NITROGEN REMOVAL IN TEXTILE WASTEWATER USING COMBINED ANAEROBIC-AEROBIC SYSTEM

By

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

September 2004

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

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Chairman: Associate Professor Azni Bin Idris, Ph.D.

Faculty: Engineering

The objective of this study is to determine the percentage of nitrogen removal in textile wastewater effluent using combined anaerobic-aerobic system. The raw wastewater was of COD concentration between 385 to 1500 ppm at normal operating conditions. The anaerobic reactor has a capacity of 18 liters; meanwhile the aerobic reactor has a capacity of 9 liters to cater for a flow rate of 18 liters/day. Concentration of biomass was achieved through entrapment in the macrostructure of Cosmo (HDPE) balls used in the anaerobic reactor. The hydraulic retention time (HRT) for the anaerobic reactors was controlled at 24, 18, 12 and 8 hours. The Cosmo balls used in the system had proven to be an effective carrier material, which functioned as a separation device, thus limiting biomass being washed out.

The maximum removal of ammoniacal nitrogen, BOD, COD and VSS for the Selangor Cotton Sdn Bhd textile wastewater were 84.62%, 63.64%, 60% and 98.9% respectively. Levels in the final effluent for ammoniacal nitrogen, BOD, and COD were recorded at 1.11 mg/l, 13.17 mg/l and 108.75 mg/l respectively.

Kinetic parameters for nitrification using the anaerobic-aerobic reactor were found to be Y_N= 0.2305 mgVSS/mgNH_4, K_d = 0.1987 day $^{-1}$, μ_m = 1.196 day $^{-1}$, K_N= 4.302 mg/l. Meanwhile the kinetic parameters for denitrification using the anaerobic-aerobic reactor were: Y_D= 0.0025 mgVSS/mgNO_3, Kd= 0.0026 day $^{-1}$, μm = 0.00543 day $^{-1}$, K_D = 18.514mg/l.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian daripada syarat untuk Ijazah Master Sains

PENYINGKIRAN NITROGEN DALAM SISA TEKSTIL MENGGUNAKAN SISTEM KOMBINASI ANAEROBIK-AEROBIK

Oleh

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September 2004

Pengerusi: Profesor Madya Azni Bin Idris, Ph.D.

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Tujuan kajian adalah untuk menentukan peratus penyingkiran nitrogen di dalam sisa air buangan dari kilang fabrik menggunakan system gabungan anaerobic-aerobik. Sisa air buangan ini mengandungi kepekatan COD antara 385 dan 1500 ppm pada keadaan operasi normal. Reaktor anaerobik mempunyai muatan sebanyak 18 liter manakala reaktor aerobik mempunyai muatan isipadu sebanyak 9 liter bagi merawat kadar aliran air sisa sebanyak 18 liter/hari. Kepekatan biomas dapat dicapai melalui proses pengumpulan dalan struktur makro bebola cosmo yang telah digunakan dalam reaktor anaerobik. Masa tahanan hidrolik bagi reaktor anaerobik dikawal oleh pam emparan pada 24, 18, 12 dan 8 jam. Bebola cosmo yang digunakan dalam penyelidikan ini terbukti berkesan sebagai bahan pengangkut dalam pemisahan dan seterusnya menghadkan biomas daripada dibasuh keluar.

Penyingkiran maksimum bagi ammoniacal nitrogen, BOD, COD dan VSS bagi sisa air tekstil Selangor Cotton Sdn Bhd adalah 84.62%, 63.64%, 60% dan 98.9%. Bacaan akhir sisa air buangan bagi ammoniacal nitrogen, BOD dan COD dicatatkan pada 1.11 mg/l, 13.17 mg/l dan 108.75 mg/l.

Parameter kinetic untuk nitrifikasi menggunakan reaktor anaerobik-aerobik adalah, K_d = 0.1987 day $^{-1}$, μ_m = 1.196 day $^{-1}$, K_N= 4.302 mg/l.. Sementara itu,parameter kinetic untuk denitrifikasi menggunakan reaktor anaerobik-aerobik adalah : Y_D= 0.0025 mgVSS/mgNO_3, Kd= 0.0026 day $^{-1}$, µm = 0.00543 day $^{-1}$, K_D = 18.514mg/l.

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to Associate Professor Dr. Azni Idris, chairperson of my committee, for his guidance, insight and patience with this research project and my education at UPM. I would also like to express my sincere gratitude to Dr. Iyuke Sunny Esayegbemu and Encik Abdul Ghani Liew Abdullah for their sharing of ideas and opinion. Also my thanks go to the Department of Chemical and Environmental Engineering for their financial support which enables this research to be done. My appreciation goes to Selangor Cotton Berhad for their ongoing generosity in supplying the wastewater and technical support. Last but not least, warm thoughts to my family for constant support, understanding and encouragement in all my undertakings.

I certify that an Examination Committee met on September 2004 to conduct the final examination of Aofah Binti Adam on her Master of Science thesis entitled “Nitrogen Removal in Textile Wastewater Using Combined Anaerobic-Aerobic System” in accordance with University Putra Malaysia (Higher Degree) Act 1980 and University Putra Malaysia (Higher Degree) Regulations 981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows: -

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations 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.

AOFAH BINTI ADAM

Date:

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LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
HRT	Hydraulic Retention Time
OLR	Organic Loading Rate
SSC	Steady State Conditions
VSS	Volatile Suspended Solid
TSS	Total Suspended Solid
PVC	Pipe Vertified Clay
HDPE	Hydraulic Density Polyethylene

CHAPTER 1

INTRODUCTION

1.1 General

Nitrogen is an essential nutrient for biological growth, normally comprising about 12-14 percent of the mass of cell protein (Barnes and Bliss, 1983). Nitrogen in wastewater can exist in four forms: organic nitrogen, ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen (Metcalf and Eddy, 1979). Nitrogen compounds are becoming increasingly important in wastewater management, because of the many effects that nitrogenous material can have on the environment. Nitrogen, in its various forms can deplete oxygen due to nitrification, fertilize aquatic plant growth, exhibit toxicity toward aquatic life, affect chlorine disinfections efficiency and present a public health hazard (Sorensen and Jorgensen, 1993).

1.2 Environmental Effects of Nitrogen

The presence of nitrogen compound in an effluent causes pollution in the receiving waterway, and provision must therefore be made for the removal of these materials in wastewater treatment. Nitrogen compounds have special polluting effects in addition to those of exerting oxygen demand and stimulating eutrophication (M.A Winkler, 1981).

Normally, nitrogen compounds that are released in the waterways are treated using biological or chemical treatment method. The present technologies used to remove nitrogen compounds are using either anaerobic or aerobic system. This research is using both system of anaerobic and aerobic to gauge the effectiveness and efficiency of this combined system. There is a need to do this research to find an alternative method or a new technology whereby the textile industry is offered a better solution to treat their wastewater. Hopefully with a proven success of this research and findings, and can be cost effective, it will be of benefit to the textile industry in Malaysia

1.3 Objectives and Scope of Research

The objectives of this study are as follows:

a) To determine the percentage of nitrogen removal in textile wastewater effluent using Combined Anaerobic-Aerobic system.
b) To determine the kinetic data for Nitrification and Denitrification processes.

Scope of this study is to determine the effects of nitrogen compound in textile wastewater effluent discharge into waterways without being treated. Characteristic of textile wastewater will be also included in this study. Review of past study done on Combined Anaerobic-Aerobic Treatment also is presented.

CHAPTER 2

LITERATURE REVIEW

2.1 Industrial Processes in the Textile Industry

The textile industry is comprised of a diverse, fragmented group of establishments that produce and/or process textile-related products (fiber, yarn, fabric) for further processing into apparel, home furnishings, and industrial goods. Textile establishments receive and prepare fibers; transform fibers into yarn, thread, or webbing; convert the yarn into fabric or related products; and dye and finish these materials at various stages of production. The process of converting raw fibers into finishing apparel and non-apparel textile products is complex; thus most textile mills specialize. Little overlap occurs between knitting and weaving, or among production of man-made, cotton, and wool fabrics. This section focuses on the following four production stages (Kathryn, 1993):

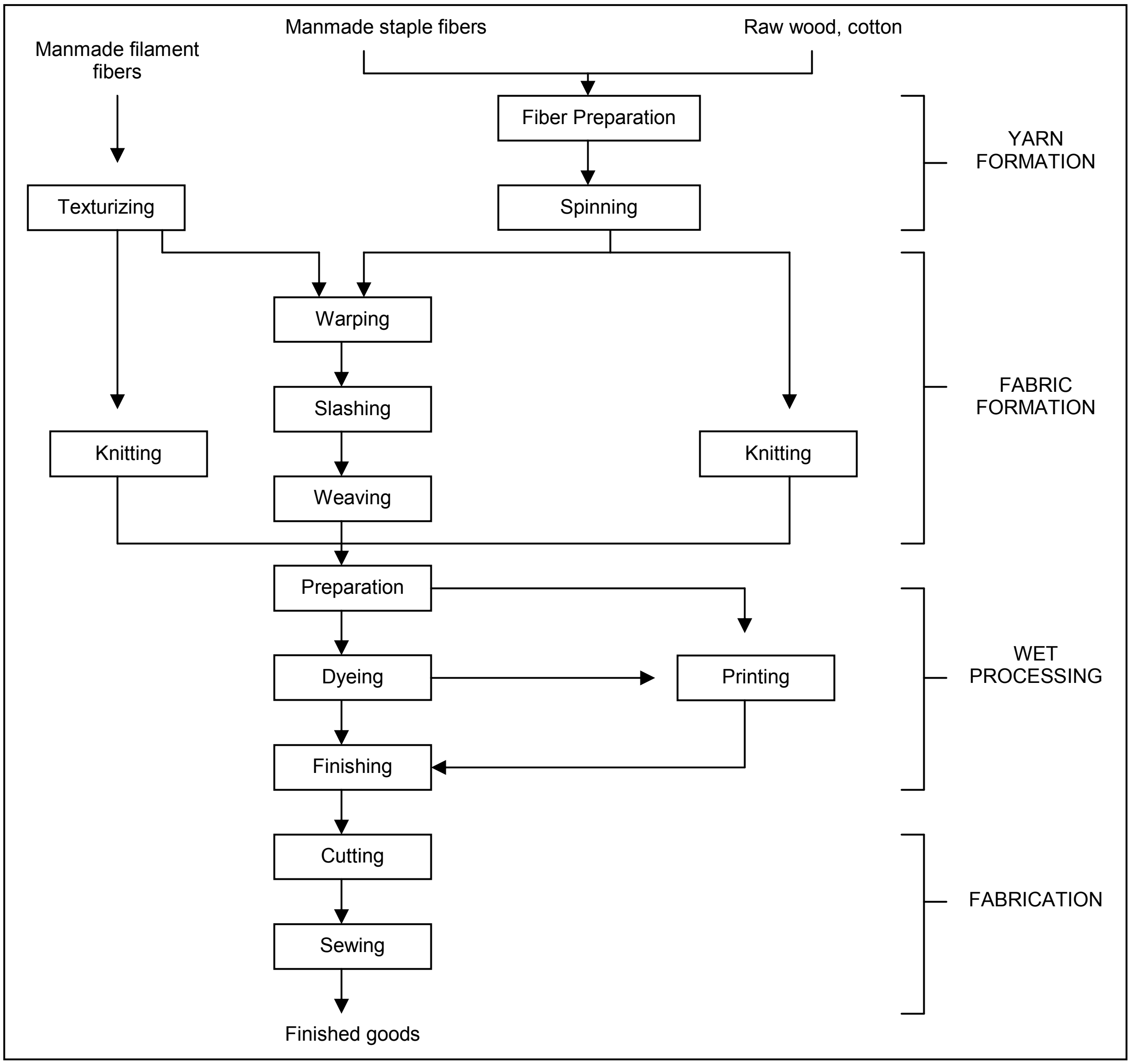
a) Yarn formation

b) Fabric formation

c) Wet processing

d) Fabrication

These stages are highlighted in the process flow chart shown in Figure 1.



(Jules, 1975)

Figure 1: Flow chart of Processes in Textile Industry

2.2 Textile Wastewater Treatment

Increasing awareness in recent years of cumulative effects of pollution has led to increasing public concern and increasingly strict legislation relating to the discharge of industrial wastes, liquid and gaseous. Certainly, the chemical industry is fundamental to the economy of any industrialized and any additional cost is reflected in the cost of virtually every manufactured product (M.A Winkler, 1981).

The characteristics of wastewater are an important factor in the design and operation of wastewater treatment facilities. Properties and constituents in wastewater depend primarily on the source of the wastewater. Traditionally, wastewater treatment has focused on the removal of gross organic and inorganic constituents and pathogens in wastewater that primarily included carbonaceous BOD and suspended solids removal and disinfecting processes.

Nutrients have become contaminants of concern in wastewater because nitrogen is essential nutrient for growth. When discharged to receiving bodies of water, they can lead to the undesirable problems such as algae blooms and eutrophication. The presence of algae and aquatic plants may obstruct the uses of water resources, the growth of aquatic life and cause aesthetic problems. When it is discharged in excessive amounts on land, it can pollute groundwater.

Nutrients in sufficient amounts can result in oxygen depletion in receiving bodies of water. Excess nitrogen is a common problem encountered in the influents and effluents of many wastewater treatment plants (Metcalf and Eddy, 1979).

2.2.1 Biological Treatment Method

Biological treatment encompasses basically aerobic and anaerobic treatment. Biological treatment may be preceded by primary treatment, typically sedimentation. Pretreatment of textile wastes before biological treatment could include any or all of the following: screening, sedimentation, equalization, neutralization, chrome reduction, coagulation or any of the other physical-chemical treatments. The performance of biological treatment in COD removal depends on the BOD_5/COD ratio (A.M Martin, 1997).

2.2.1.1 Aerobic Treatment

The biological treatment methods applicable to textile wastewater follow in order of increasing detention time (A.M Martin, 1997):

i. Trickling filters.

   The concept of a trickling filter grew from the use of contact filters, which were watertight basins filled with broken stones. In operation, the contact bed was filled with wastewater from the top, and the wastewater was allowed to contact the media for a short time. The modern trickling filter consists of a bed of highly permeable media to which microorganisms are attached and through which wastewater is percolated or trickled. The filter media usually consists of rocks, varying in size from 25 to 100 mm (1 to 4 in) in diameter. The depth of the rock varies with each particular design but usually ranges from 0.9 to 2.0 m (3 to 8 ft) and averages 1.8 m (6 ft). Trickling filters that use plastic media in more recent innovation, have been built in square and other shapes with depths varying from 9 to 12 m (30 to 40 ft). Rock filter beds are usually circular, and the liquid wastewater is distributed over the top of the bed by rotary distributor (Metcalf and Eddy, 1979).

ii. Activated sludge.

The activated sludge process is probably the most widely used biological process for the treatment of organic and industrial wastewaters (M.A Winkler, 1981). Organic waste is introduced into a reactor where an aerobic bacterial culture is maintained in suspension. The reactor contents are referred to as the mixed liquor. In the reactor, the bacterial culture carries out the conversion in general accordance with the stoichiometry. The aerobic environment in the reactor is achieved by the use of diffused or mechanical aeration, which also serves to maintain the mixed liquor in a completely mixed regime. After a specified period of time, the mixture of