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Evaluation Of Road Channel As A Drainage Function For Agricultural Land Remediation

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Abstract: The Ring Road section on the West Ring Road - Madiun City is an alternative road which connecting the outside of Madiun city to the Madiun city. That road is a road with both side of it is a rice field. As a road, it must be clean from puddles when it rains. So that it does not cause traffic problems in the form of traffic disorder. Bad road channels have an impact on flooding due to rain and make the level of road service in the area decrease. On the other hand, the road channel in the area can also be used as a channel for removing pollutants from agricultural land in the rice fields. So that the process of remediation of agricultural land can run smoothly. This highway channel is highly influenced by the local climate, especially the existing of rainfall. Based on that, there is a need for Adequacy Evaluation of the Roadside of the Rice Fields as a drainage function in Agricultural Land Remediation, with a case study on the Ring Road channel in the West Ring Road - Madiun City. From the results of the analysis in this study, it was found that there are two size of Highway Channel Size on the Ring Road in the West Ring Road - Madiun City and both of them are in good conditions. Channel A1 with size b = 0.71 m, H = 0.36 m and h = 0.11 m. Channel A2 with size b = 0.75 m, H = 0.38 m and h = 0.11 m. The results of the design flood rainfall calculation show that there are variations in values that do not much differ in the return period of 2 years to 25 years and can be used as a reference in the management of small irrigation, drainage systems, and small-scale weir buildings, including calculation of road channels on the Ring Road in the Ring Road Section West-Madiun City. From the analysis, it was found that the road channels on the West Ring Road of Madiun City are still good and adequate. From the analysis of the square and trapezoidal dimensions, it is found that the channel discharge is > the planned discharge, so the dimensions of the channel can accommodate the flood discharge that will occur in a period of 25 years, both as a function of road drainage and as drainage in Agricultural Land Remediation in the rice fields along the road. It is suggested that the need for channel maintenance on the road sections on the Ring Road in the West Ring Road - Madiun City and for further studies regarding other road infrastructure and facilities to support road service levels and as a function for agricultural land drainage.

Keywords: Channel; Highway; Agricultural Land

INTRODUCTION

The Ring Road section on the West Ring Road - Madiun City is an alternative road which connecting the outside of Madiun city to the Madiun city. That road is a road with both side of it is a rice field. As a road, it must be clean from floodwaters when it rains. Flood is an event that the land sinks (which is usually dry) due to the increased volume of water. There are two kinds of flood, the first is a flood or a puddle that occurs in areas where flooding usually does not occur. The second is a flood which occur due to the flood water runoff from the river because the flood discharge cannot be flooded by the river flow or the flood discharge is greater than the existing river drainage capacity Suripin [1]. A watershed (DAS) can be defined as an area bounded by a topographical divider that accommodates, stores, and flows rainwater that falls on it into a river which eventually disembogue into a lake or sea Manan [2]. DAS is a water movement unit that is free from other watersheds, that is, two watersheds which differ from one another in terms of water drainage. Thus, a watershed can be seen clearly as a unit of hydrological ecosystem, geography or other physical elements with the main elements are soil, water, flora and fauna resources.

The insufficient road channel that functions as a drainage channel will cause flood water inundation due to rain and make the level of road service in the area decrease. According to Suripin [1], drainage means draining, depleting, removing, or diverting water. Drainage is defined as a series of water construction which tha function is to reduce and / or remove excess water from an area or land, so that the land can be used optimally. Sukarto [3] stated that drainage is a science for draining soil. Drainage comes from the word “drain” which is a term used to describe systems related to handling excess water problems, both above and below land settlements.

On the other hand, the area is mostly rice fields and several industries, which are often used to remediate polluted agricultural land. Soil and plant contamination is currently getting the attention of many parties. This is related to land productivity and plant health. The causes are quite diverse, one of which is the use of agrochemicals that exceeds the limit. If this condition is not resolved, it will adversely affect human health and future generations. Horticultural production centers are areas that have a large influence due to the high intensity of fertilizers and pesticides. Soil contaminated with heavy metals has an effect on the environment and human health due to biomagnification. Biomagnification is an increase in the concentration of metals as an element, ranging from low to high concentrations Roy and McDonald [4]. Heavy metal ions can have a direct effect on human health because they accumulate in the food chain. Like other sources of environmental pollution, heavy metals can be transferred to areas that are very far away in the environment, then they have the potential to disrupt the life of environmental biota and ultimately affect human health even though for a long time and far from the main pollution source Suhendrayatna [5]. Apart from agricultural land, pollution is also caused by industrial waste. According to Kurnia [6] agricultural environmental pollution that occurs in several places is caused by industry. The continuous use of wastewater will result in the accumulation of heavy metals in the rice fields, which is thought to result in heavy metal contaminated grain. Accordingly, Subowo et al. [7] stated that heavy metals in agricultural soils can reduce soil productivity and the quality of agricultural products.

There are two type of remediation, namely Ex-Situ and In-Situ. Ex-situ remediation, also known as off site remediation, is an activity to clear land that is not carried out directly on site but in other places considered safer. In-situ remediation, also known as on site remediation, is an activity to clean the surface of the soil which is carried out directly on the spot. This cleaning method takes place by means of cleaning, then injection or venting and then bioremediation. In-Situ Remediation is considered cheaper and easier than Ex-Situ Remediation, and in the in-situ remediation process, drainage channels are needed. The road channel in the area can also be used as a drainage channel which functions as a disposal of pollutant material from agricultural land in the rice fields. So that the process of remediation of agricultural land can run smoothly. Drainage in rice fields can affect the condition of agricultural land such as soil aeration, soil moisture, transportation and the effectiveness of nutrients and pesticides, soil temperature, toxic substances and pests, soil erosion and flooding, plant fertility and crop yields. Aeration conditions in the soil have a major influence on nitrogen availability Van Schilfgaarde [8]. Good soil aeration is the result of a good drainage system.

From the above problems, the function of the Ring road channel in the West Ring Road-Madiun City has a dual function, there are for the drainage of the road itself and also for the remission of agricultural land in existing rice fields. That highway channel is highly influenced by the local climate, especially rainfall and the pattern of river basins (DAS) in the area. Based on this, it is necessary to evaluate the Adequacy of Road Channels as a Drainage Function for Remediation of Agricultural Land, with a case study on the Ring Road channel in the West Ring Road - Madiun City.

METHOD

1. Research Operational Framework

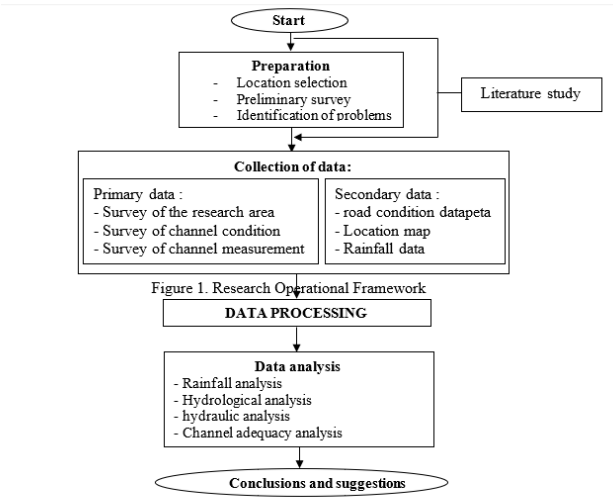

Figure 1. Research Operational Framework

2. Collection of Data

This study uses two types of data, namely primary data and secondary data. The type of primary data in this study was obtained from direct measurement and observation, with the intention of obtaining the existing state of the existing drainage channels. Primary data obtained include the condition of the existing channel along the Ring Road in the West Ring Road - Madiun City in the form of channel shape, channel width, channel depth, and slope of the channel walls. Secondary data used in this study are as follows:

A. Rainfall Data

The rainfall data used is rainfall data for the last 10 years, namely 2009 to 2019. Rainfall data is obtained from the Rain Station.

B. Map of Land Use

The map of land use are needed to determine the value of the flow coefficient at the research location. Land use is obtained from the appearance seen on Google Earth.

C. Map of the study area

The map of the study area is used to determine the condition of the research location. Map obtained from Google Earth.

D. Hydrological Analysis

The hydrological analysis steps are as follows:

a) **Calculating the maximum of area average rainfall**

The method used to calculate the average maximum regional rainfall is the algebraic method or if the rainfall station points are evenly distributed, the algebra method is used, but if the rainfall station points are not evenly distributed, the Thiessen Polygon method is used Sosrodarsono [9].

b) **Testing data outliers**

The rainfall data outlier test is used to determine whether the maximum and minimum data from the existing data series is suitable for use or not Irawan [10]

c) **Test consistency**

From the obtained rainfall data, the consistency is first tested to determine whether the data has deviations or not Indardi [11]. If there is deviation, the rainfall data needs to be multiplied by the correction rate before calculating the maximum rainfall. The consistency test used in this study was the rainfall consistency test using the RAPS (Rescale Adjusted Partial Sums) method.

d) **Analyzing the frequency of rainfall**

Analyze the frequency of rainfall with the Log Pearson III distribution method. Following are the steps for using the Log Pearson III distribution Soemarto, [12].

e) **Distribution test**

There are two kinds of distribution tests, namely the Chi-Square test and the Smirnov-Kolmogorov test. The Chi - Square test compares X2 to critical X2, if X2 <X2 is critical, then the data distribution we are doing is appropriate, otherwise another data distribution must be used. The Smirnov – Kolmogorov test compares max to Δcritical, if Δmax is smaller than Δcritical then the data distribution we do is appropriate, otherwise another data distribution must be used Suripin [1].

f) **Calculating the discharge design**

The method used to calculate the discharge design is the rational method which expressed in the following form Suripin [1].

Q = C. I. A

Where:

Q = Rainwater discharge (m^3/s)

C = Flow Coefficient

I = Rainfall intensity (m/s) A = Area of drainage area (m^2)

The value of the flow coefficient (C) is determined. Flow coefficient of each land use by calculating the weight of each part according to the area represented. Rain intensity value (I) is influenced by the length of rainfall. To be able to determine the intensity of rain, the Mononobe formula is used. The Mononobe formula is as follows Soemarto [2]:

I = R24 / t

Where:

I = rain intensity (mm / hour)

t = time or duration of rain (hours)
R24 = maximum rainfall in a day (mm)

The determination of the service area (A) is carried out by looking at the appearance of the earth's surface or topography as well as the existing drainage channels.

3. **Review of Dimensional Design**
   The dimensional design review is carried out by calculating and designing how many dimensions are suitable for drainage channels on the Ring Road in the West Ring Road - Madiun City so that it is able to accommodate the design rain for the next 10 years to 25 years. The dimensions of the channel are width, depth, slope of the channel if the channel is trapezoidal in shape and height of the line. Drainage dimension planning is adjusted to the amount of rain design 25 years, slope or slope of the channel, wet circumference of the channel, hydraulic channel radius, channel surface area and channel flow velocity.
4. **Evaluation of Drainage Drain Dimensions**
   To evaluate the dimensions of the drainage channel, it is necessary to know the capacity of the existing drainage channel. The formula used to determine the discharge capacity of the channel is Chow [13]:
   Q = V x A
   Where
   Q = Channel capacity (m^3/s)
   A = cross-sectional area (m^2)

After knowing the capacity of the existing drainage channel, it is compared with the capacity of the design channel. If the design capacity is greater than the existing channel capacity, it is necessary to change the dimensions of the channel, but if the discharge capacity of the existing channel is still greater than the design capacity, the channel does not need to be repaired or changed the dimensions of the channel because it is still able to accommodate the surface flow discharge..

RESULT AND DISCUSSION

Existing condition of the existing Salauran Highway

In general, the drainage system can be defined as a series of water structures that function to reduce or remove excess water from an area or land, so that the land can be used optimally. The drainage system building sequentially starting from the upstream consists of an interceptor drain, a collector drain, a conveyor drain, a main drain, and a receiving water body. Along the system, other structures are often found, such as culverts, bridges, gutters and sloping channels Suripin [1]. The construction of the existing drainage channel is an open drainage type. The existing drainage channel is an open channel, either in the form of a channel from river stone masonry. From the survey results, measurements and conditions of the Highway Channel on the Ring Road in the West Ring Road - Madiun City are listed in Table 1 and Figure 2.

Table 1. Size and condition of the existing channel

No	Channel	b	H	h	Condition
		m	m	m	
1	channel A1	0.71	0.36	0.11	good
2	channel A2	0.75	0.38	0.11	good

From the table above, you can find out the size of the drain:

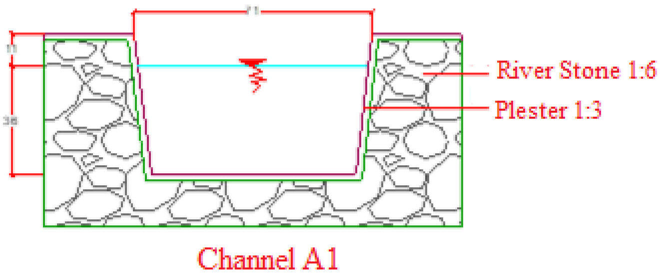

Figure 2. Drainase channel and other drawings are attached

Hydrological Analysis

Hydrology is a science related to water on earth, both regarding its circulation and distribution, its nature and its relationship to its environment, especially with living things. The many parameters make hydrological analysis difficult to complete analytically. Besides, hydrological conditions depend on changes / activities carried out by humans such as changes in land use Triatmodjo [14].

Rainfall analysis

According to Suripin [1], rain intensity is the height or depth of rain water per unit time. The general characteristic of rain is that the shorter the rain lasts, the higher the intensity tends to be and the greater the return period the higher the intensity. From the rainfall data obtained from the Madiun City irrigation service, the calculation of drainage channels is as follows:

Table 2. Calculation results of maximum daily rainfall

No	Year	Daily Rainfall
		Annual Maximum
1	2010	265.00
2	2011	84.00
3	2012	108.00
4	2013	160.00
5	2014	122.00

Then proceed with the calculation of the analysis of the frequency of rain using the Log Person Type III distribution, and continued with the calculation of the intensity of rain which is presented in Tables 2, 3,, 5 below.

Table 2. Calculation results of average rainfall intensity
Return Period = 2 year
Rain design = 134.5195 mm

No	Channel	tc (hour)	I (mm/hour)
1	Channel A1	1.83273	31.140
2	Channel A2	1.83273	31.140

Source: Calculation result

Table 3. Calculation results of average rain intensity
Return Period = 5 year
Rain design = 196.1676 mm

No	Channel	tc (hour)	I (mm/hour)
1	Channel A1	1.83273	45.411
2	Channel A2	1.83273	45.411

Source: Calculation result

Table 4. Calculation results of average rain intensity
Return Period = 10 year
Rain design = 240.7481 mm

No	Channel	tc (hour)	I (mm/hour)
1	Channel A1	1.83273	55.731
2	Channel A2	1.83273	55.731

Source: Calculation result

Tabel 5. Calculation results of average rain intensity
Return Period = 25 year
Rain design = 301.0282 mm

No	Channel	tc (hour)	I (mm/hour)
1	Channel A1	1.83273	69.685
2	Channel A2	1.83273	69.685

Source: Calculation result

Flood discharge plan

The method used to calculate the planned flood discharge is a rational method. The calculated discharge plan using the rational method is as follows:
Q (m^3/sec) = 0.278.C.I.A

Channel discharge calculation

Based on hydraulic analysis to calculate channel discharge, the following formula is used:
Square-shaped cross section
Wet cross-sectional area: A = b x h
Wet circumference (P): P = b + 2h
Hydraulic radius:

$$R = \frac{A}{P} = \frac{Bh}{B+2h}$$

Discharge of channel:

$$Q = \frac{1}{n} A. R^{2/3}. S^{1/2}$$

To determine the flood discharge plan, reviewed with the return period of 2, 5, 10, and 25 years, the Rational formula is used and the results can be seen in tables 6, 7, 8, 9.

Table 6. Results of calculated flood discharge plans
Return Period = 2 Year

No	Channel	Coef (C)	I (mm/hour)	Channel area (A) km²	Q flood Plans (m^3/s)
1	Channel A1	0.60	31.14	0.0748	0.3882405
2	Channel A2	0.60	31.14	0.0777	0.4032926

Source: Calculation result

Table 7. Results of calculated flood discharge plans
Return Period = 5 Year

No	Channel	Coef (C)	I (mm/hour)	Channel area (A) km²	Q flood Plans (m^3/s)
1	Channel A1	0.60	45.41	0.0748	0.5661652
2	Channel A2	0.60	45.41	0.0777	0.5881154

Source: Calculation result

Table 8. Results of calculated flood discharge plans
Return Period = 10 Year

No	Channel	Coef (C)	I (mm/hour)	Channel area (A) km²	Q flood Plans (m^3/s)
1	Channel A1	0.60	55.73	0.0748	0.6948300
2	Channel A2	0.60	55.73	0.0777	0.7217686

Source: Calculation result

Table 9. Results of calculated flood discharge plans
Return Period = 25 Year

No	Channel	Coef (C)	I (mm/hour)	Channel area (A) km²	Q flood Plans (m^3/s)
1	Channel A1	0.60	69.68	0.0748	0.8688064
2	Channel A2	0.60	69.68	0.0777	0.9024900

Source: Calculation result

Hydraulics Analysis of Channels

Hydraulic calculations are used to analyze cross-sectional dimensions based on the maximum capacity of the line.

Determining the dimensions of the existing or planned channels, based on the maximum debit to be flowed Suripin [1]. The channel capacity formula used is $Q_{channel} = A.\ V$

Liquids can be transported from one place to another by natural or man-made carrier structures. This carrier building can be open or closed at the top. The channel that is closed at the top is called a closed channel, while the one that is open at the top is called an open channel. Rivers, irrigation channels, ditches are open channels, while pipes and culverts are closed channels Suripin [1]. In network and dimensions of the drainage channel planning, first we must know the maximum discharge design with a certain return period and the researcher plans the maximum discharge is 25 years, from this discharge we can plan the channel dimensions. The results of channel hydraulics calculation can be seen in Table 10.

Table 10. The calculation result of the planning dimensions of a square shape

No	Channel	b	H	h	A	P	R	n	I	V	Fr	Q channel	Q plans
		m	m	m	m²	m				m/s²		m³/s	m³/s
1	Channel A1	0.71	0.36	0.11	0.25	1.42	0.18	0.025	0.07480	3.45523	1.85152	0.87089	0.86881
2	Channel A2	0.75	0.38	0.11	0.28	1.50	0.19	0.025	0.07770	3.65262	1.90438	1.02730	0.90249

From the analysis, it was found that the road channels on the West Ring Road of Madiun City are still good and adequate and in accordance with the road planning. One of the most important aspects of road planning is protecting roads from surface and groundwater. In other words, drainage is one of the most important factors in road works planning. Stagnant water on the road surface slows down vehicles and contributes to accidents due to the disruption of the scenery by splashes and sprays of water. When water enters the road structure, the pavement and subgrade become weak, making the road construction more sensitive to traffic damage. Water adversely affects road shoulders, slopes, channels and other parts of the road Suripin [1].

From the analysis of the square and trapezoidal dimensions, it is found that the channel discharge is > than the planned discharge, so the dimensions of the channel can accommodate the flood discharge that will occur in a period of 25 years. Both as a function of road drainage and as drainage in Agricultural Land Remediation in the rice fields along the road

CONCLUSION

From the results of the study analysis, the following conclusions were obtained:

1. There are two sizes of the Highway Channel on the Ring Road in the West Ring Road - Madiun City and both of them are in the good condition. Channel A1 with size b = 0.71 m, H = 0.36 m and h = 0.11 m. Channel A2 with size b = 0.75 m, H = 0.38 m and h = 0.11 m.
2. From the results of the calculation of the design flood rainfall, there are variations in values that do not differ greatly in the return period of 2 years to 25 years and can be used as a reference in the management of small irrigation, drainage systems and small-scale weir buildings, including the calculation of road channels on the Ring Road in Section West Ring Road - Madiun City.
3. From the analysis, it is found that the road channels on the West Ring Road of Madiun City are still good and adequate. From the analysis above the square and trapezoidal dimensions, it is found that the channel discharge is > than the planned discharge, so the dimensions of the channel can accommodate the flood discharge that will occur in a period of 25 years. Both as a function of road drainage and as drainage in Agricultural Land Remediation in the rice fields along the road.

From the results of the analysis, it is suggested as follows:

1. The need for channel maintenance on roads on the Ring Road in the West Ring Road - Madiun City.
2. It is recommended for further studies regarding other road infrastructure and facilities to support the level of road services and as a function of agricultural land drainage.

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