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UTILIZATION OF AGRO WASTE TO PRODUCE BIOSORBENT

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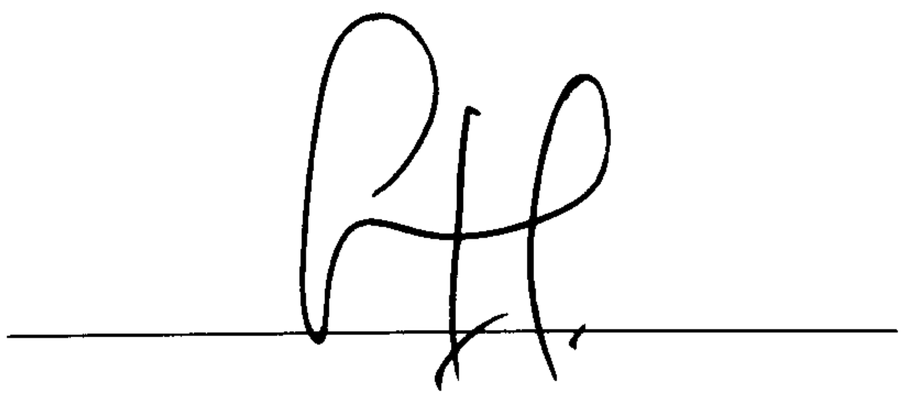

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UTILIZATION OF AGRO WASTE TO PRODUCE BIOSORBENT

THARANITHARAN ASOGE SUGUMARAN

This project is submitted to the
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in partial fulfilment of the requirements for the degree for
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Dedicated to my beloved family, friends and guru for great support

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ABSTRACT

Banana skin, an abundant agricultural by-product in Malaysia, was used to adsorb industrial dye. The industrial dye used in this study was crystal violet. Three types of biosorbents were prepared in the adsorption study, which were: 'Not Washed Banana Biosorbent', 'Washed Banana Biosorbent', and 'Chemically Treated Banana Biosorbent'. Adsoprtion isotherms of the dye onto the biosorbent were determined by batch equilibrium study. The batch equilibrium study was performed using the effects of initial dye concentration on the adsorption mechanisms at room temperature. Equlibrium data were fitted to Langmuir and Freundlich isotherm. The equilibrium data were best represented by the Freundlinch isotherm, with maximum heterogeneous adsorption capacity of 1.8197 mg/g for Chemically Treated Banana Biosorbent. Various biosorbent adsorption analyses such as Scanning Electron Microscope (SEM), Fourier Transform Infrared (FTIR) and Ultra Violet Spectroscopy (UV) were carried out. Besides that, banana skin characterization was performed for ash and moisture content. Banana skin based biosorbent shows to be a promising material for the adsorption of crystal violet dye from aqueous solution.

ABSTRAK

Kulit pisang merupakan sisa sampingan sektor pertanian yang banyak diperolehi di Malaysia. Kulit pisang digunakan untuk penyerapan agen pewarna industri. Pewarna industri yang digunakan dalam kajian ini ialah kristal ungu. Tiga jenis sampel pisang disediakan untuk kajian penyerapan, iaitu 'Bio-Penyerap Pisang yang Tidak Dicuci', 'Bio- Penyerap Pisang yang Dicuci' serta 'Bio-Penyerap Pisang yang Disediakan secara Rawatan Kimia'. Isoterma penyerapan pewarna ke atas Bio-Penyerap ditentukan menerusi kajian keseimbangan kelompok. Kesan kepekatan awal pewarna kristal ungu ke atas mekanisme penyerapan untuk kajian keseimbangan kelompok dikaji pada suhu bilik. Data penyerapan disuaikan dengan isoterma Langmuir dan Freundlinch. Isoterma Freundlich merupakan model yang paling sesuai untuk mewakili mekanisme penyerapan, dengan kapasiti maximum penyerapan "heterogeneous" sebanyak 1.8197 mg/g menerusi Bio-Penyerap Pisang yang Disediakan secara Rawatan Kimia. Pelbagai analisa kriteria dijalankan ke atas bio-penyerap, contohnya ialah analisa Pengimbasan Mikroskop Elektron (SEM), "Fourier Transform Infrared" (FTIR) Spektrometer dan UV Spektrometer. Selain itu, kriteria-kriteria kulit pisang turut dianalisa menerusi kandungan abu dan kelembapan. Bio-penyerap yang berasaskan kulit pisang menunjukan keputusan yang memberangsangkan terhadap penyerapan pewarna kristal ungu daripada larutan akuos.

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C_e	Equilibrium concentration
q_e	amount of adsorbate adsorbed per unit mass
Q_o	Langmuir constants related to adsorption capacity
b	Langmuir constants related to rate of adsorption
K_F	Freundlinch constants
SEM	Scanning Electron Microscope
FTIR	Fourier Transform Infrared Spectroscopy
$1/n$	Adsorption intensity or surface heterogeneity
Kbr	Potassium Bromide Salt
HCl	Hydrochloric Acid
H_2	Hydrogen

CHAPTER 1

INTRODUCTION

1.1 Background

One of the major issues on our planet today is pollution. Pollution has attracted serious attention and if it is not curbed, it might lead to human extinction itself. Generally, pollution can be categorized into three main categories, mainly soil pollution, air pollution and aqueous pollution. Soil and aqueous pollution have been concerning as we live and consume these resources daily and aqueous pollution has become primary concern due to its central role in mediating global-scale ecosystem processes.

Water has two closely linked dimensions. One is quality and the other one is quantity. Quality of the water is commonly defined by its physical, chemical, biological and aesthetic (appearance and smell) characteristics (Ramachandra *et al.*, 2009). A healthy environment can be described as water quality which supports a rich and varied community of organisms and protects public health (Ramachandra *et al.*, 2002). On the quality dimension, water is a limiting resource and pollution decreases the supply of usable water and increases the cost of purifying.

The major source of water pollutants includes a variety of organic and inorganic chemicals such as heavy metals, dyes and industrial compounds. Dyes can be described as chemical compounds that can attach themselves to fabrics or any other surfaces to impart colour and have become one of the globally-distributed pollutants (Ramachandra *et al.*, 2009). Human body is exposed to dye poisoning through skin contact, inhalation, and ingestion (Alok Mittal *et al.*, 2009). This can lead to skin irritation or digestive tract pain at minor levels (Alok Mittal *et al.*, 2009). In severe scenario, it can lead up to kidney failures, toxication and also permanent blindness (Alok Mittal *et al.*, 2009). The exposure to dyes is unavoidable in present day as they are present in the most significant area of modern consumerism, which starts from clothing up to hair colouring. Many dyes and pigments are toxic in nature with suspected carcinogenic and mutagenic effects (Gregory *et al.*, 1991; McKay *et al.*, 1985). Therefore these dyes should be removed from the environment and human exposure to these dyes should be minimized.

This study focuses on the removal of crystal violet dye from the environment. In most cases, crystal violet exposure to humans is through breathing, eating, drinking and skin contact (Ramachandra *et al.*, 2009). This dye colours the segment of a matter in deep purple. Crystal violet is most commonly used as a sterilizer in hospitals as well as colouring agent for cotton and silk (Ryan *et al.,* 1992; Saji *et al.,* 1995; Au *et al.,* 1979). This dye is considered highly toxic and has been reported to cause toxicity to mammalian cells (Thomas *et al.,* 1984; Jone *et al.,* 2003). The problems caused by this dye starts from as little as skin irritation up to permanent blindness (Alok Mittal *et al.,* 2009).

Therefore, a proper method should be deduced on removal of this dye from the natural waste water. The conventional method for removal of dyes includes sedimentation, filtration, chemical treatment, oxidation, electrochemical method, biological treatment, adsorption and ion exchange. These methods have limited impact due to several disadvantages which includes high capital cost, generation of toxic, high energy requirements and not environmental friendly (Volesky 2001 ; Aksu 2002 ; Zhang *et al.*,2008).

Biosorption is the removal of pollutants from aqueous streams using organic substance as biosorbent (adsorbent) (Igwe and Abia, 2006). Biosorption can be described as the ability of the biosorbent (organic substance) to attract the adsorbate (the molecules or atoms to be gathered). Basically, the method of adsorption can be segregated into two different concepts, one which is due to forces of physical nature called "Van Der Waals" forces and the second type is known as chemisorptions. The raw material for the adsorption process comes naturally from the environment. Seaweed,

moulds, yeasts, dead microbial biomass and agricultural waste material have been used as the raw material in the biosorption process to adsorb industrial dye. (Bailey *et al.,* 1999; Haung and Haung, 1996; Sudha and Abraham, 2003; Zhou and Kiff, 1991). Major advantages of this technique over other conventional methods include low cost, high efficiency, minimization of chemical and biological sludge, and regeneration of biosorbents.

In literature, agricultural waste particularly those having high cellulose content showed potential dye biosorption capacity (Ramachandra *et al.,* 2009). The basic composition of agricultural waste which contains variety of functional groups including hemicelluloses, lignin, extractives, lipids, proteins, simple sugars, water hydrocarbons and starch which helps on the dye adsorption process (Bailey *et al.,* 1999; Hashem *et al.,* 2005). Besides, agricultural waste is an idealistic raw material for biosorption due to being economic, biodegradable, abundant in nature and also renewable for industrial dye remediation. These agricultural wastes are used in the pollutant removal process either in their natural form or after some physical and chemical modification.

In this research, agricultural waste will be used as the raw material to synthesize biosorbent for crystal violet dye removal. The agricultural waste which has been chosen in this study is banana skin. Banana skin is abundance in nature and has high content of hemicelluloses and pectin materials (Chong, 2007). Besides being high in nutritional value, banana waste has become a major problem itself due to its abundance. Sarawakian Cottage Industry for producing banana chips faces a big problem in disposing the banana skin. Currently, burning the banana skins and throwing it away in land fields is their only option. Burning large scale of banana skins brings ecological

threats and contributes to a major part in environmental pollution, namely haze formation. Thus to prevent the pollution and under utilization, the banana skin have been used as the raw material in this study. If this research is successful, the underutilized banana skin will have added commercial value and will contribute in saving the planet from further pollution.

1.2 Problem Statement

Banana skins have become a major source of pollution in Sarawak due to increase in commercialization of banana based food products. Besides that, this natural resource becomes underutilized due to its unknown potential. The only way banana skin has been utilized is through composing it to fertilizer by letting it to biodegrade itself naturally. Another environmental problem which needs severe attention is pollution of industrial dye due to the increase in industrialization. Humans become vulnerable to industrial dye poisoning compared to olden days and this issue needs a full stop. Even though there are many conventional methods to remove the industrial dye, but small scale farmers and entrepreneurs do not have access to it due to its high cost of implementation. Thus, banana skin as the natural resource should be investigated for more utilization and dye pollution should be brought to a halt.