Microalgae Dynamic in Municipal and Industrial Waste and Wastewater

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1. Introduction

Microalgae have been recognized for many years as a potential resource of biofuel (Demirbas, Demirbas, & management, 2011; Song, Fu, & Shi, 2008). The algae can produce up to 80 percent lipid in total biomass (Patil, Tran, & Giselrød, 2008) with a very short period (Williams, Laurens, & Science, 2010) and less nutrient requirements (Blair, Kokabian, & Gude, 2014). Growing the algae in more economical medium such as wastewater has other advantage which for water treatment (Kebede-Westhead, Pizarro, & Mulbry, 2006; Yang et al., 2011; Zhu, Hiltunen, & Reviews, 2016). Indigenous organisms are the most suitable by which the high growth rate can achieve (Abou-Shanab et al., 2011), thus it is very important to understand at which condition the microalgae occur in abundant concentration. Nowadays, the combination of algae growth and waste is extensively studied and most of the developments emphasize on secondary treatments to remove nutrient and organic matter from the treatment effluents. Furthermore, among the condition of effluent of wastewater treatment plant which deliberated, nutrient such as nitrogen (Abe, Imamaki, & Hirano, 2002; Costa, Cozza, Oliveira, & Magagnin, 2001; Marcilhac et al., 2015), phosphate (Abe et al., 2002; Marcilhac et al., 2015) and organic compound reflected in chemical oxygen demand are very crucial and often used as the main characterization parameters of wastewater. Although these parameters are important and determining the growth of algae in nature since it can determine which microalgae and at which condition the algae is optimum to grow (Chandra, Rohit, Swamy, & Mohan, 2014), it is rarely found that these can be directly related to the algae abundant. This study thus aimed to determine the response surface concentration of COD, TP, and TKN for the highest microalgae density in waste and wastewater effluents and draw the optimum condition in nature for algae to grow in high density.

2. Method

Waste and wastewater effluent from different biological treatments were collected from swine farm manure and aerated lagoon of wastewater treatment plant of Suranaree University of Technology Municipal Wastewater Treatment, biogas wastewater of Korat Flour Industry Co., Ltd. Nakhon Ratchasima, Thailand, and. The Total Phosphate (TP), Total Keldjah Nitrogen (TKN) and Chemical Oxygen Demand (COD) were analyzed based on (Eaton, Clesceri, Greenberg, & Franson, 2005).

The samples were also diluted several times for quantitative measurement. Diluted samples was spread on BG 11 Agar medium (Barsanti & Gualtieri, 2014). The colonies that appeared were re-streaked until unialgal colony was obtained. All colony in each dilution was counted using colony counter Funke Gerber Colony Star 8500. The algae were also identified using the methods adapted from (Lee, Eisterhold, Rindi, Palanisami, & Nam, 2014). Microscopic observation using Olympus BX51 Microscope (Olympus Corp., Tokyo, Japan) with the Olympus DP73 Digital Camera and the DP73 Software Program was done to capture microalgae pictures. Photographic comparison of the original isolates with based on determination key from (Bellinger & Sigee, 2015).

3. Result

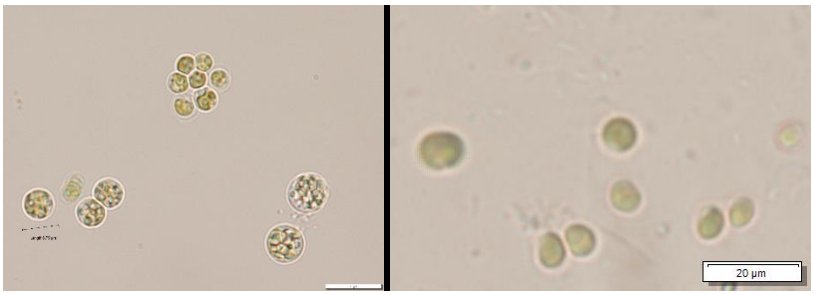

Figure 1. *Chlorella vulgaris* in wastewater treatment plant effluent

Sampling in 16 wastewater treatments shows wide range of TKN, TP, and COD which describes characteristics of each wastewater or waste dumped and diluted (Table 1) whereas *Chlorella vulgaris* appeared as the only microalga obtained from these wastewaters (Figure 1) as it has been reported that *Chlorella* is versatile alga which can grow in wide range of environmental condition including wastewater (Li et al., 2011). The occurrence of this alga addresses the possibility of utilizing the wastewater for growth medium in order to produce biodiesel since the algae has been reported to obtain more than 40 % lipid content in wastewater medium (Feng, Li, & Zhang, 2011).

Table 1. Wastewater condition in several wastewater treatment systems.

	Pig Farm Effluent	Pig Pond	AL1	AL2	AL3	AL4	AL5	AL6	AL7	AL8	DP 1	DP 2	DP 3	DP 4	Biogas Pond	Biogas Effluent
Density (1000 cfu/ml)	0.42	5.4	12	34.2	3.1	20.9	24.1	10.9	11.2	20.6	0.44	0.94	1.03	4.1	0.33	0.92
TP (mg/l)	18.9	18.5	4.5	7.6	1.3	4.8	3.8	1	3.8	6.5	2.5	2.1	1.5	2	15.8	13.8
COD (g/l)	10.4	9.6	1.6	0.8	1.6	3.2	0.8	0.8	0.8	1.6	8.8	8.8	10.4	10.4	5.6	10.4
TKN (mg/l)	294	280	98	84	140	70	28	112	42	14	210	168	196	168	252	238

Notes: AL (aerated lagoon), DP (dissolved pond).

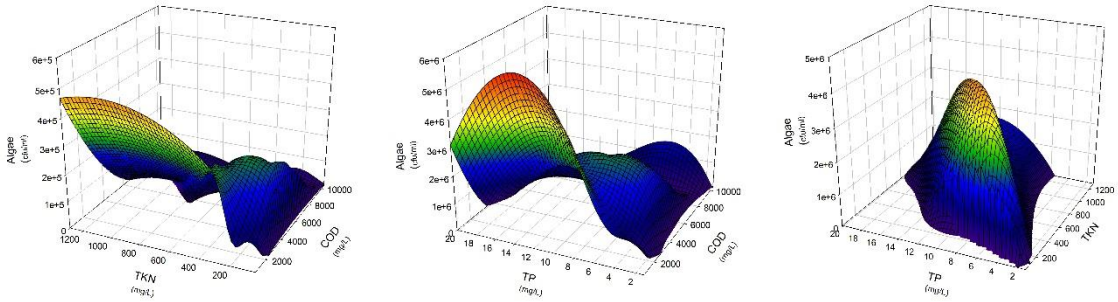

Figure 2. Surface response of TP, TKN, and COD to the microalgae density.

Determination of TKN, TP, and COD in accordance to algae density revealed the optimum condition of each combination from three water parameters (COD, TKN, and TP). From the surface method using mesh plot, it has been found that both TKN and TP in inter mediate concentration among samples which 10-16 mg/L of TP and 600-1200 mg/L of TKN were the optimum range for the highest microalgae density. It is in line with (Sreesai & Pakpain, 2007) that found the absorption of these nutrients in the form of TP and TKN are significant in *Chlorella* growth. Thus the growth is possible to be enhanced under high concentration of both TP and TKN. Nevertheless, the steep slope after optimum condition in both TKN and TP concentration indicated that high concentration of these nutrients can be an inhibition factors (Wang, Yu, Lv, & Yang, 2013). On the other hand, COD occurred to be the inhibition at any level. High COD trends showed a decrease of microalgae density (R^2=0.52) since the chemical oxygen demand is critical for algae growth since organic matter is among critical growth inhibition of microalgae (Chinnasamy, Bhatnagar, Hunt, & Das, 2010; Grossart & Simon, 2007).

Based on these response surface from observation data, it can be assumed that the optimum condition of algae is 10-16 mg/L of TP, 600-1200 mg/L of TKN, and least concentration of COD. However, to reach such condition, there was no specific wastewater which is adequate for fulfilling these optimum condition (Table 1). Furthermore, this result is optimum to apply on waste and wastewater around Thailand or other location with similar environmental condition since other environmental factors such as light intensity play an important role to this algae density (Barsanti & Gualtieri, 2014). Eventually, as the production of 40% lipid content from Chlorella vulgaris combined with wide range of TKN and TP concentration for waste and wastewater concentration, it is possible conclude that production biomass in line with treatment system for waste and wastewater is very potential to conduct.

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