UNDERGRADUATE THESIS

THE USE OF DROP-STRUCTURE TO INCREASE THE DISSOLVED OXYGEN LEVEL ALONG THE CIBARANI CHANNEL USING 1D HEC-RAS MODEL

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PERNYATAAN

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The Use of Drop-Structure to Increase the Dissolved Oxygen Level along The Cibarani Channel using 1D HEC-RAS Model

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Dinyatakan: di Tangerang

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STUDI PENGGUNAAN TERJUNAN UNTUK MENINGKATAN KADAR OKSIGEN TERLARUT PADA SALURAN CIBARANI MENGGUNAKAN MODEL HEC-RAS 1 DIMENSI

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ABSTRAK

Saluran irigasi Cibarani digunakan oleh masyarakat di sekitar DAS Cikapundung sebagai sistem drainase dan sebagai sumber air di tempat pemacingan. Berdasarkan hasil pengujian sampel yang telah dilakukan, kualitas air di saluran irigasi Cibarani tidak memenuhi kriteria baku mutu air kelas II dikarenakan adanya buangan limbah domestik yang masuk ke dalam saluran irigasi. Sejumlah studi terdahulu telah dilakukan guna mengidentifikasi pengendalian pencemaran yang terjadi baik dari pengaturan volume dan kualitas air limbah, pengaturan debit aliran masuk, dan penggunaan *baffle*. Saluran irigasi Cibarani memiliki sebuah terjunan yang dapat meningkatkan kualitas air saluran irigasi Cibarani, namun studi-studi terdahulu tidak ada yang memodelkan terjunan secara rinci. Studi ini ditujukan untuk mengkaji secara lebih rinci pengaruh terjunan yang terdapat pada saluran irigasi Cibarani dan pemanfaatannya untuk meningkatkan kualitas air khususnya parameter oksigen terlarut atau *dissolved oxygen* (DO). Untuk memodelkan hidraulik aliran dan kualitas air sepanjang Saluran Cibarani, studi ini menggunakan model HEC-RAS satu dimensi. Terjunan dimodelkan dengan menggunakan 3 alternatif, yaitu ambang tajam, dinding tegak, dan saluran curam dimana terjunan dengan konfigurasi ambang tajam memberikan hasil yang lebih logis dengan nilai koefisien reaerasi sebesar 37,5/hari dan nilai RMSE sebesar 0,48. Penempatan konfigurasi serupa di sisi hulu Saluran Cibarani diketahui mampu meningkatkan konsentrasi DO dengan nilai rata-rata 3,47 mg/L. Guna memenuhi baku mutu yang disyaratkan yaitu nilai DO sebesar 4,0 mg/L, studi ini kemudian memodelkan pengaturan pintu air dengan debit sebesar 0,07 m^3/s. Kombinasi peningkatan debit aliran masuk dan penempatan terjunan berhasil memberikan peningkatan konsentrasi DO pada Saluran Cibarani sebesar 3,9 – 6,0 mg/L. Peningkatan konsentrasi DO ini juga diketahui tidak banyak mengalami perubahan apabila debit air ditingkatkan.

Kata Kunci: Dissolved Oxygen, HEC-RAS, Pemodelan Kualitas Air, Koefisien Reaerasi, Terjunan

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ABSTRACT

Cibarani irrigation channel is used by the community in the Cikapundung river basin as a drainage system and as water source in the fishing site. Based on the test result that has been done, water quality in Cibarani irrigation channel did not meet the class II of raw water standard due to various discharges of domestic waste. Some studies had been carried out to identify the pollution control by limiting the wastewater discharge and quality, controlling the intake discharge, and using baffles. The Cibarani irrigation channel has a drop-structure which can improve the water quality. However, pervious studies had not modelled the effect of drop-structures in details. Therefore, this study is intended to examine in more detail the effect of the drop-structure along Cibarani irrigation channel and its advantage to improve water quality condition, especially Dissolved Oxygen (DO) parameter. This study uses one-dimensional HEC-RAS software to model the hydrodynamic and water quality conditions along Cibarani irrigation channel. The drop-structure was modelled using three alternatives where drop-structure with narrow-crested weir gives the most reasonable result of reaeration rate at 37.5 day^{-1} and RMSE value of 0.48. The placement of a similar configuration on the upstream part of Cibarani irrigation channel was known to be able to increase DO concentrations with an average value of 3.47 mg/L. In order to meet the required water quality standard with DO value of 4.0 mg/L, this study modelled the arrangement of a sluice gate at the intake with a discharge of 0.07 m^3/s. The combination of an increased flow and a placement of the drop-structure succeeded in increasing the DO concentration along the Cibarani irrigation channel by 3.9 - 6.0 mg/L. It is also known that DO concentrations less significantly changed when the water flows are getting higher.
Keywords: Dissolved Oxygen, HEC-RAS, Water Quality Modelling, Reaeration Rate, Drop-Structure

PREFACE

Praise to God Almighty for His greatness and His kindness that the author is able to finish his undergraduate thesis entitled “Evaluation of Drop-Structure to Increase the Dissolved Oxygen Level along Cibarani Channel using 1D HEC-RAS Model”. During the completion of this thesis, a lot of support and guidance have been given to the author. Therefore, the author wants to convey gratitude and thanks to:

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9. Other parties who cannot be mentioned one by one.

The author aware that this thesis may possibly contain many limitations. Hence, author would appreciately accept any suggestion that may enhance the development of this thesis. In the end, author hope that this thesis may give benefits for future studies.

Bandung, 5th February 2021

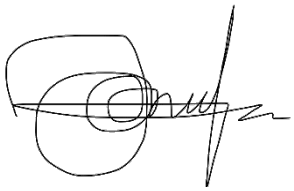

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TABLE OF CONTENTS

LIST OF NOTATION AND ABBREVIATIONS

A	:	Cross-sectional Area (m^2)
B	:	Channel Width (m)
C	:	Mass Concentration (mg/L)
C_s	:	Saturated Dissolved Oxygen (mg/L)
D	:	Dissolved Oxygen Deficit Concentration (mg/L)
E_x	:	Longitudinal Dispersion Coefficient (m^2/s)
H	:	Averaged Channel Depth (m)
L	:	Ultimate BOD Concentration (mg/L)
N	:	Number of Observational Data
Q	:	Flow Rate (m^3/s)
R	:	Hydraulic Radius (m)
S	:	Slope of The Energy Gradient (m/m)
$\bar{S}_f$	:	Average Friction Slope between Two Cross-section (m/m)
T	:	Temperature (°C)
U_*	:	Shear Velocity (m/s)
V	:	Volume (m^3)
Y_1, Y_2,	:	Depth of Water at Cross-section (m)
Z_1, Z_2	:	Elevation of The Main Channel Inverts (m)
dx	:	Differential Variable of Length
dt	:	Differential Variable of Time
g	:	Gravitational Acceleration (m/s^2)
h_e	:	Energy Head Loss (m)
k	:	Rate Constant
k_{20}	:	Rate Constant at temperature 20°C
k_a	:	First Order Deoxygenation Rate Constant (day^{-1})
$k_{a\,(20)}$	:	Reaeration Rate at Temperatur 20°C
k_d	:	First Order Deoxygenation Rate Constant (day^{-1})
k_T	:	Rate Constant at Temperature T

n	:	Manning Coefficient (s/m$^{1/3}$)
t	:	Time (s)
$\bar{u}$	:	Averaged Velocity (m/s)
x_i	:	Observational Value
$\hat{x}_i$	:	Modelled Value
α_1, α_2	:	Velocity Weighting Coefficients
∂x	:	Partial Derivative of Length
∂t	:	Partial Derivative of Time
θ	:	Temperature Correction Coefficient
BOD	:	Biochemical Oxygen Demand (mg/L)
DO	:	Dissolved Oxygen (mg/L)
TN	:	Total Nitrogen (mg/L)
TP	:	Total Phosphorus (mg/L)
RMSE	:	Root Mean Square Error

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIXES

CHAPTER 1
INTRODUCTION

1.1 Research Background

Cikapundung river is one of the rivers in Bandung that is located strategically in the middle of Bandung City. The community and the government have used the Cikapundung river for many purposes, such as a recreational spot in its riverbank called Teras Cikapundung, and clean water resources for Municipal Drinking Water Enterprise in Bandung (PDAM). Bandung city developments have created a few changes in the Cikapundung river basin (Bachrein, 2012). One of the developments in the Cikapundung river basin is population growth, which causes environmental problems such as water pollution (Rahayu et al., 2018). This problem has made the water in the Cikapundung river turbid and smelly. Other than that, the constriction of riverbanks and piling of trash also happens in the Cikapundung river (Bachrein, 2012).

Cibarani irrigation channel is one of the Cikapundung river basin channels that flow its water for irrigational purposes. However, this channel has changed its function as a drainage channel for the community wastes such as oil, detergent, and human waste. This change implies that water quality decreases in the Cibarani irrigation channel. The water produces a foul odor and becomes turbid, which may cause inconvenience to the community around it.

Based on the previous study, it is found that the Cibarani irrigation channel water quality does not meet the class II of water quality criteria, with Dissolved Oxygen (DO) concentration ranging from 2.6 to 3.8 mg/l and the minimum concentration of Biochemical Oxygen Demand (BOD) at 7.8 mg/l. One of the solutions that can be done to increase the water quality in the Cibarani irrigation channel is by raising the discharge (Trisnojoyo, 2017). Another study has discovered that baffles can be used in some channel segments to increase water quality. However, this study cannot model the phenomenon optimally, as one-dimensional

HEC-RAS is used in this study (Hayrera, 2019). Cibarani irrigation has several water structures like culvert, gutter, weirs, and drop-structure. The flow change from super-critical flow to sub-critical flow in the downstream part of the drop-structure has made a hydraulic jump. This phenomenon may increase air entrainment that could affect the water quality (Arief, 2014). Some study cases have proved that water quality will be increased with a drop-structure, increasing the DO parameter with the aeration process (Damarany et al., 2006; Triane and Suharyanto, 2015).

From both study cases that have been done in the Cibarani channel, none of them has modelled the drop-structure specifically. Therefore, this study is aimed to know about the effect of a drop-structure and its configuration to increase the dissolved oxygen along the Cibarani irrigation channel using one-dimensional hydraulic programming, namely HEC-RAS.

1.2 Research Objectives

The objectives of this study are given as follows:

1. To evaluate the effect of a drop-structure on water quality parameters along the Cibarani irrigation channel based on water sampling.
2. To model and simulate the drop-structure configuration used to improve dissolved oxygen along the Cibarani irrigation channel.

1.3 Scope of Study

Some restrictions in this study are:

1. The location of this study is the Cibarani irrigation channel from its upstream part (Cimulus Weir) to the downstream part with the approximate length of 1.3 km. This location can be seen in Figure 1.1.
2. HEC-RAS ver. 4.1.0 will be used to model the hydraulic and water quality analysis.
3. Water quality parameters that will be modelled in this study is mainly focused on Dissolved Oxygen (DO), but other parameters like, Biochemical Oxygen

Demand (BOD), Total Nitrogen (TN), and Total Phosphorus (TP) will be tested in this study.

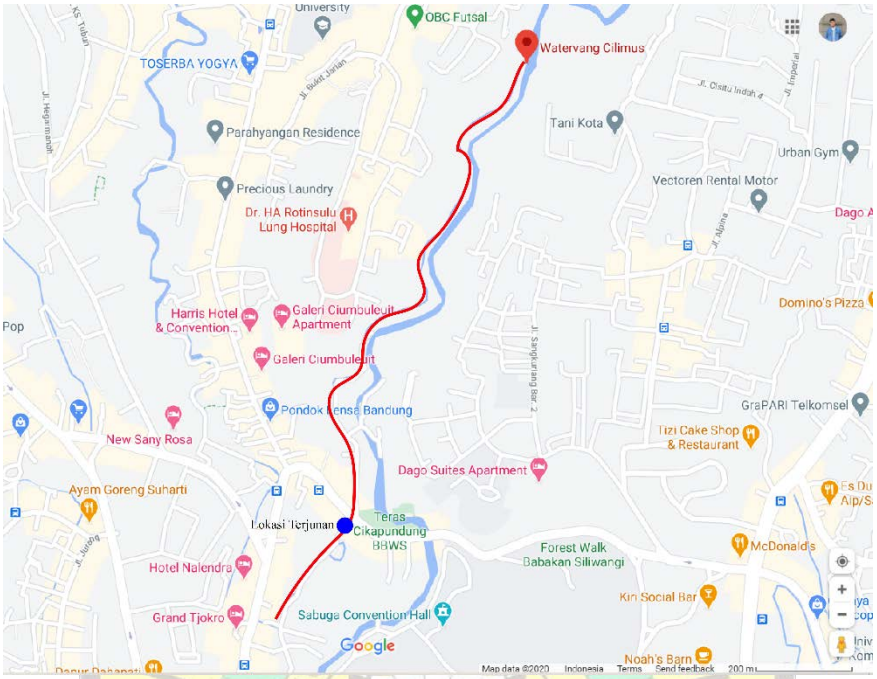

Figure 1.1 Research Location

1.4 Research Methodology

This study is started by identifying and formulating the problems in the scope of the study. Then, water quality modelling using HEC-RAS, previous studies about the Cibarani irrigation channel, and environmental engineering studies will be used as the literature studies to guide the scope of study and improve the researchers' knowledge. Other than that, hydraulic and water quality data along Cibarani irrigation channel will be obtained by conducting a site visit and laboratory test. After that, calibration and verification of hydraulic properties along Cibarani irrigation channel will be tested to ensure that the model can represent the channel's actual hydraulic condition. The same procedure will be applied to the water quality data to generate some water quality calculation coefficients as it will represent the actual condition of water quality parameters. The following research is to simulate some drop-structure configurations to the increase of water quality parameters along the Cibarani

irrigation channel. The flow chart of this methodology research is presented in Figure 1.2.

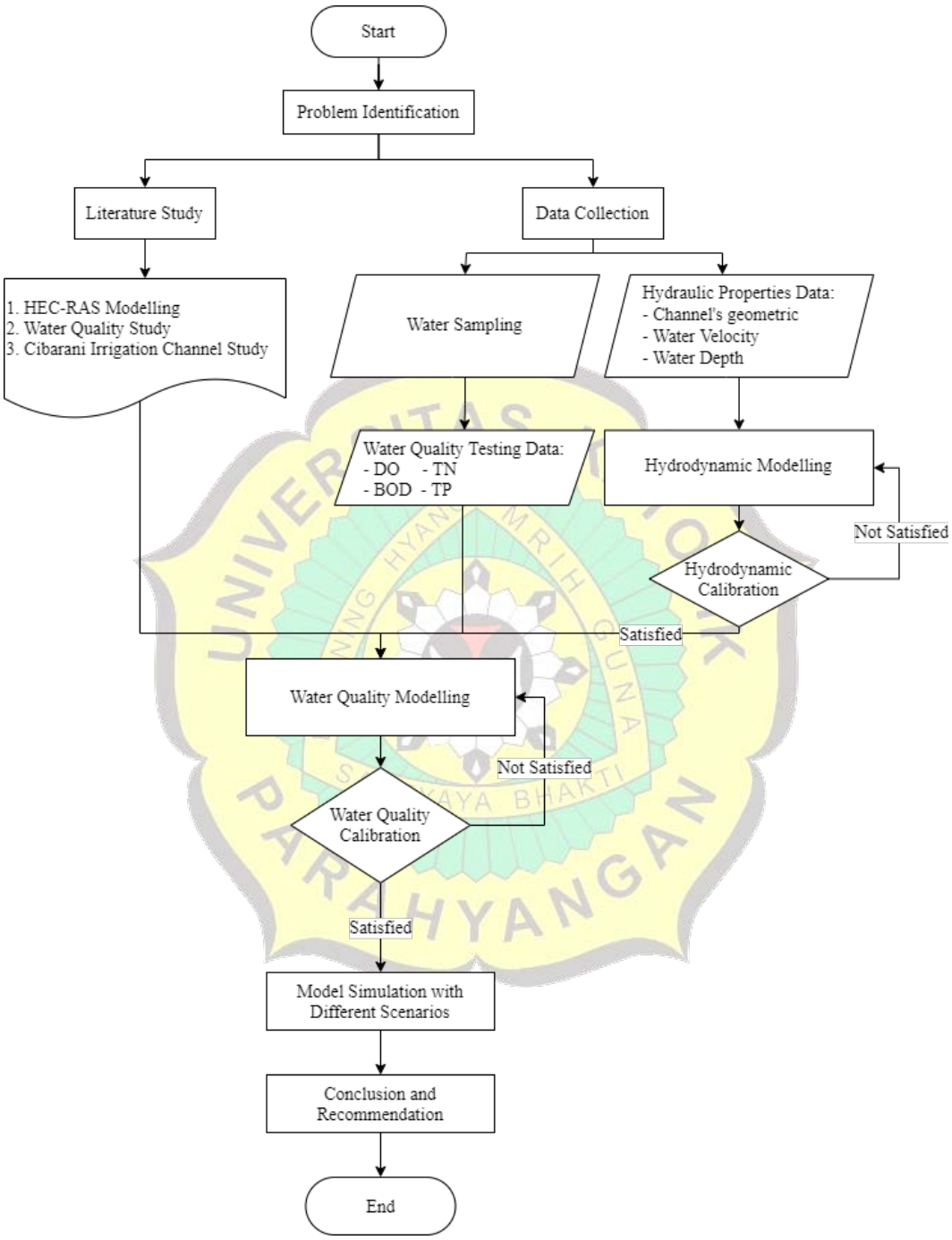

Figure 1.2 Research Flow Chart