BIOETHANOL PRODUCTION FROM BATCH AND CONTINUOUS PHYTOREMEDIATION SYSTEMS

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Dedicated to my parents,

MAT HASSAN OTHMAN & SUHANA ABDULLAH

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"In the Name of Allah, the Most Gracious and Merciful"

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ABSTRACT

The effectiveness of water hyacinth (*Eichhornia crassipes*) in remediating municipal wastewater and producing bioethanol in batch and continuous systems was compared with water lettuce (*Pistia stratiotes*) and water spinach (*Ipomoea aquatica*). Batch experiment was conducted using stagnant wastewater system and compared with continuous experiment in order to determine the best treatment system for nutrients and pollutants removal while producing high amount of biomass for bioethanol production. The batch experiment was conducted for 7 days while continuous experiment was conducted for 18 days for each of the aquatic plant. The results for the comparison between rhizofiltration plants have shown that water lettuce has better removal performance compared with water hyacinth and water spinach. The continuous system showed better performance in treatment rate and biomass production compared to batch system. The biomass harvested from water hyacinth, water lettuce and water spinach were 772±37 g/kg, 794±75 g/kg and 702±69 g/kg, respectively. Dinitrosalicyclic test was conducted to measure the reduction of sugar from plant biomass. The concentration of sugar produced by water hyacinth was 21.2±2.7 g/L, while water lettuce was 23.5±3.8 g/L, which was slightly higher than water hyacinth's sugar production. Water spinach produced the lowest sugar concentration with only 15.5±3.3 g/L. The production of bioethanol estimated from water lettuce was 0.13±0.01 g/g bioethanol. Meanwhile, water hyacinth produced 0.12±0.01 g/g of bioethanol, a value lower than water lettuce. Due to the low concentration of sugar, water spinach managed to produce only 0.10±0.02 g/g bioethanol. In conclusion, water lettuce shows better performance compared with water hyacinth in remediating wastewater and producing biofuel.

ABSTRAK

Keberkesanan remediasi kumbahan domestik dan penghasilan bioethanol dalam system takungan dan sistem aliran berterusan telah dibandingkan diantara keladi bunting (*Eichhornia crassipes*), kiambang air (*Pistia stratiotes*) dan kangkung air (*Ipomoea aquatica*). Kajian sistem bertakung telah dijalankan dengan air sisa statik dan dibandingkan dengan sistem air mengalir untuk menentukan sistem yang terbaik dalam merawat nutrien dan bahan tercemar dan pada masa sama menghasilkan biojisim untuk pengeluaran bioetanol. Kajian air bertakung dijalankan selama 7 hari manakala kajian air mengalir pula dijalankan selama 18 hari bagi setiap jenis tumbuhan akuatik. Keputusan perbandingan sesama tumbuhan penapis *rhizo* menunjukkan kiambang air mempunyai tahap keberkesanan yang lebih baik berbanding keladi bunting dan kangkung air. Kajian terhadap sistem aliran berterusan pula memberikan keputusan yang baik dalam kadar rawatan dan penghasilan biojisim berbanding sistem takungan. Nilai biojisim yang dituai daripada keladi bunting, kiambang air dan kangkung air adalah masing-masing 772±37 g/kg, 794±75 g/kg dan 702±69 g/kg. Ujian dinitrosalisilik telah dijalankan bagi mengukur penurunan gula daripada biojisim tumbuhan. Kepekatan gula yang terhasil daripada keladi bunting adalah 21.2±2.7 g/L, manakala kiambang air pula menghasilkan 23.5±3.8 g/L gula, suatu nilai yang lebih tinggi berbanding penghasilan keladi bunting. Kangkung air pula menghasilkan kepekatan gula yang terendah dengan kepekatan hanya 15.5±3.3 g/L gula terekstrak. Penghasilan bioetanol daripada kepekatan gula dapat dianggarkan yang mana kiambang air menghasilkan 0.13±0.01 g/g bioetanol manakala keladi bunting pula menghasilkan 0.12±0.01 g/g bioetanol. Kerana kandungan gula yang rendah, kangkung air hanya berjaya menghasilkan 0.10±0.02 g/g bioetanol. Kesimpulannya, kiambang air menunjukkan kebolehan yang lebih baik berbanding keladi bunting dan kangkung air dalam merawat air kumbahan domestik dan menghasilkan bioetanol.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURE

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Preamble

Excessive nutrient contamination has always been a threat to the environment. The sources of excessive nutrient usually comes from domestic and agriculture wastewater. Both domestic and agriculture wastewaters are normally treated in conventional wastewater treatment plant before it can be discharged to open waters. As human population increased, wastewater treatment plants are unable to provide proper treatment to wastewater. As a result, the effluent from wastewater treatment plant still contains significant amount of nutrient. The excessive nutrient creates unsustainable disorder upon water cycle and unstable condition to animal habitats as well as human consumption of clean water.

The increasing number of human population will also increase organic loading of municipal wastewater. Higher population creates higher concentration of nutrients. This will affect the efficiency of a conventional wastewater treatment. Due to the unproductive treatment, effluent produced from the treatment plant will still contain high content of organic loading. The high organic loading effluent shall contribute to a low water quality of the river. Therefore, the municipal treatment plants may need additional support in order to cater for excessive nutrient contaminant.

There are several options of additional support or to replace the incompetent conventional treatment plant such as activated sludge, aerobic granulation, sequencing batch reactor, membrane reactor and phytoremediation. While most of the treatments were considered as advance treatments, the cost in operating the treatments were significantly expensive compared with phytoremediation (Malik, 2007). Phytoremediation is known as a treatment of using plant as a wastewater remediation system. Current researches have improved the efficiency of treating nutrient using specific type of plants making the environmental approach of phytoremediation reliable for municipal wastewater treatment. Therefore, treating municipal wastewater with plant which previously considered as traditional approach might be one of the promising options in creating a larger treatment prospect (Abbasi and Ramasami, 1999; Narayana and Parveen, 2000).

Other than treating excessive nutrient, these phytoremediation plants have also been identified as a good biogas producer. Intensive attention was made on the potentials and constraint of water hyacinth usage for biofuel production (Singhal and Rai, 2002). The production of biofuel in replacement of fossil fuel production had caused severe conflicts of interest with environmentalists and food industries. The real problem is conversion of farmland for food to biofuel industries. For instant, in the US, up to 2004, 30% of its corn farmland that is used for producing foods was converted to serve biofuel industries, resulting in price hikes to the food industries (Chartchalerm *et al*., 2007). Not many studies have been conducted to compare the phytoremediation performance between water lettuce, water spinach and water hyacinth. This study aims to explore more on water lettuce and water spinach and compare its biofuel production with water hyacinth.

1.2 Objectives of the Study

This study embarks on the following objectives:

1) To determine nutrients removal by selected rhizofiltration plants.
2) To determine the differences of micro nutrients and pollutant removal performance between stagnant batch and continuous flow system.
3) To estimate the production of biofuel from rhizofiltration plants used in wastewater treatment process using designated experimental rig.

1.3 Scope of the Study

The experiment was conducted in a batch and continuous system. The phytoremediation plants selected were water hyacinth, water lettuce and water spanich. The nutrient removal performance were analyzed by measuring water quality in terms of BOD, COD, nitrogen and phosphorus. The growth of the plants were also being monitored by measuring its doubling time, i.e. time required for the plants to double its length and weight.

The final stage of this study includes estimation of bioethanol production from the phytoremediation plants. The phytoremediation plants are converted to biomass by conducting a pretreatment process used in converting plants to bioethanol. The bioethanol is estimated via extraction of sugar content that is produced from the biomass of the phytoremediation plants. The sugar content is produced and estimated using dinitrosalicyclic (DNS) test.

1.4 Significance of the Study

The significance of this study is contributed by comparison of removal performance for three types of phytoremediation plants i.e. water hyacinth, water lettuce and water spinach. The study also quantifies and compares the production potential of sugar content as a source of biofuel production by these phytoremediation plants. The findings of this study would be beneficial for future investigation in exploring the potential production of biofuel harvested from phytoremediation wastewater treatment system.

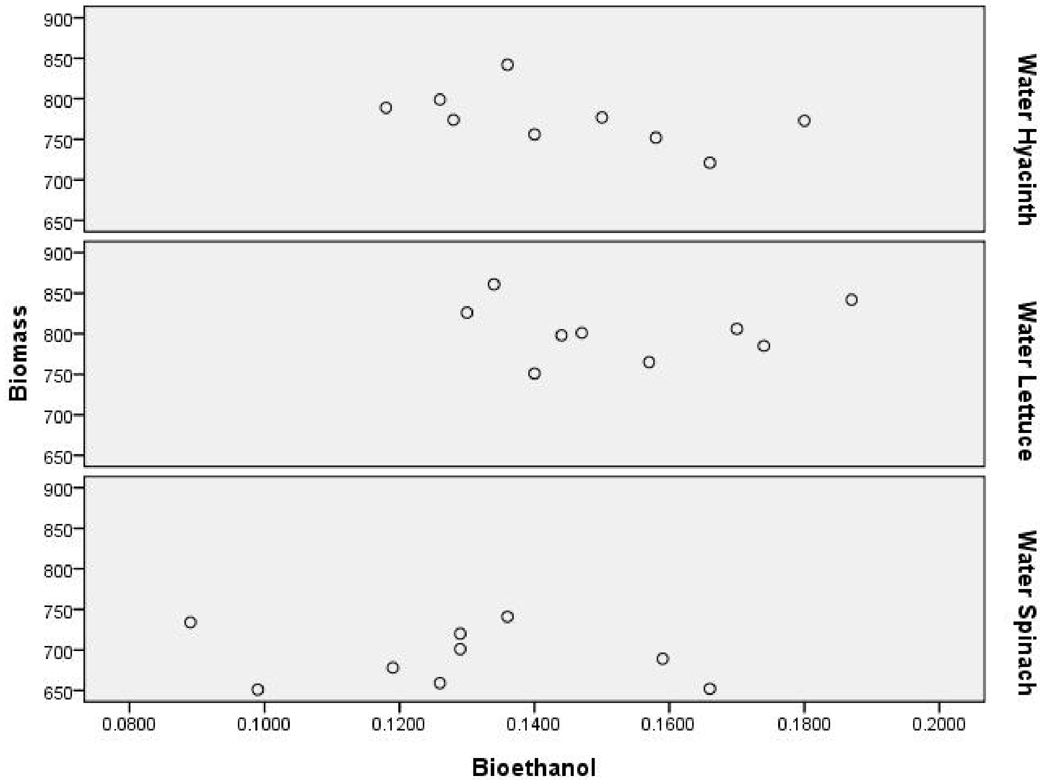

Figure 4.13 Scattered plot of biomass versus bioethanol graph with respect to rhizofiltration plants

Table 4.9: ANOVA analysis of bioethanol production from water spinach compared with water hyacinth

Water Spinach	Sum of Squares	df	Mean Square	F	Significant
Between Groups	0.001	1	0.001	4.076	0.061
Within Groups	0.005	16	0.000		
Total	0.006	17			

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