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OPTIMIZATION OF GAS TRANSFER COEFFICIENT BASED TIME VARIATION WITH TECHNOLOGY ULTRAFINE BUBBLE IN RUNOFF WATER GREEN ROOF

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**DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
FACULTY OF AGRICULTURAL ENGINEERING & TECHNOLOGY
IPB UNIVERSITY
BOGOR
2025**

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ABSTRACT

MUHAMMAD RAIHAN RAMADHANI PUTRA. Optimization of Gas Transfer Coefficient Based on Time Variation with Technology Ultrafine Bubble in Runoff Water Green Roof. Supervised by YUDI CHADIRIN and ALLEN KURNIAWAN.

The green roof system is a building roofing system utilized as an open green space to increase capacity of runoff water, which can be reused for non-potable water. The challenge in this system is the management of water quality, such as dissolved oxygen, through aeration using ultrafine bubble technology. This research aims to optimize the oxygen transfer process in green roof runoff water systems using ultrafine bubble technology through several treatments to increase dissolved oxygen levels. The methodology employed includes the development of a mathematical model to predict the oxygen transfer rate (OTR) under varying time durations and different injection treatments. The research results indicate that aeration with a 45 min duration using pure oxygen injection yields more stable and efficient results compared to 30 min and 60 min durations with ambient oxygen injection and pure oxygen + NPK, which caused a decrease in efficiency. The developed mathematical model predicts the oxygen transfer rate, especially under lower aeration conditions, and optimizes the time duration to enhance the overall system efficiency.

Keywords: aeration, dissolved oxygen, green roof, oxygen transfer rate, DO.

ABSTRAK

MUHAMMAD RAIHAN RAMADHANI PUTRA. *Optimisasi Koefisien Transfer Gas Berdasarkan Variasi Waktu dengan Teknologi Ultrafine Bubble pada Air Limpasan Green Roof*. Dibimbing oleh YUDI CHADIRIN dan ALLEN KURNIAWAN.

Sistem green roof merupakan sistem atap bangunan yang dimanfaatkan sebagai ruang terbuka hijau untuk meningkatkan kapasitas penampungan air limpasan yang dapat dimanfaatkan kembali untuk air kebutuhan salinitas. Tantangan utama dalam sistem ini adalah pengaturan kualitas air seperti oksigen terlarut dengan aerasi teknologi ultrafine bubble. Penelitian ini bertujuan untuk mengoptimalkan proses transfer oksigen pada air limpasan green roof menggunakan teknologi ultrafine bubble dengan beberapa perlakuan untuk meningkatkan kadar oksigen yang terlarut. Metodologi yang digunakan meliputi pengembangan model matematis untuk memprediksi laju transfer oksigen (OTR) pada variasi durasi waktu serta perlakuan injeksi berbeda. Hasil penelitian menunjukkan aerasi durasi waktu 45 menit dengan injeksi oksigen murni memberikan hasil yang lebih stabil dan efisien dibandingkan aerasi durasi 30 menit dan 60 menit dengan perlakuan injeksi oxygen ambient dan pure oxygen + NPK yang tidak optimal. Model matematis yang dikembangkan memprediksi laju transfer oksigen, terutama pada kondisi yang lebih rendah, dan mengoptimalkan durasi waktu untuk meningkatkan efisiensi sistem secara keseluruhan

Kata kunci: aerasi, laju transfer oksigen, oksigen terlarut, atap hijau.



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OPTIMIZATION OF GAS TRANSFER COEFFICIENT BASED TIME VARIATION WITH TECHNOLOGY ULTRAFINE BUBBLE IN RUNOFF WATER GREEN ROOF

MUHAMMAD RAIHAN RAMADHANI PUTRA

Undergraduate thesis
as one of the requirements to obtain a Bachelor's Degree in
Department of Civil and Environmental Engineering

**DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
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PREFACE

The author extends praise and gratitude to God Almighty, Allah SWT, who has given health and blessings to the author, thus he can complete his undergraduate thesis entitled " Optimization of Gas Transfer Coefficient Based on Time Variation with Technology Ultrafine Bubble in Runoff Water Green Roof " correctly and on time. This thesis appears and is submitted to fulfill one of the requirements for obtaining a bachelor's degree at the Department of Civil and Environmental Engineering, Bogor Agricultural University.

On this occasion, the author would like to thank all colleagues who have provided support in the preparation of the thesis, especially to:

1. Dr. Yudi Chadirin, S.T.P., M.Agr. as the first supervisor who has provided assistance and guidance during the work and completion of this thesis
2. Dr. Eng. Ir. Allen Kurniawan, S.T., M.T. as the second supervisor who has provided assistance and guidance during the completion of this thesis
3. Prof. Dr. Satyanto Krido Saptomo, S.T.P., M.Si. as examiner thesis exam guidance during the work and completion of this thesis
4. My beloved parents, my mother Yuni Erlinawati, an angel who is always present, giving affection to the author, and becoming the most comfortable home to return to to share all the struggles of the journey the author has faced. Thank you for the prayers she has offered all this time. Not forgetting the author's superhero Fig., Chris Rudi Arpatia, a father who always provides support for the author to keep fighting behind his fatigue of bearing the family's life, always giving motivation to the author about the true meaning of life, strength, responsibility, and independence. All of the author's struggles up to this point are dedicated to the two most precious people in my life. Life becomes so easy and smooth when we have parents who understand us better than we understand ourselves.
5. Salma Amaliani Putri, a sister who has always accompanied the author through difficult, happy, and sad times, always ready to help when the author was overwhelmed in facing this process. Thank you for listening to my complaints, contributing greatly to the writing of this thesis, and providing support, encouragement, energy, and thought
6. Luthfi and Idham as seniors who have provided information and assistance during the research period.
7. Lastly, to the author himself, Muhammad Raihan Ramadhani Putra. The greatest appreciation for being responsible for finishing what was started until the end. Feelings happiness, and hardship could always be overcome despite the many obstacles that had to be passed.

The author has compiled this thesis as well as possible, but the author also realizes that there are many imperfections both in content and grammar. Therefore, the author welcomes any constructive suggestions and corrections to improve it. The author hopes that this thesis can help enrich the knowledge of the readers.

Bogor, August 2025

Muhammad Raihan Ramadhani Putra

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LIST OF NOTATIONS

α	= The parameter to be optimized
C^*	= Saturated gas concentration, (mg/L)
C_L	= Gas concentration in water sample at the time of treatment (mg/L)
$C_{L(t)}$	= Gas concentration in water sample at the time of model (mg/L)
GCR	= Gas consumption rate
GTR	= Gas transfer rate
k_d	= Gas consumption rate constant, (min^{-1})
k_{La}	= Gas transfer coefficient, (min^{-1})
n	= Total number of observations or time steps.
R^2	= Indicates how well the model explains variance in observed data
RMSE	= Measures average prediction error magnitude (same unit as variable)
$SSE(\alpha)$	= Quantify the discrepancy between the actual and predicted model
SS_{res}	= Total squared error between predictions and actual values
SS_{tot}	= Total squared deviation of actual values from their mean
δ	= The small change applied to the parameter
t_{crit}	= Critical t value (from t value table)
t_{stat}	= Statistic t value
var	= Variance



GLOSSARY

Dissolved Oxygen (DO)	: The amount of oxygen dissolved in water or other liquid media, essential for microbial respiration.
Gas Consumption Rate (GCR)	: The rate at which microorganisms consume gas in a bioreactor.
Gas Transfer Rate (GTR)	: The rate at which gas transfers from the gas phase to the liquid phase in a bioreactor, influenced by the mass transfer coefficient and dissolved gas concentration.
Nanofiltration (NF)	: The separation process uses membranes with nanometer-sized pores to remove multivalent ions and organic molecules from water, often used in water treatment.
Oxygen Transfer Rate	: The speed of oxygen transfer from the gas phase to the liquid phase is important in the aeration process to ensure the availability of oxygen for microorganisms in wastewater treatment.
Saturated DO	: The maximum amount of oxygen that can dissolve in water at a specific temperature and pressure.
Green Roof	: The building roof that is partially or completely covered with vegetation, planted over a waterproof membrane. Green roofs are designed to provide several benefits, such as improving energy efficiency, managing stormwater,
Ultrafine bubble	: The technology of type of gas bubble that is extremely small, typically with a diameter of less than 1 micron (1 μm). These bubbles are stable and can remain suspended in liquids for extended periods.