UNIVERSITI PUTRA MALAYSIA

MICRO-ALGAE REMOVAL IN DOMESTIC WASTEWATER USING *ASPERGILLUS FLAVUS* SOFT PELLETS AS A BIO-COAGULANT

AHMAD HUSSEIN RAJAB

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By

AHMAD HUSSEIN RAJAB

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

May 2007

DEDICATION

I am happy to dedicate this work to my country “Iraq”. A country is great by the character of its people and not by its number. I adore my country because it is the land of civilizations from the time immemorial.

I would like to express my gratitude to all the people who have been supportive of my endeavor towards my M.Sc. study.

The support of my family has been encouraging me to pursue my M.Sc study. Without their support I could not have achieved thus far. To my father, mother, brothers and my friends I thank them for their supporting me for so many years. I wish to make both of them proud. You have been a constant source of strength throughout my M.Sc study whenever I need.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: Professor Azni Idris, PhD

Faculty : Engineering

Nuisance due to algae problems will become more widespread and severe as our growing urban populations and industries continue to discharge their wastes into streams. Some of the problems are odour and taste, the clogging of filters, growths in pipes, cooling towers and on reservoir walls, surface water mats or blooms and toxicity. The existing chemical and physical methods used for micro-algae removal are creating undesirable effects in the water, therefore, most of the recent researches are focusing on biological removal methods due to lesser of impact on the environment and water quality and it may be a more economical alternative to some chemical and physical methods.

This study used *A. flavus* as bio-coagulant for micro-algae removal in domestic wastewater. Jar test is used to determine the proper *A. flavus* dosage and retention time. It was determined that 5% (v/v) of *A. flavus* as optimum concentration and 12 hours as optimum retention time. At the optimum *A. flavus* concentration and

retention time removal efficiencies were recorded as: 72.3% of micro-algae cell number, 79.5% of TSS, 78.6% of VSS, 63.5% of COD, 60% of BOD, 73.5% of nitrate, 45.1% of phosphorus, 90.6% of color, 76.1% of turbidity and pH was decreased from (7.45 – 6.9) to (7.0 – 6.5).

1.2 mm of *A. flavus* soft pellets size shown a high removal in comparison with 2.5mm and 4.3mm. with 1.2mm of *A. flavus* soft pellets size used, 71.5% of micro-algae removal, 77.9% of TSS removal, 76.1% of VSS removal, 68.6% of COD removal and 82.6% of color removal at 12 hours of retention time are recorded.

The experimental results indicated that the solid capturing ability of *A. flavus* increased as the free surface area of *A. flavus* soft pellets increased. Moreover, *A. flavus* soft pellets capturing ability increased as retention time increased.

The zeta potential result revealed that the average zeta potential of micro-algae was – 23.7 milivolt which the average zeta potential of *A. flavus* was + 46.1 milivolt. The charge difference between *A. flavus* and micro-algae may have constituted to the *A. flavus* ability to capture micro-algae.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENGANSINGAN MIKRO-ALGA DI DALAM AIR SISA DOMESTIK DENGAN MENGGUNAKAN PELET LEMBUT *ASPERGILLUS FLAVUS* SEBAGAI BIO-KOAGULAN

Oleh

AHMAD HUSSEIN RAJAB

Mei 2007

Pengerusi: Profesor Azni Idris, PhD

Fakulti : Kejuruteraan

Pelbagai masalah yang diakibatkan oleh alga akan menjadi semakin meruncing dengan bertambahnya bilangan penduduk dan industri yang berterusan membuang sisa ke dalam sistem saliran. Di antara masalah yang timbul ialah rasa dan bau, sumbatan pada penapis, pertumbuhan dalam sistem perpaipan, menara penyejuk dan pada dinding reservoir, fenomena hamparan pada air permukaan, infestasi di dalam air siap dan ketoksidan. Kaedah kimia dan fizikal yang digunakan untuk mengawal mikro-alga boleh mengakibatkan kesan-kesan yang tidak diingini terhadap air. Oleh sebab itu, kebanyakan kajian terkini menumpukan kepada kaedah rawatan secara biologi supaya kesan buruk terhadap alam sekitar dan kualiti air dapat dikurangkan, selain dari menyediakan kaedah yang lebih ekonomik berbanding sebahagian kaedah kimia dan fizikal.

Dalam kajian ini, *A. flavus* digunakan sebagai bio-koagulan untuk mengawal mikro-alga di dalam air sisa domestik. Ujian balang digunakan untuk menentukan dos yang

sesuai bagi *A.Flavus*. Di dapati bahawa kepekatan optimum *A. Flavus* ialah pada 5 % (v/v) manakala masa tahanan yang optimun ialah 12 jam. Pada kepekatan *A. flavus* dan tempoh tahanan optimum, kadar penyingkiran yang efisyen telah direkodkan dimana 72.3 % jumlah bilangan sel mikro-alga berjaya disingkirkan, TSS sebanyak 78.6 %, COD sebanyak 63.5%, BOD sebanyak 60 %, nitrat sebanyak 73.5%, fosforus sebanyak 45.1 %, warna sebanyak 90.6 %, kekeruhan sebanyak 76.1 % dan bacaan pH meningkat daripada (7.45 – 6.9) kepada (7.0 – 6.5).

Palet lembut *A. Flavus* yang bersaiz 1.2 mm menunjukkan kadar penyingkiran yang lebih tinggi berbanding palet lembut bersaiz 2.5 mm dan 4.3 mm. Palet lembut *A. Flavus* bersaiz 1.2 mm telah merekodkan sebanyak 71.5 % penyingkiran mikro-alga, penyingkiran TSS sebanyak 77.9%, penyingkiran VSS sebanyak 76.1%, penyingkiran COD sebanyak 82.65 dan penyingkiran warna sebanyak 82.6% pada 12 jam masa tahanan.

Keputusan eksperimen menunjukkan kebolehan palet lembut *A. Flavus* memerangkap pepejal bertambah apabila permukaan bebas *A. Flavus* meningkat. Selain itu, kebolehan palet lembut *A. Flavus* juga meningkat apabila masa tahanan meningkat.

Selain itu, bagi spesis mikro-alga yang terlibat spesis mikro-alga yang tidak boleh bergerak adalah lebih mudah diperangkap berbanding spesis mikro-alga yang boleh bergerak. Kebolehan memerangkap pepejal bagi *A. flavus* juga meningkat dengan meningkatnya masa tahanan.

Keputusan ujian potensi zeta menunjukkan purata bagi mikro-alga adalah – 23.7 milivolt dan bahawa potensi zeta purata bagi *A. flavus* adalah + 46.1 milivolt. Di sebabkan kehadiran cas yang berlainan di antara *A. flavus* dan mikro-alga tersebut *A. flavus* boleh memerangkap mikro-alga dan memendapkannya.

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IN THE NAME OF ALLAH THE MOST GRACIOUS AND MOST MERCIFUL

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I certify that an Examination Committee met on / / 2007 to conduct the final examination of Ahmad Hussein Rajab on his Master of Science thesis entitled "Micro-algae Removal in Domestic wastewater By Using *Aspergillus flavus* Soft Pellets As Bio-coagulant" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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Date: 9 August 2007

DECLARATION

I herby declare that the thesis is based on my original work except for quotation and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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AHMAD HUSSEIN RAJAB

Date: 02/Aug/2007

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LIST OF ABBREVIATIONS

CO_2	carbon dioxide
U.S. EPA	United States. Environmental Protection Agency
NO^-_3	Nitrate
N	Nitrogen
P	Phosphorous
UV	Ultraviolet
US	Ultrasound
O_3	Ozone
TPP	Toxin Producing Plankton
A/A/O	Anaerobic/Anoxic/Oxic
COD	Chemical Oxygen Demand
NH_4-N	Ammonia-Nitrogen
IWK	Indah Water Konsortium
PDA	Potato Dextrose Agar
WF	Wheat Flour
v/v	Volume/Volume
TSS	Total Suspended Solid
VSS	Volatile Suspended Solid
BOD	Biochemical Oxygen Demand

PO_4^{3-}	Phosphorus
PtCo	Platinum-Cobalt
UPM	Universiti Putra Malaysia
USA	United States of America
UK	United Kingdom
NTU	Nephelometric Turbidity Unit
S	Sulphur
K	Potassium
Mg	Magnesium
Ca	Calcium
Fe	Iron
Na	Sodium
SMEWW	Standard Methods for Examination of Water and Wastewater
ζ	Zeta potential
Cl	Chlorine

CHAPTER 1

INTRODUCTION

Water pollution is the contamination of streams, lakes, underground water, bays, or oceans by harmful substances like pathogenic microorganisms or toxic materials. Man, animals and plants require water that is moderately pure, and cannot survive if their water is loaded with toxic or harmful microorganisms.

Water quality is a term used to describe the chemical, physical, and biological characteristics of water, usually with respect to its suitability for a particular purpose. Water quality is determined by a variety of water characteristics. Measuring temperature, clarity, algae, acidity, bacteria, heavy metals, minerals and nutrient levels are some of the ways to determine water quality. Many pollutants are invisible, so measuring and monitoring are the initial steps in preserving water quality.

As population and industrial demands increase and water supplies become inadequate, more and more lands are turning to lakes, streams, or water reservoirs for their water supplies. Such change from ground to surface source of water supply has created many new problems for those engaged in the procurement and treatment of water for domestic and other uses. All surface water contains many organisms, which may complicate the provision of potable water (Palmer, 1959).

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Algae is one of the major problems found in surface water. Some algae problems include the clogging of filters, harmful algal blooms, infestations in finished waters and toxicity. High concentration of nutrients in the water will encourage algae to grow rapidly making algae problems even more widespread in the water.

There are three techniques to remove algae from the water: physical, chemical and biological. In this study, biological method is used to remove micro-algae from domestic wastewater. This was chosen because of it is natural, friendly to environment and low cost operating as compared to physical and chemical methods.

1.1 Problem Statement

Present methods of waste disposal are intensifying the nuisance organism problems in water supplies, the number and kinds of algae and other organisms which grow in waters depend on environmental conditions. Fertilizing materials such as sewage and organic wastes from milk plants, canneries, slaughter houses, paper mills, starch factories and fish processing plants greatly increase productivity of the waters and their crops of algae and other plankton organisms, many of which produce problems when they become abundant (Palmer. 1959). This problem will become more widespread and severe as our urban population grows and industries continue to discharge their wastes into the streams. Consequently, removing micro-algae from the water body is very much desired and the method of removal has to be effective and friendly to the environment.

This study investigates the removal of micro-algae from wastewater by using *Aspergillus flavus* soft pellets as bio-coagulant. The biological method offers a choice by giving less impact on the environment and water quality and may be economical alternative to some other chemical and physical methods.

1.2 Research Objectives

The main purpose of this study is to remove micro-algae cells in the domestic wastewater by using *Aspergillus flavus* soft pellets as bio-coagulant. The specific objectives of this study are as follows:

1. To determine the optimum *A. flavus* soft pellets (2.5 mm) concentration of (1% v/v, 3% v/v and 5% v/v) for micro-algae removal and the removal efficiency of selected parameters: Micro-algae cell/mL, TSS, VSS, COD, BOD, Nitrate, Phosphorus, Color, Turbidity and pH.
2. To determine the optimum retention time for micro-algae removal by using *A. flavu*s soft pellets 2.5mm (5 % v/v) as bio-coagulant and the removal efficiency of selected parameters: Micro-algae cell/mL, TSS, VSS, COD, BOD, Nitrate, Phosphorus, Color, Turbidity and pH.
3. To investigate the effectiveness of *A. flavus* soft pellets sizes 4.3mm, 2.5 mm and 1.2 mm in removing micro-algae cells from domestic wastewater and the removal efficiency of selected parameters: Micro-algae cell/mL, TSS, VSS, Color and COD.

1.3 Importance and Significance of the Study

The importance and significance, which may be gained from this study, are:

1. The contribution in the investigation of the potential of *Aspergillus flavus* as a new bio-coagulant in wastewater treatment process and nutrients removal (nitrate, phosphorus) from wastewater
2. The trial to replace chemical coagulant by using natural bio-coagulant in wastewater treatment to avoid chemical sludge, to lower treatment cost and being friendly to the environment.

1.4 Scope of Research

1. To investigate three concentrations (1%, 3% and 5% v/v) of *A. flavus* soft pellets (2.5 mm) at six hours as retention time and determine the optimum concentration of *A. flavus*, which gives a good removal efficiency throughout the study of selected parameters: Micro-algae cell/mL, TSS, VSS, COD, BOD, nitrate, phosphorus, color, turbidity and pH.
2. To investigate *A. flavus* 5% v/v (2.5 mm) at diferent retention times (1, 3, 6, 9, 12 and 24 hours) and determine the optimum retention time for *A. flavus* 5% v/v, which record the best removal for selected parameters: Micro-algae cell/mL, TSS, VSS, COD, BOD, nitrate, phosphorus, color, turbidity and pH.