of Statistics shows that Pare District has experienced a significant increase in population. Ironically, this was followed by an increase in cases of flooding in residential areas.

In hydrology, the initial step for planning a proper drainage system is to determine the water discharge and the dimensions of the drainage canal (Chow, 1964). The water discharge here does not only come from household wastewater (greywater), but also rainwater. The production of greywater itself is raising over time following the increase in human population. Regarding rainwater, the calculation is done using the Thiesen polygon method. This method is used to calculate the average rainfall in an area, which is based on the weight average element (Triatmodjo, 2008). Each gauge has an area formed by a connecting line between the two gauge posts (Figure 1).

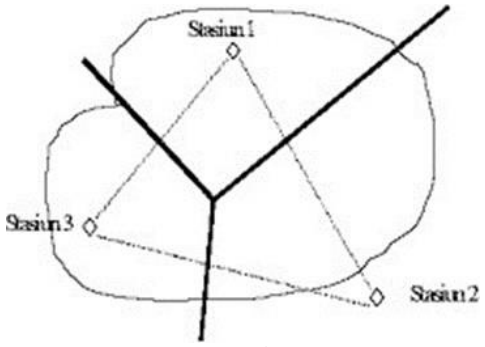

Fig. 1. Basic concept of Thiessen method

The feasibility of drainage systems is often discussed by researchers. Emiliawati (2011) studied the capacity of drainage canals in Yogyakarta. Observations of the drainage canal in the Highway area show that the height of the puddle reaches ± 7 cm in the rainy season with high rain intensity. The dimensions of the existing canals are not sufficient to accommodate the excess water. Hidayah (2016) discusses analyzing the channel capacity of the drainage system in Grobogan Regency. In his research, it was explained that drainage channels require maintenance and re-planning because they experience a decrease in quality. Puddles are still common in urban areas due to drainage channels that cannot hold water. Drainage channel is an important component in infrastructure planning. The function of these drainage channels is to drain surface water into infiltration channels, or to channels leading to natural rivers, and to control waterlogging and flooding due to increased surface runoff, especially those caused by development (Rizqiawati & Astuti, 2019). Runoff discharge that exceeds the maximum capacity of the drainage canal will cause inundation.

Preliminary studies show that the drainage system in residential areas in Kediri Regency is inadequate. Problems often arise during the rainy season, where rainwater stagnates and takes a long time to recede through the drainage channels.

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Floods especially occur at several points with minimal water catchment areas. This problem arises because the capacity of the drainage channel is no longer in accordance with the current water discharge. The increase in water discharge is not only from rainwater, but also from household activities which are increasingly high, in line with the increase in population. In addition, maintenance of the drainage channels is also not optimal, so that the channels experience sludge sedimentation and further reduce the capacity of the drainage channels to drain water. This issue requires planning and rebuilding by considering all relevant variables. For this reason, this study describes an approach to re-planning the drainage system to support the creation of clean and healthy living areas.

II. METHOD

This study applies a survey method. The initial survey was conducted to dig up more detailed problem information and description or characteristics of the research location. The research location is a housing complex in Kediri Regency, East Java. The selection is intended to represent an urbanized area. Follow-up surveys were conducted using interviews and documentation techniques. Supporting data includes location maps, topographical maps, water discharge data, watershed data, population data, climatological data, existing network system data, and water pressure data. The amount of domestic wastewater production also needs to be analyzed, and predicted to increase over the next 10 years, as an illustration of the need for a drainage system to be built. In addition, alternatives for handling drainage problems with an environmental perspective must also be determined as part of the planning.

III. RESULT AND DISCUSSION

Residential area must be equipped with a proper drainage system that suits the provisions and technical requirements stipulated in the regulations or legislation that has been in force, especially regarding the general planning procedures for the drainage network for residential areas in urban areas (Qurniawan, 2010; Syahputra, 2021). One of the provisions that applies is SNI 02-2406-1991 concerning Procedures for general urban drainage planning (Irawan, 2019). The drainage system organize the water installation system and to control water needs and to control groundwater quality. Residential drainage is planned to control erosion which can cause damage to buildings and to control excessive rainwater or stagnation of water in residential houses (Hutomo & Ingalogo, 2020). Urban drainage is a crucial infrastructure in urban areas that functions to drain rainwater and domestic wastewater. Generally, the water is discharged into the nearest river or reservoir. The drainage system is important to prevent flooding and create a comfortable and healthy living environment (Kustamar et al., 2019). Improper planning and development of drainage system can cause flooding problem, as occurred in research area in Kediri regency, as showed in Figure 2.

In planning drainage channels, there are variables that must be considered in order to construct adequate system.

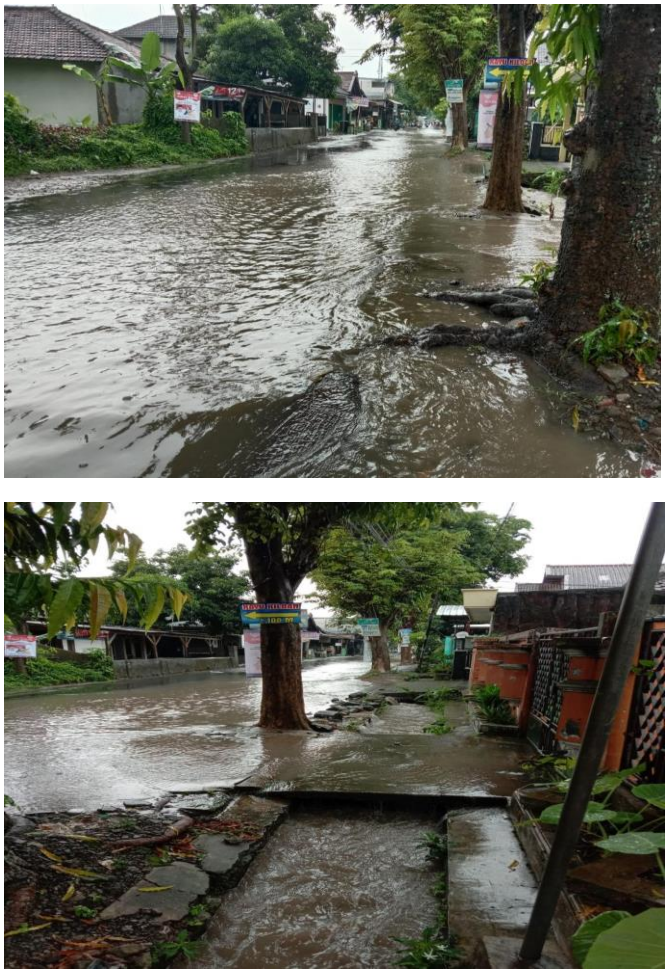

Fig. 2. Flood in local residential area due to improper drainage system

a. Free board height
   Primary channel: 0,20 – 0,30 m (w = 0,8 m - 1 m)
   Secondary channel: 0,10 – 0,20 m (w ≥ 0,5 m)
   Tertiary channel: 0,10 m (w ≥ 0,3 m)
   Water level (h) : ≥ 1,5 m
b. Drainage base width
   Width of drainage base ≥ 0,10 m
   Slope of drainage base (I)
   Primary channel I = 1 ; 1,5 - 1 : 1,2
   Secondary channel I = 1 : 1 - 1 : 1,5
   Tertiary channel I = 1 : 1
c. Slope degree
   For the lining wall slope, it is planned to be 0.33 – 0.25 for lining channels (pairs) and 1.00 – 0.33 for soil channels.
d. Manning Coefficient of Roughness (n)
   The magnitude of the Manning roughness coefficient (n) is taken from the manning roughness coefficient table, according to the condition and the canal wall.
e. Water current (v)
   The flow rate should not be too fast and not too slow, because if it is too fast the channel will be eroded and if it is too slow sedimentation will occur and it will be easy for plants to grow. Used 0.6-1.5m/s.

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Rainfall intensity is the amount of rainfall expressed in rain height or rain volume per unit time, which occurs during a period when rainwater is concentrated (Risnawati, 2018; Usman & Rahman, 2016). The amount of rain intensity varies depending on the duration of rainfall and the frequency of occurrence of rain. If what is available is short-term rainfall data, the rainfall intensity can be calculated using the Talbot, Sherman and Ishiguro formula. However, if short-term/minute rainfall data is not available, then the rainfall intensity can be calculated using the Mononobe formula (Triatmodjo, 2008).

The runoff coefficient is the ratio between the portion of rain that forms runoff and the total rain that occurs (Setiyadi, 2021; Suhardi, 2017). Coefficient values can be seen from the following table:

TABLE I. Values of coefficient C

No	Land Description/Surface Character		Coefficient
1.	Business area	Urban	0,70-0,95
		Rural	0,50-0,70
2.	Residential area	House	0,30-0,50
		Seperated multi units	0,40-0,60
		Combined multi units	0,60-0,75
		Village	0,25-0,40
		Apartment	0,50-0,70
3.	Industrial area	Moderate	0,50-0,80
		High	0,60-0,90
4.	Pavement area	Asphalt and concrete	0,70-0,95
		Bricks and pavement	0,50-0,70
5.	Roof	Roof	0,75-0,95
6.	Yard, sandy land	Flat 2%	0,05-0,10
		Average 2-7%	0,10-0,15
		Steep 7%	0,15-0,20
7.	Heavy earthen yard	Flat 2%	0,13-0,17
		Average 2-7%	0,18-0,22
		Steep 7%	0,25-0,35
8.	Forest	Flat land 0-5%	0,10-0,40
		Wavy land 5-10%	0,25-0,50
		Hilly land10-30%	0,30-0,60
9.	Railway yard		0,10-0,35
10.	Playground park		0,20-0,35
11.	Gardens, cemeteries		0,10-0,25

The drainage system in residential areas in Kediri Regency is inadequate. Problems often arise during the rainy season, where rainwater stagnates and takes a long time to recede through the drainage channels. Floods especially occur at several points with minimal water catchment areas. This problem arises because the capacity of the drainage channel is no longer in accordance with the current water discharge. The increase in water discharge is not only from rainwater, but also from household activities which are increasingly high, in line with the increase in population. In addition, maintenance of the drainage channels is also not optimal, so that the channels experience sludge sedimentation and further reduce the capacity of the drainage channels to drain water (Figure 2). The solution offered is to redesign the existing drainage channels by considering the return flood discharge for at least 10 years. The dimensions of the canal must be adjusted to the existing discharge and the predicted design flood discharge for the next 10 years. In addition, the influence of dirty water discharge and household water discharge is also one of the factors causing a decrease in drainage channel capacity. A flow guide has also been made so that the water flow leads to the canal and does not immediately run to lower areas.

The drainage system in the housing complex in Kediri Regency is included in Artificial Drainage. Drainage is made with specific aims and objectives so that it requires special buildings; concrete drains, culverts, pipes and so on. According to the location of the building, the drainage system in Kediri Regency is Surface Drainage. Drainage channels that are above the ground surface that function to drain surface runoff water. The flow analysis is an open channel flow analysis. According to its function, the planned drainage channel in this study is a multi-purpose drainage, namely a drainage channel that functions to drain several types of waste water either mixed or alternately. Meanwhile, according to the system, drainage is included in a combined system, namely a rainwater runoff disposal system, as well as a household wastewater disposal system. This combined system is advantageous on the one hand because it can drain water from two sources at once, but the disadvantage is that it is more prone to blockages because household waste water often carries sewage or kitchen waste. Another disadvantage is from the construction side. The open channel construction also triggers the community's habit of throwing garbage into the drainage canals. Related to this, it is necessary to socialize and apply sanctions so that people do not throw garbage into the drainage canals. Furthermore, maintenance of the drainage system needs to be carried out periodically to clean up sedimentation in the canals. This sedimentation causes the capacity of the drainage channel to decrease and is unable to accommodate water discharge during the rainy season.

IV. CONCLUSION

The inadequate drainage system in housing complexes in Kediri Regency is caused by several factors, namely poor initial planning, increased rainfall, increased population, lack of maintenance, and the habit of some people who still throw kitchen waste into waterways. In other words, the water discharge is increasing while the capacity of the drainage channels is actually increasingly limited due to sedimentation. Re-planning is done by making a drainage channel design whose specifications have been calculated with a minimum discharge return period of 10 years. In addition, discharge of wastewater from household activities must be included as a calculation variable.

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