# Phosphorus and Ammonium Ions Removal by Using The Microalgae *Dunaliella salina*

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Abstract: Biological treatment for industrial effluent was performed in laboratory scale experiment by using marine microalgae *Dunaliella salina*. The dark colored wastewater, containing high level of organic matter and low pH which may prevent microalgae growth. The research showed that within 5 days of incubation in the wastewater, *D. salina* grew from $3 \times 10^6$ to $1.5 \times 10^7$ cell/mL. D. salina reduced approximately phosphorus (29%), and ammonium ionic (68%). The research demonstrated the possibility of using marine microalgae for bioremediation treatment of industrial wastewater, specifically.

Keywords: phosphorus, ammonium, biological treatment, *Dunaliella salina*

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## 1 INTRODUCTION

Industrial wastewater composition varies highly. Several different industries may discharge their wastewater in many ways and those made the wastewater more difficult to treat. Each wastewater treatment was unique and possible degrading by microorganism. Because of The industrial wastewater came from different sources and main characteristics, it may has a possibility to inhibit the microalgae growth.

The main aim of primary treatment in the common procedure for wastewater remediation was to eliminate mainly suspended solid; and after the waste water must be treated microbiologically to further eliminated solids and organic matter (OM). OM degradation may produce nutrients enrichment in wastewater which usually treated chemically. In decades, that phenomena has been a growing interest in developing biological systems based on microalgae which might cheaper and more environmentally friendly[1]. In the other hand, microalgae treatments are complementary and has not been regulating in our country.

The microalgae can absorb molecule released during the early stage process in wastewater treatment. Many species of marine microalgae are used for tertiary wastewater treatment to remove various compounds of phosphorus, nitrogen, heavy metal, and toxic residues from wastewater[2,3,4,1].

*D. salina* is a type of halophile pink marine micro algae. *D. salina* cells lack a rigid cell wall, and the cell is enclosed solely by a thin elastic plasma membrane. As a result, the cells' morphology is strongly influenced by osmotic changes. *D. salina* is a kind of the unicellular green alga which is responsible for most of the primary production in hyper saline environments worldwide.

The aim of this research was to evaluate a sequential treatment of microalgae as a potential absorbent for industrial wastewater effluent.

## 2 MATERIALS AND METHODS

The industrial wastewater used in this research was the untreated washing water from all process from large sugar mill industry in Lampung Province that processes molasses to produce citric acid, ethanol, acetic acid, and various acetates. The mill potentially produces approximately 250 $m^3/h$ of this wash water.

The algae used were unicellular green algae *D. salina*. It was collected from Balai Besar Pengembangan Budidaya Laut (BBPBL) Hanura pure isolate and grown in the photo bioreactor consisted of an airlift pump that dive the culture fluid through a horizontal tubular solar receiver. The total culture volume is 0.5 $m^3$. Air was continuously supplied at a flow rate 0.02 $mol.s^{-1}$. The research was conducted on October-December 2009. *D. salina* were stored and maintained in a synthetic mineral solution under illuminating conditions. *D. salina* was acclimatized in filtered sterile wastewater for 10 days. This allowed the micro algae to exceed its population to the needed inoculation level by avoiding predation in wastewater. The synthetic mineral solution composition (mg/L) was NaCl, 7; $CaCl_2$, 4; $MgSO_4.7H_2O$, 2; $KH_2PO_4$ 21; $K_2HPO_4$ 10; $Na_2HPO_4$, 35; $NH_4Cl$ 10.

Wastewater samples were analysed in triplicates by taken 150 mL wastewater for ammonium ion, and phosphorus concentration. Wastewater samples were taken every 24 h and analysed using specific standard methods[5].

*D. salina* population growth was measured by taking samples every 24 h and counting by light microscopy using Hematocytometer. Growth rate ($K$) was determined by using the formula:

$$K = \frac{(\ln Nt_1 - \ln Nt_0)}{t_1 - t_0}$$

where $Nt_1$ is the number of cell at sampling and $Nt_0$ is the initial number of cell at the beginning of the experiment.

## 3 RESULT AND DISCUSSION

*D. salina* growth in diluted (1:10) wastewater increased constantly for the first 3 days, reaching average density $1.5 \times 10^7$ cell/mL (Figure 1). Microalgae growth decreased slightly in $4^{th}$-$6^{th}$ day of culture. Using non-sterile wastewater as a substrate was supported the *D. salina* growth to a lesser extend and was variable. Figure 1 showed 3 phases of microalgae growth. The first phase, microalgae population growth rapidly in the first 3 day of culture (DOC) which indicated that the presence of dilute wastewater has not been affected the microalgae growth. The second phase, microalgae population growth decrease slightly between 3-4 DOC which indicated that the presence of dilute wastewater affected significantly to inhibit population growth. The third phase, microalgae population growth decrease constantly between 4-5 DOC which indicated that the ambient level of dilute wastewater to affect the microalgae growth was reached closely.

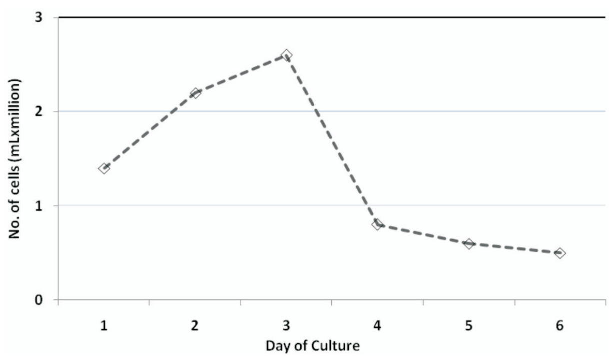


Figure 1: The *D. salina* growth in industrial wastewater

After 3 DOC, the initial ammonium ion concentration in the wastewater was vary (3.2-6.6 mg/L $NH_4^+$) (Figure 2A). The ammonium ion removal from wastewater by *D. salina* ranged from 20.8-64.7%, with an average of 42.8%. The decrease of ammonium ion from industrial wastewater has the same trend with the control. It showed that the ammonium ion removal from industrial wastewater, in case, was lower than the ammonium ion removal from agro-industrial water (94%) and even from domestic wastewater (89%) (Data not shown). The observed removal of ammonium ions from untreated wastewater is probably by an air-stripping mechanism[6].

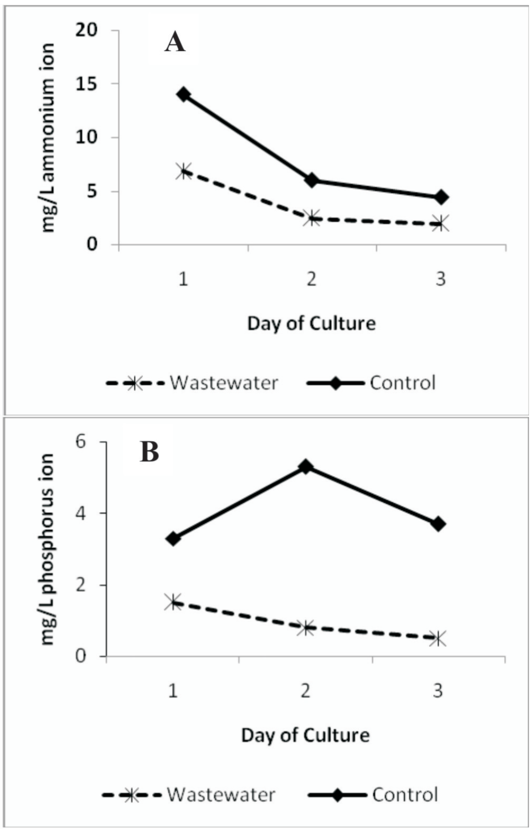


Figure 2: Removal of (A) Ammonium and (B) Phosphorus from dilute (1:10) wastewater

The initial phosphorus concentration was also high (1.2-3.1 mg/L $PO_4^{-3}$). Treatment of wastewater with *D. salina* gradually decreased the phosphorus concentration. The removal level of phosphorus ion from the treated wastewater ranged from 38-47%, with an average of 42%. The phosphorus removal from the industrial waste water was also slightly lower than from agro-industrial water (59%) and from domestic wastewater (75-82%). It indicated that phosphorus removal from the waste water accumulated into the algal biomass as showed by Chevalier and De la Noue[7] and Valderrama et al.[1].

## 4 CONCLUSIONS

There was there phases of microalgae growth as a specific adaptation from dilute wastewater presence in medium. Specifically, the result proposed a sequential treatment process for industrial wastewater by using microalgae *D. salina*. The microalgae treatment removed nutrients (phosphorus and ammonium ions) from wastewater with specific level.

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