

TABLE OF CONTENTS

TITLE	i
AUTHENTICATION	ii
DECLARATION	iii
NASKAH SOAL	iv
DEDICATION	v
ACKNOWLEDGMENT	vi
TABLE OF CONTENTS	viii
LIST OF FIGURES	xi
LIST OF TABLES	xiv
APPENDIX	xv
NOMENCLATURES	xvi
ABSTRACT	xviii
INTISARI	xix
CHAPTER I INTRODUCTION	1
1.1 Research Background	2
1.2 Problem Formulation	3
1.3 Limitation	3
1.4 Research Objectives	4
1.5 Research Benefits	4
CHAPTER II LITERATURE STUDY	5
2.1 Development of Microbubble Generator	5
2.1.1 Microbubble Generator developed by Lecoffre et al	5
2.1.2 Microbubble Generator developed by Yoon et al	6
2.1.3 Microbubble Generator developed by Ohnari et al	9
2.1.4 Microbubble Generator developed by Sadatomi et al	10
2.2 Research Study of Microbubble Generator	12
2.2.1 Study of Microbubble Generator developed by Bayu et al	12
2.2.2 Study of Microbubble Generator developed by Pandu et al	14

2.2.3	Study of Microbubble Generator by Nanda et al	15
2.2.4	Study of Microbubble Generator by Purwono et al	18
2.2.5	Study of Microbubble Generator by Enggar et al	23
2.2.6	Study of Microbubble Generator by Pradhana et al	25
2.2.7	Study of Microbubble Generator by Hans et al	31
2.3	Wastewater and the Treatment	34
2.3.1	Wastewater Definition	34
2.3.2	Wastewater Treatment	35
2.3.3	Aerobic Wastewater Treatment	36
CHAPTER III THEORETICAL BACKGROUND		37
3.1	Types of Fluid Flow	37
3.2	Basic Theory in Pump Selection	39
3.3	Microbubble Definition	45
3.4	Microbubble Characteristic	45
3.5	Microbubble Generator	48
3.6	Wastewater and its Parameter	49
3.6.1	Wastewater Definition	49
3.6.2	Wastewater Parameters	50
3.7	Aerob Bacteria	53
3.8	Basic Statistics	53
CHAPTER IV RESEARCH METHODOLOGY		55
4.1	Location	55
4.2	Research Material	55
4.3	Microbubble Generator Installation Design	55
4.4	Microbubble Generator Installation System Diagram	56
4.5	Research Equipment	57
4.5.1	Water Circulation Equipment	57
4.5.2	Air Circulation Equipment	62

4.5.3	Power Source	63
4.5.4	Test Equipment	63
4.6	Prosedures of Data Collecting and Processing	66
4.7	Research Flowchart	69
CHAPTER V RESULTS AND DISCUSSIONS		71
5.1	Analysis of Dissolved Oxygen Value in the Isolated Tank	71
5.2	Analysis of DO Value Increase in Different Depths of Isolated Tank	74
5.3	Comparison between Current and Previous MBG Installation	76
5.4	Analysis of Chemical Oxygen Demand Value	79
5.4.1	Analysis of COD Value with Ideal Treatment System	79
5.4.2	Comparison of COD Value Decrease with Previous Study	84
BAB VI CONCLUSIONS AND RECOMMENDATIONS		86
6.1	Conclusions	86
6.2	Recommendations	86
BIBLIOGRAPHY		88
APPENDIX		90

LIST OF FIGURES

Figure 2.1	Microbubble Injector	6
Figure 2.2	Porous Microbubble Generator	7
Figure 2.3	High Shear Microbubble Generator	8
Figure 2.4	Inline Microbubble Generator	9
Figure 2.5	Microbubble Generator by Swirl Jet	9
Figure 2.6	Spherical Body Microbubble Generator	10
Figure 2.7	Bubble Jet Type Air Lift Pump and its Testing Equipment	11
Figure 2.8	Multi Fluid Mixer	12
Figure 2.9	Bayu et al Different Microbubble Generator Configurations	12
Figure 2.10	Bayu et al Microbubble Generator Test Diagram	13
Figure 2.11	Bayu et al Microbubble Generator Result	13
Figure 2.12	Pandu et al Test Diagram of Bubbling Method	14
Figure 2.13	First Microbubble Generator Configuration	15
Figure 2.14	Second Microbubble Generator Configuration	15
Figure 2.15	Third Microbubble Generator Configuration	16
Figure 2.16	Trend on the Increase of DO Value in the Configuration I	16
Figure 2.17	Trend on the Increase of DO Value in the Configuration II	17
Figure 2.18	Trend on the Increase of DO Value in the Configuration III	17
Figure 2.19	DO Meter Placement on the Wastewater Pond	19
Figure 2.20	DO Value Average on Combination I	19
Figure 2.21	DO Value Average on Combination II	20
Figure 2.22	DO Value Average on Combination III	20
Figure 2.23	Changes in COD Towards the DO Values in Combination II	21
Figure 2.24	Changes in COD Towards the DO Values in Combination III	22
Figure 2.25	COD and DO Values Comparison on Variation I	24
Figure 2.26	COD and DO Values Comparison on Variation II	24
Figure 2.27	COD and DO Values Comparison on Variation III	25
Figure 2.28	Pradana et al Microbubble Generator Configuration Scheme	26
Figure 2.29	Measurement Spot for Dissolved Oxygen and Leachate	27
Figure 2.30	DO Average Value for 3 Types of Pool in each Variation	28

Figure 2.31	DO and COD Value Comparison for Variation II MBG Pool	30
Figure 2.32	DO and COD Value Comparison for Variation II Aerator Pool	30
Figure 2.33	DO and COD Value Comparison for Variation II Isolation Pool	30
Figure 2.34	Installation Design for Microbubble Generator in Isolated Tank	31
Figure 2.35	Installation Design for Common Aerator in Isolated Tank	31
Figure 2.36	Average DO Value of the Entire Measurement	32
Figure 3.1	Location of each Point Against Datum on Pump Installation	41
Figure 3.2	Value of Pipe Friction Factor on Laminar Flow	42
Figure 3.3	Interfacial Area Comparison Between Normal and Microbubble	47
Figure 4.1	Microbubble Generator Installation in the Isolated Tank	55
Figure 4.2	Side View of the Microbubble Generator Installation	56
Figure 4.3	Top View of the Microbubble Generator Installation	56
Figure 4.4	Wastewater Treatment System Diagram	57
Figure 4.5	The Specification for the Used Pump	60
Figure 4.6	1 Inch AW Type PVC Pipe	61
Figure 4.7	Isolated Tank	62
Figure 4.8	Air Hose Diameter 1 cm	62
Figure 4.9	Maestro MT8000S Diesel Generator	63
Figure 4.10	Design of Microbubble Generator in the Present Study	63
Figure 4.11	Microbubble Generator Configuration in Isolated Tank 2	64
Figure 4.12	DO Meter Lutron DO-5509 Type	64
Figure 4.13	DO Meter Lutron DO-5512SD Type	65
Figure 4.14	Flow Measurement Cup	65
Figure 4.15	Mercury Thermometer	66
Figure 4.16	The Data Collecting Location in the Isolated Tank	67
Figure 4.17	Dissolved Oxygen Measurement Point	67
Figure 4.18	Bottom Tank Lid	68
Figure 4.19	DO Measurement Point in the Second Part of Data Collecting	69
Figure 4.20	The Flowchart of the Present Study	70
Figure 5.1	Dissolved Oxygen Average Result Chronologically	73
Figure 5.2	DO Value Comparison Between Height in MBG Tank	74
Figure 5.3	The Average of DO Increase of Hans et al and Present Study	78
Figure 5.4	sCOD Value in the First Week	80
Figure 5.5	The Decrease of sCOD Value per Data	81

Figure 5.6	Sampling of the Leachate Water by the Chemist Operator	83
Figure 5.7	Sludge that Cover the Suction of the MBG Installation	83
Figure 5.8	COD Comparison with the Previous Study	85

LIST OF TABLES

Table 2.1 Types of Microbubble Generator by Pandu et al (2013)	14
Table 2.2 The Variation of Q_L and Q_G Setting	18
Table 2.3 The Variation of Q_L and Q_G Combination	23
Table 2.4 Variation Between Water Debit and Working Time of the Pump	26
Table 2.5 Average Value of Dissolved Oxygen in Each Variation	29
Table 2.6 COD Result Analysis	33
Table 3.1 Variation of K_L Value on Inlet and Outlet Side of the Pipe	44
Table 3.2 Variation of K_L Value on Some Fitting Types	44
Table 3.3 K_L Coefficient Values of Reduction and Expansion	45
Table 3.4 Wastewater Threshold Values	52
Table 5.1 The Dissolved Oxygen Progress Collected Data	72
Table 5.2 Data Summary of Tank 2 ANOVA Calculation	75
Table 5.3 ANOVA Result of MBG Tank 2 on Various Depth	75
Table 5.4 Data Summary of Tank 1 ANOVA Calculation	76
Table 5.5 ANOVA Result of Tank 1 on Various Depth	76
Table 5.6 DO Value Comparison between Present and Previous Study	76
Table 5.7 T-test between Hans et al and Present Study on MBG Performance	78
Table 5.8 COD Value Result in the First Week of Data Collecting	80
Table 5.9 T-test Result between Tank 1 and Tank 2 sCOD Value	81
Table 5.10 The sCOD Result in Second Part Data of the Present Study	84
Table 5.11 Hans et al sCOD Value Data	84

APPENDIX

Appendix 1. DO Value Data in 24 Hours Non-stop MBG Operation	90
Appendix 2. COD Value Data 1 (When the Inlet Leachet still Flowing)	91
Appendix 3. COD Value Data 2 (When the Inlet Leachate Flow Stopped)	92
Appendix 4. 1 Hour DO Increase Data	93
Appendix 5. Moody Chart	94
Appendix 6. F-Distribution Table	95

NOMENCLATURES

Latin Letters

A	= Pipe surface area (m^2)
A	= Specific interfacial area (m^{-1})
D	= Pipe diameter (m)
DO	= Dissolved oxygen (mg/L)
f	= Friction coefficient
g	= Gravity ($9.8 m/s^2$)
h	= Head (m, ft)
hL major	= Major losses (m)
hL minor	= Minor losses (m)
K	= Pipe inlet coefficient
KL	= Losses coefficient
L	= Pipe length (m)
n	= Total fitting used
P	= Power (HP, watt)
P_2	= The pressure at the end of the pipe system (m)
P_1	= The pressure at the initial point of the pipe system (m)
P	= Tekanan (atm, Pa, PSI)
QG	= Gas flow rate (m^3/h , U.S.G/M)
QL	= Liquid flow rate (m^3/h , U.S.G/M)
Re	= Reynolds number
U_b	= Terminal Velocity (m/s)
V	= Fluid velocity (m/s)
μ	= Dynamic Viscosity ($N.s/m^2.Pa.s$)
z_1	= Suction height (m)
z_2	= The height at highest point (m)

Greek Letters

Δz	= Elevation head loss (m)
ΔP	= Potential head (m)
ε	= Relative roughness of pipe (mm)
ν	= Kinematic viscosity (m^2/s , cST)
ρ	= Density (kg/m^3)