**UNIVERSITI PUTRA MALAYSIA**

# THE INTRODUCTION OF *EICHHORNIA CRASSIPES* INTO THE HIGH RATE ALGAL POND TO REMOVE NITROGEN FROM WASTEWATER

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# THE INTRODUCTION OF *EICHHORNIA CRASSIPES* INTO THE HIGH RATE ALGAL POND TO REMOVE NITROGEN FROM WASTEWATER

by

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Affectionately dedicated to

**TRAN THI HONG NHUNG**

Of Lai Khe, Ben Cat, Binh Duong

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AN | Ammoniacal Nitrogen |
| APHA | American Public Health Association |
| BOD | Biochemical Oxygen Demand |
| COD | Chemical Oxygen Demand |
| CV | Coefficient of Variation |
| DO | Dissolved Oxygen |
| HRAP | High Rate Algal Pond |
| HRT | Hydraulic Retention Time |
| N | Nitrogen |
| $NO_2$-N | Nitrite Nitrogen |
| $NO_3$-N | Nitrate Nitrogen |
| P | Level of significance |
| r | Correlation coefficient |
| TKN | Total Kjeldahl Nitrogen |
| TSS | Total Suspended Solids |
| VSS | Volatile Suspended Solids |
| WSP | Waste Stabilisation Pond |

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April 1998

*Chairman*: Assoc. Prof. Dr. Mohammad Ismail Yaziz

*Faculty*: Science and Environmental Studies

The treatment of wastewater using algal cultures has been researched and developed since 1950. The High Rate Algal Pond (HRAP) is the most efficient of this type of treatment, particularly for nitrogen removal. However, the main problem with the HRAP is the high level of organic suspended solids in the treated wastewater. Furthermore, nutrients released from the lysis of algal cells may give rise to eutrophication in the receiving water.

A laboratory-scale experiment was carried out using the HRAP in the company of an aquatic plant, waterhyacinth *Eichhornia crassipes*, as an integrated system to remove nitrogen from wastewater. The dominant algal species used was *Chlorella vulgaris*.

Twenty runs in the batch mode were operated under the conventional HRAP and the HRAP-waterhyacinth combination system. Three runs were operated in the continuous mode using the HRAP-waterhyacinth system with 50% surface area coverage and 3 different retention times (3 days, 6 days, and 9 days).

Comparison of the conventional HRAP and the HRAP-waterhyacinth system for treating diluted raw wastewater from rubber latex concentrate processing revealed better nitrogen removal efficiency by the HRAP-waterhyacinth system. Total Kjeldahl Nitrogen in the treated wastewater was 23% lower in the HRAP with waterhyacinth than that in the normal HRAP. Significant reduction of suspended solids was also recorded. Total Suspended Solids of the effluent in the HRAP-waterhyacinth system was generally less than 50 mg/L whereas it was greater than 450 mg/L in the conventional HRAP.

Within one reactor, the algae and the waterhyacinth could co-exist well. The algae did not show any inhibition towards growth of the waterhyacinth, whilst the latter allowed the algae to grow as long as there were nutrients and space for photosynthesis.

The mass balance of nitrogen depicted a partitioning of nitrogen removal in the HRAP-waterhyacinth system. This might be attributed to nitrogen assimilation by algae and bacteria, nitrogen uptake by waterhyacinth, biological nitrification-denitrification, and the volatilisation of ammonia. In the conventional HRAP, nitrogen removal was mainly due to ammonia volatilisation and assimilation.

These findings indicate that the introduction of *Eichhornia crassipes* into the HRAP may bring about better treatment of the wastewater, in terms of nitrogen and solids removal. However, further study is necessary to determine the optimum design and operation of such a system.

Abstrak Tesis Dikemukakan Kepada Senat
Universiti Putra Malaysia Sebagai Memenuhi
Keperluan Untuk Ijazah Master Sains

**PENGUNAAN *EICHHORNIA CRASSIPES***
**DI DALAM KOLAM ALGA KADAR TINGGI**
**UNTUK PENGURANGAN NITROGEN DARI AIR SISA**

Oleh

**NGUYEN NGOC BICH**

April 1998

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Pengolahan air sisa menggunakan kultur alga telah diselidik dan dimajukan sejak 1950. Kolam Alga Kadar Tinggi (KAKT) merupakan cara pengolahan yang paling cekap bagi pengolahan cara ini, terutama nya untuk pengurangan nitrogen. Walau bagaimanapun, masaalah utama sistem KAKT adalah paras pepejal terampai organik yang tinggi di dalam air sisa yang telah dirawat. Tambahan, zat makanan yang ter keluar dari pada sel alga yang mati boleh menyebabkan eutrofikasi di dalam sungai yang menerima air sisa tersebut.

Suatu kajian makmal menggunakan KAKT yang mengandungi keladi bunting *Eichhornia crassipes* sebagai sistem bersepadu telah dijalankan untuk meneliti pengurangan nitrogen dari air sisa. Alga yang dominan yang digunakan ialah *Chlorella vulgaris*.

Sebanyak dua puluh percubaan secara kelompok (batch) telah dijalankan menggunakan sistem KAKT biasa dan sistem KAKT-keladi bunting. Tiga percubaan berterusan (continuous) juga dijalankan di mana 50% permukaan air sisa di tumbuhi keladi bunting dan menggunakan tempoh penahanan hidraulik yang berlainan.

Perbandingan kedua-dua sistem untuk mengolah air sisa cecair dari kilang pemprosesan getah pekat menunjukkan sistem KAKT-keladi bunting memberi pengurangan nitrogen yang lebih baik. Kandungan Total Kjeldahl Nitrogen di dalam air sisa yang telah diolah secara KAKT-keladi bunting adalah 23% lebih rendah daripada yang diolah oleh sistem KAKT biasa. Pengurangan kandungan pepejal terampai yang lebih baik juga di catatkan. Amnya, kandungan pepejal terampai di dalam KAKT-keladi bunting adalah kurang daripada 50 mg/L manakala di dalam KAKT biasa adalah melebihi 450 mg/L.

Alga boleh bertumbuh bersama dengan keladi bunting. Alga didapati tidak menghalang pertumbuhan keladi bunting sementara keladi bunting pula tidak menghalang pertumbuhan alga selagi zat makanan dan ruang untuk fotosintesis mencukupi.

Perimbangan jisim nitrogen menunjukkan pemetakan pengurangan nitrogen di dalam sistem KAKT-keladi bunting. Pengurangan nitrogen berlaku melalui asimilasi oleh alga dan bakteria, permakanan oleh keladi bunting, nitrifikasi dan denitrifikasi, dan pemeruapan amonia. Dalam sistem KAKT biasa, pengurangan nitrogen berlaku melalui pemeruapan amonia dan asimilasi.

Penemuan-penemuan ini menunjukkan penanaman *Eichhornia crassipes* di dalam KAKT boleh menghasilkan pengolahan yang baik untuk pengurangan kandungan nitrogen dan pepejal. Walau, tambahan perlu di jalankan untuk mengena bagaimana pun pasti rekabentuk sistem yang sesuai serta cara operasi sistem berkanaan.

# CHAPTER I

## INTRODUCTION

The treatment of wastes using algal cultures has been researched and developed since 1950 (Oswald et al., 1957). The High Rate Algal Pond (HRAP) has proven to be the most efficient of this type of treatment, particularly for nitrogen removal (Fallowfield et al., 1985; Picot et al., 1992). However, since the main function of the pond is the assimilation of nutrients in wastewater by algae through their metabolism, this leads to the development of organic suspended solids in the pond. Therefore, further treatment is needed to remove algae from the treated effluent (Gaudy and Gaudy, 1981).

Many separation and harvesting techniques have been developed to remove algae from the treated effluent, the most promising amongst them being centrifugation, chemical coagulation, and autoflocculation (Oswald and

Golueke, 1960). Other algae removal techniques include ion exchange, flotation, microstraining, electric charge field, sand filtration, pond operation techniques, land application, aquaculture, floating plants, and rock filters (Golueke and Oswald, 1965; McGarry and Tongkasame, 1971; Middlebrooks et al., 1974; Harris et al., 1977; Dinges, 1978[a], 1978[b]; Wolverton and McDonald, 1979; Ellis, 1983; Fallowfield and Garrett, 1985; Nordin, 1994). However, unless the algae produced have economic value, most of the harvesting methods are costly and/or complicated due to their requirements of energy, chemicals and other materials, complex technology, and sophisticated equipment (Fallowfield and Garrett, 1985).

Amongst aquatic plants that have been used in wastewater treatment for the purpose of nutrients removal and effluent upgrading, waterhyacinth (*Eichhornia crassipes*) is one of the most effective macrophytes (Hauser, 1984; Reedy and De Busk, 1985). However, no past study has mentioned the co-existence of waterhyacinth and algae within a common treatment reactor.

This study was aimed at investigating the possibility of using an integrated treatment system

created by the introduction of waterhyacinth into the HRAP to remove nitrogen from wastewater. The structure of nitrogen removal in such a system would also be studied.